Total Maximum Daily Load Document

Sandy Run and Dean Swamp

Stations E-115 and E-030

Hydrologic Unit Codes 030502050201 and 030502050202

*Escherichia coli* Bacteria Pathogen Indicator

September 2019

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Healthy People. Healthy Communities.

Prepared by Susan Waldner

On reverse: Photographs of Sandy Run at water quality sampling site E-115 located on Cement Bridge Road in Orangeburg County, South Carolina. 33.296333, -80.292017

## Abstract

§303(d) of the Clean Water Act (CWA) and EPA's *Water Quality Planning and Management* Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are included on the §303(d) list of impaired waters. A TMDL is the maximum amount of pollutant a waterbody can assimilate while meeting water quality standards for the pollutant of concern. All TMDLs include a waste load allocation (WLA) for any National Pollutant Discharge Elimination System (NPDES)-permitted discharges, a load allocation (LA) for all nonpoint sources, and an explicit and/or implicit margin of safety (MOS). An *Escherichia coli (E. coli)* TMDL was developed for impaired stations E-030 and E-115 in the Dean Swamp Watershed located in Orangeburg and Berkeley Counties, SC. These stations are included as impaired on the State's finalized 2016 §303(d) list and draft 2018 303(d) list due to excessive fecal coliform and *E. coli* bacteria. At least 19% of the samples collected between January 2001 and December 2018 at the impaired monitoring stations exceeded the water quality standards.

Probable sources of fecal contamination include direct loading of livestock, failing septic systems, surrounding wildlife, and other agricultural activities. The load-duration curve methodology was used to calculate existing and TMDL loads for each impaired station. Existing pollutant loadings and proposed TMDL reductions for critical hydrologic conditions are presented in Table Ab-1. Critical hydrologic conditions were defined as either moist, mid-range, or dry depending on which condition demonstrated the highest load reductions necessary to meet water quality standards. To achieve the target load (slightly less than the maximum load due to the margin of safety) for the Dean Swamp Watershed, reductions in the existing loads of up to 34% will be necessary at station E-030, and reductions up to 74% will be necessary at station E-115.

For SCDOT, existing and future NPDES MS4 permittees, compliance with terms and conditions of its NPDES permit is effective implementation of the WLA to the Maximum Extent Practicable (MEP) and demonstrates consistency with the assumptions and requirements of the TMDL. For existing and future NPDES construction and Industrial stormwater permittees, compliance with terms and conditions of its permit is effective implementation of the WLA. Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures and are eligible for CWA §319 grants.

The South Carolina Department of Health and Environmental Control (SCDHEC) recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the water quality standard and we are committed towards targeting the load reductions to improve water quality in the Dean Swamp Watershed. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL target accordingly.

Total Maximum Daily Loads for the Dean Swamp Watershed Expressed as FC Bacteria or *E. coli* count/day

| | Existing Load | | TMDL | | Margin of Safety | | Waste Load Allocation (WLA) | | | Load Allocation (LA) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | Existing FC Bacteria Load (cfu/day) | Existing *E. Coli* Load (MPN/day) | FC Bacteria (cfu/day) | *E. coli* (MPN/day) | FC Bacteria (cfu/day) | *E. coli* (MPN/day) | Continuous Source[1] (MPN/day) | Non-Continuous Sources[2,3] (% Reduction) | Non-Continuous SCDOT[3,4] (% Reduction) | FC Bacteria (cfu/day) | *E. coli* (MPN/day) | % Reduction to Meet LA[4] |
| E-030 | 3.36E+11 | 2.93E+11 (see note 5) | 2.35E+11 | 2.05E+11 (see note 5) | 1.17E+10 | 1.03E+10 (see note 5) | See Note Below | 34% | 0% | 2.23E+11 | 1.95E+11 (see note 5) | 34% |
| E-115 | --- | 2.11E+12 | --- | 5.82E+11 | --- | 2.92E+10 | See Note Below | 74% | 0% | --- | 5.53E+11 | 74% |

1. WLAs are expressed as a daily maximum. There are no continuous discharges at this time. Future continuous discharges are required to meet the prescribed loading for the pollutant of concern. Future loadings will be developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100ml.
2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for pollutant of concern in accordance with their NPDES Permit.
3. Percent reduction applies to existing instream *E. coli*.
4. As long as the conditions within the SCDOT MS4 area remain the same the Department deems the current contributions from SCDOT negligible and no reduction of FC bacteria is necessary. SCDOT must continue to comply with the provisions of its approved NPDES stormwater permit.
5. Expressed as E. coli (MPN/day). Loadings are developed by applying a conversion factor to values calculated for FC bacteria. This conversion factor is derived from an established relationship between FC bacteria and E. coli WQS in freshwaters.

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# 1.0 Introduction

## 1.1 Background

The federal *Clean Water Act (CWA)* directs each state to review the quality of its waters every two years to determine if water quality standards are being met. If it is determined that the standard is not being met, the states are to list the impaired water body under §303(d) of the *CWA*. These impairments are then addressed by a Total Maximum Daily Load (40 CFR 130.31(a)).

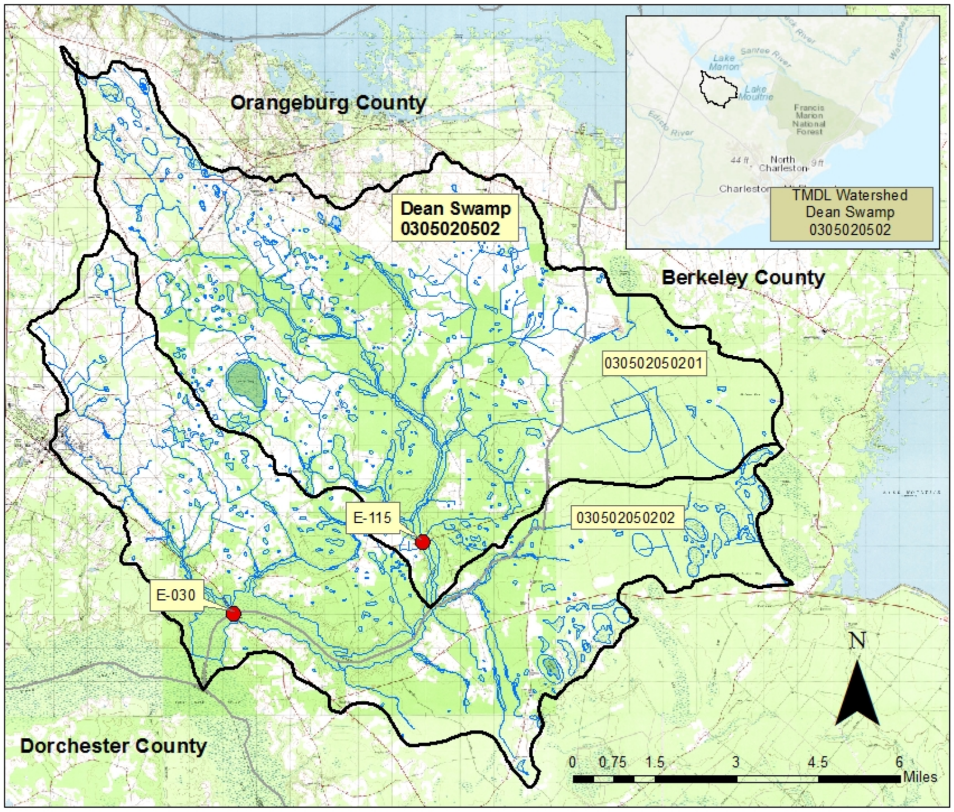
A Total Maximum Daily Load (TMDL) is a written plan and analysis to determine the maximum pollutant load a waterbody can receive and still meet applicable water quality standards. The TMDL process includes estimating pollutant loadings from all sources, linking these sources to their impacts on water quality, allocation of pollutant loads to each source, and establishment of control mechanisms to achieve water quality standards. All TMDLs include a waste load allocation (WLA) for all National Pollutant Discharge Elimination System (NPDES) permitted discharges, a load allocation (LA) for all unregulated nonpoint sources, and an explicit and/or implicit margin of safety (MOS).

*Escherichia coli (E. coli)* bacteria are members of the fecal coliform group of bacteria and are part of the normal flora of the gastrointestinal tract of warm-blooded animals. These bacteria play an important role in preventing the overgrowth of harmful bacteria in the gut, vitamin K production, lactose digestion, and fat metabolism. Some Shiga toxin producing strains of *E. coli*, such as 0157:H7 can cause gastrointestinal illnesses, kidney failure and death. *E. coli* bacteria in surface waters are indicators of recent human or animal waste contamination and may originate from failing septic systems, agricultural runoff, and leaking sewers, among other sources (Blount, 2015, Wolfson and Harrigan, 2010).

This TMDL document details the development of *E. coli* bacteria TMDLs for two water quality monitoring (WQM) stations. Dean Swamp in Berkeley County and Sandy Run in Orangeburg County were included on South Carolina's finalized 2016 303(d) list, as well the draft 2018 303(d) list, by the South Carolina Department of Health and Environmental Control (SCDHEC) for impairment due to *E. coli* bacteria exceedances. These occurred at WQM stations E-030 (Dean Swamp, HUC 12: 030502050201) and E-115 (Sandy Run, HUC 12: 030502050202).

The WQM site on Dean Swamp is a historical site with sampling data available from January 2001 through July 2009. During this time, SCDHEC used fecal coliform bacteria as a pathogen indicator. In 2014, SCDHEC changed the pathogen indicator used to determine support of recreational uses from fecal coliform bacteria to *E. coli.* Beginning with the development of South Carolina's 2014 §303(d) list, any site that had been determined to be impaired for freshwater recreational use was listed for *E. coli* bacteria rather than fecal coliform bacteria. Fecal coliform loadings from E-030 were converted to *E. coli* loadings for this TMDL. The WQM site on Sandy Run (E-115) is an active site and was sampled for *E. coli* bacteria so no conversion was necessary.

Figure 1. Dean Swamp Watershed with Locations of WQM Stations E-030 and E-115




## 1.2 Watershed Description

The Dean Swamp watershed (0305020502) occupies portions of Orangeburg and Berkeley counties and is 104.4 square miles in size. It is in the Middle Atlantic Coastal Plain ecoregion. Land uses in this watershed are predominantly evergreen forest (30.4%) and woody wetlands (22.6%) with moderate amounts of agriculture (20.4%) and minimal development (<3.5%). WQM site E-115 on Sandy Run is 1.2 miles upstream of the confluence with Dean Swamp and 5.6 miles upstream of WQM site E-030. This watershed contains portions of the towns of Holly Hill and Eutawville and may experience growth in the future as housing and industry spread from the greater Charleston area.

Table 1. Land Use in Dean Swamp HUC 10 (National Land Cover Database (NLCD), 2011)

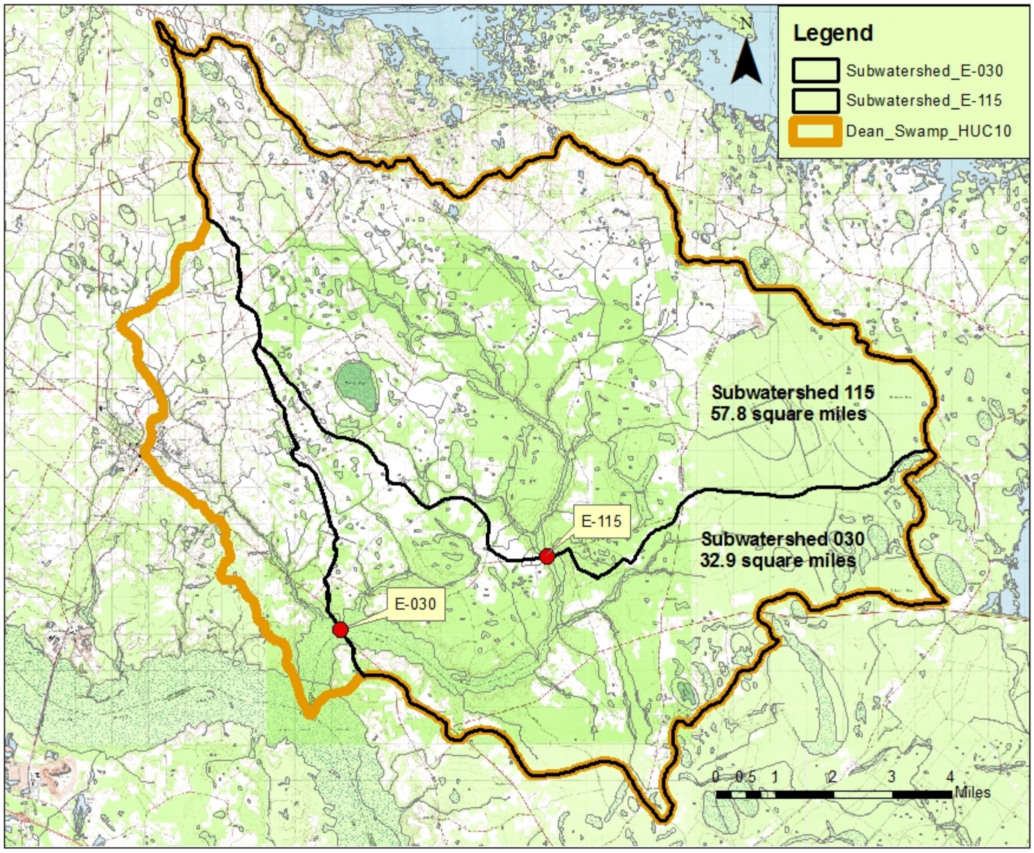
| DESCRIPTION | AREA ($MILE^2$) | PERCENTAGE |
|---|---|---|
| Evergreen Forest | 31.72 | 30.4% |
| Woody Wetlands | 23.64 | 22.6% |
| Shrub / Scrub | 15.00 | 14.4% |
| Cultivated Crops | 10.92 | 10.5% |
| Hay / Pasture | 10.33 | 9.9% |
| Herbaceous | 4.34 | 4.2% |
| Developed Open Space | 3.20 | 3.1% |
| Emergent Herbaceous | 1.41 | 1.4% |
| Mixed Forest | 1.04 | 1.0% |
| Deciduous Forest | 0.93 | 0.9% |
| Barren Land (Rock, Sand, Clay) | 0.81 | 0.8% |
| Open Water | 0.64 | 0.6% |
| Developed Low Intensity | 0.37 | 0.4% |
| Developed Medium Intensity | 0.03 | 0.03% |
| Developed High Intensity | <0.01 | <0.01% |
| TOTAL | 104.4 | 100% |

Table 2. Impaired WQM Stations in Dean Swamp Watershed

| Stream Name | WQM Station | Description |
|---|---|---|
| **Sandy Run** | E-115 | Sandy Run at Cement Bridge Road off Grooms Street |
| **Dean Swamp** | E-030 | Dean Swamp at US 78 East of Dorchester (historical) |

For purposes of analyses of pollutant loads, sources and subsequent allocation, the drainage areas associated with each of these stations are addressed individually in this document. Subwatershed 115 is the area that drains to WQM station E-115. Subwatershed 030 is the area that drains from E-115 to E-030.

Figure 2. Drainage Areas for Impaired Stations E-030 and E-115




## 1.2.1 Subwatershed 115

Subwatershed 115 drains 57.8 square miles. Sandy Run, the primary stream, originates near the town of Eutawville. It is joined by drainage from Toney Bay and tributaries Moon Savanna and Cedar Swamp before reaching the southern boundary of the drainage area at WQM site E-115. Land use is predominantly evergreen forest (27.06%), woody wetlands (19.45%), and shrub / scrub (16.06%). Less than 3.1% of the watershed is developed. Agriculture in the form of cultivated crops and hay / pasture lands account for 23.47% of the total. There are no animal feeding operations in this subwatershed and only one active NPDES permit (SCG730268). This is a general industrial permit issued to a pit quarry. There are only two instances of a discharge at this facility according to DMR records, occurring in 2013. This facility would not be expected to contribute to bacteria loading in the watershed.

Table 3. Land Use in Subwatershed 115 (NLCD, 2011)

| DESCRIPTION | AREA (MILE$^2$) | PERCENT |
|---|---|---|
| **Evergreen Forest** | 15.7 | 27.1% |
| **Woody Wetlands** | 11.3 | 19.4% |
| **Shrub Scrub** | 9.3 | 16.1% |
| **Cultivated Crops** | 6.9 | 11.9% |
| **Hay / Pasture** | 6.7 | 11.6% |
| **Herbaceous** | 2.6 | 4.5% |
| **Developed Open** | 1.6 | 2.8% |
| **Emergent Herbaceous Wetlands** | 1.0 | 1.8% |
| **Barren Land (Rock, Sand, Clay)** | 0.8 | 1.4% |
| **Deciduous Forest** | 0.7 | 1.2% |
| **Open Water** | 0.6 | 1.1% |
| **Mixed Forest** | 0.5 | 0.9% |
| **Developed Low Intensity** | 0.2 | 0.3% |
| **Developed Medium Intensity** | <0.1 | 0.03% |
| **TOTAL** | 57.9 | 100% |

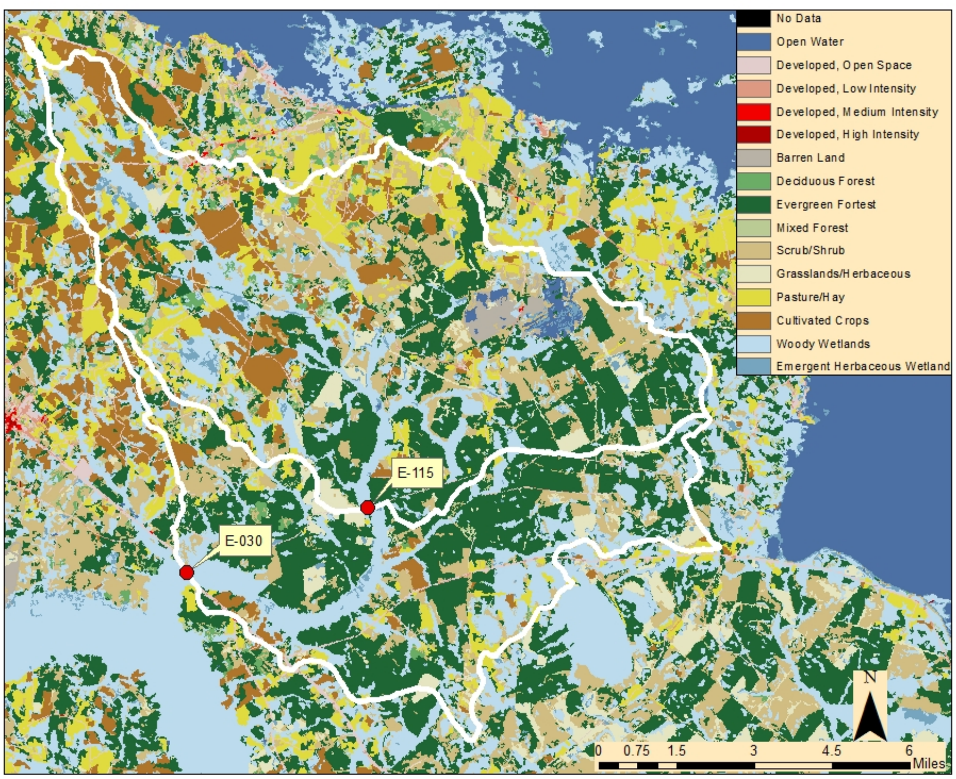
### 1.2.2 Subwatershed 030

Subwatershed 030 drains 32.9 square miles, from WQM site E-115 on Sandy Run to E-030 on Dean Swamp. In this drainage area, Little Black Creek merges with Sandy Run to form Dean Swamp which then drains to Four Hole Swamp approximately one mile downstream of E-030. Dean Swamp becomes a braided stream in the lower portion of the subwatershed and the eastern portion of the area is characterized by very little slope and several Carolina bays. There is minimal developed land (<2.2%). The drainage area is predominantly evergreen forest (42.39%) and woody wetlands (26.58%). There is a small amount of agriculture in the form of cultivated crops (3.90%) and hay / pasture (4.45%) but there are no animal feeding operations. There are no NPDES permits in this area.

Table 4. Land Use in Subwatershed 030 (NLCD, 2011)

| DESCRIPTION | AREA (MILE$^2$) | PERCENTAGE |
|---|---|---|
| **Evergreen Forest** | 14.0 | 42.4% |
| **Woody Wetlands** | 8.7 | 26.6% |
| **Shrub / Scrub** | 4.3 | 13.0% |
| **Herbaceous** | 1.6 | 5.0% |
| **Hay / Pasture** | 1.5 | 4.4% |
| **Cultivated Crops** | 1.3 | 3.9% |
| **Developed Open Space** | 0.7 | 2.0% |
| **Mixed Forest** | 0.4 | 1.1% |
| **Emergent Herbaceous Wetlands** | 0.3 | 0.8% |
| **Deciduous Forest** | 0.2 | 0.6% |
| **Developed Low Intensity** | 0.1 | 0.2% |
| **Barren Land (Rock, Sand, Clay)** | <0.01 | 0.01% |
| **Developed Medium Intensity** | <0.01 | <0.01% |
| **TOTAL** | 32.9 | 100% |

Figure 3. Land Use in Drainage Areas Associated with E-030 and E-115 (NLCD, 2011)



## 1.3 Water Quality Standard

The impaired streams addressed by this TMDL are designated as Class Freshwater (FW), which is defined in South Carolina Regulation 61-69 (2012):

"Freshwaters are suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced aquatic community of fauna and flora. Suitable also for industrial and agricultural uses".

South Carolina's water quality standard (WQS) for recreational use in freshwater is *E. coli* (R.61-68):

"Not to exceed a geometric mean of 126/100 ml based on at least four samples collected from a given sampling site over a 30 day period, nor shall a single sample maximum exceed 349/100 ml"

Prior to February 28, 2013, South Carolina's WQS for recreational use was fecal coliform (FC) bacteria:

"Not to exceed a geometric mean of 200/100 mL based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100mL."

SCDHEC has adopted a change of its pathogen indicator from FC bacteria to E. coli bacteria during 2012. The new WQS were approved by the USEPA on February 28, 2013. Starting with the effective date of February 28, 2013, E. coli bacteria is the new pathogen indicator for recreational use in freshwaters. In 1986, the United States Environmental Protection Agency (EPA) documented that E. coli and enterococcal species are better indicators than the FC bacteria group in predicting the presence of gastroenteritis-causing pathogens in freshwaters. The EPA study was based on data collected in areas where swimmers were directly exposed in freshwater lakes with established public swimming areas. The results indicated that *Enterococcus* and *E. coli* are more specific to sewage and other fecal sources than the FC bacteria group. In light of this information, EPA recommended the use of either *E. coli* or *Enterococcus* as the pathogen indicator for freshwaters.

To determine which pathogen indicator was better suited in South Carolina as the recreational use water quality standard in freshwaters, SCDHEC designed a pathogen indicator study, conducted in 2009. Weekly water samples were collected from 73 stations statewide and analyzed *for E. coli*, *Enterococcus*, and for FC bacteria group. The study results showed *E. coli* is a better indicator for predicting the presence of pathogens in South Carolina freshwaters.

During 2012, following the public participation and public comment period and legislative processes, SCDHEC submitted a proposed amendment to EPA to change the pathogen indicator from FC bacteria to *E. coli* in R. 61-68.

The proposed amendment was approved by EPA on February 28, 2013. Beginning on this date, *E. coli* as a pathogen indicator was promulgated in R. 61-68 and is now the applicable water quality standard for recreational use in freshwaters.

Beginning with the 2014 303(d) list of impaired waters, sites that had previously been listed as impaired for recreational use by FC bacteria exceedances would now be listed as impaired by *E. coli*. Once sufficient *E. coli* data are collected from impaired stations, future TMDLs will be calculated based on *E. coli* data. Until this time, TMDLs for FC impaired stations can be calculated using FC data. These FC TMDLs can then be converted to *E. coli* TMDLs by multiplying the FC TMDL by 0.8725. This ratio was derived by dividing the current single sample maximum WQS for *E. coli*, 349 MPN/100 ml, by the former single sample maximum WQS for FC bacteria, 400 cfu/100 ml.

# 2.0 Water Quality Assessment

There are three WQM stations in the Dean Swamp watershed. One was a random site sampled in 2002 (RS-02473) at the headwaters of Sandy Run. This site is not listed as impaired. The other two were included in the state's final 2016 303(d) list and the draft 2018 303(d) list due to *E. coli* exceedences. Water quality monitoring site E-030 was sampled from January 2001 through July of 2009 during which time the standard was FC bacteria. It was listed for the first time in the state's 1998 303(d) list for exceeding the FC bacteria WQS. Since 2014, this site has been listed for *E. coli* exceedences. The TMDL for this site was calculated and converted to the *E. coli* standard in accordance with the description above.

Water quality monitoring site E-115 was included for the first time on the state's 2014 303(d) list. This is an active sampling site. There are nine years' worth of bacteria data from this site, six of which are *E. coli* data. The decision was made to use only the *E. coli* data in this analysis, so no conversion is necessary.

For recreational use, if greater than 10% of the monthly geometric mean of available data collected during an assessment period exceeds the criterion, the station is included on South Carolina's §303(d) list. If sufficient data are not available to calculate a geometric mean, then the available sample results are compared against the single sample maximum (SSM) criterion. If greater than 10% of these samples exceed this criterion then the station is included on South Carolina's §303(d) list as not supporting recreational use. Table 5 provides a summary of the number of samples collected, number of exceedences, and the percentage of exceedences.

Table 5. Exceedence Summary for WQM Stations E-030 and E-115

| Station | Waterbody | Number of Samples | Number Exceeding SSM | Percent Exceeding SSM |
|---|---|---|---|---|
| **E-030** | Dean Swamp | 94 | 18 | 19% |
| **E-115** | Sandy Run | 42 | 17 | 40% |

# 3.0 Source Assessment

While there are assays available for specific human pathogens that may be present in surface water, it is time and cost prohibitive to test for every possible pathogenic organism. For this reason, indicator bacteria (such as *E. coli*) are used to indicate the presence of human pollution. These bacteria are easy to measure, have similar sources as pathogens of concern, and persist in surface waters for a similar or longer length of time. There are also pathogenic forms of *E. coli*. These may be found in the guts of ruminant animals such as cattle, goats, sheep, deer and elk, and can produce toxins (Shiga toxin-producing *E. coli* or STEC). Of these, cattle are the major source for human illnesses. A STEC infection may occur through accidental consumption (through recreational contact) of water contaminated with feces.

There are many potential sources of pathogens in surface waters. In general, these sources may be classified as point and nonpoint sources. With the implementation of technology-based controls, pollution from continuous point sources, such as factories and wastewater treatment facilities, has been greatly reduced. These point sources are required by the *CWA* to obtain a NPDES permit and in South Carolina, NPDES permits require that dischargers of sanitary wastewater meet the state standard for the relevant pathogen indicator at the point of discharge. Municipal and private sanitary wastewater treatment facilities may occasionally be sources of pathogens. However, if these facilities are discharging wastewater that meets their permit limits, they are not causing impairment. If any of these facilities is not meeting its permit limits, enforcement actions/mechanisms are required.

Non-continuous point sources required to obtain NPDES permits include stormwater discharges from municipal separate storm sewer systems (MS4s), industrial activities and construction sites. Each may be a source of pathogens. These sources are expected to meet the percentage reductions as prescribed in this TMDL or the existing instream standard for the pollutant(s) of concern through compliance with the terms and conditions of their permit. If MS4s and discharges from construction sites meet the percentage reduction or the water quality standard as prescribed in Section 5 of this TMDL development document and required in their MS4 permits, they should not be causing or contributing to an instream pathogen impairment.

Nonpoint sources of pollution come from many sources. It is usually the result of overland runoff and as such, may be the predominate source in wet conditions. Malfunctioning septic tanks, sanitary sewer overflows, pet waste, and poorly managed livestock operations are some of the potential sources of pathogens in surface water.

## 3.1 Point Sources

Point sources are defined as pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants, industrial waste treatment facilities, or regulated storm water discharges. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river. Point sources can be further broken down into continuous and non-continuous.

### 3.1.1 Continuous Point Sources

There are currently no continuous point sources in the Dean Swamp watershed. Any future NPDES-permitted dischargers of *E. coli* and other FC bacteria in this watershed will be required to implement the WLA and demonstrate consistency with the assumptions and requirements of this TMDL.

### 3.1.2 Non-Continuous Point Sources

Non-continuous point sources include all NPDES-permitted stormwater discharges, including current and future MS4s, construction and industrial discharges covered under permits numbered SCS -and SCR and regulated under SC *Water Pollution Control Permits* Regulation R61-9, §122.26(b)(4),(7),(14) - (21) (SCDHEC, 2011). All regulated MS4 entities have the potential to contribute *E. coli* and FC bacteria loadings in the delineated drainage area used in the development of these TMDLs and as such may be subject to the WLA portion of the TMDL.

The South Carolina Department of Transportation (SCDOT) is currently the only designated MS4 within the Dean Swamp Watershed. The SCDOT operates under NPDES MS4 Permit SCS040001 and owns and operates roads within the watershed. However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits.

Developed land use in the Dean Swamp Watershed is 0.38% of the total (approximately 0.4 square miles). Based on current Geographic Information System (GIS) information (available at time of TMDL development) there are no SCDOT facilities located in the referenced watershed area. According to the SCDOT website, there are no highway rest areas in the watershed area.

Other than SCDOT, there are currently no permitted sanitary sewer or stormwater systems in this watershed. Future permitted sanitary sewer or stormwater systems in the referenced watershed are required to comply with the load reductions prescribed in the WLA and demonstrate consistency with the assumptions and requirements of the TMDL.

Industrial facilities that have the potential to cause or contribute to a violation of a water quality standard due to storm water discharge are covered by the NPDES Storm Water Industrial General Permit (SCR000000). Construction activities are usually covered by the NPDES Storm Water Construction General Permit SCR100000. Where construction has the potential to affect water quality of a water body with a TMDL, the Storm Water Pollution Prevention Plan (SWPPP) for the site must address any pollutants of concern and adhere to any waste load allocations in the TMDL. Note that there may be other stormwater discharges not covered under permits numbered SCS and SCR that occur in the referenced watershed. These activities are not subject to the WLA portion of the TMDL.

Like regulated MS4s, potentially designated MS4 entities (as listed in 64 FR, 235, P.68837) or other unregulated MS4 communities located in the Dean Swamp watershed and surrounding watersheds may have the potential to contribute *E. coli* and other FC bacteria in stormwater runoff. These unregulated entities are subject to the LA for the purposes of this TMDL.

Sanitary sewer overflows (SSOs) to surface waters have the potential to severely impact water quality. These untreated sewage discharges result in violations of the WQS. It is the responsibility of the NPDES wastewater discharger, or collection system operator (for non-permitted 'collection only' systems), to ensure that releases do not occur. Unfortunately, releases to surface waters from SSOs are not always preventable or reported. There are no NPDES-permitted wastewater dischargers or community collection systems in the Dean Swamp watershed, so SSOs are not expected to contribute to *E. coli* in this area.

The Department acknowledges that progress with the assumptions and requirements of the TMDL by MS4s is expected to take one or more permit iteration. Progress towards achieving the WLA reduction for the TMDL may constitute MS4 compliance with its SWMP, provided the Maximum Extent Possible (MEP) definition is met, even where the numeric percent reduction may not be achieved in the interim.

## 3.2 Nonpoint Sources

Nonpoint source pollution is defined as pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related either to land or water use including failing septic tanks, improper animal-keeping practices, agriculture, forestry practices, wildlife and urban and rural runoff.

Wildlife, agricultural activities, grazing animals, malfunctioning septic tanks, and other nonpoint source contributors located within unregulated areas (outside the regulated MS4 area) may contribute to *E. coli* in the Dean Swamp watershed. Nonpoint sources located in unregulated areas are subject to the LA and not the WLA of the TMDL document.

Nonpoint source contributions to *E. coli* may be expected to increase in response to rainfall. Because of this, a strong positive correlation between rainfall and bacteria concentrations may indicate that nonpoint sources are predominantly responsible for bacteria exceedences. In the Dean Swamp Watershed as a whole, there was no clear relationship between rainfall amounts and bacteria exceedances. At WQM station E-115, there was a positive correlation between rainfall and bacteria amounts with a correlation coefficient of 0.78. However, just a few miles downstream at E-030 the correlation was much weaker (r=0.22).

Figure 4. Correlation Between Rainfall and Fecal Coliform Bacteria at E-030

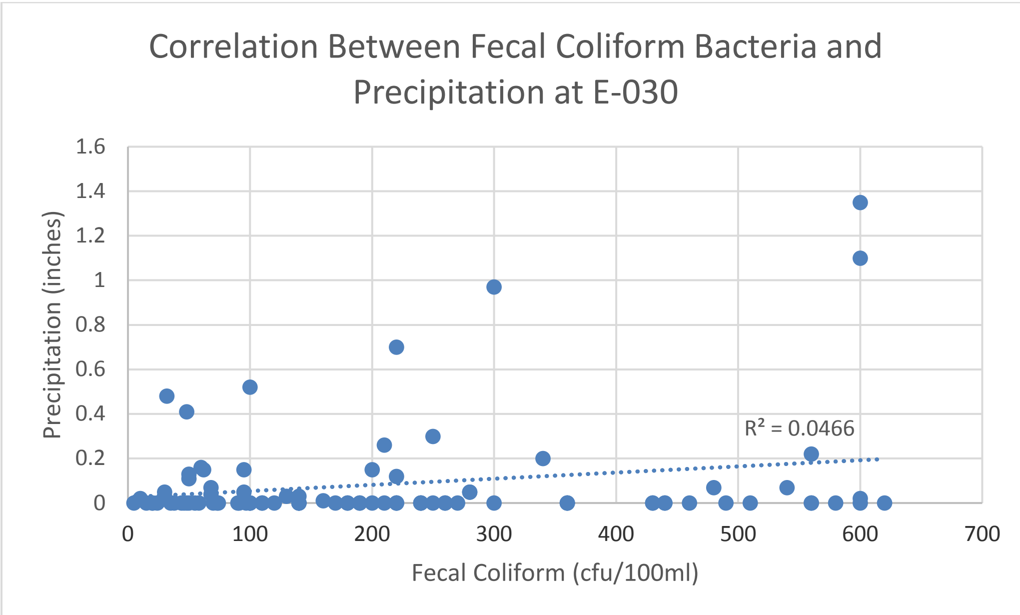



Figure 5. Fecal Coliform Bacteria and Precipitation at E-030

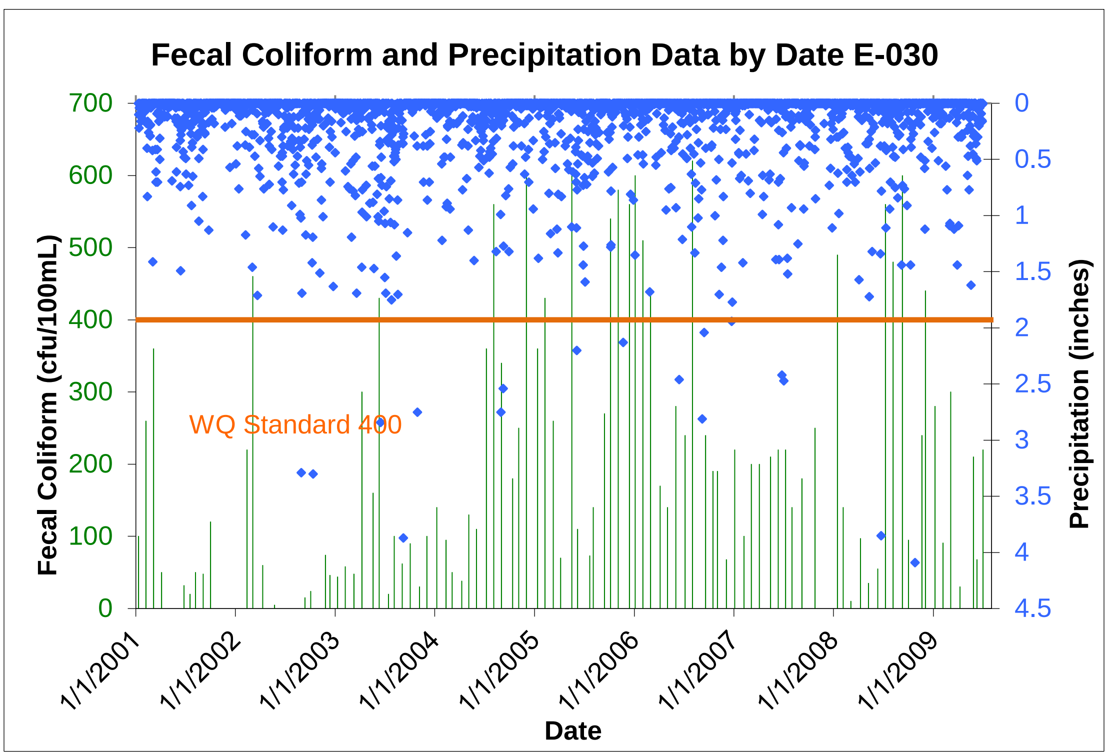


Figure 6. Correlation Between Rainfall and *E. coli* at E-115

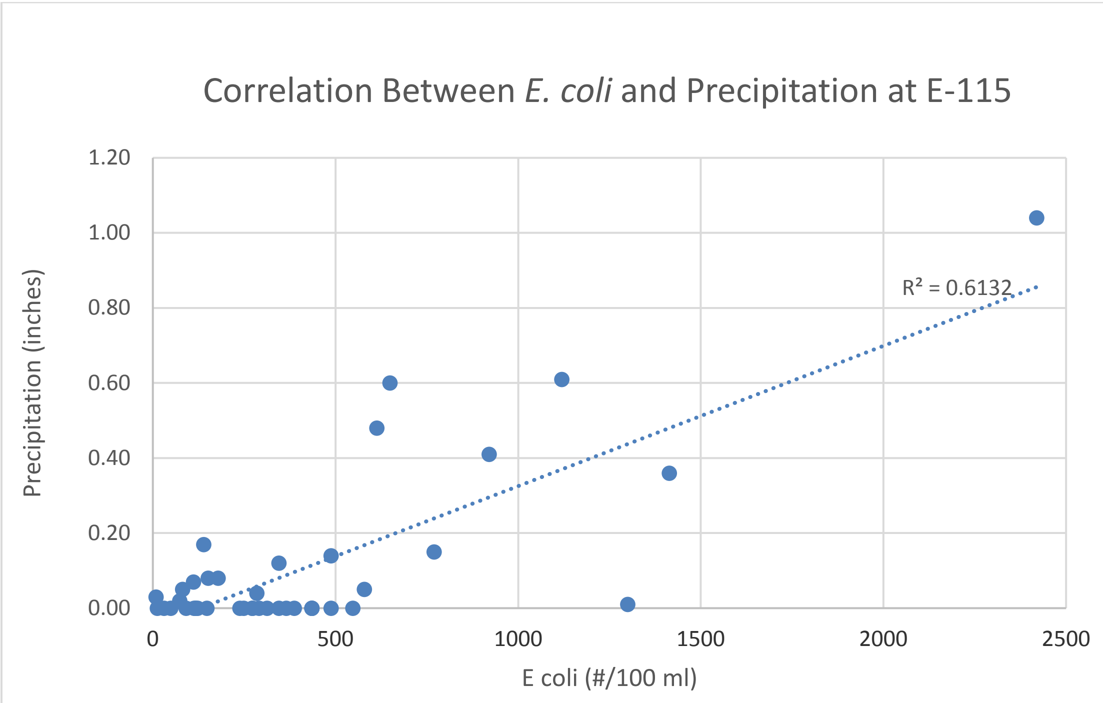



Figure 7. *E. coli* and Precipitation at E-115

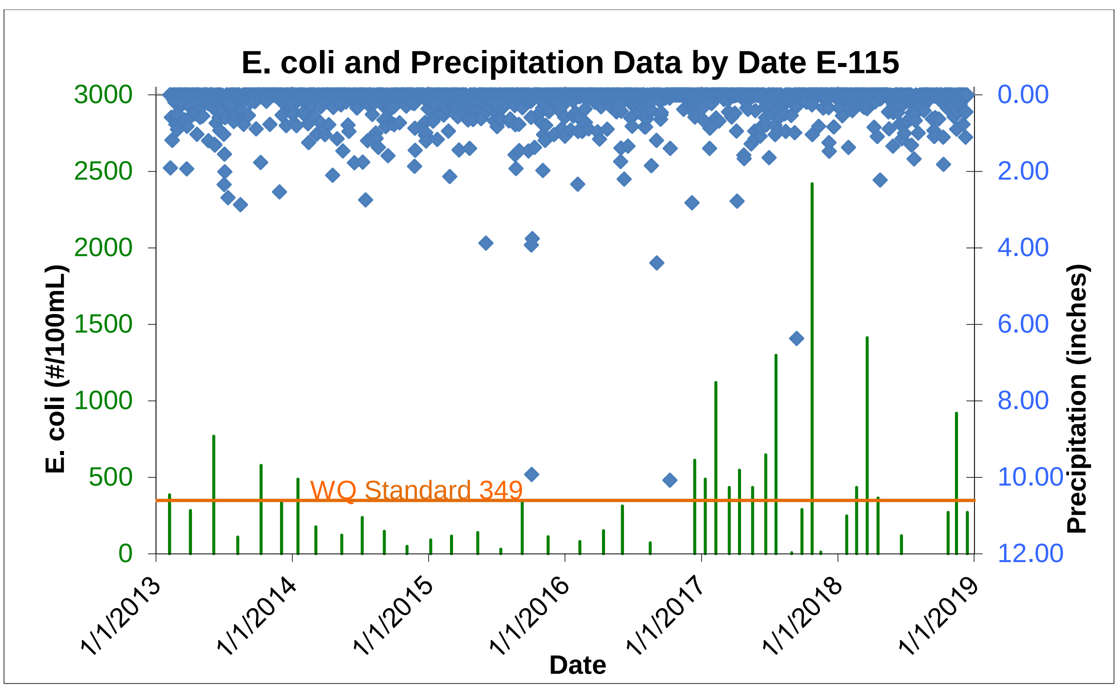


Table 6. Correlations Between Precipitation and Bacteria

| Station | Waterbody | Correlation Coefficient (r) | Coefficient of Determination ($r^2$) |
|---|---|---|---|
| **E-030** | Dean Swamp | 0.22 | 0.05 |
| **E-115** | Sandy Run | 0.78 | 0.61 |

### 3.2.1 Wildlife

Wildlife can contribute to *E. coli* and other FC bacteria found in waterways. Wildlife in this area typically includes deer, squirrels, raccoons, and a variety of birds. Wildlife feces are carried into nearby streams by runoff following rainfall or deposited directly in streams. According to a study conducted by South Carolina Department of Natural Resources (SCDNR) in 2013 and GIS analysis, the deer population ranges from 3646 to more than 4080 within the E-030 and E-115 subwatersheds. The SCDNR study estimated deer density based on suitable habitat (forests, croplands, and pastures). The FC bacteria production rate for deer has been shown to be 347 x $10^6$ cfu/head-day in a study conducted by Yagow (1999), of which only a portion will enter the water. Wildlife may contribute a significant portion of the overall bacterial load within this rural, undeveloped watershed. Evidence of deer was seen during the site visit conducted in May, 2019 (Figures 13 and 14).

### 3.2.2 Agriculture

Agricultural activities that involve livestock or animal wastes are potential sources of pathogen contamination of surface waters. Fecal matter can enter the waterway via runoff from the land or by direct deposition into the stream. Although there is not a great deal of animal agriculture in the Dean Swamp watershed, agricultural activities may still represent a significant source of bacteria due to the large numbers of bacteria associated with animal waste.

#### 3.2.2.1 Agricultural Animal Facilities

Owners/operators of most commercial animal growing operations are required by SC Regulation 61-43, *Standards for the Permitting of Agricultural Animal Facilities*, to obtain permits for the handling, storage, treatment (if necessary) and disposal of the manure, litter and dead animals generated at their facilities (SCDHEC, 2002). The requirements of R. 61-43 are designed to protect water quality; therefore, we have a reasonable assurance that facilities operating in compliance with this regulation should not contribute to downstream water quality impairments. The state of South Carolina does not have any confined animal feeding operations (CAFOs) under NPDES coverage at this time; however, the state does have permitted animal feeding operations (AFOs) covered under R. 61-43. These permitted operations are not allowed to discharge to waters of the State and are covered under 'no discharge' (ND) permits. Discharges from these operations to waters of the State are illegal and are subject to enforcement actions by the SCDHEC. Currently there are no AFOs in the Dean Swamp watershed.

#### 3.2.2.2 Grazing

Livestock, especially cattle, are frequently a contributor of *E. coli* and other FC bacteria in streams. Cattle on average produce some 1.0E+11 cfu/day per animal of FC bacteria (ASAE 1998). Grazing cattle and other livestock may contaminate streams with bacteria indirectly by runoff from pastures or directly by defecating into streams and ponds. Direct loading by cattle or other livestock to surface waters within the Dean Swamp watershed is a possible contributing source of *E. coli* and other FC bacteria. However, the grazing of unconfined livestock (in pastures) is not regulated by SCDHEC.

The United States Department of Agriculture's National Agricultural Statistics Service reported 12,670 cattle in Orangeburg County and 1,936 cattle in Berkeley County in 2017 (USDA 2019). Assuming an even distribution across the hay / pasture land in the counties, subwatershed 030 contains 94 cattle and subwatershed 115 contains 718 cattle. These cattle can be expected to produce 9.39E+12 and 7.18E+13 cfu fecal coliform bacteria per day, some of which may enter the waterways.

The NLCD land classification 'pasture / hay' includes grazing land (pasture) with land planted for seed or hay crops (hay). The latter will be harvested and is not grazed. Also, not all cattle counted by the USDA census are grazed. Dairy cattle and feedlot cattle are usually confined and would therefore not be evenly distributed across the pasture / hay land. For these reasons, the calculations provide only a rough estimate of cattle population. A tour of the watershed in May of 2019 uncovered only one instance of cattle grazing (Figure 16). There is a pond in the center of this pasture that does not appear to have any connection to the stream (according to satellite imagery) and the animals did not have direct access to the stream. It is still possible that runoff from the pasture could impact the stream, however. There were two instances of horses grazing, but no more than two or three horses were in a single pasture.

### Table 7. Head of Cattle per Acre of Pasture/Hay in Each County

| County | Number of Cattle | Acres Pasture-Hay | Cattle/Acre Pasture-Hay |
|---|---|---|---|
| Berkeley | 1936 | 31595 | 0.06128 |
| Orangeburg | 12670 | 74933 | 0.16908 |

### Table 8. Cattle in Subwatershed 030

| | Pasture-Hay Acres | Cattle /Acre Pasture-Hay | Cattle in Subwatershed 030 | Bacteria Produced (cfu/day) |
|---|---|---|---|---|
| Berkeley County portion | 600.46 | 0.06128 | 37 | |
| Orangeburg County Portion | 337.59 | 0.16908 | 57 | |
| Total | | | 94 | 9.39E+12 |

### Table 9. Cattle in Subwatershed 115

| | Pasture-Hay Acres | Cattle /Acre Pasture-Hay | Cattle in Subwatershed 115 | Bacteria Produced (cfu/day) |
|---|---|---|---|---|
| Berkeley County portion | 79.84 | 0.06128 | 5 | |
| Orangeburg County Portion | 4214.79 | 0.16908 | 713 | |
| Total | | | 718 | 7.18E+13 |

### 3.2.3 Land Application of Industrial, Domestic Sludge, or Treated Wastewater

NPDES-permitted industrial and domestic wastewater treatment processes may generate solid waste bi-products, also known as sludge. In some cases, facilities may be permitted to apply sludge to land at designated locations and under specific conditions. There are also some NPDES-permitted facilities authorized to apply treated effluent to land at designated locations and under specific conditions. Land application permits for industrial and domestic wastewater facilities may be covered under SC Regulation 61-9, Sections 503, 504, or 505. If properly managed, waste is applied at a rate that ensures pollutants will be incorporated into the soil or plants and pollutants will not enter streams. Land applications sites can be a source of fecal coliform bacteria and stream impairment if not properly managed. Similar to AFO land application sites, land application sites are not allowed to directly discharge to the waterways. Direct discharges from land applications sites to surface waters of the State are illegal and are subject to enforcement actions by SCDHEC.

### 3.2.4 Leaking Sanitary Sewers and Illicit Discharges

Leaking sewer pipes and illicit sewer connections represent a direct threat to public health since they result in discharge of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume and its proximity to the surface water. Typical values of FC bacteria in untreated domestic wastewater range from $10^4$ to $10^6$ MPN (Most Probable Number)/100mL (Metcalf and Eddy 1991).

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. Aside from SCDOT, there are no permitted MS4s in the Dean Swamp watershed. There are few if any public sewer lines in the area, so leaking sewers and illicit sewer connections are unlikely to be a significant contributing source of *E. coli*.

### 3.2.5 Failing Septic Systems

Studies demonstrate that groundwater located four feet below properly functioning septic systems contain on average less than one FC bacteria organism per 100 mL (Ayres Associates 1993). Failed or non-conforming septic systems, however, can be a major contributor of *E. coli* and other FC bacteria to the Dean Swamp watershed. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Although loading to streams from failing septic systems is likely to be a continual source, wet weather events can increase the rate of transport of pollutants from failing septic systems because of the wash-off effect from runoff and the increased rate of groundwater recharge.

Based on the 2010 U.S. census, there are an estimated 359 households with 832 people in subwatershed 115. Within subwatershed 030 there are 1500 household with 3345 people. Because none of these households are serviced by a public sewer system, there are as many septic systems as there are households. Some number of these are likely to be failing and contributing to bacteria in the stream.

### 3.2.6 Urban and Suburban Runoff

Dogs, cats, and other domesticated pets are the primary source of *E. coli* and other FC bacteria deposited on the urban and suburban landscape. There are also ‘urban’ wildlife sources, squirrels, raccoons, pigeons, and other birds, all of which contribute to the bacteria load. Urban runoff is likely negligible within the Dean Swamp watershed since there is little development. This area may see growth in the future as communities and industries spread outward from the Charleston area, however.

Similar to regulated MS4s, potentially designated MS4 entities (as listed in FR 64, 235, p.68837) or other unregulated MS4 communities located in the Dean Swamp watershed may have the potential to contribute *E. coli* and FC bacteria in stormwater runoff. Future permitted stormwater systems in this watershed will be required to comply with the load reductions prescribed in the WLA and demonstrate consistency with the assumptions and requirements of the TMDL.

While WQM site E-115 is in a very rural area, the bridge and stream banks are used for fishing, as evidenced by two anglers present with their dog on the day of the site visit (May, 2019). There are also remnants of fishing line, bobbers, and bait containers around the stream. ATV tracks leading off the road into the woods along the stream indicate the area is used for off-road vehicles also. There was a large amount of debris deposited into the stream (full black plastic garbage bags, tires, bottles and cans, fast food waste, etc.) on the stream banks and along the roadside. “No Dumping” signs posted to trees near the bridge indicate that there is a history of this behavior in the area, along with an effort to stop it (Figure 17). Some of this trash and ground disturbance could contribute to bacteria in the stream.

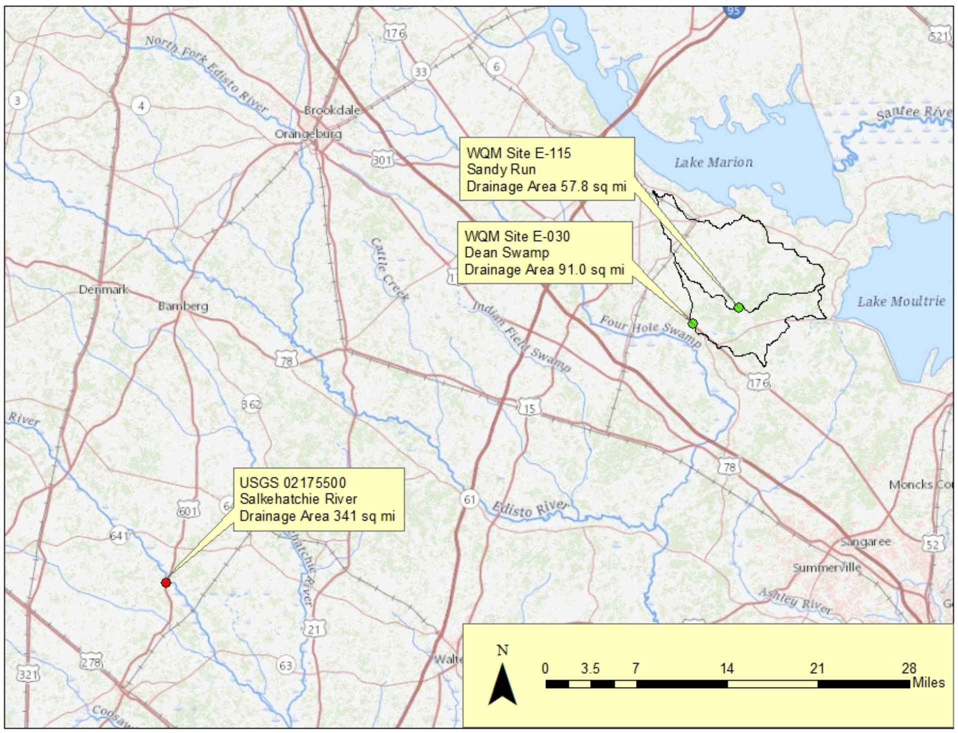
# 4.0 Load-Duration Curve Method

The load-duration curve method was developed as a means of incorporating natural variability, uncertainty, and risk assessment into TMDL development (Bonta and Cleland 2003). The analysis is based on the range of hydrologic conditions for which there are appropriate water quality data. The load-duration curve method uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate existing and TMDL loads for a water body. Development of the load-duration curve is described in this chapter.

The load-duration curve method depends on an adequate period of record for stream flow data with which to create a flow-duration curve. Since Sandy Run and Dean Swamp are not gauged, a gauged stream similar to these streams was identified. In this case, the United States Geological Survey (USGS) gauge used was 02175500 on the Salkehatchie River near Miley, South Carolina. This gauge has been recording daily flow data since 1985 and is in the same ecoregion as Sandy Run and Dean Swamp (mid-Atlantic floodplains and low terraces).

Flow data from USGS 02175500 corresponding to the sampling periods for the impaired WQM stations were used to create the flow duration curve (2/6/2013 to 12/13/2018 for E-115 and 1/10/2001 to 7/1/2009 for E-030). The record for these periods was complete. The drainage areas for the WQM stations were delineated using USGS topographic maps and ArcMap software. Flow at the WQM stations was estimated based on the ratio of the WQM station drainage area to the drainage area of USGS 02175500. For example, 02175500 records flow from 341 square miles. The drainage area for E-115 is 57.8 square miles, or 17% of the drainage area at 02175500. Daily flows at the gauge were multiplied by 0.17 to arrive at an estimated flow at E-115. Figure 8 provides an illustration of monitoring and gauge locations and Table 10 a summary of drainage area statistics used to establish flow at the un-gauged monitoring stations.

### Figure 8. Locations of USGS Gauge 02175500 and WQM Stations E-030 and E-115




### Table 10. Drainage Area Statistics

| Site | Area (square miles) | Ratio Used to Estimate Flow at WQM Sites |
|---|---|---|
| USGS Gauge 02175500 | 341 | |
| E-115 | 57.8 | 57.8 / 341 = 0.19 |
| E-030 | 91.0 | 91.0 / 341 = 0.27 |

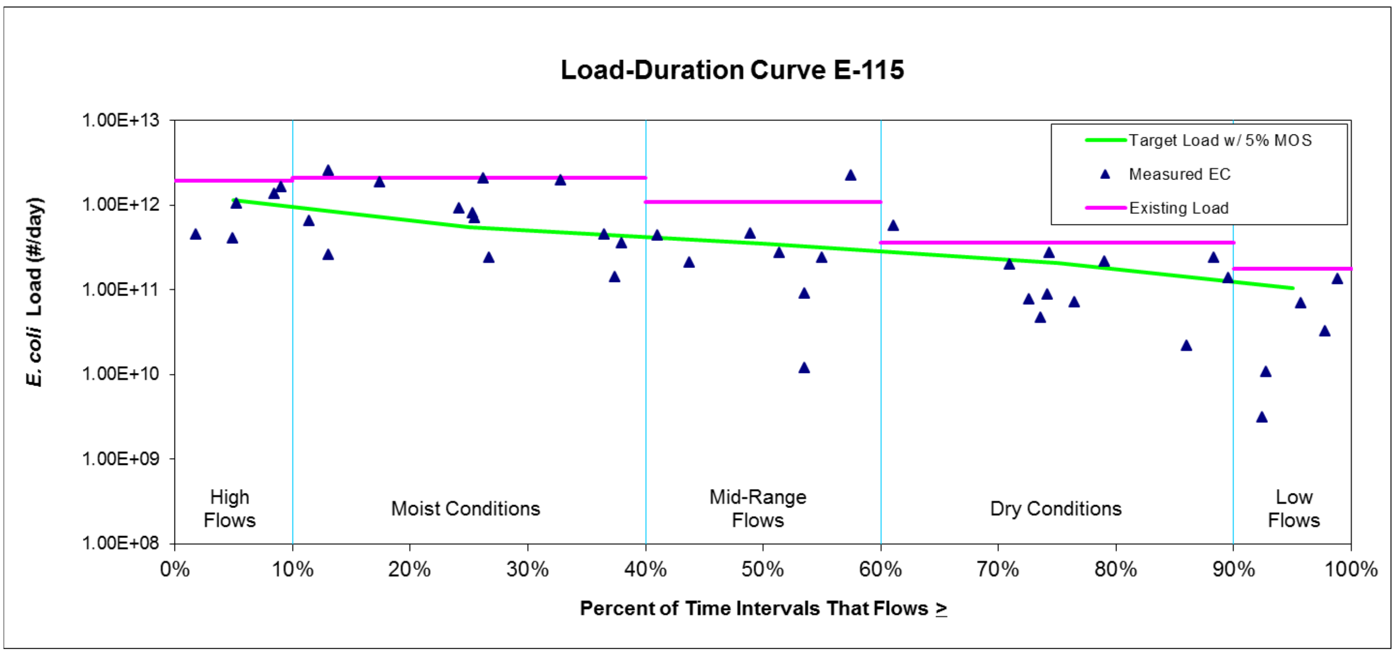
A flow duration curve was then created by ranking estimated flows at the WQM site from highest to lowest and calculating the probability of occurrence (presented as a percentage or duration interval), where zero corresponds to the highest flow. The duration interval can be used to determine the percentage of time a given flow is achieved or exceeded, based on the period of record. The flow duration curve was divided into five hydrologic condition categories (High Flows, Moist Conditions, Mid-

Range, Dry Conditions and Low Flows). Categorizing flow conditions and plotting sampling data on the same graph can assist in determining which hydrologic condition results in the greatest number of exceedences. A high number of exceedences under dry conditions might indicate a point source or illicit connection issue, whereas moist conditions may indicate nonpoint sources. In the case of E-030 and E-115, violations were seen during all flow conditions, indicating that they are due to a combination of runoff and direct sources.

Data within the High Flow and Low Flow categories are generally not used in the development of a TMDL due to their infrequency.

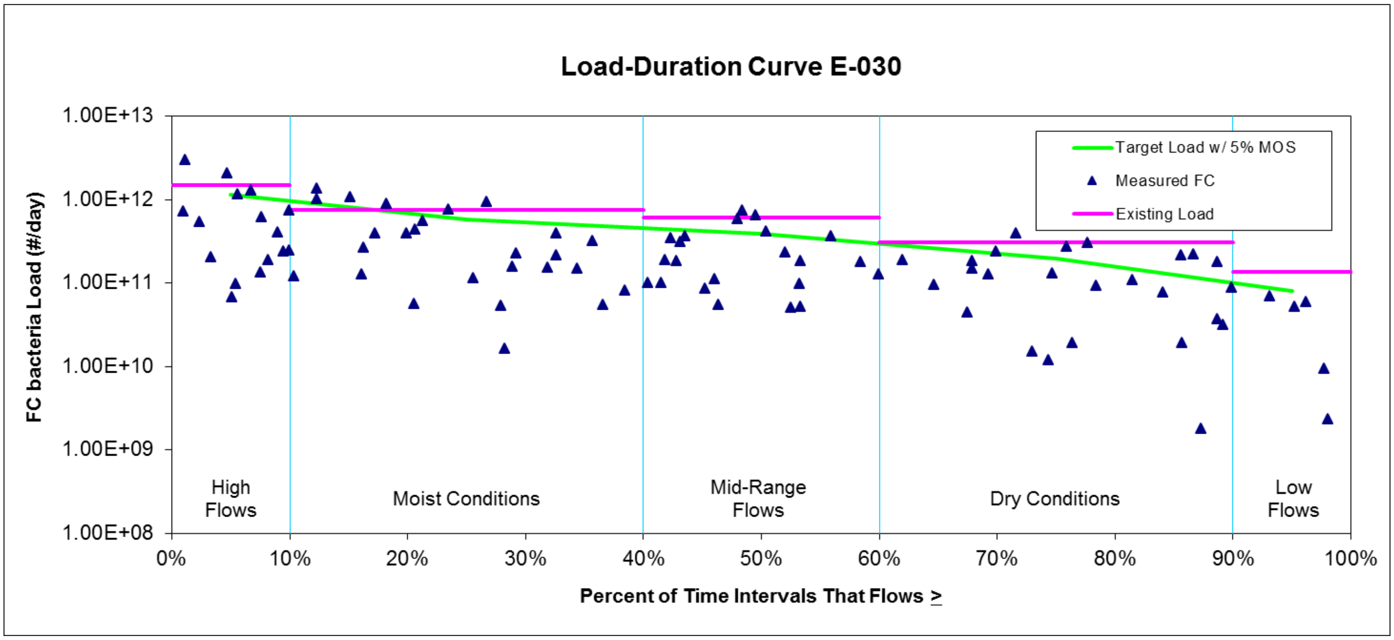
For WQM site E-115, the load-duration curve was created using *E. coli* bacteria data. The allowable load was determined using daily flow and the *E. coli* water quality criterion. The water quality target was set at 332 MPN/100ml which is 5% lower than the instantaneous water quality criterion of 349 MPN/100ml. A 5% explicit margin of safety (MOS) was reserved from the water quality criterion. The load duration curve for E-115 is presented in Figure 10.

## Figure 9. Load Duration Curve E-115




The load duration curve for WQM site E-030, was created using FC bacteria data (Figure 11). The allowable load was determined using daily flow, the FC bacteria water quality criterion that was in use before the water quality standard was changed to *E. coli*, and a unit conversion factor that converts the FC bacteria load to an *E. coli* load. The water quality target was set at 380cfu/100ml which is 5% lower than the FC bacteria instantaneous criterion of 400cfu/100ml. A 5% explicit MOS was reserved from the water quality criterion. The unit conversion factor used for E-030 was derived from the relationship established between FC bacteria and *E. coli* bacteria in freshwaters determined during SCDHEC's 2009 pathogen indicator study.

## Figure 10. Load Duration Curve E-030




In a load-duration curve, the independent variable (X axis) represents the percentage of time that the estimated flow would be greater than X. In this case flows are represented by categories: high, moist, mid-range, dry, and low. The dependent variable (Y axis) represents the bacteria load (cfu/100ml for FC bacteria and MPN/100ml for *E. coli*) at each flow. In each of the flow ranges represented on the graph, existing and target loads for E-115 were calculated by the following:

- Existing Load (MPN/day) = Mid-Point Flow in Each Hydrologic Category ($ft^3/s$) x $90^{th}$ Percentile *E. coli* Concentration x Conversion Factor (24465758.4)
- LA to Achieve Target Load (*E. coli* bacteria MPN/day) = Mid-Point Flow in Each Hydrologic Category ($ft^3/s$) x 332 (*E. coli* Bacteria WQ criterion minus a 5% MOS (MPN/100 ml)) x Conversion Factor (24465758.4)
- Percent Reduction = (Existing Load – Target Load) / Existing Load

In each of the flow ranges represented on the graph, existing and target loads for E-030 were calculated by the following:

- Existing Load (cfu/day) = Mid-Point Flow in Each Hydrologic Category ($ft^3/s$) x $90^{th}$ Percentile FC Concentration x Conversion Factor (24465758.4)

- LA to Achieve Target Load (FC bacteria cfu/day) = Mid-Point Flow in Each Hydrologic Category ($ft^3/s$) x 380 (FC Bacteria WQ criterion minus a 5% MOS (cfu/100 ml)) x Conversion Factor (24465758.4)
- Percent Reduction = (Existing Load – Target Load) / Existing Load

Instantaneous loads were calculated for each station by converting measured bacteria concentrations into numbers of bacteria per day. *E. coli* or FC bacteria samples (MPN or cfu/100ml) were multiplied by the estimated in-stream flow on the day of sampling. This value was then multiplied by a conversion factor to determine loading. Load data were plotted on the load-duration graph based on the flow duration interval for the day of sampling. Samples that lie above the target line on the load-duration curve are violations of the WQS while those below it are in compliance (Figures 9 and 10). Only the instantaneous WQS was targeted because there was insufficient data to evaluate against the 30-day geometric mean.

An existing load was determined for each hydrologic category for the TMDL calculations. The $90^{th}$ percentile of measured bacteria concentrations within each of the hydrologic categories was multiplied by the flow at each category midpoint (i.e., flow at the 25% duration interval for moist conditions, 50% interval for mid-range, and 75% for dry conditions). Existing loads were then plotted on the load-duration curve (Figures 9 and 10). These values were compared to the target load (which includes an explicit 5% MOS) at each hydrologic category midpoint to determine the percent load reduction necessary to achieve compliance with the WQS. The TMDL assumes that if the highest percent reduction is achieved then the WQS will be attained under all flow conditions.

# 5.0 Development of the Total Daily Maximum Load

A TMDL for a given pollutant and water body is comprised of the sum of individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicit or explicit, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is represented by the equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while still achieving compliance with the WQS. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provides the basis to establish water quality-based controls.

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of number, colony forming units (cfu), organism counts (or resulting concentration), or MPN, in accordance with 40 CFR 130.2(l).

## 5.1 Critical Conditions

These TMDLs are based on flow intervals between 10% and 90% and exclude extreme high and low flow conditions; flows that are characterized as 'Low' or 'High' in Figure 10 were not included in the analysis. The critical condition for each monitoring station is identified as the flow condition requiring the largest percent reduction, within the 10-90% duration intervals. Critical conditions for the Dean Swamp Watershed pathogen impaired stations are listed in Table 10. These data indicate that for WQM site E-115, moist conditions result in larger bacteria loads and this is the critical condition for that station. For station E-030, dry conditions result in larger bacteria loads and is therefore critical condition for that station.

## 5.2 Existing Load

An existing load was determined for each hydrologic category for the TMDL calculations as described in Section 4.0 of this TMDL document. The existing load under the critical condition described in Section 5.1 was used in the TMDL calculations. Loadings from all sources are included in this value: cattle-in-streams, failing septic systems as well as wildlife. The existing load for stations E-030 and E-115 are provided in Appendix A.

Table 11. Percent Reduction Necessary to Achieve Target Load by Hydrologic Category

| WQM Site | Stream | Moist Conditions | Mid-Range Flow | Dry Conditions |
|---|---|---|---|---|
| E-030 | Dean Swamp | 22% | 20% | 34% |
| E-115 | Sandy Run | 74% | 68% | 43% |

Highlighted cells indicate critical conditions.

## 5.3 Waste Load Allocation

The waste load allocation (WLA) is the portion of the TMDL allocated to NPDES-permitted point sources (USEPA 1991). Note that all illicit dischargers, including SSOs, are illegal and not covered under the WLA of these TMDLs.

### 5.3.1 Continuous Point Sources

There are currently no permitted dischargers of *E. coli* and other FC bacteria in the Dean Swamp Watershed. Because South Carolina has recently adopted a change from FC bacteria to *E. coli* bacteria as a recreational use standard in all freshwaters, future continuous discharges will be required to meet the prescribed loading for *E. coli* based on permitted flow and an allowable permitted maximum concentration of 349MPN/100mL.

### 5.3.2 Non-continuous Point Sources

Non-continuous point sources include all NPDES-permitted stormwater discharges, including current and future MS4s, construction and industrial stormwater discharges covered under permits numbered SCS000000 & SCR100000 and regulated under SC *Water Pollution Control Permits* Regulation 122.26(b)(14) & (15) (SCDHEC 2011). Illicit discharges, including SSOs, are not covered under any NPDES permit and are subject to enforcement mechanisms. Any area defined as an "Urbanized Area" by the US Census is required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater. Other non-urbanized areas may be required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater. At the time of the TMDL development, no part of the Dean Swamp Watershed is classified as urbanized area.

The South Carolina Department of Transportation (SCDOT) is currently the only designated MS4 within the Dean Swamp Watershed. The SCDOT operates under NPDES MS4 Permit SCS040001 and owns and operates roads within the watershed. However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits.

Waste load allocations for stormwater discharges are expressed as a percentage reduction instead of a numeric loading due to the uncertain nature of stormwater discharge volumes and recurrence intervals. All current and future stormwater discharges are required to meet the percentage reduction or the existing instream standard for the pollutant of concern. The percent reduction is based on the maximum percent reduction (critical condition) within any hydrologic category necessary to achieve target conditions. Table 12. presents the reduction needed for the impaired stations. The reduction percentages in these TMDLs also apply to the FC bacteria or *E. coli* waste load attributable to those areas of the watershed that are covered or will be covered under NPDES MS4 permits.

As appropriate information is made available to further define the pollutant contributions for the permitted MS4, an effort may be made to revise these TMDLs. This effort will be initiated as resources permit and if deemed appropriate by the Department. For the Department to revise these TMDLs the following information should be provided, but not limited to:

1) An inventory of service boundaries of the MS4 covered in the MS4 permit, provided as ARCGIS compatible shape files.

2) An inventory of all existing and planned stormwater discharge points, conveyances, and drainage areas for the discharge points, provided as ARCGIS compatible shape files. If drainage areas are not known, any information that would help estimate the drainage areas should be provided. The percentage of impervious surface within the MS4 area should also be provided.

3) Appropriate and relevant data should be provided to calculate individual pollutant contributions for the MS4 permitted entities. At a minimum, this information should include precipitation, water quality, and flow data for stormwater discharge points.

Table 12. Percent Reduction Necessary to Achieve Target Load

| WQM Site | Stream | % Reduction |
|---|---|---|
| E-030 | Dean Swamp | 34% |
| E-115 | Sandy Run | 74% |

Compliance with terms and conditions of existing and future NPDES sanitary and stormwater permits (including all construction, industrial and MS4) will effectively implement the WLA and demonstrate consistency with the assumptions and requirements of the TMDL. However, the Department recognizes that the SCDOT is not a traditional MS4 in that it does not possess statutory taxing or enforcement powers. The SCDOT does not regulate land use of zoning, issue building or development permits.

## 5.4 Load Allocation

The Load Allocation applies to the nonpoint sources of *E. coli* and other FC bacteria and is expressed both as a load and as a percent reduction. The load allocation is calculated as the difference between the target load under the critical condition and the point source WLA. The load allocation is listed in Table 13. There may be other unregulated MS4s located in the Dean Swamp Watershed that are subject to the LA components of these TMDLs. At such time that the referenced entities, or other future unregulated entities become regulated NPDES MS4 entities and are subject to applicable provisions of SC Regulation 61-68D, they will be required to meet load reductions prescribed in the WLA component of the TMDL. This also applies to future discharges associated with industrial and construction activities that will be subject to SC R. 61-9 122.26(b)(14) & (15) (SCDHEC 2011).

## 5.5 Seasonal Variability

Federal regulations require that TMDLs consider the seasonal variability in watershed loading. The variability in these TMDLs is accounted for by using multi-year hydrological and water quality sampling data sets.

## 5.6 Margin of Safety

The margin of safety (MOS) may be explicit and/or implicit. The explicit margin of safety is 5% of the TMDL, or in the case of FC TMDLs, 20 cfu/100mL of the instantaneous criterion of 400 cfu/100 mL (380 cfu/100mL); and, in the case of *E. coli* TMDLs, 17 MPN/100mL of the instantaneous criterion of 349 MPN/100 mL (332 MPN/100mL). The MOS is expressed as the value calculated from the critical condition defined in Section 5.1 and is the difference between the TMDL and the sum of the WLA and LA.

A 5% MOS in freshwaters impaired for *E. coli* may be calculated as the ratio of *E.coli* MPN/100 mL to FC bacteria cfu/100 mL or 20*0.8725 = 17 MPN/100 mL of the instantaneous *E. coli* criterion of 349

MPN/100 mL (332 MPN/100 mL). This conversion is deemed appropriate by the Department and was derived from an established relationship between FC bacteria and *E. coli* WQS in freshwaters determined during the 2009 Pathogen Indicator Study.

## 5.7 TMDL

For most pollutants, TMDLs are expressed as a mass load (e.g., kilograms per day). For bacteria, however, TMDLs are expressed in terms of cfu or MPN or organism counts, in accordance with 40 CFR 130.2(l). Only the instantaneous water quality criterion was targeted for the Dean Swamp Watershed because there is insufficient data to evaluate against the 30-day geometric mean. The target load is defined as the load (from point and nonpoint sources) minus the MOS that a stream station can receive while meeting the WQS. The TMDL value is the median target load within the critical condition (i.e., the middle value within the hydrologic category that requires the greatest load reduction) plus the WLA and MOS.

While TMDL development was primarily based on instantaneous water quality criterion, terms and conditions of NPDES permits for continuous discharges require facilities to demonstrate compliance with both geometric mean and instantaneous water quality criteria for FC bacteria in treated effluent. NPDES permits for continuous dischargers require data collection sufficient to monitor for compliance of both criteria at the point of outfall.

Table 13 indicates the percentage reduction or water quality standard required for each subwatershed in the Dean Swamp Watershed. Note that all future regulated NPDES-permitted stormwater discharges will also be required to meet the prescribed percentage reductions, or the water quality standard. It should be noted that in order to meet the WQS for *E. coli* bacteria prescribed load reductions must be targeted from all sources, including NPDES permitted and nonpoint sources.

Based on the available information at this time, the portion of the Dean Swamp Watershed that drains directly to a regulated MS4 and that which drains through the unregulated MS4 has not been clearly defined within the MS4 jurisdictional area. Loading from both types of sources (regulated and unregulated) typically occurs in response to rainfall events, and discharge volumes as well as recurrence intervals are largely unknown. Therefore, where applicable, the regulated MS4 is assigned the same percent reduction as the non-regulated sources in the watershed. Compliance with the MS4 permit in regard to this TMDL document is determined at the point of discharge to waters of the state. The regulated MS4 entity is only responsible for implementing the TMDL WLA in accordance with their MS4 permit requirements and is not responsible for reducing loads prescribed as LA in this TMDL document.

## Table 13. Total Maximum Daily Loads for the Dean Swamp and Sandy Run Watersheds

| | Existing Load | | TMDL | | Margin of Safety | | Waste Load Allocation (WLA) | | | Load Allocation (LA) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **Existing FC Bacteria Load (cfu/day)** | **Existing *E. Coli* Load (MPN/day)** | **FC Bacteria (cfu/day)** | ***E. coli* (MPN/day)** | **FC Bacteria (cfu/day)** | ***E. coli* (MPN/day)** | **Continuous Source[1] (MPN/day)** | **Non-Continuous Sources[2,3] (% Reduction)** | **Non-Continuous SCDOT[3,4] (% Reduction)** | **FC Bacteria (cfu/day)** | ***E. coli* (MPN/day)** | **% Reduction to Meet LA[4]** |
| **E-030** | 3.36E+11 | 2.93E+11 (see note 5) | 2.35E+11 | 2.05E+11 (see note 5) | 1.17E+10 | 1.03E+10 (see note 5) | (see note 1) | 34% | 0% | 2.23E+11 | 1.95E+11 (see note 5) | 34% |
| **E-115** | --- | 2.11E+12 | --- | 5.82E+11 | --- | 2.92E+10 | (see note 1) | 74% | 0% | --- | 5.53E+11 | 74% |

1. WLAs are expressed as a daily maximum. There are no continuous discharges at this time. Future continuous discharges are required to meet the prescribed loading for the pollutant of concern. Future loadings will be developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100ml.
2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for pollutant of concern in accordance with their NPDES Permit.
3. Percent reduction applies to existing instream *E. coli.*
4. As long as the conditions within the SCDOT MS4 area remain the same the Department deems the current contributions from SCDOT negligible and no reduction of FC bacteria is necessary. SCDOT must continue to comply with the provisions of its approved NPDES stormwater permit.
5. Expressed as E. coli (MPN/day). Loadings are developed by applying a conversion factor to values calculated for FC bacteria. This conversion factor is derived from an established relationship between FC bacteria and *E. coli* WQS in freshwaters.

## 5.8 Reasonable Assurance

NPDES permits are issued for regulated dischargers, including continuous and non-continuous sources of pathogenic bacteria. In freshwaters, the applicable recreational use water quality standard is *E. coli* bacteria. Continuous discharges are required to target the *E. coli* water quality standard at the point of discharge. For regulated non-continuous discharges, the *E. coli* standard should be targeted to the maximum extent practicable. There may be other regulated activities present that could contribute to *E. coli* loadings in the watershed. New septic tanks, animal feeding operations (AFOs), land application of treated sludge or wastewater also require permits that reduce the potential for runoff of bacteria into waters of the State.

Unregulated sources of *E. coli* loadings in the watershed may include wildlife, improper agricultural or silvicultural activities, urban and suburban runoff. These sources may be reduced through means such as best management practices, local ordinances, and outreach education efforts, as well as 319 grant opportunities. SCDHEC has fostered effective partnerships between other federal, state and local entities to help reduce the potential for runoff of bacteria into waters of the State. Once implemented, all these reduction mechanisms will provide reasonable assurance that the recreational use water quality standard will be attained in this watershed.

# 6.0 Implementation

Implementation of both point (WLA) and non-point (LA) source components of the TMDL are necessary to bring about the required reductions in *E. coli* bacteria loading to the Dean Swamp Watershed. Using existing authorities and mechanisms, implementation guidance providing information on how point and non-point sources of pollution may be abated to meet water quality standards is provided. Sections 6.1.1-6.1.7 presented below correspond with sections 3.1.1-3.2.5 of the source assessment presented in the TMDL document. As the implementation strategy progresses, SCDHEC will continue to monitor the effectiveness of implementation measures and evaluate water quality where deemed appropriate.

Point sources are discernible, confined, and discrete conveyances of pollutants to a water body including but not limited to pipes, outfalls, channels, tunnels, conduits, man-made ditches, etc. The Clean Water Act's primary point source control program is the National Pollutant Discharge Elimination System (NPDES). Point sources can be broken down into continuous and non-continuous point sources. Some examples of a continuous point source are wastewater treatment facilities (WWTF) and industrial facilities. Some examples of non-continuous point sources include MS4s and construction activities. Current and future NPDES discharges in the referenced watershed are required to comply with the load reductions prescribed in the waste load allocation (WLA).

Nonpoint source pollution originates from multiple sources over a relatively large area. It is diffuse in nature and indistinct from other sources of pollution. It is generally caused by the pickup and transport of pollutants from rainfall moving over and through the ground. Nonpoint sources of pollution may include, but are not limited to wildlife, agricultural activities, illicit discharges, failing septic systems, and urban runoff. Nonpoint sources located in unregulated portions of the Dean Swamp Watershed are subject to the load allocation (LA) and not the WLA of the TMDL document.

South Carolina has several tools available for implementing the non-point source components of these TMDLs. The *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina* (SCDHEC 1998) document is one example. Another key component for interested parties to control pollution and prevent water quality degradation in the Dean Swamp Watershed would be the establishment and administration of a program of Best Management Practices (BMPs). Best management practices may be defined as a practice or a combination of practices that have been determined to be the most effective, practical means used in the prevention and/or reduction of pollution.

Interested parties (local stakeholder groups, universities, local governments, etc.) may be eligible to apply for CWA §319 grants to install BMPs that will implement the LA portions of these TMDLs and reduce nonpoint source *E. coli* loading to the Dean Swamp Watershed. Congress amended the Clean Water Act (CWA) in 1987 to establish the Section 319 Nonpoint Source Management Program. Under Section 319, States receive grant money to support a wide variety of activities including the restoration of impaired waters. TMDL implementation projects are given highest priority for 319 funding. SCDHEC will also work with existing agencies in the area to provide nonpoint source education in the Dean Swamp Watershed.

The Department recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the water quality standard and we are committed towards targeting the load reductions to improve water quality in the Dean Swamp Watershed. As additional data and/or information become available, it may become necessary to revise and/or modify the TMDL target accordingly.

## 6.1 Implementation Strategies

The strategies presented in this document for implementation of the Dean Swamp Watershed TMDL are not inclusive and are to be used only as guidance. The strategies are informational suggestions that may lead to the required load reductions being met while demonstrating consistency with the assumptions and requirements of the TMDL. Application of certain strategies provided may be voluntary and are not a substitute for actual NPDES permit conditions.

### 6.1.1 Continuous Point Sources

Continuous point source WLA reductions are implemented through NPDES permitting. There are no existing continuous point sources in Dean Swamp Watershed. Any future continuous discharges are required to meet the prescribed loading for the pollutant of concern and demonstrate consistency with the assumptions and requirements of the TMDL. *E. coli* loadings are developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100mL.

### 6.1.2 Non-continuous Point Sources

An iterative BMP approach as defined in the general stormwater NPDES MS4 permit is expected to provide significant implementation of the WLA. Permit requirements for implementing WLAs in approved TMDLs will vary across waterbodies, discharges, and pollutant(s) of concern. The allocations within a TMDL can take many different forms – narrative, numeric, specific BMPs – and may be complimented by other special requirements such as monitoring.

The level of monitoring necessary, deployment of structural and non-structural BMPs, evaluation of BMP performance, and optimization or revisions to the existing pollutant reduction goals of the Storm Water Management Plan (SWMP) or any other plan is TMDL and watershed specific. Hence, it is expected that NPDES permit holders will evaluate their existing SWMP or other plans in a manner that would effectively address implementation of these TMDLs with an acceptable schedule and activities for their permit compliance. The Department (permit writers, TMDL project managers, and compliance staff) is willing to assist in developing or updating the referenced plan as deemed necessary. Please see Appendix B for additional information on evaluating the effectiveness of an MS4 Permit as it relates to compliance with approved TMDLs. For SCDOT, existing and future NPDES MS4 permittees, compliance with terms and conditions of the NPDES permit is effective implementation of the WLA to the Maximum Extent Practicable (MEP) and demonstrates consistency with the assumptions and requirements of the TMDL. For existing and future NPDES construction and industrial stormwater permittees, compliance with terms and conditions of the permit is effective implementation of the WLA. Required load reductions in the LA portion of this TMDL can be implemented through voluntary measures and are eligible for CWA §319 grants.

The Department acknowledges that progress with the assumptions and requirements of the TMDL by MS4s is expected to take one or more permit iteration. Achieving the WLA reduction for the TMDL may constitute MS4 compliance with its SWMP, provided the MEP definition is met, even where the numeric percent reduction may not be achieved in the interim.

Regulated MS4 entities are required to develop a SWMP that includes the following: public education, public involvement, illicit discharge detection & elimination, construction site runoff control, post construction runoff control, and pollution prevention/good housekeeping. These measures are not exhaustive and may include additional criteria depending on the type of NPDES MS4 permit in question. The following examples are recognized as acceptable stormwater practices and may be applied to unregulated MS4 entities or other interested parties in the development of a stormwater management plan.

An informed and knowledgeable community is crucial to the success of a stormwater management plan (USEPA, 2005). MS4 entities may implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impacts of stormwater discharges on local waterbodies and the steps that can be taken to reduce stormwater pollution. Some appropriate BMPs may be brochures, educational programs, storm drain stenciling, stormwater hotlines, tributary signage, and alternative information sources such as websites, bumper stickers, etc. (USEPA, 2005).

The public can provide valuable input and assistance to a stormwater management program and they may have the potential to play an active role in both the development and implementation of the stormwater program where deemed appropriate by the entity. There are a variety of practices that can involve public participation such as public meetings/citizens panels, volunteer water quality monitoring, volunteer educators, community clean-ups, citizen watch groups, and “Adopt a Storm Drain” programs which encourage individuals or groups to keep storm drains free of debris and monitor what is entering local waterways through storm drains (USEPA, 2005).

Illicit discharge detection and elimination efforts are also necessary. Discharges from MS4s often include wastes and wastewater from non-stormwater sources. This enters the system through either direct connections or indirect connections. The result is untreated discharges that contribute high levels of pollutants, including heavy metals, toxics, oil and grease, solvents, nutrients, viruses, and bacteria to receiving waterbodies (USEPA, 2005). Pollutant levels from these illicit discharges have been shown in EPA studies to be high enough to significantly degrade receiving water quality and threaten aquatic, wildlife, and human health. MS4 entities may have a storm sewer system map which shows the location of all outfalls and to which waters of the US they discharge. If not already in place, an ordinance prohibiting non-stormwater discharges into a MS4 with appropriate enforcement procedures may be developed. Entities may also have a plan for detecting and addressing non-stormwater discharges. The plan may include locating problem areas through infrared photography, finding the sources through dye testing, removal/correction of illicit connections, and documenting the actions taken to illustrate that progress is being made to eliminate illicit connections and discharges.

A program might also be developed to reduce pollutants in stormwater runoff to the MS4 area from construction activities. An ordinance or other regulatory mechanism may exist requiring the implementation of proper erosion and sediment controls on applicable construction sites. Site plans should be reviewed for projects that consider potential water quality impacts. It is recommended that site inspections should be conducted, and control measures enforced where applicable. A procedure might also exist for considering information submitted by the public (USEPA, 2005). For information on specific BMPs please refer to the SCDHEC Stormwater Management BMP Handbook online at: https://scdhec.gov/environment/water-quality/stormwater/bmp-handbook

Post-construction stormwater management in areas undergoing new development or redevelopment is recommended because runoff from these areas has been shown to significantly affect receiving waterbodies. Many studies indicate that prior planning and design for the minimization of pollutants in post-construction stormwater discharges is the most cost-effective approach to stormwater quality management (USEPA, 2005). Strategies might be developed to include a combination of structural and/or non-structural BMPs. An ordinance or other regulatory mechanism may also exist requiring the implementation of post-construction runoff controls and ensuring their long term-operation and maintenance. Examples of non-structural BMPs are planning procedures and site-based BMPs (minimization of imperviousness and maximization of open space). Structural BMPs may include but are not limited to stormwater retention/detention BMPs, infiltration BMPs (dry wells, porous pavement, etc.), and vegetative BMPs (grassy swales, filter strips, rain gardens, artificial wetlands, etc.).

Pollution prevention is also a key element of stormwater management programs. This requires the MS4 entity to examine and alter their programs or activities to ensure reductions in pollution are occurring. A plan should be developed to prevent or reduce pollutant runoff from municipal operations into the storm sewer system and employees trained on ways to incorporate and document pollution prevention/good housekeeping techniques. The MS4 operator can use training materials that are available from EPA or relevant organizations (USEPA, 2005).

### 6.1.3 Wildlife

Methods for managing the bacteria contribution from wildlife will vary from location to location. In developed areas it may make sense to divert wildlife from sensitive areas by fencing, mowing, landscaping changes, and trimming trees to reduce bird roosting. Food sources for wildlife can be kept to a minimum by prohibiting feeding by the public, by removing trash, pet food, and palatable plant species. In rural, undeveloped areas, such as the Dean Swamp Watershed, these methods would not be practical.

Although there are many ways to discourage birds and other wildlife from waterways by removing attractants or harassing nuisance species, any plans to do so should be undertaken only with a good understanding of the animal populations in question. Federal and state permits may be required to interfere with wildlife, and some nuisance species such as Canada geese and other migratory birds are protected by federal law. It is recommended that the South Carolina Department of Natural Resources, USDA-APHIS, and the United States Fish and Wildlife Service be consulted prior to interfering with wildlife (USEPA, 2001).

### 6.1.4 Agricultural Activities

Suggested forms of implementation for agricultural activities will vary depending on location. Agricultural BMPs can be vegetative, structural, or management oriented. When selecting BMPs, it is important to keep in mind that nonpoint source pollution occurs when a pollutant becomes available, is detached, and then transported to nearby receiving waters. For BMPs to be effective, the transport mechanism of the pollutant, in this case *E. coli* bacteria, needs to be identified.

For livestock in the watershed, installing fencing along the streams within the watershed and providing an alternative water source where livestock are present would eliminate direct contact with the streams. There were few grazed pastures noted during the source assessment survey conducted on May 1, 2019. However, when grazing animals have access to streams, they have a large impact on bacteria loads even if few in number. If fencing is not feasible, it has been shown that installing water troughs within a pasture area reduced the amount of time livestock spent drinking directly from streams by 92% (Sheffield et al.,1997). In addition to reducing bacteria in the stream, this BPM resulted in a 77% reduction in stream bank erosion.

Most of the agricultural activities observed in the Dean Swamp Watershed consisted of row crops, hay fields and silviculture. For row crops in the referenced watershed, many practices exist to reduce nonpoint source pollution. Unstabilized soil directly adjacent to surface waters can contribute to bacteria loading during periods of runoff after rain events. Agricultural field borders and filter strips (vegetative buffers) can provide erosion control around fields. These borders may be harvested as hay and provide an area in which farmers can turn equipment around when working the field (SCDNR, 1997). A study conducted in 1998 by the American Society of Agricultural and Biological Engineers (ASABE 1998) has shown that a vegetative buffer measuring 6.1 meters in width can reduce fecal bacteria runoff concentrations to a non-detectable amount. A buffer of this width was also shown to reduce phosphorous and nitrogen concentrations in runoff by 75%.

The agricultural BMPs listed above are just a sample of the many accepted practices that are currently available. Many other techniques such as conservation tillage, responsible pest management, and precision agriculture also exist and may contribute to an improvement in overall water quality in the Dean Swamp Watershed. Education should be provided to local farmers on these methods as well as acceptable manure spreading and holding (stacking sheds) practices. South Carolina-specific information on agriculture BMPs is available from the Clemson Cooperative Extension Service. http://www.clemson.edu/extension/water

The Natural Resources Conservation Service (NRCS, a division of USDA) provides financial and technical assistance to help landowners address natural resource concerns, promote environmental quality, and protect wildlife habitat on property they own or control. Their website contains a wealth of information on agriculture BMPs and water quality issues associated with agricultural practices. Cost-share funds are available through the NRCS's Environmental Quality Incentives Program (EQIP). EQIP helps farmers improve production while protecting environmental quality by addressing such concerns as soil erosion and productivity, grazing management, water quality, animal waste, and forestry concerns. More information about conservation and funding sources may be found at: https://www.farmers.gov/ and https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/ .

### 6.1.5 Leaking Sanitary Sewers

Leaking sanitary sewers and illicit discharges, although illegal and subject to enforcement, may be occurring the Dean Swamp Watershed. Due to the high concentration of pollutant loading that is generally associated with these discharges, their detection may provide a substantial improvement in overall water quality in the watershed. Detection methods may include, but are not limited to: dye testing, air pressure testing, static pressure testing, and infrared photography. SCDHEC recognizes illicit discharge detection and elimination activities are conducted by regulated MS4 entities pursuant to compliance with existing MS4 permits. Note that these activities are designed to detect and eliminate illicit discharges that may contain FC bacteria or *E. coli*. It is the intent of SCDHEC to work with the MS4 entities to recognize FC bacteria or *E. coli* load reductions as they are achieved. SCDHEC acknowledges that these efforts to reduce illicit discharges and SSOs are ongoing and some reduction may already be accountable (i.e., load reductions occurring during TMDL development process). Thus, the implementation process is an iterative and adaptive process. Regular communication between all implementation stakeholders will result in successful remediation of controllable sources over time. As designated uses are restored, SCDHEC will recognize efforts of implementers where their efforts can be directly linked to restoration.

### 6.1.6 Failing Septic Systems

A septic system, also known as an onsite wastewater system, is defined as failing when it is not treating or disposing of sewage in an effective manner. The most common reason for failure is improper maintenance by homeowners. Untreated sewage contains disease-causing bacteria and viruses, as well as unhealthy amounts of nitrate and other chemicals. Failed septic systems can allow untreated sewage to seep into and pollute wells, groundwater, and surface water bodies. Pumping a septic tank is probably the single most important thing that can be done to protect the system. Information on how a septic tank works and proper maintenance is available here: https://scdhec.gov/environment/your-home/septic-tanks and tips on proper usage here: https://www.epa.gov/septic/dos-and-donts-homeowners-brochure

### 6.1.7 Urban and Suburban Runoff

Urban runoff is surface runoff of rainwater created by urbanization outside of regulated areas. Pavement, compacted areas, roofs, reduced tree canopy and open space increase runoff volumes that rapidly flow into receiving waters. The increase in volume and velocity of runoff may cause stream bank erosion, channel incision and sediment deposition in stream channels. In addition, runoff from these developed areas can increase stream temperatures. This, along with the increase in flow rate and pollutant loads negatively affect water quality and aquatic life (USEPA 2005). Runoff can pick up bacteria along the way. Many strategies currently exist to reduce bacteria loading from urban runoff and the USEPA nonpoint source pollution website provides extensive resources on this subject:

https://www.epa.gov/nps/nonpoint-source-urban-areas

Some examples of urban nonpoint source BMPs are street sweeping, stormwater wetlands, pet waste receptacles (equipped with waste bags), and educational signs which can be installed adjacent to receiving waters in the watershed such as parks, common areas, apartment complexes, trails, etc. Low impact development (LID) may also be effective. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements (USEPA, 2009).

Education should be provided to individual homeowners in the referenced watershed on the contributions to bacteria loading from pet waste. Education to homeowners in the watershed on the fate of substances poured into storm drain inlets should also be provided. For additional information on urban runoff please see the SCDHEC nonpoint source program web page:

https://www.scdhec.gov/environment/your-water-coast/watersheds-program/section-319-nonpoint-source-program

## 7.0 Resources for Pollution Management

- Citizen's Guide to Protecting Our Water Resources from Runoff Pollution

  https://scdhec.gov/sites/default/files/media/document/CR-002358.pdf

- Polluted Runoff: Nonpoint Source (NPS) Pollution – EPA's landing page for all things NPS

  https://www.epa.gov/nps

- National Menu of Best Management Practices (BMPs) for Stormwater – Based on the six minimum control measures for Phase I and Phase II MS4s

  https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

- South Carolina Forestry Commission Best Management Practices – Includes streamside management, stream crossings, and managing drainage to protect water quality

  https://www.state.sc.us/forest/refbmp.htm#contents

- Clemson Public Service and Agriculture – Center for Watershed Excellence offers professional training for managing stormwater ponds, assessing BMPs, and landscape managing to protect waterways

  https://www.clemson.edu/public/water/watershed/

- SCDOT Stormwater Management

  https://www.scdot.org/business/storm-water.aspx

- Agricultural Waste Management Field Handbook

  https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/?&cid=stelprdb1045935

- Manure Management for Small Farms

https://lpelc.org/manure-management-on-small-farms/

- Managing Canada Geese in Urban Environments

  https://ecommons.cornell.edu/handle/1813/66

## References and Bibliography

American Society of Agricultural Engineers (ASAE). 1998. ASAE Standards, 45th edition. D384.1 DEC93. Manure production and characteristics St. Joseph, Mich.

American Society of Agricultural and Biological Engineers (ASABE). 1998. Vegetative Filter Strip Removal of Cattle Manure Constituents in Runoff. Transactions of the ASAE, Vol. 41(5): 1375-1381

Ayres Associates 1993. Onsite Sewage Disposal Systems Research in Florida. The Capacity of Fine Sandy Soil for Septic Tank Effluent Treatment: A Field Investigation at an In-Situ Lysimeter Facility in Florida.

Bonta, J.V., Cleland, B. 2003. Incorporating Natural Variability, Uncertainty, and Risk into Water Quality Evaluations Using Duration Curves. *Journal of American Water Resource Association* 39(12):1481-1496

Blount, Z.D., The Unexhausted Potential of *E. coli*. eLife 2015, 4:e05826, www.ncbi.nlm.nih.gov/pmc/articles/PMC4373459/

Gaffield, S. J., R. L. Goo, L.A. Richards, and R. J. Jackson. 2003. Public Health Effects of Inadequately Managed Stormwater in Runoff. *American Journal of Public Health* 93(9): 1527-1533. September 2003.

Metcalf and Eddy, Inc. 1991. Wastewater Engineering: Treatment, Disposal, Reuse. Third Edition.

National Land Cover Data Set (NLCD). 2011. Available through the Multi-Resolution Land Characteristics (MRLC) Consortium. http://www.mrlc.gov/

Sheffield, R.E., Mostaghimi, S., Vaughan, D.H., Collins, E.R., Allen, V.G. 1997. Off-Stream Water Sources for Grazing Cattle as a Stream Bank Stabilization and Water Quality BMP. *Transactions of the ASAE*, Vol. 40(3): 595-604

South Carolina Department of Health and Environmental Control. 1998. Implementation Plan for Achieving Total Maximum Daily Load Reductions from Nonpoint Sources for the State of South Carolina.

South Carolina Department of Health and Environmental Control. 2012. *Water Classifications and Standards* (Regulation 61-68). Bureau of Water. Columbia, SC

South Carolina Department of Health and Environmental Control. 2002. *Standards for the Permitting of Agricultural Animal Facilities* (Regulation 61-43). Bureau of Water. Columbia, SC

South Carolina Department of Health and Environmental Control. 2011. *Water Pollution Control Permits* (Regulation 61-9) Office of Environmental Quality Control, Columbia, SC.

South Carolina Department of Health and Environmental Control. 1997. Farming for Clean Water in South Carolina.

South Carolina Department of Natural Resources. 2013. Deer Density Map. http://www.dnr.sc.gov/wildlife/deer/deermap.html

United States Department of Agriculture (USDA). 2019. National Agriculture Statistics Service. 2017 Cattle statistics by county.

United States Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, EPA 440/4-91-001.

United States Environmental Protection Agency (USEPA). 2001. Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, EPA 841-R-00-002.

United States Environmental Protection Agency (USEPA). 2001 Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. EPA 916-F-01-027

United States Environmental Protection Agency (USEPA). 2005. National Pollutant Discharge Elimination System (NPDES). Available at http://cfpub.epa.gov/npdes/home.cfm?program_id=6

US Geological Survey. Water-Resources Real-time Data South Carolina Water Year.

*Water Quality Planning and Management,* Title 40 Code of Federal Regulations, Pt. 130.2(i). 2006 ed.

Wolfson, L., Harrigan, T. 2010. Cows, Streams, and *E. Coli*: What Everyone Needs to Know. Michigan State University Extension. E3103.

Yagow, G. 1999. Unpublished monitoring data. Mountain Run TMDL Study. Submitted to Virginia Department of Environmental Quality. Richmond, Virginia.

# Appendix A: Data Tables for E-030 and E-115

## Data WQM Station E-030

E-030 Fecal Coliform Bacteria Counts (exceedences highlighted)

| **Date** | **cfu/100ml** |
|---|---|
| 1/10/2001 | 100 |
| 2/6/2001 | 260 |
| 3/6/2001 | 360 |
| 4/4/2001 | 50 |
| 6/26/2001 | 32 |
| 7/18/2001 | 20 |
| 8/7/2001 | 50 |
| 9/4/2001 | 48 |
| 10/1/2001 | 120 |
| 2/12/2002 | 220 |
| 3/5/2002 | 460 |
| 4/10/2002 | 60 |
| 5/23/2002 | 5 |
| 9/12/2002 | 15 |
| 10/3/2002 | 24 |
| 11/26/2002 | 74 |
| 12/12/2002 | 46 |
| 1/9/2003 | 44 |
| 2/6/2003 | 58 |
| 3/10/2003 | 48 |
| 4/9/2003 | 300 |
| 5/20/2003 | 160 |
| 6/11/2003 | 430 |
| 7/15/2003 | 20 |
| 8/5/2003 | 100 |
| 9/3/2003 | 62 |
| 10/2/2003 | 90 |
| 11/6/2003 | 30 |
| 12/2/2003 | 100 |
| 1/8/2004 | 140 |
| 2/11/2004 | 95 |
| 3/4/2004 | 50 |
| 4/8/2004 | 38 |
| 5/4/2004 | 130 |
| 6/1/2004 | 110 |
| 7/7/2004 | 360 |
| 8/3/2004 | 560 |

| | |
|---|---|
| 9/1/2004 | 340 |
| 10/11/2004 | 180 |
| 11/3/2004 | 250 |
| 12/1/2004 | 600 |
| 1/11/2005 | 360 |
| 2/7/2005 | 430 |
| 3/10/2005 | 260 |
| 4/5/2005 | 70 |
| 5/16/2005 | 600 |
| 6/6/2005 | 110 |
| 7/21/2005 | 73 |
| 8/3/2005 | 140 |
| 9/13/2005 | 270 |
| 10/5/2005 | 540 |
| 11/2/2005 | 580 |
| 12/14/2005 | 560 |
| 1/3/2006 | 600 |
| 2/1/2006 | 510 |
| 3/1/2006 | 440 |
| 4/5/2006 | 170 |
| 5/2/2006 | 140 |
| 6/1/2006 | 280 |
| 7/6/2006 | 240 |
| 8/1/2006 | 620 |
| 9/19/2006 | 240 |
| 10/16/2006 | 190 |
| 11/1/2006 | 190 |
| 12/4/2006 | 68 |
| 1/3/2007 | 220 |
| 2/6/2007 | 100 |
| 3/5/2007 | 200 |
| 4/4/2007 | 200 |
| 5/15/2007 | 210 |
| 6/12/2007 | 220 |
| 7/9/2007 | 220 |
| 8/1/2007 | 140 |
| 9/6/2007 | 180 |
| 10/25/2007 | 250 |
| 1/15/2008 | 490 |
| 2/5/2008 | 140 |
| 3/4/2008 | 10 |

| | |
|---|---|
| 4/8/2008 | 97 |
| 5/7/2008 | 35 |
| 6/10/2008 | 55 |
| 7/8/2008 | 560 |
| 8/5/2008 | 480 |
| 9/9/2008 | 600 |
| 10/1/2008 | 95 |
| 11/19/2008 | 240 |
| 12/2/2008 | 440 |
| 1/6/2009 | 280 |
| 2/4/2009 | 91 |
| 3/4/2009 | 300 |
| 4/7/2009 | 30 |
| 5/27/2009 | 210 |
| 6/9/2009 | 68 |
| 7/1/2009 | 220 |

90th Percentile FC Bacteria Concentration (cfu/100ml) by Hydrologic Category

| **WQM Site** | **High Flow 0-10%** | **Moist Cond. 10-40%** | **Midrange 40-60%** | **Dry Cond. 60-90%** | **Low Flow 90-100%** | **Number of Samples** |
|---|---|---|---|---|---|---|
| E-030 | 435 | 485 | 477 | 572 | 268 | 94 |

Flow (cfs) at Midpoint of Each Hydrologic Category

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-030 | 139.6 | 71.0 | 48.0 | 24.0 | 9.9 |

Existing Load (number FC bacteria/day) at each Midpoint of Each Hydrologic Category Flow

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-030 | 1.49E+12 | 8.42E+11 | 5.60E+11 | 3.36E+11 | 6.47E+10 |

Target Load (number FC bacteria/day) at each Midpoint of Each Hydrologic Category Flow

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-030 | 1.30E+12 | 6.60E+11 | 4.46E+11 | 2.23E+11 | 9.18E+10 |

Load Reduction Necessary (number FC bacteria/day) at Midpoint of Each Hydrologic Category Flow

| WQM Site | High Flow (5%) | Moist Cond. (25%) | Midrange (50%) | Dry (75%) | Low Flow (95%) |
|---|---|---|---|---|---|
| E-030 | NA | 1.82E+11 | 1.14E+11 | 1.13E+11 | NA |

Percent Reduction Necessary at Midpoint of Each Hydrologic Category Flow

| WQM Site | High Flow (5%) | Moist Cond. (25%) | Midrange (50%) | Dry (75%) | Low Flow (95%) |
|---|---|---|---|---|---|
| E-030 | NA | 22% | 20% | 34% | NA |

## Data WQM Station E-115

E-115 *E. coli* (exceedences highlighted)

| Date | MPN/100ml |
|---|---|
| 2/6/2013 | 387.3 |
| 4/2/2013 | 285.1 |
| 6/4/2013 | 770.1 |
| 8/7/2013 | 111.2 |
| 10/9/2013 | 579.4 |
| 12/3/2013 | 344.8 |
| 1/15/2014 | 488.4 |
| 3/4/2014 | 178.5 |
| 5/13/2014 | 122.3 |
| 7/7/2014 | 238.2 |
| 9/4/2014 | 148.3 |
| 11/4/2014 | 49.5 |
| 1/6/2015 | 90.9 |
| 3/3/2015 | 116.2 |
| 5/12/2015 | 139.6 |
| 7/13/2015 | 30.5 |
| 9/8/2015 | 344.8 |
| 11/17/2015 | 112.6 |
| 2/9/2016 | 81.6 |
| 4/13/2016 | 151.5 |

| | |
|---|---|
| 6/2/2016 | 313 |
| 8/16/2016 | 73.8 |
| 12/13/2016 | 613.1 |
| 1/10/2017 | 488.4 |
| 2/8/2017 | 1119.9 |
| 3/16/2017 | 435.2 |
| 4/12/2017 | 547.5 |
| 5/17/2017 | 435.2 |
| 6/21/2017 | 648.8 |
| 7/19/2017 | 1299.7 |
| 8/30/2017 | 8.5 |
| 9/26/2017 | 290.9 |
| 10/24/2017 | 2419.6 |
| 11/16/2017 | 12.2 |
| 1/24/2018 | 248.9 |
| 2/20/2018 | 435.2 |
| 3/20/2018 | 1413.6 |
| 4/18/2018 | 365.4 |
| 6/20/2018 | 118.7 |
| 10/23/2018 | 272.3 |
| 11/14/2018 | 920.8 |
| 12/13/2018 | 272.3 |

90th Percentile *E. coli* Bacteria Concentration (MPN/100ml) by Hydrologic Category

| **WQM Site** | **High Flow 0-10%** | **Moist Cond. 10-40%** | **Midrange 40-60%** | **Dry Cond. 60-90%** | **Low Flow 90-100%** | **Number of Samples** |
|---|---|---|---|---|---|---|
| E-115 | 563 | 1264 | 1031 | 579 | 557 | 42 |

Flow (cfs) at Midpoint of Each Hydrologic Category

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-115 | 142.4 | 68.2 | 43.8 | 25.5 | 13.0 |

Existing Load (number *E. coli*/day) at each Midpoint of Each Hydrologic Category Flow

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-115 | 1.96E+12 | 2.11E+12 | 1.10E+12 | 3.61E+11 | 1.78E+11 |

Target Load (number *E. coli*/day) at each Midpoint of Each Hydrologic Category Flow

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-115 | 1.16E+12 | 5.53E+11 | 3.55E+11 | 2.06E+11 | 1.06E+11 |

Load Reduction Necessary (number *E. coli*/day) at Midpoint of Each Hydrologic Category Flow

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-115 | NA | 1.56E+12 | 7.45E+11 | 1.55E+11 | NA |

Percent Reduction Necessary at Midpoint of Each Hydrologic Category Flow

| **WQM Site** | **High Flow (5%)** | **Moist Cond. (25%)** | **Midrange (50%)** | **Dry (75%)** | **Low Flow (95%)** |
|---|---|---|---|---|---|
| E-115 | NA | 74% | 68% | 43% | NA |

# Appendix B: Evaluating the Progress of MS4 Programs and Meeting the Goals of TMDLs

Described below are approaches that may be used by MS4 permit holders and others implementing TMDLs. These are recommendations and examples only. SCDHEC-BOW recognizes that other approaches may be utilized or employed to meet compliance goals.

1. Calculate pollutant load reduction for each best management practice (BMP) deployed:
    - Retrofitting stormwater outlets
    - Creation of green space
    - LID activities (e.g., creation of porous pavements)
    - Creations of riparian buffers
    - Stream bank restoration
    - Scoop the poop program (how many pounds of poop were scooped/collected)
    - Street sweeping program (amount of materials collected etc.)
    - Construction & post-construction site runoff controls
2. Description & documentation of programs directed towards reducing pollutant loading:
    - Document tangible efforts made to reduce impacts to urban runoff
    - Track type and number of structural BMPs installed
    - Parking lot maintenance program for pollutant load reduction
    - Identification and elimination of illicit discharges
    - Zoning changes and ordinances designed to reduce pollutant loading
    - Modeling of activities & programs for reducing pollutant reductions
3. Description & documentation of social indicators, outreach, and education programs:
    - Number/Type of training & education activities conducted and survey results
    - Activities conducted to increase awareness and knowledge – residents, business owners. What changes have been made based on these efforts? Any measured behavior or knowledge changes?
    - Participation in stream and/or lake clean-up events or activities
    - Number of environmental action pledges
4. Water quality monitoring: A direct and effective way to evaluate the effectiveness of stormwater management plan activities:
    - Use of data collected from existing monitoring activities (e.g., SCDHEC data for ambient monitoring program available through STORET; water supply intake testing; voluntary watershed group's monitoring, etc)
    - Establish a monitoring program for permitted outfalls and/or waterbodies within MS4 areas as deemed necessary– use a certified lab
    - Monitoring should focus on water quality parameters and locations that would both link pollutant sources and BMPs being implemented

Useful Links:

Evaluating the Effectiveness of Municipal Stormwater Programs.

https://www3.epa.gov/npdes/pubs/region3_factsheet_swmp.pdf

The International Stormwater Best Management Practices Database Project

http://www.bmpdatabase.org/

National Water Quality Monitoring Council - Water Quality Data

https://www.waterqualitydata.us/portal/

Spreadsheet Tool for Estimating Pollutant Loads (STEPL)

https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl

Measurable Goals Guidance for Phase II Small MS4s

https://www3.epa.gov/npdes/pubs/measurablegoals.pdf

National Menu of BMPs for Stormwater

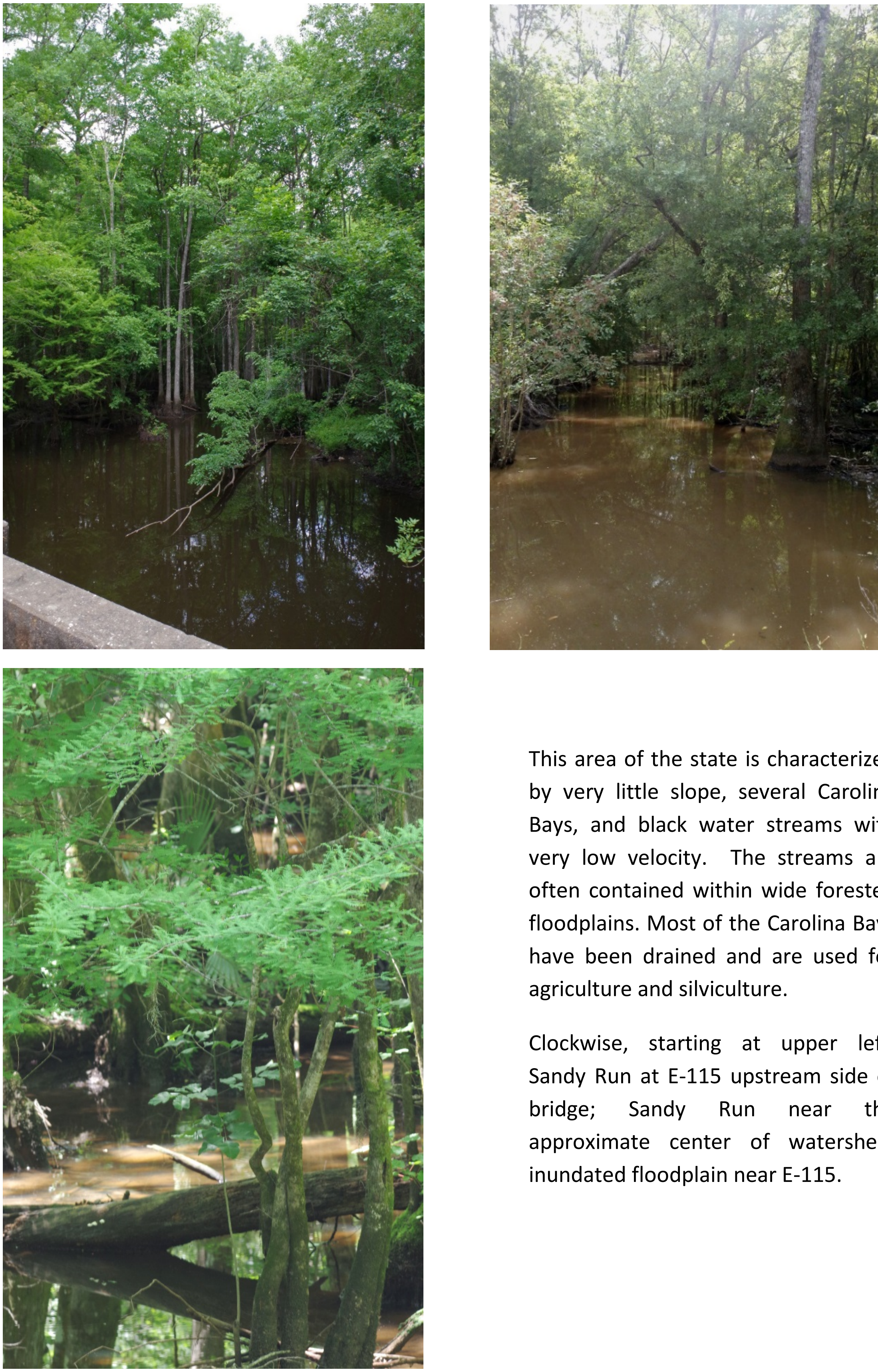
https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

SCDHEC – BOW: The 319 grant program (https://www.scdhec.gov/environment/your-water-coast/watersheds-program/watersheds-program-contacts) can provide guidance on estimating load reductions for the following BMPs:

- Septic tank repair or replacement
- Removing livestock from streams
- Livestock fencing
- Waste Storage Facilities
- Strip cropping
- Prescribed grazing
- Critical Area Planting
- Runoff Management System
- Waste Management System
- Solids Separation Basin
- Riparian Buffers

# Appendix C: Source Assessment Photographs

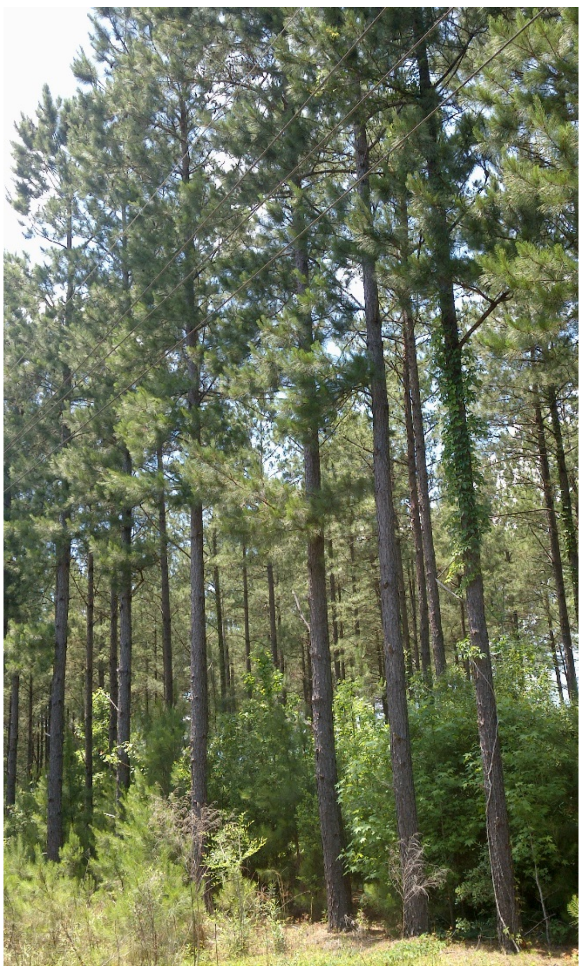
Figure 11. Stream characteristics in the Dean Swamp Watershed



This area of the state is characterized by very little slope, several Carolina Bays, and black water streams with very low velocity. The streams are often contained within wide forested floodplains. Most of the Carolina Bays have been drained and are used for agriculture and silviculture.

Clockwise, starting at upper left: Sandy Run at E-115 upstream side of bridge; Sandy Run near the approximate center of watershed; inundated floodplain near E-115.

Figure 12. Silviculture



Silviculture in all stages – clear cut, young growth, and mature trees - was evident in all parts of the watershed. There were large areas of disturbed land where clear cutting was recent.

Figure 13. Wildlife

Because this area is largely undeveloped, wildlife may be significant contributors to *E. coli* exceedences in the watershed. Wildlife observed in the area include this barred owl, a hen turkey with her poults, great blue herons, egrets, deer, squirrels, and many other birds. There were several turtles present, but ectotherms are not typically implicated as sources of *E. coli* bacteria in streams. These photographs were taken at WQM site E-115.

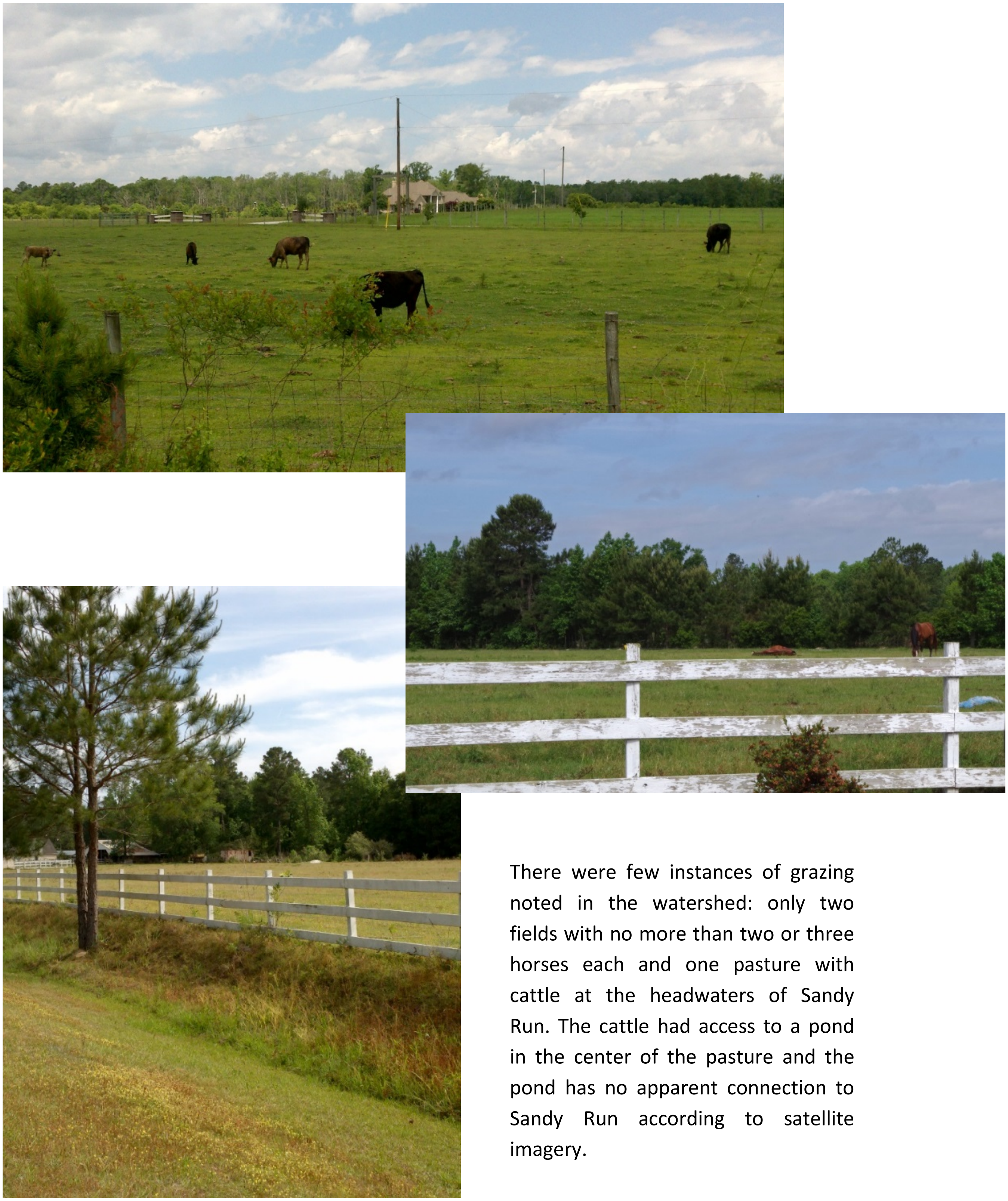
Figure 14. Deer in Dean Swamp Watershed


Deer are abundant in the watershed. According to SCDNR, there may be as many as 4000, or approximately 38 deer per square mile. They may be contributing a significant amount to the bacteria load.

Figure 15. Farming in Dean Swamp Watershed

Cultivated crops make up only 10% of the Dean Swamp Watershed. During a visit to the area in May 2019, there were fields being tilled, planted, and fertilized. There was a large area devoted to peach orchards in the upper northeastern part of the watershed.

Figure 16. Animal Agriculture in Dean Swamp Watershed



There were few instances of grazing noted in the watershed: only two fields with no more than two or three horses each and one pasture with cattle at the headwaters of Sandy Run. The cattle had access to a pond in the center of the pasture and the pond has no apparent connection to Sandy Run according to satellite imagery.

Figure 17. Trash and land disturbance in Sandy Run and vicinity

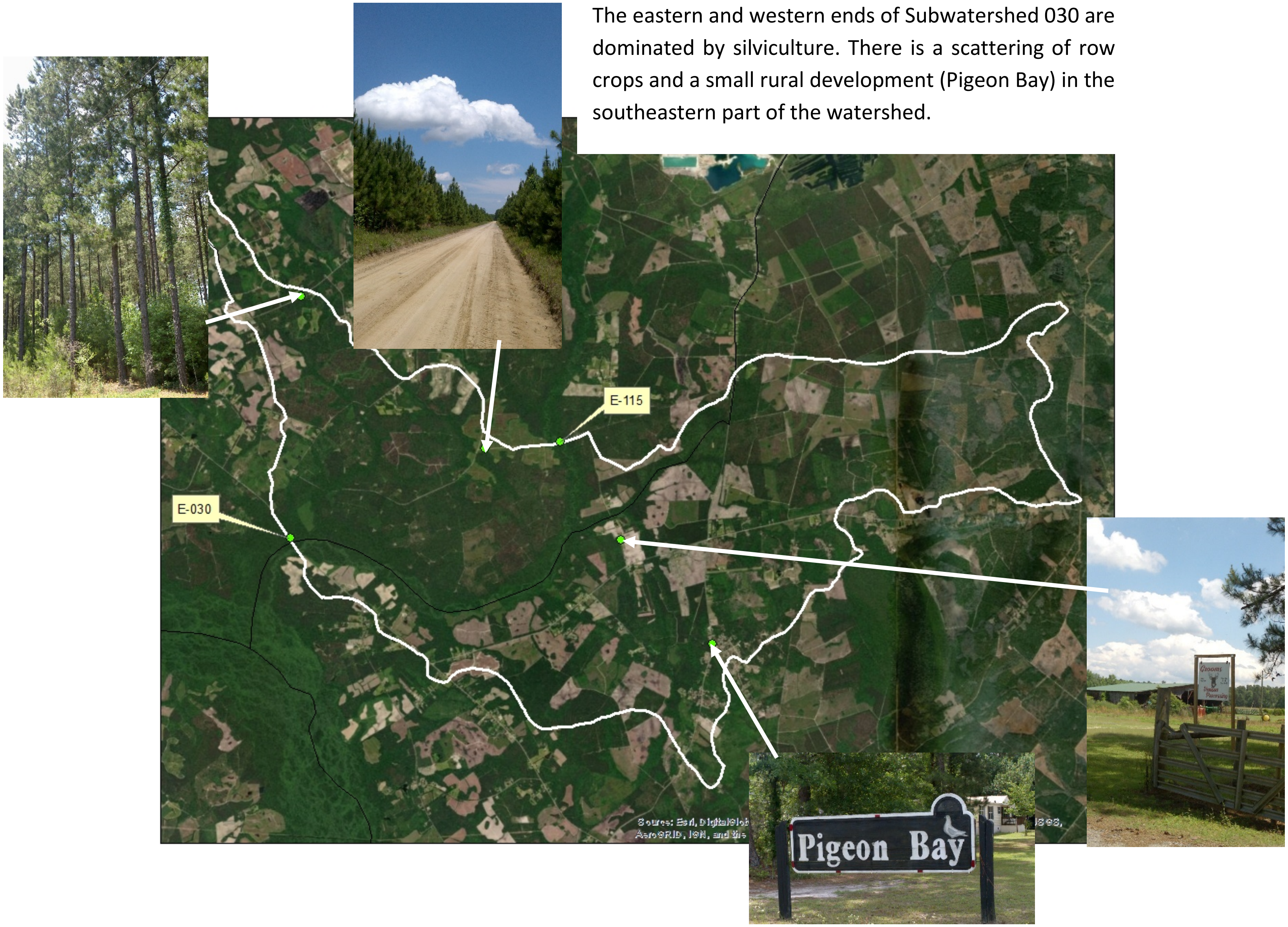

These pictures were taken at WQM station E-115. Recreational use of the stream is evidenced by the waste left behind. There were bags of trash, tires, and other rubbish dumped directly into the stream, despite the sign posted by the Orangeburg County litter control department. There are some trails made by ATVs heading off into the flood plain in this area as well.

Figure 18. Subwatershed 115 source assessment

The eastern two thirds of subwatershed 115 is largely occupied by silviculture and a large quarry. The western third consists of row crops, peach orchards, and silviculture. The only instance found of cattle grazing is in this area. Sandy Run is a black water stream, typical in this area of the state.

## Figure 19. Subwatershed 030 source assessment

The eastern and western ends of Subwatershed 030 are dominated by silviculture. There is a scattering of row crops and a small rural development (Pigeon Bay) in the southeastern part of the watershed.



# Amendments

The following amendments were made by the Department to the Sandy Run and Dean Swamp E. coli Bacteria TMDL document and associated appendices after the original 30-day public comment period. These amendments were not made as a result of written comments received but may have been the result of an error, omission or the need for clarification.

**Abstract Table, Page IV and TMDL Table 13, Page 26:**

Initial TMDL calculations were completed using the appropriate load duration (LD) methodology. As the existing loads, load allocations (LAs), margins of safety, and percentage reductions were copied from the LD worksheet to the TMDL document, the LAs were inadvertently transposed as TMDL values in the TMDL tables. The TMDL values in the tables have been corrected prior to finalizing the document. All other values in the table were correct in the original draft and were not changed.

Revised TMDL loadings:

E-030 FC Bacteria TMDL (cfu/day): 2.35E+11

E-030 *E. coli* TMDL (MPN/day): 2.05E+11

E-115 *E. coli* TMDL (MPN/day): 5.82E+11