Twelvemile Creek Watershed Plan to Address *E. coli* Pollution, Pickens County, SC

MAY 2024

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Lake Hartwell Partners for Clean Water

Anderson Regional Join Water System

Anderson-Pickens Stormwater Partners

Pickens County, SC

Anderson Soil and Water Conservation District

Easley Central Utilities

City of Pickens

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ACRONYMS

ACEP – Agricultural Conservation Easement Program
BMP – Best Management Practice
CWA – Clean Water Act
EQIP – Environmental Quality Incentives Program
FC – Fecal Coliform
FTIR – Fourier-Transform Infrared Spectroscopy
FW – Fresh Water
LHPCW – Lake Hartwell Partners for Clean Water
MPN – Most Probable Number
MS4 – Municipal Separate Storm Sewer System
MSL – Mean Sea Level
NAIP – National Agriculture Imagery Program
NLCD – National Land Cover Database
NPDES – National Pollutant Discharge Elimination System
NRCS – Natural Resources Conservation Service
NTU – Nephelometric Turbidity Unit
PCB – Polychlorinated Biphenyls
PCE – Polychloroethylene
QAPP – Quality Assurance Project Plan
SC AAS – SC Adopt-a-Stream
SCDHEC – South Carolina Department of Health and Environmental Control
SCDNR – South Carolina Department of Natural Resources
STEM – Science, Technology, Engineering, and Mathematics
SWCD – Soil and Water Conservation District
SSO – Sewer Service Overflow
TCE – Tetrachloroethylene
TMDL – Total Maximum Daily Load
TSS – Total Suspended Solids
USDA – United States Department of Agriculture
US FWS – United States Fish and Wildlife Service
US EPA – Environmental Protection Agency
UF – Upstate Forever
VOC – Volatile Organic Compound
WBP – Watershed Based Plan
WQS – Water Quality Standards
WWTP – Wastewater Treatment Plan

EXECUTIVE SUMMARY

This Watershed Plan intends to address the consistent water use impairments of bacterial loading to the Twelvemile Creek watershed (the watershed) in addition to sedimentation issues and potential nutrient impairments. The watershed is completely within and comprises a third of Pickens County, a significant area of 154 square miles draining through agricultural and forested areas until it reaches Clemson, South Carolina, discharging to Lake Hartwell. This watershed highlights the features of what the project team values about land and water in the Southern Inner Piedmont: rolling green pastures, tablelands, isolated mountains, and bedrock outcroppings that create small series of rapids in upstream river reaches.

This predominantly rural watershed has struggled with past fecal coliform and now *Escherichia coliform*, *E. coli*, impairments throughout several iterations of South Carolina's 303(d) List of Impaired Waters and Total Maximum Daily Load (TMDL) calculations dating back to 1998. While funding has benefited water quality by way of agricultural best management practices and more, this pollutant of concern persists and affects water quality, with the potential to put human health at risk. *E. coli* after all is an indicator of the presence of waste and the associated bacteria, pathogens, and viruses that threaten the recreational safety of those designated waters.

Evidence also exists indicating that excessive sediment and nutrient loading are affecting the ecology, flow, and water quality of Twelvemile Creek. Sediment can allow bacteria to over-winter, sustaining the population of *E. coli* in waterways. Therefore, to fully control and remediate bacteria in the watershed, minimizing sediment input into waterways is a critical measure. Due to the interconnectedness of these pollutants in this system, and several factors identified below, the project team is emphasizing to local leaders, conservation groups, utilities, and interested stakeholder groups that an integrated watershed and wastewater plan be developed for Pickens County.

- Our analysis found that the majority of the watershed is classified as severely limited in its ability to treat septic effluent. However, most homes in the watershed rely on septic, or onsite wastewater treatment systems, as their primary means to treat wastewater.
- Sewer service treatment exists in areas of the watershed, utilizing pumping stations to move effluent to sewer plants where gravity-fed lines are not an option. Sewer service maps were not easily available for this project. Also, industries in the region may be utilizing those lines, or cluster systems may be present. This lack of information calls for more centralized data sources related to wastewater treatment.
- SC Code Sections 44-55-1410 and 5-31-2010 authorize county and municipal governments to determine if a wastewater treatment facility is accessible to properties. By these codes, a home must be provided sewer (and must tie in to the sewer line) when within 300' of an available sewer line.
- Drinking water supplies are changing in the watershed. Whereas Twelvemile Creek has been a source of drinking water for those on municipal supplies for decades, a new plant is being built to carry water from Lake Keowee for customers; the Twelvemile intake will be a secondary emergency source. This change could impact concern and motivations to be more protective of Twelvemile Creek.

Recommendations of this plan include zoning ordinance changes and an agritourism district as means to protect this valuable waterway and major tributary to Lake Hartwell, the region's source water. Proactive steps are already moving forward with Pickens County's administration, and their partnership in this plan's development demonstrated more than receptiveness to addressing the link between the vitality of natural resources and the vitality of their community. An integrated watershed and wastewater management plan would bring entities together to study area growth and drinking and wastewater utility needs, in balance with conservation goals so that this watershed and its water quality can have proactive, long-standing protection. The costs of restoration far exceed the costs of being proactive, while preserving what cannot be replaced.

This integrated watershed and wastewater plan would be a critical opportunity to engage residents across Pickens County and have a unified conversation about values, needs, and economic growth opportunities for the region.

Specific projects recommended by this project team include the following, all paired with strategic education and outreach for residents.

1. **Riparian Buffer Zoning Ordinance** to protect the Twelvemile Creek, tributaries, and riverbanks from the impacts of adjacent land uses and sediment loss to the streams, while ensuring flood storage and habitat conservation along waterways.
2. **Septic System Repair and Replace Cost-Share Program** that addresses the need to continue use of onsite wastewater treatment systems in this rural watershed, while not degrading water quality. Cost-share will allow those in need to maintain their septic systems, which they may have not been able to afford to do otherwise.
3. **Land Protection** is a critical strategy to protecting the most vulnerable lands for the protection of water quality, water quantity, sediment control, habitat, and species protection. The data presented here, in conjunction with areas emphasized in both the South Carolina Forestry Service's Green Infrastructure Plan of 2023 and the South Carolina Conservation Bank's Conservation Priority Areas provide readily available information for areas most vital to protect.
4. **Agricultural BMPs and Agritourism District** are two measures to protect and grow the rural, cultural values so evident in the mid-section of the watershed. In addition to traditional agricultural BMPs, voluntary Residential Agricultural Zoning would limit the number of dwellings per acre, maintain wooded roadways, and encourage small farm agribusiness and conservation. The agritourism district would capitalize from the Doodle Trail's increased accessibility across the county and address documented food desert issues in this area.
5. **Wetland Assessment and Restoration** will begin to address the sediment that has accumulated in wetlands and is flushed to the Twelvemile Creek and its tributaries during significant storms. Wetlands are critical capture points for sediment, natural treatment mechanisms for nutrients, critical habitat areas, and important flood storage points during major storms. Wetlands are a critical strategy for climate-resilient communities and lessen volume of stormwater impacting waterways.
6. **Jaycee Park Green Infrastructure Project, Pickens** includes large parking lot and facility renovations, increases STEM programming for youth, and includes a suite a green infrastructure practices to better manage the increasing and damaging volumes of stormwater runoff from neighboring properties.
7. **Cateechee Point Park Rain Gardens and Xeriscaping** include low maintenance, xeriscaping options for residents that will address sediment loss and erosion at this new

park facility. Additionally, rain gardens and bioswales improve stormwater retention and treatment before discharge to Twelvemile Creek.

8. **Equoni Park and Overall Public Access Trail Stabilization** represent practices and locations, including Equoni Park, that would benefit from natural stabilization techniques to prevent erosion and sediment loss to waterways.
9. **Trash Reporting App, Outreach, and Engagement** will empower Pickens County stakeholders to take more action against litter. Trash is so much more than litter, impacting home values, deterring businesses, and leading to more pollution. A reporting app will create an improved mechanism to gather littering data in the county, activate personnel, educate the public, and enforce anti-littering rules.
10. **Wolf Creek Demonstration Space** is another opportunity to demonstrate low impact and green infrastructure practices that improve aesthetics, biodiversity, and stormwater treatment. This project is partner-ready!
11. **Feral Hog Management** will help to address disperse sources of bacteria across the watershed and additionally address disturbances and sediment loss due to feral hog populations in wetlands and river corridors.

1.0 GETTING TO KNOW THE WATERSHED

1.1: WATERSHED SUMMARY

The Twelvemile Creek watershed (the watershed) is the picturesque landscape (Figure 1) that one imagines when visualizing Pickens County, SC, with mountains on the not-so-distant horizon, rolling pastures, and large tracts of timber. The area is rich in agriculture, forest, and water, with dozens of streams adding volume to the Twelvemile Creek as it flows towards Clemson and to Lake Hartwell, a man-made source water reservoir that serves 200,000 South Carolina residents their drinking water.

Watershed 03060101-04 (formerly 03060101-060, -070) is located entirely in Pickens County and consists primarily of Twelvemile Creek and its tributaries to its confluence with the Keowee River forming an arm of Lake Hartwell. The watershed occupies 98,964 acres (154 square miles) of the Blue Ridge and Piedmont regions of South Carolina. Land use/land cover in the watershed includes 55.6% forested land, 29.7% agricultural land, 12.4% urban land, 1.2% water, 0.7% barren land, and 0.4% forested wetland (swamp). A map depicting this watershed is found in Section 1.2 and 1.3.

Middle Fork Twelvemile Creek (Cove Creek, Big Rock Lake, Youngs Branch, Blacks Branch, Mill Shoals Creek, California Branch, Adams Creek) and North Fork (Findleys Lake, Hagood Branch) join to form Twelvemile Creek. Downstream from the confluence, Twelvemile Creek accepts drainage from Town Creek, Cannon Creek (Gregory Creek, West Fork, Hayes and Collins Lake), Wolf Creek (Raven Branch), Praters Creek, and Rice's Creek (Country Club Lake). Golden Creek (Murphey Branch) enters the stream next, followed by Shoal Creek, Camp Creek, Huggins Creek, Todd Creek, and Pike Creek before forming an arm of Lake Hartwell. There are a total of 371.3 stream miles and 1,193.2 acres of lake waters in this watershed, all classified Freshwater (FW).

Fig. 1. The Twelvemile Creek is a popular Upstate river for kayaking, canoeing, tubing, birdwatching, and fishing. Photo credit: Haley Dennison.

1.2: LOCATION, HYDROLOGY, GEOLOGY

The Twelvemile Creek watershed is entirely within Pickens County, SC, located between Highway 288 to the north, Highway 93 to the east, Highway 123 to the south, Martin School Road and Highway 11 to the west, and intersected by Moore Field Memorial Highway. Nearby cities/towns include Pickens, Six Mile, Clemson, Central, Norris, Liberty, and Easley. Much of the watershed is located within the Southern Inner Piedmont Ecoregion (EPA Level IV), but the northwest corner is within the Blue Ridge ecoregion (EPA Level III). Northern tracts of the watershed in the Blue Ridge ecoregion vary from narrow ridges to hilly plateaus and to more massive mountainous areas with high peaks with elevation ranges from 850-3,500 feet above Mean Sea Level (MSL). In the southern reaches of the watershed, the land generally has lower elevation, classified as irregular plains, dominated by forested areas. Elevation ranges in the Piedmont ecoregion ranges from 355-760 feet. Figure 2 shows the many tributaries of the Twelvemile Creek watershed.

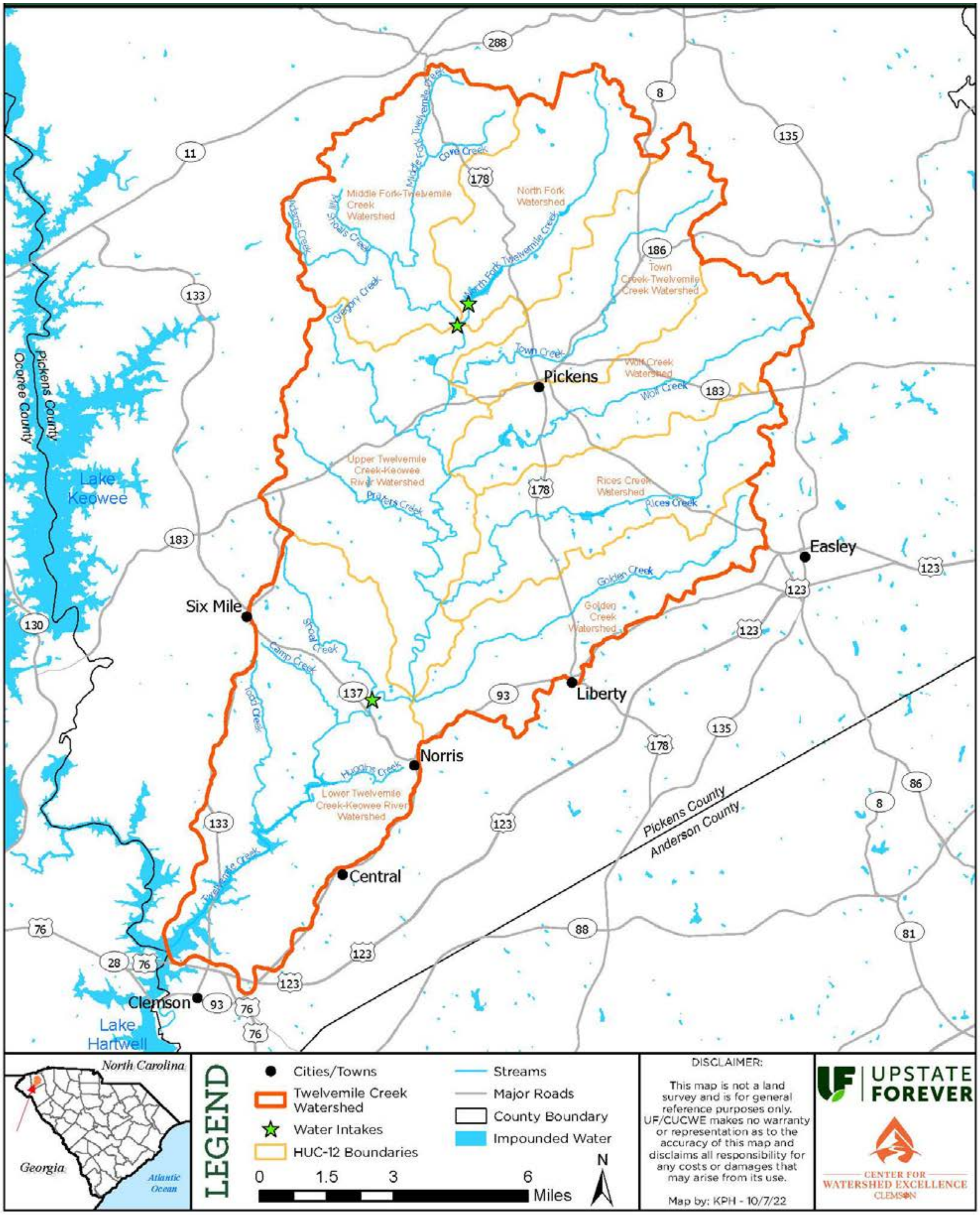


Fig. 2. There are many major tributaries and subwatersheds of the Twelvemile Creek watershed.

This watershed is defined by the Six Mile thrust sheet, which cuts off below the watershed within Anderson County and transforms to Laurens thrust sheet. Lithology is primarily defined by granite rock, and most soils are classified as clay. Principle soils include Pacolet, Cataula, Cecil, Hiwassee, Toccoa, and Saluda. The soil erodibility factor, or K-factor, for the soils in the focus area ranges from 0.10 to 0.32. K-factor values closer to 1.0 indicate higher soil erodibility, which implies a greater need for protective measures against erosion and soil loss. Taken as a whole, the soils found in the focus area are well-drained, moderately permeable soils.

1.3: LAND COVER

Sourced from the 2019 National Land Cover Dataset (NLCD), land cover in the focus area has been divided into eight categories, as shown in Table 1 and Figure 3. Considering the NLCD is only updated every five years, Table 1 shows land cover in 2019, which was the most recent data available at the time of analysis. Forested land cover is the largest land classification in the focus area, totaling nearly 58%.

Tab. 1. 2019 Land Cover in the Twelvemile Creek watershed

Land Cover Type	Land Cover in 2019 (acres)	Percent Coverage
Open Water	1,022.33	1.0%
Urban	18,563.3	18.8%
Barren	320.9	0.3%
Forest	56,983.3	57.6%
Shrub/Scrubland	2,065.2	2.1%
Grassland/Herbaceous	1,873.3	1.9%
Pasture/Hay	17,696.7	17.9%
Wetlands	423.9	0.4%
Total	**98,948.8**	

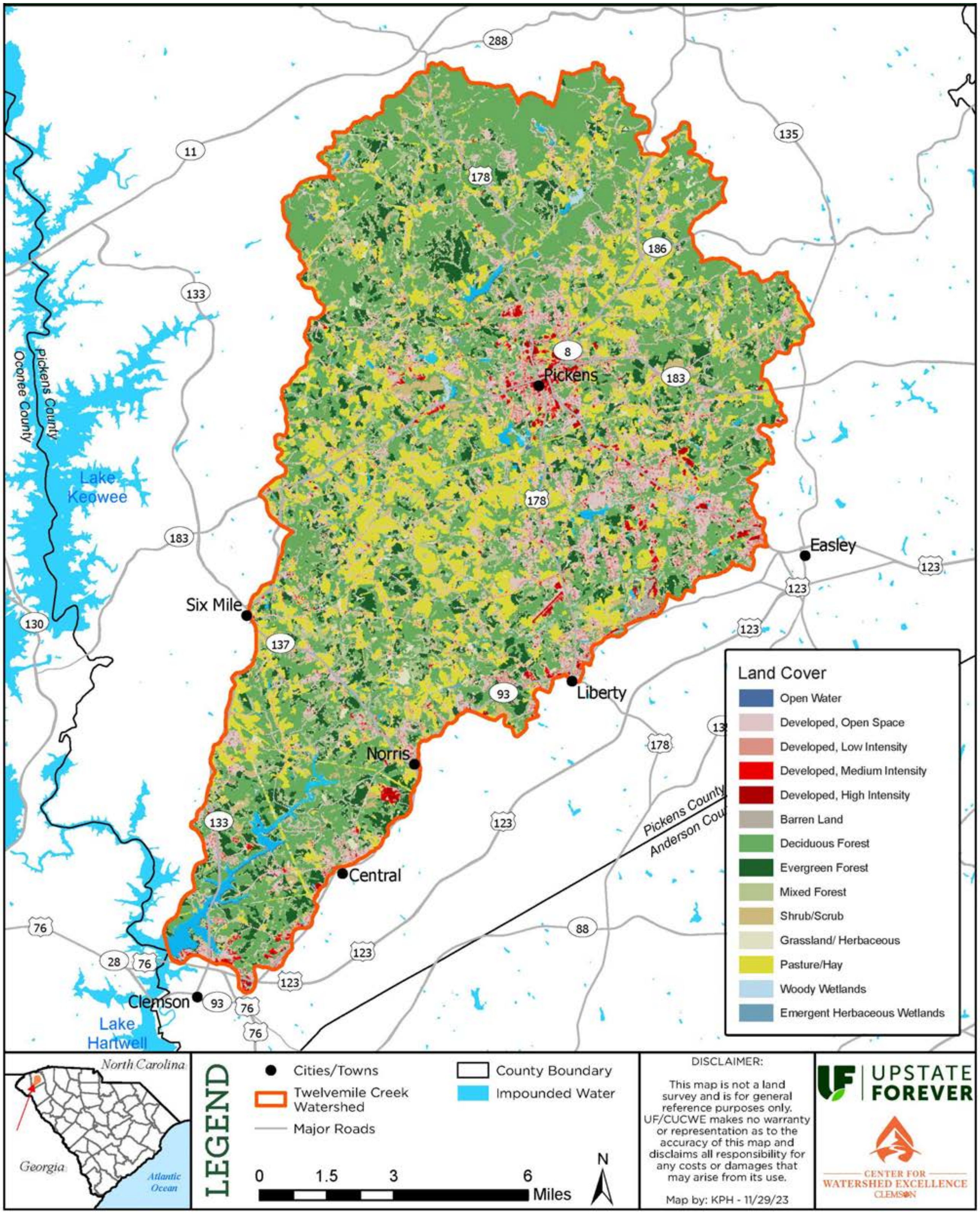


Fig. 3 Land Cover in the Twelvemile Creek watershed

1.4: RECREATION

The Twelvemile Creek is a popular retreat for fishing and kayaking. Whitewater kayakers enjoy the faster pace river sections from the Easley Central Water District Dam to Lay Bridge Road. This whitewater section of Twelvemile Creek includes the new park built in 2018, Cateechee Point, Norris, SC (Figure 4). The park includes shelters, kayak launch area, and fishing piers. More information on boating access and safety precautions can be found on the Twelve Mile River Blueway map published by Upstate Forever (https://www.upstateforever.org/blueway-mapping).

Fig. 4. Whitewater at Cateechee Point Park.

Lake Hartwell is a manmade reservoir, like all lakes in South Carolina, and a significant recreational resource for the area. Lake Hartwell has found fame as the four-time host location to the Bassmaster Classic prestigious fishing tournament. Where the Twelvemile opens up to Lake Hartwell, water is characterized as flat water and is used by boaters, serves as the practice area for the Clemson University Water Ski Team, and is the location of stand-up paddleboard races, fishing, and boat tubing.

Bikers and walkers in the area have a safe place to enjoy the view from the Doodle Trail (Figure 5), a rails-to-trails project that opened in 2015. The former "Pickens Doodle Line" ran commodities between Pickens and Easley and was aptly named due to its inability for a train to turnaround, but instead go forwards and backwards like a doodle bug down its 8.5-mile stretch. The trail crosses agricultural wetlands, tributaries, and over streams and is a great resource to its community.

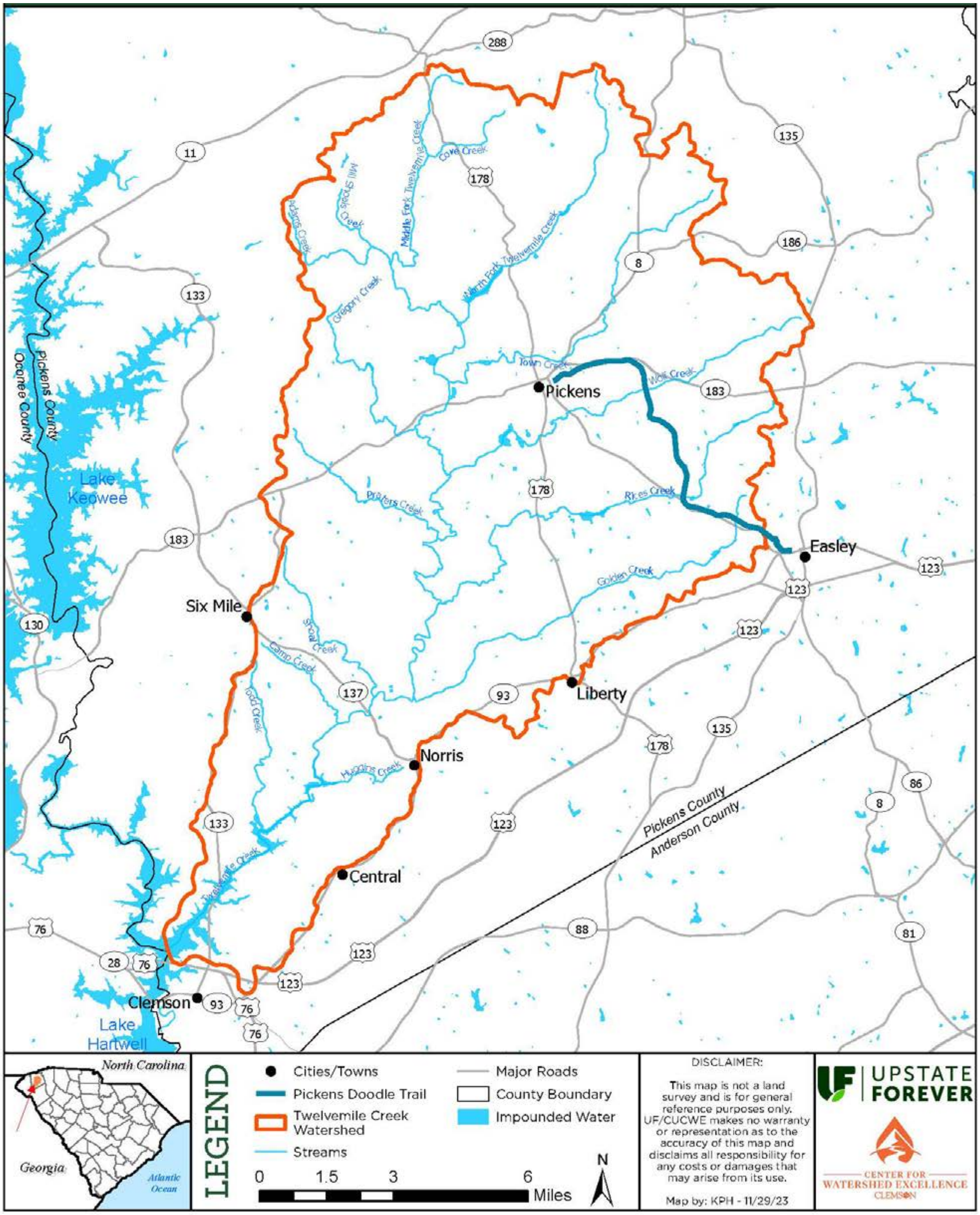


Fig. 5. The Doodle Trail crosses over several tributaries of the Twelvemile Creek watershed, connecting Pickens to Easley for bikers and walkers.

1.5: POINT SOURCES IN THE TWELVEMILE WATERSHED

LAND APPLICATION SITES

With less than 20% of the watershed categorized as Urban based on the 2019 NLCD, there are a limited number of permitted point source dischargers in this 154-square mile watershed. The 2003 Total Maximum Daily Load (TMDL) Report for Twelvemile Creek (https://scdhec.gov/sites/default/files/docs/HomeAndEnvironment/Docs/tmdl_12mile.pdf) lists potential sources of bacteria from point sources, though this report is now two decades old. These regulated permittees are identified as wastewater treatment plants/facilities, livestock operations, and land applications, as well as unregulated point sources such as SSOs. In this watershed, there was one livestock operation (small poultry building), six land application permit sites (five of which are WWTP/Fs), nine wastewater treatment facilities/plants (domestic and municipal), and seven SSOs (from 2020-2023). See Figure 6 for locations of identified point sources for bacteria.

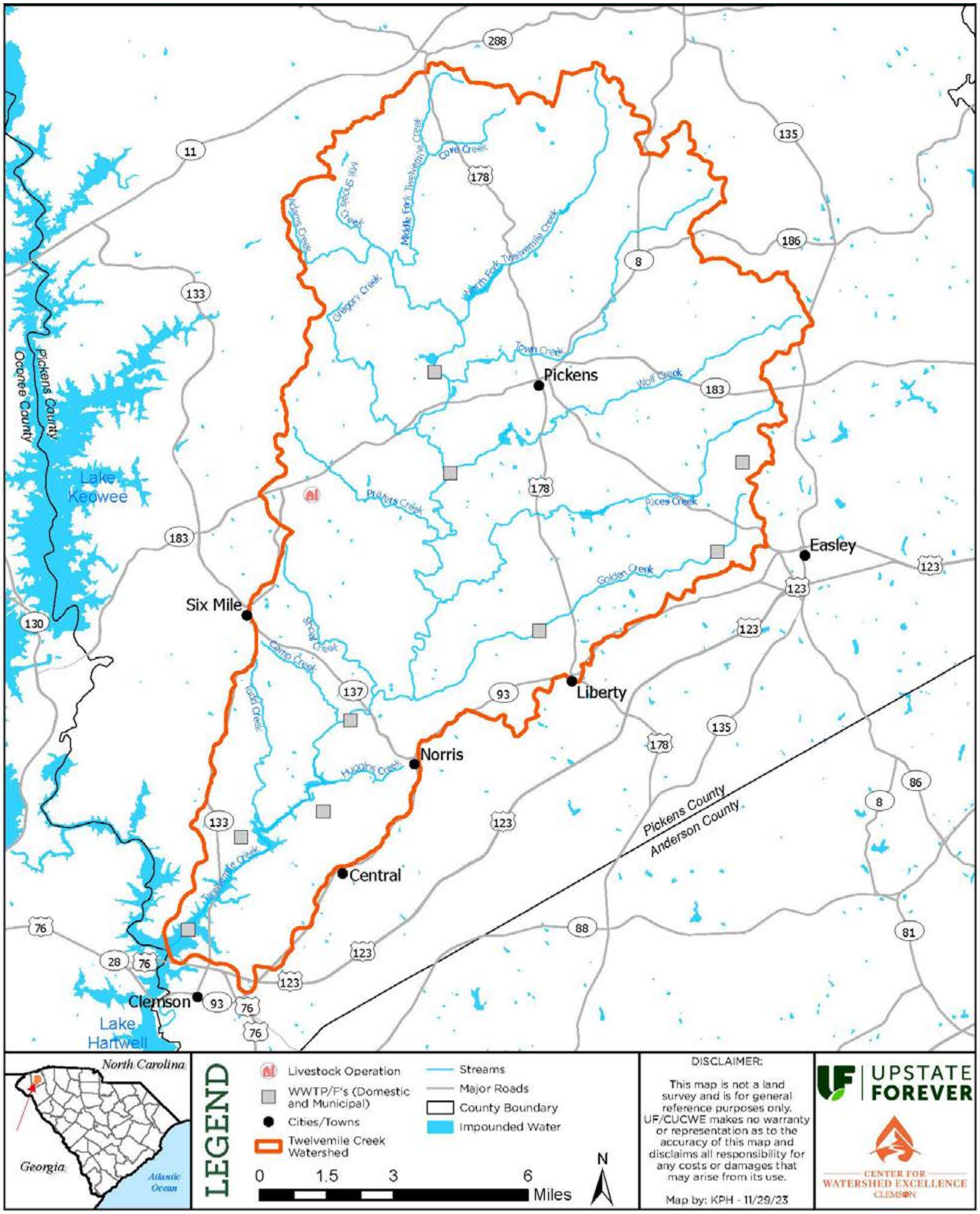


Fig. 6. Potential point sources of bacteria loading.

There have been numerous sewer service overflows as reported to SCDHEC and available as public information, identified in Table 2.

Tab. 2. Reported Sewer Service Overflows (2020-2021)

Responsible Party Name	Site Name	Permit Number	Discharge Type/ Failure	Reported Gallons Spilled	Start Date	End Date	Receiving Waters
City of Clemson	Clemson Cochran Road WWTP	SC0020010	Grease	600	4/23/21	4/23/21	Small stream at the property of 213 Riggs Drive
City of Clemson	Clemson Cochran Road WWTP	SC0020010	Pump Station Failure	2500	10/26/20	10/26/20	Lake Hartwell
City of Clemson	Clemson Cochran Road WWTP	SC0020010	Grease	600	6/8/20	6/8/20	Behind the property of 520 Squire Circle
City of Clemson	Clemson Cochran Road WWTP	SC0020010	Grease, Wipes	1500	4/15/20	4/15/20	Behind 501 Bayberry Lane between Earl Anderson Park
City of Clemson	Clemson Cochran Road WWTP	SC0020010	Sewer, Sand, Grease	5000	2/9/20	2/9/20	No Data
BASF CORP	BASF CORP Clemson Plant	SC0000302	Pump Station Overflowed	2700	3/19/20	3/19/20	Twelve Mile Creek

Sewer service lines often require the use of pump stations to move waste up-gradient to the wastewater treatment plant. Modernized stations include an alert system when the system has failed, resulting in wastewater overflows. However, during power outages, the alert system can possibly fail, and the overflow continues. In this watershed assessment, not having a map of the pump stations to analyze location and relationship to water quality monitoring stations and monitoring data was a hindrance; this is discussed in the Data Gaps section of this plan.

NPDES PERMITS & MS4 DESIGNATIONS

The National Pollution Discharge and Elimination System (NPDES) controls water pollution by regulating point sources that discharge pollutants into Waters of the United States. Major municipal dischargers include all facilities with design flows greater than one million gallons per day, while minor dischargers are less than one million gallons per day (U.S. EPA, 2017). There are 21 NPDES permits in the watershed that are permitted to discharge pollutants into the watershed, listed in Table 3 and shown on Figure 7.

Municipal Separate Storm Sewer Systems, or MS4s, are systems of conveyance that include catch basins, curbs, gutters, ditches, manmade channels, pipes, tunnels, and storm drains that discharge into Waters of the State. According to SCDHEC, for these conveyances or system of conveyances to be recognized as an MS4, a state, city, town, village, or other public entity must own them and may not operate as a combined sewer. Operators of large, medium, and regulated small MS4s are required to obtain NPDES permit coverage in order to discharge pollutants into Waters of the State (SCDHEC, 2023). Portions of the watershed fall under Phase II (small) MS4 designations for Pickens County and the Cities of Pickens, Easley, Clemson, and Liberty. Additionally, the Towns of Central and Norris have MS4 designations that have not yet been permitted (see Figure 7).

Tab 3. NPDES Permits within the Twelvemile Creek watershed

Map ID	NPDES	Name	Facility Type	Description
1	ND0067407	MONTE VISTA S/D	Domestic	Operators of Dwellings Other Than Apartment Buildings
2	SC0000302	SHAW INDUSTRIES GROUP/CLEMSON	Industrial	Plastics Material and Synthetic Resins, and Nonvulcanizable Elastomers
3	SC0000434	SPANGLER'S GROCERY	Industrial	Coin-Operated Laundries and Drycleaning
4	SC0020010	CLEMSON/COCHRAN ROAD WWTP	Municipal	Sewerage Systems
5	SC0022012	CATEECHEE VILLAGE INC WWTF	Domestic	Sewerage Systems
6	SC0023035	EASLEY/GOLDEN CREEK LAGOON	Municipal	Sewerage Systems
7	SC0023141	ISAQUEENA MOBILE HOME PARK	Domestic	Operators of Residential Mobile Home Sites
8	SC0024996	PICKENS CO PSC/CENTRAL-NORTH	Municipal	Sewerage Systems
9	SC0026191	PICKENS CO-LIBERTY/ROPER	Municipal	Sewerage Systems
10	SC0026492	ONE WORLD TECHNOLOGY IND	Industrial	Power-Driven Handtools
11	SC0046612	SCHLUMBERGER/SANGAMO WESTON PL	Industrial	Oil And Gas Field Services
12	SC0047716	PICKENS/12 MILE RV & WOLF CRK	Municipal	Sewerage Systems
13	SC0047899	PICKENS COUNTY STOCKADE	Municipal	Sewerage Systems
14	SCG250154	KENT MANUFACTURING COMPANY	Industrial	Yarn Spinning Mills
15	SCG250169	IMPERIAL DIE CASTING	Industrial	Aluminum die-castings
16	SCG570001	AMERICAN HOUSE SPINNING INC	Industrial	Broadwoven Fabric Mills, Manmade Fiber and Silk
17	SCG570028	ALICE MANUFACTURING CO - ELLJEAN/FOSTER PLANTS	Industrial	Broadwoven Fabric Mills, Cotton
18	SCG646024	PICKENS, CITY OF WTP	Municipal	Water Supply
19	SCG730065	VULCAN CONST MAT/LIBERTY	Industrial	Crushed and Broken Granite
20	SCG731062	BREZEALE SHORELINE EROSION CONTROL/PIC'S MINE	Industrial	Miscellaneous Non-metallic minerals
21	SCG731102	PICKENS COUNTY/PRISON CAMP MINE	Industrial	Miscellaneous non-metallic minerals

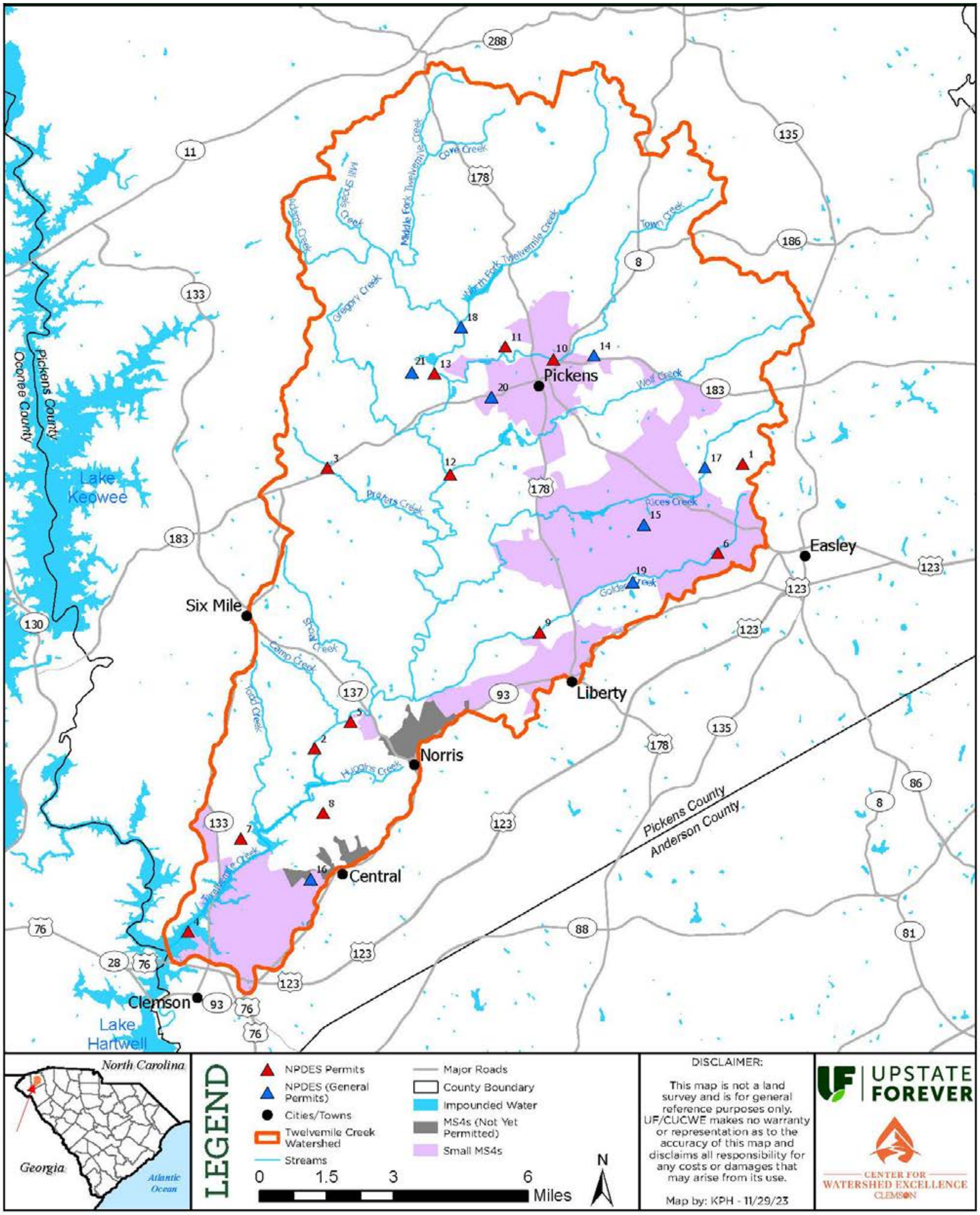


Fig. 7. NPDES Permit Locations and MS4 Designations within the Twelvemile Creek watershed

1.6: INDUSTRIAL HISTORY OF PCB CONTAMINATION

The Twelvemile Creek Watershed has been a host to significant water quality improvement work over the years. First, the Twelvemile was home to an EPA superfund clean-up initiative to remove PCB contamination and restore the health of the river and receiving waters until January of 2015. PCBs, or polychlorinated biphenyls, are synthetic organic chemicals widely used in the manufacturing of electrical equipment due to their beneficial insulating properties. PCBs were banned in 1977 when it was discovered that they accumulate in the environment and can have immunological, development, and reproductive effects on fish, mammals, and birds.

The Sangamo-Weston, Inc. Superfund Site included seven disposal areas affected by PCB-contaminated soil and debris. More than 7000 tons of material were removed in the first remedial action, as well as capacitors and other pollution-releasing equipment. Primary contaminants of concern from this site to the Twelvemile and Lake Hartwell affecting soil, sludge, debris, and ground water are volatile organic carbons (VOCs) including PCE and TCE; and other organics including PCBs. In 2009, UF became involved in the Superfund cleanup to ensure that the river was restored to improve aquatic habitat for fish and to provide recreational opportunities. The contaminated sediment was removed from behind two dams known as Woodside I and II, and these dams were dismantled to allow clean sediment to cover remaining contaminated sediment to help naturally restore the river (Figures 8 and 9). Additionally, consultants implemented a stream restoration strategy to create a more natural channel for Twelvemile Creek that included creating a natural stream bank with rock toe, streambank vegetation, rock weirs, rock vanes, boulder placement, and cross vanes (Arcadis US, 2009). The single dam that remains on the Twelvemile mainstem is there to supply drinking water by Easley Central Utilities and to prevent non-native fish from depleting the native fish population.

Fig. 8. Demolition of the Woodside II Dam in July 2011 (Photo: Greenville News)

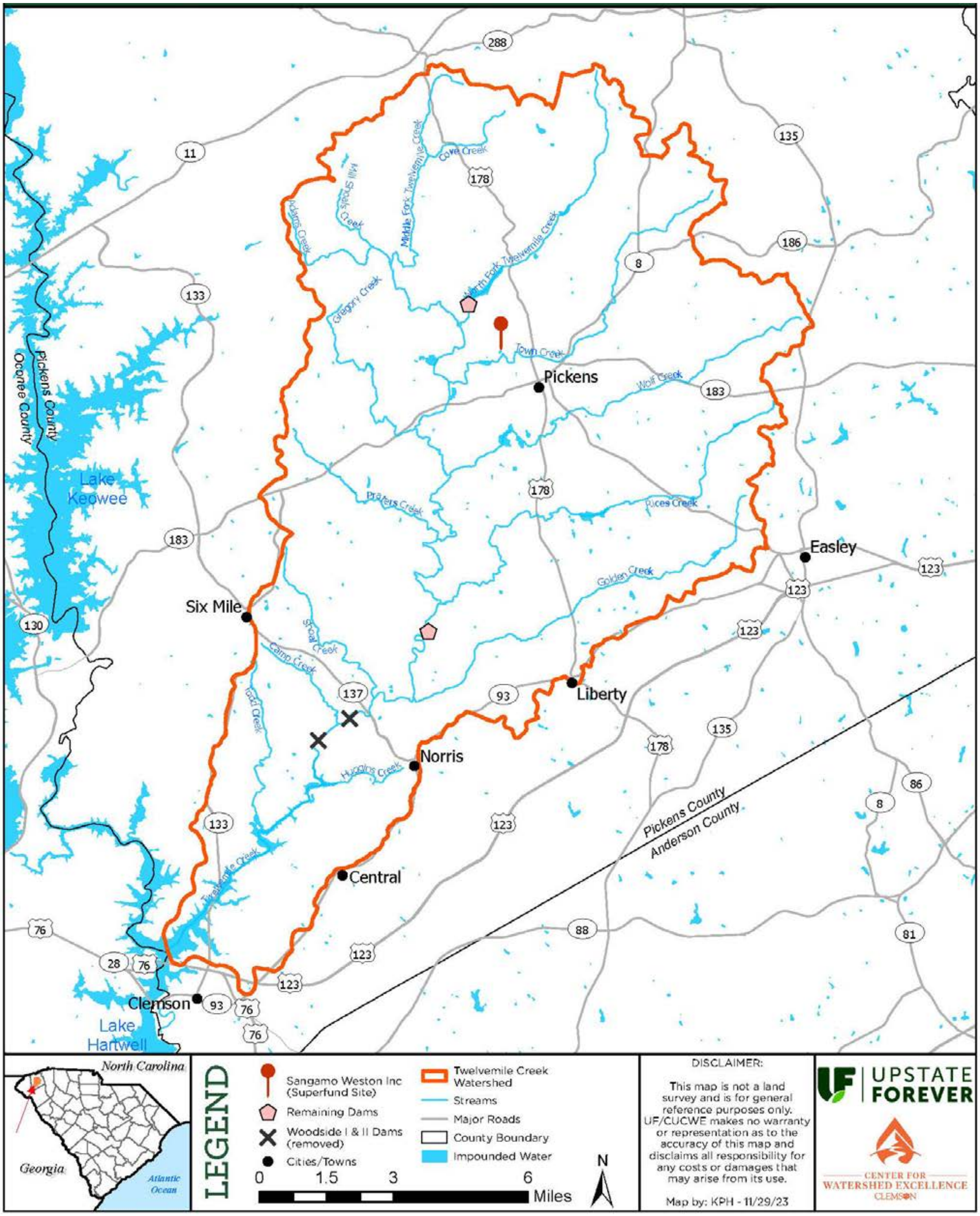


Fig. 9. Locations of the dismantled Woodside I & II Dams, remaining dams, and the Sangamo-Weston Inc. Superfund site.

The watershed's industrial history can also be viewed from the banks of the Twelvemile. As one walks along the creek in the Twelvemile Gorge, Central, SC, there are remains of a closed manufacturing facility (Figure 10). Along the shoreline, there are by the dozens what look like shiny black river rocks in all shapes and sizes (Figure 11). Upon further inspection, it is a very lightweight, scratchy foam material that floats easily, does not hold water, and is able to travel downstream from its original industrial location.

Fig. 10. The Twelvemile Gorge still shows the industrial history of this area of Pickens County, SC.

Fig. 11. An example of the glass foam found in abundance along the shores of Twelvemile Creek within the gorge.

Specimens were brought to the Clemson University Materials Science and Engineering Department for further analysis. The "rock" is manmade foam that has traveled the creek, being rounded and shaped by the water. FTIR spectroscopy determined the materials to be 100% glass ($SiO2$). When the surface is scratched, there is a strong hydrogen sulfide odor. The final determination is that this is foam glass (also referred to Foamglas®) insulation material, an inert, 100% inorganic material used for insulating roofs, walls, and below-grade surfaces such as slabs. It is typically produced in 18”x24” blocks. The high-compressive-strength insulation can be used without flame retardants and hazardous chemicals and is seen as a “green” building product for these reasons and because it can be created using recycled glass (Building Green, 2023). Iron sulfate is used in the manufacturing process, and a small amount of hydrogen sulfide is produced in the process, which is why the material emits a rotten egg smell when scratched. The detriment to the environment and aquatic life were not able to be determined within the scope of this project. The source of this material however was identified as insulation from the decaying facility at the rapids on Twelvmile Creek in the gorge. As the brick outer wall subsides, the rectangular foam insulation is exposed, falls, and is picked up by flood waters.

1.7: PARTNERS & STAKEHOLDER ENGAGEMENT

This planning effort has become more multi-dimensional due to the partners who have assisted the project in providing local insights, data, stakeholder contacts, field tours, and helpful information. It is with gratitude that these partners are recognized here.

- Pickens County for their significant sharing of data pertinent to this plan. Without their water quality and microbial source tracking data, the project team would lack critical insights that will help prioritize projects that mitigate *E. coli* sources and impairments. Pickens County departments and staff have been active in field work, discussion of sediment control and erosion, sharing their vision for parks along waterways, sharing information on illegal dumping and litter control, and more.
- Clemson University Molecular Plant Pathogen Detection Lab, which partnered with the Clemson University Center for Watershed Excellence and Pickens County in providing microbial source tracking services in support of expediting solutions to bacteria problems in water. Though this service is not currently offered, it provided pertinent information to address water quality impairments and served stakeholders in a novel way for South Carolina watershed and wastewater management.
- Easley Central Utilities staff and board members were especially helpful in providing field assistance for sample collection and in sharing the long and complicated history of this watershed, as well as future insights to drinking water supplies.
- Clemson University Materials Science and Engineering Department for their assistance with material identification and the energized Biosystems Engineering students that helped remove foam glass insulation identified during field work.
- Clemson Extension Service agents who provided insights about the watershed, land use, and stakeholders and assisted in turning concerns to actionable projects to address water quality concerns.
- Lake Hartwell Partners for Clean Water (LHPCW) – this non-profit environmental conservation organization which began in 2020 (incorporated as a 501(c)3 non-profit in 2022) is comprised of local leaders in drinking water, parks management, watershed science, real estate, sediment and erosion control, public outreach and engagement, and more. This group has supported this watershed planning effort by lending insights and organizing partners.
- Anderson Regional Joint Water Systems provided additional funding support for the advanced spatial analysis to better evaluate this watershed’s septic suitability and land use/land cover change between 2011 and 2021.

- SC Adopt-a-Stream (SC AAS) state team leaders and SC AAS volunteers, whose data greatly assisted in providing insights on less monitored, smaller waterways within this watershed.
- SCDHEC for their provision of funds and guidance during plan development. Also, SCDHEC Environmental Quality Control officers provided an insightful presentation regarding common threats to water quality in the Lake Hartwell watershed and assisted in concerns related to sewage treatment related to RV living.

1.8: PAST 319 PROJECTS

From 2004-2008, Pickens County Soil and Water Conservation District successfully completed projects within the watershed to address necessary fecal coliform TMDL reductions. This project was initiated by the five SCDHEC sampling sites on the Twelvemile Creek that were placed on the 303(d) list of impaired waters due to fecal coliform exceedances. To achieve reductions in this watershed, this project successfully installed a total of 221 agricultural BMPs on 31 farms at a value of $321,547 in addition to the installation of three pet waste stations at city park trails in the City of Pickens and the Town of Liberty at a value of $1,589.

The Lower Twelve Mile (HUC 030601010408) has been included in a WBP developed by Pickens County Beautification and Environmental Advisory Committee in 2016. This WBP, Lower Twelve Mile, Eighteen Mile, and Golden Creek Watershed Based Plan, includes watershed descriptions, water quality assessment of impairments, sources of pollution, load reductions, and prioritized BMPs to reduce loading and increase public outreach and education.

These previously approved Watershed Plans can be accessed and downloaded at https://scdhec.gov/environment/your-water-coast/watersheds-program/dhec-funded-watershed-based-plans.

2.0 AVAILABLE WATER QUALITY DATA

Water quality data is limited to that collected by SCDHEC and Pickens County. Non-regulatory data collected by certified SC Adopt-a-Stream (SC AAS) volunteers sheds more light on pollutant sources for this watershed plan development.

E. coli in and of itself does not direct resource managers and environmental scientists to the source of the bacteria and waste entering the stream. Further, *E. coli* is present in the natural environment. Research shows that sediment in a streambed may extend the life of *E. coli* populations, including allowing *E. coli* to overwinter (Perry, 2011). The shallow areas of Twelvemile Creek, inundated by sediment, moving bedload, and sediment-filled wetlands, are a critical consideration in a strategy that addresses the *E. coli* impairment that persists in this watershed.

2.1: SCDHEC

BACTERIA SAMPLING RESULTS

The stations of primary significance to this watershed plan are those used in the development of the fecal coliform TMDL. Results from recent water quality monitoring are shown in Figure 12 and Table 4. The *E. coli* water quality standard (WQS) for a single grab sample is 349 col/100mL. The SCDHEC water monitoring data analyzed for this plan was collected during dry weather. The following regulatory stations exist and provided data to this planning effort.

- **SV-137** is on the mainstem Twelvemile River at Maw Bridge Road (Hwy 337), and monthly, dry weather sampling results from 2015 through 2021 are used in this analysis. Results from these 70 sampling events comprise the majority of *E. coli* data for this watershed. This station had been on the 303(d) List of Impaired Waterbodies in 2000 and 2003.
- **RS-19473** is a random sampling location on a tributary to Golden Creek that was monitored by SCDHEC on a monthly basis in 2019. Monthly data includes *E. coli* results.
- **RS-11009** is a random sampling location, monitored four times in 2019, but not for *E. coli*. The site is located on Twelvemile Creek just below Liberty Highway and upstream of the confluence with Golden Creek.

Monitoring data exists for SV-137 prior to 2015 but are considered as too outdated for use in the development of this plan, given changes in the watershed and implementation projects undertaken in previous 319(h) work.

Additionally, the following stations in this watershed were listed on the 303(d) List of Impaired Waterbodies for fecal coliform in 2000 and 2002, demonstrating a long history of bacteria concerns in these waters:

- SV-015,
- SV-136,
- SV-206,
- SV-239.

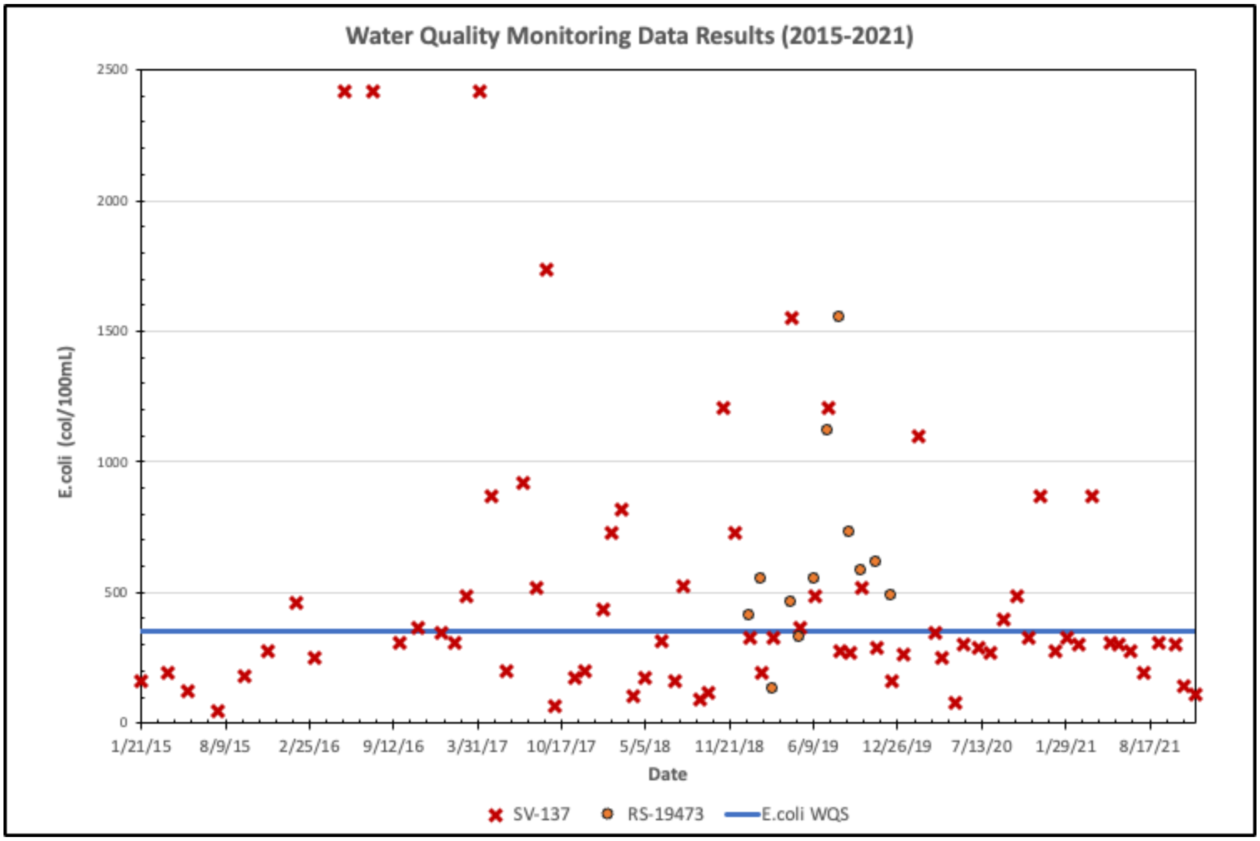


Fig. 12. E. coli results at SV-137 Twelvemile Creek and RS-19473 Golden Creek Tributary, plotted against E. coli water quality standard for single grab samples (349 col/100mL).

This watershed plan has selected to include an evaluation of additional parameters that may provide insights to resolving the *E. coli* impairments of this watershed. These include the amounts of suspended sediments and materials in water, measured as total suspended solids (TSS) in mg/L; turbidity, a measure of the relative clarity in the water column, recorded as NTUs (Nephelometric Turbidity Units); and nutrients where available. Nitrate and nitrite data are available and measured in mg/L. Table 4 summarizes these data from SCDHEC.

Tab. 4. SCDHEC Monitoring results summarized for 2015-2021.

Water Quality Monitoring Station Data - Twelvemile Creek Watershed - 2015-2021

	SV-137 Twelvemile Creek				**RS-19473 Golden Creek**			**RS-11009 Twelvemile Creek**
	E. coli col/ 100 mL	**TSS** mg/L	**Turbidity** NTU	**Inorganic nitrogen (nitrate and nitrite)** mg/L	***E. coli*** col/ 100 mL	**TSS** mg/L	**Turbidity** NTU	**TSS** mg/L
n	72	19	71	70	12	4	11	4
Min Result	43.7	2.0	3.2	0.2	129.6	1.0	2.0	5.1
Max Result	*2419.6	30.0	160.0	0.5	1,553.1	23.0	5.8	13
Geometric Mean	*338.8	8.6	13.1	0.4	533.0	3.1	3.2	8.3
n above WQS	26		6		10		0	
% above WQS	**36%**		8%		**83%**		0	

* *E. coli* samples found to be "Present Above Quantification Limit" have been assigned the detection quantification limit according to the method used, which is reported as, 2419.6 col/100 mL. The WQS for E. coli is 349 col/100mL for a single grab sample. The WQS for Turbidity is 50 NTU for freshwaters.

TURBIDITY SAMPLING RESULTS

In this watershed particularly, the project team felt it important to address sediment movement in the watershed where data and observations are available. Turbidity affects light penetration into water, ecological productivity, recreational appeal, and may also represent a health concern, for example, in cloudy drinking water. Excessively turbid waters or excessive sediment in a stream bottom can create environmental conditions suitable for the growth and regrowth of pathogens in water, especially where warmer water temperatures may exist. Figure 13 presents images of Twelvemile Creek and its tributaries showing examples of how infrastructure failures lead to streambank destabilization and in-stream sediment loading, as well as how sediment is transported in Twelvemile watershed mainstem and tributaries. Since Lake Hartwell is a source water, this relationship between pathogens and sediment load is critical to the health of this downstream reservoir and is compared in Figure 14.

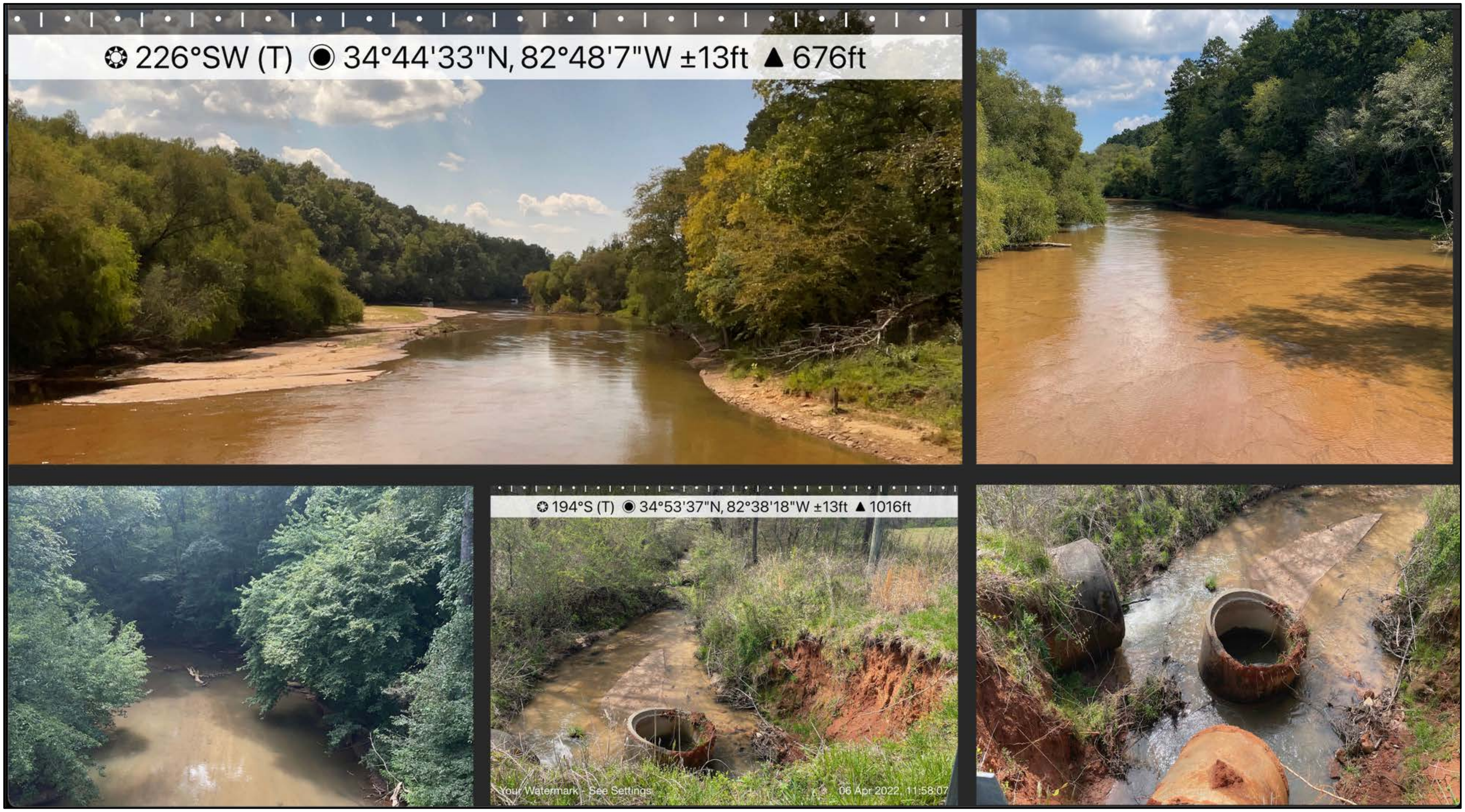


Fig. 13. Sediment deposits along the banks of a very shallow and slow-moving mainstem Twelvemile Creek (top left); looking upstream from that same location on the Twelvemile, a visible sediment island can be seen in the top right corner, as well as sediment movement profiles in the forefront of the photo (top right); a turbid stretch of upstream Twelvemile Creek (bottom left); infrastructure failure leading to streambank destabilization and continued sediment loading until this site is repaired (bottom middle and right).

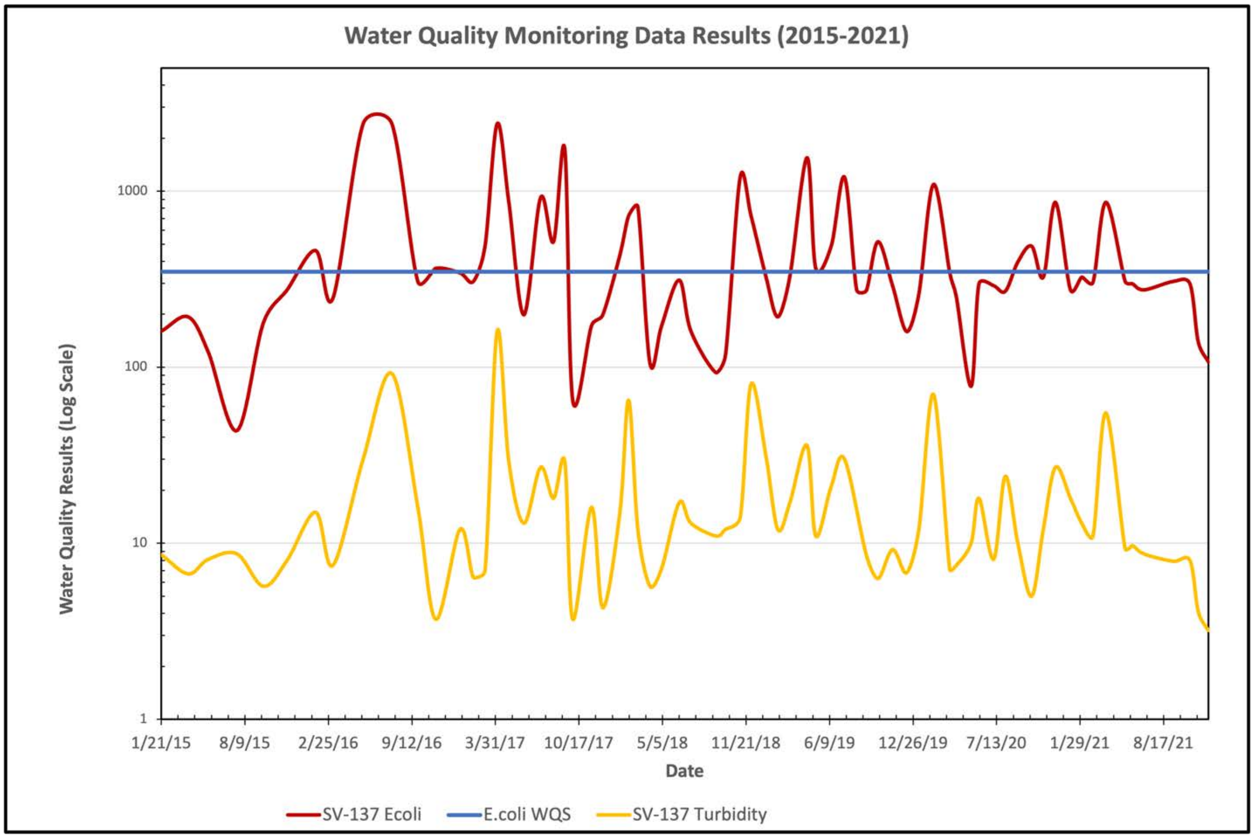


Fig. 14. E. coli and Turbidity results at SV-137 Twelvemile Creek, plotted on a logarithmic scale against the freshwater E. coli standard for single grab samples (349 MPN/100mL).

This very apparent relationship at SV-137 demonstrated between 2015 through 2021 exists in dry weather conditions. This demonstrates that managing sediment in the watershed, and its impacts on in-stream health and flow, would have great potential to address the exceedances of bacteria that are leading to impairment at this station. Potentially, managing the Twelvemile Creek's ability to have improved flow rates within its channel could also reduce the levels of bacteria at this site.

2.2: PICKENS COUNTY, SC

As a permitted MS4, Pickens County has collected a significant amount of data pertinent to this plan, since their MS4 is within a TMDL watershed. Given the nature of their monitoring, Pickens County monitoring data is the only data set available that includes wet weather monitoring events. Eight of the county's 16 monitoring sites are within the Twelvemile Creek Watershed. Of the eight, data has been collected and provided for the following stations, all on Golden Creek, and mapped in Figure 15 and results summarized in Table 5:

- Campground Road (CR),
- Campground Road Upstream,
- Campground Road Before Outfall,
- Campground Road Tributary.

Fig. 15. Campground Road monitoring locations, sampled by the Pickens County Stormwater Department.

Tab. 5. Summarized water quality results from four stations monitored by Pickens County in Golden Creek subwatershed.

Water Quality Data from Pickens County, SC - 2015-2018 *E. coli* Results (col/100 mL)				
Station	***Campground Road***	***Campground Road (BO)***	***Campground Road (T)***	***Campground Road (U)***
# of Samples	21	2	9	12
All Weather Mean	2,743	557	2,728	2,129
Dry Weather Mean	1,128	662	616	1,781
Wet Weather Mean	2,743	557	2,728	2,129
# of All Samples > 349 col/100mL	18	2	8	8
% of All Samples Exceeding WQS	86%	100%	89%	67%

The graphed data in Figure 16 demonstrates that bacteria loading to Golden Creek has the potential to contribute to the *E. coli* impairments observed downstream on the Twelvemile Creek at SV-137. Campground Road Tributary had the highest *E. coli* result of all recorded data 2015-2021 (the data considered for this watershed plan) at 17,330 MPN/100mL (n=14). Eighty-six percent of samples collected on this tributary exceeded the *E. coli* grab sample water quality standard of 349 col/100mL. The mainstem Golden Creek at Campground Road was impacted by the tributary's discharge, with 85% of samples (n=26) exceeding the water quality standard and maximum recorded result of 16,330 col/100mL. Only seven samples were collected at the Campground Road Before Outfall site towards the later part of this study conducted by Pickens County. Results range from 452 to 1314 col/100mL, and 100% exceed the water quality standard.

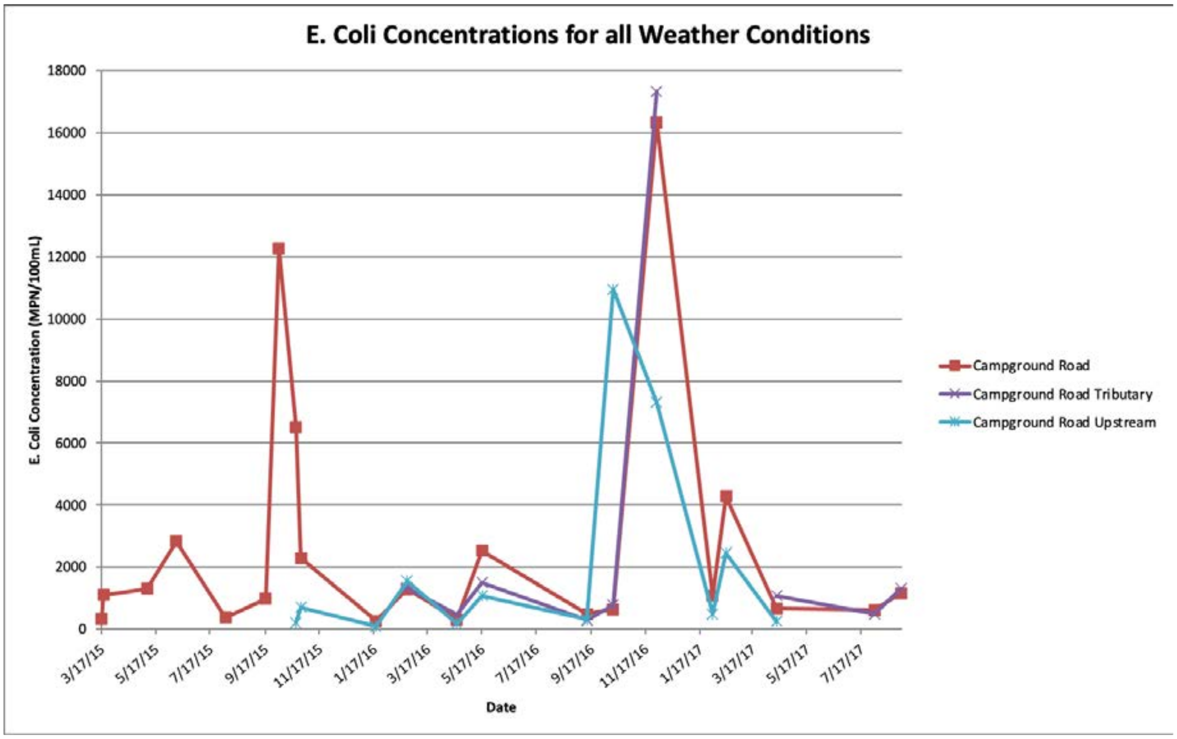


Fig. 16. E. coli results on Golden Creek at Campground Road area, Pickens County, SC.

Figure 17 further shows the impacts of the Campground Road Tributary to the already high *E. coli* at Golden Creek at Campground Road, most especially in the November 2016 wet weather data point. Rainfall greater than 1" is correlated to the highest *E. coli* counts of any monitoring site used in the development of this watershed plan. However, as shown in Figure 18, even dry weather events are greater than the individual grab sample standard (349 col/100mL), demonstrating a need for background pollutant mitigation and efforts that improve the management of wet weather bacteria loads.

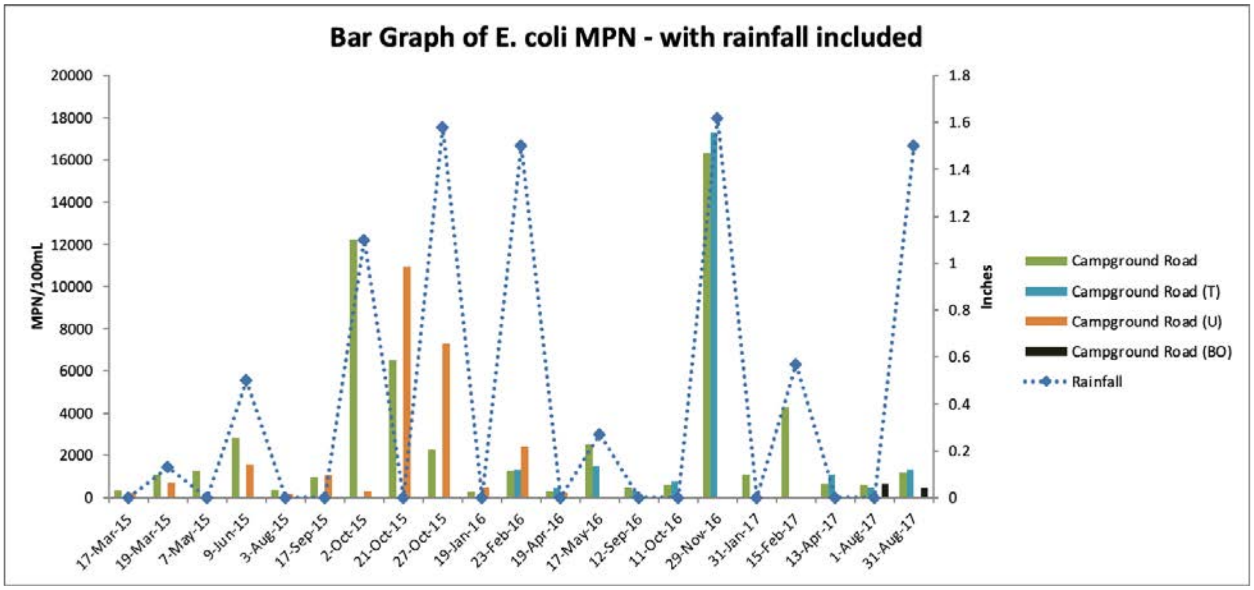


Fig. 17. Rainfall of 1" or more results in the highest E. coli concentrations seen at any site used in the development of this watershed plan.

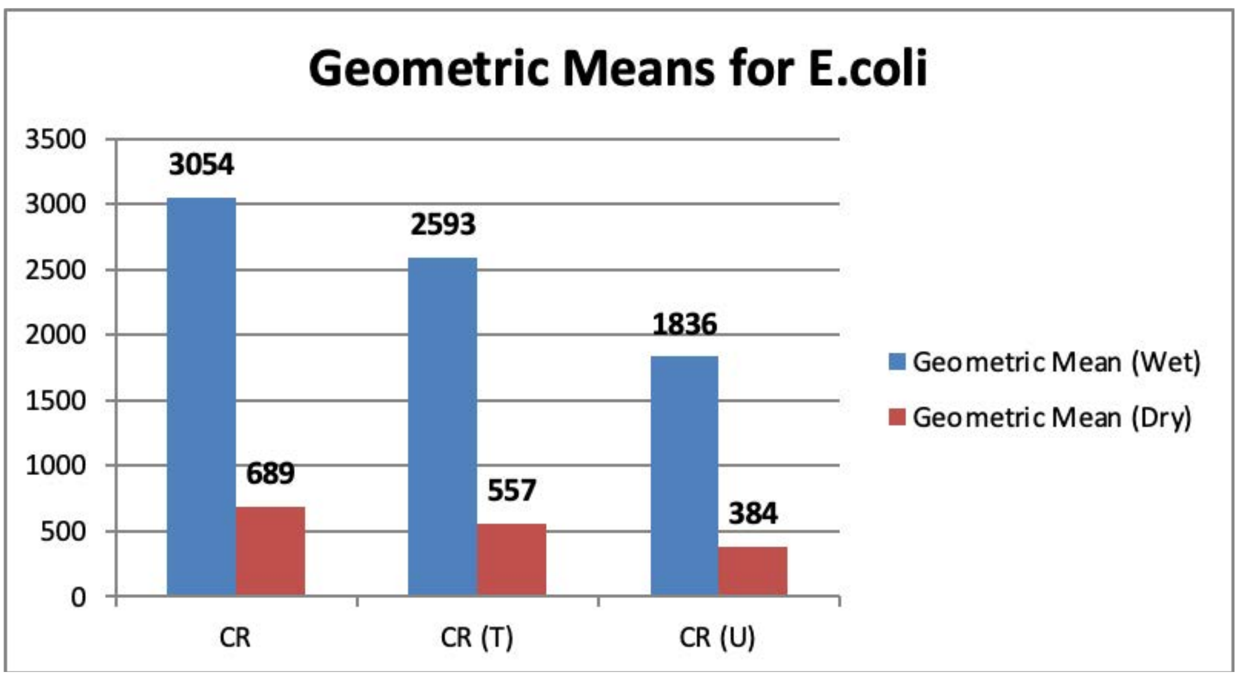


Fig. 18. Golden Creek and the tributary monitored to Golden Creek demonstrate high E. coli bacteria during both dry and wet weather monitoring events, though certainly exacerbated during and after rain events.

2.3: MICROBIAL SOURCE TRACKING RESULTS

To further investigate these high bacteria loads, the Pickens County Stormwater Department partnered with the Clemson University Center for Watershed Excellence and the Clemson University Molecular Plant Pathogen Detection Laboratory in 2015 and provided samples for microbial source tracking on collected sample water, concluding in 2019. Microbial source tracking is an overarching title for a suite of practices that use RNA or DNA to identify the specific sources of bacteria.

This method includes RNA extraction and amplification based on the detection of previously developed, non-library, species-specific bacteria primers. These primers target and quantify the amplified sequences in a process called quantified polymerase chain reaction, or qPCR. Primers used were for human, bovine, canine, and swine detection and quantify their detected presence so that bacteria sources can be related amongst each other. This would allow someone to interpret this data in a way that sets priorities around what source(s) most need to be controlled of those identified. *Bacteroides* is the detected cell, which only exists in the gut of warm-blooded mammals and cannot exist otherwise in nature; a finding of *Bacteroides* is a finding of waste in sample waters.

Results shown in Figure 19 indicate that there was a *near constant input of human fecal waste during the four-year timeframe of this sampling effort at all four monitoring stations,* followed by the positive presence of swine, most notably at the Campground Road Before Outfall site.

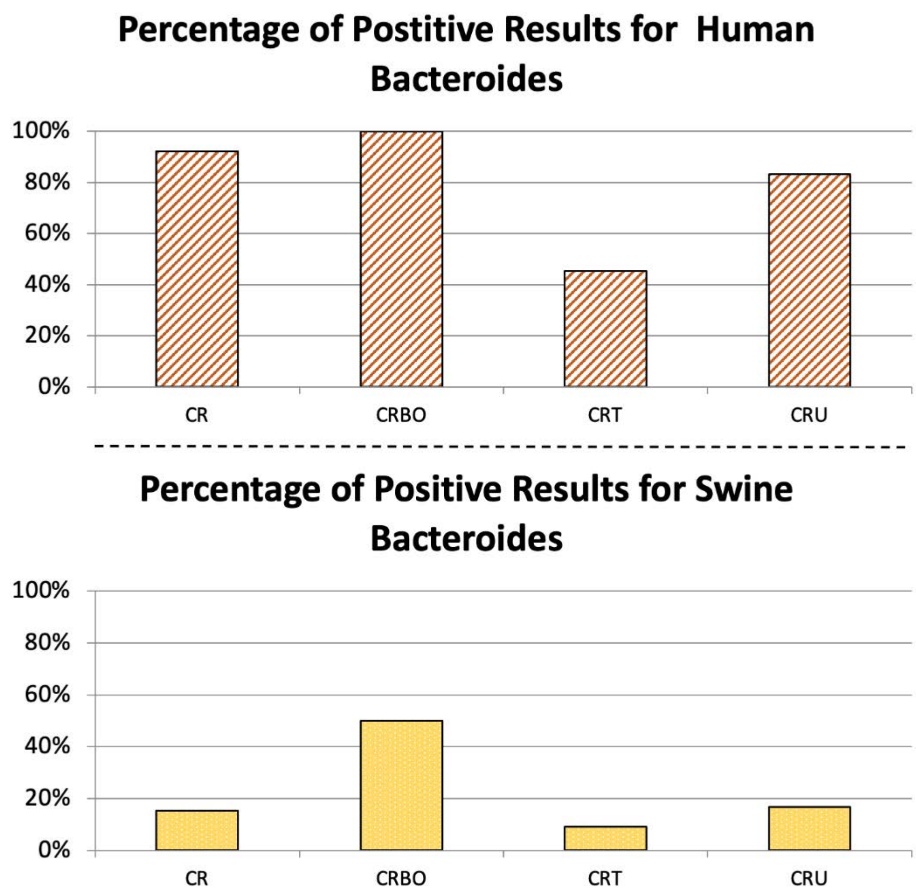


Fig. 19. Considering only monitoring results greater than the single grab sample water quality standard, human waste was the most significantly identified contributor to exceedances, followed by swine.

These types of data can expedite analysis of bacteria sources in impaired watersheds and lead to the development of strategic and more effective control measures to reduce bacteria impairments in our waterways and the threats that accompany them. The strong presence of human-detected bacteria from this analysis over four years is critical information for the development of an effective watershed plan.

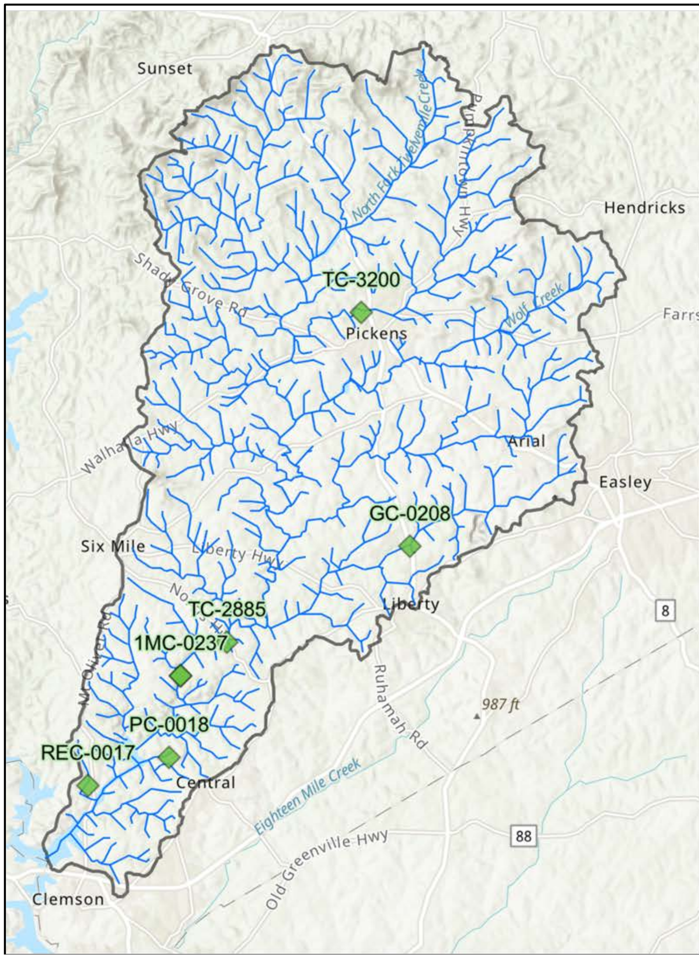
2.4: SC ADOPT-A-STREAM COMMUNITY SCIENCE MONITORING

The SC AAS community science monitoring program is South Carolina's largest community science water quality and ecosystem monitoring program. SC AAS has been active since 2017 and certifies volunteers to monitor freshwater streams, assess macroinvertebrate community health and diversity, and monitor tidal saltwater creeks. Program training protocols and data storage maintain sufficient integrity for education and outreach, the collection of baseline data, and for use by local authorities; the data is non-regulatory, though does alert local authorities and the state when the potential for pollution and illicit discharges exist. A Quality Assurance Project Plan (QAPP) has been approved by SCDHEC and the US Environmental Protection Agency (U.S. EPA) to certify volunteers and their collected data for these purposes. SCDHEC and the Clemson University Center for Watershed Excellence co-lead the program, alongside dozens of training partners, SC AAS Hubs, and kit loan locations. Data is stored and shared in the program's database, managed by Clemson University, allowing all viewers to explore data and download monitoring data for locations of interest.

Freshwater monitoring protocols include the measure of pH, dissolved oxygen (DO), air and water temperature, and the incubation and count of *E. coli* bacteria. New to the program, but not yet available at the time of the writing of this plan, is the measure of turbidity. Volunteers are also trained to conduct a Stream Habitat Assessment; these data describe the conditions of the banks, riparian buffer zones, and in the stream. These characteristics, when considered in combination or individually, are useful data points for projects that would address water quality issues related to turbidity, macroinvertebrate habitat, nutrient enrichment, and *E. coli* management.

More information, access to data, and program resources can be found at the program's website, www.scadoptastream.org.

Certified SC AAS volunteer data has been included in this watershed plan to assist in filling gaps on smaller, lesser monitored waterways within this large watershed. Figure 20 shows the monitoring station locations and *E. coli* data only beginning in 2015. Appendix A includes all of the volunteer monitoring SC AAS data collected in this watershed after 2014 by monitoring site.



Site	Date	E. coli (cfu/100mL)
TC-2885 - Twelvemile Creek	1/29/23	466.67
	12/27/22	233.33
	12/2/22	700
	10/25/22	133.33
	9/29/22	266.67
	9/18/22	166.67
	8/24/22	333.33
	7/18/22	166.67
	6/12/22	233.33
1MC-0237 Twelvemile Creek	2/10/21	300
	2/16/20	366.67
	10/23/19	433.33
	5/4/19	633.33
	3/10/19	733.33

Site	Date	E. coli (cfu/100mL)
REC-0017 RC Edwards Creek	12/5/19 8:25	366.67
	11/7/19 11:45	866.67
	10/6/19 15:00	1233.33
	10/3/19 10:00	2700
	9/5/19 10:00	1133.33
	4/4/19 9:45	100
	12/6/18 9:12	33.33
	10/4/18 10:00	433.33
	6/7/18	33.33
	9/7/17 14:21	266.67
	10/12/16 0:00	200
	9/3/16 0:00	500
PC-0018 Pappy's Creek	6/13/18 11:00	100
	10/12/16 0:00	100
	9/3/16 0:00	5400
GC-0208 Golden Creek	9/26/18 0:00	400
TC-3200 Town Creek	7/21/22 0:00	400

Fig. 20. SC Adopt-a-Stream monitoring sites and E. coli data after 2014 in the Twelvemile Creek Watershed, mainstem and tributaries.

2.5: RIVER COLOR

When considering turbidity and its impacts on ecosystem production from an overhead view, more patterns of river color emerge in the mainstem Twelvemile Creek. A study evaluating the color change of rivers between 1984 and 2018 using remote sensing showed that eastern United States rivers are more blue-shifting in general and red-shifting in spring. Where red-shifting is not occurring, it was proposed by the authors that this is due to dams in series and sediment settling out (Gardner et al, 2020). This scenario fits the color patterns seen on the Twelvemile from the ground as well as overhead satellite imagery. Color, ultimately, is one of the longest used methods in history to establish the health of a waterway.

Close to and above SV-137 are a series of large wetlands, shown in Figure 21. This area referred to as Blue Branch is near the area of these large wetland pockets and flood storage areas. The color difference of the Twelvemile is most apparent when evaluated relative to the cove at Equoni Point Park shown below.

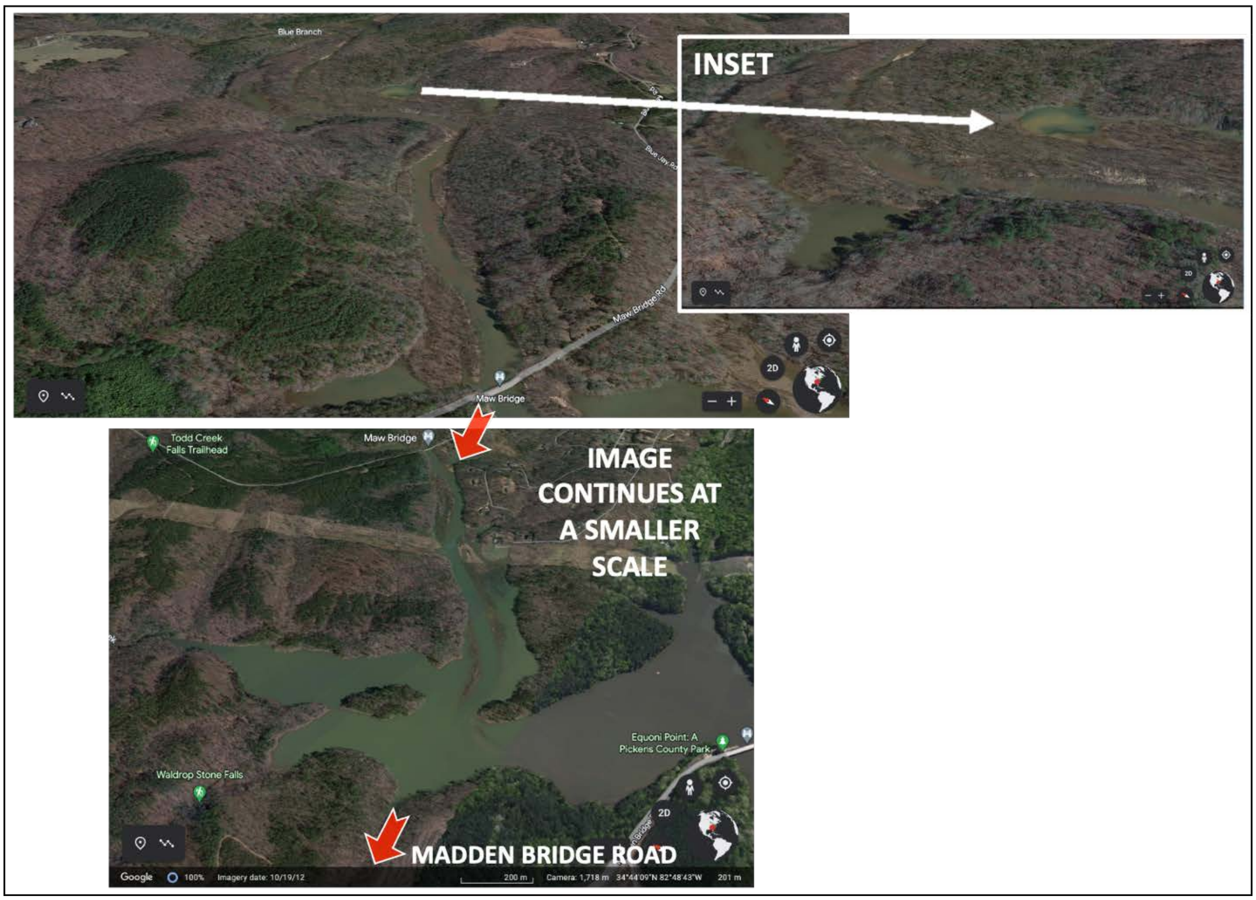


Fig. 21. A series of satellite images showing the green-blue water of the Twelvemile Creek mainstem and adjacent wetlands.

The sequence of events in the history of this watershed – dam removal due to contamination, sediment redistribution, agriculture and industrialization – have modified the sediment load of the Twelvemile Creek very visibly. The existence of these wetlands is positive for ecological function, biodiversity, flood storage, and pollutant trapping. It is proposed that the function of these wetlands be restored, and where needed, reconnected with the larger system, to better address water quality,

flow, and sediment trapping. **Agricultural practices that minimize nutrient runoff and sediment loss and are designed for extreme weather events and climate changes, would better protect the function of restored wetlands for the future health of the Twelvemile.**
The most recent ruling on wetland protection afforded by the Clean Water Act (CWA) by the U.S. Supreme Court, known as Sackett v. EPA (Natural Resources Defense Council. 2023), redefined Waters of the US. In this new definition, wetlands that are physically disconnected from navigable waterways are no longer afforded protection by the CWA and now vulnerable to development, destruction, and pollution. With regard to sediment containment from agriculture, silviculture, and development practices, this may result in more sediment making its way to the waters of the Twelvemile Creek watershed. For the purposes of water quality, flood control, ecosystem protection, and biodiversity, local ordinances that restrict development and filling in of disconnected wetlands can regain these protections. According to EPA, wetlands "are among the most productive ecosystems in the world, comparable to rainforests and coral reefs." Wetlands also store massive amounts of carbon in their abundant vegetation and can uptake nutrients before runoff occurs.

2.6 CURRENT WATER QUALITY IMPAIRMENTS

According to the 2022 SCDHEC 303(d) List, there are currently four water quality monitoring stations that are considered impaired for biological criteria or PCB contamination (Table 6). Site SV-206 is within a watershed where an approved TMDL for bacteria has been developed (see Section 3.1). Several other water quality monitoring sites are within watersheds that fall under the TMDL developed, further discussed in Section 3.1.

Tab. 6. Water Quality Impairments According to the 2022 303(d) List

Station	**Impairment**	**Impaired Use**	**Within a TMDL Watershed**
SV-107	PCB	fish	
SV-206	biological	aquatic life	✓
SV-738	biological	aquatic life	
SV-740	biological	aquatic life	

2.7: DATA GAPS

MONITORING DATA AND SPATIAL COVERAGE

Essentially, one SCDHEC monitoring station provided the most data for the mainstem Twelvemile Creek. The other current SCDHEC monitoring station with *E. coli* results provided insights only on a small tributary to Golden Creek. While Pickens County had initially shown 16 monitoring locations in the region, only four locations had data provided to the project team by the County for the creation of this plan. The greatest utility of this data is in the ability to analyze the impacts of wet weather events on *E. coli* in waterways. Only the TMDL provided loading data based on stream gauging data.

To create a more geographic specific watershed plan, more widespread water quality monitoring data is needed. Community science monitoring with SC AAS could provide beneficial insights for this large watershed, complementing additional state regulatory stations. Suggested SC AAS monitoring station locations are based on several factors, including safe access, history of prior data collection, and geographical gaps in monitoring (Section 7.0).

INVENTORY OF WASTEWATER INFRASTRUCTURE AND OWNERSHIP

Sanitary sewer lines often use pumping stations to move wastewater up-gradient to the wastewater treatment plant. Because of the number of smaller, rural, centralized wastewater treatment plants, the project team could not locate any ArcGIS-ready data layer or complete set of information on the location of sewer infrastructure as well as pumping stations. Due to the nature of their remote use and locations, it is difficult to locate these across the watershed and evaluate water quality data, MST data, and proximity to these distribution centers of wastewater. It is the recommendation of this project team that a greater effort be made to make available sewer service line information and pumping station locations for all planning related activities, be it smart growth or watershed management.

Added to this data need is a better understanding of floodplains and the potential of wastewater structures (*i.e.*, public bathrooms, portable toilets) that exist within areas that are increasingly prone to flooding during extreme storms and increasingly susceptible to future flooding due to growth and increases in impervious surfaces and runoff. An example of this is the porta johns located near the banks of Twelvemile Creek at the Pickens County Flea Market.

Further, it was observed and relayed to the project team that there has been an increase in RV parks as well as RVs being established as home sites on lots with and without existing homes and infrastructure. Though inherently mobile, there are concerns that this move towards long-term RV home establishment could have implications on wastewater affecting local wetlands and waterways. The rural nature of this large watershed and widespread detection of *E. coli* bacteria and human-related source findings elevates these environmental health concerns. Beyond conversational anecdotal evidence, there was not enough current water quality data to draw any further conclusions. However, based on discussions with SCDHEC staff, identifying and addressing homemade sewer solutions at RV sites is at times difficult and can face many delays between correspondence to repair. It is suggested that more information be distributed to residents regarding permitting, wastewater treatment, and how to communicate concerns in a way that will expedite follow-up.

ADDITIONAL NEEDS IDENTIFIED

In discussions with stakeholders, additional needs that would benefit overall planning and conservation include the following:

1. Landowner survey that more accurately accounts for the size of the feral hog issue throughout the county;
2. Overall assessment of the conditions of wetlands in the county to prioritize improvements.

3.0 POLLUTANT LOADING AND REDUCTIONS NEEDED

3.1: BACTERIAL LOADING

Prior to 2013, South Carolina used fecal coliform (FC) as the bacterial indicator to evaluate the safety of freshwaters for recreational purposes. In 2013, SCDHEC switched to *Escherichia coli (E. coli)* as the bacterial indicator for freshwater. Since this transition in bacteria standards, the majority of current water quality monitoring results are recorded as *E. coli.* This plan is designed specifically to address *E. coli* bacteria, and as such, numbers originally listed as FC have been converted to *E. coli* by multiplying values by 0.8725 (SCDHEC, 2013).

THE BACTERIA TMDL

A TMDL was developed for several waterways within the Twelvemile Creek watershed in 2003 by SCDHEC (https://scdhec.gov/sites/default/files/docs/HomeAndEnvironment/Docs/tmdl_12mile.pdf). A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet water quality standards for that pollutant. There are a total of five waterways included in the approved TMDL Stations included in this 2003 TMDL are SV-136, SV-137, SV-015, SV-239, and SV-206. Since 2003, three additional stations have been added within the TMDL area: SV-362, RS-11009, and RS-19473.

BACTERIAL LOAD REDUCTIONS

Bacterial load reductions for this plan were based on the bacteria TMDL for Twelvemile Creek. Within the TMDL document, existing loads of both point and nonpoint source bacterial pollution were calculated, and target percentage reductions were identified. Table 7 below summarizes the estimated existing loads and target reductions needed to meet the identified TMDLs for the watershed. Because the TMDL is calculated for fecal coliform (FC), numbers were converted to *E. coli* for consistency with current sampling results and Best Management Practices' (BMP) load reduction calculations by multiplying values by 0.8725 (SCDHEC, 2013). In summary, an estimated load reduction of 3.70E+15 counts/year (*E. coli*) is required to meet water quality standards for bacteria. As seen in Figure 22 below, three of the TMDL sites are located within the Lower Twelvemile Creek-Keowee River subwatershed, at the base of the greater Twelvemile Creek watershed; these three sites account for nearly 97% of the load reduction needs detailed in Table 7. The Existing Load column in Table 7 correlates to the nonpoint loading numbers from the TMDL document divided by 30 to get the daily load reduction needed. With bacterial load reduction needs the greatest at the base of the watershed, it will be important to focus reduction efforts across the watershed.

Tab.7. Bacterial Load Reduction Calculations

Station	**Existing Load (counts/day) (nonpoint sources only)**	**Target Reduction (%)**	**Reduction Needed (counts/day)**	**Reduction Needed (counts/year)**	**Reductions Needed (counts/year) *E. coli******
SV-015	8.30E+12	64%	5.31E+12	1.94E+15	1.69E+15
SV-136	4.87E+10	56%	2.27E+10	9.94E+12	8.68E+12
SV-137	9.24E+12	64%	5.91E+12	2.16E+15	1.88E+15
SV-206	3.32E+11	39%	1.29E+11	4.72E+13	4.12E+13
SV-239	3.46E+11	64%	2.21E+11	8.08E+13	7.05E+13
				SUM	**3.70E+15**

**Numbers in this column were multiplied by 0.8725 to convert from FC to E. coli*

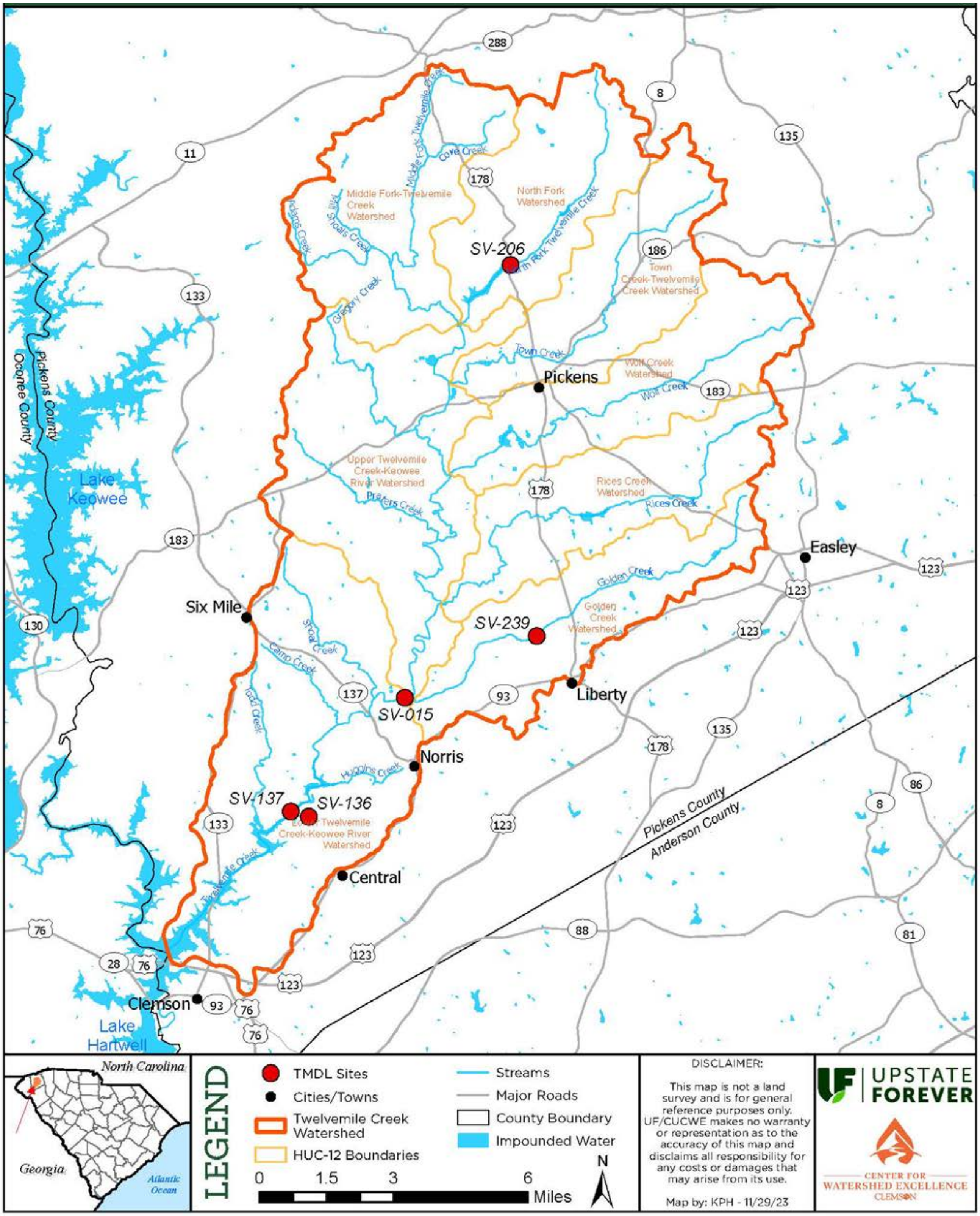


Fig. 22. Initial TMDL Site Locations in the Twelvemile Creek Watershed based on the 2003 TMDL Report

BACTERIAL POLLUTION SOURCES

Bacterial pollution can be attributed to both point and nonpoint sources within the Twelvemile Creek watershed, including wastewater effluent, agricultural land uses, urban runoff, and wildlife, as detailed in Section 3 of the 2003 TMDL. Examples of each category are listed in Table 8.

Tab. 8. Potential Point and Nonpoint Sources of Bacterial Pollution in the Focus Area

Wastewater	Agriculture	Urban	Wildlife
• Failing/Faulty Septic Tanks • Private Wastewater Treatment Plants • Sanitary Sewer Overflows (SSO's)	• Cattle • Horses • Sheep & Goats • Poultry • Swine • Cropland	• Stormwater Runoff • Domestic Pets	• Waterfowl • Wild Hogs • Deer • Beavers

BACTERIAL LOAD REDUCTIONS FROM BMPS

As mentioned in Table 7, the total annual bacterial load reductions needed to satisfy the TMDL is 3.70E+15 counts/year. Table 9 outlines a suite of BMPs that can be used to address bacterial impairments in the watershed and how much bacteria would be removed from each installation. Specific project recommendations are listed in Section 5. These estimations were derived using the standard annual bacterial removal rates as detailed in Section 5.2 and Appendices C-E of the Three and Twenty Creek Watershed-Based Plan. Prevention of bacterial pollution through land protection was derived based on standard land use annual pollutant loadings per unit area (Shaver et al., 2007). While septic repairs/replacements, agricultural BMPs, and riparian buffer enhancements all address bacteria removal, land protection proactively addresses bacteria from a prevention perspective. An agricultural BMP bundle refers to agricultural projects often done in conjunction with one another; for calculation purposes as explained in Appendix B, an agricultural BMP bundle includes one well with pump, 1,686 feet of fencing, 2,138 square feet of heavy use area protection, 599 linear feet of waterline, one watering facility, and 0.23 acres of riparian buffer area. Bacterial load reductions for feral hog management are based on standard numbers provided by SCDHEC (SCDHEC, 2023).

Tab. 9. Standard Bacterial Load Reductions (E. coli) per BMP

BMP	Standard Bacterial Load Reduction (counts/year)	Unit of Measurement	BMP Description
Septic Repairs/Replacements	2.11E+10	Per repair	Section 5: Strategy 2; page 68
Agricultural BMP Bundle	1.62E+13	Per BMP bundle	Section 3.1; page 44
Land Protection	1.25E+09	counts/acre/year	Section 5: Strategy 3; page 68
Feral Hog Management	3.17E+12	Per hog	Section 5: Strategy 11; page 91

3.2: SEDIMENT LOADING

ESTIMATED SEDIMENT LOADING

Annual sediment loading for the watershed was calculated using the Spreadsheet Tool for Estimating Pollutant Load (STEPL). The STEPL model estimates annual sediment and nutrient loading based on the Universal Soil Loss Equation (USLE) and considers sediment loading from land uses (e.g., urban, cropland, pastureland, and forest lands) (U.S. EPA, 2018). Using this tool, it is estimated that cumulatively the watershed contributes 19,248 tons of sediment per year to the region (Table 10), largely attributed to pastureland and urban development (Figure 23).

Tab. 10. Annual Sediment Loading per Subwatershed

Watershed (HUC-12)	Waterway	Sediment Loading (tons/year)
30601010401	Middle Fork Twelvemile Creek	1,689
30601010402	North Fork Twelvemile Creek	1,508
30601010403	Town Creek	2,310
30601010404	Wolf Creek	2,147
30601010405	Rices Creek	2,471
30601010406	Golden Creek	2,259
30601010407	Upper Twelvemile Creek-Keowee River	3,746
30601010408	Lower Twelvemile Creek-Keowee River	3,118

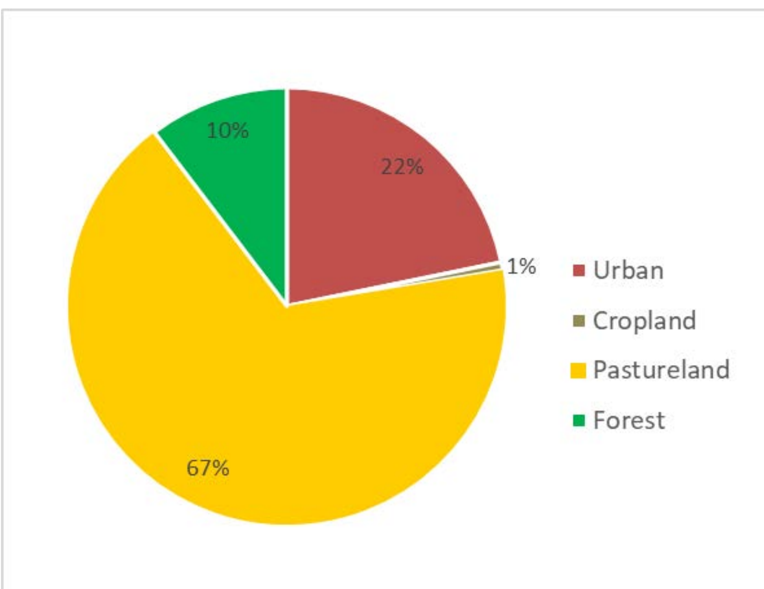


Fig. 23. Sediment Loading per Land Use

SEDIMENT POLLUTION SOURCES

In the Twelvemile Creek watershed, pastureland and urban development are linked to most of the sedimentation issues. According to the U.S. EPA, the most common source of pollution from agriculture is soil that is washed from fields during rain events (U.S. EPA, 2005). Agricultural practices that exacerbate sediment erosion include overgrazing, misplaced and mismanaged feeding operations, over-plowing, and poorly timed or excessive fertilizer, pesticide, and irrigation water applications. Additionally, livestock with access to streams can also contribute to sediment pollution by causing erosion along streambanks.

Urban development is the next largest land-use contributor to sedimentation. Activities most associated with sedimentation from urbanization are land disturbances, channelization of streams, the expansion of impervious surfaces, and increases in stormwater runoff (SC AAS, 2018). Sediment pollution from urban areas is usually linked to mismanaged construction sites, but can also come from streets, yards, and the stream itself. Using the STEPL model for the Twelvemile Creek watershed, sedimentation is predicted as highest in the subwatersheds with higher urban land and pastureland, pointing to urban and agricultural activities as major contributors of sediment pollution in this area (Figure 24).

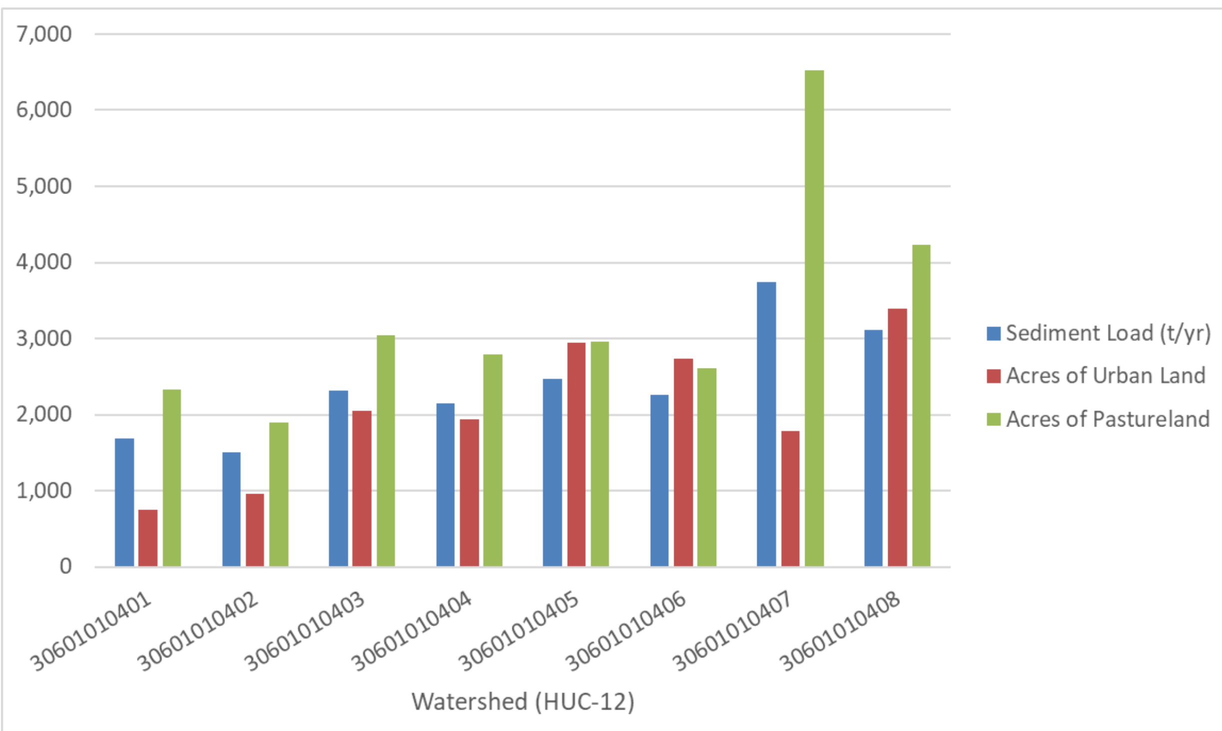


Fig. 24. Comparison between Sedimentation and Land Cover

Field observations indicate that sedimentation from activities on the ground is related to the following, examples of which are shown in Figure 25:

- Eroded areas of soil that are not re-seeded;
- Low deck mowing and dust distribution;
- Dirt road and parking area maintenance;
- Ditch scraping;

- Failures to manage sediment loss on active construction sites, most notably on single lot construction sites;
- Construction site road access points;
- Unofficial trails being created to access waterways.

Fig. 25. Sources of sediment are prevalent across the watershed, caused often by issues easily addressed, such as raising mower decks and reseeding, as well as purposeful trail installation and maintenance.

The observations of sediment in-stream were previously outlined as related to dam removals and overwhelmed wetland storage. Channelization and undercutting related to urban river syndrome were not observed frequently in this watershed; therefore, the riparian buffers that exist to protect streambanks from failures and collapse are no cost BMPs that should continue to be a priority management solution.

SEDIMENT LOAD REDUCTIONS FROM BMPS

Sediment load reductions (and preventions) were estimated for three BMP categories: agricultural BMPs, riparian buffer enhancements, and land protection.

Each of these load reductions were based on the high priority sites as identified in Section 4 from the respective categories. Load reductions for agricultural and riparian buffer BMPs were calculated using the STEPL model. Prevention of sedimentation through land protection was derived based on standard land use annual pollutant loadings per unit area (Shaver et al., 2007). Other standard removal numbers/percent reductions are sourced from EPA's Best Management Practice Efficiency References for the Pollutant Load Estimation Tool (2023). The standard numbers calculated are detailed in Table 11. Specific project recommendations are listed in Section 5.

Tab. 11. Standard Sediment Load Reductions per BMP

BMP	Standard Sediment Load Reduction	Unit of Measurement	BMP Description
Agricultural BMP Bundle	5.4	Tons/BMP bundle	Section 3.1; page 70
Riparian Forest or Grass Buffer	1.3	Tons/100 linear feet	Section 5: Strategy 4; page 72
Land Protection	0.03	tons/acre/year	Section 5: Strategy 3; page 68
Stabilizing Farm Road Access	1.76-3.6	lbs/foot	Section 5: Strategy 4; page 71
Filter Strips	60%	Per project	Section 5: Strategy 4; page 71
Conservation Tillage	46%	Per acre	Section 5: Strategy 4; page 72
Conservation Cover/ Cover Crops	10-20%	Per acre	Section 5: Strategy 4; page 72
Wetland Restoration	78%	Per acre	Section 5: Strategy 5; page 75
Bioswales (Vegetated Swale)	48%	Per impervious acre	Section 5: Strategy 6; page 77
Rain Gardens/Bioretention	80%	Per project	Section 5: Strategy 6 page 82; Strategy 7, page 86
Streambank Stabilization	75%		Section 5: Strategy 4; page 72
Streambank Protection	40%		Section 5: Strategy 4; page 72
Conservation Landscaping (Bioretention)	56%		Section 5: Strategy 5; page 72, Strategy 7, page 86

3.3: NUTRIENT LOADING

CURRENT NUTRIENT LOADING

Annual nutrient loading for the watershed was calculated using the STEPL model, which showed that current loading in the watershed is equal to 72,601 pounds/year of phosphorus and 478,813 pounds/year of nitrogen (cumulatively 551,414 pounds/year). Nutrient loading in this watershed is largely attributed to pastureland and urbanization (Figure 26), similar to current sediment loading sources. Urbanization and septic system failures together account for 38% of all nutrient loading in the watershed, while agricultural practices (pasturelands and croplands) account for 56% of nutrient loading in the watershed.

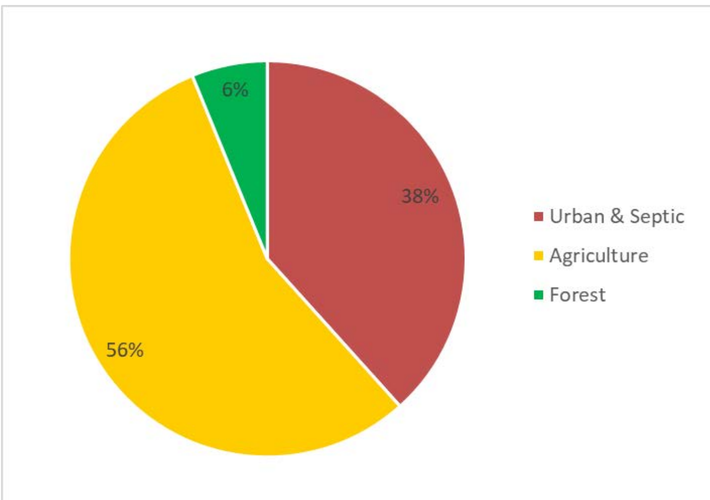


Fig. 26. Nutrient Loading per Land Use

Sediment transport is a natural process that is exacerbated by land use changes such as deforestation, construction, agricultural practices, and developmental activities that accelerate erosion rates. Sediments contain organic matter, minerals, and nutrients, such as nitrogen and phosphorus. Nutrients are essential for the growth of aquatic plants and algae, but too much of them can cause eutrophication, which is a process that depletes oxygen in water and harms aquatic life. Therefore, where you see increased sediment pollution there is corresponding increased nutrient pollution that further degrades the quality of water for drinking, wildlife, and the land surrounding streams (Figure 27).

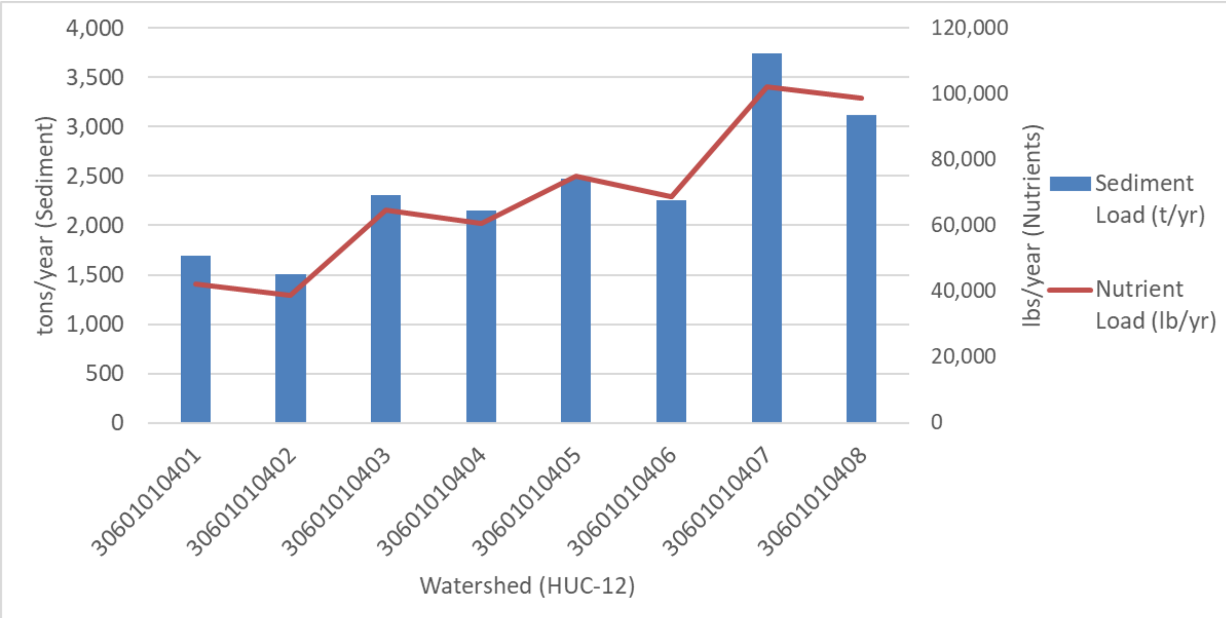


Fig. 27. Comparison between Sedimentation and Nutrient Loading

NUTRIENT POLLUTION SOURCES

Nutrient pollution is considered one of the most widespread and difficult challenges for water quality in the U.S. (U.S. EPA, 2018). According to the U.S. EPA, nutrient concentrations in streams are directly related to land use with agricultural activities contributing the most to higher concentration levels. Excess levels of nitrogen and phosphorus in groundwater systems can affect both ecosystem function and human use of waters. In ecosystems, excess nutrients can cause algal blooms, decreasing dissolved oxygen and impairing aquatic habitat (USGS, 2010). Similarly, human consumption of drinking water with high levels of nutrients, nitrate especially, can affect human blood oxygenation and can cause higher cost of water treatment for drinking water utilities (USGS, 2010). Nutrient pollution in this watershed is attributed to both point and nonpoint sources, mostly from human activity. Point sources of nutrients can include both wastewater and industrial facilities. Nonpoint sources of nutrient pollution in this watershed are largely attributed to agricultural practices, urbanization, and wastewater. Agriculture is considered one of the largest sources of nutrient pollution to waterways in the country (U.S. EPA, 2018). Fertilizers and animal manure, both rich in nutrients, are the primary causes of nutrient pollution from agriculture when not managed properly. Stormwater runoff from urban areas can include high levels of nutrients from yard waste, fertilizers, and pet waste. Domestic wastewater contains nutrients from human waste, food scraps, as well as certain soaps and detergents. Consequently, improperly managed septic systems can release nutrients into local waterways or groundwater (U.S. EPA, 2018).

NUTRIENT LOAD REDUCTIONS FROM BMPS

Nutrient load reductions (and preventions) were estimated for four BMP categories: agricultural BMPs, riparian buffer enhancements, septic repairs/replacements and land protection. Each of these load reductions were based on the high priority sites as identified in Table 13 from the respective categories. Load reductions for septic and riparian buffer BMPs were calculated using the STEPL model. Agricultural BMP load reduction calculations are explained in Appendix B. Prevention of nutrient pollution through land protection was derived based on standard land use annual pollutant loadings per unit area (Shaver et al., 2007). Other standard removal numbers/percent reductions are sourced from The Chesapeake Bay Program's BMP Guide (The Chesapeake Bay Program, 2022) and the EPA's Best Management Practice Efficiency References for the Pollutant Load Estimation Tool (2023). The standard numbers calculated are detailed in Table 12. Specific project recommendations are listed in Section 5.

Tab. 12. Standard Nutrient Load Reductions per BMP

BMP	Standard Nitrogen Load Reductions	Standard Phosphorus Load Reductions	Unit of Measurement	BMP Description
Septic Repairs/Replacements	32.62	12.78	lbs/repair or replacement	Section 4.2: page 55
Agricultural BMP Bundle	9.90	3.80	lbs/BMP bundle	Section 3.1; page 70
Riparian Forest or Grass Buffer	33.7	3.40	lbs/100 linear feet	Section 5: Strategy 4; page 72
Land Protection	0.40	1.61	lbs/acre/year	Section 5: Strategy 3; page 68
Filter Strips	40%	45%	Per project	Section 5: Strategy 4; page 71
Conservation Tillage	>1%	36%	Per practice	Section 5: Strategy 4; page 72
Conservation Cover/ Cover Crops	11-45%	7-15%		Section 5: Strategy 4; page 72
Wetland Restoration	42%	40%		Section 5: Strategy 5; page 75
Constructed Wetlands	25-55%	50-75%		Section 5: Strategy 5; page 76
Bioswales (Vegetated Swales)	70%	75%		Section 5: Strategy 6; page 77
Rain Gardens/Bioretention	63%	80%		Section 5: Strategy 6 page 82; Strategy 7, page 86
Streambank Stabilization	75%			Section 5: Strategy 4; page 72
Streambank Protection	25%	30%		Section 5: Strategy 4; page 72
Conservation Landscaping (Bioretention)	20%	54%		Section 5: Strategy 5; page 72, Strategy 7, page 86

4.0 WATERSHED CHARACTERIZATION

4.1: LAND USE CHANGE IN THE RIPARIAN CORRIDOR

ANALYSIS OF LAND USE CHANGE IN THE RIPARIAN CORRIDOR

Understanding land cover and land use changes over time is a critical part of watershed planning, as different types of land cover can affect an area's biodiversity and water quality, quantity, and hydrology. Land use change adjacent to waterbodies is an especially important consideration, as water quality can often be correlated with neighboring land uses due to stormwater runoff. According to the U.S. EPA, land cover and impervious surface coverage such as roads, buildings, parking lots, and turf grass can seriously impact the biotic integrity in streams.

In this study, high-resolution imagery from the National Agriculture Imagery Program (NAIP) for the years 2011 and 2021 were used to classify land cover for the Twelvemile Creek watershed. The analysis is more fully detailed in Appendix C. These years allowed for comparison of changes in a 500-foot riparian buffer zone over a ten-year period, until the most recent imagery of 2021. Imagery used provided one-meter (2011) and 0.6-meter (2021) resolutions for higher accuracy classifications and change detection. The area was classified into the following five different classes:

- forested;
- barren/non-forested;
- pasture/grassland/crops;
- urban (impervious);
- water.

Barren land includes any unvegetated landscape such as rock outcrops, dirt/graded land, and gravel/dirt roads and driveways, as well as some clearcut forests and non-forested wetlands. Forested wetlands are largely classified as forest. A quarry on the southern boundary of the watershed, just east of Liberty, is classified as urban. This quarry had to be manually reclassified from barren in the 2021 imagery to match the 2011 classification.

RESULTS FROM ANALYSIS

Comparison between the 2011 and 2021 land cover maps shows an approximate 2.62% loss of urban land cover and a 3.36% gain of forested land cover in riparian buffer zones over ten years (Table 13). Small-scale development can be seen in some areas, while a few buildings/structures/parking lots have since been demolished and are now classified as pasture/grassland/crops or barren. Growth of vegetative cover or differences in visibility of structures between the two imagery sets also accounts for some of these differences. Across this studied watershed, new development within riparian zones has been limited. Significant forest loss in the riparian corridor was not observed in the field or in this land cover analysis.

Tab. 13. Land use change in the 500-foot riparian buffer zone between 2011 and 2021.

Land cover classes	Acres (US)		Percent change
	2011	2021	
Forested	36,392.56	37,616.60	3.36%
Pasture/Grassland/Crops	8,612.76	6,926.37	-19.58%
Water	1,460.16	1,277.05	-12.54%
Urban	2,647.59	2,578.11	-2.62%
Barren/Non-forested	642.23	1,361.16	111.94%

Analysis of forested and non-forested land cover in the entire watershed showed an increase in both over the ten-year period, with an approximate 22% loss of water (Table 14). This is largely associated with increased resolution and accuracy of the 2021 classification, which eliminated or reduced small patches of land that were misclassified as water in the 2011 imagery (Fig 28).

Tab. 14: Forested and non-forested land cover change in the Twelvemile Creek watershed.

Land cover classes	2011		2021		Percent change
	Acres	Percent	Acres	Percent	
Forested	68,297.95	69.03%	70,815.40	69.44%	3.55%
Non-forested	28,976.62	29.29%	29,796.99	29.22%	2.75%
Water	1,665.16	1.68%	1,363.90	1.34%	-22.09%

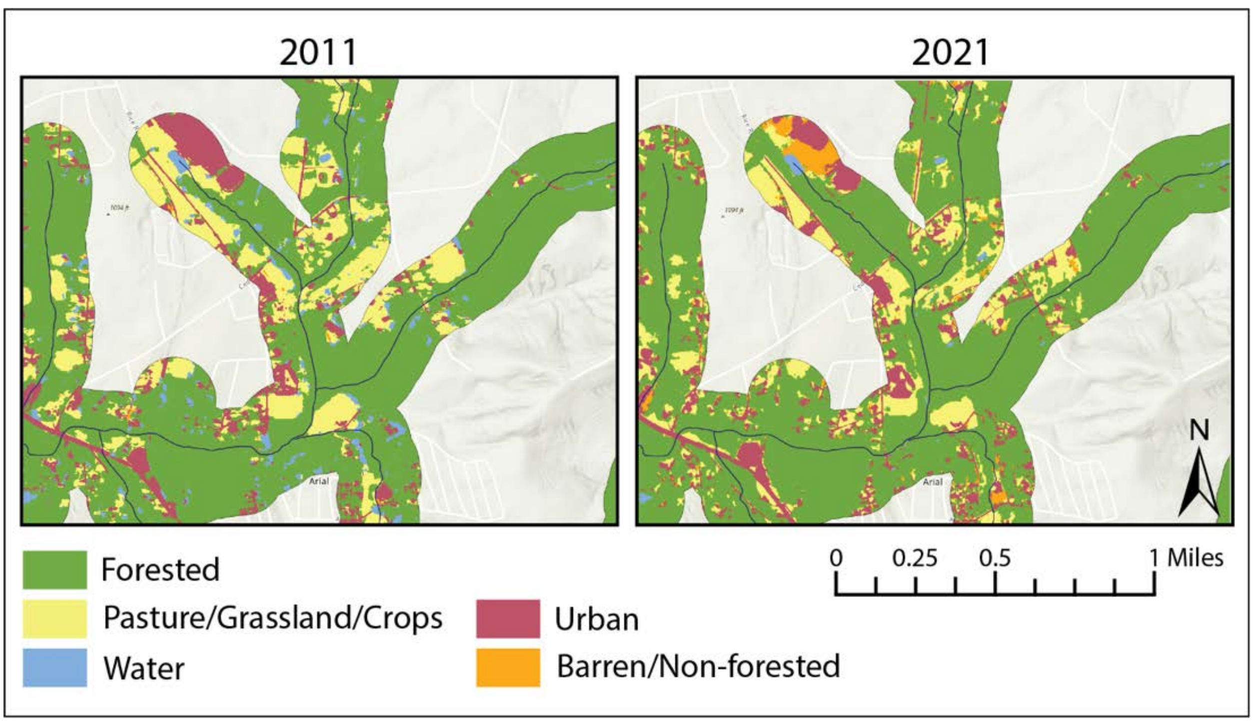


Fig. 28: Many small patches of land erroneously classified as water in the 2011 imagery were correctly identified as non-water land cover types in the 2021 classification.

4.2: WASTEWATER TREATMENT

Based on analysis, approximately 10% of the project watershed is served by sewer service for wastewater treatment. Small package treatment plants may exist at schools or industrial sites, but that information has not been readily available to the project team. The remainder of this overall rural watershed relies upon onsite sewer systems, also known as septic systems, to treat wastewater effluent. It was therefore imperative to understand what limitations may exist in treating septic system wastewater and this method of treatment's relationship to known bacteria issues that continue to occur in Twelvemile Creek.

SEPTIC SYSTEM GEOSPATIAL ANALYSIS AND SOIL SUITABILITY

When septic systems fail, they become a potential source of bacteria pollution to groundwater and surface water. Failure to properly treat wastewater occurs when the system is improperly sized, not sited appropriately, not maintained, disturbed by roots and heavy items that impact the drain field (such as driving large vehicles over the adsorption field or placement of an above ground pool), and other factors. Septic system operations rely on soil suitability, characterized by the soil layer's ability to infiltrate, the separation between system and high-water table, and the presence of bedrock.

The project team conducted geospatial analysis to better evaluate the potential impact of septic system failures and bacterial pollution to surface waters in the watershed. Several assumptions were made to develop a data layer of homes served by septic systems within a 300' buffer of open water:

1. All buildings within the administrative boundaries of the cities of Pickens, Easley, Central, Liberty, and Clemson were labeled as being served by sewer.
2. All buildings within 500' of sewer line were labeled as being served by sewer.
3. Buildings classified as outbuildings, sheds, or similar were assumed to not be connected to septic systems and were removed from analysis.
4. All homes within 300' of open water were assumed to have the greatest potential impact on local water quality, if their system were to fail.
5. Age of septic systems were characterized in the following groups (years): 2001-2002, 1971-2000, pre-1970, no information.

Based on the Natural Resource Conservation Service (NRCS) SSURGO database, the rating classes of septic tank absorption fields are:

- "*Not limited*" – the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected.
- "*Somewhat limited*" – the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected.
- "*Very limited*" – the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

In this evaluation, only the soil between depths of 24 and 60 inches is evaluated. Ratings are based on the soil properties that affect absorption of effluent, construction and maintenance of the system, and public health, such as: soil structure, saturated hydraulic conductivity, stones and boulders, depth to bedrock or a cemented pan, water movement, depth to water table, flooding, subsidence, and slope. Further information can be found in Appendix D.

SEPTIC SUITABILITY ANALYSIS RESULTS

The results found 3,300 buildings likely on septic systems within 300' of surface waters. Of these, 486 have septic systems from this century; 1,476 have septic systems built between 1971 and 2000; 837 are dated as 1970 or earlier; no information was available for 501 buildings.

Based on this analysis, an estimated 37% of the watershed is rated as somewhat limited, and 61% is considered very limited (Figure 29). **Within the 300' riparian buffer zone, only 18% of the soils are rated as somewhat limited and 78% are very limited.** Most septic systems in close proximity to surface waters were installed between 1971 and 2000, making them a minimum of 23 years old. With septic suitability ratings of "very limited" widespread throughout the watershed, the project team recommends focusing septic repairs upstream of TMDL site(s) SV-136/SV-137 to help achieve bacterial load reduction goals. While participation in a septic repair program is voluntary, further prioritization of outreach to landowners could include those adjacent to streams, upstream of water quality monitoring stations, and north of the City of Pickens where higher concentrations of high priority areas are seen. Further management recommendations are included in Section 5.0 of this watershed plan.

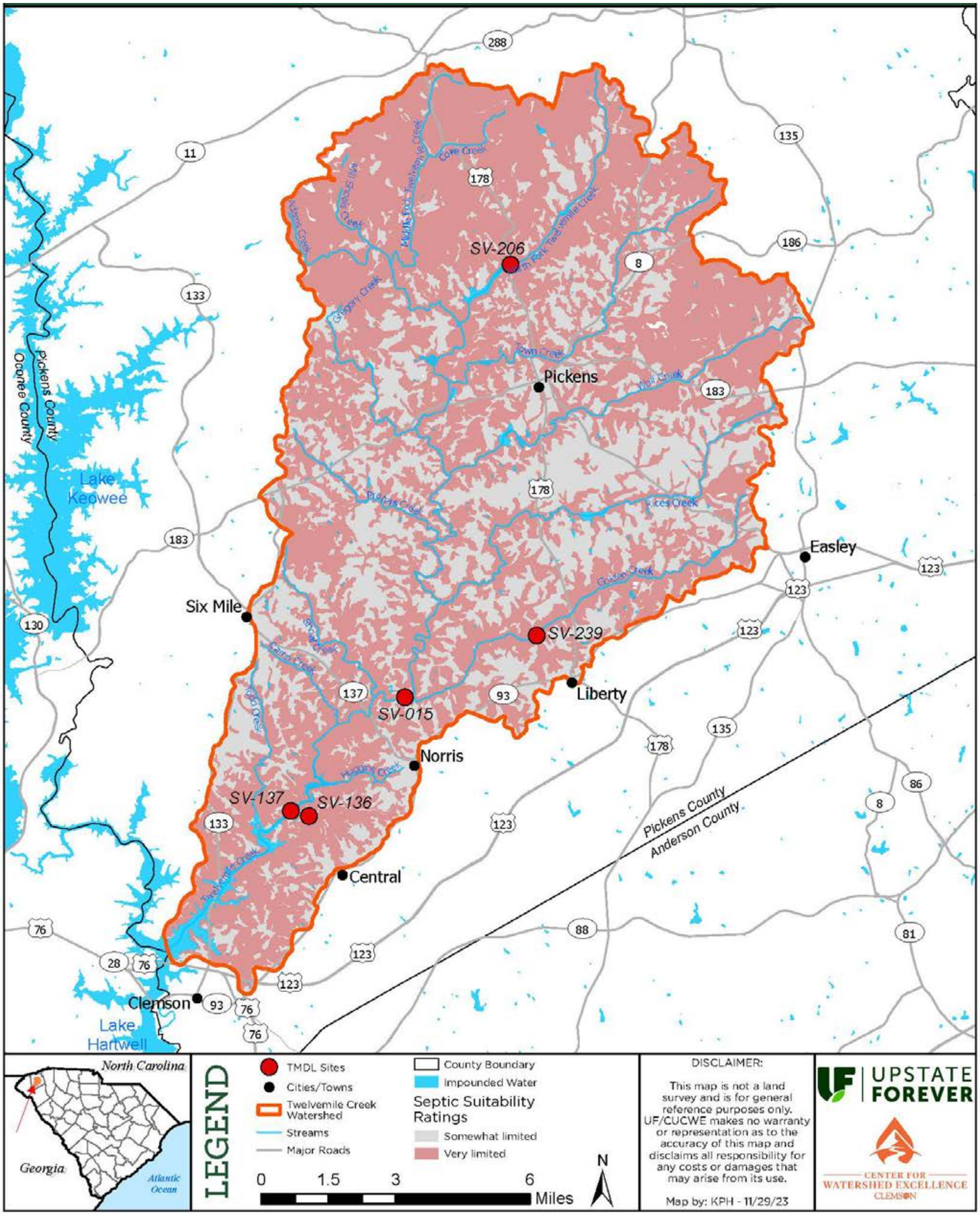


Fig. 29. Septic Suitability Ratings

4.3: LAND PRIORITIZATION FOR AGRICULTURAL BMPS

Agricultural practices can be major contributors of bacteria, sediment, and nutrient pollution. Livestock with access to streams can contribute bacteria directly into waterways through their fecal matter or indirectly by disturbing streambanks and causing erosion. Runoff from agricultural facilities or farms can also lead to increases in bacteria levels as well as other contaminants such as nutrients from fertilizers. Although agricultural land cover only accounts for 18% of the watershed, based on the STEPL model, agricultural practices account for 67% and 56% of current sediment and nutrient loading, respectively (Sections 3.2-3.3). To address bacteria, sediment, and nutrient inputs into the watershed, agricultural BMPs should focus on strategies such as restricting animal access to streams across the region, improving heavy use areas, providing alternative water sources, stabilizing streambanks, and adding riparian buffers (Section 5). Agricultural BMPs often require several components in combination with one another.

AGRICULTURAL BMP RESULTS

UF conducted an analysis to identify agricultural areas that may be contributing sources of bacteria, sediment, and nutrient pollution and prioritized areas that would be most impactful in reducing pollutants with the installation of agricultural BMPs. For a detailed overview of the criteria and scoring, please refer to Appendix F of the Three and Twenty Creek Watershed Based Plan. This analysis identified 343 parcels as high priority for agricultural BMPs, concentrated along streams in the middle section of the watershed (see Figure 30). Based on the results of the analysis, UF recommends focusing agricultural BMP installations specifically within the following four subwatersheds:

- Upper Twelvemile-Keowee River (0306010104-07)
- Wolf Creek (0306010104-04)
- Rices Creek (0306010104-05)
- Golden Creek (0306010104-06)

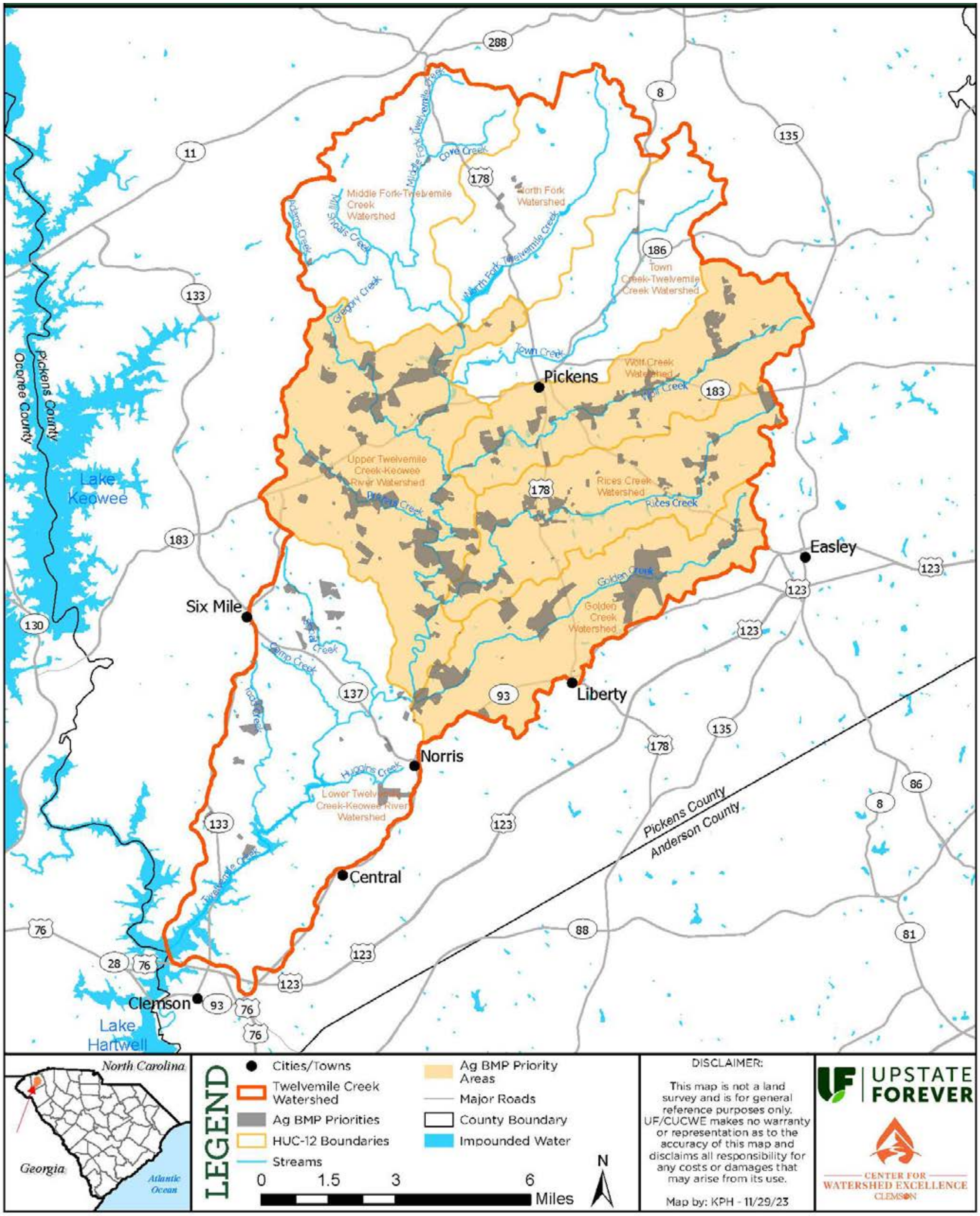


Fig. 30. Priority Areas for Agricultural BMPs

4.4: LAND PRIORITIZATION FOR LAND PROTECTION

Protecting lands that remain in good condition or may be currently providing significant benefits to water quality can help mitigate future impairments or loss of benefits. The goal of this analysis was to identify areas that, if developed, would have the biggest impact on water quality through prevention of pollution. While most water quality strategies focus on reduction of current pollutant loads, protecting high quality land and preventing loads from entering waterways can be just as effective in pollutant management, especially if land is prevented from development or another land use that causes higher rates of erosion, runoff, or removal of environmental benefits such as flood mitigation and riparian buffers. Currently, only 7.8% of land in the watershed is considered protected (*e.g.*, parks, heritage preserves, utility owned properties, conservation easements, etc.), with only 1.6% protected through parks and conservation easements. This is staggeringly low for a watershed with such high potential for agricultural land conversion.

Forested lands can play a critical role in watershed health. Forested subwatersheds naturally improve water quality and enhance water storage; regulate stream flows by uptake, slowing stormwater runoff, and increasing groundwater recharge; reduce flood damages as trees and their root systems stabilize soils and streambanks; reduce the likelihood of thermal impacts to waterways; and benefit the overall ecosystem and wildlife habitat area (USDA, 2023).

In the face of a changing climate, forested subwatersheds are a critical consideration in sustaining natural resources and making responsible decisions for community, economics, environmental quality, and overall quality of life. For these reasons, the USGS has created a "Slow the Flow" educational campaign to build climate resilience into watershed planning. These management strategies include the following:

- Restore stream complexity, adding natural features to tributaries (*i.e.*, logs);
- Increase sinuosity by restoring bends and meanders in our streams;
- Reconnect streams to their floodplains for natural attenuation, avoiding development within the floodplain;
- Reduce impervious surfaces and increase the volume of water filtering into groundwater.

This graphic can be found in Figure 31. These considerations should be part of an overall integrated wastewater and watershed planning framework, using the land protection analysis as a starting point for land and water protection.

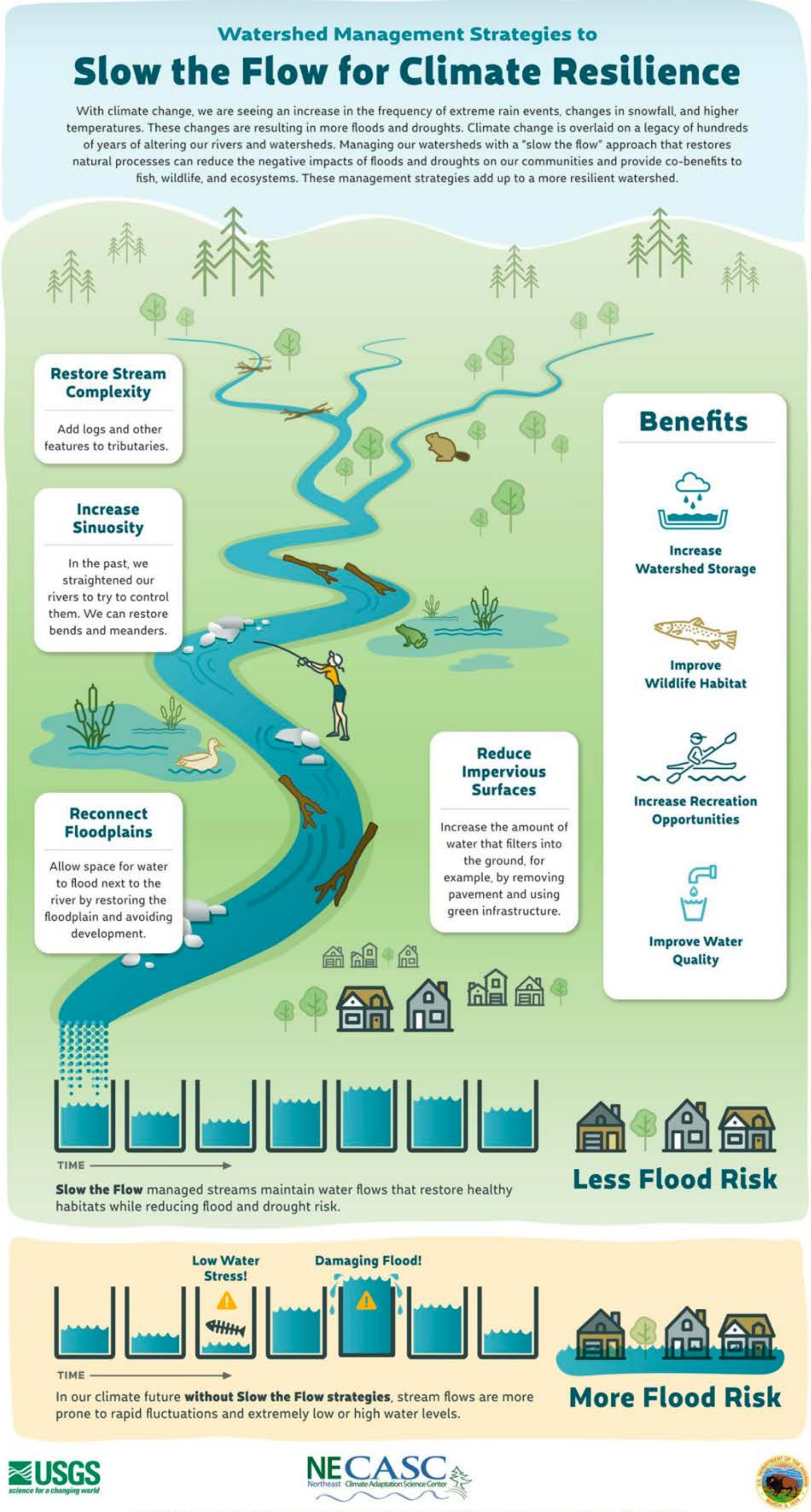


Fig. 31. Slow the Flow graphic created by USGS and partners to demonstrate practices that build watershed resiliency to the impacts of climate change. The graphic can also be viewed here.

LAND PROTECTION ANALYSIS RESULTS

UF conducted an analysis of land in the watershed that is not already protected to gauge what high-quality tracts of land would be most important to protect from development. For a detailed overview of the criteria and scoring, refer to Appendix F of the Three and Twenty Creek Watershed Based Plan. This analysis identified 129 parcels as high priority for land protection through methods such as conservation easements, concentrated along major streams throughout the watershed (see Figure 32). Based on the results of the analysis, UF recommends focusing outreach efforts to the 129 identified landowners and evaluating potential conservation easements for their benefit to water quality protection.

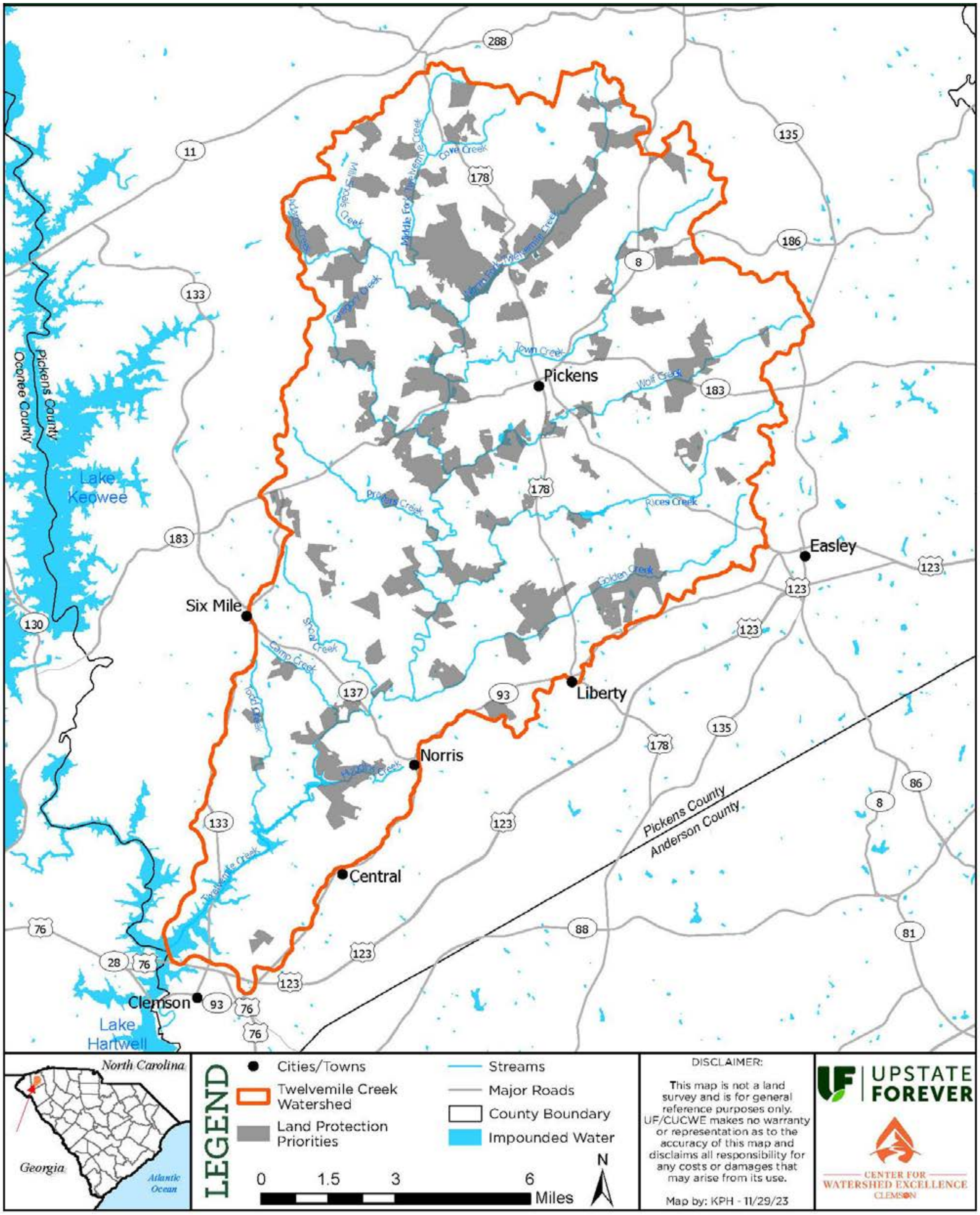


Fig. 32. Priority Areas for Land Protection

5.0 WATERSHED RESTORATION STRATEGIES

As much as possible, each prioritized restoration strategy outlined below should include public engagement and outreach components, weaving these changes into the fabric of community perspectives, polices, and expectations. Consistent language and signage should be utilized so that messages are repeated to the public for increased retention and understanding. Best education practices also listed in Section 6.0 are additional protective water quality measures for this watershed, when outreach and public engagement are implemented successfully and lead to long-term, documented protection of water quality.

The proceeding pages in this section will describe BMPs that have been demonstrated to reduce levels of bacteria, mitigate stormwater pollution, slow stormwater volumes, reduce erosion, and be protective of water quality. These include land protection, septic repairs, agricultural BMPs, rain gardens, bioretention cells, vegetated swales, vegetated riparian buffers, regenerative stormwater conveyance, parking lot retrofits, and the combination of solutions referred to as a treatment train. Regeneratative stormwater conveyance is an innovative method to convey and treat stormwater so that it is not erosive to the receiving waterbody. This best practice relies on a series of grade-control structures that "step" stormwater down into pools and riffles, then allow the stormwater to slowly infiltrate or cascade over a fixed structure to the next pool, effectively slowing flow and removing some stormwater volume. These solutions are described in more detail as each practice is recommended.

There are many locations across this 154-square mile watershed that would benefit from the recommended practices, beyond what was encountered during field work and at the time of the writing of this plan. Numerous school and corporate campuses exist in the watershed, for example, that could make use of these practices to better manage runoff and stormwater pollution, while engaging students and staff in education and participation. The recommended site improvements that follow were prioritized as these had ready support from landowners. However, with more time and communication, more locations implementing these practices would continue to improve water quality and the ecosystem of the Twelvemile Creek and tributaries, building a "new norm" for managing stormwater effectively across the watershed.

STRATEGY 1. RIPARIAN BUFFER ZONING ORDINANCE

At the time of this watershed plan's development, growth is occurring in Pickens County. A moratorium on development by the City of Clemson (now lifted) pushed development plans outside city limits, to Pickens and Oconee Counties. Growth in Easley, SC and annexation has occurred in 2023 and is expected to continue. Amongst all these land use conversions, important for decision-makers and based on this current and high-resolution land use change analysis, **no growth of residential land use has been observed in the 500-foot buffer around waterways of the Twelvemile Creek watershed within the ten-year time frame that was analyzed** (Figure 33)**.** At the same time, septic system suitability is largely very limited in this same buffer zone based on analysis, amplifying the need for greater conservation within the buffer zone.

Therefore, this is a prime opportunity for local leaders in the city and county to create permanent protection for the Twelvemile at little financial or political costs. Riparian buffers are natural ecotones along waterways that slow stormwater runoff, trap sediment and nutrients, provide extensive root systems that stabilize streambanks, and provide a natural corridor for wildlife. The latter of this list aligns also with values of many Pickens County residents who enjoy hunting and use harvested meat to feed their families. Protection of riparian corridors is not only protective of water quality, but can ensure resilience against flooding, mitigate drought through the increase in soil permeability, and ensure cooling through shading effects of shrubberies and trees (Climate Adapt, 2024).

Adjacent to Pickens County, Greenville County has conducted extensive analysis on a 100-foot riparian buffer zoning ordinance specific to the Reedy River, permitting averaging as a means to accommodate slopes, high water tables, and development plans. This zoning ordinance and the economic study that supports it are a model for the mainstem Twelvemile Creek, its riparian wetlands, and long-standing protection. Given the slopes of the Piedmont and thin area of Mountain ecoregion in the watershed, this model ordinance provides avenues for homeowners on smaller lots or slopes to seek a means to meet buffer requirements and develop in a way that is more protective of water quality. More information on this can be found at https://cleanreedy.org/riparian-buffer-zoning/. It is recommended that a riparian buffer zoning ordinance be passed to allow for 100 feet of buffer along the mainstem Twelvemile Creek, which at times is only slightly more than the creek's width, limiting activities within this buffer zone to utility easements and walking paths, but protecting the banks from further compaction, erosion, and stormwater runoff.

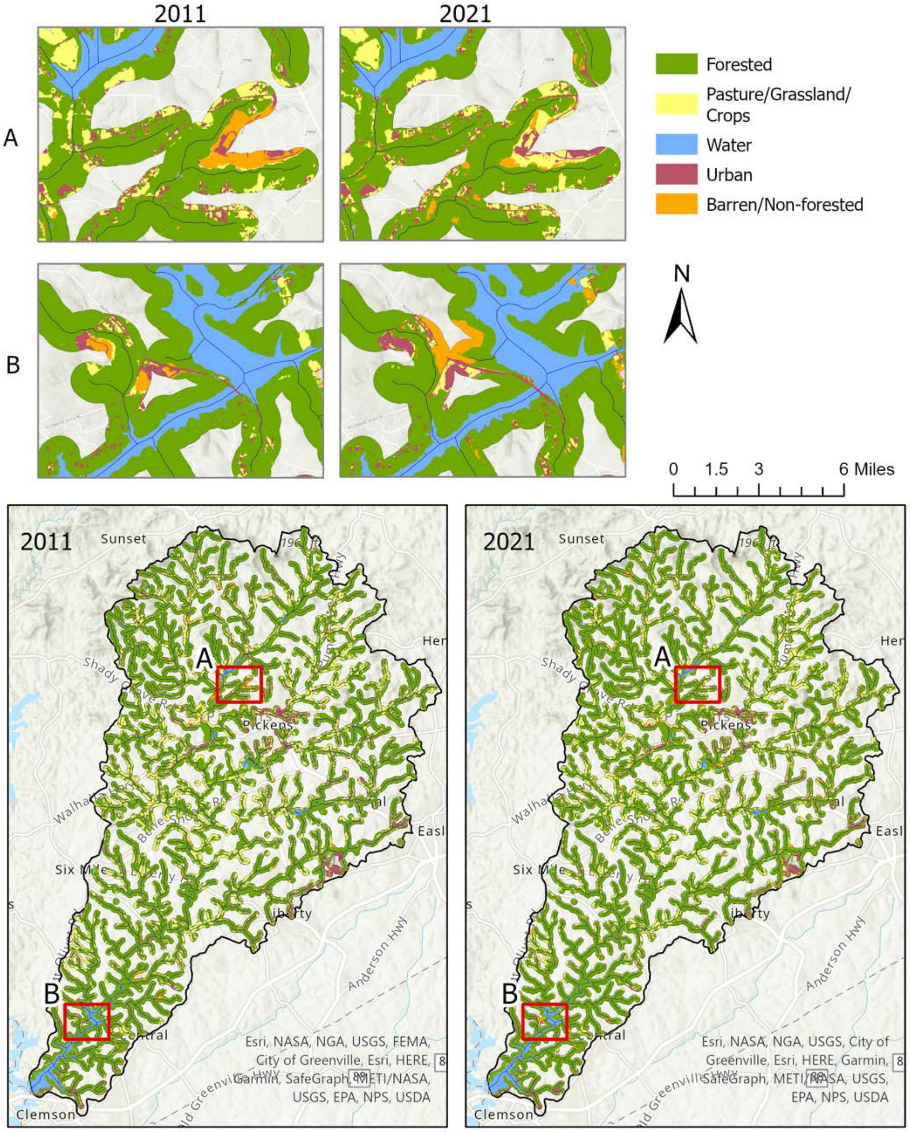


Fig. 33. The 500-foot buffer zone around Twelvemile Creek and its tributaries remained dominantly forested between 2011 and 2021. Urban growth has been limited to small-scale developments; Pickens High School (A) and a residential neighborhood and RC Edwards Middle School (B) are shown here.

Along all other tributaries to the Twelvemile Creek, it is recommended that the county and city consider riparian buffer zoning of a width of 50 feet of stream protection, again allowing for utility easements and walking trails, but minimizing impervious surfaces along the creeks. Within the MS4 boundary, the already mandatory construction buffer could be converted to permanent buffer post-construction with an additional 20 feet, with no cost to the person(s) purchasing the property. Currently per SCDHEC's Construction General Permit made into law in 2021, a 30-foot buffer is to be kept natural for the duration of construction activities, and 45-foot natural buffer is required for waterways classified by the state as Sensitive. Given the observed increases in bacteria during wet weather events and frequency of impairments at all monitoring sites, a 50-foot buffer would ensure that onsite wastewater treatment is also not designed within this buffer zone. On the mainstem Twelvemile Creek, with its wider stream width, a 100-foot buffer would be protective of the streambanks and manage nutrient and sediment runoff (Sections 3.2 and 3.3), both of which are contributing factors to the persistence of *E. Coli* found in this waterway. Both buffer widths will improve the chances that creeks will access their floodplain, preventing downstream scouring, erosion, and flooding, and building a more resilient watershed in extreme storm events (Figure 34).

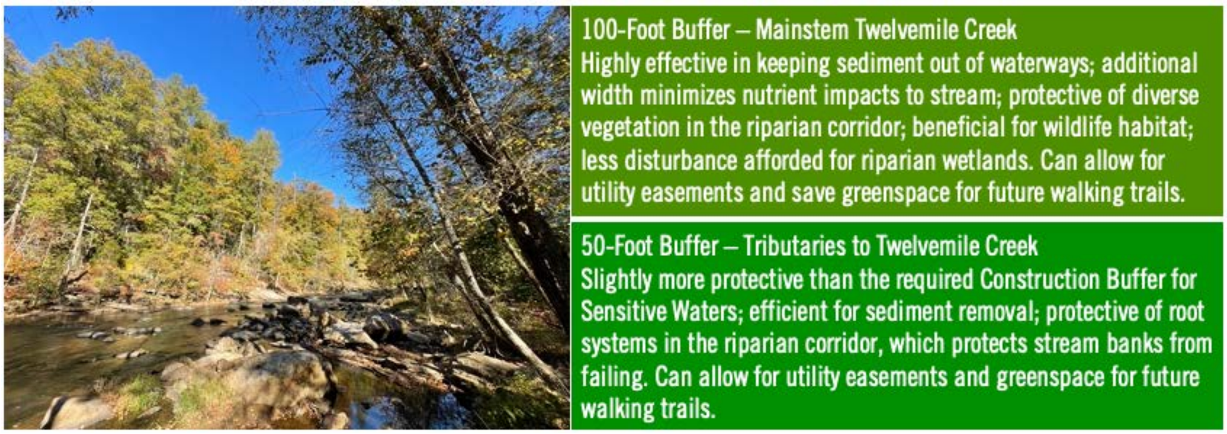


Fig. 34. Forested riparian buffers are an inexpensive means to proactively conserving stream bank health, protecting water quality, building biodiversity, and providing corridors for wildlife; width is a significant factor to consider in regard to level of protection provided and goals for this watershed.

STRATEGY 2. SEPTIC SYSTEM REPAIR AND REPLACE COST-SHARE PROGRAM

Based on the findings detailed in Section 4.2 the project team recommends focusing septic repairs upstream of TMDL site(s) SV-136/SV-137 to help achieve bacterial load reduction goals. The project team recommends implementing a septic system repair and replace program providing cost-share to homeowners as an incentive to repair or replace faulty systems or to tie into sewer services where available. In addition to providing cost-share opportunities to homeowners, it is imperative to implement an education strategy for proper septic maintenance, ensuring the longevity of this onsite wastewater treatment service once installed. Because this watershed is characterized by larger tracts of rural lands, there is a greater need for targeted outreach to farmers and other large landowners regarding older systems and cost share opportunities. There are many large churches with multiple buildings along creeks; outreach to churches should be a priority. Additionally, further prioritization of outreach to landowners could include those adjacent to streams, upstream of water quality monitoring stations, and north of the City of Pickens where higher concentrations of high priority areas are seen. Once funding for an incentivized septic program has been secured, it is recommended to partner with the aforementioned collaborating partners to send informational mailings to homeowners in the watershed advertising available funding. Homeowners who participate in the program should receive a post-installation packet that includes educational information on proper septic system maintenance practices.

In nearby watersheds of Upstate, SC, the average cost of a septic tank repair/replacement has been $6,400 in the Anderson/Pickens County area, $8,500 in the Pickens/Oconee County area, and $6,500 in the Spartanburg/Greenville County area. Higher costs have been associated with mountainous, lakeside homes with difficult-to-access septic systems as well as availability of contractors. Based on this data, it is estimated that the cost of septic system repairs in the Twelvemile watershed will be close to $6,500-$7,000 per system.

Fig. 35. Examples of septic repair work in the Three and Twenty Creek watershed, which neighbors the Twelvemile River watershed. (photo provided by Upstate Forever).

STRATEGY 3. LAND PROTECTION

While other strategies such as deed restrictions, fee simple purchases, and land donations are beneficial forms of land protection, it is recommended to focus specifically on land protection through conservation easements. A conservation easement is a voluntary contract between a landowner and a qualified land trust, which allows the landowner to legally restrict certain land uses from occurring on their property in perpetuity. These agreements are permanent and remain with the land even after it has been sold or willed to heirs. The terms of a conservation agreement are individually negotiated and vary greatly depending on the landowner's plans for their property.

The cost of placing land under a conservation easement can sizeable and sometimes prohibitive to landowners. Many landowners have a deep history with their lands and possess a strong desire to protect them through conservation easements, but often lack the financial resources to do so. Based on information obtained from UF's land trust, it is estimated that it can cost upwards of $23,250 per acre to place a conservation easement on a property. Finding cost-share programs and grant funding for landowners is an essential part of land conservation as it allows landowners to protect their lands without prohibitive costs. Benefits to landowners of placing land under a conservation easement include federal tax deductions, state tax credit, estate tax benefits, as well as incentives from other funding sources to cover the cost of placing land under easement. Funding sources such as SCDHEC 319(h) grant program, the South Carolina Conservation Bank (SCCB) and Anderson Watershed Protection Council, all mutually prioritize properties with matching funding sources to leverage against one another.

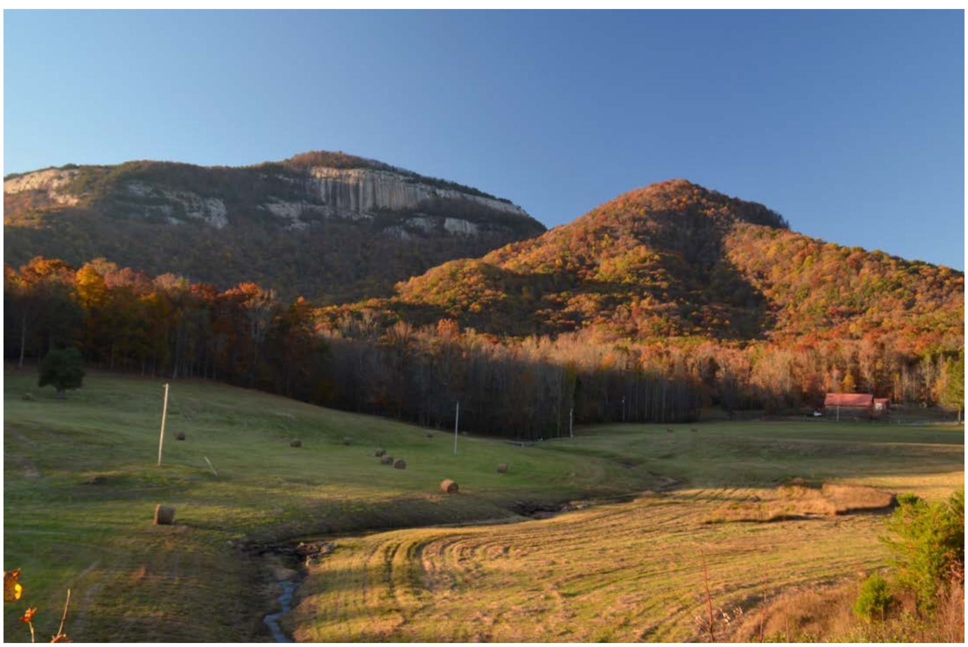


Fig. 36. A partnership between Upstate Forever and the landowners, as well as a grant from the South Carolina Conservation Bank, made the conservation of Grant Meadow in Pickens County possible. The scenic vista is one of the most photographed spots in South Carolina and is in the Twelvemile Creek watershed (photo provided by Upstate Forever).

STRATEGY 4. AGRICULTURAL BMPS AND AGRITOURISM DISTRICT

TRADITIONAL AGRICULTURAL BMPS

Agricultural land is concentrated throughout the middle portion of the watershed, primarily along major tributaries. Although agricultural land only covers 18% of the watershed, agricultural practices account for 67% and 56% of current sediment and nutrient loading, respectively (Sections 3.2-3.3). Based on windshield surveyance, results from microbial source tracking, and land cover, it is not estimated that agricultural practices are a major contributor to bacterial impairments but could play a significant role in longstanding sediment concerns.

Examples of agricultural BMPs include the following: fencing livestock out of streams, improving heavy use areas, stabilizing streambanks, providing alternative watering sources, armored streambank crossings, cross-fencing, farm road access, road drainage and ditch maintenance, and adding riparian buffers. Oftentimes, agricultural BMPs are installed in combination with one another. An example of this is fencing cattle out of streams on a property and providing an alternative watering source, such as a well. Unit costs for agricultural BMPs are listed in Table 15 and based on information provided by the USDA (SC EQIP, 2023).

Tab. 15. Agricultural BMP Unit Costs (SC EQIP, 2023)

BMP	EQIP Code	Estimated Cost Per Unit
Linear Streambank Fencing	382	$2.46/ft
Water Well	642	$5,546.21 each
Linear Pipeline	516	$31.41/lb
Alternative Watering Sources	614	$940.33 each
Heavy Use Area Protection	561	$2.57/sq ft
Riparian Forest or Grass Buffer	390	$476.85/acre
Filter Strip	393	$205.51/acre
Streambank Stabilization	580	$52.55/ft
Stabilizing Farm Access Roads	560	$13.51/ft
Stream Crossing	578	$7.96/sq ft
Conservation Cover	327	$177.41/acre
Cover Crop	340	$61.79/acre
No-Till Drill*	n/a	$6,000-$9,000

*Price based on market value, not included in EQIP cost sheet

NO-TILL SEED DRILL

No-till drills are a way of planting seed without tilling an entire field, where a heavy drill cuts through the cover, and a disc widens the planting zone, just before seed is placed. No-till drills reduce erosion and loss of soil nutrients, greatly benefiting soil health and adjacent waterways.

Currently, one no-till seed drill exists in the watershed for loan; at the end of the harvesting season, when producers are looking to install conservation cover/cover crops, there is more demand than can be met with one drill. The addition of another no-till seed drill will benefit farmers and the watershed, increasing conservation cover/cover crop usage and modifying agricultural practices in this basin. Change happens slowly, but perhaps with the influence of more equipment and increased conversations about the benefits of conservation cover/cover crops, this will become a new "norm" for this watershed and beyond. Furthermore, the no-till seed drill can be used to replant riparian corridors, clay soils, and flood-prone lands, enriching soil with legumes and winter rye that will benefit soil health and denitrification. Healthy soils provide better growing conditions for plants, protecting lands from soil loss, improving groundwater infiltration, and rebuilding healthy soil profiles, and are a key component of maintaining a healthy watershed.

STABILIZING FARM ACCESS ROADS

Long drives to barns, pastures, and fields are typically prone to heavy use and large equipment and can be areas of soil loss and erosion transported by wind as dust or by rain as stormwater runoff. It is recommended that funds be used for heavy use area protection. These practices may include stabilizing private and public dirt drives and providing areas of stormwater treatment (for example, linear rain gardens, regenerative stormwater conveyance, vegetated ditches) to better manage this source of sediment to nearby wetlands and waterways. This work may require grading, installation of ditch check dams, stabilization, crushed concrete (as a low budget road material), and stormwater runoff capture and treat areas.

ROAD DRAINAGE AND DITCH MAINTENANCE

Roadside ditches act to protect the integrity of a road by moving water away; a properly maintained ditch can reduce turbidity of water runoff, reduce sedimentation/erosion, and filter pollutants before it reaches creeks/streams. Correcting sediment buildup, unblocking culverts, replacing damaged culverts, and adding in erosion control measures such as rocks, riprap, or plantings can ensure proper function of water runoff (Regents of the University of Minnesota, 2014).

STREAMBANK FENCING

Installing fences limits livestock access to waterways. This practice ensures that manure is not deposited directly into streams or ponds, protects riparian vegetation, and reduces erosion along streambanks,

ALTERNATIVE WATERING SOURCES/WATER WELLS AND LINEAR PIPELINE

Streams and ponds in pastures are often used as the primary watering source for livestock. If fences restrict livestock access to water, an alternative watering source will be needed. Alternative watering sources support removal of livestock from waterways, therefore reducing manure deposited directly into streams. Linear pipelines may be necessary to transport water from the well to the alternative watering sources.

HEAVY USE AREA PROTECTION

Installing durable material (*e.g*., crush and run gravel) can reduce erosion and pollutant loading of stormwater runoff, especially around areas of heavy use such as an alternative watering source. This can be utilized as an alternative to maintaining vegetation.

RIPARIAN FOREST OR GRASS BUFFERS/FILTER STRIPS

Riparian buffers are vegetated areas along waterways that stabilize soil, filter runoff, and provide wildlife habitat. In an agricultural setting, they can function to filter runoff from farms that could include manure, sediment, fertilizers, or pesticides. Similarly, filter strips are typically located on croplands adjacent to waterways and are usually made up of native grasses, legumes, and/or flowers; they provide filtration of sediment, nutrients, and other contaminants.

ARMORED STREAMBANK CROSSINGS/CULVERT CROSSINGS

When stream crossings are necessary to move livestock from one area to another, armored crossings can provide additional support to areas around streams that are prone to erosion.

CONSERVATION COVER/COVER CROPS

Conservation cover is a permanent protective vegetative cover of plants on lands that will not be used for forage production; it can reduce soil erosion and sedimentation and improve water quality (NRCS, 2022). Similarly, cover crops are plantings of grasses, legumes, and forbs on lands that will be utilized for future crop production. Benefits include erosion control, suppressing weeds, reduction of soil compaction, increasing moisture and nutrient content of soil, improving yield potential, and more.

CONSERVATION TILLAGE

Conservation Tillage is a practice that manages the amount, orientation, and distribution of crop and other plant residue on the soil surface over the course of the year while limiting soil-disturbing activities in fields used for crop production. By leaving the crop residue, sheet, rill, and wind erosion are decreased, and soil health is improved.

STREAMBANK STABILIZATION

Streambank Stabilization is the act of minimizing erosion of streambanks and channels, fortifying streambanks to prevent them from failing into the waterway or otherwise modifying or redirecting the flow that is impacting the streambank. This best practice may also include livestock crossings or livestock fencing with the objective of minimizing in-stream and streambank erosion.

STREAMBANK PROTECTION

Streambank protection includes the practices outlined in streambank strabilization but does not include fencing. Streambank protection does include vegetated buffers and top-of-bank plantings that strengthen the streambank over time and reduce streambank failure.

CRITICAL AREA PLANTING

The planting of grasses, legumes, or other vegetation to stabilize slopes or other areas susceptible to erosion. These plantings are permanent vegetation that are most helpful in areas such as gullies, over-grazed hillsides, and terraced backslopes. (SCDHEC, 2023).

AGRITOURISM DISTRICT

The mid-section of the Twelvemile Creek watershed includes idyllic rolling green pastures, plentiful, natural streams, and views of the mountains. The area is dominated by small farms with livestock and horses, country roads, and quaint country life. This area includes some of the prettiest drives in Pickens County, with additional views of the mountains including Glassy Mountain and Table Rock.

Additionally, areas in the mid to northern portion of this watershed have been designated as “food deserts” (Figure 37), where the population in such areas have limited access to a variety of healthy and affordable food supplies.

There is room for innovation and entrepreneurial thinking in this region to better protect resources, promote family farms, and address the lack of local food distribution and resilient food systems in this current economy. With the engaged and supportive voices of the residents of this area, this region or portions of this region would benefit from a Rural Residential Zoning designated area, which would limit the density of structures, maintain wooded roadsides, provide natural protection for waterways with the aforementioned riparian buffer zoning, and long-term protect water quality and wildlife habitat. The zoning could be made voluntary, and work with the residents to craft this protective zoning with a focus on also protecting farmland. Seed funding from the US Department of Agriculture and other resources could supply the area with building agribusiness opportunities. Further investigation is needed to identify specialty crops and food production in the area, develop resilient food systems (for example, Farm to School programs) that address food desert concerns, and capture cultural farming values that resonate with the area’s residents and resources, providing for the continuation of agricultural values for the next generation. Programs exist to build resilience and community health through startup funds for food cooperatives, agritourism funding, diversity and equity in agriculture, careers in agriculture, and more, that would feed this area in terms food production, employment, and economic growth.

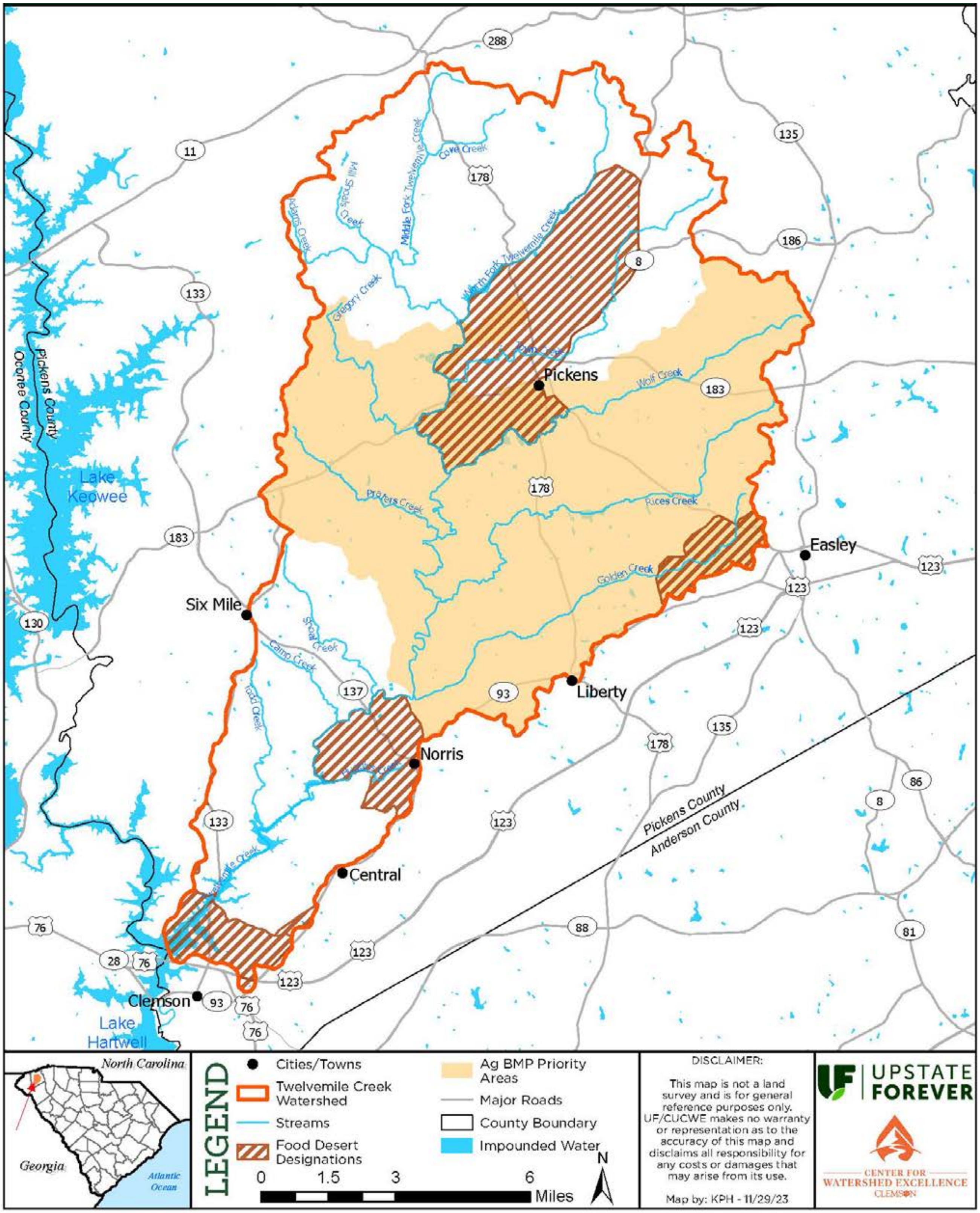


Fig. 37. Food Desert Designations in the Twelvemile Creek Watershed (USDA) overlaid with Agricultural Best Management Practice Priority Areas.

STRATEGY 5. WETLAND RESTORATION

Wetlands provide many natural ecosystem services such as water filtration, acting as pollutant sinks, wildlife habitat, erosion control, and flood management. Wetlands have also demonstrated their ability to store carbon, a critical task to reduce climate change impacts. Wetlands naturally capture sediment. In this watershed, where sediment is believed to be such a significant contributor to *E. coli* survival, overwintering, and sustenance, addressing sediment-full wetlands is a critical water quality improvement project. It is already known that wetlands in agricultural landscapes have shorter topographical lives than wetlands in grasslands. In the most severe cases, anthropogenic activities expedite sediment inputs to wetlands, and this capturing of nutrient-laden sediment can instead become a source of pollution to waterways (Gleason and Euliss, 1998).

Wetlands that have been impacted or inundated are likely no longer providing the myriad of important ecological and water quality benefits that are possible. Restoring impacted, low quality, and inundated wetlands is ecologically beneficial and can reduce the costs of water treatment, flood management, and pollution control by providing these services naturally. With urban lands accounting for nearly 19% of land coverage in this watershed and development in Pickens County estimated to consume over 79,000 acres by the year 2040 (City Explained, 2017; Urban 3, 2017), wetland restoration and mitigation strategies could help decrease higher volumes of runoff and sedimentation occurring from increased development activities.

Factors that can measure the difference between high functioning wetlands and impacted wetlands include the following:

- Ratio of vegetated areas to open water,
- Number of plant species (or the diversity of plant species),
- Biomass (production of plant material per unit area),
- Amount of organic matter in soil,
- Range of water-level fluctuation,
- Sedimentation rate.

These factors, previously identified by Turner and Swenson (1994) can be used to design a protocol specific for SC Piedmont wetland characterization that would help prioritize restoration funds.

WETLAND MITIGATION BANKING

According to NRCS, wetland mitigation banking is the "restoration, creation or enhancement of wetlands for the purpose of compensating for unavoidable impacts to wetlands at another location," commonly utilized by developers to offset wetland impacts. In the Twelvemile Creek watershed there are 3,250 acres of wetlands, 566 (17%) of which are classified as modified (beaver, partially drained/ditched, farmed, diked/impounded, managed, or excavated), further classified in Table 16. Although the NLCD data classifies only 423.9 acres of land as wetlands (Table 1 and Figure 3), more exist on lands classified as forest, open water, grasslands, and pasture/hay.

Tab. 16. Wetlands in the Twelvemile Creek Watershed

Wetland Type	Acreage	Modified	Percentage Modified
Freshwater Emergent Wetland	248.1	169.7	68.4%
Freshwater Forested/Shrub Wetland	1,025.1	127.2	12.4%
Freshwater Pond	304.1	all	100%
Lake	918.7	all	100%
Riverine	753.6	all	100%
	3,249.6		

With 23% of freshwater emergent and freshwater forested/shrub wetlands classified as modified, utilizing wetland mitigation strategies in partnership with upstream developers could include restoration or enhancement of degraded wetlands.

CONSTRUCTED/ARTIFICIAL WETLANDS

Constructed, or artificial wetlands are those manually installed where wetland functions can be created to provide treatment of wastewater, stormwater runoff, or other waterflows. are artificial ecosystems with hydrophytic vegetation for the biological treatment of water (NRCS, 2022). These can be especially helpful in an agricultural setting or in areas with high volume of stormwater runoff.

WETLAND PRESERVATION & BUFFER ESTABLISHMENT

Preserving high quality existing wetlands through conservation easements or establishment/ preservation of buffer zones are strategies to utilize in unmodified/high-quality wetland areas. Critical area plantings (permanent vegetation) are utilized in areas of high erosion rates and can reduce erosion and stabilize streambanks, shorelines, and slopes. The upper reaches of the watershed are classified by high slopes and mountainous landscapes and are especially prone to sedimentation and would benefit from critical area plantings and riparian buffer protection/establishment. Finding high-quality wetlands in the upper reaches of the watershed could serve as significantly beneficial mitigation projects utilizing land protection strategies or establishing buffer zones around prone waterways (Figure 38).

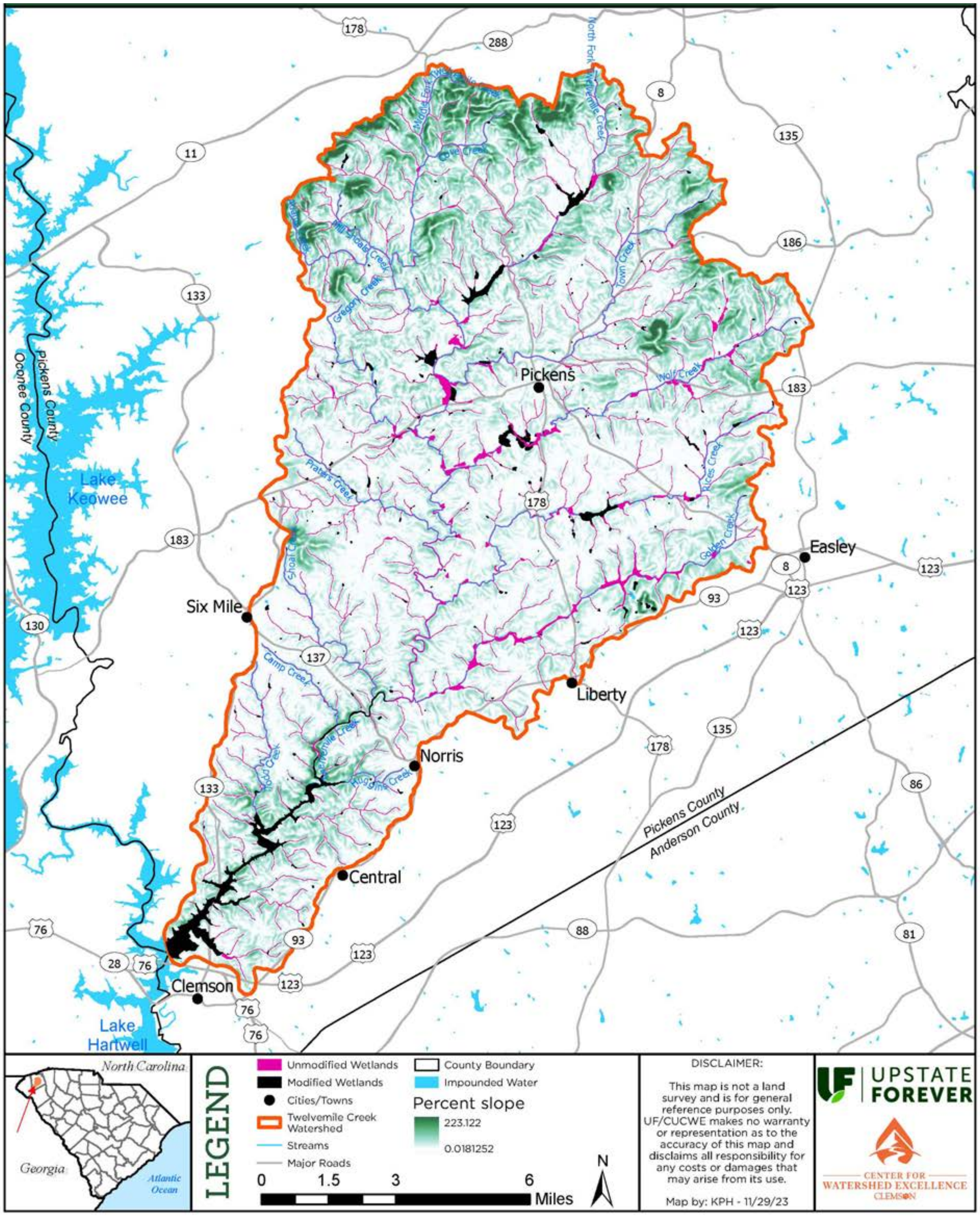


Fig. 38. Wetlands are found throughout the watershed. Protecting the high-quality wetlands that are not inundated with sediment, and improving the wetlands that are, both are strategies that will benefit sediment, nutrient, and E. coli issues of the watershed.

STRATEGY 6. JAYCEE PARK GREEN INFRASTRUCTURE PROJECT

Jaycee Park, located at 149 North Homestead Road and 238 West Jones Avenue, is an extensive 23-acre park behind downtown Pickens and a popular spot for little league games and biking enthusiasts. It lies on both sides of Town Creek; facilities include two picnic shelters, restrooms, a covered bridge (known as Collins Bridge), two ball fields, two lighted baseball fields, two lighted tennis courts, playground, a lighted football field with grandstands and pressbox, and two paved parking lots. The Town Creek Trail joins Jaycee Park to the Pickens Recreation Center and its fields, as well as to the adjacent BMX bike park.

At the time of the writing of this plan, the park is undergoing a redesign process with a private contractor hired by the City of Pickens. During field work with staff from the City of Pickens, several locations were identified where BMPs would result in meaningful water quality improvements in Town Creek; these are noted below. Since the park is undergoing renovation, there is potential to add to these projects identified below and apply these same concepts to all areas undergoing renovation, as well as address stream restoration. Field reconnaissance could not include all stream restoration needs in this area, knowing that it is best to initiate stream improvements once upstream problems such as overland stormwater volumes are mitigated.

W. JONES AVENUE BIOSWALE

This area of the park includes city staff access roads, a small recreation building, and bleachers at the baseball field. Behind the baseball field is a wide riparian buffer, dominated by invasive bamboo, along Town Creek. From the road to the top of the baseball field, the site is graded to direct runoff to a low area parallel to the fence line. At times of heavy rain, this area must be more inconvenience than flood storage, providing mosquitoes a place to lay eggs and hatch.

It is proposed that this low-lying area be converted into a bioswale as shown in Figure 39. A bioswale is typically a vegetated channel used in place of a ditch to slow stormwater runoff and encourage infiltration and pollutant uptake. Installation of a bioswale at this location would result in less area to mow, increased ground water recharge, sediment trapping, nutrient uptake, and overall beautification and biodiversity. This is a very popular location for little league games and an ideal spot within this park for educational signage on stormwater, bioswales, and native plants.

JAYCEE PARK – STORMWATER TREATMENT OPPORTUNITIES

Fig. 39. The creation of a bioswale in this already pooling, low-lying area would provide beautification, stormwater treatment, and be an ideal location for education. Photo credits: Clemson Extension Carolina Clear Rain Garden illustration (top left), bioretention basin photo from Western Pennsylvania Conservancy (right), low-lying area at Jaycee Park (bottom left).

WEST JONES AVENUE PARKING LOT RETROFITS

This main, large parking area provides parking for this very popular little league park. In the years since this parking lot was built, stormwater volumes have become too overwhelming for the existing stormwater drainage, as evidenced by the observed stormwater grate in the lower area of the lot. To address this clogged and under-sized drainage, upon inspection, it appears that a PVC hose was installed from grate to a trench off of the parking lot that directs stormwater volumes directly to a small tributary to Town Creek. The problem is presented in Figure 40.

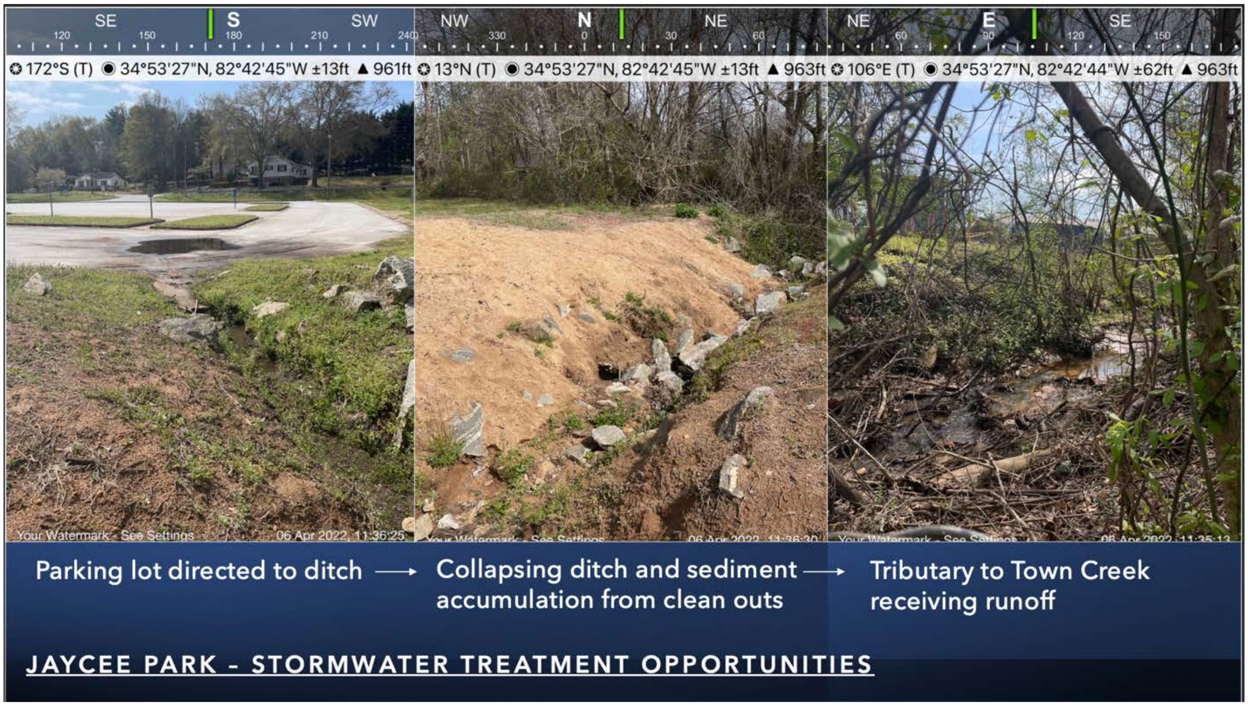


Fig. 40. Captured stormwater runoff and trench to Town Creek tributary, with stockpiled sediment from trench maintenance that increases sediment deposition to the stream without treatment.

The amount of sediment being captured in this parking lot and manmade ditch presents the need for an improved natural engineering solution. By capturing and treating runoff at more locations in the green spaces around the parking lot, a treatment train of BMPs can better protect the stream than a single capture point (currently parking lot to drainage ditch). The parking lot would also be beautified in the process, using innovation to add beautification and biodiversity through use of curbless, planted parking lot islands that would slow traffic and capture and treat runoff. With engineering model results that take into account the full watershed drainage to this parking lot, a determination of the use of porous asphalt options cold be identified. These suggested solutions are in Figure 41. In addition to those presented, a pollinator garden between parking lot and Town Creek would extend the treatment area, allowing greater green space for infiltration, and add biodiversity to this riparian corridor in a very visible path towards the covered bridge. Educational signage can provide information on native plants, pollinators, and stormwater treatment for visitors.

Fig. 41. Overview of large parking area's opportunities for stormwater treatment and retention (top left); street view of existing parking area (top right);example of porous asphalt use in a parking lot with center drainage and no curbs (bottom right); example of curbless planted parking lot median with drainage from Pennsylvania State University Sea Grant (bottom middle); example of bioretention treatment area with curb cut from RK&K (bottom left)

STREAMBANK RESTORATION OF TOWN CREEK TRIBUTARY

Stream restoration includes a series of techniques and structures to restore a stream to its more natural and healthy state. Further east in Jaycee Park, moving towards Ann Street, there are opportunities to improve stream function, storage, ecology, and mitigate the threat of pathogens. A county-owned facility at the corner of Ann Street and West Jones Avenue has gutters that capture runoff from the roof and pipe the stormwater runoff from each gutter to the same tributary that downstream (Figure 41), collects the trenched stormwater runoff from the West Jones parking lot (shown in the right-most image of Figure. 39).

In addition, the banks of the tributary have been covered by rip rap on both sides (right side, Figure 42). Based on observations at this park, increasing stormwater volumes must have been threatening the county-owned parking lot and equipment adjacent to the tributary. An incising stream would otherwise wear away at the banks and make that bank more vulnerable to collapsing, especially under adjacent heavy pressure and traffic.

JAYCEE PARK - STREAM RESTORATION

Fig. 42. Disconnecting impervious surfaces from direct discharge to waterways is a critical stormwater pollution prevention strategy. Within these tight quarters shown in the top left image, a solution may be found to do just that as part of a larger park renovation and stream restoration plan. Restoring the tributary to a more natural state will also benefit pollutant attenuation, in comparison to the existing armoring at the tributary.

Retrofits at the West Jones Avenue parking lot would slow down and infiltrate some of the overwhelming stormwater volumes. Additionally, some parking area would have to be lost to mitigate high flow volumes as this catchment area increasingly grows in land cover high in imperviousness.

It is recommended that rip rap be removed, and the tributary be restored to its natural functional state. With an engineering study, more information on improving this creek to its natural state will be revealed and may include grading, rock placement, installation of a vegetated buffer, as well as changes in surrounding land uses and proximity of impervious surfaces to the creek. Additionally, opportunities to disconnect neighboring rooftop runoff from the receiving water should be included in this creek's restoration plan. A treatment area exists above the piped tributary that captures runoff below the sidewalk and from roadways (as it enters the parking lot). This greenspace could instead be used as a native azalea demonstration area, leaving the area green, minimizing maintenance and compaction, and buffer the tributary. The City of Pickens is home to the long-standing azalea festival, and such a demonstration project would be an additional improvement to this park space that would increase interest and slow and infiltrate stormwater runoff.

RELOCATION OF RESTROOM FACILITIES

On the north side of Town Creek in Jaycee Park is the bathroom facilities, lying close to Town Creek. Upon GIS analysis, these facilities lie in the 100-year regulated flood zone (Zone AE) with 1% annual chance of flooding. The location coupled with age of the building raise concerns for the potential of sewer leaks, as well as inflow and infiltration, also known as "I&I" to the wastewater treatment industry. I&I is a term that describes additional flows beyond wastewater that occur from infiltrating groundwater and inflow from storm-generated infiltration to wastewater effluent lines through degrading and defective junctures in the pipe network. While some I&I is expected, excessive volumes can lead to sewer service overflows, which impact water quality, and increase costs to transport and treat incoming effluent.

Locations that are outside of the 100-year floodplain include uphill areas of the park near North Homestead Road, as well as behind the city-owned building near Patrick Lane in the southwest area of the park.

This project adds to the major upgrades and improvements being recommended for Jaycee Park that will benefit water quality, environmental education, and overall environmental health. The project team hopes that these recommendations are well-timed with planned park improvements.

FROM DITCHES TO BIOSWALES

Additionally on the north side of the park between ballfield and picnic facilities is a series of ditches collecting runoff from above North Homestead Avenue, the street itself, and the park. These are grassy swales that in some areas are rilling and obviously contributing to sediment in Town Creek, based on field inspection. Each of these collection points (Figure 43) could be modified to improve stormwater treatment and groundwater recharge in a treatment train of BMPs.

Fig. 43. Treatment train solution to stormwater runoff collection, ultimately reducing stormwater pollution in Town Creek.

These steps include:

a. Re-grade bowl to take advantage of slope for a rain garden. A rain garden, sometimes called an infiltration basin or swale, is a depressed and typically vegetated area that captures runoff, slows it down, and encourages infiltration and pollutant trapping and uptake. It is designed to be in the natural grade of where the runoff starts and its endpoint. The following will be required: replace soils, structure a natural outlet, and install native vegetation in this sunny location. Relocate the park sign towards telephone poles to make room for consistent educational signage at this park.

b. Widen entrance of ditch to better receive stormwater runoff. Replace soils to increase organic content and porosity and install native vegetation.
c. Below pipe, gently widen ditch to collect and treat park area runoff. Create a series of gentle step pools for sediment containment and easy maintenance. Plant low grasses and native herbaceous materials to slow and treat runoff, but not obstruct the view. Check dams placed along the swale can mimic a berm that will allow users to cross easily and help deter trampling of installed native vegetation.
d. Outfall has collapsed because the bank has eroded back. Below the outfall is some eroding of streambank and creek bottom. This area of stream has great potential for stream restoration solutions, if and when the source of issues upstream is resolved.

"MINI TOWN CREEK PARK"

The northwest side of Jaycee Park is closed for major playground renovation as of November 2023 and the writing of this plan. This area includes ample treatment area below the playground area to capture stormwater, install a rain garden system, and create an environmentally focused playground area specifically tailored to children. If engineered and built, this large demonstration rain garden will capture playground and tennis court runoff, and is in full sun, offering many options for native plant success. The project should include sensory play with plants, ecosystem accessories such as toad homes, and natural features such as a small boardwalk, timber logs for balancing play, and a mini covered bridge to push trucks and cars through that mimics the older covered bridge on site. This "Mini Town Creek Park" play area would be a place to engage families and youth in developing a sense of place in the Town Creek watershed. Current conditions are shown in Figure 44 and are a high priority upgrade for the City of Pickens.

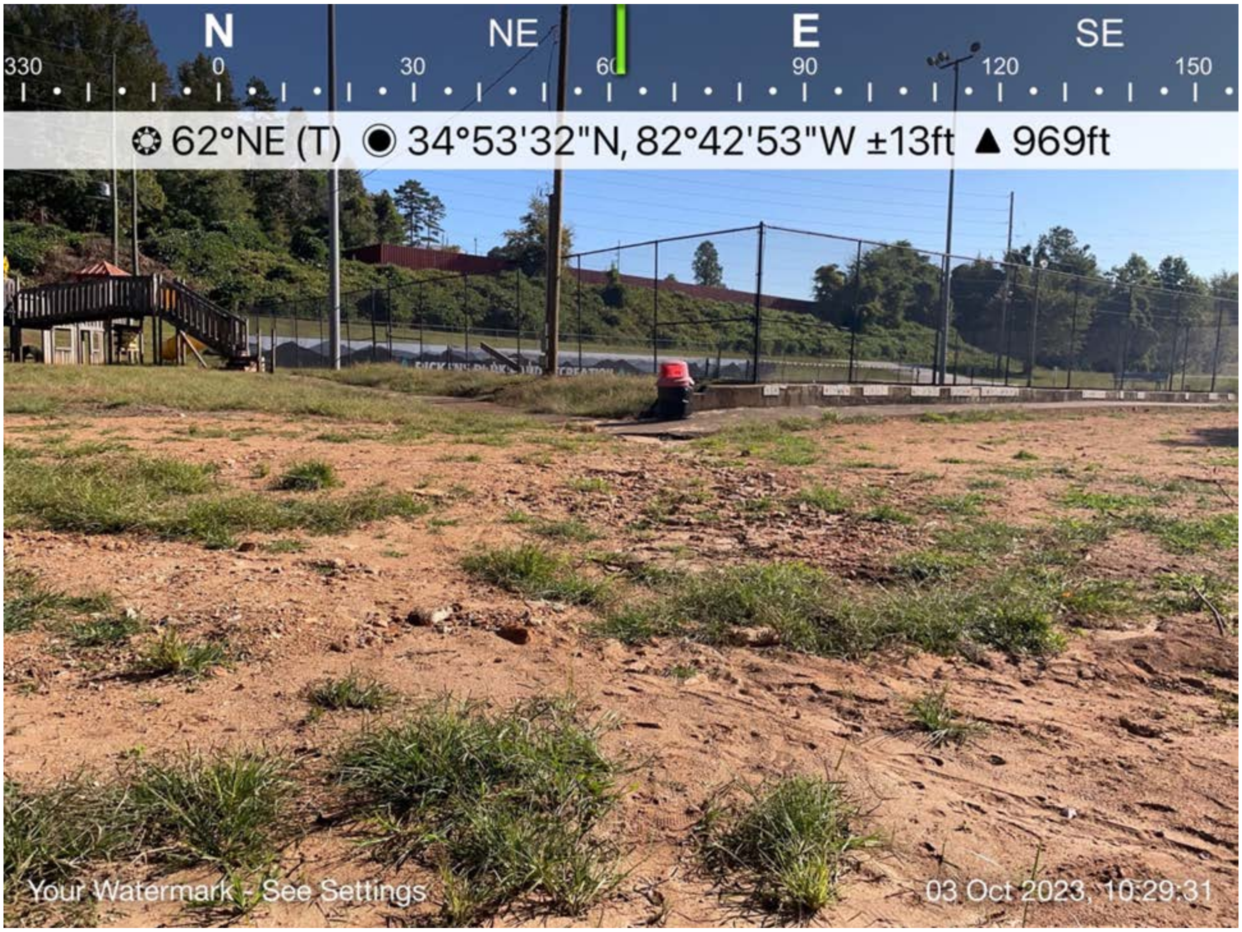


Fig. 44. Current status of closed playground area and ongoing erosion. A rain garden installed between here and trail would capture and slow runoff and be a fitting location for an environmentally focused playground tailored for youth that engages them in nature and a sense of place.

STRATEGY 7. CATEECHEE POINT PARK RAIN GARDENS AND XERISCAPING

Cateechee Point Park was built in 2018 and is one of Pickens County's newest parks. The park boasts opportunities for increased connection with Twelvemile Creek and entry points for kayaks and canoes, as well as passive recreation, including bird watching. The observation deck offers a beautiful, natural view of a rocky bend of river. Improvements at this location will have an immediate benefit to water quality of the Twelvemile.

GREEN INFRASTRUCTURE AND STORMWATER TREATMENT

Ample opportunities exist to capture and treat stormwater runoff in a treatment train of solutions at this park; existing conditions and visual references are in Figure 45.

1. **Rip Rap to Rain Garden:** Road runoff is currently captured in a swale leading to the rip rap area shown in Figure 44, installed to reduce soil erosion on this hillside. The area already has the beginnings of a bowl-shape, which is advantageous for a future rain garden site. Re-engineering this area to store and treat stormwater runoff would require:
    a. Remove rip rap and any existing geotextile;
    b. Deeply amend soils to improve storage, infiltration, and organic matter;
    c. Install native, low maintenance vegetation that will stabilize the area and treat stormwater runoff;
    d. Install signage consistent with other rain garden outreach in the area to continue impressing upon residents the impacts of stormwater pollution and rain gardens as a solution that would benefit water quality and biodiversity watershed-wide.

2. **Riverside Linear Rain Garden (Bioretention):** Along the river is a low-lying area that captures and transports parking area runoff (right-most image in Figure 44). More storage and treatment would be provided by retrofitting to a linear rain garden. A linear rain garden functions the same as a rain garden, but it is designed in a linear versus bowl fashion. Conservation Landscaping/Bioretention is simply the practice of creating a landscape reflective of conservation values at home, school, work, parks, and other green spaces. Conservation landscaping includes the use of native plants, xeriscaping, designing spaces for pollinators and biodiversity, minimizing turf and pesticide use, and overall planning for a landscape that has a positive impact on the environment.
    a. Calculate rain garden square footage;
    b. Deeply amend soils to improve storage, infiltration, and organic matter;
    c. Plant native, low maintenance vegetation that will slow and treat stormwater runoff. Ensure that selected plants are also safe plants for park landscapes and continue to add to the view of the river;
    d. Continue educational signage showing the movement and treatment of stormwater pollution that is protecting the Twelvemile Creek and its wildlife. Include outreach that emphasizes the different values resulting from water quality improvements, including drinking water cost savings, wildlife protection, improved fisheries, healthy and swimmable waterways.

Fig. 45. Two rain garden opportunities for improved stormwater pollution prevention and enhanced groundwater storage. The right most image includes an area depicting the observed low point for stormwater capture and treatment.

3. **Native Grass Installation:** At the lowest area of the park space, adjacent to the river, is an engineered stormwater detention area with a concrete riser, inflow, and outflow structure. Sediment from the surrounding impervious surfaces is accumulating at the outflow. It is recommended that this basin be planted with native grasses which would reduce mowing (which is also leaving soil bare) and to slow stormwater, allowing sediment to settle out across this basin area and reduce the likelihood of this pollutant making its way to the river. Helpful pictures and maintenance benefits are further described by the Marion County Soil and Water Conservation District in their bioswale fact sheet.

XERISCAPING DEMONSTRATION

The large picnic shelter at the top of this park sits in full sunlight. As shown in Figure 46, the surrounding area is actively eroding and will soon expose the concrete pad and leave it vulnerable for further erosion. In addition, it is likely high maintenance to manage incoming weeds and regularly restore the mulch cover.

Fig. 46. The picnic shelter at Cateechee Point Park provides a great opportunity to demonstrate low impact landscaping design and ecological improvements that would also better manage the ongoing soil erosion.

This shelter makes for a great demonstration site for low impact landscaping (xeriscaping) that may aid homeowners and businesses in the watershed in better managing soil erosion. The following improvements are recommended for water quality and ecological improvements.
The site should first be evaluated to identify the need for regrading. Much erosion has occurred since initial construction, and topsoil may be needed for the recommended plantings to establish. Municipal and county compost, if available, could be a good and free source for organic material to enrich the soils on this hillside.

Heat tolerant, full-sun native plants should be installed on this hillside to maintain soil and prevent soil rilling. This would eventually improve soil pore spaces and the ability for this hillside to remain stable in large storm events and infiltrate stormwater runoff. Plants recommended for this hillside include Muhlygrass (*Muhlenbergia capillaris)* and Brown-Eyed Susans (*Rudbeckia hirta*), to be planted in the late fall. This makes for a great public volunteer and engagement opportunity that also meets NPDES MS4 Permit Requirements.

Gutters should be installed on each edge of the building, and rain barrels placed at each corner. This could also be part of a larger homeowner-focused workshop on the capture and reuse of rainwater. The rain barrels should be hooked to a hose or punctured PVC pipe to mimic a level spreader that would slowly release collected rainwater to the planted hillside at multiple points rather than one discharge (which could lead to erosion).

In all instances, it is recommended that park-appropriate native plants be selected that do not bunch up too large or too tall, which could prevent a clear view of sight and provide a sense of security for park visitors.

STRATEGY 8. EQUONI PARK AND OVERALL PUBLIC ACCESS TRAIL STABILIZATION

Recreational opportunities abound along Twelvemile Creek; within this rural watershed, it is not uncommon to see footpaths near bridges where recreators walk to the river with fishing rods and boats. As these informal access points become worn in, they evolve into stormwater conveyance systems, moving sediment, gravel, and trash to the shores of the Twelvemile. Efforts should be made to stabilize these paths and better protect water quality at these locations. This may require heavy use area protection such as gravel, mulch, geotextile fabric, and timber or boulder steps to be installed. Some locations are identified here below, though others exist throughout the watershed.

1. **Equoni Park:** mulch the trail leading from the sidewalk to water access points.
2. **Maw Bridge Road:** multiple access points exist, and trails are most utilized on the northwest side of the river, both sides of the bridge. A combination of mulch, gravel, and steps may be needed to stabilize these access points.

Additional measures should be investigated and implemented to mitigate trash accumulation at these locations with signage and maintained trash receptacles.

Equoni Park offers additional retrofit opportunities that would directly benefit the health of Twelvemile Creek as it flows into Lake Hartwell.

1. Modify the drainage swale along Madden Bridge Road to a vegetated bioswale, with low grasses that require less maintenance and trap stormwater pollutants, while still having the capacity to convey stormwater from the 100-year storm.
2. Shoreline protection such as armored streambanks below the picnic shelter to withstand conditions causing it to collapse (*i.e.*, freeze-thaw cycles, historical compaction, and wave action).
3. Plant native grasses such as Little Bluestem (*Schizachyrium scoparium*) along the sidewalk edge to prevent erosion along the sidewalk edge that will eventually undermine the sidewalk on the downhill slope.

STRATEGY 9. TRASH REPORTING APP, OUTREACH, AND ENGAGEMENT

Trash is a considerable issue in this watershed. Litter is so much more than trash - lowering housing values, discouraging new businesses, impacting wildlife and water quality, and overall is demotivating to take extra measures to improve the watershed. It is ultimately a costly issue.

Based on observations, litter occurs most in this watershed from illegal dumping, general littering, and trash from pickup truck beds. It is recommended that an education and engagement campaign include the following:

- A trash reporting app similar to Greenville County's Litter Ends Here app (County of Greenville, SC (greenvillecounty.org)) would provide concerned residents a method to report illegal dumping and excessive litter, empowering them to engage. Additionally, the app would accrue data that would help prioritize enforcement actions and placement of trash receptacles;
- Partnership with Palmetto Pride to distribute tarps for pickup truck beds to contain trash and debris. This has proven to be successful in other areas of the Upstate;
- Educational information provided to county and city councils, police departments, Pickens County Sherriff's Office, and building codes inspectors that emphasizes how damaging littering is to the economy, environment, and overall quality of life to the residents they serve.

STRATEGY 10. WOLF CREEK DEMONSTRATION SITE

The AnMed Health Cannon Memorial Hospital facility is located on Highway 178, Pickens, SC, and adjoins properties owned by the city, as well as the Pickens County Administration Building, Soil and Water Conservation District, Health Department, and Department of Social Services. There is a small, incised tributary that flows through these properties south to Wolf Creek. Additionally, there is a newly opened trail system, the Tohi (Wellbeing) Trail that loops through these properties and parallels the Wolf Creek tributary in several sections. The tributary is primarily cut off from its floodplain through this area due to upstream impervious surface flow and parking lot flow at the hospital. Efforts have been made to stabilize streambanks through increased vegetative cover.

Partners at the Pickens County Soil and Water Conservation District and Clemson Extension of Pickens County have already begun to seek funding for low impact demonstration areas at the Soil and Water Conservation District (144 McDaniel Avenue, Pickens) as part of their vision for a public sensory garden at the building and accessible through this trail system. To improve water quality and ecosystem health, the following projects are recommended and shown in Figure 47:

1. A rain garden that captures rooftop and parking lot runoff;
2. Pollinator garden that addresses erosion;
3. Rain barrel collection systems to recover rooftop runoff for irrigation;
4. Mulched path that invites visitors to tour these practices and view the accompanying educational signage.

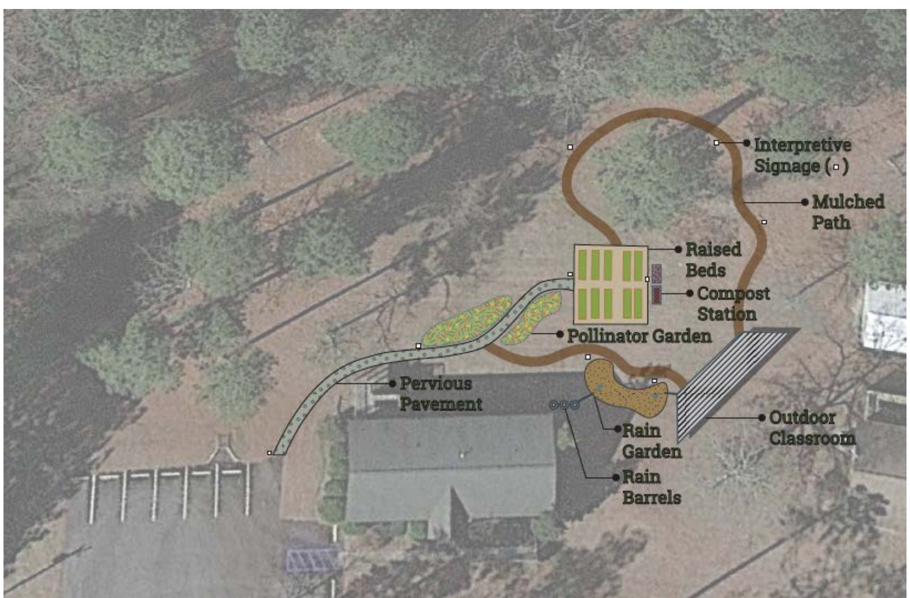


Fig. 47. Location of best practices recommended for the Pickens County Soil and Water Conservation District building as part of their overall sensory garden open for public visitation. Credit: Anaston Porter (Anderson County SWCD) and Susan Lunt (Cooperative Extension Clemson University).

The sensory garden is envisioned to have three themes to improve stakeholders' connections to nature, the watershed, and best practices for a healthier lifestyle:

1. Human health – walking trail, nature immersion;
2. Ecosystem – connectivity with land and animals; native plants; pollinators; watershed identification;
3. StoryWalk – stories and art features from local elementary schools that incorporates messages and best practices for soil health.

STRATEGY 11. FERAL HOG MANAGEMENT

While conducting field work for the development of this watershed plan, wildlife tracks and disturbances caused by feral hog populations were observed; the detrimental presence of feral hogs was also confirmed with residents and county staff. While feral hogs have been in South Carolina since the Colonial Period, their documented increase in population is harmful to people, property, native wildlife, and livestock. Feral hogs have damaging rooting habits, impact crops and livestock, and can spread disease. In terms of bacteria to waterways, they are an additional source of nonpoint source pollution as the team of hogs travel through the riparian corridor and wetlands. It is suggested that more outreach be provided to large landowners, especially those along waterways, to reduce the number of feral hogs in the watershed, partnering with the SCDNR to set traps and reduce population numbers. Clemson Extension has held workshops related to information on feral hogs, the concerns for landowners, and demonstrations of traps, which the project team believes would be of interest to stakeholders in this watershed. It would also give county and city staff a more accurate depiction of the extent of the issue for their residents.

6.0 WATERSHED EDUCATION STRATEGIES

Long-term protection of the Twelvemile Creek watershed will require the engagement of the whole community that resides, enjoys, and makes their living in this watershed. The following strategies are proposed as additional means to remove *E. coli* from continuing to be an impairment for these waterways, reduce associated pollutants that create conditions that influence *E. coli*, and create a culture of new norms that help protect this watershed long-term. In addition, all recommendations in 5.0 Watershed Restoration Strategies should include public engagement, cooperation, and outreach so that community values may be strengthened towards conservation of this natural resource and a strengthened personal responsibility to reduce pollution.

STRATEGY 1. SEPTIC SYSTEM EDUCATION

The reliance on septic systems to treat residential wastewater will continue in this rural watershed. To alleviate the bacteria issues that persist in these waterways, both the knowledge of the importance of maintaining a healthy septic system and the ability to do so must be present. It is recommended that an educational campaign be developed to specifically target residents by subwatershed, increasing awareness of the residents' connections with their waterways and the impacts of a failing septic system to a healthy, safe environment. With this educational campaign, lessons learned can be applied as the campaign moves across the whole watershed.

In partnership with companies that pump and install septic systems, outreach should also include funds available for septic system repairs and replacement. The provision of funds for private septic system repairs should include a reconnaissance of the conditions and cause of failure and GPS location as part of a larger analysis that would benefit Pickens County's integrated watershed and wastewater management strategy.

Septic Smart Week, which is federally designated and occurs each fall is a prime opportunity to capitalize on resources in partnership with the Clemson Extension Service.

STRATEGY 2. DOODLE TRAIL SIGNAGE

The Doodle Trail that stretches from Pickens to Easley courses through beautiful pine stands, woodlands, and alongside wetlands. Ample opportunities exist for signage that highlight the following:

- Importance of wetlands for flood storage, water quality protection, livestock, and ecological biodiversity;
- Importance of a healthy riparian buffer corridor and forested watershed areas that protect water quality, wildlife, and groundwater supplies;
- Identify stream crossings, which include Wolf Creek, Rices Creek, and Golden Creek.

At the Moose Family Lodge, Easley, the Doodle Trail runs along the property line. There are opportunities to link watershed education signage with projects at this location that include stormwater runoff treatment, kudzu removal, and pollinator/native plant garden. The Doodle Trail also could be an ideal location for an art contest focusing on protecting a healthy Twelvemile Creek and its tributaries.

STRATEGY 3. COMMUNITY SCIENCE MONITORING WITH SC AAS

The SC Adopt-a-Stream (SC AAS) community science monitoring program is South Carolina's largest community science water quality and ecosystem monitoring program. SC AAS has been active since 2017 and certifies volunteers to monitor freshwater streams, assess macroinvertebrate community health and diversity, and monitor tidal saltwater creeks. Program training protocols and data storage maintain sufficient integrity for education and outreach, the collection of baseline data, and for use by local authorities. The community science data is non-regulatory, though does alert local authorities and the state when the potential for pollution and illicit discharges exist. SCDHEC and the Clemson University Center for Watershed Excellence co-lead the program, alongside dozens of training partners, SC AAS Hubs, and kit loan locations. Data is stored and shared in the program's database, managed by Clemson University, allowing all viewers to explore data and download monitoring data for locations of interest.

Volunteers are already actively monitoring for *E. coli* and have contributed significantly to data availability for smaller tributaries across this large watershed. Certified Volunteers can seek Macroinvertebrate Monitoring Certification and conduct annual habitat assessments, which would be able to inform additional sediment control and restoration priorities.

It is recommended that SC AAS outreach strategies include the following as next steps:

- Programming at parks and other public locations that energize groups and share data with park visitors (ex., Hagood Mill, Jaycee Park);
- More links on county and city websites that share SC AAS program information, events, a link to the database for their residents, and a means to celebrate their active volunteers;
- Generated local sponsorship to maintain volunteer monitoring kits, provide training handbooks, and incentives (ex., contests with prizes) in the region;
- A high school-aged scholarship program similar to the one being offered by Friends of Lake Keowee Society that provides scholarship funds paid directly to college for students' active participation in monitoring and reporting data. Lake Hartwell Partners for Clean Water, Duke Energy, Clemson Extension, and others could be essential partners in this program;
- Education that utilizes the transparency tube, a new addition to the SC AAS Freshwater Monitoring Protocol, to visualize the widespread concern for too much sediment in our waterways that also lead to Lake Hartwell;
- Use of the SC AAS high school-aged curriculum in STEM outreach and classroom activities;
- Given the amount of riparian corridor on private land, an outreach campaign targeting landowners and introducing them to SC AAS monitoring would provide much more data and observations for the Twelvemile. Their engagement would also benefit potential future initiatives regarding riparian buffers, tree giveaways, stream restoration data, and septic system maintenance outreach by already having developed this relationship between people, waterways, and the health of their adjacent ecosystem.

More information, access to data, and additional program resources can be found at the program's website, www.scadoptastream.org. Appendix A includes volunteer monitoring results.

STRATEGY 4. RAISE IT UP MOWING CAMPAIGN FOR PUBLIC WORKS, PARKS AND RECREATION, AND LANDSCAPING COMPANIES

Oftentimes, simple strategies can make for the best and long-term approaches to address watershed pollutants and create new social and cultural norms, similar to natural riparian corridors. In the case of widespread low mowing, a "Raise It Up" campaign or similar message would explain the benefits of a raised mower deck coupled with increased no-mow zones. This outreach strategy should include the following benefits to water quality and soil health:

- Raising mower decks to encourage healthier, full stands of grass coverage;
- Utilizing the SC Department of Transportation seed mix recommendations for ditches and roadsides to minimize bare soils vulnerable to erosion;
- Recognizing low spots in the landscape that regularly hold rain water and encouraging adaptations to rain gardens or bioswales, requiring less mowing;
- Similarly, recognizing areas that have difficulty sustaining grass and addressing the cause and/or planting native vegetation or shrubs instead of turf.

The Clemson Extension Carolina Clear Rain Garden Manual includes rain garden installation instructions and plant lists for every zone and ecoregion of SC. The Clemson Extension Rain Garden Initiative includes the manual and more resources for all homeowners, staff, and landscaping companies. Additionally, the Carolina Yards and Neighborhoods program offered by Clemson Extension hosts a CYN Plant Database that sorts plants based on objectives and conditions set by the user. Plant lists include grasses and herbaceous plants, shrubs, and trees.

STRATEGY 5. RESIDENT CANADA GEESE DETERRENTS

Resident Canada Geese populations can be more than a nuisance; the guts of these waterfowl contain a high amount of *E. coli* bacteria, and their honing skills are stronger than that of salmon, meaning that all offspring will annually find their way back to their origin to lay eggs and hatch the next generation of Canada Geese. Residents of privately-owned ponds in the watershed should be involved in programming and/or outreach related to Clemson Extension's Carolina Yards program, and stewardship of water resources by those living adjacent to a stream or pond. Effective signage is available from Clemson Extension's Carolina Clear program (Figure 48) to deter feeding geese at public locations, as well as fact sheets, and information that can be provided to landowners to encourage these geese to continue their migration and not settle as residents of this watershed.

Fig. 48. Signage developed by Clemson Extension Carolina Clear to discourage feeding of Canada Geese, for water quality and for the health of the animal.

STRATEGY 6. ELIMINATING SSOs FROM FATS, OILS, GREASE, AND WIPES

Fats, oils, and grease, also known as FOGs, are an especially nasty cause of failures in wastewater conveyance. Sewer lines are sized to handle typical estimated discharge of waste fluids to a wastewater treatment plant. When FOGs are introduced to the system, the substances cool in the pipes, and accumulate along the walls of the sewer line, slowly decreasing the diameter available for conveyance of waste. Over time, this can lead to total blockage of pipes, back-ups into basements and buildings, sewer spills, and overflowing manholes. It is stated that most sewer line failures can be traced back to FOGs (City of Red Wing, 2018). Furthermore, FOGs leave greasy accumulations along settling basins, screens, pipes, and other units of the wastewater treatment plant, causing issues during the wastewater treatment process.

In addition, "flushable" wipes have become widespread issues in the realm of wastewater treatment. "Flushable" wipes refer to pre-moistened, woven, multi-layer towelettes used for hygienic purposes. The patent states that the design of flushable wipes includes water dispersibility characteristics so that when flushed, it will not clog plumbing and sewage treatment in comparison to non-woven wipes (Kimberly Clark Worldwide Inc, 1996). However, these are not functioning as intended, with fabrics rejoining together within the sewer system and combining with grease to create blockages.

FOGs and flushable wipes have been documented as causing significant issues in the sewer systems of the Upstate of South Carolina. Just on the other side of Lake Keowee, in neighboring

Oconee County, SC, the Oconee County Joint Regional Sewer Authority saw sewer failures increase from 20 to nearly 70 in just one year (2018-2019) completely due to flushable wipes. The results of these failures have included back-ups into residences and buildings, overflowing manholes, and sewer spills. These occurrences are a source of fecal pollution, nutrients, and suspended solids to the watershed.

Cities across the country are dealing with these same issues. Pottstown, Pennsylvania reported in March 2018 that flushable wipes had cost their wastewater facility $100,000 to $120,000 in repairs, maintenance, and response. Upgrades to the plant to address this issue will cost the facility $500,000 (Perez, 2018). Ultimately, these costs are typically passed to residents.

Though this watershed is vastly rural, high *E. coli* and potential risks from bacteria, viruses, and other pathogens can still be caused by SSOs. More than 60% of the reported SSOs were attributed at least in part to FOGs and wipes. A uniform and repeated message by the utilities to those residences and businesses they serve is a recommended outreach strategy to minimize this issue. Important for the health of Lake Hartwell, but below the TMDL watershed, housing areas for Clemson University students should post messages in bathrooms, kitchens, dining halls, and rental units for greater awareness of what individuals can do to protect the recreational health of Lake Hartwell.

7.0 IMPLEMENTATION, MILESTONES, AND MEASURABLE GOALS

The project team recommends the implementation of this plan in a multi-phased approach over the next 12 years, broken up into three-year phases, with the intent of decreasing/preventing bacteria, sediment, and nutrient loads in the Twelvemile Creek watershed. Table 17 details the cost, potential funding sources, potential project partners, and estimated timeframe of implementation for each BMP. Although total restoration of the project area would be ideal, the plan focuses on incremental improvements in water quality over a 12-year timeframe.

For each three-year phase, the following structure of implementation will help to ensure that projects stay on schedule and budget. Measures of success are also included:

- Year 1
    - Education and outreach: begin outreach to landowners through various strategies including direct communication through mailings, stakeholders, and online.
    - Begin BMP installations: site designs and bids as needed, work with landowners to complete projects and required documents
    - Quarterly updates to stakeholders and on project website
    - **Measures of Success**:
        - project website development and updates
        - # of targeted mailings
        - # of social media blitzes and engagement
        - # of stakeholder engagement
        - # of in-person meetings/workshops
        - # of BMPs installed
- Year 2
    - Education and outreach: revise strategy as needed, continue methods listed in Year 1, work with landowners who have completed BMP projects to reach out to other landowners who might be interested in participating.
    - BMP installations: continue installations, identify potential water quality monitoring efforts
    - Quarterly updates to stakeholders and on project website
    - **Measures of Success**:
        - project website updates and website views
        - # of targeted mailings
        - # of social media blitzes and engagement
        - # of stakeholder engagement
        - # of in-person meetings/workshops
        - # of BMPs installed
- Year 3
    - Education and outreach: send surveys and post-BMP maintenance packets to participating landowners, revise strategy as needed

- BMP installations: finalize installations; prepare for next phase by beginning site designs as needed
- Quarterly updates to stakeholders and on project website
- Phase wrap-up and final summary of projects/results including estimated load reductions
- **Measures of Success**:
  - # of post-BMP packets distributed
  - # of survey results
  - # of BMPs installed
  - Estimated load reductions from installed BMPs
  - Measurable water quality improvements

Tab. 17. Summarized Watershed Management Strategies

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
Riparian Buffer Zoning Ordinance	• Pickens County adopts 100' of riparian buffer protection for mainstem Twelvemile Creek. • Pickens County adopts 50' of riparian buffer protection for all tributaries leading to Twelvemile Creek. • City of Pickens expands protection to align with 50' of riparian buffer for waterways within city limits.	$1,000 *SCDHEC 319(h) for education and outreach on riparian buffers (what they are, how they are instrumental in protecting water quality, stream ecology, and habitat).* *Partnership with Lake Hartwell Partners for Clean Water to create unified source water protection initiatives, capitalizing on examples such as Pickens County.*	• Pickens County Council • Appalachian Council of Governments • Pickens County Soil and Water Conservation District • City of Pickens • Lake Hartwell Partners for Clean Water • Friends of Lake Keowee Society	2024-2025
Septic System Repair and Replace Cost-Share Program	• Contact local septic providers to distribute information on the program. • Send targeted mailings to homeowners in high priority areas. • Complete 200 septic repairs or replacements upstream of SCDHEC Station SV-137	$6,400-8,500 per system $1,280,00-$1,700,000 (est. 200 septic systems) *SCDHEC 319(h); SC Clean Water Revolving Fund; Water Utilities; Local Governments; USDA Rural Development Office; Pickens County Public Service Commission; SC Rural Infrastructure Authority*	• Lake Hartwell Partners for Clean Water • Pickens County • City of Pickens • Septic system pumping, repair, and installation companies • Churches • SC Rural Infrastructure Authority	2024-2036

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
Land Protection	• Identify projects underway that would qualify for cost-share assistance. • Identify at-risk species in the watershed that would benefit from US FWS Conservation Planning Assistance funding. • Conduct habitat assessments; alternatively, emphasize use of the SC Adopt-a-Stream program and habitat assessment protocol. • Utilize these data in addition to the *SC Green Infrastructure Plan* of 2023, created by the SC Forestry Commission to protect our most valuable resources and their connectivity. • Provide education to residents on land use changes in Pickens County, importance of wetlands, watershed identification, habitat protection, threatened and endangered species. • Conduct outreach on source water protection and the	$16,000 per conservation easement (average price of eligible closing costs for a CE) 8 conservation easements $128,000 *SCDHEC 319(h); Anderson County Watershed Protection Council; Agricultural Conservation Easement Program (ACEP), South Carolina Conservation Bank (SCCB); US Fish and Wildlife Service Cooperative Endangered Species Conservation Fund: Conservation Planning Assistance; Pickens County Land Conservation Bank; Water Utilities; US FWS Cooperative Endangered Species Conservation Fund: HCP Land Acquisition; US FWS Recovery Challenge Fund*	• Upstate Forever • Local land trusts such as Upstate Forever • Naturelland Trust • Savannah Land Trust • The Nature Conservancy • Farm Service Agency • US Fish and Wildlife Service • SC Rivers Forever • SC Forestry Commission	2024-2036

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	impacts of headwaters on drinking water resources.			
Agricultural BMPs and Agritourism District	• Partner with producers to implement 16 traditional agricultural BMP projects, addressing sediment, nutrient, and bacteria pollutants. • Partner with producers to locate an additional no-till seed drill in a convenient loan location in the watershed. Identify funding mechansisms to minimize cover crop seed costs to encourage this practice becoming a new "norm." • Launch a program to cost-share farm road access improvements, erosion control, and drainage solutions. These are unique opportunities to demonstrate erosion management with native vegetation as a solution to sustaining healthy soils for a healthy watershed. • Identify opportunities to enhance agritourism, building economic vitality, local food	Varies based on BMP. Average cost per project/bundle estimated at $27,575 (based on WBP implementation in the Three and Twenty Creek watershed, 2020-2024) *SCDHEC 319(h); Environmental Quality Incentive Program (EQIP); Anderson County Watershed Protection Council; USDA; SC Farm Bureau*	• NRCS • Clemson Cooperative Extension Service • Pickens County Soil and Water Conservation District • Pickens County • Appalachian COG • Upstate Forever	2024-2036

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	supply, jobs, and meaningful conservation efforts through education and zoning.			
Wetland Assessment and Restoration	• Assess conditions of wetlands and prioritize wetland restoration projects in terms of costs and watershed benefits, especially considering special waters designations and threatened and endangered species. • Work to promote wetland mitigation banking where construction activities would be offset in the very same subwatershed as much as possible. • Evaluate the benefits of wetlands to carbon storage and flood mitigation. • Utilize conservation easements and the riparian buffer zoning to further protect wetlands from degradation, engaging residents in the importance of wetlands to protect waterways, habitat, and lessen flooding impacts.	Varies based on number, size, and condition of wetlands *Building Resilient Infrastructure in Communities; Flood Mitigation Assistance Funding; Wetland Mitigation Banking Program; Clean Water State Revolving Fund; Duke Energy; US FWS Cooperative Endangered Species Conservation Fund: HCP Land Acquisition; US FWS Recovery Challenge Fund; SCDHEC 319(h)*	• Pickens County Council • Appalachian Council of Governments • NRCS • Audubon Society of SC • SC Rivers Forever • SCDNR • Army Corps of Engineers • US Fish and Wildlife Service • The Nature Conservancy • Clemson University • Upstate Forever	2027-2036

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	• Restore critical wetlands and ensure maintenance agreements exist to extend their function. Restoration includes a sequence and variety of activities including sediment removal, grading, erosion controls, structural changes such as outlet structures, and revegetation.			
Jaycee Park Green Infrastructure Project	• Construct the W. Jones Avenue Bioswale. • Renovate the W. Jones Parking Lot to remove curbs, including tree islands and porous asphalt (or other pervious solution) to minimize stormwater runoff and pollution. • Capture W. Jones Parking Lot runoff in a large rain garden alongside Town Creek that would naturally overlow to Town Creek during large storm events. Remove existing trench and stockpiled sediment. • Reduce flows to W. Jones Avenue by capturing	$500,000 *SCDHEC 319(h); SC Clean Water Revolving Fund; SC State Revolving Fund; Ingles Grants and Sponsorship; Pickens County and State Accommodations Tax Grants; FEMA; Inflation Reduction Act; SC Rural Infrastructure Authority; Rotary Clubs*	• City of Pickens • Pickens County • Wastewater Utilities • Pickens County School District • Lake Hartwell Partners for Clean Water • Clemson Extension • Pickens County Soil and Water Conservation District • SC Rural Infrastructure Authority • Ingles	2024-2033

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	stormwater in a treatment zone and native azalea garden project. • Begin to address naturalizing the tributary to Town Creek currently covered in riprap and secluded from its natural floodplain. • Permanently close bathroom facilities within the floodplain. • Modify the series of ditches from N. Homestead Avenue to a treatment train of solutions and beautification that treats runoff before entrance to Town Creek. Stabilize the outfall. • Build a stormwater capture area that is youth-friendly and serves as a STEAM (science, technology, engineering, art, and mathematics) attraction for youth and families. • With the exception of restroom facilities closing, all renovations and improvements should include			

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	a trail of educational signage emphasizing the history and conservation of Town Creek as an important tributary to our drinking water source, highlighting monitoring data with SC AAS, green infrastructure solutions, stormwater pollution identification, wildlife protection, and ecosystem improvements.			
Cateechee Point Park Rain Gardens and Xeriscaping	• Convert riprap covered drainage area to a rain garden, capturing, slowing, and treating stormwater runoff and adding biodiversity to this park space. • Create a linear rain garden near kayak launch area to treat parking lot runoff before overflow to Twelvemile Creek. • Install native grasses in the stormwater detention basin especially where soil is being eroded and exiting to the creek.	$85,000 *SCDHEC 319(h); SC Clean Water Revolving Fund; SC State Revolving Fund; Pickens County Accommodations Tax Grant; FEMA; Duke Energy*	• Pickens County • Easley Combined Utilities • Town of Norris • Clemson Extension of Pickens County • Pickens County Soil and Water Conservation District • Paddling groups and organizations • Lake Hartwell Partners for Clean Water	2024-2027

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	• Create a xeriscaping demonstration area by the picnic shelter, stabilizing and beautifying the hillside with low maintenance native vegetation. Protect the toe of the picnic shelter with grasses and boulders. Install gutters and rain barrels for water sources.			
Equoni Park and Overall Public Access Trail Stabilization	• Use native vegetation to stabilize eroding areas. • Mulch and improve the trail leading to water access points at Equoni. • Build a small linear rain garden along Madden Bridge Road, Equoni Park to treat road runoff and reduce erosion to Twelvemile Creek and Lake Hartwell. • Purchase easements to allow for safe, stabilized access points at Maw Bridge and Lay Bridge Roads on Twelvemile Creek. Utilize	$50,000 *SCDHEC 319(h); SC Clean Water Revolving Fund; SC State Revolving Fund; Pickens County Accommodations Tax Grant; Duke Energy*	• Pickens County • Town of Central • Clemson Extension of Pickens County • Pickens County Soil and Water Conservation District • Lake Hartwell Partners for Clean Water • R.C. Edwards Middle School (volunteer planting days, outreach)	2024-2030

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
	grading boulders, logs, mulch, and other natural materials to create accessible trails. • Create educational kiosks at both locations that showcase the historic and environmental significance of Twelvemile Creek. Include waste bins at kiosks. • At the Twelvemile Creek at Lay Bridge Road location, stabilize a kayak take-out where white water kayakers are leaving the creek.			
Trash Reporting App, Outreach, & Engagement	• Work with Greenville County's Litter Ends Here program and IT Specialists to identify ways to mimic their app for Pickens County. • Modify app for purposes and operations of Pickens County. • Launch an education campaign that addresses the far-reaching impacts of litter.	$25,000 *SCDHEC 319(h); Palmetto Pride; Utilities*	• Pickens County • Pickens County Keep America Beautiful • City of Pickens • Greenville County • Palmetto Pride • Clemson Extension • Pickens County Soil and Water Conservation District • Real Estate sponsors • SC State Parks	2024-2025

STRATEGY	MILESTONES	EST. BUDGET & POTENTIAL FUNDING	PROJECT PARTNERS	ESTIMATED TIME OF COMPLETION
Wolf Creek Demon-stration Space	• Organize a discussion with neighboring property owners to discuss the public space in planning and interests and objectives of neighboring properties. • Assess and implement rooftop capture and rain barrels. • Install a rain garden to collect runoff. • Install the pollinator garden. • Install the mulched walking path. • Install educational signage.	$35,000 *SCDHEC 319(h); Pickens County; SCDHEC Champions of the Environment*	• Pickens County • City of Pickens • Clemson Extension of Pickens County • Pickens County Soil and Water Conservation District • Environmental Education Association of South Carolina	2025-2026
Feral Hog Management and Education	• Offer a workshop on the impacts of feral hogs and options in managing populations. • Utilize workshop feedback to more accurately depict the extent of the feral hog issue. • Provide educational resources and connections with landowners and trapping resources.	$1000 *SCDHEC 319(h)*	• Pickens County • SCDNR • Pickens County Soil and Water Conservation District • Private Landowners • Clemson Extension	2024-2025

8.0 IMPLEMENTATION MONITORING PLAN

This 154-square mile watershed needs more monitoring station locations to document existing conditions, discern and activate when threats to water quality are identified, and measure improvements from the implementation of measures prioritized in this watershed plan. The following Figure 49 and Table 18 include recommended monitoring stations and rationale for each monitoring station, based on water quality data review and field analysis.

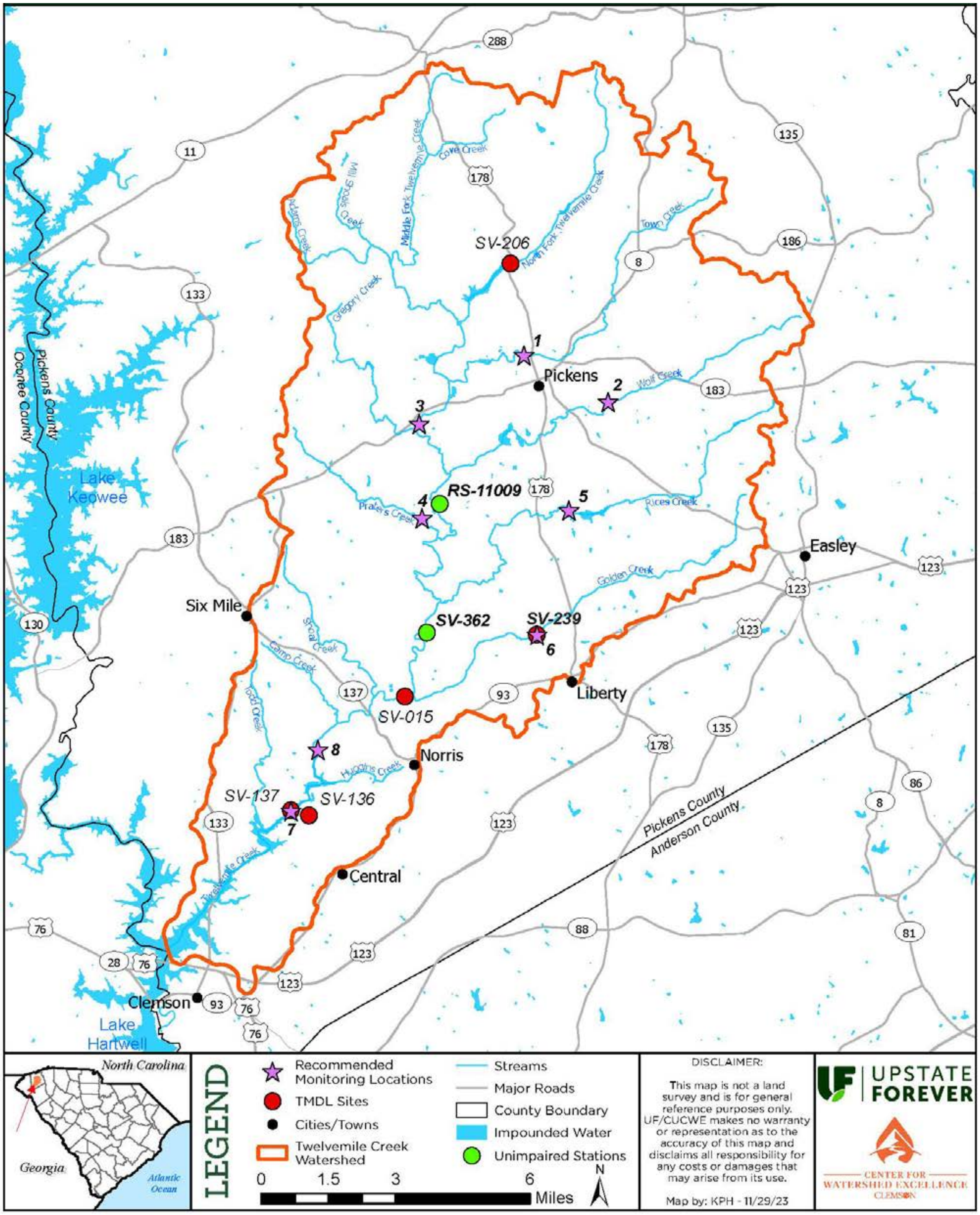


Fig. 49. Recommended Water Quality Monitoring Locations.

Tab. 18. Water Quality Monitoring Site Suggestions and Rationale

Site #	Waterbody	Description	Reasoning	Future Conditions and Considerations
1	Town Creek	at Jaycee Park, Pickens, near covered bridge; public parking available	This is the most upstream monitoring site, just behind and upstream of downtown City of Pickens; Town Creek is currently unmonitored, but high bacteria results have been found by SC AAS volunteers. Within this watershed, there are industrial sites, several schools, park facilities.	Increased duration of soil saturation and higher flows from extreme rain events could compromise wastewater treatment in this older section of town. The existing bathroom at Jaycee Park is within the regulatory flood zone. Recommend monitoring by SCDHEC, Pickens County, and/or SC AAS until results can be further evaluated.
2	Wolf Creek	at Turner Road and intersection with Ireland Road; parking available	The role of pump stations in high bacteria in this watershed is not well-understood; monitoring at this location would provide insight regarding this potential source and capture water quality data on a major unmonitored tributary to the Twelvemile.	Growth in Pickens County is inevitable; therefore, more wastewater volume will be generated to the multiple sewer treatments plants operating in the area. This is viewed as an important site, best fit to be monitored by Pickens County and/or SCDHEC.
3	Twelvemile Creek	near Walhalla Highway behind the Pickens County Maintenance Building	This station would monitor the more rural headwaters of this watershed, just downstream of the very popular Pickens County Flea Market. Portables are located within the floodplain of Twelvemile Creek.	The Pickens County Flea Market has flooded several times in the past ten years during major storm events. The potential of increasing floods may necessitate greater consideration of sewer treatment and debris handling. Due to limited access to the facility, may be best monitored by Pickens County.
4	Praters Creek	at Belle Shoals Road; roadside parking available	This rural western arm leading to the Twelvemile is currently unmonitored. The watershed is iconic Pickens County, and the creek is well-buffered. This is an ideal location to possibly demonstrate the role of	This is a smaller tributary, very suitable for SC AAS monitoring, though parking safely is a consideration.

Site #	Waterbody	Description	Reasoning	Future Conditions and Considerations
			forests, wetlands, and riparian buffers to conservation of water quality.	
5	Rices Creek	at Country Club Road	Located downstream of Pickens Country Club, which is approved for redevelopment as an RV Park and Campground, with 213 RV sites. The addition of cabins (and no tents) will require increased wastewater treatment capacity than currently existing for the country club. Rices Creek is a fairly large tributary to the Twelvemile above the confluence with Golden Creek monitoring contribution from the City of Easley.	Soil saturation during and following large storm events is a major consideration for septic system design and function. Recommend monitoring by SCDHEC and/or Pickens County.
6	Golden Creek	at Campground Road	High bacteria has previously been identified by Pickens County at this location. The watershed includes a quarry, airport wastewater treatment, aging infrastructure, and headwaters in Easley.	Golden Creek watershed had the greatest area of very limited classification for septic system performance. With increases in homes and potential for soil saturation, monitoring this watershed for bacteria load is seen as critical for overall Twelvemile health and safety. Recommend continued monitoring by Pickens County.
7	Twelvemile Creek	at beach below Lay Bridge Road	Data from this location may highlight the differences in bacteria densities (and other parameters) comparing the quality of flowing, deep water and the shallow, wide waters of the mainstem Twelvemile downstream at Maw Bridge Road. Analysis could be informative for restoration, sediment management, and role of sediment in perpetuating bacteria survival.	Recommend continued monitoring by DHEC.

Site #	Waterbody	Description	Reasoning	Future Conditions and Considerations
8	Twelvemile Creek	above Maw Bridge Road (SV-137)	This site continues to be important for assessing the overall health of this watershed above the influence of Lake Hartwell. Additionally, this location is downstream of the former Sangamo Superfund site, and the river flows differently here: slow, shallow, wide, and in full sun. The relationship between sediment, nutrients, and bacteria in the water column can be compared with upstream monitoring at Lay Bridge Road.	Recommend continued monitoring by DHEC.

9.0 CLIMATE PLANNING

The Twelvemile Watershed is predominantly rural with mostly forested and agricultural land cover (Section 1.3). The topography of this watershed is characterized by mountainous slopes with high elevations in the northern portion and lower elevations in the southern reaches (Section 1.2). This watershed's topography and current land use paired with the City of Pickens location in the northern portion of the watershed poses the inevitability that continued development will occur in areas more susceptible to erosion. Pickens County is estimated to consume over 79,000 acres by the year 2040 (City Explained, 2017; Urban 3, 2017) and, according to the United States Census Bureau, has seen a 15.23% increase in population since 2010. The SC Office of Resilience estimates that population growth in Pickens County will be an additional 6% by 2035 (SCOR, 2023). With rising populations and increased development comes pressures on aging infrastructures, conversion of forested and agricultural land to developed land, and higher demand for clean drinking water, among others.

RISKS IN THE TWELVEMILE WATERSHED

A changing climate brings threats of flooding, drought, rising temperatures, more severe storms, and more. FEMA's National Risk Index estimates that Pickens County is at higher risk for monetary loss due to ice storms, landslides, and high winds (FEMA, 2024). Specific to the Twelvemile Watershed, it will be essential to protect against these risks especially given the erodibility of the northern portion of the watershed and estimated increase in development and population growth. These risks could lead to higher pollutant loads of bacteria, sediment, and nutrients if runoff increases from more frequent and severe storms. Additionally, protective measures on lands currently serving as mitigation to climate risks is an important consideration. This plan mentions many BMPs that will be effective tools in climate planning and can be used as a framework to address these concerns; overall, smart growth strategies and the recommendation of an integrated water, wastewater, and watershed plan will lead the way for greater resiliency (environmental, economic, community) for the watershed and Pickens County.

ADDRESSING RISKS WITH POLICY AND PARTNERSHIPS

Addressing climate risks at a community-wide level begins with effective and strong partnerships with local municipalities, government entities, community groups, and landowners. BMPs and strategies addressing climate risks with policy change and local partnerships include:

- Riparian Buffer Zoning Ordinance
- Wetland Mitigation Banking
- Land Protection
- Feral Hog Management
- Trash Reporting App
- Increased water quality monitoring
- Community Science Monitoring with AAS

ADDRESSING RISKS WITH STRUCTURAL BMPS

Prioritizing investment of funding in strategic locations addresses current water quality concerns as well as climate change risks. For example, the Jaycee Park Green Infrastructure project addresses the current concerns of high levels of stormwater runoff and sedimentation with solutions that also mitigate against risks of flooding. Structural BMPs addressing climate risks include:

- Septic Repairs/Replacements
- Agricultural BMPs
- Wetland Restoration
- Jaycee Park Green Infrastructure Project
- Cateechee Point Park Rain Gardens and Xeriscaping
- Equoni Park and Overall Public Access Trail Stabilization
- Wolf Creek Demonstration Space

ADDRESSING RISKS WITH OUTREACH AND EDUCATION

Empowering citizens with knowledge and resources to affect change positively is an important aspect of integrating climate change considerations in watershed planning. Long-term protection of the Twelvemile Creek watershed will require the engagement of the whole community that resides, enjoys, and makes their living in this watershed. All recommendations in Section 5.0 should include public engagement, cooperation, and outreach so that community values may be strengthened towards conservation of this natural resource and a strengthened personal responsibility to reduce pollution. Strategies addressing climate risks include:

- Post-BMP maintenance packets sent to landowners who install structural BMPs such as septic systems and agricultural BMPs
- Septic System Education
- Doodle Trail Signage
- Community Science Monitoring with AAS
- Raise It Up Mowing Campaign for Public Works, Parks and Recreation, and Landscaping Companies
- Resident Canada Geese Deterrents
- Eliminating SSOs from Fats, Oils, Grease, and Wipes

INTEGRATING THE SC STRATEGIC STATEWIDE RESILIENCE AND RISK REDUCTION PLAN

The South Carolina Office of Resilience developed a statewide resilience plan in 2023 that identifies major flood risks around the state and potential losses that could occur because of extreme weather events. The plan also provides strategies for local governments to implement resilience into their communities in order to mitigate potential flood risks (SCOR, 2024). Strategies included in the resilience plan that overlap with strategies listed in this watershed plan include:

- Coordinate watershed-based resilience planning and projects
- Incorporate resilience into planning, land use, and other regulatory processes
- Maintain natural flood protection through conservation

The SC Resilience Plan paired with the findings of this watershed plan leads to a strong case of support for future funding opportunities to implement elements of this plan and protect against extreme climatic events.

10.0 SUMMARY AND CONCLUSION

With cost estimates detailed in Table 19, the project team estimates implementation of this watershed plan to cost approximately $3 million.

As mentioned in Section 3.1, a total of 2.62E+14 counts/year bacterial load reduction is needed. The project team recommends incrementally achieving load reduction goals through a multi-phased approach of project implementation. The projects listed in Table 19 address the bacterial load reduction requirements from the TMDL; sediment and nutrient reductions are necessary inclusions given the issues detailed in this plan. Table 19 details implementation timeframes broken into three-year phases. Successful implementation of this watershed plan will be measured in anticipated load reductions, projects completed, and public engagement and education. Phase completion is dependent upon funding and landowner participation.

Tab. 19: Summary of Project Implementation Timelines, Costs, and Estimated Load Reductions

Strategy:	**Phase 1: 2024-2027**	**Phase 2: 2027-2030**	**Phase 3: 2030-2033**	**Phase 4: 2033-2036**
Riparian Buffer Zoning Ordinance*	x			
Septic System Repairs/ Replacements	x	x	x	x
Land Protection	x	x	x	x
Agricultural BMPs & Agritourism District	x	x	x	x
Wetland Assessment & Restoration		x	x	x
Jaycee Park Green Infrastructure Project*	x	x	x	
Cateechee Point Park Rain Garden & Xeriscaping*	x			
Equoni Park & Overall Public Trail Access Trail Stabilization*	x	x		
Trash Reporting App, Outreach, & Engagement*	x			
Wolf Creek Demonstration Space*	x			
Feral Hog Management & Education*	x			
Estimated Project Cost/Phase:	**$905,800**	**$759,300**	**$734,300**	**$567,300**
Estimated Bacterial Load Reductions/Phase:	**6.60E+13 counts/yr**	**6.60E+13 counts/yr**	**6.60E+13 counts/yr**	**6.60E+13 counts/yr**
Estimated Sediment Load Reductions/Phase	**21 tons/yr**	**24 tons/yr**	**24 tons/yr**	**24 tons/yr**
Estimated Phosphorus Load Reductions/Phase	**655 lbs/yr**	**662 lbs/yr**	**662 lbs/yr**	**662 lbs/yr**
Estimated Nitrogen Load Reductions/Phase	**1,674 lbs/yr**	**1,741 lbs/yr**	**1,741 lbs/yr**	**1,741 lbs/yr**

**Load reduction estimates not included; property specific and dependent on practices installed*

The project team has been fortunate to have capable, interested, and ready partners in Pickens County and the City of Pickens. Additional input has been provided by the Clemson Extension Service and Natural Resources Conservation District in Pickens County. It is feasible that many of these projects will be implemented in partnership with SCDHEC and additional sponsors that will address nonpoint source *E. coli* pollution as well as nutrients and sediment.

Ultimately, resolving *E. coli* concerns in the watershed will need to be a concerted effort amongst community members, elected and appointed officials, utilities, agriculture, and conservation groups. An Integrated Watershed Plan would bring multiple parties to the table to outline a future for water distribution, wastewater management, smart growth, economic and conservation planning for a healthy Twelvemile Creek watershed.

REFERENCES

Arcadis US. 2009. Twelvemile Creek Restoration Final Design Plans. Signed by Paul Doody.

Building Green. 2023, April 3. Foamglas – My New Favorite Material. https://www.buildinggreen.com/blog/foamglas---my-new-favorite-insulation-material.

Chesapeake Bay Program. 2022. Chesapeake Bay Program Quick Reference Guide for Best Management Practices (BMPs): Nonpoint Source BMPs to Reduce Nitrogen, Phosphorus and Sediment Loads to the Chesapeake Bay and its Local Waters. CBP/TRS-323-18. Second edition. https://d18lev1ok5leia.cloudfront.net/chesapeakebay/documents/BMP-Guide_Full.pdf

City of Red Wing. 2018, May 22. *Frequently Asked Questions about Fats, Oils, and Grease*. Red Wing, MN.

City Explained. Urban3, and Stantec. 2017. *Shaping Our Future: Growth Alternatives Analysis*. 2017.7.20_SOF_FINAL_Report.pdf (upstateforever.org).

Climate Adapt. 2024. *Establishment and restoration of riparian buffers*. Accessed March 2024. https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/establishment-and-restoration-of-riparian-buffer-s/#source

Federal Emergency Management Agency. 2024, March. *National Risk Index*. https://hazards.fema.gov/nri/map.

Gardner, J.R., Yang, X., Topp, S.N., Ross, M. R.V., Altenau, E.H., and Pavelsky, T.M. 2020. The Color of Rivers. *Geophysical Research Letters, 48,* e2020GL088946.

Gleason, R.A. and Euliss, Jr., N.H. 1998. *Sedimentation of Prairie Wetlands.* Great Plains Research 8: 97-112.

Kimberly Clark Worldwide Inc. 1996. US Grant US5667635A.

Natural Resources Defense Council. 2023, July 10. *What the Supreme Court's Sackett v. EPA Ruling Means for Wetlands and Other Waterways*. https://www.nrdc.org/stories/what-you-need-know-about-sackett-v-epa?gclid=CjwKCAjwtuOlBhBREiwA7agf1h4xPvxHFci WqTw3x_4w0goX7egzWyZxL6GgPhMfNWE73oQVIuQK2hoCrqEQAvD_BwE

Perez, W. 2018, March 4. *"Flushable" Wipes Creating Expensive Problem at Local Sewage Plant*. WPVI-TV Action News [Pottstown, PA].

Perry, A. 2011. *E. coli can survive in streambed sediments for months*. USDA Agricultural Research Service Research News.

Regents of the University of Minnesota. 2014. *Field Guide for Maintaining Rural Roadside Ditches.* University of Minnesota Sea Grants Program. https://www.lakesuperiorstreams.org/stormwater/toolkit/contractor/resources/DitchGuide_SeaGrant.pdf

Shaver, E., Horner, R., Skupien, J., May, C., and G. Ridley. 2007. *Fundamentals of Urban Runoff Management: Technical and Institutional Issues* 2nd Edition.

South Carolina Department of Health and Environmental Control (SCDHEC). 2003. Total Maximum Daily Load Development for Twelve Mile Creek Watershed, SC; Fecal Coliform Bacteria for Stations: SV-015, SV-136, SV-137, SV-206, SV-239. https://scdhec.gov/sites/default/files/docs/HomeAndEnvironment/Docs/tmdl_12mile.pdf.

South Carolina Department of Health and Environmental Control (SCDHEC). 2013. Fact Sheet: *Freshwater Recreational Use Water Quality Standard Change from Fecal Coliform to Escherichia coli and its Effect on Established and Future Pathogen TMDLs*.

South Carolina Department of Health and Environmental Control (SCDHEC). 2022. Impaired Waters & Contaminant Limits - 303(d). TMDL. 2023. http://www.scdhec.gov/HomeAndEnvironment/Water/ImpairedWaters/Overview/#1.

South Carolina Department of Health and Environmental Control (SCDHEC). 2023. *Calculating Bacterial Load Reductions in South Carolina for GRTS Reporting.* https://scdhec.gov/sites/default/files/media/document/Calculating%20Bacterial%20Load%20Reductions.pdf.

South Carolina Department of Health and Environmental Control (SCDHEC). 2023. *Municipal Separate Storm Sewer Systems (MS4s)*. Municipal Separate Storm Sewer Systems (MS4s) | SCDHEC.

South Carolina Department of Health and Environmental Control (SCDHEC). 2023. *Sanitary Sewer Overflows*.

South Carolina Office of Resiliency (SCOR). 2023. *Strategic Statewide Resilience and Risk Reduction Plan*. https://scor.sc.gov/sites/scor/files/Documents/FINAL%20RESILIENCE%20PLAN_06282023_compressed.pdf

Turner, R.E. and Swenson, E. M. 1994. Indicator development for evaluation estuarine conditions. Salt Marsh Technical Narrative (draft final report), Louisiana State University, Baton Rouge, LA.

United States Department of Agriculture. 2024, March 8. Conservation Cover. www.nrcs.usda.gov/sites/default/files/2022-09/Conservation_Cover_327_Overview.pdf

United States Department of Agriculture. 2023, October 2. Forested Watersheds Climate Change Adaptation Menu. https://www.climatehubs.usda.gov/hubs/northern-forests/topic/forested-watersheds-adaptation-menu#:~:text=Taking%20action%20now%20can%20help,a%20 myriad%20of%20other%20benefits.

United States Department of Agriculture. 2023, October 1. *Wetland Mitigation Banking Program*. https://www.nrcs.usda.gov/wetland-mitigation-banking-program .

United States Department of Agriculture. 2022. *Conservation Practice Standard Constructed Wetlands*. Conservation Practice Standard Constructed Wetland (Code 656) (usda.gov)

United States Department of Agriculture. 2024, March 8. *Cover Crops and Crop Rotation*. https://www.usda.gov/peoples-garden/soil-health/cover-crops-crop-rotation

United States Census Bureau. 2024, March. *Data*. https://www.census.gov/data.html

United States Environmental Protection. 2023. Agency Enforcement and Compliance History Online. https://echo.epa.gov/ https://echo.epa.gov/.

United States Environmental Protection Agency (U.S EPA). 2002. Onsite Wastewater Treatment Manual. EPA/625/R-00/008. https://pubs.usgs.gov/fs/2010/3078/pdf/fs20103078.pdf

United States Environmental Protection Agency (U.S EPA). 2002. *Wetland Restoration*. https://nepis.epa.gov/Exe/ZyPDF.cgi/200053Q5.PDF?Dockey=200053Q5.PDF

United States Environmental Protection Agency (U.S EPA). 2017. *Septic Systems Overview*. https://www.epa.gov/septic/septic-systems-overview.

United States Environmental Protection Agency (U.S EPA). 2017. *National Pollutant Discharge Elimination System (NPDES): NPDES Permit Basics*.

United States Environmental Protection Agency (U.S EPA). 2018. *Polluted Runoff: Nonpoint Source Pollution. Nonpoint Source Forestry*. https://www.epa.gov/nps/nonpoint-source-forestry

United States Environmental Protection Agency (U.S EPA). 2019. *Urban Runoff: Model Ordinances for Aquatic Buffers*. https://www.epa.gov/nps/urban-runoff-model-ordinancesaquatic-buffers .

United States Environmental Protection Agency (U.S EPA). 2019. *Welcome to the STEPL and Region 5 Model*. http://it.tetratech-ffx.com/steplweb/.

United States Environmental Protection Agency (U.S. EPA). 2023. *Best Management Practice Efficiency References for the Pollutant Load Estimation Tool*. https://ordspub.epa.gov/ords/grts/r/grtsadm/files/static/v287/BMP%20Efficiency%20References%20Doc%20082023.pdf

United States Environmental Protection Agency (U.S EPA). 2023. *Welcome to the STEPL and Region 5 Model*. https://19january2021snapshot.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl_.html.

United States Geological Survey (USGS). 2010. *Nutrients in the Nation's Streams and Groundwater: National Findings and Implications.* https://pubs.usgs.gov/fs/2010/3078/pdf/fs20103078.pdf.

Upstate Forever (UF). 2019. *Watershed-Based Plan for the Three and Twenty Creek Watershed.* https://scdhec.gov/sites/default/files/media/document/Three%20and%20Twenty%20WBP%202019_FINAL.pdf.

Upstate Forever (UF). 2017. *The Twelve Mile River Blueway*. https://www.upstateforever.org/files/files/TwelveMileBluewayMap.pdf.

APPENDIX A – SCAAS WATER QUALITY MONITORING RESULTS

Station Name	River name	Monitoring groups						
TC-2885	Twelvemile Creek	Cateechee Point, FOLKS Scholarship						
Date	**E. coli (cfu/100ml)**	**pH (Standard Unit)**	**Conductivity (µS/cm)**	**Water Temp (°C)**	**Air Temp (°C)**	**DO (mg/L or ppm)**	**Macro-invertebrate Assessment**	**Stream Habitat Assessment**
5/14/23 16:15	166.67	7	N/A	20	23	7.8	Not available	Not Available
3/31/23 17:30	200	7	N/A	15	18	8.5	Not available	Not Available
2/26/23 15:10	166.67	7	N/A	15	23	7.65	Not available	Good
2/24/23 11:30	400	7	N/A	16.5	26	8.5	Not available	Not Available
1/29/23 11:30	466.67	7	N/A	7.5	12	10.5	Not available	Not Available
12/27/22 2:00	233.33	7	N/A	5	12	11	Not available	Not Available
12/2/22 11:00	700	7	N/A	8	19	9.4	Not available	Not Available
10/25/22 0:00	133.33	7	N/A	13	21.5	8.5	Not available	Not Available
9/29/22 12:00	266.67	7	N/A	15	20	8.3	Not available	Not Available
9/18/22 17:15	166.67	7	N/A	22	24	6.05	Not available	Good
8/24/22 18:00	333.33	7	N/A	25	28	6.2	Not available	Not Available
7/18/22 5:45	166.67	7	N/A	27	30	5.85	Not available	Not Available
6/12/22 16:29	233.33	7	N/A	24	31.5	8.4	Not available	Excellent
# of samples	9							
N >349 #/100mL	**2**							
% >349 #/100mL	**22%**							
Geometric Mean	262.2							
Min Result	133.33							
Max Result	700.0							
Station Name	**River name**	**Monitoring groups**						

REC-0017	RC Edwards Creek	Upstate Master Naturalist Association,Upstate Master Naturalists						
Date	**E. coli** **(cfu/100ml)**	pH **(Standard Unit)**	**Conductivity** **(µS/cm)**	**Water Temp** **(°C)**	**Air Temp** **(°C)**	**DO** **(mg/L or ppm)**	**Macro-invertebrate Assessment**	**Stream Habitat Assessment**
12/5/19 8:25	366.67	7	68	16	23.5	7.95	Fair	Not Available
11/7/19 11:45	866.67	N/A	N/A	N/A	N/A	N/A	Not available	Not Available
10/6/19 15:00	1233.33	N/A	N/A	N/A	N/A	N/A	Not available	Not Available
10/3/19 10:00	2700	N/A	N/A	N/A	N/A	N/A	Not available	Not Available
9/5/19 10:00	1133.33	7	36	20.8	22.8	6.9	Fair	Good
5/2/19 10:00	N/A	7	70	16.9	23.3	9.1	Not available	Not Available
4/4/19 9:45	100	7	68	12.2	18.6	9.7	Not available	Not Available
2/7/19 13:30	N/A	7	68	16	23.5	7.95	Fair	Not Available
12/6/18 9:12	33.33	6.75	N/A	N/A	N/A	10.5	Not available	Not Available
10/4/18 10:00	433.33	7	77	19.7	20.8	N/A	Not available	Not Available
9/6/18 10:00	N/A	N/A	N/A	N/A	N/A	N/A	Fair	Not Available
6/7/18	33.33	7	71	18.9	23.6	7	Fair	Not Available
5/2/18 10:00	N/A	7	70	13.6	16.4	9.1	Not available	Not Available
3/8/18 10:00	N/A	7	75	9	6.7	9.8	Good	Not Available
12/7/17 10:00	N/A	6.75	72	10.6	8.7	9.3	Fair	Not Available
9/7/17 14:21	266.67	7	71	20.7	24	8.3	Good	Not Available
6/1/17 0:00	N/A	N/A	N/A	39.14	N/A	N/A	Good	Not Available
3/9/17 0:00	N/A	6.5	N/A	26.24	11.1	9.2	Poor	Not Available
10/12/16 0:00	200	7	N/A	28.03	12	9	Not available	Not Available
9/3/16 0:00	500	N/A	N/A	N/A	N/A	N/A	Not available	Not Available
8/31/16 0:00	Too Numerous to Count	7	N/A	42.72	28	9.7	Fair	Not Available
# of samples	12							
N >349 #/100mL	**8**							
% >349 #/100mL	**67%**							
Geometric Mean	327.8							
Min Result	33.33							

Max Result	TNTC								

Station Name	River name	Monitoring groups							
PC-0018	Pappy's Creek	Upstate Master Naturalist Association, Upstate Master Naturalists							
Date	E. coli (cfu/100ml)	pH (Standard Unit)	Conductivity (µS/cm)	Water Temp (°C)	Air Temp (°C)	DO (mg/L or ppm)	Macro-invertebrate Assessment	Stream Habitat Assessment	
6/13/18 11:00	100	N/A	N/A	N/A	N/A	N/A	Not available	Not Available	
10/12/16 0:00	100	N/A	N/A	N/A	N/A	N/A	Not available	Not Available	
9/3/16 0:00	5400	7.12	N/A	19.63	24	6.3	Good	Not Available	

# of samples	3
N >349 #/100mL	**1**
% >349 #/100mL	**33%**
Geometric Mean	378
Min Result	100
Max Result	5400

Station Name	River name	Monitoring groups						
1MC-0237	Twelvemile Creek							
Date	E. coli (cfu/100ml)	pH (Standard Unit)	Conductivity (µS/cm)	Water Temp (°C)	Air Temp (°C)	DO (mg/L or ppm)	Macro-invertebrate Assessment	Stream Habitat Assessment
2/10/21 0:00	300	7	40	12.1	17.3	9.5	Not available	Not Available
2/16/20 0:00	366.67	6.88	40	10	7.7	9.65	Not available	Not Available
10/23/19 0:00	433.33	6.88	40	16	15.5	7.7	Not available	Not Available
5/4/19 9:36	633.33	6.88	22	19	20.5	7.7	Not available	Not Available
3/10/19	733.33	7	38	13.5	20	9.35	Not available	Not Available
# of samples	5							

N >349 #/100mL	**4**								
% >349 #/100mL	**80%**								
Geometric Mean	466.69								
Min Result	300								
Max Result	733.33								
Station Name	**River name**	**Monitoring groups**							
TC-3200	Town Creek	FOLKS Scholarship							
Date	**E. coli (cfu/100ml)**	**pH (Standard Unit)**	**Conductivity (µS/cm)**	**Water Temp (°C)**	**Air Temp (°C)**	**DO (mg/L or ppm)**	**Macro-invertebrate Assessment**	**Stream Habitat Assessment**	
4/5/23 9:45	666.67	6	N/A	15	20	8.1	Not available	Not Available	
2/8/23 13:45	100	6	N/A	12	20	8	Not available	Not Available	
7/21/22 0:00	400	6.5	N/A	25	30	6	Not available	Not Available	
# of samples	3								
N >349 #/100mL	**2**								
% >349 #/100mL	**67%**								
Geometric Mean	298.8								
Min Result	100								
Max Result	666.7								

APPENDIX B – STANDARD LOAD REDUCTION NUMBERS AND CALCULATIONS

STANDARD NUMBERS FROM SCDHEC

Estimated Pollutant Loads from Faulty Septic Systems

- Bacteria: 2.76 x10E+6/hr*24*365=2.4176 E+10 per household
- Nitrogen: 31.1lb/yr *(load from one septic tank, per the StepL septic input page)*
- Phosphorus: 12.2 lb/yr

Estimated Pollutant Loads from Cattle

These numbers assume direct input to stream(s) from cattle with stream access, and year-round spring deposition rate (*reference 5)*

- Bacteria 5.4 x E+8 bacteria/day/cow * 365=1.97 x E+11/yr/cow *(reference 5)*
- Phosphorus: 0.004lbs/day/cow * 365=0.73 lbs/yr/cow
- Nitrogen: 0.005lbs/day/cow * 365= 1.83 lbs/yr/cow *(reference 5)*

Estimated Pollutant Loads from Dogs

- 4.09 xE09 bacteria/day

Estimated Fecal Colonies

These numbers are in lbs/animal/day (*reference 4)*

- Chicken (layers): 1.36 x 10E+8
- Turkey: 9.3 x 10E+7
- Hogs: 1.08 x 10E+10
- Horse: 4.20 x 10E+8

Livestock Equivalents

These numbers compare mass of waste produced per day, in PBCE (pasture beef cow equivalents)

- Beef Cow: 1
- Dairy Cow: 2.6
- Horse: 1.1
- Hog: 0.24
- Sheep: 0.04
- Goat: 0.04
- Camel: 0.5
- Llama: 0.5
- Dog: 0.01

Annual FC Bacterial Loading for Livestock Animals

The table below shows the amount of FC bacteria available for deposit on the watershed per individual animal per year (100 % does **not** wash off). (*Reference 10)*

Livestock	CFU/year	Reference
Cow	1.97×10^{12}	Metcalf and Eddy, 1991
Horse	1.53×10^{11}	ASAE, 1998
Hog	3.63×10^{12}	Metcalf and Eddy, 1991; ASAE 1998
Sheep	1.10×10^{13}	Metcalf and Eddy, 1991; ASAE 1998
Hen	4.61×10^{10}	Calculated from fecal waste of chicken (CFU/year) multiplied by hen: chicken mass ratio
Goat	1.10×10^{13}	(Assumed same as sheep)
Chicken	1.39×10^{11}	Metcalf and Eddy, 1991; ASAE 1998

Standard numbers for Pollutant Loading From Land Use

Annual Pollutant Loads by Land Use

Annual pollutant loads by land use (kg/ha-yr) are listed in the table below *(reference 11)*.

Land Use		TSS	TP	TN	Pb	In	Cu	FC
Road	Minimum	281	0.59	1.3	0.49	0.18	0.03	7.10 E+07
	Maximum	723	1.5	3.5	1.1	0.45	0.09	2.80 E+08
	Median	502	1.1	2.4	0.78	0.31	0.06	1.80 E+08
Commercial	Minimum	242	0.69	1.6	1.6	1.7	1.1	1.70 E+09
	Maximum	1,369	0.91	8.8	4.7	4.9	3.2	9.50 E+09
	Median	805	0.8	5.2	3.1	3.3	2.1	5.60 E+09
Single Fam Residential Low density	Minimum	60	0.46	3.3	0.03	0.07	0.09	2.80 E+09
	Maximum	340	0.64	4.7	0.09	0.2	0.27	1.60 E+10
	Median	200	0.55	4	0.06	0.13	0.18	9.30 E+09
Single Fam Residential High Density	Minimum	97	0.54	4	0.05	0.11	0.15	4.50 E+09
	Maximum	547	0.76	5.6	0.15	0.33	0.45	2.60 E+10
	Median	322	0.65	5.8	0.1	0.22	0.3	1.50 E+10
Multi Fam Residential	Minimum	133	0.59	4.7	0.35	0.17	0.17	6.30 E+09
	Maximum	755	0.81	6.6	1.05	0.51	0.34	3.60 E+10
	Median	444	0.7	5.6	0.7	0.34	0.51	2.10 E+10
Forest	Minimum	26	0.1	1.1	0.01	0.01	0.02	1.20 E+09
	Maximum	146	0.13	2.8	0.03	0.03	0.03	6.80 E+09
	Median	86	0.11	2	0.02	0.02	0.03	4.00 E+09
Grass	Minimum	80	0.01	1.2	0.03	0.02	0.02	4.80 E+09
	Maximum	588	0.25	7.1	0.1	0.17	0.04	2.70 E+10
	Median	346	0.13	4.2	0.07	0.1	0.03	1.60 E+10

Pasture	Minimum	103	0.01	1.2	0.004	0.02	0.02	4.80 E+09
	Maximum	583	0.25	7.1	0.015	0.17	0.04	2.70 E+10
	Median	343	0.13	4.2	0.01	0.1	0.03	1.60 E+10

Land Use pollutant load Conversions

- Conversion from kgs to lbs: multiply by 2.2
- Conversion from hectares to acres: multiply by 0.404
- To get lbs/ac/yr, multiply values in the above table by 0.45 then 0.404
- To get number of bacteria/acre-year, multiple values in the table above by 0.404

Appendix B References:

1. STEP_L model
2. Watershed Characterization System References Tab, Septics Tab per Horsley and Whitten 1999
3. USEPA July 2003 National Management Measures for the Control of Nonpoint Pollution from Agriculture
4. EPA-841-B-03-004 ASAE 1998 ASAE Standards 45 edition Standards Engineering Practices Data pp 646 (With EPA Region IV input)
5. University of California Extension Fact Sheet No 25. Manure Loading into Streams from Direct Fecal Deposits
6. http://dnrweb.dnr.state.md.us/watersheds/surf/bmp/swbmp.asp
7. http://rpitt.eng.ua.edu/Publications/4_Stormwater_Characteristics_Pollutant_Sources_and_Land_Development_Characteristics/Stormwater_characteristics_and_the_NSQD/NSQD%203.1%20summary%20for%20EPA%20Cadmus.pdf
8. Mednick A. C. "Development of a Tool for Predicting and Reducing Bacterial Contamination at Great Lakes Beaches." Wisconsin DNR, Oct 2011.
9. Mishra A. et al. "Bacterial Transport from Agricultural Lands Fertilized with Animal Manure". Water Air and Soil Pollution 189:127-134. (2008)
10. http://www.crwr.utexas.edu/gis/gishydro05/Modeling/WaterQualityModeling/BacteriaModel.htm
11. Shaver, Ed, et al "Fundamentals of Urban Runoff: Technical and institutional issues: 2nd edition, 2007

TYPICAL AGRICULTURAL BMP BUNDLE AND BACTERIA REMOVAL CALCULATIONS

Typical Agricultural BMP Bundle: Agricultural BMPs are most often installed in packages, or combinations of multiple BMPs. The SCDHEC Nonpoint Source Management Program 2012 Annual Report outlines several current and past 319 projects for both agriculture and septic BMPs.

Within the Upstate region of South Carolina, there are five completed 319 projects that load reduction calculations focus on which have focused predominantly on either septic or agricultural BMPs. The five projects completed various combinations of agricultural and/or septic BMPs, shown in the table below.

TMDL / 319 Project	Total FC Removal (CFU)	Alt. Water Sources (units)	Controlled Stream Access for Livestock Watering (ft)	Fence (ft)	Water Well (units)	HUA Protection (sq. ft)	Pipe line (ft)	Watering Facilities (units)	Vegetated Riparian Buffers (ac)	Septic System (units)	Streambank and Shoreline Protection (ft)
Rabon Creek	3.87E+13	2	152	3,143		10,918		1	2	43	
Cane/ Little Cane Creek	6.22E+11									17	2,644
Long Cane Creek	2.87E+12	5		3,735		23,491				9	41,916
Twelve Mile Creek	1.34E+14	4		57,122	14	55,391	14,135	44	10		29,267
Tyger River	3.14E+12	19		27,385	5	14,994	15,193			57	27,385
Total	***1.79E+14***	***30***	***152***	***91,385***	***19***	***104,794***	***29,328***	***45***	***12***	***126***	***101,212***

Looking only at the agricultural BMPs, which would include all but the onsite wastewater treatment system projects, there are only a few BMPs that are measured in units: watering facilities, water wells and alternative watering sources. Out of these three BMPs, water wells have the lowest total number of installations. Using this, we can assume that for every one waste well that is installed, there is an average of 1868 feet of fencing, 2138 square feet of heavy use area protection, 599 feet of pipeline, 2 watering facilities, and 0.23 acres of riparian buffer installed. An average agricultural BMP bundle therefore looks like this:

Average Agricultural BMP Bundle:

- 1 well with pump
- 1,686 feet of fencing
- 2,138 square feet of Heavy Use Area protection
- 599 linear feet of waterline
- 1 watering facility
- 0.23 acres of riparian buffer area

<u>Average Bacteria Removal</u>: The SCDHEC Nonpoint Source Management Program 2012 Annual Report contains total fecal coliform removed from all septic and agricultural BMP project combined. To determine the average fecal coliform bacteria one BMP bundle removes it is necessary to separate fecal reductions from septic and agricultural BMPs.

Since the Cane/Little Cane Creek project dealt exclusively with septic projects, we can determine the average bacteria reductions from a septic project.

$$\text{Average Septic Project Fecal Coliform Reductions} = \frac{\text{Total \# Septic Projects Completed}}{\text{Total Fecal Coliform Reduction}}$$

TMDL/319 Project	Total Fecal Coliform Removal (CFU)	Onsite Wastewater Treatment System Projects (units)	Average Fecal Coliform Removed by 1 Septic Project
Cane/Little Cane Creek	6.22E+11	17	3.66E+10

The average septic project fecal coliform reduction can then be used to calculate the average reduction of an agriculture BMP bundle. Since the Rabon Creek 319 project had both septic and agricultural BMPs, we can determine the agricultural reduction by removing the total bacteria removed from septic.

TMDL/ 319 Project	Total FC Removal (CFU)	Alt. Water Sources (units)	Controlled Stream Access for Livestock Watering (ft)	Fence (ft)	Water Well (units)	HUA Protection (sq. ft)	Pipe line (ft)	Watering Facilities (units)	Vegetated Riparian Buffers (ac)	Septic System (units)	Streambank and Shoreline Protection (ft)
Rabon Creek	3.87E+13	2	152	3,143		10,918		1	2	43	

The table above shows all of the projects installed during the Rabon Creek 319 project. Using the calculated average septic reduction, the 43 septic projects removed 1.57E+12 CFU of fecal coliform. Subtracting this number from the total fecal coliform removal gives us the remaining reductions, 3.71E+13 CFU that resulted from agricultural BMPs.

Using the average agriculture BMP bundle calculations from earlier, we can assume that the Rabon Creek 319 funds installed about 2 average agricultural BMP bundles.

TMDL/319 Project	Fecal Coliform Removal from Septic Projects	Remaining Fecal Coliform Removal (total septic removal)	Number of Agricultural BMP Bundles Installed	Average Fecal Coliform Removal from Agricultural BMP Bundles
Rabon Creek	(43*3.66E+10)=1.57 E+12	(3.87E+13-1.57E+12) = 3.71E+13	2	(3.71E+13/2) = 1.86E+13

Dividing the total agricultural BMP removal by the 2 installed agricultural BMPs results in an average fecal coliform reduction of 1.86E+13 CFU per agricultural BMP bundle. Converting this number from FC to *Escherichia coli (E. Coli)*, 1.86E+13 CFU is multiplied by 0.8725 to get 1.62E+13 counts/year.

APPENDIX C – ARCGIS PRO DEEP LEARNING METHODS

Land cover classification analysis

Tab. 1: Data sources used for the land cover change analysis in riparian buffer zones.

NO	Name	Data type	Source
1	National Agriculture Imagery Program (NAIP) Imagery (2011, 2021)	Raster	U.S. Geological Survey
2	Streams data	Polyline	National Hydrography Dataset

Data and methods

High-resolution NAIP imagery (1-meter for 2011, 0.6-meter for 2021) was selected for analysis of the study area in ArcGIS Pro. All image processing and classification, including the accuracy assessment, were completed in ArcGIS Pro. The Deep Learning Image Classification tool was used to complete unsupervised classification on both image sets and detect land use changes over time.

Image preprocessing and classification

All the NAIP imagery for each year was combined into a single raster image for that year in ArcGIS Pro, then clipped to the Twelvemile Creek watershed boundary. Using Deep Learning Image Classification, training samples were manually created for each year, classified into five different classes: forested; barren/non-forested; urban; pasture/grassland/cultivated crops; and water. A minimum of 500 training polygons were delineated for each land cover classification except for barren/non-forested, which received fewer training samples due to limited identification of that land cover type. Once a satisfactory number of training samples were created for each year, the *Train Deep Learning Model* tool and *Classify Pixels Using Deep Learning* tool were used to train the model and then perform the land cover classification for the entire image. Accuracy assessment was completed for each year in ArcGIS Pro. The land use change detection over ten years was obtained by comparing the land cover classification of the years 2011 and 2021. Finally, the change was expressed by classifying the area into forested and non-forested land cover.

Tab. 2. The percentage of the user's and producer's overall kappa statistics for the land cover classification

	2011		2021	
Land cover category	User's accuracy	Producer's accuracy	User's accuracy	Producer's accuracy
Forested	99.71	98.29	99.44	99.44
Urban	79.41	71.05	93.94	96.88
Barren/Non-forested	100.00	52.63	86.96	100.00
Pasture/Grassland/Cultivated Crops	96.23	98.08	100.00	95.70
Water	40.00	100.00	100.00	100.00
Overall accuracy	89.07		97.13%	

APPENDIX D – WATERSHED SEPTIC SYSTEM SUITABILITY ANALYSIS

Septic tank analysis:

Table 1: Data sources used in the septic system suitability analysis.

NO	Name	Data type	Source
1	Sewer system lines	Polyline	Pickens County
2	Streams data	Polyline	National Hydrography Dataset
3	Improvements data	Point	Pickens County
4	Parcels polygon	Polygon	Pickens County
5	Administrative boundary (Pickens, Easley, Central, Liberty, Clemson)	Polygon	U.S. Census
6	Soil Suitability	Polygon	NRCS SSURGO Database

Assumptions:

1. All buildings within 500 feet of sewer system have been assigned as on sewer.
2. All buildings within the administrative boundaries of the cities of Pickens, Easley, Central, Liberty, and Clemson were labeled as being served by sewer.
3. Buildings classified as outbuildings, sheds, or similar were assumed to not be connected to septic systems and were removed from analysis.
4. Less than 300 feet to the stream is a distance that septic leachate could cover, given that this buffered area likely includes the adsorption field.

Mapping the Septic Tank Absorption Fields based on SSURGO data

Description of Septic Tank Absorption Fields

Septic tank absorption fields describe the areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. In this evaluation, only the soil between depths of 24 and 60 inches is evaluated. The ratings were based on the soil properties that affect absorption of the effluent, construction, and maintenance of the system, and public health. Saturated hydraulic conductivity (Ksat), depth to a water table, ponding, depth to bedrock or a cemented pan, and flooding affect absorption of the effluent. Stones and boulders, ice, and bedrock or a cemented pan interfere with installation. Subsidence interferes with installation and maintenance. Excessive slope may cause lateral seepage and surfacing of the effluent in downslope areas (NRCS).

The ratings classes of Septic Tank Absorption Fields:

1. **Not limited** indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected.
2. **Somewhat limited** indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected.
3. **Very limited** indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Data sources used in this analysis include:

- Parcel map of Pickens County;
- Improvements map of Pickens County containing year built/age of structures;
- Sewer service lines provided by Pickens County;
- Administrative boundary maps of cities with municipal sewer: Pickens, Easley, Central, Liberty, and Clemson (data from U.S. Census);
- Natural Resource Conservation Service (NRCS) SSURGO Database.