**Name of Project - Middle Creek & Shoal Creek Watershed-Based Plan**

**Lead Organization –**

**TenneSEA (Student Environmental Alliance)**

# TABLE OF CONTENTS



# 1 WATERSHED IDENTIFICATION

This project is located within the Nickajack Lake Upper Watershed (HUC 06020001 1202), a sub watershed of the Lower Tennessee River Watershed. It is focused particularly on Middle Creek (TN06020001109) and Shoal Creek (TN06020001087) and their impaired tributaries, These streams have their source on Walden's Ridge in Hamilton County, TN and flow off of the ridge through the Town of Signal Mountain and into the Tennessee River at the Tennessee River Gorge just downstream of downtown Chattanooga. In 2010, the population density in the Town of Signal Mountain was 1,112.6 people per square mile but as a total watershed the density is much lower since downstream of the Town of Signal, the watershed is undeveloped as part of Prentice Cooper State Forest. The areas of Short Creek, Bee Branch and Middle Creek that flow through Prentice Cooper are also designated as exceptional Tennessee waters.

Since most of the upper watersheds are urbanized, issues arising from septic systems, sewer overflows, and sedimentation originate there and are exacerbated by the increasing percentage of impervious surfaces in the watersheds.

# 2 CAUSES AND SOURCES OF NONPOINT POLLUTION IN THE WATERSHED

Middle Creek Watershed is approximately 7.37 Square miles or 4,717 Acres of which four tributaries are listed as impacted: Stanley Branch, Fruedenberg Creek, Short Creek and Bee Branch. The main stem of Middle Creek itself is not listed on the 303d list. Shoal Creek Watershed is approximately 2.4 square miles and is impaired in its entirety. The 303d listed segments are shown in Table 1 (TDEC 2018 final 303 d list).

| Stream | Reach ID | Area of subwatershed | Miles impaired | Cause of impairment |
|---|---|---|---|---|
| **Middle Creek (TN06020001109)** | | | | |
| Stanley Branch | _0100 | 0.88 sq mi (563 acres) | 1.05 | Low pH (abandoned mine lands) |
| Fruedenberg Creek | _0200 | 0.87 sq mi (557 acres) | 1.4 | Iron, low pH (abandoned mine lands) |
| Short Creek | _0300 | 0.67 sq mi (429 acres) | 2.5 | E. coli (Municipal and Onsite Treatment systems) |
| Bee Branch | _0400 | | 1.55 | E. coli (Municipal and Onsite Treatment systems) Sedimentation (Urban) |
| **Shoal Creek (TN06020001087)** | | | | |
| Shoal Creek | _1000 | 2.4 sq mi (1536 acres) | 5.4 | E. coli (Municipal, On-site Treatment Systems, Sanitary Sewer Overflows ) |

This watershed based plan addresses acid mine drainage, sediment and pathogens within these watersheds. Efforts in the watersheds will address stormwater runoff which causes rapid increases in stream flow, severely eroding the stream banks and increasing sediment loading, particularly in Bee Branch. Runoff also causes issues with the sewer and septic systems, increasing pathogen concentrations. Restoration will focus on passively treating acid mine drainage, reducing stormwater runoff, disconnecting stormwater conveyances from the sewer system, stream bank repair, pathogen reduction practices via septic system repair, and public education about watershed pollution. Our goal with full implementation of this plan is move closer to removing these watersheds from the 303 d list of impaired streams

### *Discuss all that is known about the water quality problems in the watershed. Use all local knowledge of the current land usages in the watershed, and how these contribute to the problems affecting water quality*

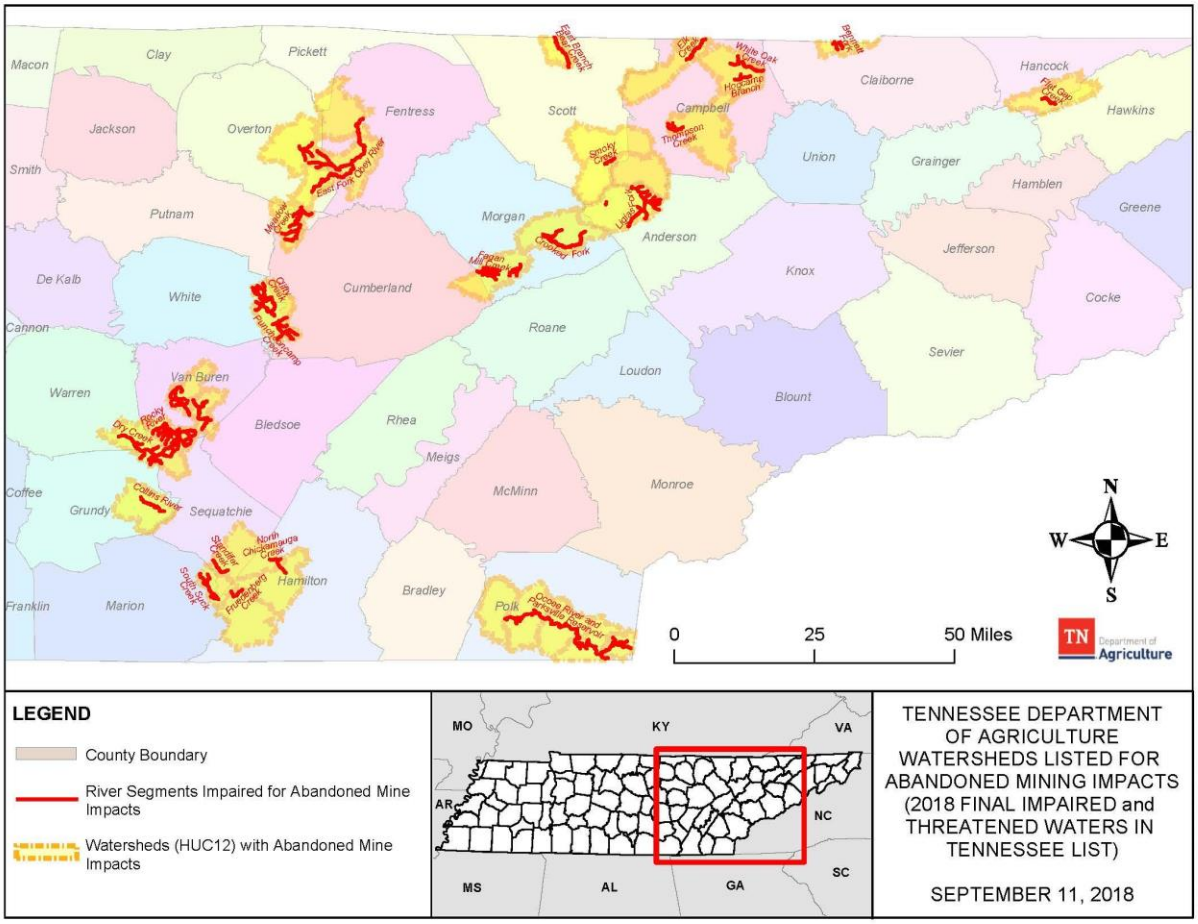
Middle Creek and Shoal creek watersheds originate on Walden's Ridge (Signal Mountain) and flow through urban areas until falling off the plateau into Prentice Cooper State Forest and finally emptying into the Tennessee River in the gorge. Walden's Ridge is in the Cumberland Plateau (68a) Ecoregion. According to the Lower Tennessee TMDL for pH/iron on Suck Creek:

"Cumberland Plateau (68a) tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally 1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is covered by well drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist."

Signal Mountain is no exception to the extensive mining, likely dating to the 1920's. Several subdivisions have been constructed on abandoned mining sites with high walls and spoil piles still in evidence. Indeed, while two tributaries to Middle Creek are designated as impaired due to low pH, many other smaller tributaries could also be so designated. In addition, these two Acid Mine Drainage (AMD )listed tributaries, as well as other localities downstream, are also prone to ATV trails, which also increases the sedimentation in the creeks.

Housing developments cover the upper watersheds adding to the imperviousness of the landscape and septic system malfunction. All across the ridge, the soils are very shallow, but even more so on old mining sites. This reduced soil depth adds to the critical malfunctioning of septic systems in the neighborhoods such as Hidden Brook, St. Ives and Birnam Wood. These small watersheds are prone to rapid rises in streamflow after a storm even due to urban impervious cover, causing stream scouring and road sediment to be added to the streams, most notably in Bee Branch. Runoff also causes issues with sewer systems increasing pathogen concentrations. Restoration should focus on acid mine drainage remediation, reduction of runoff, septic system rehabilitation, stream bank stabilization, and public education.

*Figure 1.  Watersheds Listed for Abandoned Mining Impacts (2018)*




## 2.1 PATHOGENS

Shoal Creek, Bee Branch and Short Creek within the Town of Signal Mountain are significantly degraded due to septic system malfunction and sewer leaks.  The sewage treatment system is regularly infiltrated with stormwater which causes the sewage treatment plant to send minimally treated waste directly to the Tennessee River.  It also causes frequent sewer line overflows, causing very high E. coli contamination in some of the streams. The aging sewer line running down Shoal Creek is constructed with jointed clay pipes which are not only showing their age through cracks and fissure, but the joints themselves are infiltrating high volumes of stream water which cause sewer line overflows downstream. The biggest need for the sewer system is improved infrastructure, which the WWTA has begun to work on, lining some of the pipes in the Shoal Creek watershed.  However, since only approximately 30 percent of the homes within the Town of Signal are connected to sewers, the other big contributor is septic system waste. Most septic system drain fields on Signal Mountain are distributed in very shallow soils.  The bedrock is very close to the soil surface, not providing adequate soil surface area and porosity to complete the sewage treatment of the septic system.  The septic outflow drains quickly to solid bedrock, resulting in sheet flow on top of the rock to the nearest stream, bringing with it the high bacteria levels now found in the Signal Mountain drainages. The field lines in these systems are insufficient when considering the shallow soils. In May of 2007, both Dr. Dick Urban, then head of TDEC's water quality branch in Chattanooga and then Mayor of the Town of Signal Mountain, Dr. Paul Hendricks, discouraged people from getting into the creeks due to the sewer overflows and septic discharges (Town of Signal Mountain Council Minutes,). A summary of TDEC's Water Monitoring Data for E. coli is found below in Table 1.

*Figure 2. Impaired Reaches in the Middle and Shoal Creek Watersheds on Signal Mountain.*

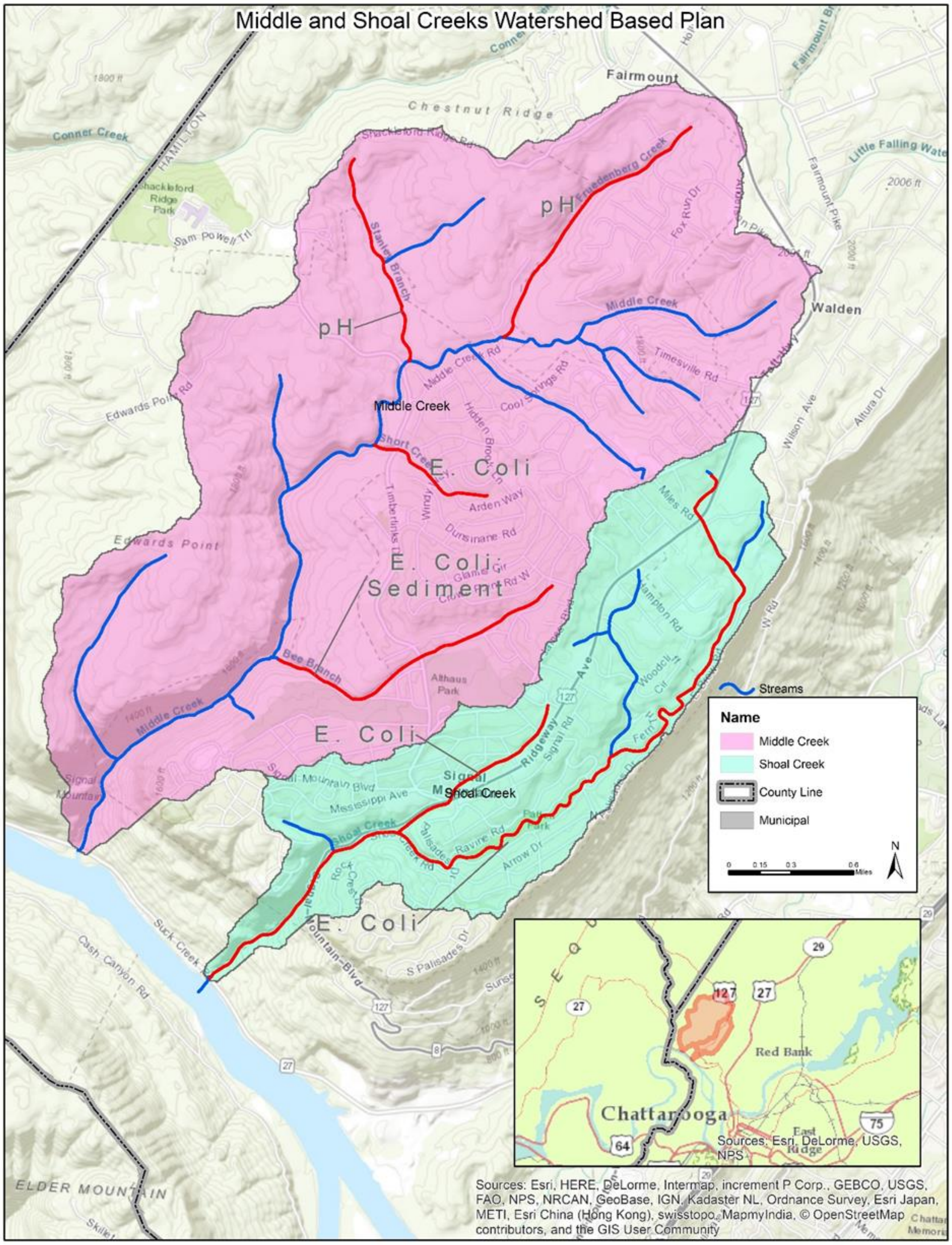


*Table 1. Summary of TDEC Water Quality Monitoring Data in Middle and Shoal creeks*

| Monitoring Station | Data Range | # Of Data Points | Min | Avg | Max | # Times Exceeded Maximum |
|---|---|---|---|---|---|---|
| Bee Branch | 2005-09 | 16 | 90 | 983 | 2419.6 | 11 |
| Short Creek | 2005-09 | 16 | 43.2 | 853 | 2419.6 | 9 |
| Shoal Creek | 2005-09 | 16 | 52.8 | 787 | 2419.6 | 7 |

The Town of Signal Mountain's Stormwater Program has a monitoring program in place to determine improvement in the streams within their boundaries. E coli data from 2015 is shown in the Table 2 below.

*Table 2. Summary of Town of Signal Mountain E. Coli Monitoring Data*

| Site | 7/23/2015 | 7/20/2015 | 7/16/2015 | 7/13/2015 | 7/7/2015 | Geometric Mean |
|---|---|---|---|---|---|---|
| 1-Shoal Creek downstream | 6300 | 30 | 120 | 10 | 20 | 85.38 |
| 2-Carlin Creek | 1800 | 240 | 220 | 160 | 70 | 254.35 |
| 3-Shoal Creek upstream | 5500 | 320 | 150 | 70 | 160 | 312.01 |
| 4-Bee Branch downstream | 4800 | 90 | 180 | 20 | 140 | 185.18 |
| 5-Bee Branch at Timeberlinks | 4400 | 200 | 90 | 60 | 90 | 211.95 |
| 6- UT at Whispering Pines | 1700 | 360 | 190 | 310 | 470 | 442.38 |
| 7-Short Creek | 2200 | 110 | 140 | 280 | 90 | 243.37 |
| 8-Middle Creek at Timberlinks | 1700 | 180 | 200 | 30 | 80 | 171.16 |
| 9-Stanley Branch | 270 | 40 | 1 | 1 | 1 | 6.41 |
| 10-Fruedenberg Branch below Sweet Shrub | 300 | 80 | 20 | 80 | 30 | 64.91 |
| 11-Fruendenberg below mine at Creekshire | 10 | 1 | 1 | 1 | 1 | 1.58 |
| 12-Middle Creek @ middle creek road | 2000 | 150 | 40 | 20 | 10 | 75.17 |

In addition, Citizen Science Monitoring has been taking place sporadically for many years. The Citizen Science results, while not quality controlled, do indicate rapid increases of E coli and sediment in streams after heavy rains, but returning to background levels within two to three days. The branch of Shoal Creek that flows by Hampton Road is well known for sewer overflows, despite not being monitored by TDEC, and Citizen Scientists have noted increases in E coli concentrations over 2 orders of magnitude after rain events. (background levels less than 400 cfu/100mL, post rain levels over 40,000 cfu/100 mL).

Increases in Short Creek and Bee Branch after heavy rainfalls only note a one order of magnitude increase, presumably because these watersheds are mostly covered by septic systems, not sewers.

According to the TMDL written in 2010, “Management measures to reduce pathogen loading from urban nonpoint sources include stormwater, illicit discharges, septic systems, pet waste, and wildlife”

While stormwater BMP’s are not specifically designed to reduce bacterial loading, they do reduce sewer overflows and septic discharges as well as reduce the sediment to which the bacteria is often attached. Therefore, reducing stormwater volume can have a big impact on bacterial loading of the streams. In addition, because of the high percentage of homes on septic systems, identifying failing systems and improving the functioning of these systems is a top priority. The long term solution is to connect homes to the sewer system, but since TDEC has placed a moratorium on new connections to the sewer system until the frequent overflows are solved, that is not a solution which will soon be realized. While wildlife may be a source of pollutants, the other more likely source would be pet waste. Since the streams are in urban settings, the number of pets per acre is very high. If the waste is not disposed of properly, these bacteria can also contribute to pathogen loading. Education of pet owners on proper disposal of pet waste will assist with this issue. In addition, since wildlife are attracted to campsite areas around the creek, buffering creeks from potential waste areas will assist with wildlife contributions to pathogen loading.

The TMDL for all three streams is 1.20 x 1010 x Q (Q=Streamflow)

The Load Allocations are as follows:

Bee Branch 2.541 x 107 x Q

Short Creek 2.770 x 107 x Q

Shoal Creek 7.068 x 106 x Q

Taking into account flow rates and based on Geometric Mean data from TDEC, the percent load reduction goals to achieve the TMDL, are as follows:

Bee Branch: 91.9%

Short Creek 61.9%

Shoal Creek: 79.3%

The TMDL also provided effectiveness ratings for BMP’s based on the flow rates. These are depicted below in Table 3.

*Table 3. BMP effectiveness ratings based on Flow Zone taken from the Lower Tennessee River Watershed (HUC 06020001) E. Coli TMDL 9/15/10*

| Management Practice | Duration Curve Zone (Flow Zone) | | | | |
|---|---|---|---|---|---|
| | High | Moist | Mid-Range | Dry | Low |
| **Low impact development** | | | | | |
| Disconnecting impervious areas | | L | M | H | |
| Bioretention | L | M | H | H | |
| Pervious pavement | | L | M | H | |
| Green Roof | | L | M | H | |
| Buffers | | H | H | H | |
| **New/existing on-site wastewater treatment systems** | | | | | |
| Permitting & installation programs | | L | M | H | M |
| Operation & maintenance programs | | L | M | H | M |
| **Other** | | | | | |
| Point source controls | | L | M | H | H |
| Landfill control | | L | M | H | |
| Riparian buffers | | H | H | H | |
| Pet waste education & ordinances | | M | H | H | L |
| Wildlife management | | M | H | H | L |
| Inspection & maintenance of BMPs | L | M | H | H | L |

__Note__: Potential relative importance of management practice effectiveness under given hydrologic condition (*H: High, M: Medium, L: Low*)

| | | | | | |
|---|---|---|---|---|---|
| **Bacteria source reduction** | | | | | |
| Remove illicit discharges | | | L | M | H |
| Address pet & wildlife waste | | H | M | M | L |
| **Combined sewer overflow management** | | | | | |
| Combined sewer separation | | H | M | L | |
| CSO prevention practices | | H | M | L | |
| **Sanitary sewer system** | | | | | |
| Infiltration/Inflow mitigation | H | M | L | L | |
| Inspection, maintenance, and repair | | L | M | H | H |
| SSO repair/abatement | H | M | L | | |
| Illegal cross-connections | | | | | |
| **Septic system management** | | | | | |
| Managing private systems | | L | M | H | M |
| Replacing failed systems | | L | M | H | M |
| Installing public sewers | | L | M | H | M |
| **Storm water infiltration/retention** | | | | | |
| Infiltration basin | | L | M | H | |
| Infiltration trench | | L | M | H | |
| Infiltration/Biofilter swale | | L | M | H | |
| **Storm Water detention** | | | | | |
| Created wetland | | H | M | L | |

Using the non-point source management practices suggested in the TMDL will augment remediation being implemented by the WWTA and Town of Signal to significantly reduce the E coli loading to these creeks.

## 2.2 Sediment

Bee Branch is the only sub watershed impaired for sediment or siltation which not only has a detrimental effect on residents in the creek, but also the surrounding watershed. Reducing sediment load will in turn, improve the health of the entire ecosystem.

Although no TMDL has been written for sediment for Bee Branch, the lower TN Sediment TMDL written in 2006 is pertinent to this stream as well.

According to the TMDL, "siltation is the most frequently cited cause of water body impairments in Tennessee, impacting over 5,800 miles of streams and rivers. Unlike many chemical pollutants, sediments are typically present in water bodies in natural or background amounts and are essential to normal ecological function. Excessive sediment loading, however, is a major ecosystem stressor that can adversely impact biota, either directly or through changes to physical habitat." (TMDL for Sediment)

While Bee Branch certainly has short term impacts from construction activities, the primary sources for sediment loading occur during storm events through road drainage, storm drains, and sediment flow off of the adjacent golf course. The stream is frequently inundated with sand flowing from the golf course. Accumulated dirt running off of impervious surfaces during rain events is also a contributor. That silt is likely originating from yards in the watershed, where lawns are often maintained up to the edge of the bank. The flashy nature of the stream is also a contributor of the sediment loading. Due to the high percentage of impervious surfaces in this small watershed, creek levels rise quickly and scour the stream bank, adding additional sediment to the stream itself.

While we do not have the current sediment loading for Bee Branch from the TMDL, the ecoregion is the same as for North Chickamauga Creek and South Suck Creek, 68a, and therefore the target maximum load should be the same as well at 135.5 lb/acre/year. It should be noted that reducing the sediment load could potentially aid in reducing the pathogen loading as well.

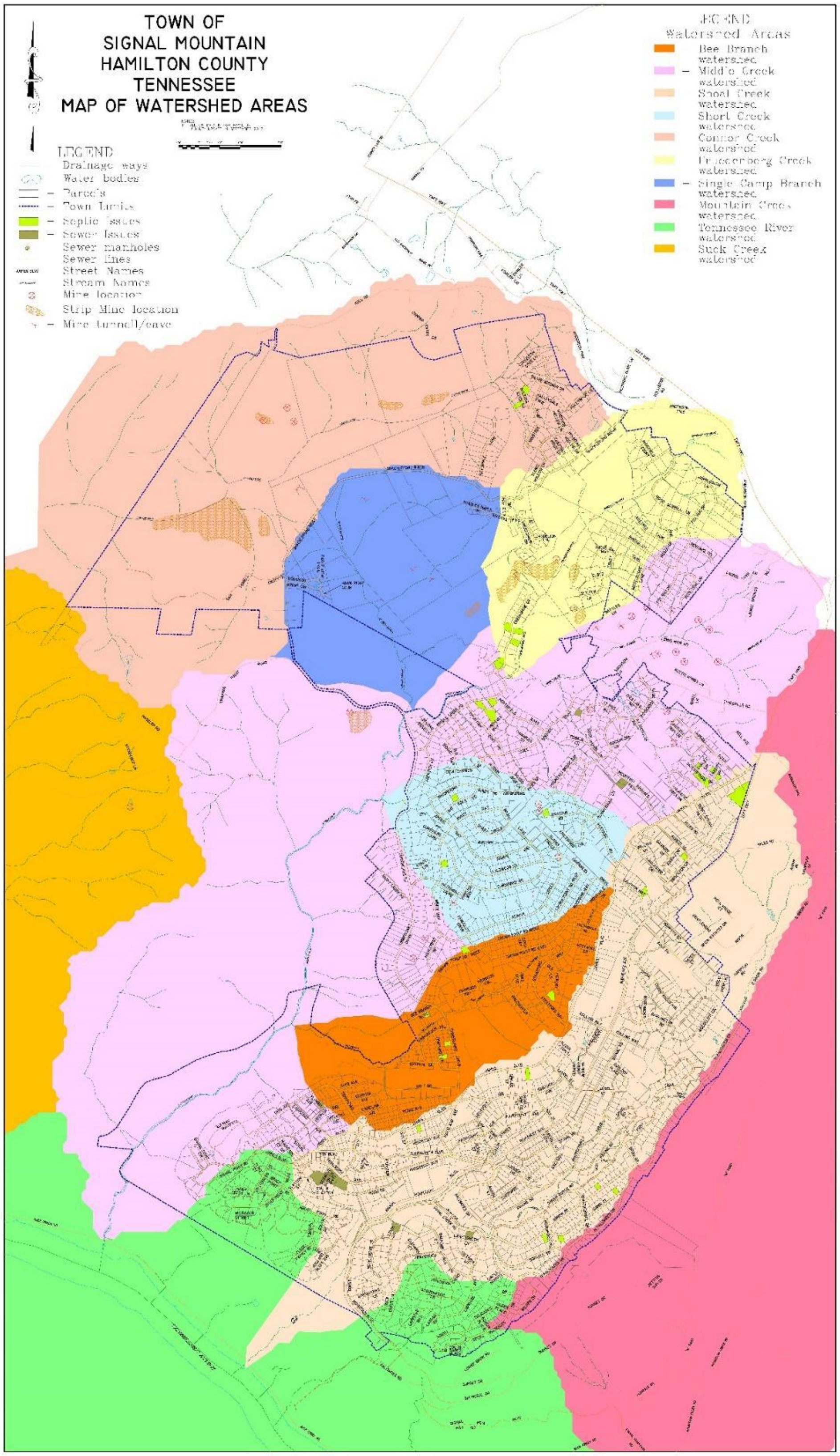
## 2.3 Acid Mine Drainage

As shown in the Map of Watershed Areas from the Town of Signal, there has been significant mining throughout many of the watersheds. Both Stanley Branch and Fruedenberg Creek are listed as impaired for low pH due to abandoned mine lands. Fruedenberg is also listed for high iron concentrations, which is a frequent impact at abandoned mined due to the iron pyrite dissolution chemistry.

No TMDL has been written for remediating acid mine drainage in these two streams, although one written for North and South Suck Creek should be pertinent for Middle Creek since they are adjacent watersheds. In Suck Creek, the "water quality documented during sampling conducted for this TMDL was not typical of the more severe acid mine drainage situations. Acid mine drainage has one or more of four major components: high acidity (low pH < 6 or alkalinity < 20 mg/L), high metal concentrations (> 500 µg/L), elevated sulfate levels (> 74 mg/L), and excessive suspended solids and/or siltation. While monitoring data for North and South Suck Creek indicates high acidity and low pH, metals and sulfate concentrations remain low. "

We expect the same in the Middle Creek Drainages, since low pH and high iron are the reasons for impairment. They monitored for net alkalinity to illustrate the reduction in acidity and/or increase in total alkalinity.

*Figure 3. Acid Mine Drainage Sites in the Vicinity of the Town of Signal Mountain*



To prioritize and select sites for remediation we will:

Step 1: Conduct additional water and minespoil testing to identify specific AMD sites and delineate actual areas of acid production at each site.

Step 2: Once sites have been identified, remediation plans will be developed utilizing primarily passive treatment schemes (versus treatment by chemical addition) to provide a long-term solution to stream impairment.

Remediation measures that have proved successful include, but are not limited to:

- Regrading of spoil
- Isolation of acid producing material from water contact
- Anoxic limestone drains
- Constructed wetlands.

We will also work with the Signal Mountain Bible Church, homeowners and landowners who have small AMD areas to experiment with smaller passive systems utilizing acid loving vegetation creating small wetlands or other diversions from the creeks.

The TMDL also suggests similar reclamation to Suck Creek as the Three Sisters Site on the North Chickamauga Creek which occurred in 2000. Our AMD expert, Greg Brodie, assisted with that project and will be our lead for these watersheds. According to Brodie (2015), "The properties of acid drainage vary from site to site, although many characteristics are similar. Classic AMD is composed of water, sulfuric acid, dissolved and precipitated iron compounds, sulfate ions, and dissolved metals (especially aluminum). Acid drainage may be associated with elevated concentrations of heavy metals. These metals, rather than the acidity, are particularly toxic to the aquatic environment."

Passive treatment of acid mine drainage consists of several key technological components that use chemical, physical, and biological processes to decrease metal concentrations and acidity. Passive treatment components are configured in stages that optimize the natural sequential processes of pollutant removal. For instance, it is generally more cost effective and efficient to remove as much iron as possible by aerobic means before resorting to relatively more expensive anaerobic technologies. The key technologies range from single-pollutant treatment stages, such as an anoxic limestone drain for increasing alkalinity, to technologies aimed at multi-pollutant treatment, such as an aerobic wetland to remove suspended solids, precipitate metals, and to increase dissolved oxygen (Brodie, G. 2015)

Since Stanley Branch and Fruedenberg Creek are impaired due to abandoned mine lands, remediating the pH and iron with passive treatment systems would be the most cost effective. The Abandoned Mine Lands Program within TDEC is planning a reclamation of strip mines along Fruedenberg Creek near Timesville Road in the near future. That area contains a high number of high walls and collapsing pits from deep mines. Evaluation of the areas for restoration will include the neighborhood areas at the end of Creekshire Drive and adjacent to Whispering Pines Drive. In addition, the Signal Mountain Bible Church is situated at the headwaters of Stanley Branch and has acid mine drainage streams on their property which may be appropriate to remediate. Collaboration with the Abandoned Mine Lands Program will be essential to achieving our goal of removing these streams from the 303d list.

# 3 ESTIMATE OF LOAD REDUCTIONS

We predict that the BMPS we have proposed will reduce sediment and e coli loading due to reduced stormwater and septic system failures as well as help with sewer system overflows since more water will be infiltrated or disconnected from the sewer system.. Increasing riparian buffering, particularly in the golf course will also decrease sedimentation in Bee Branch. and increased buffering. In addition, passively treating several sections of acid mine drainage will remediate the pH and iron issues in parts of Stanley Branch and Fruedenberg Creek.

According to the TMDL for E coli, load reduction of 61.9% for Short Creek, 91.9% for Bee Branch and 79.3% for Shoal Creek would need to occur to reach the TMDL for these streams . Data from Citizen Scientists indicate that the first flush of a heavy rain event caused the biggest impacts on E. col, so rehabilitation of septic and reducing stormwater through green infrastructure will be important to meeting the TMDL for these streams. Citizen Scientists and our partners in the Town of Signal Mountain and Hamilton County will assist in monitoring project sites to understand the impacts of these remediations. The watershed based plan and monitoring will continue to evolve as projects, partners and restoration projects aslo evolve. This plan is written for a 12 year time, as funding becomes available.

| Best Management Practice | Pollutant | Quantity | Load Reduction Per Unit | Total Load Reduction |
|---|---|---|---|---|
| Septic System repair | Sediment | 25 | 3.564 tons/unit/yr | |
| Septic System repair | E. coli | 25 | n/a | |
| Downspout/sump disconnect | E. coli | 120 | n/a | |
| Rain Gardens: household | Sediment | 3 | .006 | |
| Demonstration rain garden | Sediment | 1 | | |
| Other Green Infrastructure | Sediment | 10 | .006 | |
| Roof Runoff collection systems | Sediment | 25 (50 gallon) | n/a | |
| Native Plant filter strips | Sediment | 1 acre | 32.9 tons/acre/yr | |
| Riparian Zone Enhancement | Sediment | 1200 feet | 3 tons/acres/year | |
| Streambank Stabilization | Sediment | 3 | 4.224 tons/year | |
| Acid mine drainage passive system large | AMD | 1 | n/a | |
| Acid Mine Drainage passive system small/experimental | AMD | 4 | n/a | |
| | | | | |
| | | | | |
| | | | | |

# 4 BMP List, Education Activities, and Budget

This watershed based plan intends to reduce sediment and E. coli and mitigate acid mine drainage in the impaired streams by installing the BMPS listed above. These are the potential BMP's we may use, but they may change as conservation plans are developed with landowners. We also will engage residents in the watersheds through the My Tennessee award system for stormwater mitigation in yards. Students in schools and streams teams will be engaged through assisting with projects and education sessions. Homeowners and students will receive pet waste management education as well, Awareness raising about the importance of our watersheds and protecting the creeks is essential to building a community commitment to restoring the creeks that are literally in their backyards.

| BMP Name | Quantity | Cost/Unit | Budget Estimate |
|---|---|---|---|
| Septic System repair | 50 | $5,000 | $250,000 |
| Downspout/sump disconnect | 25 | $300 | $7,500 |
| Rain Gardens | 5 | $1,500 | $7,500 |
| Large Demonstration rain garden | 1 | $8,000 | $8,000 |
| Other Green Infrastructure | 10 | $1,000 | $10,000 |
| Roof Runoff collection systems | 30 | $400 | $12,000 |
| Native Plant filter strips | 1 acre | $10,000 | $10,000 |
| Riparian Zone Enhancement | 1200 feet | $100 | $120,000 |
| Streambank Stabilization | 1 | $40,000 | $40,000 |
| Acid mine drainage passive system large | 1 | $125,000 | $125,000 |
| Acid Mine Drainage passive system small/experimental | 4 | $15,000 | $60,000 |
| | | | |
| | | | |

| Educational Event | Quantity | Cost/Unit | Budget Estimate |
|---|---|---|---|
| Stream Team Educational event | 18 | $250 | $4,500 |
| My Tennessee awards | 24 | $150 | $3,600 |
| Rain Garden Workshops | 2 | $3,000 | $6,000 |
| Creek Days at Rainbow Lake/ Middle Creek | 3 | $500 | $1,500 |
| Creek Exploration Days at Shoal Creek | 3 | $500 | $1,500 |
| Septic Tank Education Presentations | 2 | $250 | $500 |
| Pet waste disposal education | 3 | $250 | $750 |
| DIY stream bank workshop | 1 | $3,000 | $3,000 |
| Community riparian zone planting workshop | 1 | $5,000 | $5,000 |
| Responsible ATV with Cabelas | 1 | $500 | $500 |
| Total Budget for Project: | **$676,850** | | |

## 5 Timeline, Tasks, and Assessments

This watershed based plan is envisioned as a comprehensive 12 year plan, but also building on our initial education and green infrastructure installation at Thrasher Elementary School, to be completed by 2031 as funding becomes available. The plan is divided into four 3 year periods.

## 6 Criteria to Assess Achievement of Load Reduction Goals

Load reduction goals will be difficult to measure since we have little baseline loading data. Reduction in E. coli loading will be measured through geometric means of E. coli concentrations and streamflow measurements to assess reduction of E coli over time during both high flow and low flow times. AMD will be measured by ph improvement and reduction of iron concentrations. Sedimentation will be assessed through turbidity or TSS data.

# 7 MONITORING AND DOCUMENTING SUCCESS

Monitoring will be conducted by the Town of Signal Mountain, Hamilton County Water Quality and TDEC to document improvements due to implementation of restoration and education measures. Measures of pH, iron, E coli and turbidity or sedimentation in the stream will assist with this evaluation, as well surveys of macroinvertebrate EPT richness, particularly in Bee Branch..