Lower Twelve Mile, Eighteen Mile, and Golden Creek

Watershed Based Plan

Developed by:

Pickens County Beautification & Environmental Advisory Committee

Submitted to:

South Carolina Department of Health and Environmental Control

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Acknowledgements

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Project Cooperators & Partners

- Pickens County Beautification and Environmental Advisory Committee
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INTRODUCTION

A watershed refers to an area of land which drains to a stream, lake, or river. Watershed land use affects the quality of their receiving water bodies. Healthy watersheds help in protecting water quality and also providing benefits to the people and wildlife living in them. These benefits are the primary objectives of the South Carolina Department of Health and Environmental Control (SCDHEC) and the United States Environmental Protection Agency (US EPA). Through monitoring and management, federal and state agencies establish regulatory mechanisms such as Total Maximum Daily Loads (TMDL) to quantify load reductions necessary to meet water quality standards. These pollutant restrictions provide a basis for maintaining healthy watersheds that can be properly utilized for their maximum benefits. It is this concept and concern that brought forth the compilation of data and analysis of this watershed based plan. The Lower Twelve Mile, Eighteen Mile, and Golden Creek Watershed Based Plan (WBP) focuses exclusively on quantification and reduction of *Escherichia coli* (*E.coli*) as the sole impairment of concern

The Clean Water Act established in 1972 requires surface waters to be monitored and regulated for specific quality standards and with the goal of minimizing the amount of pollutant loading; therefore minimizing detrimental health and ecological effects. Regulated by US EPA, states are required to assess water quality, identify polluted surface waters, implement pollutant load regulations and see that the regulations are followed. By monitoring Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds it was determined that the pollutant loads within each were 39-69% above the permissible level, resulting in bacterial impairment.

To address stream impairments, Pickens County Beautification & Environmental Advisory Committee, Clemson Extension, and dedicated project partners collaborated to establish and develop a management plan with the goal to reduce *E.coli* levels within the watersheds and meet SCDHEC water quality standards for Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds of the Upper Savannah River Basin. By providing an extensive evaluation and analysis of the potential point and non-point bacterial pollutants within the watershed, this watershed based plan will provide insight and best management strategies of reducing pollutants in critical areas to enhance quality of restoration and water quality management. Furthermore, this watershed based plan will present strategies to acquire funding for mitigation efforts, as well as establish a plan for community outreach to promote public knowledge and involvement.

GENERAL WATERSHED DESCRIPTIONS

Basin Summary

This watershed based management plan targets three subwatersheds of the Seneca River (Hydrological Unit Code: HUC 03060101). The Seneca River watershed is contained within the upper portions of the Savannah River Basin, and is located within Oconee, Anderson, and Pickens counties of South Carolina. The watershed is composed of 12 subwatersheds and travels over 1,269 square miles within the borders of South Carolina. For the purpose of this watershed based plan, our concerns and efforts are focused on three subwatersheds of the Seneca River: Lower Twelve Mile, Eighteen Mile, and Golden Creek which

encompass 69,165 acres total and their HUCs are mentioned in Table 1 (obtained from (South Carolina Watershed Atlas).

Table 1: HUC codes of the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	12-digit Hydrological Unit Code (HUC)
Lower Twelve Mile	030601010408
Eighteen Mile (Upper)	030601010601
Eighteen Mile (Lower)	030601010602
Golden Creek	030601010406

Location

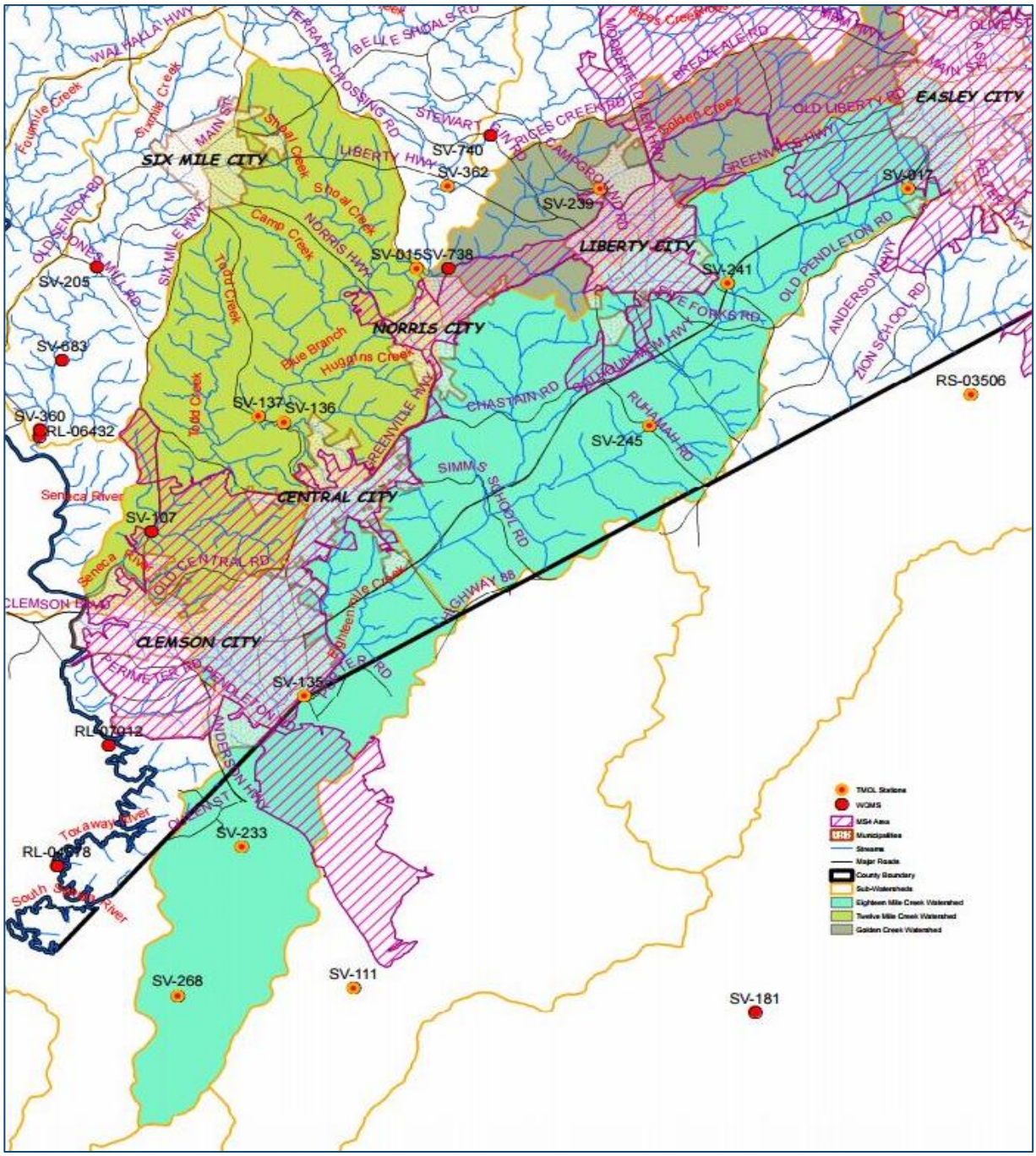
The three watersheds located in the Piedmont Ecoregion of South Carolina, mostly within the Pickens and Anderson counties, are similar in characteristics and land use.

Eighteen Mile creek originates near the southwest portion of Easley, SC and travels southwest along Highway 123. It flows through the towns of Liberty, Norris, Central, and Pendleton, eventually flowing through Fant's Grove Wildlife Management Area and ending in Lake Hartwell.

Golden Creek originates near the western portion of Easley, SC and flows southwest along the eastern edge of the Eighteen Mile creek and eventually converges into the main stream of the Lower Twelve Mile creek at the confluence located north of the town of Norris. The watershed includes portions of the cities of Easley and Liberty and the town of Norris.

The Lower Twelve Mile creek begins at the confluence where Golden Creek joins Twelve Mile creek located north of the town of Norris. The creek travels southwest to eventually flow into an arm of Lake Hartwell. The cities of Easley, Liberty, Central and Clemson along with the towns of Six Mile and Norris are located within the watershed.

Figure 1: Map depicting the area encompassed by Lower Twelve Mile, Eighteen Mile and Golden Creek watersheds



Overview of Watershed Flow Area

Understanding the land characteristics within impaired watersheds is key in determining how land-use affect water quality. This also helps in figuring out solutions that can be implemented, keeping in the mind the objective to satisfy multiple uses and needs.

The three watersheds encompass approximately 69,169 acres total with Lower Twelve Mile, Eighteen Mile, and Golden Creek covering 20,818.03 acres, 38,104 acres, and 10,242.64 acres respectively. Using year 2015 data from the National Hydrography dataset, the miles of stream and river flow as well as total flowlines (artificial paths and streams/rivers) for the three watersheds were determined and can be seen below (Table 2).

Table 2: National Hydrography data (2015) depicting overview of watershed flow area (in miles)

Subwatersheds	Streams and Rivers	All Flowlines
Golden Creek	33.74	34.28
Lower Twelve Mile Creek-Keowee River	70.95	87.99
Eighteen Mile Creek	121.26	136.96
Total (all 3 watersheds)	225.95	259.23

Geographic Information System (GIS)

Spatial data was retrieved from various sources, including ESRI (GIS company: http://www.esri.com/), United States Geological Survey (USGS), United States Department of Agriculture (USDA), and the United States Census Bureau. Data was processed using ESRI ArcGIS 10.3.1 software. Queries, clips, and reclassifications were completed using spatial analysis tools available in ESRI's ArcToolbox.

Land Use and Population

Although the three watersheds, Lower Twelve Mile, Eighteen Mile and Golden Creek, are adjacent to one another, land usage influenced by the local economy, residential areas, and parks (Figure 2). Three major categories of land use were taken into consideration: forested, developed and agricultural land. Forested area land use type is the dominant land class cover for all three watersheds, ranging almost 50% for each (Table 3). Golden Creek and Eighteen Mile watersheds are centrally located and surrounded by developing cities, towns, and neighborhoods.

The figure below (Figure 2) depicts a full categorization of land cover types along with road infrastructure for all three watersheds.

Figure 2: Depiction of land cover classes in the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

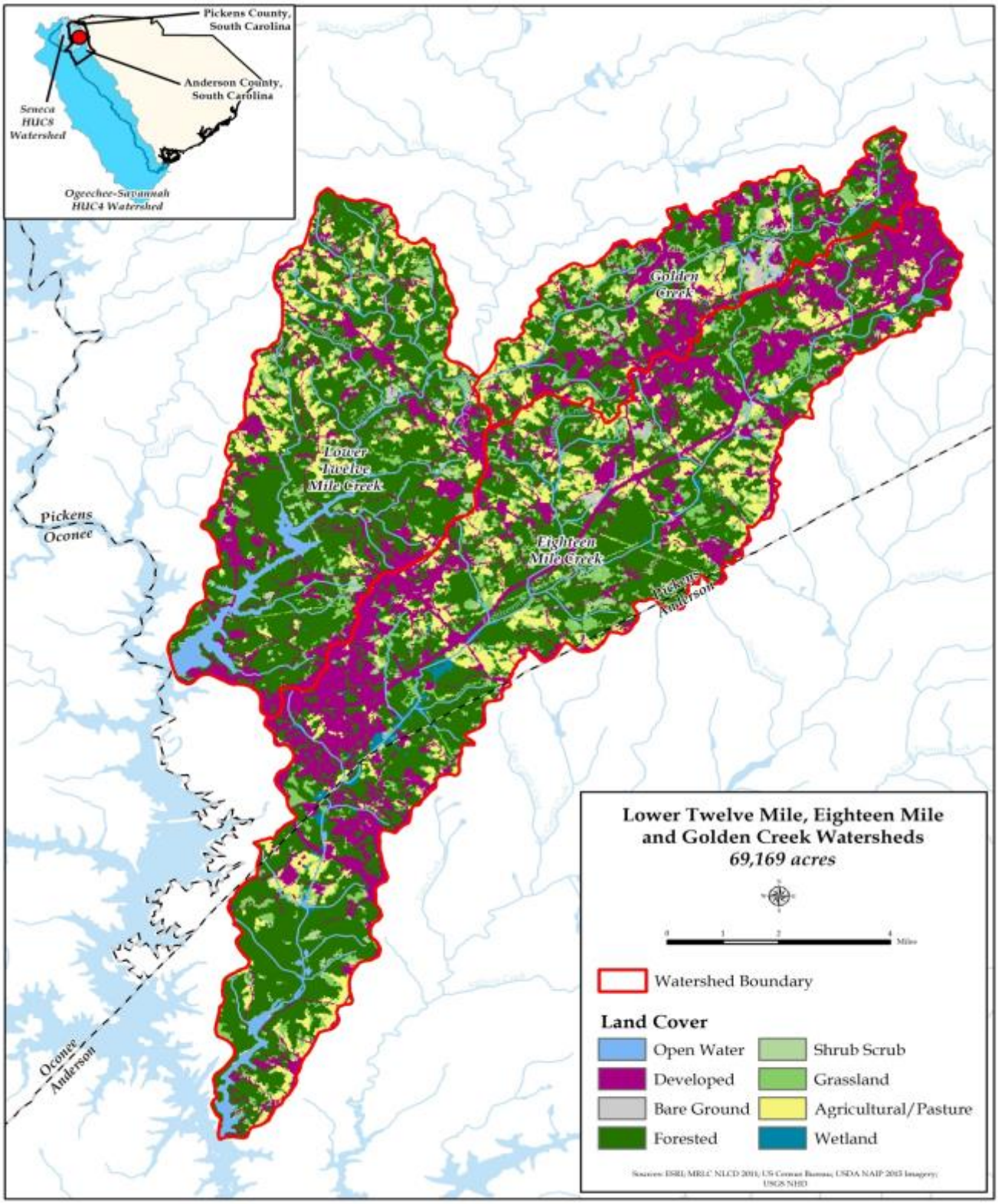


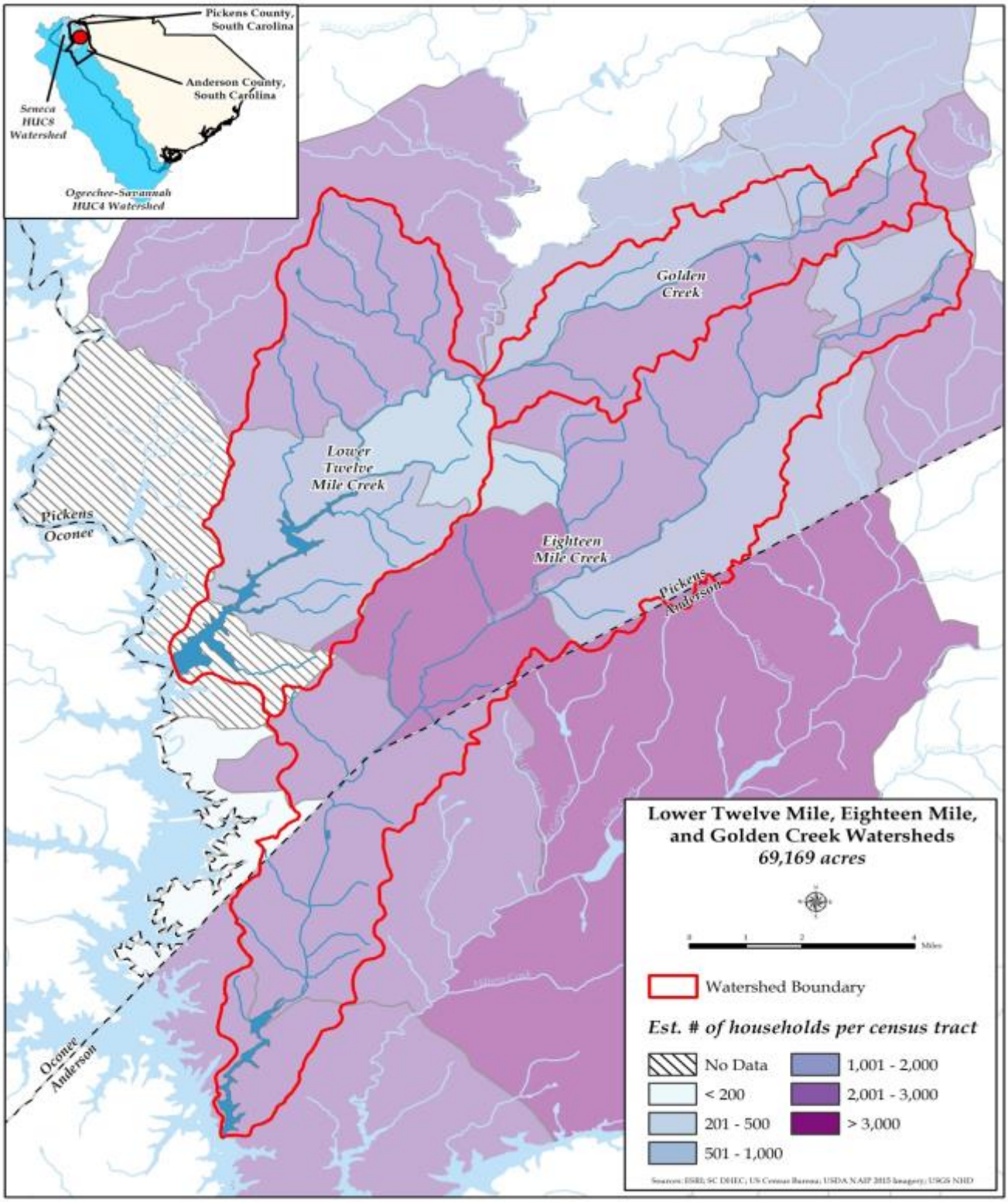
Table 3: A summary of National Land Cover Database (NLCD) 2011 and Multi-Resolution Land Characteristics (MRLC) Consortium data showing the summarized statistical acreages and percent class cover of the three dominant types within the three watersheds.

Subwatersheds	Class	Area (ac)	Percent
Golden Creek	Forested	4268	42
	Developed	2753	27
	Planted	1367	13
Lower Twelve Mile	Forested	11827	57
	Developed	3409	16
	Planted	2382	11
Eighteen Mile	Forested	18197	48
	Developed	9880	26
	Planted	4350	13
Total	Forested	34393	50
	Developed	16042	23
	Planted	8098	14

Statistics gathered from the U.S. Census Bureau, for the regions within Pickens and Anderson Counties, determined that the three watersheds: Lower Twelve Mile, Eighteen Mile, and Golden Creek had populations of 6,418, 6,475, and 27,426 respectively in 2010. In total there are approximately 40,319 people within the 69,169 acres of the three watersheds. If we assumed an even distribution, the average population density would be approximately 373 people per square mile. A general idea of population density can be understood by looking at the map depicting number of households within the watersheds (Figure 3).

Forested land cover dominates in comparison to developed land use areas by a minimum of 14.8 % on each of the three watersheds (Table 2). However, being centrally placed between major highways (SC 93, SC 153, SC 123, I-85, and US 76 corridor) and other larger cities, such as Easley and Clemson, the road infrastructure provides a suitable mean for residential, commercial, and industrial expansion.

Figure 3: Household density in the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds



WATER QUALITY ASSESSMENT

Water Quality Impairments and Sources

Stormwater runoff occurs when impervious or saturated surfaces such as sidewalks and roads, reduces the levels of water infiltration. As the amount of water and speed escalates across the surface of the land, the pollutant load continues to increase. Stormwater pollutants include sediment, excess nutrients, bacteria, debris, and household waste (e.g. domestic pet waste). Without sources of filtration, these non-point pollutants enter nearby waterbodies and have the ability to degrade entire watershed systems if not promptly assessed and controlled. Stormwater runoff is the primary source of pollution impacting water quality in this region.

In order to reduce diminishing habitat quality and hazardous health possibilities, US EPA requires regular monitoring of waters within each state. Under section 303(d) of the Clean Water Act, once a watershed has been determined impaired by pollutants, a TMDL assessment must be conducted to determine the sum of pollutants within the watershed. Once the amounts of pollutants are determined, levels of pollutant reduction must be established to meet the watershed's specified level for adequate water quality to support full usage of the water body.

In South Carolina, there is an overwhelming majority of impairments to surface waters due to bacterial pathogens. *E.coli* is bacteria found in the intestinal tracts of warm blooded animals. Although generally non-threatening to human health, the presence of *E.coli* is an indicator that other pathogens, bacteria, viruses, and parasites may be present in the water. These may have the potential for negative impacts on the habitat's fauna and flora including humans. Hence, monitoring stations have been strategically placed throughout the three watersheds: Lower Twelve Mile, Eighteen Mile, and Golden Creek to monitor levels of *E.coli* based on the US EPA standards.

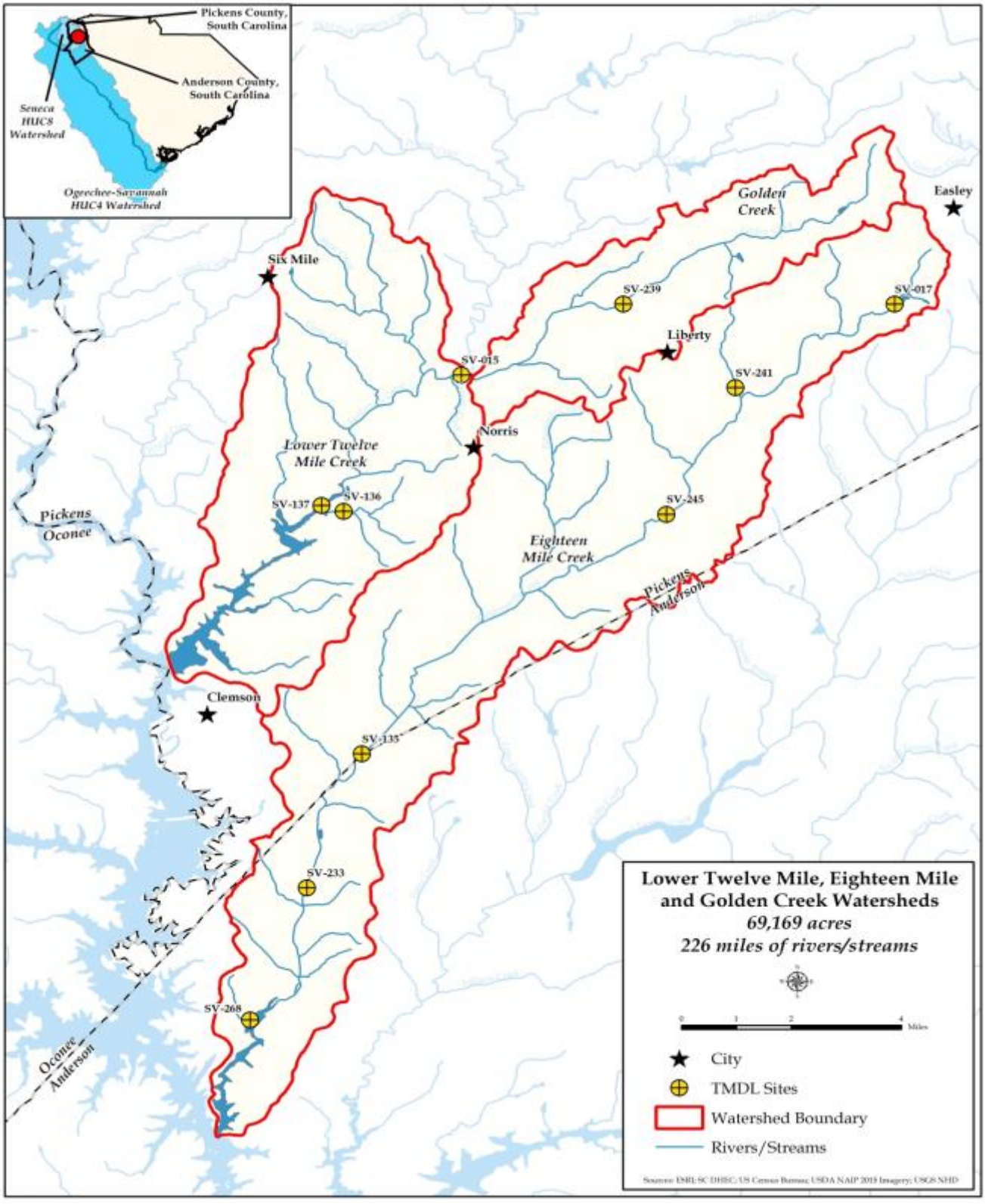
Water Quality Monitoring Stations

Of the total 69,169 acres of the three watersheds, there are currently ten strategically placed water quality monitoring stations: three located in Lower Twelve Mile, six in Eighteen Mile, and one in Golden Creek watershed (Table 4). The data from these stations, have been collected and analyzed by SC DHEC from 2002-2016.

Table 4: Locations of the 10 Water Quality Monitoring (WQM) Stations and the watersheds in which they are strategically sited

Subwatersheds	SCDHEC WQM Station	WQM Station Location	Ambient Surface
Eighteen Mile Creek	SV-017	Eighteen Mile Creek at unnumbered county Rd. 2.25 mi. SSW of Easley	Current
Eighteen Mile Creek	SV-245	Eighteen Mile Creek at S-39-27 3.3 Mi. S of Liberty	Current
Eighteen Mile Creek	SV-135	Eighteen Mile Creek at S-39-93 SW of Central	Current
Eighteen Mile Creek	SV-233	Eighteen Mile Creek at 2-04-279	Current
Eighteen Mile Creek	SV-268	Lake Hartwell Eighteen Mile Creek BR at 2-04-1098	Current
Eighteen Mile Creek	SV-241	Woodside Branch at US 123 1.5 Mi. East of Liberty	Current
Twelve Mile Creek	SV-137	Twelve Mile Creek at S-39-337	Current
Twelve Mile Creek	SV-136	First Creek after leaving Central at CLVP on Maw Bridge	Historic
Twelve Mile Creek	SV-015	Twelve Mile Creek at S-39-51 N of Norris	Current
Golden Creek	SV-239	Golden Creek at S-39-222 1.2 Mi. NW of Liberty	Current

Figure 4: Map of Lower Twelve Mile, Golden, and Eighteen Mile Creek watersheds and the locations of each Water Quality Monitoring Station



Implications of Clean Water Act Section 303(d)

Bacteria levels can be elevated in natural waterbodies resulting from both point and nonpoint sources. Section 303(d) of the Clean Water Act requires states and territories to develop total maximum daily loads for those waterbodies not meeting designated use standards. Until 2012 South Carolina used Fecal Coliform (FC) as the bacterial indicator for evaluation of water quality in freshwater systems. The water quality standard used for FC was a concentration of 400 colony forming units (CFU's) per 100 milliliters (ml) of water for any single sample, or a 30-day geometric mean of 200 counts per 100 ml. Exceeding this standard more than 10% of the time would be considered unsafe for recreational purposes (*http://sc.water.usgs.gov/publications/abstracts/fs085-98.html).* Monitoring sites that are considered impaired would be placed in SCDHEC's 303 (d) list.

Since *E.coli* is considered by USEPA to be a more accurate measure of fecal contamination, SCDHEC switched from FC to *E.coli* as an indicator in 2012. The current standard followed by South Carolina states that *E.coli* concentration should not exceed 349 MPN/ 100 ml with a geometric mean of 126 MPN/100 ml (over 30 days). Based on this revised standard, FC TMDLs written prior to 2012 are converted to *E.coli* TMDLs by multiplying FC TMDL number by a conversion factor of 0.8725. This number is a ratio of Water Quality Standard (WQS) for *E.coli*, 349 MPN/100 ml and WQS for FC, 400 CFU/100 ml (SCDHEC 2012).

The Lower Twelve Mile, Golden Creek, and Eighteen Mile Creek are classified as freshwater systems. These subwatersheds are generally used for primary and secondary recreation, drinking water supply, agricultural and industrial utilization. A total of 32.4 stream miles within the 3 subwatersheds have been declared impaired for their designated use resulting from bacterial loading. Since ambient monitoring began in 1999, elevated levels of *E.coli* have contributed to the degradation of Lower Twelve Mile, Golden, and Eighteen Mile subwatersheds. Ten bacteria TMDLs were written to correspond with reaches associated with each of the SCDHEC monitoring stations. At present, eight of the TMDLs are "not supported", while the remaining two (SV-015 and SV-137) have achieved water quality standards and are thus considered "fully supported."

Table 5 (a) summarizes data from US EPA's water quality STOrage and RETrieval (STORET) data files for calculations on the presence and abundance of bacteria (both FC and *E.coli*) within the three watersheds as measured at each monitoring station. The numeric outputs as shown in the table, support both the original 303(d) placement and subsequent TMDL development. Table 5 (b) summarizes more recent *E.coli* data for these monitoring stations provided by SCDHEC.

Table 5 (a): STORET data file summaries of fecal coliform levels (1999-2012) for each of the 10 Water Quality Monitoring Stations

Station	Subwatersheds	Sample Years	Avg Sample* (MPN/100 ml)	Percent Exceedances	Highest Sample * (MPN/ 100 ml)
SV 015	Lower Twelve Mile	1999-2008	256	10	750
SV 136	Lower Twelve Mile	1999-2008	435	13	6980
SV 137	Lower Twelve Mile	1999-2008	289	11	5,671
SV 239	Golden Creek	1999-2008	160	27	750
SV 268	Eighteen Mile	1999-2012	414	24	3752
SV 233	Eighteen Mile	1999-2012	679	44	12,215
SV 135	Eighteen Mile	1999-2005	537	56	1309
SV 245	Eighteen Mile	1999-2005	794	30	7591
SV 241	Eighteen Mile	1999-2006	533	17	5933
SV 017	Eighteen Mile	1999-2007	2473	46	32,283

* CFU/100 ml values have been converted to MPN/100 ml (for *E. coli*) by multiplying with 0.8725 (SCDHEC 2012).

The most important calculations in the table above involve the percent exceedances of the daily average (349 MPN/100 mL) standard. All stations experienced a range between 10-56% exceedance in *E.coli* levels with the highest samples ranging between 750 -56,713 MPN/100 mL.

Table 5 (b): SCDHEC data file summaries of *E.coli* levels for each of the 10 Water Quality Monitoring Stations (2002-2016).

Station	Subwatersheds	Sample Years	Avg Sample* (MPN/100 ml)	Percent Exceedances	Highest Sample * (MPN/ 100 ml)
SV 015	Lower Twelve Mile	2007-2010	197	8	570
SV 136	Lower Twelve Mile	2005-2010	480	23	8000
SV 137	Lower Twelve Mile	2003-2016	409	21	6500
SV 239	Golden Creek	2005-2010	607	23	6400
SV 268	Eighteen Mile	2003-2016	479	31	4300
SV 233	Eighteen Mile	2002-2016	776	57	14,000
SV 135	Eighteen Mile	2005	493	50	1400
SV 245	Eighteen Mile	2005	1098	25	8700
SV 241	Eighteen Mile	2005	673	17	6800
SV 017	Eighteen Mile	2005	3988	50	37000

The WQM stations experienced a range between 8-57% exceedance in *E.coli* levels with the highest samples ranging between 570 – 14,000 MPN/100 mL.

POLLUTION SOURCES

Bacterial pollution is directly attributable to both point (waste load allocation) and nonpoint sources (load allocation) within the subwatersheds. Table 6 lists potential sources within the drainage areas and include agricultural land uses, wastewater effluent, urban runoff and various warm-blooded wildlife.

Table 6: Potential sources of bacterial pollution in Lower Twelve Mile, Golden Creek and Eighteen Mile Creek watersheds

Source	Specific examples
Agriculture	Cattle, horses, goats, chicken, Cropland Manure Management
Wastewater	Septic tanks, Wastewater treatment plants
Urban	Stormwater runoff, domestic pets
Wildlife	Deer, waterfowl, beavers, geese, feral hogs

While point sources are readily associated with a direct discharge from such physical operations as wastewater treatment facilities or factories, nonpoint source pollution generally comes from diffuse sources. When rainfall moves over the ground surface, it picks up and transports directly into the receiving waterbody (US EPA, 2013). For the Lower Twelve Mile, Eighteen Mile, and Golden Creek and watersheds

Point Sources of Pollution

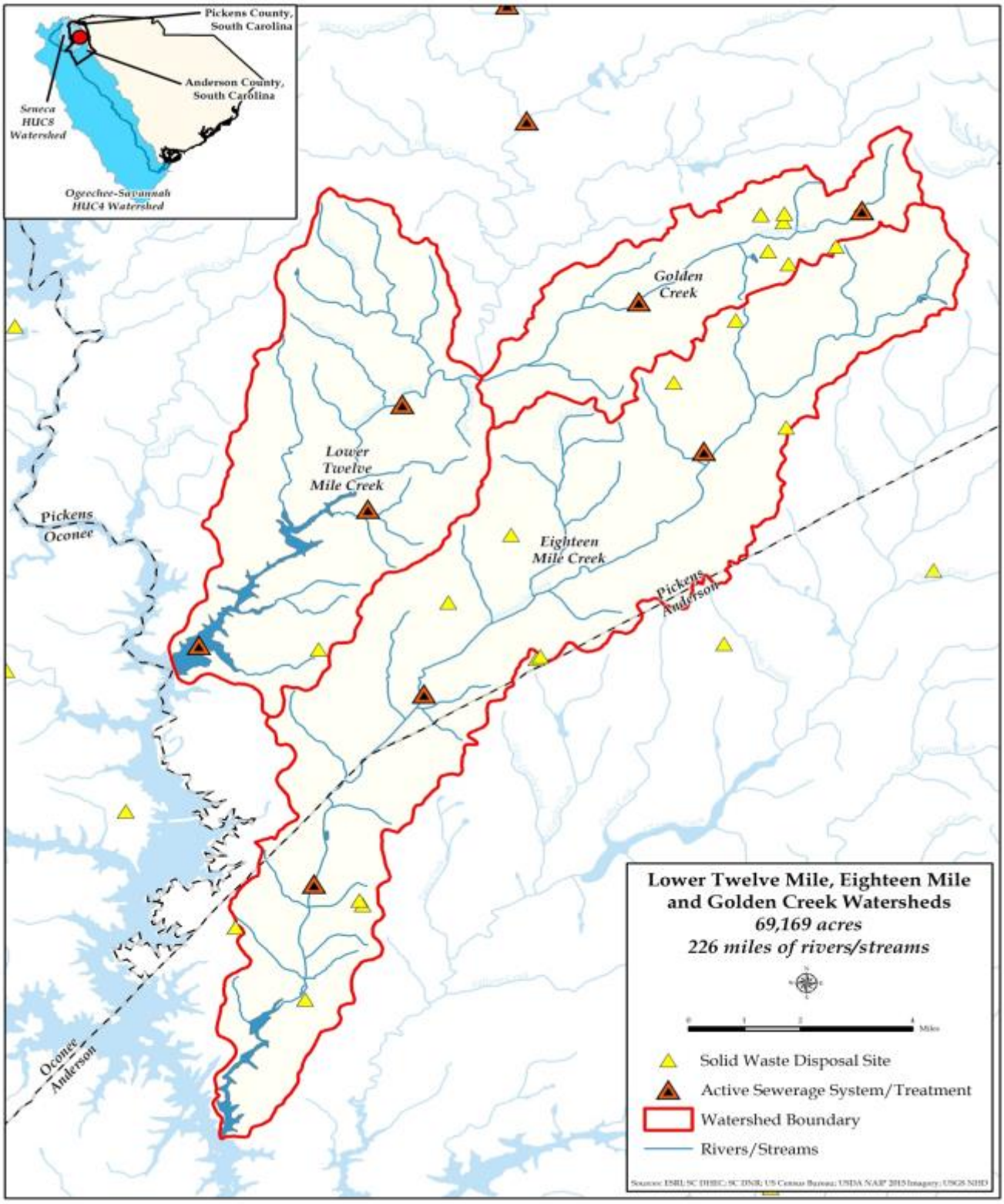
Environmental and human health necessitate the presence and full functionality of wastewater treatment facilities. The National Pollution Discharge and Elimination System (NPDES) requires water treatment facilities to ensure treated effluent does not contaminate free flowing waters. Nevertheless, problems within the wastewater treatment facility may arise from excess runoff, pipe blockage or breakage, or construction activities.

Lower Twelve Mile, Golden Creek and Eighteen Mile watersheds contain 20 NDPES facilities permitted to discharge bacteria. Table 7 provides the names, locations, and type (domestic or industrial) of each facility and Figure 5 shows the locations of solid waste disposal and wastewater treatment facilities. Permitted flows range from 0.008 to 2 million gallons per day (MGD). Four of the locations do not have a specified allowable flow limits, and only required to measure and report (MR) their flow. In South Carolina, NPDES permittees must meet the same state criterion for *E. coli* bacteria at the point of discharge (i.e., daily maximum concentration of 349 MPN/ 100 ml with a geometric mean of 126 MPN/100 ml (over 30 days)

Table 7: Active NPDES facilities permitted to discharge bacteria into waterbodies of the Twelve Mile, Eighteen Mile and Golden Creek watersheds

Twelve Mile and Golden Creek		
Creek Name	**Facility Name**	**NPDES # and Type**
Rices Creek	Alice MFG/Foster + ELLJEAN PLT	SC0000370 Minor Industrial
Twelve Mile Creek	Pickens County Stockade WWTF	SC0047899 Minor Domestic
Lake Hartwell/Twelve Mile Creek Arm	City of Clemson/Cochran Rd WWTP	SC0020010 Major Domestic
Lake Hartwell/Twelve Mile Creek Arm	RC Edwards Jr. High School	SC0028762 Minor Domestic
Lake Hartwell Tributary	Christoff Construction CO./Isaqueena Villiage	SC0023141 Minor Domestic
Huggins Creek & Twelve Mile Creek	Shaw Industries Group/Clemson	SC0000302 Major Industrial
Twelve Mile Creek	Cateechee Villiage Inc. WWTP	SC0022012 Minor Domestic
Twelve Mile Creek Tributary	Pickens County PSC/Central/North Plant	SC0024996 Minor Domestic
Golden Creek	Pickens County - Liberty/Roper Lagoon	SC0026191 Minor Domestic
Golden Creek	Vulcan Construction Materials/Liberty	SCG730065 Minor Industrial
Pike Creek	American House Spinning	SC0000132 Minor Industrial
Golden Creek Tributary	Imperial Die Casting Corp.	SCG250169 Minor Industrial
Golden Creek Tributary	Pickens County/Training facility mine	SCG731111 Minor Industrial
Eighteen Mile Creek		
Creek Name	**Facility Name**	**NPDES # and Type**
Eighteen Mile Creek	Milliken & Co./Pendleton Finishing	SC0000477 Major Industrial
Eighteen Mile Creek	Town of Pendleton-Clemson Reg. WWTP	SC0035700 Major Domestic
Eighteen Mile Creek	Pickens County/18mile Ck Upper Reg. WWTP	SC0042994 Major Domestic
Eighteen Mile Creek	Pickens County/18mile Ck Middle Reg. WWTP	SC0047856 Major Domestic
Eighteen Mile Creek Tributary	Heatherwood SD/Madera Util.	SC0029548 Minor Domestic
Eighteen Mile Creek Tributary	Easley Custom Plastics Inc.	SCG250077 Minor Industrial
Woodside Branch	Liberty Denim LLC.	SC0000264 Major Industrial

Figure 5: Depiction of solid waste disposal sites and active sewage system sites in the Twelve Mile, Eighteen Mile and Golden Creek watersheds



Non-Point Sources of Pollution

Non-point source pollutants result from indeterminate areas. Many of these pollutants arise from agricultural practices, domestic pets, and wildlife. Each of the three watersheds of concern in this management plan is predominantly forested, and contain between 11.44 and 13.55 % cultivated land. As it becomes difficult to address wildlife populations directly, this plan will focus on generating awareness on pollution that can be caused by nuisance wildlife, agricultural activities and domestic pets.

Septic Systems

Septic systems have been important in controlling the levels of *E.coli* waste into the environment from individual households; hence reducing the probability of bacteria-induced health problems. In 2007, one in every four households within the United States used an onsite septic system. Most individual onsite septic systems are used throughout rural and sub-rural areas, which is a prevalent land cover class in the three watersheds of concern in this management plan.

US EPA data states that approximately 40% of South Carolina residents have onsite septic systems; of these systems 10-30% are failing to some degree due to misuse, age, or lack of proper maintenance and checks. By taking the mean of failing systems (20%) and applying the number of households for each watershed, the number of failing septic systems was determined as seen below (Table 8).

Table 8: Approximate number of households likely to be experiencing onsite septic system failure as obtained through US EPA and US Census Bureau statistics

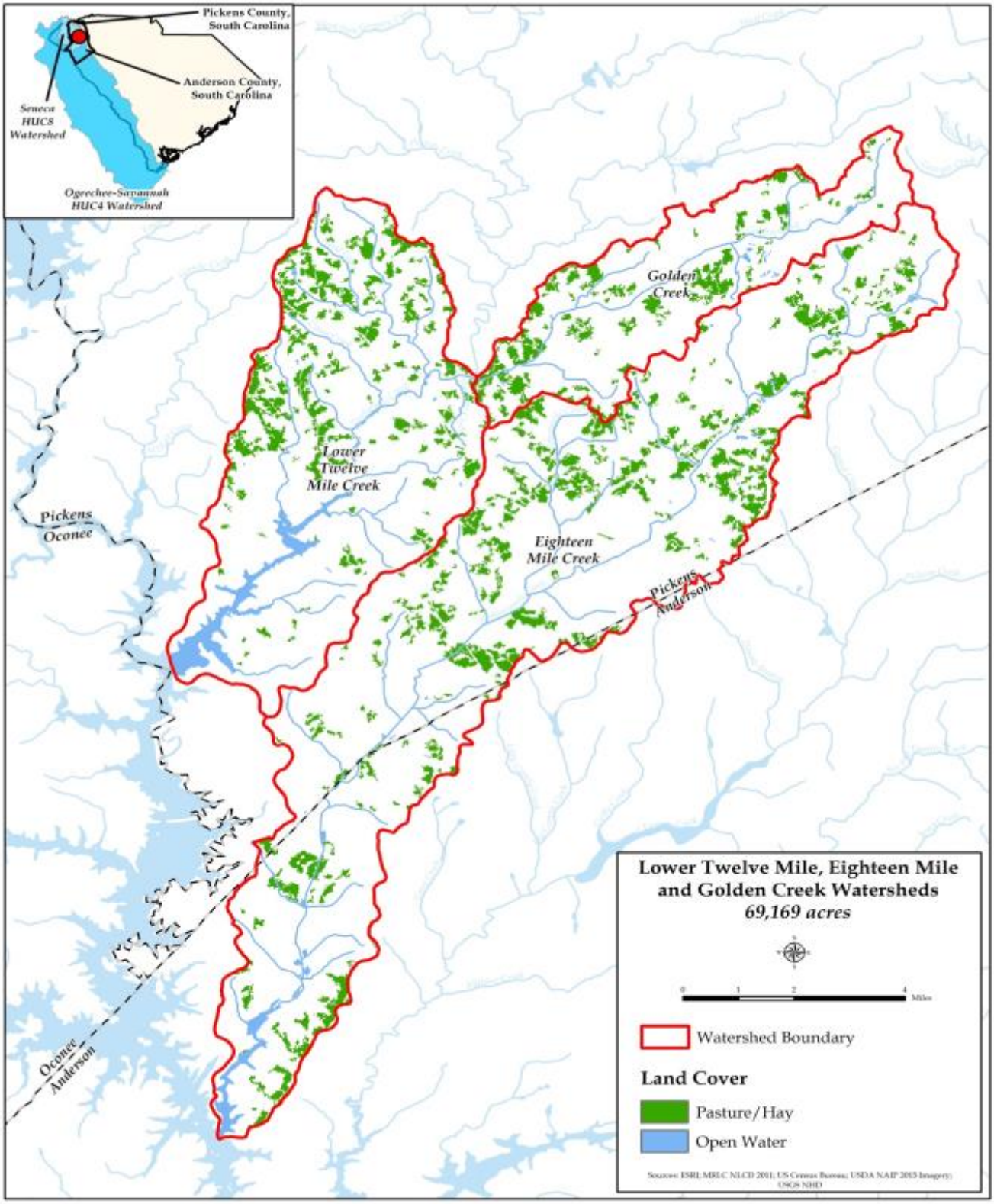
Subwatersheds	# Households	# Households with Onsite Septic systems	# Households with Failing systems
Lower Twelve Mile	2373	949	190
Eighteen Mile	12285	4914	983
Golden Creek	2836	1134	227
Total	*17494*	*6997*	*1399*

Agriculture and Livestock

While considering agricultural practices, livestock is the key component that can impact watershed systems. In terms of *E.coli*, livestock contributes to water degradation via stream and other waterways that are utilized by the livestock. Also, the use of livestock manure as fertilizer on agricultural fields has a high potential to influence water bodies. When rain events occur, the excrements may get washed down sloping hills into water bodies, affecting not only the area of impact but also areas downstream.

The figure below (Figure 6) shows the cultivated/pasture land area within and around the three watersheds.

Figure 6: Map depicting cultivated/pasture land area in the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds



Using 2012 agriculture census data, the number of livestock per watershed was determined as can be seen below (Table 9).

Table 9: Number of livestock located within each watershed calculated via U.S. Department of Agriculture (USDA) census

Creek Name	Cattle	Swine	Horses	Poultry
Lower Twelve Mile	410	24	88	167
Eighteen Mile	1058	51	140	254
Golden Creek	201	12	43	82

The United States Agriculture Waste Management Field Handbook was used to determine the approximate levels of waste for livestock, seen below (Table 10), which was then calculated to determine total amounts (lbs) of waste produced per livestock/day in each watershed (Table 11).

Table 10: Total amount (lbs) of waste produced per animal/day in the three watersheds; data collected from the U.S. Agricultural Waste Management Field Handbook

Livestock	Waste (lb)/animal/day
Cattle	120
Swine	15
Horse	57
Poultry	74

Table 11: Total amount (lbs) of livestock waste produced within each watershed/day

Creek Name	Cattle	Swine	Horses	Poultry
Lower Twelve Mile	49200	355.2	5016	12358
Eighteen Mile	126960	754.8	7980	18796
Golden Creek	24120	177.6	2451	6068

Domestic pets

Domestic pets are considered as an increasingly important contributor to *E.coli* levels, particularly originating in urbanized areas where impervious surfaces transport the waste into streams. From land use data, Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds have a developed land percentage of 16.36%, 24.87 %, and 26.86 % respectively with patterns of increased urbanization of all watersheds within the future years.

Using the total number of households within each of the watersheds and a formula that was developed by the American Veterinary Medical Foundation (shown below), it was estimated that a total of 10,216 dogs live within the three watersheds. While using this formula it is kept into account that the national percentage of dog-owning households is 36.5% and the national average of dogs per home is 1.6. According to US EPA, on average a dog will produce 274 pounds of waste per year or 0.75 pounds of waste per day. The following formulas listed below were used to calculate the total number of dog-owning households, total number of dogs and total amount of waste produced per day (Table 12).

Number of Dog-Owning Households = **National Percentage of Dog-Owning Homes (36.5%)** X **Total Number of Households**

Number of Dogs = **National Average of Dogs in Homes (1.6)** X **Total Number of Dog-Owning Households**

Total amount of Waste (lbs) = **Average Waste produced per day by a dog (0.75 lbs)** X **Number of Dogs**

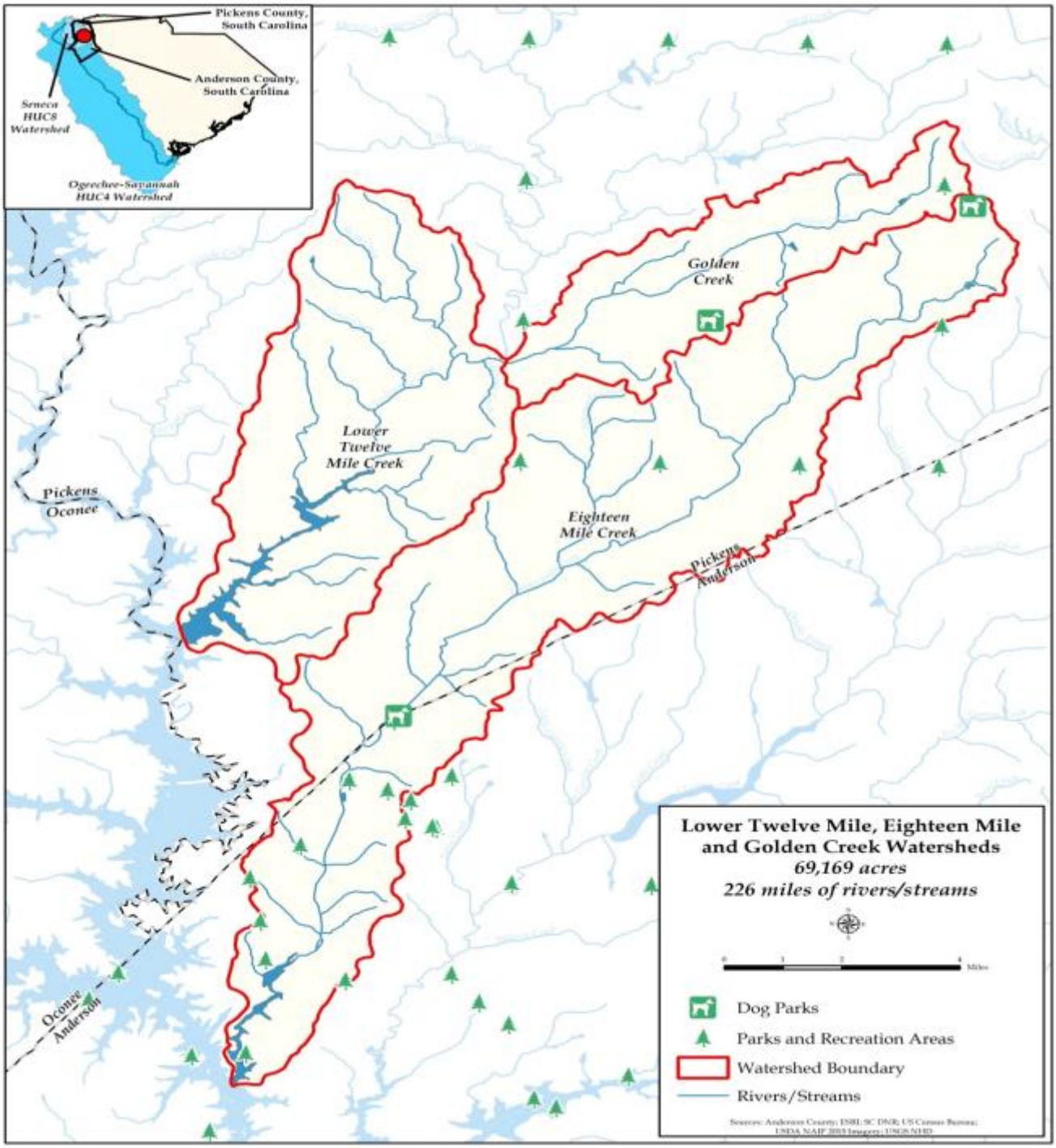
Table 12 : Estimate of total amount of pet waste (lbs) produced in the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	Total Number of Households	Number of Dog-Owning Households	Number of Dogs	Total Amount (lbs) of Waste
Lower Twelve Mile	2373	866	1386	1040
Eighteen Mile	12285	4484	7174	5381
Golden Creek	2836	1035	1656	1242
Total	*17494*	*6385*	*10216*	*7662*

If owners do not pick up the fecal waste, storm water runoff could transport the waste to nearby waterways. Currently, the three watersheds of concern have a moderate to high potential growth rate within the next ten years. Hence, considerations to strategically implement pet waste management areas

in dog parks and community parks would help to reduce the potential of fecal waste contamination throughout the watersheds.

Figure 7: Map depicting areas where dog parks and community parks are located within the three watersheds



Wildlife

Wildlife is another source of bacterial non-point source pollution in these three watersheds. It has been predetermined that the effects of healthy, but controlled populations have a relatively minimal *E.coli* impact to such watersheds as their effects are termed natural causes of *E.coli* from a healthy system. With 49.32 % of the watershed being forested land, multiple wildlife entities may contribute to non-point source pollution. Controlled populations have a relatively minimal fecal coliform impact to watersheds and are deemed natural causes of fecal coliform in a healthy system. However, nuisance wildlife can have a negative impact. Nuisance wildlife refers to animal species that can cause problem or damage to property and sometimes even transfer diseases; this includes deer, raccoons, waterfowl, geese, beavers, and feral hogs.

Within the management plan area, there are approximately 15-30 deer/mi^2. According to 20^{th} century research that is still applied in today's deer management, a single deer defecates approximately 13 times a day dropping 75 pellets per pile (http://bowsite.com/bowsite/features/armchair_biologist). In recent years, beaver populations within Pickens County have increased. Beaver activity has a major influence on watersheds by altering hydrology. Beaver dams increase the surface area of water resulting in increased waterfowl populations, potentially leading to an increase of wildlife *E.coli* within the stream channels. In addition, feral hogs have become an increasingly abundant nuisance animal within Pickens and Anderson counties. Although precise data cannot be determined for the number of feral hog individuals within the area of concern, the overall population within South Carolina is approximately 150,000 and increasing.

Geese have the ability to become nuisance species contributing largely to the increased *E.coli* input to streams. A single Canada goose can produce an average of 82 grams (or 2.6 ounces) of waste a day and can defecate between 28 to 92 times per day.

BACTERIA LOAD REDUCTIONS

Exceeding levels of *E.coli* in the three streams (Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds) contributed towards their impaired characteristics and were placed by US EPA on the 303(d) impaired waters list. This action then required consistent monitoring of the streams to gain a detailed understanding of the pollutants that hinder the quality of the streams. A TMDL was enforced establishing the daily quantity of pollutants allowed into the streams before impairments result or persist. The objective of the TMDL is to reduce pollutant loading into a stream; henceforth restoring the stream's water quality and US EPA designated use. A TMDL is expressed as "the sum of all Waste Load Allocations (WLAs: point source loads), Load Allocations (LAs: nonpoint source loads), and an appropriate Margin of Safety (MOS), which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality." (US EPA, 2007)

A TMDL is calculated as expressed below:

$$TMDL = \sum WLA + \sum LA + MOS$$

Following 303(d) placement, ambient monitoring has occurred throughout the years to determine if adaptive management and observation of point and non-point sources could reduce potential hazards to the stream.

Table 13: Waste Load Allocations (WLAs) for NPDES facilities permitted to discharge bacteria

NPDES#	Facility Name	Flow (MGD)	Load (counts/day) *
SC0000370	Alice MFG/Foster	0.043	2.80E+08
SC0047899	Pickens County Stockade WWTF	0.008	3.95E+08
SC0020010	City of Clemson/Conhran Rd WWTP	0.735	7.59E+09
SC0028762	RC Edwards Jr. High School	0.008	1.19E+08
SC0023141	Christoff Construction CO./Issaqueena Village	0.01	1.59E+08
SC0000302	Shaw Industries Group/Clemson	0.092	6.05E+08
SC0022012	Cateechee Village Inc. WWTP	0.013	1.32E+08
SC0024996	Pickens County PSC/Central/North Plant	0.07	9.95E+08
SC0026191	Pickens County - Liberty/Roper Lagoon	0.148	3.32E+09
SCG730065	Vulcan Construction Materials/Liberty	MR	MR
SC0000132	American House Spinning	0.044	6.16E+08
SCG250169	Imperial Die Casting Corp	MR	MR
SCG731111	Pickens County/training facility mine	MR	MR
SC0000477	Milliken & Co./Pendelton Finishing	0.171	2.26E+09
SC0035700	Town of Pendelton & Clemson Reg. WWTP	2	2.64E+10
SC0042994	Pickens County/18 Mile Creek Upper Reg. WWTP	1	1.32E+10
SC0047856	Pickens County/18 Mile Creek Middle Reg. WWTP	1	1.32E+10
SC0029548	Heatherwood SD/Madera Util.	0.072	9.51E+08
SCG250077	Easley Custom Plastics Inc.	MR	MR
SC0000264	Woodside Branch Liberty Denim LLC	0.397	5.24E+09

* FC equivalent values have been converted for *E. coli* equivalent by multiplying with 0.8725 (SCDHEC 2012)

Acronyms in the above table:

Waste Water Treatment Facility (WWTF) and Waste Water Treatment Plant (WWTP)

Table 14: Summary of bacteria load reductions for Water Quality Monitoring Stations located within Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

SCDHEC WQM Station	WLAs (MPN/day)*	MS4 WLA (% reduction)	LA (MPN/day or % reduction)*	MOS	TMDL (MPN/day or % reduction)*	Percent Reduction
SV-015	1.52E+10	64	64	Explicit & Implicit	64	64
SV-136	9.95E+08	NA	9.42E+11	Explicit & Implicit	9.42E+11	56
SV-137	1.59E+10	64	64	Explicit & Implicit	64	64
SV-239	7.13E+09	64	64	Explicit & Implicit	64	64
SV-268	0.00E+00	77	77	4.74E+10	9.51E+11	77
SV-233	2.26E+09	57	57	2.74E+10	5.48E+11	57
SV-135	1.41E+10	77	77	2.22E+10	4.43E+11	77
SV-245	1.32E+10	89	89	9.43E+09	1.88E+11	89
SV-241	5.24E+09	NA	7.99E+10	4.49E+09	8.99E+10	89
SV-017	0.00E+00	76	76	4.70E+08	9.42E+09	76

* CFU/day values have been converted to MPN/day values by multiplying with 0.8725 (SCDHEC 2012)

Bacteria Load Reduction Calculations

Bacteria load reductions for this plan were based on the TMDL Development for Twelve Mile Creek Watershed, SC, the Upper Saluda River Basin TMDL for fecal coliform bacteria ("EPA Finalized TMDL Upper Saluda River Basin", 2004) and the Watershed-Based Plan for Georges Creek in the Saluda River Basin, SC. Data provided were used to calculate specific nonpoint source bacteria load reductions for Lower Twelve Mile, Eighteen Mile, and Golden Creek subwatersheds.

TMDL Existing Load calculation comes directly from the 2003 TMDL Development for Twelve Mile Creek Watershed, SC for Fecal Coliform Bacteria and represents the total bacteria load from both point and nonpoint sources. The TMDL Existing Load is 1.06E+12 counts/day or 9.25E+11 MPN/day.

WLA: This information comes directly from the 2003 TMDL Development for Twelve Mile Creek Watershed, SC for Fecal Coliform Bacteria. Subtracting WLA from the TMDL Existing Load helps in calculating the load reduction (MPN/day).

The formulas used to arrive at the numbers in Table 15 are as follows:

Load Reduction (MPN/day) = TMDL – WLA

Load Reduction (MPN/day) = (9.25E+11) - WLA

Table 15: Estimating *E.coli* load reduction for the Water Quality Monitoring Stations at the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

WQM Station	Subwatersheds	WLAs (MPN/day)*	Load Reduction (MPN/day)*
SV-015	Lower Twelve Mile	1.52E+10	9.10E+11
SV-136	Lower Twelve Mile	9.95E+08	9.24E+11
SV-137	Lower Twelve Mile	1.59E+10	9.09E+11
SV-239	Golden Creek	7.13E+09	9.18E+11
SV-268	Eighteen Mile	0.00E+00	9.25E+11
SV-233	Eighteen Mile	2.26E+09	9.23E+11
SV-135	Eighteen Mile	1.41E+10	9.11E+11
SV-245	Eighteen Mile	1.32E+10	9.12E+11
SV-241	Eighteen Mile	5.24E+09	9.20E+11
SV-017	Eighteen Mile	0.00E+00	9.25E+11

* Counts/day values have been converted to MPN/day values by multiplying with 0.8725 (SCDHEC 2012)

Nonpoint Load Reduction Needed (MPN/day): This represents the *E.coli* load reduction needed from nonpoint sources and is calculated by multiplying the Existing Nonpoint Load Allocation by the TMDL Nonpoint Percent Reduction Needed. The average load reductions for each of the three subwatersheds are summarized in Table 16.

Nonpoint Load Reduction Needed (MPN/year): This represents the *E.coli* load reduction needed from nonpoint sources and is calculated by multiplying the Nonpoint Load Reduction Needed (MPN/day) by 365 days/year. Results are shown in MPN/year in order to facilitate calculations for recommended BMP installations per year (Table 16).

The formula used to facilitate calculations for recommended BMP installations per year:

Nonpoint Load Reduction Needed (MPN/year) = Nonpoint Load Reduction Needed (MPN/day) X 365 days/year

Table 16: Estimate of average load reductions for Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

E.coli load reductions	Lower Twelve Mile	Golden Creek	Eighteen Mile
MPN/day	9.14E+11	9.18E+11	9.19E+11
MPN/year	3.34E+14	3.35E+14	3.36E+14

The recommended septic reductions listed in Table 16 refer to what is ideally needed annually in order to repair all malfunctioning septic systems in households that fall under the 20% failure rate. This is found by multiplying the number of homes on septic by 20% failure rate and by the standard bacteria load per household/year (2.42E+10 colonies).

Standard *E.coli* load per household per year = (2.42E+10) x 0.8725 = 2.11E+10 MPN

Recommended Septic Reduction = **Number of Homes on Septic** X **20% Failure Rate** X **Standard *E.coli* load per household/year**

Table 17: Recommended Annual Septic Reduction for Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	# Households with Onsite Septic systems	# Households with Failing systems	Recommended Septic Reduction (MPN/year)
Lower Twelve Mile	949	190	4.00E+12
Eighteen Mile	4914	982	2.08E+13
Golden Creek	1134	226	4.76E+12
Total	*6997*	*1398*	2.94E+13

The amount of bacteria removed annually by fencing livestock out of 0.25 mile stretch of riparian buffer represent recommended agriculture reductions. Recommended agricultural reduction rates can be found by multiplying the total number of livestock within 0.25 mile of waterway by the annual waste produced by the specific livestock animal.

Annual waste produced (bacteria) per animal (cattle) = 1.97E+11

Annual waste produced (*E.coli*) per animal (cattle) = (1.97E+11) x 0.8725 = 1.72E+11 MPN

Recommended Agricultural Reduction = **Number of cattle within 0.25 mile of waterway** X **Annual Waste (*E.coli*) produced per animal**

Table 18: Recommended Annual Agricultural Reduction for Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	# Cattle	Recommended Agricultural Reduction (MPN/year)
Lower Twelve Mile	410	7.052E+13
Eighteen Mile	1058	1.82E+14
Golden Creek	201	3.457E+13
Total	*1669*	*2.871E+14*

Pet waste reductions represent the annual bacteria reductions expected from the installation of pet waste stations. This is with an assumed 50% success rate. By multiplying the number of dogs in the area by a 50% success rate and by the standard annual bacteria load per dog (1.49E+12 colonies), one is able to calculate recommended pet waste reductions.

Standard annual *E.coli* load per dog = (1.49E+12) x 0.8725 = 1.30E+12 MPN

Table 19: Recommended Annual Pet Waste Reduction for Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	# Dogs in the area	# Number of dogs considering 50% success rate	Recommended Pet Waste Reduction (MPN/year)
Lower Twelve Mile	1386	693	9.009E+14
Eighteen Mile	7174	3587	4.663E+15
Golden Creek	1656	828	1.076E+15
Total	*10216*	5108	6.64E+15

After *E.coli* load reductions were calculated for all three subwatersheds under the three BMPs (septic, agricultural, and pet waste), recommended *E.coli* reductions from various BMPs were summarized, as seen in Table 20.

Table 20: Recommended Annual Total Load Reductions from different BMPs for Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	**Recommended Septic Reductions (MPN/Year)**	**Recommended Agricultural Reductions (MPN/Year)**	**Recommended Pet Waste Reductions (MPN/Year)**	**Recommended Total Bacterial Reduction (MPN/Year)** *(Based on adding individual BMP reductions)*	**Recommended Total Bacterial Reduction (MPN/Year)** *(Based on estimation from monitoring stations' TMDLs)*
Lower Twelve Mile	4.00E+12	7.052E+13	9.009E+14	9.75E+14	3.34E+14
Golden Creek	2.08E+13	1.82E+14	4.663E+15	4.87E+15	3.35E+14
Eighteen Mile	4.76E+12	3.457E+13	1.076E+15	1.12E+15	3.36E+14

OVERVIEW OF BEST MANAGEMENT PRACTICES

Septic System BMPs

Septic system repairs and replacements are another way to reduce *E.coli* pollution in our local waterways. When septic systems are inspected and maintained regularly, bacteria leakage from faulty systems is likely prevented. The following BMPs are considered to be the most effective for residential areas contributing to bacteria pollution related to wastewater.

Septic System Repairs and Replacement: It is estimated that in an average year, 10-30% of septic systems experience failure, usually due to poor maintenance ("Overview – Septic Tanks", 2014). In order to prevent bacteria from leaking into nearby waterways, septic systems that are not functioning properly need to be repaired or replaced. In order to maintain efficiency, septic tanks should be inspected and pumped, as needed, every 3 to 5 years ("Pumping (Cleaning Out a Septic Tank)", 2014).

Extending Sewer Lines**:** In areas with highly confirmed concentrations of failing septic systems, the most long-term cost effective solution may be to extend municipal sewer lines to areas of concern, where possible.

In order to keep track of when repairs and replacements should be made before problems arise, it is also recommended that septic systems be inspected every one to two years ("Septic Tank Inspections", 2014).

Septic System BMP Unit Cost Estimates and Funding Options

Many homes within the three subwatersheds are not within access for municipal sanitary sewer lines and therefore septic systems are the most appropriate option for wastewater treatment. If not maintained, repairs for septic systems are often necessary. Estimates for septic system BMP unit costs are based on information provided by EPA and Easley Combined Utilities. Cost estimates and potential funding options for septic system BMPs are described in the following table.

Table 21: Septic System BMP Unit Costs and Potential Funding Sources

Nonpoint Sources of Bacteria Pollution	BMP	Estimated BMP Unit Cost	Potential Funding Sources
Septic Tanks	Replacement or repair of onsite septic systems	$4,000 per system	• SC DHEC 319 Grant • Local Governments • USDA Rural Development • State Revolving Funds

Potential funding source programs for septic system repairs and replacements are listed below.

South Carolina Department of Health and Environmental Control (SC DHEC)

319 Nonpoint Source Pollution Grants are available through SC DHEC in efforts to help reduce nonpoint source contributions to South Carolina's waterbodies. These grants pay up to 60% of eligible project costs, with a 40% non-federal match.

Local Governments

Local counties and cities should have the potential to be partners by providing in-kind support for local water quality projects as funding becomes available. Local sewer authorities may also be able to provide the appropriate assistance for septic system repairs and replacements.

State Revolving Funds

There are currently two State Revolving Funds, the Clean Water State Revolving Fund and the Drinking Water State Revolving Fund. These funds are administered to provide low-interest loans for investments associated with water and sanitation infrastructures, as well as for implementation of nonpoint source pollution control projects.

Duke Energy Foundation

They provide limited funds to qualifying organizations to assist with the repair and replacement of septic system, typically for low-income families.

USDA Rural Development Office

The Section 504 Very Low-Income Housing Repair Program offers low-interest loans to rural residents who earn less than 50% of the area median income. These low-interest loans are to be used specifically to render the home more safe or sanitary. Homeowners over 62 years in age may be eligible for grant funds.

Agricultural BMPs

With the desire to manage for and maintain healthy water quality, the state and federal government provides numerous opportunities and programs for assistance and guidance on agricultural BMPs. U.S. Department of Agriculture (USDA) has guidelines regarding animal waste management practices. By offering incentives to farmers the USDA hopes to promote farmers' compliance to adopt practices that protect water quality. Incentives such as education, technical support and financial assistance not only

encourage compliance from farmers/landowners but also provide means of overall improvement for future interactions and water quality management.

At the federal, state, and local levels there are multiple cost-share programs available for funding landowners depending upon the BMP goal of both the landowner and the agency.

Programs offered in which farmers can participate are listed below:

- Environmental Quality Incentive Program (EQIP)
- Conservation Technical Assistance (CTA)
- Wetlands Reserve Program (WRP)
- Conservation Reserve Program (CRP)
- Wildlife Habitat Incentive Program (WHIP)
- US Fish and Wildlife Service
- SCDHEC 319 Funds

The Environmental Quality Incentive Program is one of the most commonly used cost-share programs under the Farm Bill. This program provides up to 75% cost-share assistance to landowners who incur material and land use costs to implement BMPs with the intent to enhance water and air quality, reduce soil erosion and degradation, and improve wildlife habitat. EQIP contracts are conducted for up to a 10 year time period for agricultural and non-industrialized lands.

Conservation Technical Assistance is a voluntary program that is comprised of a network of eleven locally-based professional conservationists who can assist landowners in BMP decisions, monitoring and design, and development of conservation plans. While this program doesn't provide assistance, participation can increase possibilities of funding from financial aid sources.

The Wetlands Reserve Program focuses on achieving maximum protective benefit of wetland processes and functions through restoration efforts and long term conservation practices. This program involves implementation of conservation easements. A permanent easement will have 100% cost-share coverage. Cost incurred for landowners implementing a temporary (30 year) easement or restorative efforts will have up to 75% cost paid by the USDA.

The Conservation Reserve Program located under the USDA Farm Service Agency, provides an annual stipend in exchange for BMP techniques applied by farmers to enhance water and air quality, reduce soil erosion and degradation, improve wildlife habitat and remove sensitive land areas from productive use.

Wildlife Habitat Incentive Program is another Farm Bill program that focuses on providing funding to landowners who have the desire to devote areas of land to the cause of enhancing wildlife habitat for specific fauna and flora, reducing invasive species impact, and maintaining suitable wildlife corridors. Landowners can receive up to 75% cost share assistance over a period of 10 years.

The US Fish and Wildlife Services sponsors a program for private landowners called "Partners for Fish and Wildlife" which focuses on improving fish and wildlife habitat. Financial and technical assistance is provided to manage for native ecosystems.

SCDHEC 319 Funds are allocated to landowners through select grants with a focus to enhance water quality from non-point source pollution by implementing TMDLs and BMPs to reduce the overall pollutant effects. Funds from the grants typically cover up to 60% of the determined project costs.

Some other options are to use conservation buffers which preserve vegetative strips along the Streamside Management Zone (SMZ) and irrigation management to ensure water applied to the fields, which may have fecal matter from either livestock or fertilizer, is utilized, reducing storm water runoff and integration into the stream. Options such as nutrient management and conservation tillage can also be applied to reduce water contamination from the livestock fields into the stream. Livestock with full access into stream areas may result in direct *E.coli* input into the stream. For preventive purposes, streambank fencing in conjunction with alternative water sources are an appropriate option.

Monetary concerns are often a barrier to landowner participation in these types of projects. Table 22 lists multiple BMP options and the estimated cost associated per unit.

Table 22: Agricultural BMP options and unit cost associated

BMP	Estimated BMP Unit Cost
Linear Streambank Fencing	$3.57/foot
Well (500' deep)	$9169.18 each
Linear Pipeline	$1.43/foot
Alternate Watering Source	$774.29 each
Heavy Use Area	$1.02/foot
Riparian Buffer	$254.7/acre
Average Total Agriculture BMP Bundle	*$ 19,695.39*

As briefly mentioned above, manure application of livestock litter has been commonly practiced on agricultural land throughout the three watersheds. With agricultural land usage comprising of 6753.54 acres total within the watersheds, BMP practices should be implemented to ensure reduced potential runoff and its effects. Here is a list of manure application BMPs that can be applied by landowners:

- Incorporate manure as soon as possible after application to minimize runoff
- Apply manure uniformly with properly calibrated and operated equipment
- Time liquid manure applications to match crop nutrient uptake patterns to reduce potential runoff
- Limit solid manure applications on frozen or saturated ground to fields that are at low risk for runoff
- Create a buffer area away from surface water, irrigation return flow ditches, and well sources where no manure is applied to prevent possibility of water contamination
- Apply manure on a rotational basis to fields that will be planted promptly
- Apply manure on terraced fields if slope is relatively steep to reduce continual downhill runoff
- Construct composting buildings/areas for the storage of manure

Urban BMPs

Implementation of targeted BMPs for urban and residential areas can be an effective way for preventing bacteria runoff into nearby waterways. Domestic pet waste and stormwater runoff management are the two focuses for these subwatersheds. The following list is of BMPs are considered effective for urban areas within this watershed for *E.coli* pollution ("Best Management Practices", 2014).

Pet Waste Stations: When pet waste is left on the ground, it can be carried into nearby waterways during rain events; therefore pet waste should be properly collected and disposed of in order to prevent bacteria from entering nearby streams. The use of pet waste stations in public or well-traveled areas encourages the proper disposal of pet waste. It is important that pet waste stations are regularly emptied and restocked with new bags.

Storm Drain Markers: Storm drains typically transport stormwater directly into nearby waterways. By marking storm drains with educational markers, the public will become more aware of how pollutants in or near storm drains end up in their local waters. Public areas and neighborhoods serve as great places to mark storm drains.

Stream Bank Rehabilitation: Highly eroded areas along streams, as well as areas taken over by invasive plants, serve as prime locations for stream bank rehabilitations. Sites where the public has access are ideal, providing opportunity for education through involvement. Stream banks are able to reduce and filter out some pollutants before entering into the stream.

Rain Gardens: These largely urban BMPs are shallow basins or landscaped areas that make use of engineered soils and selected vegetation to capture and treat stormwater runoff from smaller rain events. Bacteria are removed by filtration and microbial degradation. E. coli removal rates are 50%-70%, depending on design and installation specifics (Schueler and Holland, 2000). Rain gardens make excellent demonstration sites and can have long-lasting educational benefits as well.

Urban BMP Unit Cost Estimates and Funding Options

Estimates for urban BMP unit costs are based on information provided by Pickens County Stormwater Partners (PCSP). The following table includes estimated costs and potential funding sources for urban BMPs.

Table 23: Urban BMP Unit Costs and Potential Funding Sources

Nonpoint Sources of Bacteria Pollution	BMP	Estimated BMP Unit Cost	Potential Funding Sources
• Domestic Pets • Stormwater Runoff	Pet Waste Stations	$169 each station	• SC DHEC 319 Funds • Pickens County Stormwater Partners • Local Governments
	Pet Waste Bags	$40/2000 bags	
	Storm Drain Markers and Glue	$1400/500	
	Stream bank Rehabilitation	$100/sq ft	
	Rain Gardens	$12/sq ft	

The previous BMPs would work as both public education and involvement for nearby communities on ways to reduce *E.coli* pollution in local waterways. Public education and involvement are both requirements in SC DHEC's Municipal Separate Storm Sewer System (MS4) permit. It is key for these BMPs to be placed in well-traveled and visible areas in order to impact as many people as possible. PCSP conducts stormwater education and involvement for Pickens County and will serve as an important partner in reaching local communities.

Details on Pet-Waste BMPs

Within the subwatersheds there are three dog parks: Nettles Park, Freedom Park/Liberty Park, and Hagood Park. Nettles Park is located on Nettles Park Road in the City of Clemson and is within the Eighteen Mile watershed. Freedom Park/Liberty Park is located at the intersection of Blue Ridge Drive and Mountain View Drive in the City of Liberty and is within Golden Creek Watershed. Hagood Park is located at Hagood Park Drive in Easley and is within the Golden Creek watershed.

To reduce levels of pet waste, two pet waste stations should be implemented in each of the three dog parks. However, many pet owners may also use community parks if they are located closer to their residence than dog parks; hence two pet waste stations will be established in each of the 11 community parks located within the three watersheds.

Overall, a total of 28 pet waste stations will be needed. Table 24 below describes the monetary value of establishing and maintaining proper functioning pet waste stations for the public's use.

Table 24: Costs associated with setting up 28 pet waste stations in the three dog parks and 11 community parks

Location of Pet Waste Stations	Number of pet waste stations	Cost associated with pet waste station ($169/station)	Number of pet bags (2000/station /year)	Cost associated with pet waste bags ($40/2000 bags)	Total cost associated
Nettles Park	2	$338	4000	$80	$418
Freedom/Liberty Park	2	$338	4000	$80	$418
Hagood Park	2	$338	4000	$80	$418
11 Community Parks	22	$3718	44,000	$440	$4158
Total	*28*	*$4732*	*56,000*	*$680*	*$5412*

Wildlife BMPs

Forested areas provide habitat for a variety of wildlife, allowing for their contribution to *E.coli* levels in nearby streams. Wildlife populations and their foraging and nesting locations change frequently making them hard to target. Wildlife BMPs are both animal and site specific; therefore it will be more cost effective to further identify nuisance wildlife populations and specific priority BMPs as part of the public outreach and education campaign. This will be done through workshops open to the public regarding proper management of nuisance wildlife. Once nuisance wildlife are identified, locations and types of BMPs can be prioritized

It is critical to implement preventative measures within areas that may be easily subjected to nuisance wildlife. A few options that can be applied are as follows:

- Hunting – Hunting provides a regulated ability to control populations. Out of season permits (or time of day permits) for species such as deer and feral hogs can also be attained through DNR applications if the land becomes sensitive to nuisance wildlife.

- Trapping/removal – Trapping/removal is usually conducted to remove feral hogs; box, cage, and corral traps are usually implemented. Corral traps are becoming more commonly used by wildlife removal personnel. This particular method is extremely effective for feral hog populations as they tend to travel together in packs. The same techniques are applicable for beaver populations as well. A variety of trapping and removal services are offered throughout the three watersheds.

- Dam removal – Beavers alter an area's habitat by building dams to provide for stable populations. Removal of beaver dams can legally be conducted at any time. With the removal of flooded waters, less waterfowl may populate the area.

- No feeding – Feeding nuisance wildlife is a large contributor to dense populations, especially in urban areas. Providing food has many negative impacts such as causing wild animals to become

familiar with and dependent upon humans for food, resulting in unnatural behavioral patterns (not migrating) and damage to land.

- Riparian buffer – In relation to protecting the stream from nuisance wildlife, riparian buffers provide a "transition zone" of vegetation that helps to remove bacteria from runoff before entering the stream. Most riparian buffers are forested and hence may provide critical habitat to species that prefer edge patches such as deer and hogs. Management of riparian buffers may be important to ensure ecosystem services to the stream.

- Filter strips – This form of BMP generally coincides with the riparian buffer zones, although filter strips are composed of herbaceous or shrubby vegetation and can be located along or away from streams. Their purpose is to disrupt the flow of harmful bacteria, nutrients, and sediment.

- Streambank fencing – Fencing is a common and effective method of preventing nuisance wildlife from entering into the stream area. The result is less bacteria and stream bank erosion.

Wildlife BMP Unit Cost Estimates and Funding Options

Several listed wildlife BMPs are also mentioned as possible agricultural BMPs. These can be used to control both wildlife and livestock populations. Some of the potential funding sources for wildlife BMPs are also mentioned in the agricultural BMP section. Estimates for Wildlife BMP unit costs are based on information provided by the USDA and SC DNR. The following table provides an overview of wildlife BMP unit costs and possible funding sources.

Table 25: Wildlife BMP Unit Costs and Potential Funding Sources

Nonpoint Sources of Bacteria Pollution	BMP	Estimated BMP Unit Cost	Potential Funding Sources
• Feral Hogs • Beavers • Deer • Canada Geese	Streambank Fencing	$3.50/foot	• SC DHEC 319 Funds • WHIP • EQIP • AWEP • County Governments
	Riparian Buffers	$250/acre	
	Box, Swing, and Corral Traps	$320-460 each	

Potential funding sources for wildlife BMPs are listed below.

South Carolina Department of Health and Environmental Control (SC DHEC)

319 Nonpoint Source Pollution Grants are available through SC DHEC in efforts to help reduce nonpoint source contributions to South Carolina's waterbodies. These grants pay up to 60% of eligible project costs, with a 40% non-federal match.

US Department of Agriculture Natural Resources Conservation Service (NRCS)

NRCS offers several different programs to homeowners that provide both financial and technical assistance for improvements on their land, including installing riparian buffers, protecting wetlands, and conserving water resources. Such programs include the Wildlife Habitat Incentives Program (WHIP), the Environmental Quality Incentives Program (EQIP), and the Agricultural Water Enhancement Program (AWEP).

Local Governments

Local counties and cities have the potential to be partners by providing in-kind support for local water quality projects as funding becomes available.

Community Participation

Involvement through community participation includes voluntary contributions from residents within the watershed, such as monetary and in-kind. These contributions can be used to meet match requirements from other grant funding sources.

PUBLIC OUTREACH AND EDUCATION

Public education and involvement is an important factor in order to ensure the success of key components explained within this watershed management plan. Education and awareness can enhance the ability of landowners to participate in improving their own properties, henceforth improving the overall quality of the watersheds of concern.

Some public involvement techniques are as follows:

- Public education and information: newsletters, brochures, articles, and public meetings
- Exchange of information between public and agency: public meetings, public hearings, public comments, key informants, focus groups, nominal group processes, and workshops
- Direct public participation in decision-making: workshops, collaboration, negotiation, mediation, and co-management

Public outreach will be focused on enhancing the public and stakeholder knowledge of the importance and benefits of their efforts for the surrounding landscape where they each reside. Seven components to be discussed are the following:

1. Overview of the management plan
2. The issues and goals associated for each sub-watershed as well as goals compiled for all three watersheds of concern
3. The available BMPs for both point and non-point sources including agriculture, septic systems, urban areas, and domestic pets
4. The financial costs and aid available for BMP implementation
5. Updates on progression of plan objectives
6. Community stormwater education and participation opportunities
7. Provide evidence of watershed improvement

There are many entities through which public outreach can be targeted. Within the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds there are 13 total schools (Table 26). This provides an important basis for educational opportunities that not only targets landowners within the watershed but also provides the educational factor for both landowners and students alike. Schools along with community service organizations and buildings (Table 27) can be potential outreach and meeting areas to discuss the desired restoration goals, benefits, and management opportunities.

Table 26: List of schools in the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds

Subwatersheds	**Schools**
Lower Twelve Mile	D.W. Daniel High School
	R.C. Edwards Middle School
	Central Elementary School
Eighteen Mile	Clemson Montessori School
	Riverside Middle School
	Clemson Elementary School
	Episcopal Day School
	Chastain Road Elementary School
	Southern Wesleyan University
	Pickens County Career & Technology Center
Golden Creek	Liberty High School
	Liberty Middle School
	Liberty Elementary School

Table 27: Community groups, municipalities, and organizations to consider for public outreach

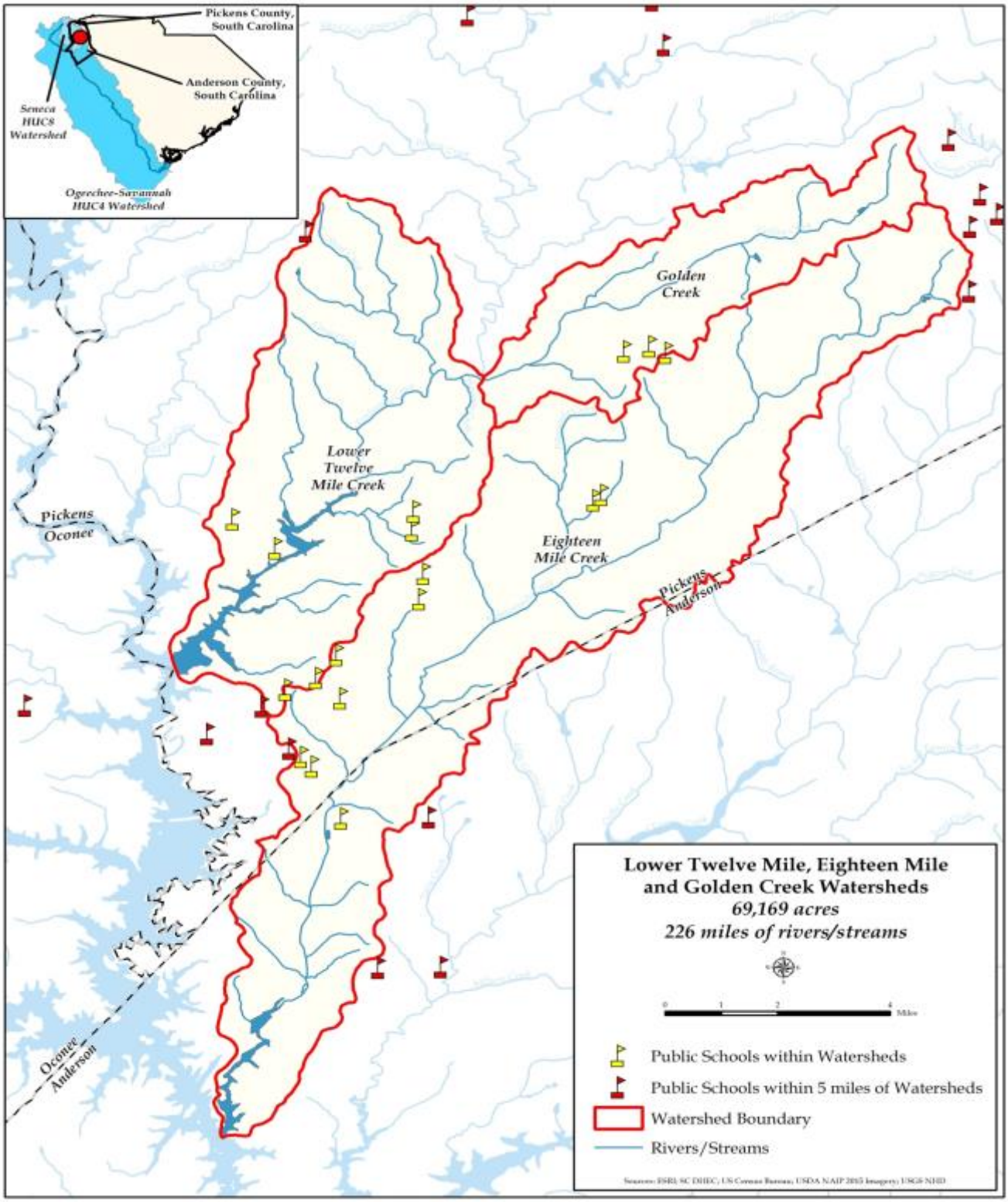
List of Community Groups within the Subwatersheds
Cities and Towns: • Town of Norris • Town of Pendleton • Town of Six Mile • City of Easley • City of Clemson • City of Liberty • City of Central
Libraries: • Liberty Library (Golden Creek) • Central-Clemson Regional Branch Library (Lower Twelve Mile) • Pendleton Branch Library (Eighteen Mile) • Claude A. Rickman Library (Eighteen Mile)
Community Centers: • Central-Clemson Recreation Center (Eighteen Mile) • Littlejohn Community Center (Eighteen Mile) • Clemson Arts Center (Lower Twelve Mile) • Rosewood Center (Golden Creek)
Cub Scout Pack & Boy Scout Troops: • Troop 235 (Clemson Area) • Troop 161 (Clemson Area) • Troop 26 (Easley) • Troop 227 (Liberty)

Within the impaired watershed areas there are a variety of community groups that may benefit from the knowledge provided about restoration of the watersheds. A few examples of these groups are as follows:

- Student Groups
- Clemson Forest Recreationalists
- Equestrian Groups
- Lake Hartwell Association
- The Green Crescent (Eighteen Mile Watershed)
- Cattlemen's Association

Another method for public outreach is to incorporate updated information from the watershed management plan on websites that could benefit individuals within the management area or of a broader region. The main website concerning this management plan can be located at the following URL: https://sites.google.com/site/clemsonarea319watershedproject/

Figure 8: Map depicting public schools located in the Twelve Mile, Eighteen Mile and Golden Creek watersheds



PROJECT IMPLEMENTATION, MILESTONES, AND MEASURABLE GOALS

This watershed-based plan implementation schedule will cover a span of 10 years and work to decrease bacteria loads and increase the overall water quality of Lower Twelve Mile, Eighteen Mile, and Golden Creek subwatersheds. Implementation strategy for this watershed will include the following: Project Identification, Implementation, Evaluation, and Refinement.

Project Identification: Before projects can be identified, the main focus for this period includes building and identifying partnerships and relationships with homeowners and organizations. Guidance from a variety of organizations will be needed to reach the four targeted categories of BMPs: Agricultural and Livestock, Septic Systems, Urban Areas (dog parks and county parks), and Wildlife. Building relationships with homeowners will be essential for the installation of agricultural and wildlife BMPs. These categories have similar BMPs and are very site specific. Partnerships with Clemson Extension, Carolina Clear, and Pickens County Stormwater Partners may be used to conduct a public outreach campaign for septic system BMPs. Finally, potential locations for pet waste stations will need to be identified as well as neighborhoods within the watershed where storm drains need to be marked.

Project Implementation: Projects that are considered to be of higher priority will be implemented first. The number of projects implemented will depend on landowner participation and available funding. The implementation schedule provided prioritizes action items and milestones that build on an initial concerted effort at watershed-wide outreach followed by or concurrent with targeted efforts by BMP type.

Evaluation and Refinement: Since it is impossible to accurately predict outcomes due to landowner participation and a variety of potential obstacles, periodic reassessments of project goals will be necessary. Evaluation of public education and outreach strategies as well as individual BMP projects will be very important. Keeping records of problems that arise before, during, and after construction of BMPs will allow for a better management process for any future participants. It is very important to be able to identify problems faced and be able to adapt to new solutions.

To begin, relationships between project partners and landowners should be secured with general ideas of what BMPs or other implementation tasks are desired per landowner, which funding opportunities are specifically available for the desired implementation tasks, and the level of cooperation required to successfully achieving the installments and the proper management for continuous benefit. Therefore, an initial outreach based plan should be introduced and implemented during the first two years. The timeline for outreach based initiatives has been elaborated in Table 28.

Table 28: BMP implementation timeline for outreach during the first two years of the WBP implementation

Outreach Milestones	Time Frame (Months)
Build relationships with landowners and recruit participation	1-3
Create educational displays for public locations	1-12
Create outreach materials on nuisance wildlife	2-6
Write articles to feature in local newsletters and newspapers	2-12
Host a manure management workshop	6-8
Provide educational materials to landowners with nuisance wildlife problems	6-22
Host a septic system maintenance workshop	15-17
Host a pond & geese management workshop	20-22
Survey participating landowners	24

The implementation timeline to establish all the four types of BMPs in each of the three subwatersheds has been estimated to be spread over 10 years. We have divided the implementation timeline into first five years (Table 29 (a)) and the next five years (Table 30 (a)) to provide more clarity on milestones and goals for each of the BMPs.

Table 29 (a): Watershed Based Plan Measurable Milestones: Action items during years 1-5

Action (1-5 years)	Subwatershed	Percent Complete
Secure funding required for restoration related efforts in this plan	T,G, and E	40
Urban BMPs: • Install 12 pet waste stations • Install 6 rain gardens demonstration sites (2 per subwatershed) • Install 1500 storm drain markers (500 per subwatershed) • Outreach and Education	T,G, and E	40
Agricultural BMPs: • Get 15% of farms to participate in structural and non-structural BMPs • Install 6 agricultural BMPs • Outreach and Education	T,G, and E	40
Septic BMPs: • 20% of failing Septic Tank repair or replacement in each of the subwatersheds • Outreach and Education	T (38) ,G (45), and E (197)	30
Wildlife BMPs: • Assisted guidance in practice of hunting, trapping, and no-feeding • Develop programs to remove beaver dams, manage riparian buffers/filter strips, and rehabilitate/construct stream bank fencing • Outreach and Education	T,G, and E	50
Semi-annual meetings with workgroups at the three subwatersheds	T,G, and E	40
Annual updates to Councils within the three subwatersheds	T,G, and E	40
Quarterly updates on the website to keep public informed	T,G, and E	40
Quarterly email updates to stakeholders	T,G, and E	40

This table based on rubric obtained from the Twenty Five Mile Creek Watershed Based Plan, SCDHEC

During the first five years of implementing these action items in each of the three subwatersheds, we suggest that prioritization should be done based on pollutant source and *E.coli* load in each of the subwatersheds. Therefore we suggest the following schedule for implementation during the first five years shown in Table 29 (b).

Table 29 (b): Phased Implementation Timeline for three subwatersheds, distributed over years 1-5

BMP selection and Placement	Year 1	Year 2	Year 3	Year 4	Year 5
Eighteen Mile					
Urban					
Agricultural					
Septic					
Wildlife					
Golden Creek					
Urban					
Agricultural					
Septic					
Wildlife					
Lower Twelve Mile					
Urban					
Agricultural					
Septic					
Wildlife					

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Table 30 (a): Watershed Based Plan Measurable Milestones: Action items during years 6-10

Action (6-10 years)	Subwatershed	Percent Complete
Secure funding required for restoration related efforts in this plan	T,G, and E	100
Urban BMPs: • Install 16 pet waste stations • Install 9 rain garden demonstration sites • Install 2250 storm drain markers • Outreach and Education	T,G, and E	100
Agricultural BMPs: • Get additional 25% of farms to participate in structural and non-structural BMPs • Install additional 9 agricultural BMPs • Outreach and Education	T,G, and E	100
Septic BMPs: • Additional 20% of Septic Tank repair or replacement in each of the subwatersheds • Outreach and Education	T (38) ,G (45), and E (197)	60
Wildlife BMPs: • Assisted guidance in practice of hunting, trapping, and no-feeding • Develop programs to remove beaver dams, manage riparian buffers/filter strips, and rehabilitate/construct stream bank fencing • Outreach and Education	T,G, and E	100
Biannual meetings with workgroups at the three subwatersheds	T,G, and E	100
Annual updates to Councils within the three subwatersheds	T,G, and E	100
Quarterly updates on the website to keep public informed	T,G, and E	100
Quarterly email updates to stakeholders	T,G, and E	100

This table based on rubric obtained from the Twenty Five Mile Creek Watershed Based Plan, SCDHEC

Table 30 (b): Phased Implementation Timeline for three subwatersheds, distributed over years 6-10

BMP selection and Placement	Year 6	Year 7	Year 8	Year 9	Year 10
Eighteen Mile					
Urban					
Agricultural					
Septic					
Wildlife					
Golden Creek					
Urban					
Agricultural					
Septic					
Wildlife					
Lower Twelve Mile					
Urban					
Agricultural					
Septic					
Wildlife					

To monitor water quality from the 10 stations located strategically throughout the Lower Twelve Mile, Eighteen Mile, and Golden Creek watersheds as well as locations on landowners' properties to have a basis of data for future data comparison:

- The most effective BMP locations need to be determined and recorded.
- Installation of BMPS for agriculture, septic systems, urban areas, and domestic pets should be conducted.
- The 10 monitoring stations and water travelling through property with installed BMPs should be monitored after installation.
- If no improvement has been achieved for the watersheds after first five years with management adaptations and water quality control modifications then a new TMDL will need to be determined

Table 31 is a timeline of milestones that were set for a period of 12 months to draft and submit the watershed management plan to SCDHEC for review.

Table 31: Timeline for achieving milestones involved in writing and submitting a watershed management plan for the Lower Twelve Mile, Eighteen Mile and Golden Creek watersheds

#	Month	Milestone
1	Quarterly	Submit progress reports, invoices, and MBE/WBE forms per schedule outlined in grant agreement. (Note: All report and invoice forms will be provided by DHEC)
2	1	Build partnerships with cooperating organizations through meetings and identify additional stakeholders. Define scope of efforts and complete initial list of issues of concern.
3	1-2	Assess current conditions of watersheds by completing a comprehensive review of water quality data and an initial GIS analysis. Select indicators to measure environmental conditions.
4	3	Confirm list of issues of concern with stakeholders. Identify preliminary and measurable goals and indicators, and outline public outreach needs and strategies.
5	4	Compile pollutant concerns and possible causes, goals, and public outreach plan and submit to SCDHEC for review.
6	4-6	Analyze data, identify additional data gaps and compile more information where needed. Complete modeling tools and continue GIS analysis. Identify all possible management strategies and estimate load reductions from each. Identify potential criteria for measuring progress. Identify possible funding and technical assistance resources.
7	4-6	Identify reduction and removal goals for all pollutants of concern, evaluate management options and criteria with stakeholders. Identify most suitable outreach and monitoring strategy.
8	6-9	Compile pollutant reduction and removal goals, BMPs, estimated load reductions, criteria, and potential funding resources and submit to SCDHEC for review.
9	7-9	Select final pollutant reduction and removal goals, criteria, monitoring, and management strategies. Develop logical and efficient timeline of implementation steps, including milestones that should be tracked.
10	10	Compile timeline, milestones, and criteria information and submit to SCDHEC for review.
11	9-11	Compile final draft Watershed Based Plan.
12	30 days prior to project completion	Submit final draft watershed-based plan to SCDHEC for review.
13	11	Revise Watershed Based Plan based on SCDHEC's review
14	Last day of grant period	Submit final watershed-based plan to SCDHEC.
15	30 days after project completion	Submit final invoice and final technical closeout report to SCDHEC. Submit Final Budget Report within 45 days of project close.

Appendix A

Public Meeting: Location: Byrant Lodge, Pendleton, SC Time: 6:00 PM – 7:30 PM

Date: 2/4/2016

Water Quality Concerns

-Recreation (Swimming, Fishing, etc.)

-Contact

-Safety

-Preserving water quality

-Blue-ways, Trails

-Development

-Litter

-Aesthetics

-Sedimentation – Erosion

Locations of Concern

-Equestrian Center at Clemson University (Eighteen Mile)

-DNR Managed lands for waterfowl (all watersheds)

-WWTPs – overflows (all watersheds)

-Failing Septic Systems – homes (Olden)

-Farmers fertilizing fields – chicken litter, non-composited (all watersheds)

-Sanitary sewers – leaking pipes (all watersheds)

Appendix B

1) COOPERATING ORGANIZATIONS:

Clemson University faculty members from the Department of Agriculture and Environmental Sciences will assist with oversight and guidance of developing the watershed plan. Student research water quality monitoring projects are on-going at several sites in the watersheds and will continue to help provide data, however, monitoring will not receive grant funding nor will it be counted toward the grant match.

Southern Wesleyan University faculty members in the Biology Department will assist with guidance and data information to develop the watershed plan. Several water quality monitoring research projects are on-going and will continue to help provide data, however, monitoring will not receive grant funding nor be used as grant match.

Pickens County Stormwater Department will provide available data, participate in the stakeholder group and help identify practices to reduce pollutant loads, as well as provide GIS support.

Anderson County Stormwater Department will provide available data, participate in the stakeholder group and help identify practices to reduce pollutant loads

Anderson & Pickens Counties Stormwater Partners staff will provide pertinent available data, participate in the stakeholder group process, assist in public outreach and education efforts, and provide input to watershed plan development.

Pickens County Cooperative Extension Service is committed to assist in this project by engaging in the stakeholder process and sharing knowledge about agricultural best management practices.

Pickens County Soil & Water Conservation District is committed as a stakeholder to assist with watershed knowledge and public outreach.

Oconee County Cooperative Extension Service will assist as a stakeholder and provide oversight on the plan as well as septic tank expertise.

Lake Hartwell Association technical committee will participate in the stakeholder meetings and provide guidance on water quality data analyses and assist with education and outreach initiatives.

City of Easley has committed to participate in the stakeholder group process by attending meetings, providing input to the development of the plan, and support with outreach to the local residents.

Upstate Forever staff will participate in the stakeholder meetings and provide guidance on plan development, GIS, outreach and data analyses.

Naturaland Trust staff will attend stakeholder meetings, help determine BMPs, and assist with outreach to develop the plan.

SC Department of Natural Resources will participate in stakeholder meetings and provide expertise on wildlife management.

2. PROJECT STAFF EXPERTISE:

The project team has extensive expertise with local knowledge of the watersheds and landowners; experience working with landowners, municipalities, local businesses and industries; writing watershed-based plans; and implementation of watershed-based plans.

Pickens County Beautification and Environmental Advisory Committee - Charles Gill is the president of the committee, has worked in industry in engineering and purchasing, prepares financials for non-profit groups including churches, and is a coordinator for Adopt-a-Highway. Cathy Reas Foster serves on the committee and assists with environmental grant writing, including 319s, as well as grant coordination and environmental outreach and education.

Clemson University – Cal Sawyer has extensive experience preparing watershed-based plans and research in water quality, stormwater and sediment-bacteria dynamics. Jeremy Pike coordinates the Clemson program for Certified Erosion Prevention and Sediment Control, teaches watershed management courses, leads student research projects monitoring local streams and is evaluating the 12-Mile Creek restoration project. Forestry and Environmental Conservation student Alicia McAlhaney worked in the Soil Sciences and Stream labs and is taking a watershed management course. Jinna Larkin holds a M.S. degree in Natural Resources and Environmental Science, Remote Sensing, and has been a recent GIS intern with National Wild Turkey Federation and Ducks Unlimited. Namrata Sengupta is a recent PhD graduate from the Environmental Toxicology program is currently appointed as a Natural Resources Tech IV with the Department of Environmental and Agricultural Sciences. They will be the key contributors in oversight and the writing of the plan.

Anderson University – Rocky Nation is associate professor of Biology and teaches environmental science and principles of biology. He has extensive knowledge in ecology, conservation biology, and water quality monitoring and leads research and volunteer monitoring efforts in the watershed.

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