Total Maximum Daily Load Document
Jeffries Creek and Tributaries
Stations: PD-167, PD-256, PD-065, PD-230, RS-07205, PD-035, and PD-231
(Hydrologic Unit Codes: 030402010901, 030402010902, 030402010903, 030402010904, and 030402010905)
Escherichia coli Bacteria,
Indicator for Pathogens

June 2016
Prepared for:
Bureau of Water
SCDHEC Technical Number 1004-16

D H E C
PROMOTE PROTECT PROSPER

Prepared by:

Harvey S. Daniel

Photographs on Title Page

Photograph in the foreground: proximity of the South Carolina Department of Health and Environmental Control's (SCDHEC) Water Quality Monitoring Station PD-231 in Jeffries Creek at County Route S-21-24 near the Town of Claussen in Florence County, SC (date of photography: January 11, 2016). Photograph in the background: proximity of the SCDHEC's Water Quality Monitoring Station PD-167 in Willow Creek at County Route S-21-57 in Florence County, SC (date of photography: January 7, 2016).

Abstract

§303(d) of the federal *Clean Water Act (CWA)* and the United States Environmental Protection Agency's (USEPA) *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 all 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). 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 *Escherichia coli (E. coli)* bacteria. The following six (6) impaired water quality monitoring (WQM) stations in Jeffries Creek, and in tributaries to Jeffries Creek, in Florence County, SC are listed on the 2014 §303(d) list for *E. coli* bacteria: **a)** station PD-256 in Jeffries Creek; **b)** station PD-230 in Middle Swamp; **c)** station RS-07205 in Polk Swamp; **d)** station PD-035 in Jeffries Creek; **e)** station PD-231 in Jeffries Creek; and, **f)** station PD-167 in Willow Creek. *E. coli* bacteria TMDLs were developed for four (4) WQM stations, station PD-256, station PD-230, station PD-035, and station PD-167 using *E. coli* bacteria data from the South Carolina Department of Health and Environmental Control's (SCDHEC) 2009 Pathogen Indicator Study (PIS) to determine which pathogen indicator bacteria is better suited in South Carolina as the recreational use water quality standard in fresh waters. Fecal coliform (FC) bacteria TMDLs were developed for two (2) WQM stations, station RS-07205 and station PD-231, using FC bacteria data collected between January 2007 and December 2012; and, these two (2) FC bacteria TMDLs were converted to *E. coli* bacteria TMDLs for purposes of implementation of the current *E. coli* water quality standard (WQS). Furthermore, all six (6) sites will be included on future §303(d) lists due to exceedances of the current *E. coli* WQS until such time such that sufficient *E. coli* data are collected that demonstrate the standard is attained, or until such time that these TMDLs are approved to address the parameter of concern.

In addition, a revision was made to an existing FC bacteria TMDL approved by the USEPA, Region IV in September 2005 for impaired WQM station PD-065 in Gulley Branch, another tributary to Jeffries Creek, in Florence County, SC. The revised TMDL for WQM station PD-065 was developed as an *E. coli* bacteria TMDL using *E. coli* bacteria data from the SCDHEC's 2009 PIS. At least eleven (11) percent of the samples collected between January 2007 and December 2012 at the aforementioned seven (7) impaired WQM stations exceeded the water quality standards.

Probable sources of fecal contamination include direct loading by 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 segment. 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. In order to achieve the target load for the Jeffries Creek and tributaries, the following reductions in the existing loads at the respective WQM stations will be necessary: **a)** up to 59% at PD-256; **b)** up to 90% at PD-065; **c)** up to 73% at PD-230; **d)** up to 53% at RS-07205; **e)** up to 66% at PD-035; **f)** up to 45% at PD-231; and, **g)** up to 64% at PD-167. For the South Carolina Department of Transportation (SCDOT), existing and future NPDES municipal separate storm sewer system (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 TMDLs. 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 these TMDLs can be implemented through voluntary measures and are eligible for *CWA* §319 grants.

The Department recognizes that adaptive management/implementation of these TMDLs might be needed to achieve the water quality standard and the Department is committed towards targeting the load reductions to improve water quality in the Jeffries Creek and tributaries watersheds. As additional data and/or information become available, it may become necessary to revise and/or modify these TMDLs targets accordingly.

Table Ab-1. Total Maximum Daily Loads for the Jeffries Creek and Tributaries Watershed
Loads are expressed as FC bacteria or *E. coli* count/day

	Existing Load (count/day)		TMDL (count/day)		Margin of Safety (MOS) (count/day)		Waste Load Allocation (WLA)				Load Allocation (LA)		
							Continuous Source[3] (count/day)		Non-Continuous Sources[4,5] (%Reduction)	Non-Continuous SCDOT[5] (%Reduction)	Load Allocation (count/day)		% Reduction to Meet LA[5]
March 2016 Total Maximum Daily Loads													
Station	FC (cfu/day)[1]	*E. coli* (MPN/day)[2]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)	(Percent)	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)
PD-256	---	4.71E+11	---	2.01E+11	---	1.01E+10	---	See Note Below	59	59[7]	---	1.91E+11	59
PD-230	---	1.50E+12	---	4.31E+11	---	2.16E+10	---	See Note Below	73	73[7]	---	4.10E+11	73
RS-07205	8.13E+10	---	4.07E+10	3.55E+10	2.03E+09	1.77E+09	See Note Below	See Note Below	53	53[7]	3.86E+10	3.37E+10	53
PD-035	---	2.57E+12	---	9.14E+11	---	4.57E+10	---	See Note Below	66	66[7]	---	8.68E+11	66
PD-231	4.15E+12	---	2.39E+12	2.09E+12	1.19E+11	1.04E+11	See Note Below	See Note Below	45	45[7]	2.27E+12	1.98E+12	45
PD-167	---	7.16E+11	---	2.70E+11	---	1.35E+10	---	3.30E+08	64	0[6]	---	2.56E+11	64
March 2016 Total Maximum Daily Loads (Revised from September 2005)													
Station	FC (cfu/day)[1]	*E. coli* (MPN/day)[2]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)	(Percent)	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)
PD-065	---	1.15E+11	---	1.19E+10	---	5.93E+08	---	See Note Below	90	90[7]	---	1.13E+10	90

Table Notes:

1. Existing fecal coliform loads were determined from the 90 percentile instream fecal coliform concentrations and stream flows during critical flow conditions. Fecal coliform concentrations were determined during the Department's water quality monitoring program.
2. Existing *E. coli* loads were determined from the 90 percentile instream *E. coli* concentrations and stream flows during critical flow conditions. *E. coli* concentrations were determined during the Department's 2009 Pathogen Indicator Study.
3. WLAs are expressed as a daily maximum. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern. For the purposes of NPDES permitting, continuous discharges may be required to meet a loading equivalent of FC bacteria, based upon permitted flow and an allowable permitted maximum FC bacteria concentration of 400 cfu/100ml, until such time that *E. coli* limits are incorporated into individual permits. *E. coli* limits will be developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100ml.
4. 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.
5. Percent reduction applies to existing instream FC bacteria or *E. coli.*
6. As long as the conditions within the SCDOT MS4 area remain the same the Department deem the current contributions from SCDOT negligible and no reduction of FC bacteria or *E. coli* is necessary. SCDOT must continue to comply with the provisions of its approved NPDES stormwater permit.
7. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 Permit to address fecal coliform or *E. coli,* the SCDOT will comply with these TMDLs and its applicable WLA to the MEP as required by its MS4 permit.
8. Expressed as *E. coli* (MPN/day). Loadings are developed by applying a conversion factor to values calculated for FC bacteria. This conversion is derived from an established relationship between FC bacteria and *E. coli* water quality standards in freshwaters.

Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 Introduction

1.1 Background

The federal *Clean Water Act (CWA)* directs each state to review the quality of its waters every two (2)years to determine if water quality standards are being met. If it is determined that the water quality standard is not being met, the states are to list the impaired water bodies under §303(d) of the *CWA*. 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 *Escherichia coli (E. coli)* bacteria. The following six (6) impaired water quality monitoring (WQM) stations in Jeffries Creek, and in tributaries to Jeffries Creek, in Florence County, SC are listed on the 2014 §303(d) list for *E. coli* bacteria: **a)** station PD-256 in Jeffries Creek; **b)** station PD-230 in Middle Swamp; **c)** station RS-07205 in Polk Swamp; **d)** station PD-035 in Jeffries Creek; **e)** station PD-231 in Jeffries Creek; and, **f)** station PD-167 in Willow Creek. And, prior to the 2014 listing, one of the water bodies placed on the State's 2004 §303(d) list by the South Carolina Department of Health and Environmental Control (SCDHEC) for impairment due to Fecal Coliform (FC) bacteria exceedances was Gulley Branch, also a tributary to Jeffries Creek (determined by results from WQM Station PD-065 in Florence County to be impaired). These seven (7) WQM stations are identified in Figure 1 and Table 1.

Figure 1. Location of Water Quality Monitoring Stations PD-256, PD-065, PD-230, RS-07205, PD-035,PD-231, and PD-167 Impaired for Freshwater Recreational Use

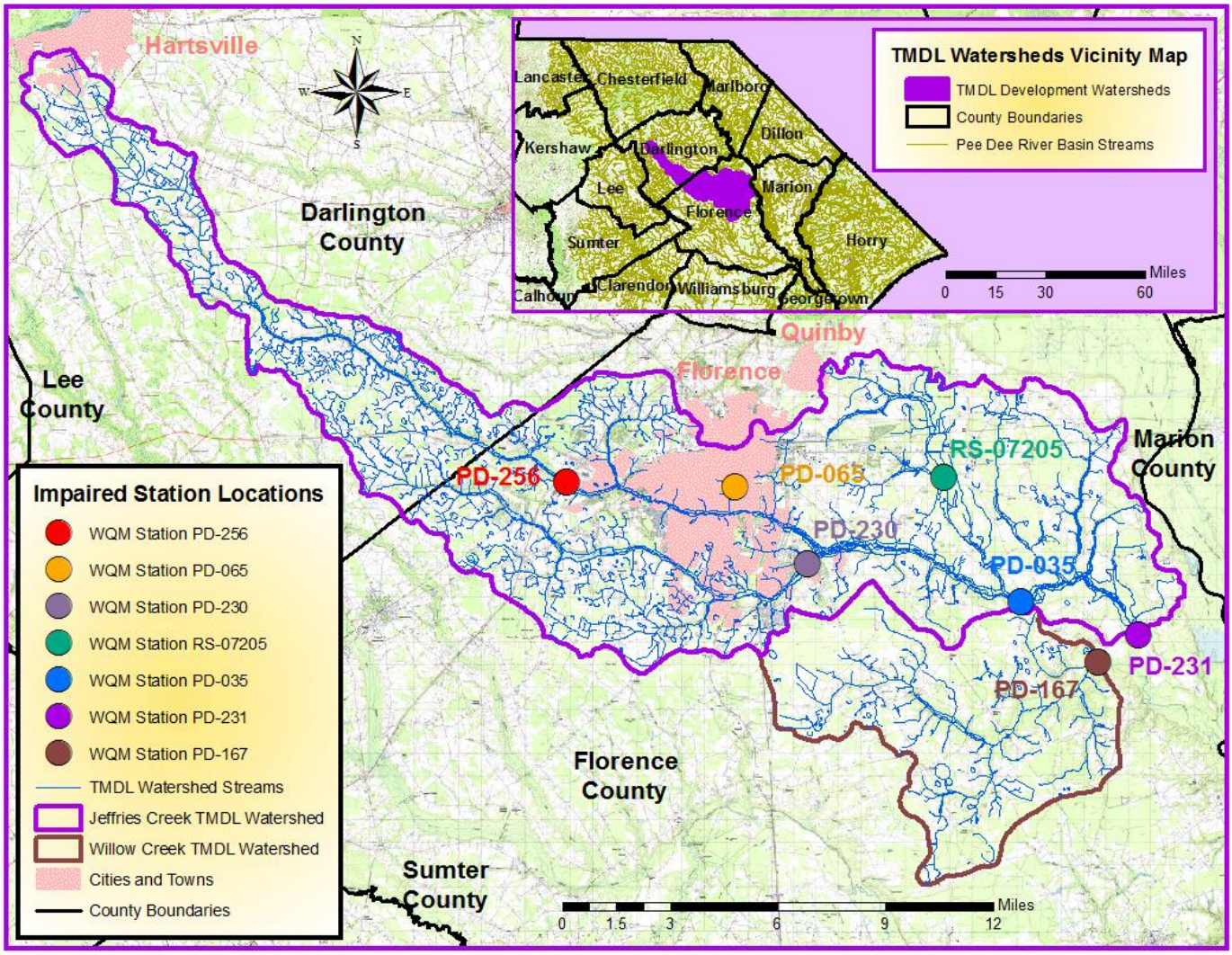


Table 1. Jeffries Creek and Tributaries Watershed Recreational Use Impaired Waters

Waterbody	Station Number	Description
Jeffries Creek	PD-256	Jeffries Creek at S-21-112, 4.8 miles west of Florence in Florence County
Gulley Branch	PD-065	Gulley Branch at S-21-13, Timrod Park in Florence County
Middle Swamp	PD-230	Middle Swamp at SC 51, 3.5 miles south-southeast of Florence in Florence County
Polk Swamp	RS-07205	Polk Swamp at S-21-918 (Old Wallace Road), 5.75 miles east-southeast of Florence in Florence County
Jeffries Creek	PD-035	Jeffries Creek at SC 327, at Claussen in Florence County
Jeffries Creek	PD-231	Jeffries Creek at S-21-24 (Paper Mill Road), 3.3 miles east-southeast of Claussen in Florence County
Willow Creek	PD-167	Willow Creek at S-21-57 in Florence County

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 pollutant sources to their impacts on water quality, allocation of pollutant sources to each source and establishment of control mechanisms to achieve water quality standards (USEPA, 1999).

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). TMDLs are required to be developed for each waterbody and pollutant combination on the States' §303(d) lists by 40 CFR 130.31(a) (USEPA, 1999).

E. coli bacteria are members of the FC group of bacteria and are part of the normal flora of the gastrointestinal tract of warm-blooded animals including humans. These harmless bacteria play an important role in preventing the growth of harmful bacteria, vitamin K production, and lactose digestion as well as producing compounds necessary for fat metabolism (Starr and Taggart, 1992; Wolfson and Harrigan, 2010). Some verotoxin producing strains of *E. coli*, such as 0157:H7, a major cause of foodborne illnesses, can cause gastrointestinal illnesses, kidney failure and death (Nadakavukaren, 1995; Wolfson and Harrigan, 2010).

E. coli bacteria in surface waters are indicators of recent human or animal waste contamination and originate from failing septic systems, agricultural runoff, leaking sewers among other sources. Section §303(d) of the *CWA* and the USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop TMDLs for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in stream water quality conditions so that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA 1991).

This TMDL document documents the development of *E. coli* bacteria TMDLs for the following four (4) WQM stations in Florence County using *E. coli* bacteria data from the SCDHEC's 2009 Pathogen Indicator Study (PIS): **a)** station PD-256 in Jeffries Creek; **b)** station PD-230 in Middle Swamp; **c)** station PD-035 in Jeffries Creek; and, **d)** station PD-167 in Willow Creek. FC bacteria TMDLs were developed for two (2) WQM stations, station RS-07205 in Polk Swamp and station PD-231 in Jeffries Creek, using FC bacteria data collected between January 2007 and December 2012. The FC bacteria TMDLs for these two (2)WQM stations, i.e., station RS-07205 and station PD-231, were converted to *E. coli* bacteria TMDLs for the purposes of implementation of the current *E. coli* water quality standard (WQS).

The SCDHEC placed WQM Station PD-065 in Gulley Branch in Florence County on the State's 2004 §303(d) list due to FC bacteria exceedances. In September 2005, the U.S. Environmental Protection Agency (USEPA) approved a FC bacteria TMDL that was developed internally by the SCDHEC for WQM Station PD-065 (SCDHEC Technical Report No.: 029-05; see Section 1.3 of this TMDL development

document) (USEPA, 2005). This TMDL development document also documents the revision of the TMDL for WQM Station PD-065. The TMDL was revised as an *E. coli* bacteria TMDL due to availability of *E. coli* data collected at the monitoring location during the SCDHEC's 2009 PIS.

1.2 Watershed Descriptions

The following six (6) impaired WQM stations in Jeffries Creek, and in tributaries to Jeffries Creek, in Florence County, SC that are listed on the State's 2014 §303(d) list for *E. coli* bacteria are addressed in this TMDL development document: **a)** station PD-256 in Jeffries Creek; **b)** station PD-230 in Middle Swamp; **c)** station RS-07205 in Polk Swamp; **d)** station PD-035 in Jeffries Creek; **e)** station PD-231 in Jeffries Creek; and, **f)** station PD-167 in Willow Creek. Also addressed is WQM Station PD-065 in Gulley Branch (also a tributary to Jeffries Creek) in Florence County, which was placed on the State's 2004 §303(d) list for impairment due to FC bacteria. For purposes of this TMDL development document, all of the watersheds draining through these seven (7) WQM stations will be referred to collectively as the Jeffries Creek and Tributaries (JCT) Watershed.

The JCT Watershed is 204.77 mi^2 (131,092.79 acres) in size, is located in Florence and Darlington Counties in South Carolina, and lies in both the Southeastern Plains and Middle Atlantic Coastal Plains ecoregions of the State. The general stream flow direction in the JCT Watershed is in the southeastern direction. The upper northwestern part of the watershed is located at the City of Hartsville in Darlington County, and the lower southeastern part of the JCT Watershed is located in Florence County about four (4) miles northwest of the Town of Pamplico.

Watersheds for the following six (6) WQM stations in the JCT Watershed are hydrologically connected: **a)** station PD-256 in Jeffries Creek; **b)** station PD-065; **c)** station PD-230; **d)** station RS-07205; **e)** station PD-035; and, **f)** station PD-231. Flows for these six (6) watersheds ultimately flow through the WQM Station PD-231 in Jeffries Creek. Therefore, for purposes of this TMDL development document, these six (6) watersheds will be referred to collectively as the Jeffries Creek Watershed. The watershed for WQM Station PD-167 in Willow Creek is not hydrologically connected to the aforementioned six (6) watersheds. Therefore, the watershed for WQM Station PD-167 will be referred to as the Willow Creek Watershed in this TMDL development document.

1.2.1 The Jeffries Creek Watershed; Terminal WQM Station PD-231

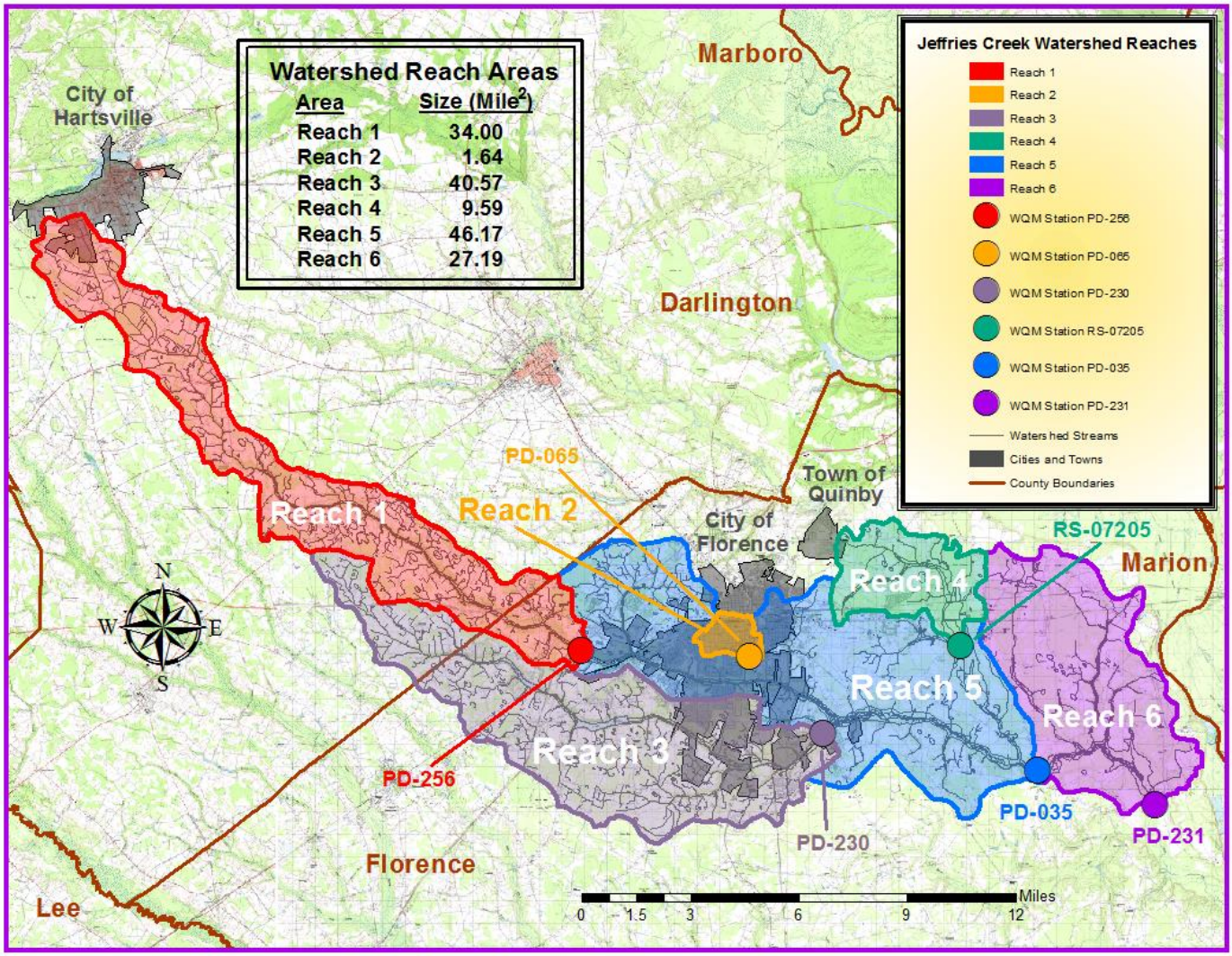
The Jeffries Creek Watershed is 159.16 mi^2 (101,894.69 acres) in size, and is located in Florence and Darlington Counties in South Carolina. The upper northwestern part of the watershed is located at the City of Hartsville in Darlington County, and the lower southeastern part of the watershed is located in Florence County about nine (9) miles east of the City of Florence in Florence County. The six (6) WQM station watersheds in the Jeffries Creek Watershed for which TMDLs are developed in this TMDL development document are addressed as separate distinct reaches in the Jeffries Creek Watershed. The six (6) reaches are: **a)** Reach 1 - the watershed draining through WQM station PD-256 in Jeffries Creek; **b)** Reach 2 - the watershed draining through WQM station PD-065 in Gulley Branch; **c)** Reach 3 - the watershed draining through WQM station PD-230 in Middle Swamp; **d)** Reach 4 - the watershed draining through WQM station RS-07205 in Polk Swamp; **e)** Reach 5 - the watershed draining through WQM station PD-035 in Jeffries Creek; and, **f)** Reach 6 - the watershed draining through WQM station PD-231 in Jeffries Creek. The reaches of the Jeffries Creek Watershed are shown in Figure 2.

1.2.1.1 Reach 1 of the Jeffries Creek Watershed; Terminal WQM Station PD-256

Reach 1 of the Jeffries Creek Watershed covers a drainage area of 34.00 mi^2 (21,766.81 acres) in size that drains into Jeffries Creek and its tributaries from an area at the southern portion of the City of Hartsville in Darlington County, in a general southeastern fashion to impaired station PD-256 in Jeffries Creek at County Route S-21-112, at the western portion of the City of Florence in Florence County (Figure 2). The reach lies in the Southeastern Plains ecoregion of the State.

Land use within Reach 1 of the Jeffries Creek Watershed is predominately Cultivated Crops (45.76%), and Woody Wetlands (23.94%) (Figure 3a, Table 2a). Developed lands (residential, commercial, industrial, or open urban space) comprise 14.42% of the reach (Table 3). At the time of the development of this TMDL, there were no animal feeding operations in the reach.

Figure 2. Location of the Jeffries Creek Watershed Reaches



According to Geographic Information System (GIS) information (available at time of TMDL development), there are approximately two hundred and seven (207) miles of streams within Reach 1 of the Jeffries Creek Watershed. The streams are all classified as freshwater (FW or FW-SP). From WQM Station PD-256, Jeffries Creek flows for approximately twenty-four (24) stream miles to the Great Pee Dee River on the Florence and Marion County border approximately 4.7 miles north-northeast of Town of Pamplico in Florence County.

1.2.1.2 Reach 2 of the Jeffries Creek Watershed; Terminal WQM Station PD-065

Reach 2 of the Jeffries Creek Watershed covers a drainage area of 1.64 mi^2 (1050.37 acres) in size that drains into Gulley Branch and its tributaries from an area in the northern portion of the City of Florence in Florence County, in a general southern fashion to impaired station PD-065 in Gulley Branch at Timrod Park in the central portion of the City of Florence (Figure 2). The reach lies in the Southeastern Plains ecoregion of the State.

Land use within Reach 2 of the Jeffries Creek Watershed is predominately Low Intensity Developed (38.73%), and Open Space Developed (29.96%) (Figure 3b, Table 2b). Developed lands (residential, commercial, industrial, or open urban space) comprise 96.29% of the reach (Table 3). At the time of the development of this TMDL, there were no animal feeding operations in the reach.

According to GIS information, there are approximately 0.6 miles of streams within Reach 2 of the Jeffries Creek Watershed. The streams are all classified as FW. From WQM Station PD-065, Gulley Branch flows for approximately 0.9 stream miles to Jeffries Creek in the southern portion of the City of Florence in Florence County.

Figure 3a. Land Use Diagram for Reach 1 of the Jeffries Creek Watershed

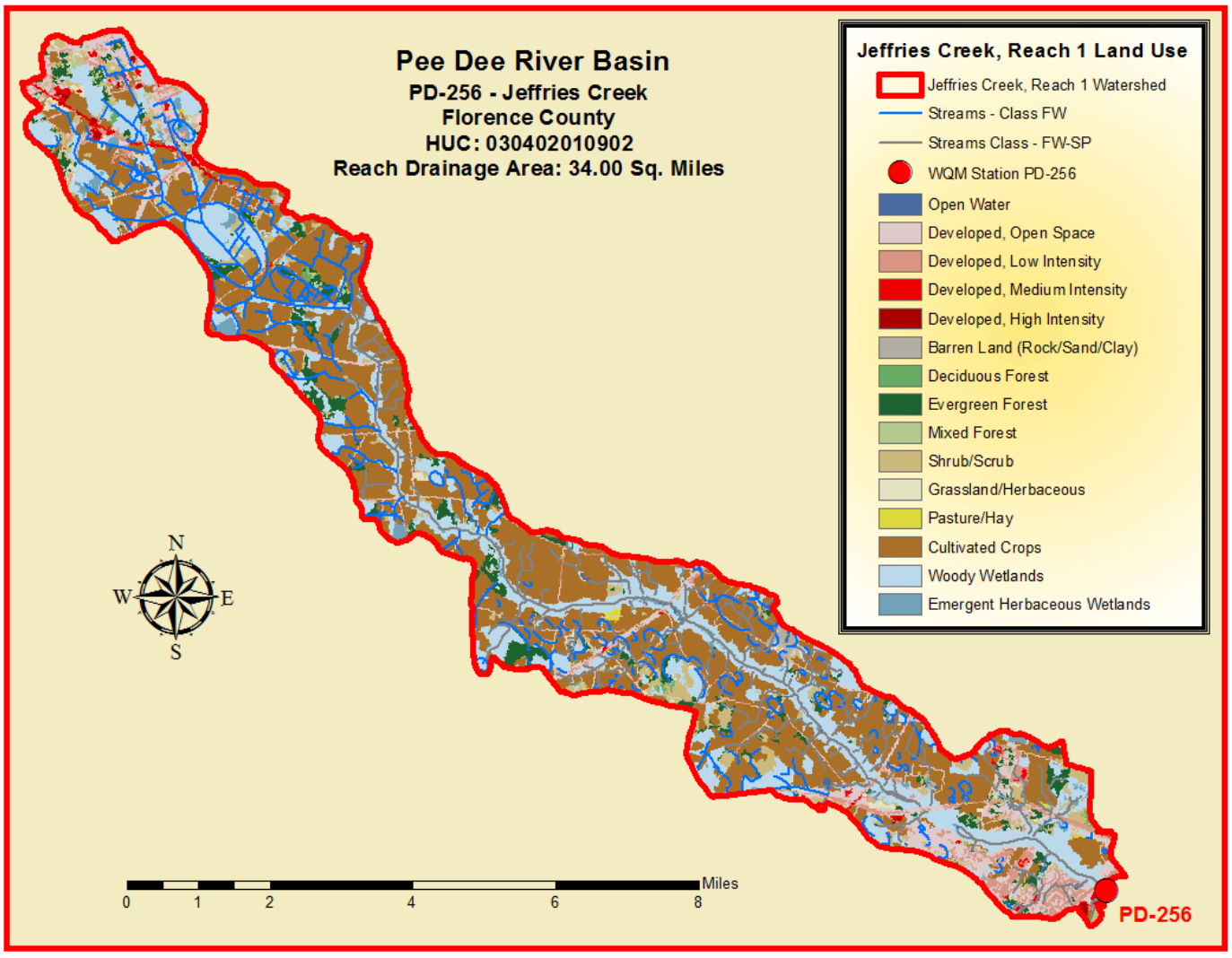


Table 2a. Jeffries Creek Watershed: Land Use in Reach 1 (WQM Station PD-256)
(Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area (Mile^2)	Percent
Cultivated Crops	9959.91	15.56	45.76%
Woody Wetlands	5210.91	8.14	23.94%
Developed, Open Space	1936.83	3.03	8.90%
Shrub/Scrub	1374.84	2.15	6.32%
Evergreen Forest	1203.82	1.88	5.53%
Developed, Low Intensity	933.83	1.46	4.29%
Emergent Herbaceous Wetlands	324.70	0.51	1.49%
Grassland/Herbaceous	238.18	0.37	1.09%
Developed, Medium Intensity	219.95	0.34	1.01%
Mixed Forest	85.62	0.13	0.39%
Barren Land (Rock/Sand/Clay)	69.61	0.11	0.32%
Open Water	66.05	0.10	0.30%
Deciduous Forest	58.27	0.09	0.27%
Developed, High Intensity	48.48	0.08	0.22%
Pasture/Hay	35.81	0.06	0.16%
Totals	**21,766.81**	**34.00**	**100.00%**

Table 3. Developed Areas in the Jeffries Creek and Tributaries Watershed

Watershed	Watershed Description	Watershed Area (mi^2)	Developed Area (mi^2)	Percent Developed
Reach 1 of Jeffries Creek	From an area at the southern portion of the City of Hartsville in Darlington County to impaired station PD-256 in Jeffries Creek at County Route S-21-112, at the western portion of the City of Florence in Florence County.	34.00	4.90	14.42%
Reach 2 of Jeffries Creek	From an area in the northern portion of the City of Florence in Florence County to impaired station PD-065 in Gulley Branch at Timrod Park in the central portion of the City of Florence.	1.64	1.58	96.29%
Reach 3 of Jeffries Creek	From an area approximately 6.5 miles southwest of the City of Darlington in Darlington County to impaired station PD-230 in Middle Swamp at SC 51 at the southeastern portion of the City of Florence in Florence County.	40.57	11.90	29.32%
Reach 4 of Jeffries Creek	From an area at the eastern portion of the Town of Quinby in Florence County to impaired station RS-07205 in Polk Swamp at County Route S-21-918 (Old Wallace Road), approximately 4 miles southeast of the Town of Quinby in Florence County.	9.59	1.02	10.64%
Reach 5 of Jeffries Creek	From an area approximately 3 miles northwest of the City of Florence in Florence County to impaired station PD-035 in Jeffries Creek at SC 327, approximately 6 miles southeast of the City of Florence in Florence County.	46.17	16.62	36.00%
Reach 6 of Jeffries Creek	From an area approximately 6.5 miles east-northeast of the City of Florence in Florence County to impaired station PD-231 in Jeffries Creek at County Route S-21-24 (Paper Mill Road), approximately 10 miles east-southeast of the City of Florence in Florence County.	27.19	1.37	5.03%
	Total Area in the Jeffries Creek Watershed	159.16	37.39	23.49%
Willow Creek	From an area approximately 9 miles northwest of the Town of Pamplico in Florence County to impaired station PD-167 in Willow Creek at County Route S-21-57, approximately 7 miles north-northwest of the Town of Pamplico in Florence County.	45.61	1.75	3.84%
	Total Area in the Jeffries Creek and Tributaries Watershed	204.77	39.14	19.11%

1.2.1.3 Reach 3 of the Jeffries Creek Watershed; Terminal WQM Station PD-230

Reach 3 of the Jeffries Creek Watershed covers a drainage area of 40.57 mi^2 (25,972.06 acres) in size that drains into Middle Swamp and its tributaries from an area approximately 6.5 miles southwest of the City of Darlington in Darlington County, in a general southeastern fashion to impaired station PD-230 in Middle Swamp at SC 51 at the southeastern portion of the City of Florence in Florence County (Figure 2). The reach lies in the Southeastern Plains and Middle Atlantic Coastal Plains ecoregions of the State.

Figure 3b. Land Use Diagram for Reach 2 of the Jeffries Creek Watershed

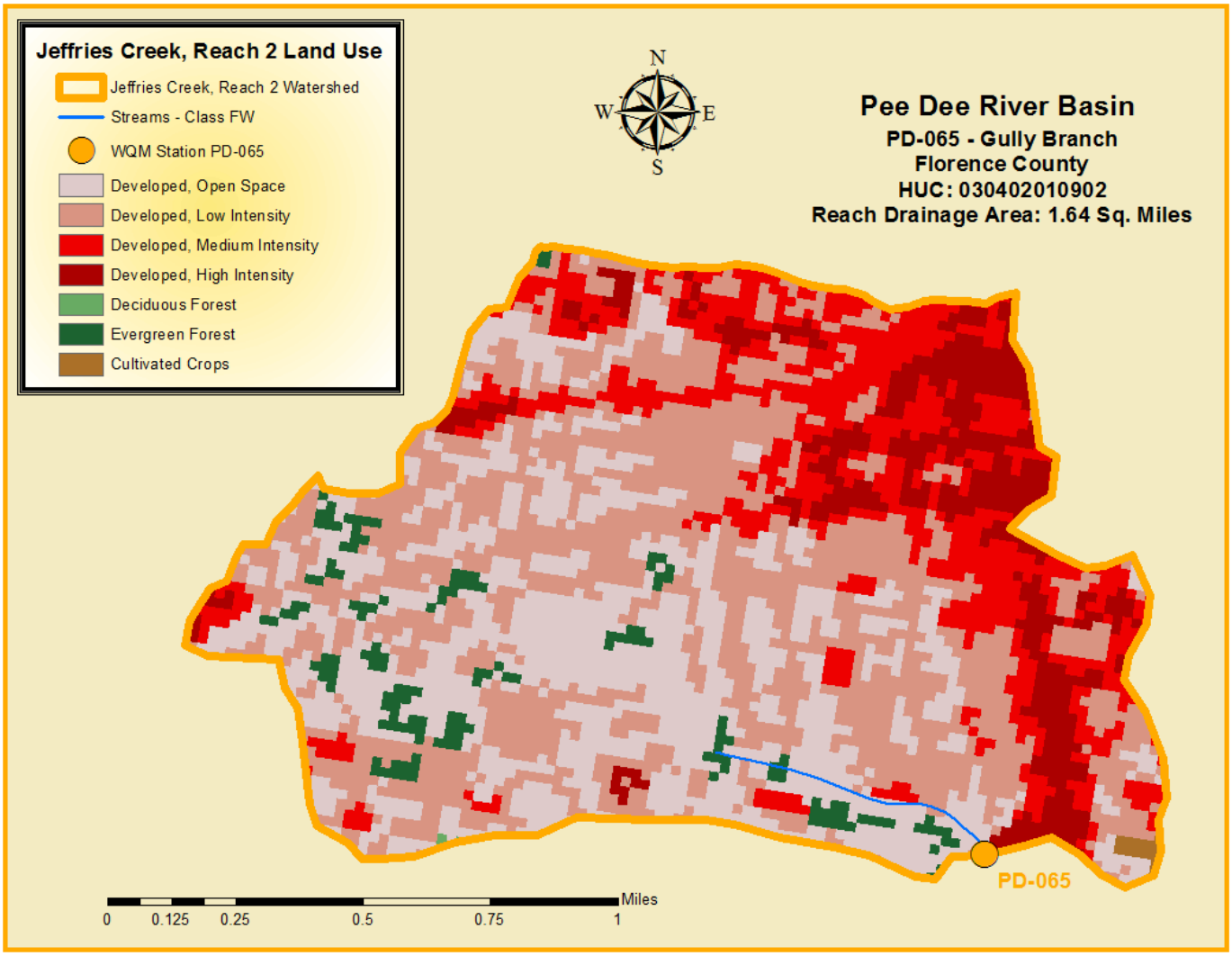


Table 2b. Jeffries Creek Watershed: Land Use in Reach 2 (WQM Station PD-065)
(Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area (Mile^2)	Percent
Developed, Low Intensity	406.76	0.64	38.73%
Developed, Open Space	314.69	0.49	29.96%
Developed, Medium Intensity	183.48	0.29	17.47%
Developed, High Intensity	106.53	0.17	10.14%
Evergreen Forest	35.58	0.06	3.39%
Cultivated Crops	2.67	0.00	0.25%
Deciduous Forest	0.67	0.00	0.06%
Totals	**1050.37**	**1.64**	**100.00%**

Land use within Reach 3 of the Jeffries Creek Watershed is predominately Cultivated Crops (27.30%), and Woody Wetlands (22.58%) (Figure 3c, Table 2c). Developed lands (residential, commercial, industrial, or open urban space) comprise 29.32% of the reach (Table 3). At the time of the development of these TMDLs, the only active animal feeding operations in the reach was the Mitch Tyler broiler facility, a poultry facility off Lake Swamp Road in Darlington County in the northwestern part of the reach (Figure 3c).

Figure 3c. Land Use Diagram for Reach 3 of the Jeffries Creek Watershed

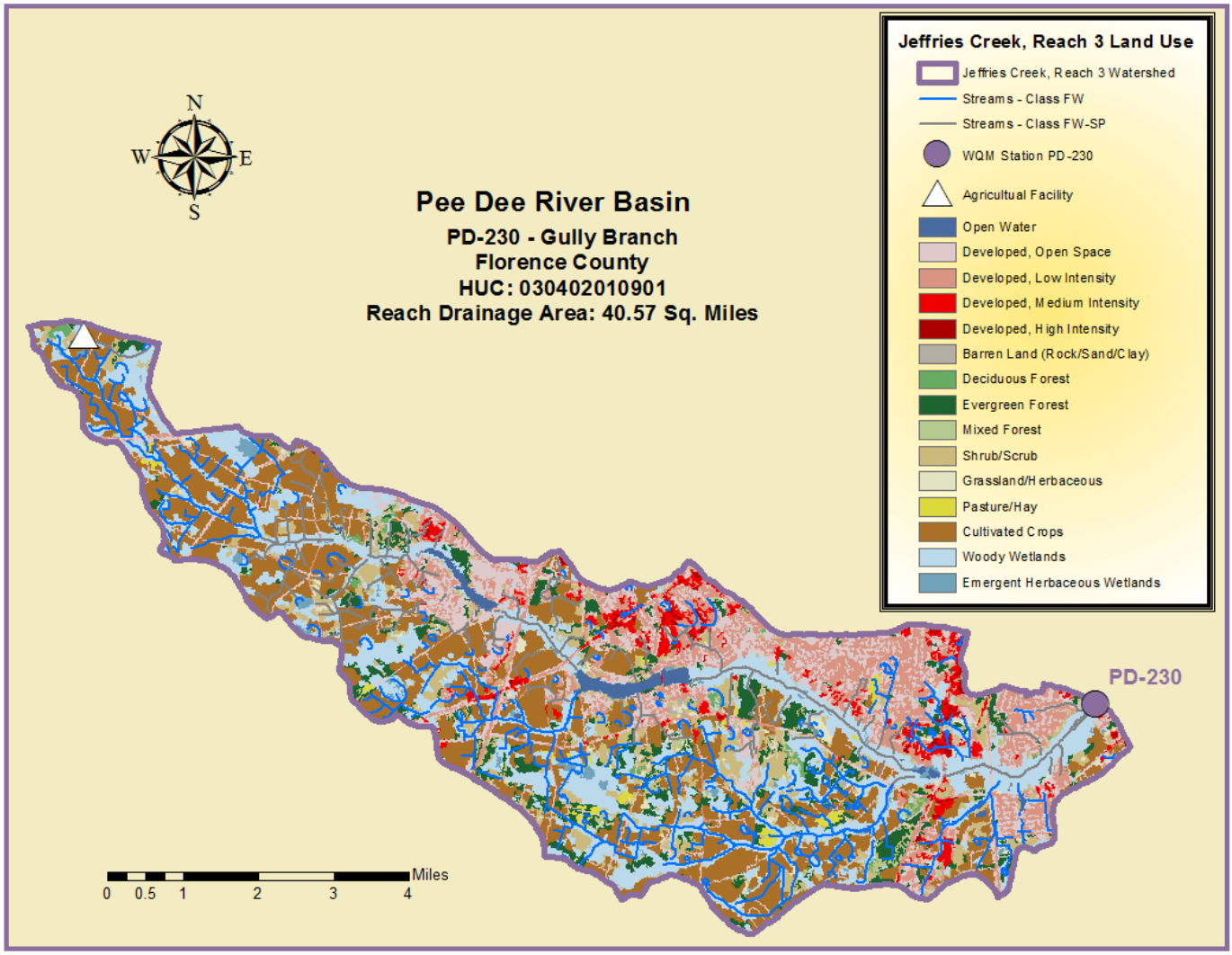


Table 2c. Jeffries Creek Watershed: Land Use in Reach 3 (WQM Station PD-230)
(Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area (Mile^2)	Percent
Cultivated Crops	7089.92	11.08	27.30%
Woody Wetlands	5864.75	9.16	22.58%
Developed, Open Space	3522.05	5.50	13.56%
Developed, Low Intensity	3084.83	4.82	11.88%
Shrub/Scrub	2250.63	3.52	8.67%
Evergreen Forest	1765.14	2.76	6.80%
Developed, Medium Intensity	859.78	1.34	3.31%
Open Water	342.04	0.53	1.32%
Grassland/Herbaceous	301.12	0.47	1.16%
Emergent Herbaceous Wetlands	294.00	0.46	1.13%
Pasture/Hay	184.81	0.29	0.71%
Developed, High Intensity	148.78	0.23	0.57%
Deciduous Forest	137.22	0.21	0.53%
Mixed Forest	102.30	0.16	0.39%
Barren Land (Rock/Sand/Clay)	24.69	0.04	0.10%
Totals	**25,972.06**	**40.57**	**100.00%**

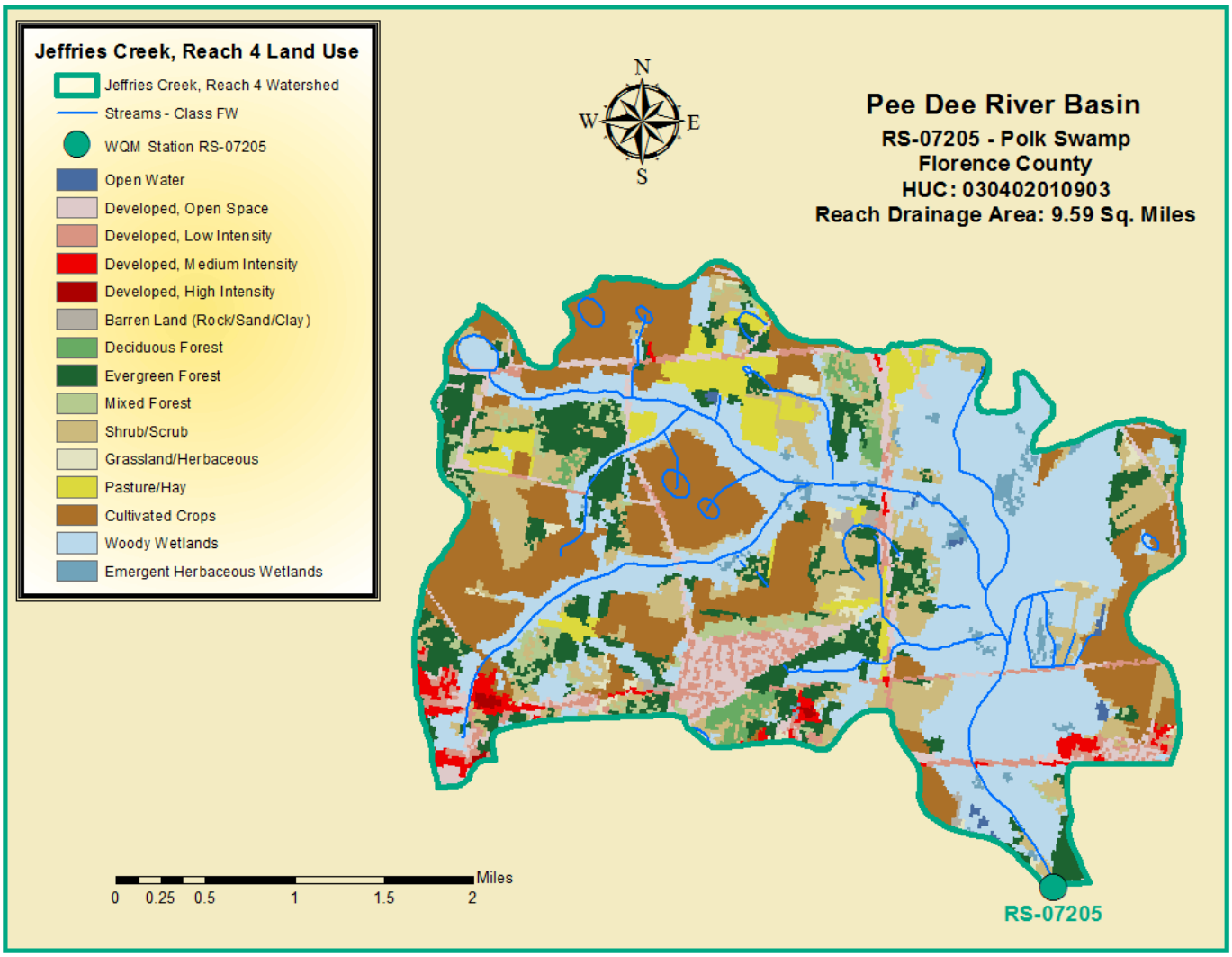
According to GIS information, there are approximately two hundred and two (202) miles of streams within Reach 3 of the Jeffries Creek Watershed. The streams are all classified as FW or FW-SP. From WQM Station PD-230, Middle Swamp flows for approximately 0.5 stream miles to Jeffries Creek in the southeastern portion of the City of Florence in Florence County.

1.2.1.4 Reach 4 of the Jeffries Creek Watershed; Terminal WQM Station RS-07205

Reach 4 of the Jeffries Creek Watershed covers a drainage area of 9.59 mi^2 (6140.07 acres) in size that drains into Polk Swamp and its tributaries from an area at the eastern portion of the Town of Quinby in Florence County, in a general southeastern fashion to impaired station RS-07205 in Polk Swamp at County Route S-21-918 (Old Wallace Road), approximately four (4) miles southeast of the Town of Quinby in Florence County (Figure 2). The reach lies in the Southeastern Plains ecoregion of the State.

Land use within Reach 4 of the Jeffries Creek Watershed is predominately Woody Wetlands (35.53%), and Cultivated Crops (20.98%) (Figure 3d, Table 2d). Developed lands (residential, commercial, industrial, or open urban space) comprise 10.64% of the reach (Table 3). At the time of the development of this TMDL, there were no animal feeding operations in the reach.

Figure 3d. Land Use Diagram for Reach 4 of the Jeffries Creek Watershed



According to GIS information, there are approximately forty-one (41) miles of streams within Reach 4 of the Jeffries Creek Watershed. The streams are all classified as FW. From WQM Station RS-07205, Polk Swamp flows for approximately four (4) stream miles to Jeffries Creek approximately 5.6 miles east-southeast of the City of Florence in Florence County.

Table 2d. Jeffries Creek Watershed: Land Use in Reach 4 (WQM Station RS-07205) (Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area ($Mile^2$)	Percent
Woody Wetlands	2181.68	3.41	35.53%
Cultivated Crops	1288.33	2.01	20.98%
Shrub/Scrub	736.12	1.15	11.99%
Evergreen Forest	640.05	1.00	10.42%
Developed, Open Space	340.04	0.53	5.54%
Pasture/Hay	253.75	0.40	4.13%
Developed, Low Intensity	204.60	0.32	3.33%
Mixed Forest	153.90	0.24	2.51%
Developed, Medium Intensity	98.08	0.15	1.60%
Emergent Herbaceous Wetlands	76.73	0.12	1.25%
Deciduous Forest	64.69	0.10	1.05%
Grassland/Herbaceous	54.04	0.08	0.88%
Barren Land (Rock/Sand/Clay)	20.91	0.03	0.34%
Open Water	16.68	0.03	0.27%
Developed, High Intensity	10.67	0.02	0.17%
Totals	**6140.07**	**9.59**	**100.00%**

1.2.1.5 Reach 5 of the Jeffries Creek Watershed; Terminal WQM Station PD-035

Reach 5 of the Jeffries Creek Watershed covers a drainage area of 46.17 mi^2 (29,559.49 acres) in size that drains into Jeffries Creek and its tributaries from an area approximately three (3) miles northwest of the City of Florence in Florence County, in a general southeastern fashion to impaired station PD-035 in Jeffries Creek at SC 327, approximately six (6) miles southeast of the City of Florence in Florence County (Figure 2). The reach lies in the Southeastern Plains ecoregion of the State.

Land use within Reach 5 of the Jeffries Creek Watershed is predominately Woody Wetlands (24.53%), and Open Space Developed (15.01%) (Figure 3e, Table 2e). Developed lands (residential, commercial, industrial, or open urban space) comprise 36.00% of the reach (Table 3). At the time of the development of this TMDL, there were no animal feeding operations in the reach.

According to GIS information, there are approximately 195 miles of streams within Reach 5 of the Jeffries Creek Watershed. The streams are all classified as FW or FW-SP. From WQM Station PD-035, Jeffries Creek flows for approximately 10 stream miles to the Great Pee Dee River on the Florence and Marion County border approximately 4.7 miles north-northeast of Town of Pamplico in Florence County.

1.2.1.6 Reach 6 of the Jeffries Creek Watershed; Terminal WQM Station PD-231

Reach 6 of the Jeffries Creek Watershed covers a drainage area of 27.19 mi^2 (17,405.89 acres) in size that drains into Jeffries Creek and its tributaries from an area approximately 6.5 miles east-northeast of the City of Florence in Florence County, in a general south-southeastern fashion to impaired station PD-231 in Jeffries Creek at County Route S-21-24 (Paper Mill Road), approximately ten (10) miles east-southeast of the City of Florence in Florence County (Figure 2). The reach lies in the Southeastern Plains ecoregion of the State.

Land use within Reach 6 of the Jeffries Creek Watershed is predominately Woody Wetlands (32.90%), and Cultivated Crops (19.52%) (Figure 3f, Table 2f). Developed lands (residential, commercial, industrial, or open urban space) comprise 5.03% of the reach (Table 3). At the time of the development of this TMDL, there were no animal feeding operations in the reach.

According to GIS information, there are approximately 103 miles of streams within Reach 6 of the Jeffries Creek Watershed. The streams are all classified as FW or FW-SP. From WQM Station PD-231, Jeffries Creek flows for approximately six (6) stream miles to the Great Pee Dee River on the Florence and Marion County border approximately 4.7 miles north-northeast of Town of Pamplico in Florence County.

Figure 3e. Land Use Diagram for Reach 5 of the Jeffries Creek Watershed

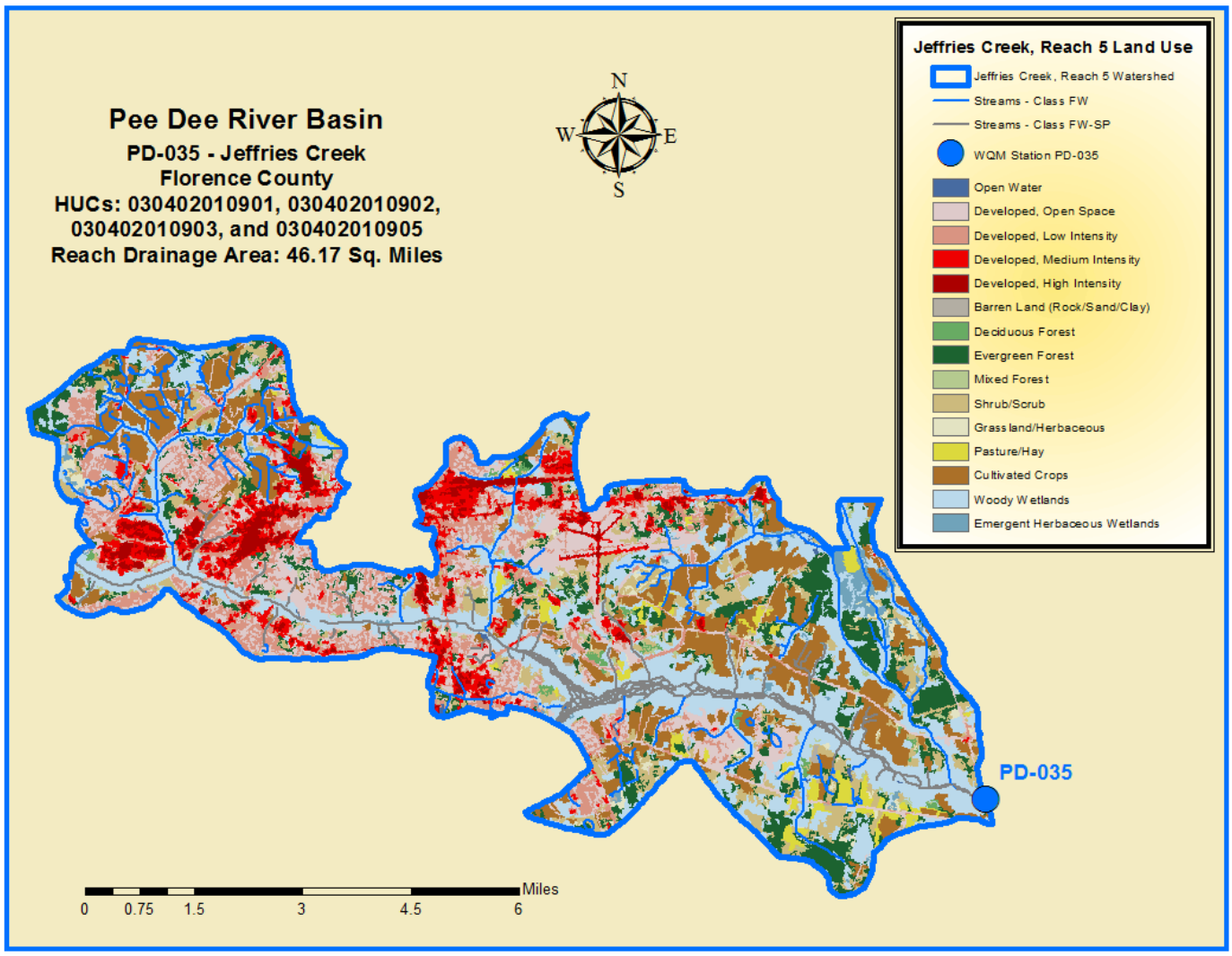


Table 2e. Jeffries Creek Watershed: Land Use in Reach 5 (WQM Station PD-035)
(Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area (Mile^2)	Percent
Woody Wetlands	7249.60	11.32	24.53%
Developed, Open Space	4437.87	6.93	15.01%
Cultivated Crops	4380.27	6.84	14.82%
Developed, Low Intensity	3387.06	5.29	11.46%
Evergreen Forest	3028.56	4.73	10.25%
Shrub/Scrub	2550.86	3.98	8.63%
Developed, Medium Intensity	1849.87	2.89	6.26%
Developed, High Intensity	965.63	1.51	3.27%
Pasture/Hay	557.32	0.87	1.89%
Emergent Herbaceous Wetlands	402.53	0.63	1.36%
Grassland/Herbaceous	336.93	0.53	1.14%
Mixed Forest	202.16	0.32	0.68%
Deciduous Forest	141.00	0.22	0.48%
Open Water	38.92	0.06	0.13%
Barren Land (Rock/Sand/Clay)	30.91	0.05	0.10%
Totals	**29,559.49**	**46.17**	**100.00%**

Figure 3f. Land Use Diagram for Reach 6 of the Jeffries Creek Watershed

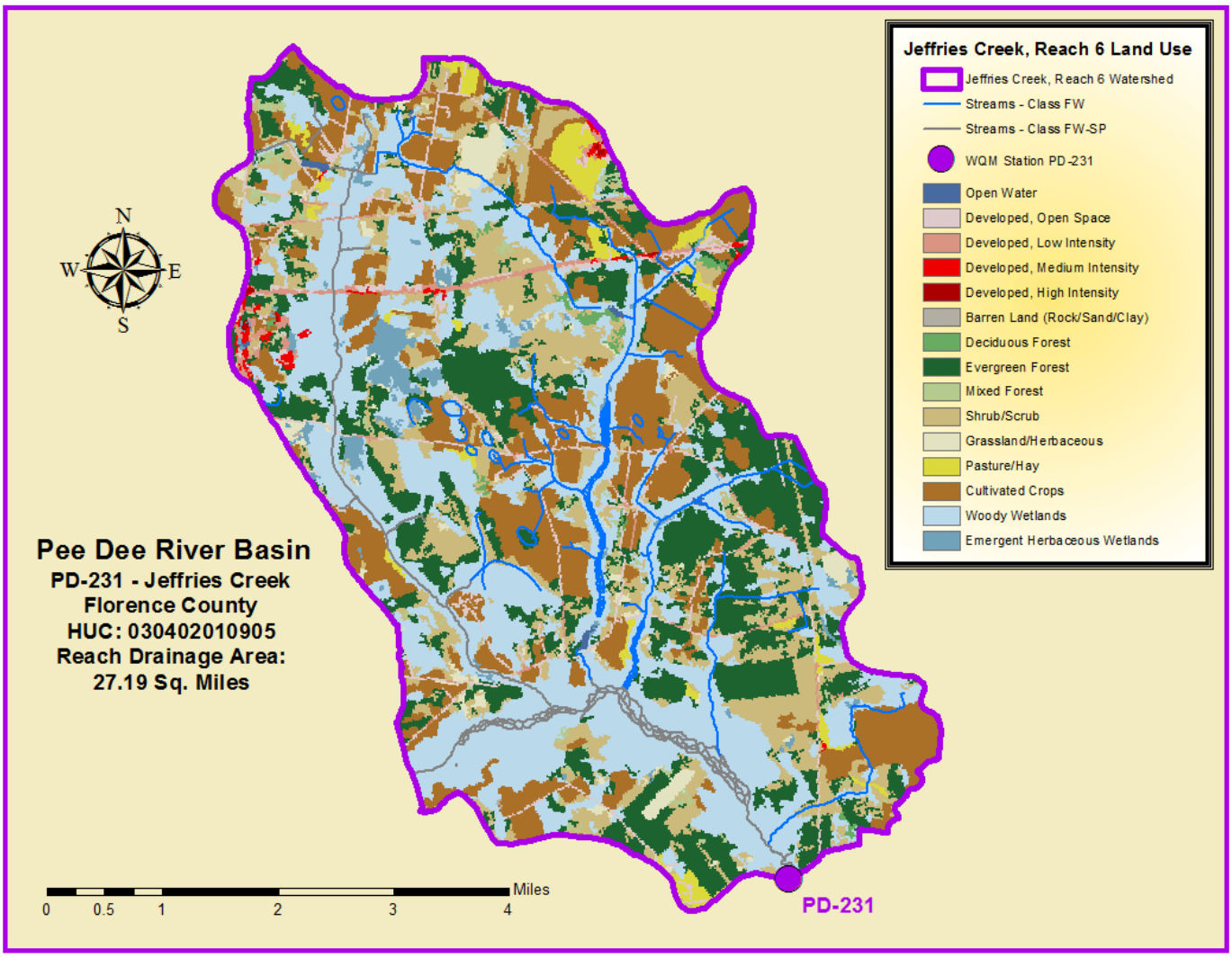


Table 2f. Jeffries Creek Watershed: Land Use in Reach 6 (WQM Station PD-231)
(Derived from National Land Cover Database (NLCD) 2011)

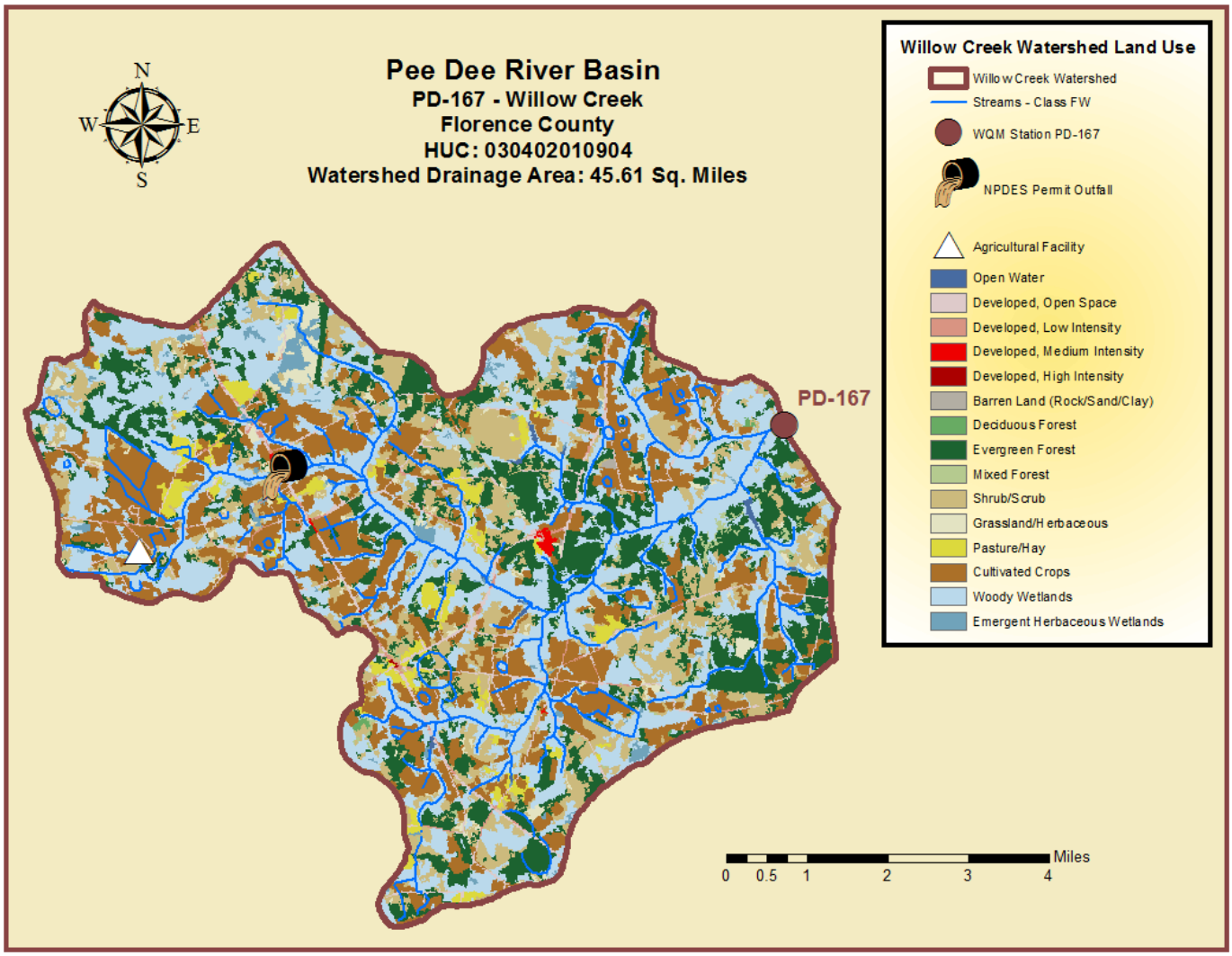
Description	Area (Acres)	Area (Mile^2)	Percent
Woody Wetlands	5726.42	8.95	32.90%
Cultivated Crops	3397.51	5.31	19.52%
Evergreen Forest	3341.25	5.22	19.20%
Shrub/Scrub	2753.24	4.30	15.82%
Developed, Open Space	552.20	0.86	3.17%
Pasture/Hay	371.40	0.58	2.13%
Grassland/Herbaceous	351.16	0.55	2.02%
Emergent Herbaceous Wetlands	331.14	0.52	1.90%
Developed, Low Intensity	236.85	0.37	1.36%
Mixed Forest	155.45	0.24	0.89%
Developed, Medium Intensity	73.61	0.11	0.42%
Deciduous Forest	70.28	0.11	0.40%
Open Water	29.36	0.05	0.17%
Developed, High Intensity	13.34	0.02	0.08%
Barren Land (Rock/Sand/Clay)	2.67	0.00	0.02%
Totals	**17,405.89**	**27.19**	**100.00%**

1.2.2 The Willow Creek Watershed; Terminal WQM Station PD-167

The Willow Creek Watershed covers a drainage area of 45.61 mi^2 (29,198.10 acres) in size that drains into Willow Creek and its tributaries from an area approximately 9 miles northwest of the Town of Pamplico in Florence County, in a general east-northeastern fashion to impaired station PD-167 in Willow Creek at County Route S-21-57, approximately 7 miles north-northwest of the Town of Pamplico in Florence County. The watershed lies in the Southeastern Plains and Middle Atlantic Coastal Plains ecoregions of the State.

Land use within the Willow Creek Watershed is predominately Woody Wetlands (33.14%), and Cultivated Crops (22.17%) (Figure 4, Table 4). Developed lands (residential, commercial, industrial, or open urban space) comprise only 3.84% of the watershed (Table 3). At the time of the development of these TMDLs, the only active animal feeding operations in the watershed was the Turner Swine facility, a swine facility off Pine Oak Road in Florence County in the western part of the watershed (Figure 4).

Figure 4. Land Use Diagram for the Willow Creek Watershed



According to GIS information, there are approximately 117 miles of streams within the Willow Creek Watershed. The streams are all classified as FW. From WQM Station PD-167, Willow Creek flows for approximately 1 stream mile to Jeffries Creek approximately ten (10) miles southeast of the City of Florence in Florence County.

Table 4. Willow Creek Watershed: Land Use in the Watershed (WQM Station PD-167) (Derived from National Land Cover Database (NLCD) 2011)

Description	Area (Acres)	Area (Mile^2)	Percent
Woody Wetlands	9677.70	15.12	33.14%
Cultivated Crops	6472.55	10.11	22.17%
Evergreen Forest	5331.23	8.33	18.26%
Shrub/Scrub	4382.72	6.85	15.01%
Developed, Open Space	888.24	1.39	3.04%
Pasture/Hay	796.17	1.24	2.73%
Grassland/Herbaceous	565.99	0.88	1.94%
Emergent Herbaceous Wetlands	458.80	0.72	1.57%
Mixed Forest	287.56	0.45	0.98%
Developed, Low Intensity	185.70	0.29	0.64%
Open Water	65.16	0.10	0.22%
Developed, Medium Intensity	42.03	0.07	0.14%
Deciduous Forest	24.02	0.04	0.08%
Barren Land (Rock/Sand/Clay)	15.35	0.02	0.05%
Developed, High Intensity	4.89	0.01	0.02%
Totals	**29,198.10**	**45.61**	**100.00%**

1.3 Revision of the Existing Gulley Branch TMDL

1.3.1 The 2005 TMDL Development for Gulley Branch (WQM Station PD-065)

The SCDHEC placed WQM Station PD-065 in Gulley Branch in the City of Florence in Florence County on the State's 2004 §303(d) list due to excessive FC bacteria. A description of the watershed for WQM Station PD-065 is given in Section 1.2.1.2 of this TMDL development document. In September 2005, the USEPA approved a FC bacteria TMDL that was developed internally by the SCDHEC for WQM Station PD-065 based on water quality monitoring data from 1998 through 2002 (SCDHEC Technical Report No.: 029-05) (USEPA, 2005). Table 5 summarizes the sampling data supporting the USEPA approved 2005 TMDL for WQM Station PD-065.

Table 5. FC Bacteria Observed at WQM Station PD-065 (1998-2002)[1]

Station	Waterbody	Number of Samples	Maximum Concentration Cfu/100 mL	Number of Samples >400/100 mL	% Samples Exceed WQS
PD-065	Gulley Branch	33	12,000	24	73%

[1]Source: USEPA, Region IV. 2005

The 2005 TMDL for WQM Station PD-065 in Gulley Branch identified mid-range stream flows as the critical conditions, i.e., the stream flow conditions requiring the greatest percentage of FC loading reduction to meet the LA in the TMDL (see Section 5.1 of this TMDL development document). A 99% reduction was established to meet the LA. Extreme high and low flow conditions were not evaluated during the 2005 TMDL for WQM Station PD-065. Table 6 gives the components of the 2005 TMDL.

Since the time of the original 2005 TMDL development, additional pathogen data have been collected at site PD-065 and *E. coli* was adopted as the pathogen indicator in freshwaters.

1.3.2 CWA §319 Load Reduction Project in the Gulley Branch TMDL Watershed

Congress amended the *CWA* in 1987 to establish the §319 Nonpoint Source Management Program. Under §319, States receive grant money to support a wide variety of activities including the restoration of impaired

Table 6. Total Maximum Daily Load for Gulley Branch (WQM Station PD-065), September 2005[1]

Station	Existing FC Load (cfu/day)[2]	TMDL (cfu/day)	Margin of Safety (MOS) (cfu/day)	Load Allocation (LA) (cfu/day)	Reduction To Meet LA (Percent)	Reduction to Meet LA (cfu/day)	Critical Condition
PD-065	1.51E+12	1.47E+10	7.34E+08	1.39E+10	99	1.50E+12	Mid-Range

[1]Source: USEPA, Region IV. 2005

[2]Existing FC Load (CFU/day) at the time of TMDL development in September 2005

waters. TMDL implementation projects are given highest priority for 319 funding. *CWA* §319 grants are not available for implementation of the WLA component of TMDLs, but may be available for the LA component of a TMDL within permitted municipal separate storm sewer system (MS4) jurisdictional boundaries.

1.3.2.1 CWA §319 Grant for the Gulley Branch TMDL Watershed (WQM Station PD-065)

Pursuant to Section 319 of the *CWA,* on November 5, 2014, the SCDHEC entered into a grant agreement with the City of Florence for funding the "Lucas and Timrod Park Restoration Project" (LTPRP) to improve water quality in the Jeffries Creek Watershed (10-digit HUC: 0304020109). According to the City of Florence's work plan for the LTPRP, the City plans to reduce erosion and sediment loading, with the ultimate goal of reducing bacteria loading in the watershed, by reducing sediment loading and enhancing riparian corridors within Lucas Park and Timrod Park, two (2) parks within the City's incorporated area. Also, according to the work plan, the two (2) parks will also serve as prime educational opportunities by providing locales for direct educational outreach.

Runoff from both Lucas Park and Timrod Park in the City of Florence drain into Gulley Branch. And, both parks lie within the Upper Jeffries Creek Watershed (12-digit HUC: 030402010902), a sub-watershed of the Jeffries Creek Watershed. However, all areas of Timrod Park lie within the watershed for WQM Station PD-065. No areas of Lucas Park lie within the watershed for WQM Station PD-065. Therefore, for purposes of this TMDL development document, references to the Section 319 grant for the LTPRP is to refer to portions of the grant applicable to Timrod Park.

1.3.2.2 The Timrod Park Restoration Project

According to the City of Florence's work plan for the LTPRP, Timrod Park is located within the incorporated area of the City between Timrod Park Drive and West Waters Avenue. The park is a highly utilized 18-acre recreation area with tennis courts, playground, picnic areas, gardens, nature trails, fitness courses, and dog walking paths. The park is the largest city-owned property within the Gulley Branch watershed, and it contains areas accessible to a free flowing Gulley Branch. As Gulley Branch enters the park, it becomes a naturally flowing aboveground waterway. WQM Station PD-065 is located in Gulley Branch at Cherokee Road (County Route S-21-13) as the stream exits the park, just upstream from Lucas Park.

According to the work plan for the LTPRP, the overall goal of the project is to reduce bacterial loading (fecal coliform and *E. coli*) in Gully Branch to the maximum extent practicable through the implementation of the Gully Branch Watershed Plan. The major objectives of the project, as those objectives apply to Timrod Park, are to: **a)** install tree planter boxes to filter sediment within the park; **b)** stabilize eroded stream banks and reduce erosion potential through the installation of two (2) infiltration trenches along with associated stream bank stabilization; **c)** increase awareness of watershed topics including watershed services, function, and importance of riparian zones, and the causes and impacts of stormwater pollution through the education of citizens in the surrounding neighborhood who frequent the park; and, **d)** demonstrate bacteria load reductions (fecal coliform and *E. coli*) in Gully Branch in the final report to the SCDHEC following a period of post implementation monitoring.

It is expected that work will continue on the LTPRP through 2017. And, after project completion, the City of Florence has to monitor the project for success for twelve (12) months. According to the SCDHEC's Nonpoint Source Coordinator, as of the time of the development of these TMDLs, work had not begun on the LTPRP**.**

1.3.3 Revision of the Gulley Branch TMDL (WQM Station PD-065)

Additional monitoring data have been compiled for WQM Station PD-065 since the USEPA approved the TMDL for this station in September 2005. Notably, *E. coli* bacteria data were collected at the monitoring location during the SCDHEC's 2009 PIS. An examination of that *E. coli* bacteria data from the 2009 PIS shows that South Carolina's water quality standards for recreational use in freshwaters for *E. coli* bacteria continue to be exceeded, although at different levels than that of FC bacteria values observed during the 1998-2002 time-frame. Because more recent 2009 *E. coli* data collected at PD-065 may be demonstrating existing conditions in the watershed have changed since original 2005 pathogen TMDL development, it was deemed appropriate to revise the TMDL targets for site PD-065. Revision of the TMDL targets will also provide baseline information as the LTPRP commences in the near future.

1.4 Water Quality Standard

The impaired stream segments of the JCT Watershed basins are designated as Class Freshwater (FW or FW-SP), which is defined in SC Regulation 61-69 (2012) as:

> "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 current 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 (SCDHEC, 2012)."

Prior to February 28, 2013, South Carolina's WQS for recreational use in freshwaters was FC bacteria (R.61-68):

> "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 400/100 mL." (R.61-68).

Primary contact recreation is not limited to large streams and lakes. Even streams that are too small to swim in, will allow small children the opportunity to play and immerse their hands and faces. Essentially all perennial streams should therefore be protected from pathogen impairment.

2.0 WATER QUALITY ASSESSMENT

In 1986, the USEPA documented that *E. coli* and *Enterococcus* bacteria are better indicators than FC bacteria group in predicting the presence of human gastroenteritis (upset stomach, nausea, diarrhea, vomiting) causing pathogenic bacteria in fresh waters. The USEPA study was based on data collected when swimmers were directly exposed in freshwater lakes with established public swimming areas. In almost all cases of water-borne illnesses, pathogens come from inadequately treated waste of humans or other warm-blooded animals. Also, *Enterococcus* and *E. coli* are more specific to sewage and fecal sources than the FC bacteria group. In light of this information, USEPA has recommended the use of either *E. coli* or *Enterococcus* as the pathogen indicator for fresh waters.

In order to determine which pathogen indicator bacteria is better suited in South Carolina as the recreational use water quality standard in fresh waters, the SCDHEC designed a PIS and conducted the study during 2009. Weekly water samples were collected from seventy-three (73) stations statewide and analyzed for *E. coli, Enterococcus* and for FC bacteria group. PIS results showed *E. coli* (a member of the FC bacteria group) is a better indicator for predicting the presence of pathogens in South Carolina freshwaters.

During 2012 and following the public participation, public comment period and legislative processes, the SDHEC submitted a proposed amendment to EPA to change the pathogen indicator from FC bacteria to *E. coli* in R. 61-68. Details of this process as well as PIS raw data can be found at:

http://www.scdhec.gov/environment/water/fwater.htm. The proposed amendment was approved by the USEPA on February 28, 2013 and *E. coli* has been promulgated in R. 61-68. *E. coli* is the applicable water quality standard for recreational use in fresh waters.

Beginning with the 2014 §303(d) list of impaired waters, sites included as impaired for recreational use FC bacteria on the 2012 §303(d) lists was listed as impaired for *E. coli.* Once sufficient *E. coli* data are collected from impaired stations, future TMDLs will be calculated based on *E. coli* data. Until sufficient data are collected, TMDLs for currently FC impaired stations can be calculated using FC data. Then, these FC TMDLs can be converted to *E. coli* TMDLs by multiplying the FC TMDL number by 0.8725. A 0.8725 ratio was derived by dividing the current single sample maximum (SSM) WQS for *E. coli*, 349 MPN/100ml by former SSM WQS for FC bacteria, 400 cfu/100 ml.

The SCDHEC currently has seven (7) monitoring locations within the JCT Watershed described earlier in this TMDL development document. The following six (6) of those seven (7) WQM stations in Jeffries Creek, and in tributaries to Jeffries Creek, in Florence County, SC are listed on the 2014 §303(d) list for *E. coli* bacteria: **a)** station PD-256 in Jeffries Creek; **b)** station PD-230 in Middle Swamp; **c)** station RS-07205 in Polk Swamp; **d)** station PD-035 in Jeffries Creek; **e)** station PD-231 in Jeffries Creek; and, **f)** station PD-167 in Willow Creek. The seventh monitoring location, WQM Station PD-065 in Gulley Branch in the City of Florence in Florence County, was included on the State's 2004 §303(d) list for exceeding the FC bacteria WQS. 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 there are not an adequate number of monthly samples to calculate a geometric mean, then the available sample results are compared against the SSM criterion. If greater than 10% of these samples exceed this criterion then the station is included on South Carolina's §303(d) list due to recreational use. These stations will be included on future §303(d) lists due to exceedances of the current *E. coli* WQS until such time such time that sufficient *E. coli* data are collected and demonstrate the WQS is attained or such time that TMDLs are developed and approved to address the parameter of concern.

As discussed previously, this TMDL document addresses the development of *E. coli* TMDLs for the following four (4) WQM stations in the JCT Watershed on the 2014 §303(d) list using *E. coli* bacteria data from the SCDHEC's 2009 PIS: **a)** station PD-256; **b)** station PD-230; **c)** station PD-035; and, **d)** station PD-167. The development of FC bacteria TMDLs for two (2) of the WQM stations in the watershed on the 2014 §303(d) list, station RS-07205 and station PD-231, using FC bacteria data collected between January 2007 and December 2012 is also addressed. These two (2) FC bacteria TMDLs were converted to *E. coli* bacteria TMDLs for the purposes of implementation of the current *E. coli* WQS. This TMDL development document also addresses the revision of a FC bacteria TMDL for the seventh WQM station in the JCT Watershed (i.e., WQM Station PD-065) using *E. coli* bacteria data from the SCDHEC's 2009 PIS. Table 7 provides a summary of number of samples collected, number of exceedences and exceedence percentages.

Figure 5 illustrates precipitation and FC bacteria by data and date for WQM Station PD-231. The graph and Table 8 show that there is little or no correlation between the amount of precipitation and the temporal FC bacteria exceedences of water quality standards (r = 0.063). The graphs for precipitation and FC bacteria or *E. coli* bacteria by data and date for the other six (6) WQM stations in the JCT Watershed are shown in Appendix A. Like for WQM Station PD-231, Table 8 and the graphs (in Appendix A) show that there is little or no correlation between the amount of precipitation and the temporal FC bacteria exceedences of water quality standards for WQM Station RS-07205, or between the amount of precipitation and the temporal *E. coli* bacteria exceedences of water quality standards for WQM Station PD-230. However, Table 8 and the graphs (in Appendix A) show that there is a strong positive correlation between the amount of precipitation and the temporal *E. coli* bacteria exceedences of water quality standards for WQM stations PD-256, PD-065, and PD-035. There is a moderate positive correlation between the amount of precipitation and the temporal *E. coli* bacteria exceedences of water quality standards for WQM Station PD-167.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

The SCDHEC has adopted a change of its pathogen indicator from FC bacteria to *E. coli* 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* is the new pathogen indicator for recreational use in freshwaters.

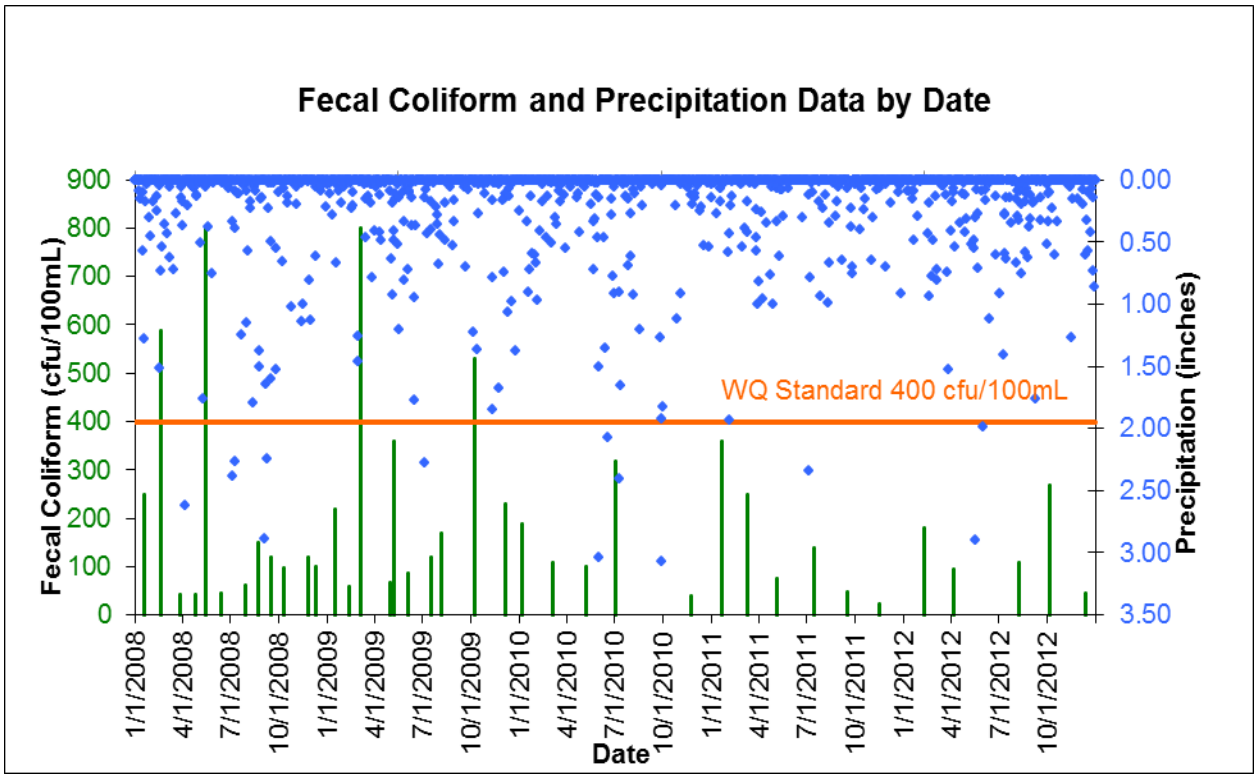
Table 7. FC and *E. coli* WQS Exceedence Summary for Impaired Stations (2007-2012)

WQM Station	Waterbody	Sample Constituent	Maximum Concentration (units/100mL)[1]	Number of Samples	Number of Samples >WQS[2]	% Samples Exceeding WQS
March 2016 Total Maximum Daily Loads						
PD-256	Jeffries Creek	*E. coli*	1953.6	50	13	26%
PD-230	Middle Swamp	*E. coli*	4479.6	51	9	18%
RS-07205	Polk Swamp	Fecal Coliform	880	7	2	29%
PD-035	Jeffries Creek	*E. coli*	2595.2	51	8	16%
PD-231	Jeffries Creek	Fecal Coliform	800	38	4	11%
PD-167	Willow Creek	*E. coli*	2746.8	50	7	14%
March 2016 Total Maximum Daily Loads (revised from September 2005)						
PD-065	Gulley Branch	*E. coli*	9678.4	51	36	71%

[1]Sampling results for FC are given as cfu (colony forming units)/100 mL; and, results for *E. coli* are given as MPN (most probable number)/100 mL.

[2]The number of FC samples exceeding 400 cfu/100 mL; and, the number of *E. coli* samples exceeding 349 MPN/100 mL.

Figure 5. Precipitation and FC Bacteria Data by Date for Water Quality Monitoring Station PD-231



Even though there are tests for specific pathogens, it is difficult to determine beforehand which organism may be present, and test for those specific organisms. Indicators such as FC bacteria, enteroccoci, or *E. coli*, which are indicators for human pollution, are easier to measure, have similar sources as pathogens, and persist in surface waters for a similar or longer length of time (Tchobanoglous & Schroeder, 1987). These bacteria are not in themselves disease causing, but indicate the potential presence of organisms that may result in illness.

Table 8. Correlations Between Rainfall and FC Bacteria and *E. coli* Bacteria in the Jeffries Creek and Tributaries Watershed

Station	Waterbody	Correlation Coefficient (r)	Coefficient of Determination (r^2)
March 2016 Total Maximum Daily Loads			
PD-256	Jeffries Creek	0.627	0.393
PD-230	Middle Swamp	0.160	0.026
RS-07205	Polk Swamp	0.024	0.000
PD-035	Jeffries Creek	0.423	0.179
PD-231	Jeffries Creek	0.063	0.004
PD-167	Willow Creek	0.387	0.150
March 2016 Total Maximum Daily Loads (revised from September 2005)			
PD-065	Gulley Branch	0.577	0.332

E. coli is used by the State of South Carolina as the indicator for pathogens in surface waters. Pathogens, which are usually difficult to detect, cause disease and make full body contact recreation in lakes and streams a risk to public health.

There are many sources of pathogen pollution 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 (WWTF), has been greatly reduced. These point sources are required by the *CWA* to obtain a NPDES permit. In South Carolina NPDES permits require that dischargers of sanitary wastewater must meet the state standard for the relevant pathogen indicator at the point of discharge. Municipal and private sanitary WWTFs may occasionally be sources of pathogens. However, if these facilities are discharging wastewater that meets their permit limits, then the facilities are not causing impairment. If any of these facilities is not meeting its permit limits, enforcement actions/mechanisms are required.

Other non-continuous point sources required to obtain NPDES permits that may be a source of pathogens include MS4s and stormwater discharges from construction or industrial sites. MS4s may require NPDES discharge permits for industrial and construction activities under the NPDES stormwater regulations. These sources are also required to comply with the state standard for the pollutant(s) of concern. 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, then the MS4s should not be causing or contributing to an instream pathogen impairment.

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 WWTFs, industrial waste treatment facilities, or regulated stormwater 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 is only one FC bacteria related continuous point source in the JCT Watershed authorized under an NPDES permit issued by the SCDHEC. The Commander Nursing Center has a domestic WWTF located off SC 51 between the intersection of SC 51 and County Route S-21-726 and the bridge over Little Willow Creek, approximately 7.5 miles south south-east of the City of Florence in Florence County. The facility is authorized under the SCDHEC's NPDES Permit No. SC0034703 to discharge to Little Willow Creek, and ultimately to Willow Creek in the Willow Creek Watershed (Figure 6 and Table 9). Under the terms and conditions of the permit, the facility has limitations on the discharge of FC bacteria, and is authorized to

discharge a monthly average of up to 0.025 MGD. The permit was issued on July 19, 2011, and will expire on August 31, 2016. At the time of NPDES permit reissuance, *E. coli* limits will be incorporated into this permit in lieu of FC bacteria limits. There are currently no NPDES permitted *E. coli* bacteria related continuous point sources in the JCT Watershed.

Figure 6. NPDES Permitted FC Bacteria Discharge in the Willow Creek Watershed

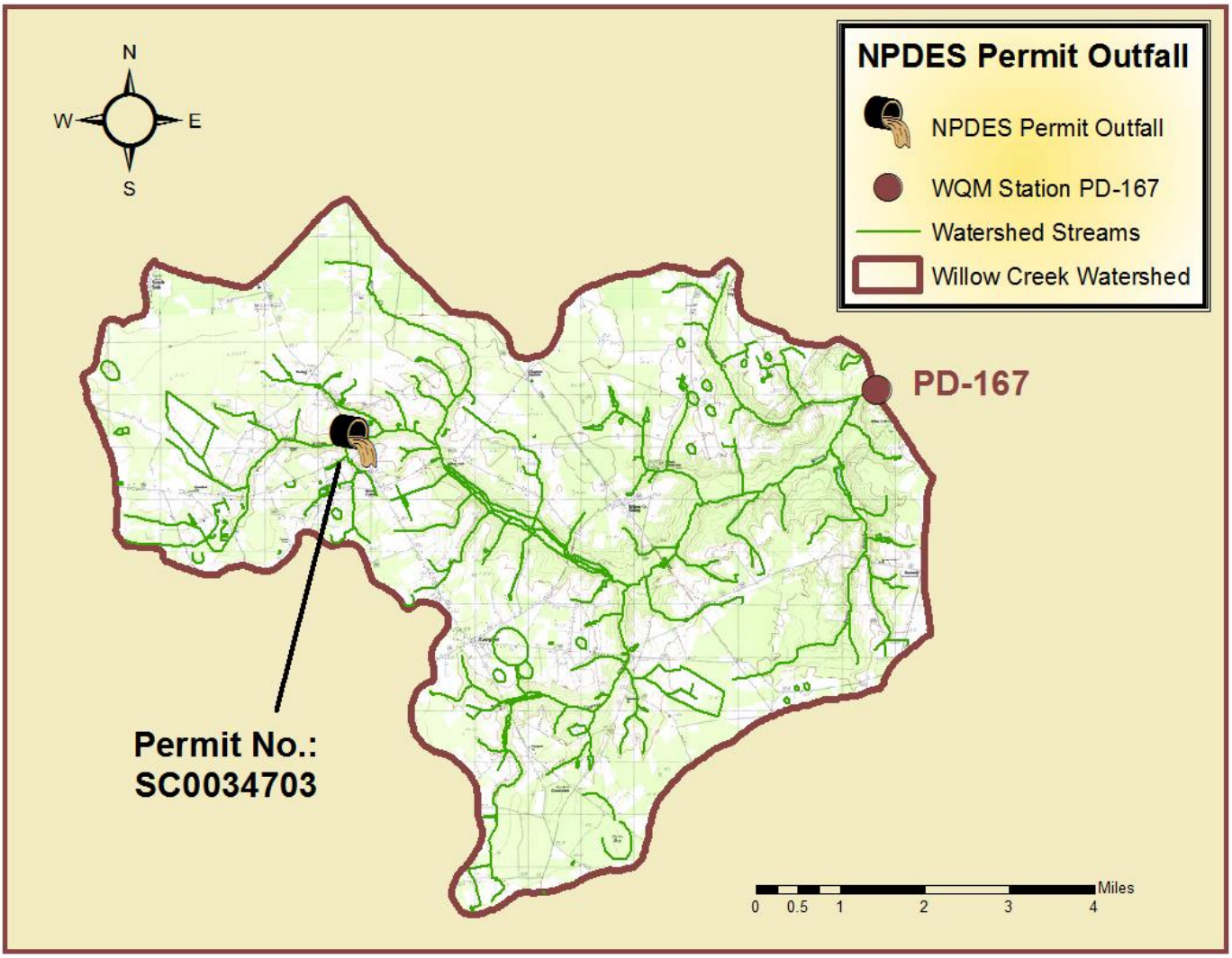


Table 9. NPDES Permitted Fecal Coliform Bacteria Discharge in the Willow Creek Watershed

Impaired Station Watershed	Permitted Facility	NPDES Permit Number	Permit Type	Permit Limitation (FC Unit/Volume)	Permitted Flow (MGD)	Outfall Stream
PD-167	Commander Nursing Center	SC0034703	Minor	400 cfu/mL	0.025	Willow Creek

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/or regulated under South Carolina Water Pollution Control Permits: R61-9, §122.26(b)(4),(7),(14) - (21) (SCDHEC, 2011). All regulated MS4 entities have the potential to contribute *E. coli* and other FC bacteria pollutant loadings in the delineated drainage area used in the development of this TMDL.

There are five (5) regulated MS4s in the JCT Watershed: **a)** The South Carolina Department of Transportation (SCDOT); **b)** Darlington County; **c)** The City of Florence; **d)** the Town of Quinby; and,

e) Florence County. The SCDOT is the only large MS4 in the watersheds. There are no medium MS4s in the watersheds. The other four (4) MS4s are small MS4s. The SCDOT operates under the SCDHEC's NPDES MS4 Permit SCS040001 and owns and operates roads within all of the watersheds in the JCT Watershed (Figure 7 and Table 10). However, the Department recognizes that SCDOT is not a traditional MS4 in that it does not possess statutory taxing or has enforcement powers. SCDOT does not regulate land use or zoning, issue building or development permits.

Figure 7. SCDOT Owned and Maintained Roads in the Jeffries Creek and Tributaries Watershed

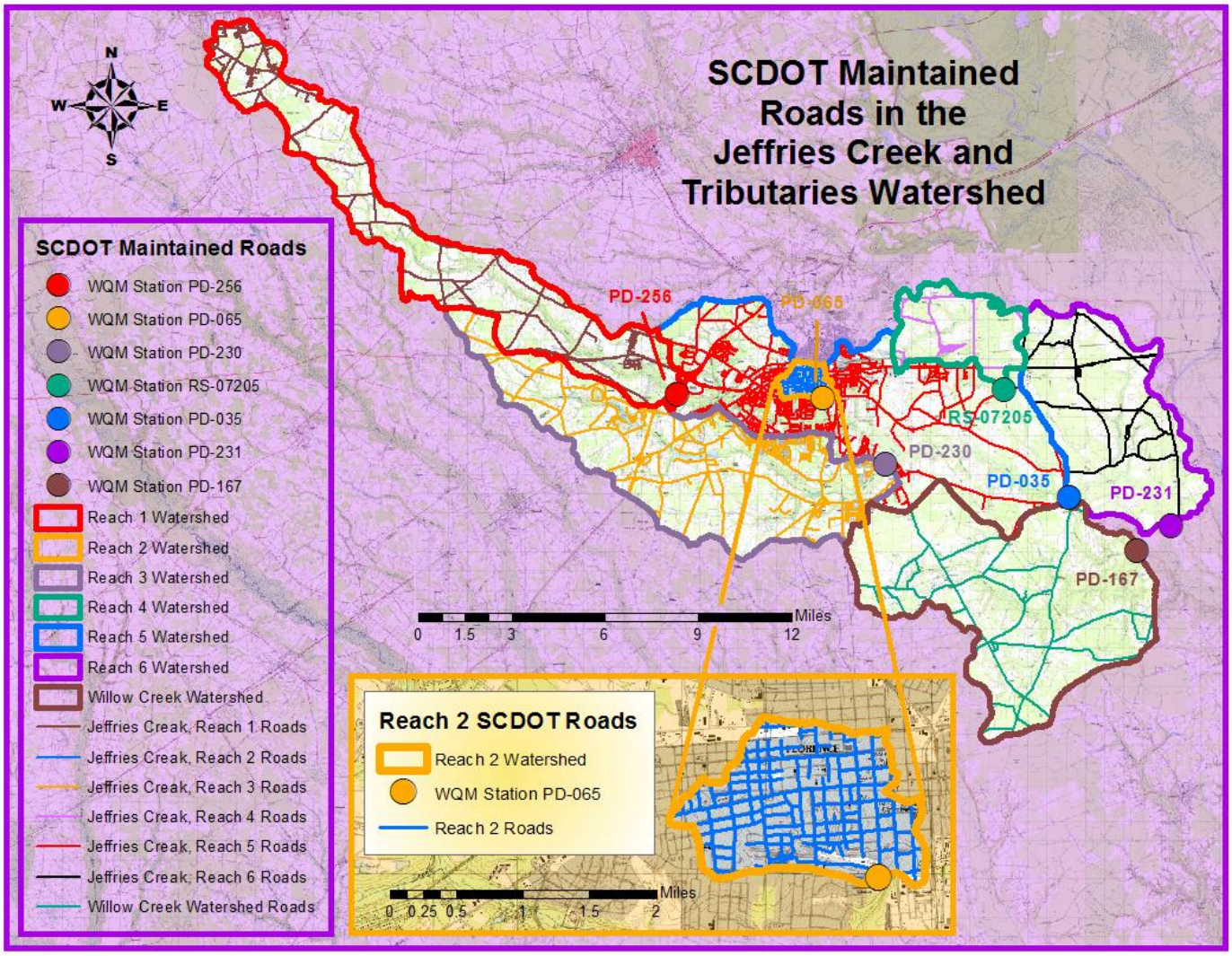


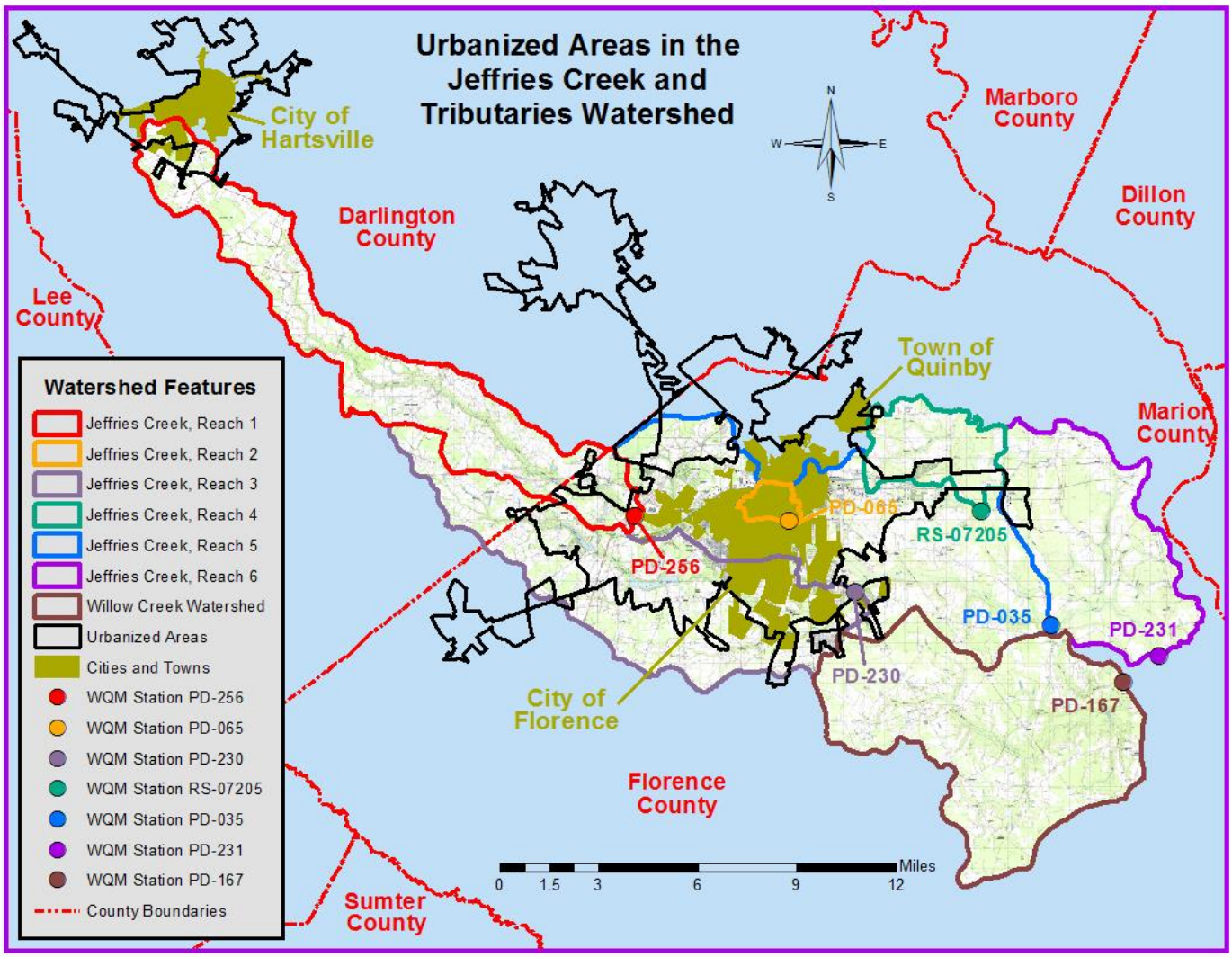
Table 10. SCDOT Maintained Road Miles in the Jeffries Creek and Tributaries Watershed

Watershed	WQM Station	Waterbody	Road Miles
March 2016 Total Maximum Daily Loads			
Jeffries Creek – Reach 1	PD-256	Jeffries Creek	93.51
Jeffries Creek – Reach 3	PD-230	Middle Swamp	131.98
Jeffries Creek – Reach 4	RS-07205	Polk Swamp	20.84
Jeffries Creek – Reach 5	PD-035	Jeffries Creek	196.11
Jeffries Creek – Reach 6	PD-231	Jeffries Creek	44.53
Willow Creek	PD-167	Willow Creek	56.29
March 2016 Total Maximum Daily Loads (revised from September 2005)			
Jeffries Creek – Reach 2	PD-065	Gulley Branch	26.12

Current developed land use for the JCT Watershed range from 3.84% to 96.29% (Table 3). Based on GIS information, the SCDOT has a facility in Reach 5 of the Jeffries Creek Watershed, located on US 76 approximately 2.5 miles east-northeast of the City of Florence in Florence County. There are no other SCDOT facilities in the JCT Watershed. And, based on the SCDOT website, there are no highway rest areas in the watershed.

Small MS4s that discharge stormwater in urbanized areas, as designated by the U.S. Bureau of Census, are regulated under SC *Water Pollution Control Permits* Regulation 122.26(b)(16) and 122.32. Urbanized areas in the JCT Watershed are shown in Figure 8. Darlington County, a small MS4, discharges stormwater in urbanized areas in Reaches 1 and 2 of the Jeffries Creek Watershed (Figure 8). The county operates under the SCDHEC's NPDES MS4 Permit SCR033101.

Figure 8. Urbanized Areas in the Jeffries Creek and Tributaries Watershed as Designated by the U.S. Bureau of Census



The City of Florence and the Town of Quinby are two small MS4 municipalities that discharge stormwater in urbanized areas in the Jeffries Creek Watershed (Figure 8). The City operates under the SCDHEC's NPDES MS4 Permit SCR034101, and discharges stormwater in Reaches 3 and 5 of the watershed. The Town operates under the SCDHEC's NPDES MS4 Permit SCR034103, and discharges stormwater in Reach 4 of the watershed.

Florence County, also a small MS4, discharges stormwater in urbanized areas in all of the watersheds in the JCT Watershed (i.e., discharges in Reaches 1 through 6 of the Jeffries Creek Watershed, and discharges in the Willow Creek Watershed) (Figure 8). The county operates under the SCDHEC's NPDES MS4 Permit

SCR034102. At the time of the development of these TMDLs, there were no regulated medium MS4 discharges in the JCT Watershed.

Other than the above mentioned MS4 owned and/or operated storm sewer systems, there are currently no permitted stormwater systems that discharge into the JCT Watershed. Future permitted sanitary sewer or stormwater systems in the referenced watersheds will be required to comply with the load reductions prescribed in the WLA and demonstrate consistency with the assumptions and requirements of the TMDLs in this TMDL development document.

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

Sanitary sewer overflows (SSOs) to surface waters have the potential to severely impact water quality. These untreated sanitary discharges result in violations of the WQS. It is the responsibility of the NPDES wastewater discharger, or sewer 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.

According to GIS information, a community sewer collection system serves a portion of each watershed in the JCT Watershed. The City of Hartsville's sewer collection system serves a small area in the northwestern portion of Reach 1 of the Jeffries Creek Watershed (terminal WQM Station PD-256). And, the City of Florence's sewer collection system serves a small area in the southeastern portion of the reach. The total area served is 4.17 mi^2 (2666.12 acres). This represents only 12% of the 34.00 mi^2 reach being served by a sewer collection system (Table 11).

Table 11. Areas Served by Community Sewer Collection Systems in the Jeffries Creek and Tributaries Watershed

WQM Station	Watershed	Watershed Area (mi^2)	Area Served by Sewer Collection Systems (mi2)	% Watershed Covered by Sewer Collection Systems
March 2016 Total Maximum Daily Loads				
PD-256	Reach 1 of Jeffries Creek	34.00	4.17	12%
PD-230	Reach 3 of Jeffries Creek	40.57	18.84	46%
RS-07205	Reach 4 of Jeffries Creek	9.59	3.31	35%
PD-035	Reach 5 of Jeffries Creek	46.17	28.00	61%
PD-231	Reach 6 of Jeffries Creek	27.19	3.41	33%
PD-167	Willow Creek	45.61	0.35	1%
March 2016 Total Maximum Daily Loads (revised from September 2005)				
PD-065	Reach 2 of Jeffries Creek	1.64	1.64	100%

The entire 1.64 mi^2 (1050.09 acres) area of Reach 2 of the Jeffries Creek Watershed (terminal WQM Station PD-065) is served by the City of Florence's community sewer collection system (Table 11).

The City of Florence's community sewer collection system serves the central and northeastern portion of Reach 3 of the Jeffries Creek Watershed (terminal WQM Station PD-230). The total area served is

18.84 mi^2 (12,060.20 acres). This represents 46% of the 40.57 mi^2 reach being served by a sewer collection system (Table 11).

The City of Florence's community sewer collection system serves the central and southwestern portion of Reach 4 of the Jeffries Creek Watershed (terminal WQM Station RS-07205). The total area served is 3.31 mi^2 (2121.39 acres). This represents 35% of the 9.59 mi^2 reach being served by a sewer collection system (Table 11).

The City of Florence's community sewer collection system serves the central portion of Reach 5 of the Jeffries Creek Watershed (terminal WQM Station PD-035). The total area served is 28.00 mi^2 (17,922.24 acres). This represents 61% of the 46.17 mi^2 reach being served by a sewer collection system (Table 11).

The City of Florence's community sewer collection system serves an area in the northern portion of Reach 6 of the Jeffries Creek Watershed (terminal WQM Station PD-231); and, serves an area in the southern portion of the reach. The total area served is 3.41 mi^2 (2181.92 acres). This represents 33% of the 27.19 mi^2 reach being served by a sewer collection system (Table 11).

The City of Florence's community sewer collection system serves only a small area in the northwestern portion of the Willow Creek Watershed (terminal WQM Station PD-167). The total area served is 0.35 mi^2 (226.66 acres). This represents only 1% of the 45.61 mi^2 watershed being served by a sewer collection system (Table 11).

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

The Department acknowledges that progress with the assumptions and requirements of the TMDLs by MS4s is expected to take one or more permit iteration. Progress towards achieving the WLA reduction for the TMDLs 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.

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.

The Department recognizes that there may be wildlife, agricultural activities, grazing animals, septic tanks, and/or other nonpoint source contributors located within unregulated areas (outside of NPDES permitted area) of the JCT Watershed. Nonpoint sources located in unregulated areas are subject to the load LA and not the WLA of the TMDL development document.

Pathogenic forms of *E. coli,* found in the guts of ruminant animals such as cattle, goats, sheep, deer and elk, produce toxins and are called "Shiga toxin-producing" *E. coli* or STEC. Of these ruminant animals, cattle are the major source for human illnesses. STEC infections start with ingestion of human or animal feces, contact with cattle, unpasteurized apple cider, soft cheeses made from raw milk, consumption of contaminated unpasteurized raw milk and water (CDC, n.d.).

3.2.1 Wildlife

Resident and migrant wildlife (mammals and birds) can be a significant contributor of *E. coli* and other FC bacteria. Wildlife in this area typically includes deer, squirrels, raccoons, and other mammals as well as a variety of birds. Wildlife wastes are carried into nearby streams by runoff following rainfall or deposited directly in streams. According to a study conducted by the SC Department of Natural Resources (SCDNR) in 2008, there are an estimated fifteen (15) to thirty (30) deer per square mile in the northern 20 percent

portion of reach 1 of the Jeffries Creek Watershed (terminal WQM Station PD-256), and less than fifteen (15) deer per square mile in the rest of the reach (SCDNR 2008).

According to the SCDNR study, there are an estimated fifteen (15) to thirty (30) deer per square mile in the northern half of Reach 2 of the Jeffries Creek Watershed (terminal WQM Station PD-065), and less than fifteen (15) deer per square mile in the southern half of the reach (SCDNR 2008).

According to the SCDNR study, there are less than fifteen (15) deer per square mile in Reach 3 of the Jeffries Creek Watershed (terminal WQM Station PD-230) (SCDNR 2008).

According to the SCDNR study, there are an estimated fifteen (15) to thirty (30) deer per square mile in Reach 4 of the Jeffries Creek Watershed (terminal WQM Station RS-07205) (SCDNR 2008).

According to the SCDNR study, there are an estimated fifteen (15) to thirty (30) deer per square mile in the northeastern half of Reach 5 of the Jeffries Creek Watershed (terminal WQM Station PD-035), and less than fifteen (15) deer per square mile in the southwestern half of the reach (SCDNR 2008).

According to the SCDNR study, there are an estimated fifteen (15) to thirty (30) deer per square mile in Reach 6 of the Jeffries Creek Watershed (terminal WQM Station PD-231) (SCDNR 2008).

And, according to the SCDNR study, there are an estimated thirty (30) to forty-five (45) deer per square mile in a small southern portion (approximately 5% of the watershed area) of the Willow Creek Watershed (terminal WQM Station PD-167); there is an estimated thirty (30) to forty-five (45) deer per square mile in the central and northeastern portion (approximately 60% of the watershed area) of the watershed; and, there is less than fifteen (15) deer per square mile in the northwestern portion (approximately 35% of the watershed area) of the watershed (SCDNR 2008).

The SCDNR's 2008 study estimated deer density based on suitable habitat (forests, croplands, and pastures). The FC production rate for deer has been shown to be 347×10^6 cfu/head-day in a study conducted by Yagow (1999), of which only a portion will enter the JCT Watershed. Wildlife may contribute a significant portion of the overall *E. coli* and other FC bacteria load within the watersheds.

3.2.2 Agricultural Activities

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. Unstabilized soil directly adjacent to surface waters can contribute to pollutant loading during periods of runoff after rain events. During these events, fertilizer and wildlife wastes can be transported into the creek and carried downstream. Agricultural activities may represent a contributing source in the JCT Watershed where agricultural activities constitute a greater portion of the land use.

3.2.2.1 Agricultural Animal Facilities

Owners/operators of most commercial animal growing operations are required by South Carolina 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, the Department has a reasonable assurance that facilities operating in compliance with this regulation should not contribute to downstream water quality impairments. South Carolina currently does not have any confined animal feeding operations (CAFOs) under NPDES coverage; 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.

At the time of the development of these TMDLs, there were two (2) active AFOs with regulated structures or activities in the JCT Watershed. The Mitch Tyler broiler facility, a poultry facility off Lake Swamp Road in Darlington County, is located in the northwestern part of Reach 3 of the Jeffries Creek Watershed (terminal WQM station PD-230) (Figure 3c). The Turner Swine facility, a swine facility off Pine Oak Road in Florence

County, is located in the western part of the Willow Creek Watershed (terminal WQM station PD-167) (Figure 4). The poultry operation is regulated according to Section 122.23 of SC Regulation 61-9, *Water Pollution Control Permits*. There may also be land application sites associated with these facilities. These facilities are routinely inspected for compliance. Permitted agricultural facilities that operate in compliance with their permit are not considered to be sources of impairment.

3.2.2.2 Grazing Animals

Livestock, especially cattle, are frequently major contributors of FC bacteria or *E. coli* to 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 FC bacteria (including *E. coli*) 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 JCT Watershed is likely to be a contributing source of *E. coli* and other FC bacteria. However, the grazing of unconfined livestock (in pastures) is not regulated by the SCDHEC.

The United States Department of Agriculture's (USDA) National Agricultural Statistics Service reported 3165 and 2812 cattle and calves in Darlington and Florence Counties, respectively, in 2012 (USDA 2014). According to the 2011 National Land Cover Database (NLCD), there are 5662.37 and 15,476.62 acres of pastureland in Darlington and Florence Counties, respectively. This relates to 0.56 and 0.18 cattle per acre of pastureland in Darlington and Florence Counties, respectively, assuming an even distribution of cattle across pastureland in the counties. Table 12 shows the number of acres of pastureland in the JCT Watershed and, based on this acreage, an estimate of the number of cattle in the JCT Watershed. And, based on the number of cattle, the table shows an average of cfu/day of FC bacteria produced by cattle in the watershed. Based on the table, following is the average FC bacteria produced per day by the estimated total cattle and calves within each watershed: **a)** 1.72E+12 cfu/day by an estimated seventeen (17) cattle and calves in Reach 1 of the Jeffries Creek Watershed (terminal WQM Station PD-256); **b)** 3.91E+12 cfu/day by an estimated thirty-nine (39) cattle and calves in Reach 3 of the Jeffries Creek Watershed (terminal WQM Station PD-230); **c)** 4.61E+12 cfu/day by an estimated forty-six (46) cattle and calves in Reach 4 of the Jeffries Creek Watershed (terminal WQM Station RS-07205); **d)** 1.01E+13 cfu/day by an estimated one hundred and one (101) cattle and calves in Reach 5 of the Jeffries Creek Watershed (terminal WQM Station PD-035); **e)** 6.75E+12 cfu/day by an estimated sixty-seven (67) cattle and calves in Reach 6 of the Jeffries Creek Watershed (terminal WQM Station PD-231); and, **f)** 1.45E+13 cfu/day by an estimated one hundred and forty-five (145) cattle and calves in the Willow Creek Watershed (terminal WQM Station PD-167). Based on the 2011 NLCD, there is no pastureland in Reach 2 of the Jeffries Creek Watershed (terminal WQM Station PD-065).

Table 12. Cattle FC per Day in the Jeffries Creek and Tributaries Watershed

Downstream Impaired Station	County	Pasture Area (Acre) per Watershed	Cattle per Watershed	Cattle Fecal Coliform, cfu/day
PD-256	Darlington	27.80	16	1.55E+12
	Florence	9.12	2	1.66E+11
PD-230	Darlington	14.90	8	8.33E+11
	Florence	169.46	31	3.08E+12
RS-07205	Florence	253.75	46	4.61E+12
PD-035	Florence	557.32	101	1.01E+13
PD-231	Florence	371.40	67	6.75E+12
PD-167	Florence	796.17	145	1.45E+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 land apply sludge at

designated locations and under specific conditions. There are also some NPDES-permitted facilities authorized to land apply treated effluent 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. It is recognized that there may be operating, regulated land application sites located in the JCT Watershed. 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 pathogen loadings and stream impairment if not properly managed. Similar to AFO land application sites, the permitted land application sites described in this section are not allowed to directly discharge to JCT Watershed. 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.

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. Besides the SCDOT, Darlington and Florence Counties, and the City of Florence, there are currently no entities subject to an NPDES MS4 permit within or with impact to the JCT Watershed.

3.2.5 Failing Septic Systems

Failing, leaking or non-conforming septic systems, however, can be a major contributor of *E. coli* and other FC bacteria to the JCT 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.

3.2.5.1. Septic Systems in Reach 1 of the Jeffries Creek Watershed (WQM Station PD-256)

According to GIS information, sewer lines for the City of Hartsville extend into a small area of the northwestern portion of the 21,766.81-acre Reach 1 of the Jeffries Creek Watershed; and, sewer lines for the City of Florence extend into a small area in the southwestern portion of the reach. However, the vast majority of Reach 1 (approximately 88%) is not served by the City of Hartsville or City of Florence sewer systems, or any other community sewer system. Based on GIS information, 2013 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are 1473 households within the reach not served by a community sewer system. Therefore, assuming one septic tank per household, it is estimated that there are approximately 1473 septic tanks within the reach. This translates into 0.068 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.2. Septic Systems in Reach 2 of the Jeffries Creek Watershed (WQM Station PD-065)

According to GIS information, sewer lines for the City of Florence extend into the entire area of Reach 2 of the Jeffries Creek Watershed. Therefore, it is estimated that there are little or negligible septic tanks in the 1050.37-acre reach.

3.2.5.3. Septic Systems in Reach 3 of the Jeffries Creek Watershed (WQM Station PD-230)

According to GIS information, sewer lines for the City of Florence extend into the central and northeastern portion of the 25,972.06-acre Reach 3 of the Jeffries Creek Watershed. However, approximately 54% of the reach is not served by the City of Florence's sewer system or any other community sewer system. Based on GIS information, 2013 USDA aerial photography of the watershed, and based on the 2010 U.S.

population census, there are 2005 households within the reach not served by a community sewer system. Therefore, assuming one septic tank per household, it is estimated that there are approximately 2005 septic tanks within the reach. This translates into 0.077 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.4. Septic Systems in Reach 4 of the Jeffries Creek Watershed (WQM Station RS-07205)

According to GIS information, sewer lines for the City of Florence extend into the central and southwestern portion of the 6140.07-acre Reach 4 of the Jeffries Creek Watershed. However, approximately 65% of the reach is not served by the City of Florence's sewer system or any other community sewer system. Based on GIS information, 2013 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are three hundred and seventy-eight (378) households within the reach not served by a community sewer system. Therefore, assuming one septic tank per household, it is estimated that there are approximately 378 septic tanks within the reach. This translates into 0.062 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.5. Septic Systems in Reach 5 of the Jeffries Creek Watershed (WQM Station PD-035)

According to GIS information, sewer lines for the City of Florence extend into the central portion of the 29,559.49-acre Reach 5 of the Jeffries Creek Watershed. However, approximately 39% of the reach is not served by the City of Florence's sewer system or any other community sewer system. Based on GIS information, 2013 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are 1028 households within the reach not served by a community sewer system. Therefore, assuming one septic tank per household, it is estimated that there are approximately 1028 septic tanks within the reach. This translates into 0.035 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.6. Septic Systems in Reach 6 of the Jeffries Creek Watershed (WQM Station PD-231)

According to GIS information, sewer lines for the City of Florence extend into the northern portion of the 17,405.89-acre Reach 5 of the Jeffries Creek Watershed. However, the vast majority of Reach 5 (approximately 67%) is not served by the City of Florence's sewer system or any other community sewer system. Based on GIS information, 2013 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are nine hundred and ninety-six (996) households within the reach not served by a community sewer system. Therefore, assuming one septic tank per household, it is estimated that there are approximately nine hundred and ninety-six (996) septic tanks within the reach. This translates into 0.057 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

3.2.5.7. Septic Systems in the Willow Creek Watershed (WQM Station PD-167)

According to GIS information, sewer lines for the City of Florence extend into a very small area of the northwestern portion of the 29,198.10-acre Willow Creek Watershed. However, the vast majority of watershed (approximately 99%) is not served by the City of Florence's sewer system or any other community sewer system. Based on GIS information, 2013 USDA aerial photography of the watershed, and based on the 2010 U.S. population census, there are 1296 households within the watershed not served by a community sewer system. Therefore, assuming one septic tank per household, it is estimated that there are approximately 1296 septic tanks within the watershed. This translates into 0.044 septic tanks per watershed acre. At the time of the development of these TMDLs, their status in relation to function was unknown.

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 landscape. There are also 'urban' wildlife, squirrels, raccoons, pigeons, and other birds, all of which contribute to the FC bacteria (including *E. coli*) load. There is significant urban area within the JCT Watershed. Based on GIS information, some portions of three (3) incorporated areas lie within the JCT Watershed (Figure 2).

According to GIS information, 20.12% of the incorporated area of the City of Hartsville (i.e., 645.29 acres of 3206.86 acres) lie within in the northwestern portion of the 21,766.81-acre Reach 1 of the Jeffries Creek Watershed. However, this translates to only 2.96% of the reach being incorporated areas (Figure 2).

According to GIS information, 9.08% of the incorporated area of the City of Florence (i.e., 1039.28 acres of 11,441.99 acres) lie within in the vast majority of the 1050.37-acre Reach 2 of the Jeffries Creek Watershed. This translates to 98.94% of the reach being incorporated areas (Figure 2).

According to GIS information, 28.50% of the incorporated area of the City of Florence (i.e., 3261.49 acres of 11,441.99 acres) lie within in the northeastern portion of the 25,972.06-acre Reach 3 of the Jeffries Creek Watershed. However, this translates to only 12.56% of the reach being incorporated areas (Figure 2).

According to GIS information, 9.70% of the incorporated area of the Town of Quinby (i.e., 70.28 acres of 724.51 acres) lie within in the northwestern portion of the 6140.07-acre Reach 4 of the Jeffries Creek Watershed. However, this translates to only 1.14% of the reach being incorporated areas (Figure 2).

And, according to GIS information, 48.96% of the incorporated area of the City of Florence (i.e., 5602.21 acres of 11,441.99 acres) lie within in the western half of the 29,559.49-acre Reach 5 of the Jeffries Creek Watershed. This translates to 18.95% of the reach being incorporated areas (Figure 2) There are no incorporated areas in Reach 6 of the Jeffries Creek Watershed; and, there are no incorporated areas in the Willow Creek Watershed.

Similar to regulated MS4s, potentially designated MS4 entities (as listed in FR 64, 235, p.68837) or other unregulated MS4 communities located in the JCT Watershed may have the potential to contribute pollutant loadings in stormwater runoff. Only 23.49% of the Jeffries Creek Watershed is developed; and, only about 3.84% of the Willow Creek Watershed is developed (Table 3). Therefore, there is potential for growth in the JCT Watershed.

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 flow data. Three (3) United States Geological Survey (USGS) gages were used for collecting “real-time” flow data for the JCT Watershed TMDLs, based primarily on the size of the drainage area to the downstream gage, and secondarily on the general land use in the drainage area. The USGS gage used for collecting flow data for Reaches 5 and 6 of the Jeffries Creek Watershed (WQM Stations PD-035 and PD-231) was the Lumber River gage near Maxton, NC (Gage Number: 02133624). This gage has a drainage area of 365 square miles, began recording daily flows in 1987 and provides the flow data required to establish flow duration curves for these two (2) impaired stations.

The USGS gage used for collecting flow data for Reaches 1, 3, and 4 of the Jeffries Creek Watershed (WQM Stations PD-256, PD-230, and RS-07205), and for the Willow Creek Watershed (WQM Stations PD-167) was the Bear Creek gage at Mays Store, NC (Gage Number: 0208925200). This gage has a drainage area of 57.7 square miles, began recording daily flows in 1987 and provides the flow data required to establish flow duration curves for these four (4) impaired stations.

And, the USGS gage used for collecting flow data for Reach 2 of the Jeffries Creek Watershed (WQM Stations PD-065) was the Smith Branch gage at North Main Street at Columbia, SC (Gage Number: 02162093). This gage has a drainage area of 5.67 square miles, began recording daily flows in 1976 and provides the flow data required to establish the flow duration curve for this impaired station.

For example, flow data for a 10-year period (January 1, 2003 to December 31, 2012) from the USGS Maxton, NC gage was used to establish the flow duration curve for Reach 6 of the Jeffries Creek Watershed (WQM Station PD-231). The records for this period were complete (i.e., no missing dates). The drainage area of the sampling station was delineated using USGS topographic maps using ArcMap software. The cumulative area drained was calculated and used to estimate flow based on the ratio of the monitoring station drainage area to the downstream USGS gage. For example, the Maxton, NC gage records flow from 365 square miles (sq mi). The cumulative drainage area for the Reach 6 of the Jeffries Creek Watershed at WQM Station PD-231 (in Jeffries Creek at County Route S-21-24 (Paper Mill Road), 3.3 miles east-southeast of Claussen in Florence County) is 159.16 sq mi, or 43.61% of the area drained at the Maxton, NC gage. Therefore, mean daily flow for the PD-231 monitoring location was assumed to be 43.61% of the daily flow at the Maxton, NC gage.

Figure 2 provides an illustration of monitoring and gage locations along with a summary of drainage area statistics used to establish flows at un-gaged monitoring stations in the Jeffries Creek Watershed.

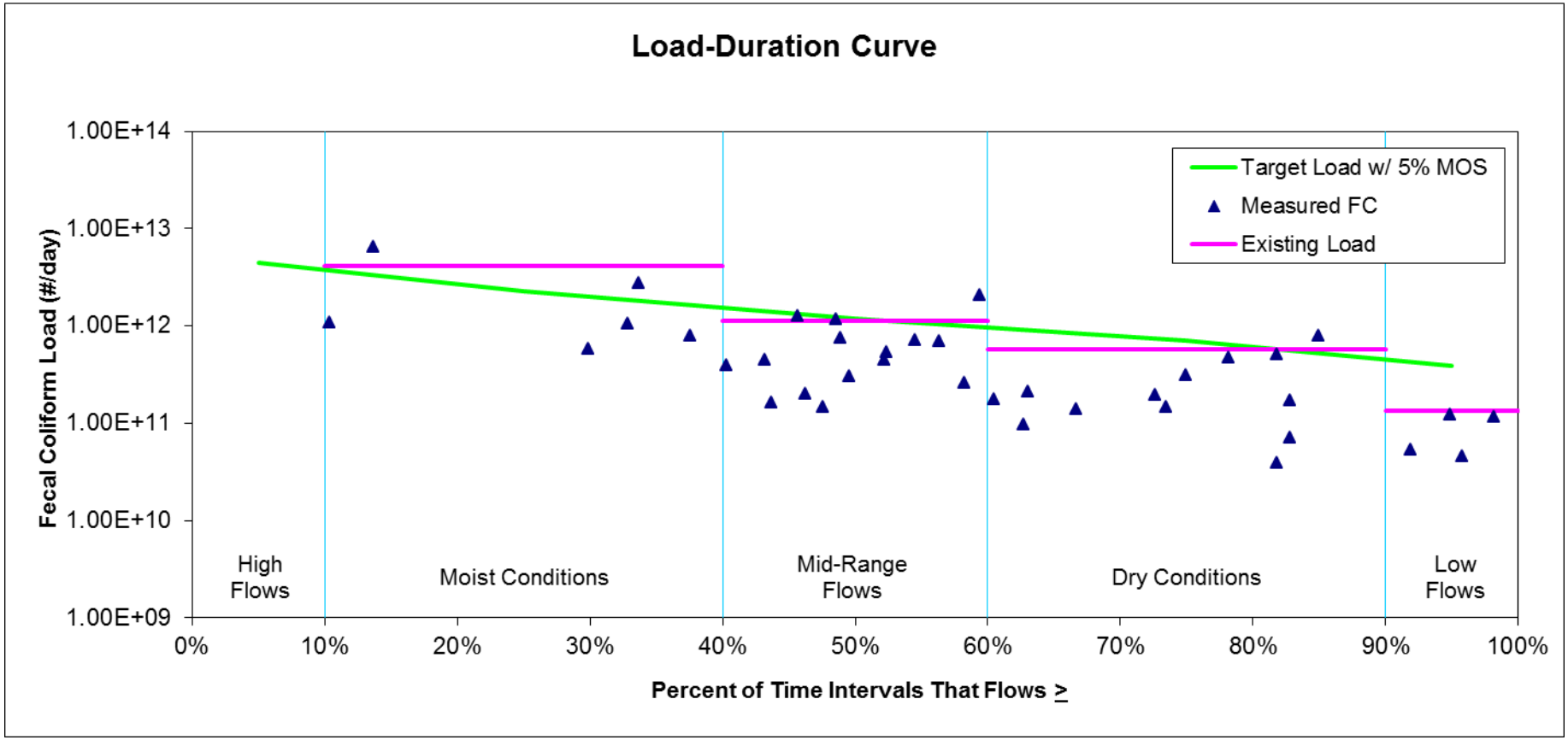
Flow duration curves were developed by ranking flows from highest to lowest and calculating the probability of occurrence (presented as a percentage or duration interval), where zero corresponds to the highest flow. The duration interval can be used to determine the percentage of time a given flow is achieved or exceeded, based on the period of record. The flow duration curves were divided into five (5) hydrologic condition categories (High Flows, Moist Conditions, Mid-Range, Dry Conditions and Low Flows). Categorizing flow conditions can assist in determining which hydrologic conditions result 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. Data within the High Flow and Low Flow categories are generally not used in the development of a TMDL due to their infrequency.

For those WQM stations where the target load-duration curves were created using existing FC bacteria data (i.e., stations RS-07205 and PD-231), the curves were created by calculating the allowable load using daily flow, the former FC WQS concentration and a unit conversion factor. The water quality target was set at 380 cfu/100ml for the instantaneous criterion, which is five (5) percent lower than the former water quality criterion of 400 cfu/100ml. A five (5) percent explicit MOS was reserved from the water quality criteria in developing target load-duration curves. The load-duration curve for station PD-231 is presented in Figure 9 as an example. The load-duration curve for station RS-07205 is presented in Appendix B.

Target loads in freshwaters impaired for *E. coli* may alternatively be calculated as the ratio of *E.coli* bacteria MPN/100 ml to FC bacteria cfu/100 ml or (349/400=0.8725). This conversion is derived from an established relationship between FC bacteria and *E. coli* WQS in freshwaters determined during the SCDHEC's 2009 PIS. Accordingly, because SC has recently adopted a change from FC bacteria to *E. coli* bacteria as a recreational use standard in all freshwaters, this TMDL development document also includes converted *E. coli* TMDLs for WQM Stations RS-07205 and PD-231, for purposes of implementation of the current recreational use standard. For these calculations, the daily flow and a unit conversion factor were used and the water quality target was set at 332 MPN/100ml for the instantaneous criterion, which is five (5) percent lower than the water current quality criteria of 349 MPN/100ml. A five (5) percent explicit MOS was reserved from the water quality criteria in developing target load-duration curves. For the purposes of establishing these two (2) TMDLs, FC bacteria percent reductions should also be representative of reductions necessary to meet the *E. coli* WQS.

For those WQM stations where the target load-duration curves were created using existing *E. coli* bacteria data from the SCDHEC's PIS (i.e., stations PD-256, PD-065, PD-230, PD-035, and PD-167), the curves were created by calculating the allowable load using daily flow, the current *E. coli* WQS concentration and a unit conversion factor. The water quality target was set at 332 MPN/100ml for the instantaneous criterion, which is five (5) percent lower than the current water quality criterion of 349 MPN/100ml. A five (5) percent explicit MOS was reserved from the water quality criteria in developing target load-duration curves. The load-duration curves for these five (5) WQM stations are presented in Appendix B.

Figure 9. Load Duration Curve for Reach 6 of the Jeffries Creek Watershed, Water Quality Monitoring Station PD-231



For all curves, including Figure 9, the independent variable (X-Axis) represents the percentage of estimated flows greater than value x. The dependent variable (Y-Axis) represents the FC bacteria or *E. coli* bacteria loading at each estimated flow expressed in terms of colony forming units per day (cfu/day), or most probable number per day (MPN/day). In each of the defined flow intervals for WQM Stations RS-07205 and PD-231, existing and target loadings were calculated by the following equations:

Existing Load = Mid-Point Flow in Each Hydrologic Category x 90th Percentile FC Concentration x 10000

Target Load = Mid-Point Flow in Each Hydrologic Category x 380 (WQ criterion minus a 5% MOS) x 10000

Percent Reduction = (Existing Load – Target Load) / Existing Load

In each of the defined flow intervals for WQM Stations PD-256, PD-065, PD-230, PD-035, and PD-167, existing and target loadings were calculated by the following equations:

Existing Load = Mid-Point Flow in Each Hydrologic Category x 90th Percentile E. coli Concentration x 10000

Target Load = Mid-Point Flow in Each Hydrologic Category x 332 (WQ criterion minus a 5% MOS) x 10000

Percent Reduction = (Existing Load – Target Load) / Existing Load

Instantaneous loads for each of the impaired stations were calculated. Measured FC bacteria concentrations or *E. coli* bacteria from 2007 through 2012 were multiplied by measured (or estimated flow based on drainage area) flow on the day of sampling and a unit conversion factor. These data were plotted on the load-duration graph based on the flow duration interval for the day of sampling. Samples above the target line are violations of the WQS while samples below the line are in compliance (see Figure 9, for example). Only the instantaneous water quality criterion was targeted because there is insufficient data to evaluate against the 30-day geometric mean.

An existing load was determined for each hydrologic category for the TMDL calculations. For the seven (7) WQM stations in the JCT Watershed, the 90th percentile of measured FC bacteria concentrations or *E. coli* bacteria concentrations within each hydrologic category were multiplied by the flow at each category midpoint (i.e., flow at the 25% duration interval for the Moist Conditions, 50% interval for Mid-Range, and 75% for Dry Condition).

Existing loads are plotted on the load-duration curves presented in Appendix A as well as the example for WQM Station PD-231 in Figure 9. These values were compared to the target loads (which includes an explicit 5% MOS) at each hydrologic category midpoint to determine the percent load reduction necessary to achieve compliance with the WQS. These TMDLs assumes that if the highest percent reduction is achieved, then the WQS will be attained under all flow conditions.

5.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

A TMDL for a given pollutant and water body is comprised of the sum of individual WLAs for point sources, and LAs for both nonpoint sources and natural background levels. In addition, the TMDL must include a MOS, either implicitly or explicitly, 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 WQS. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established and thereby provide 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

The critical condition is identified as the stream flow condition requiring the greatest percentage of pollutant loading reduction to meet the LA in the TMDL. Data within the High Flow and Low Flow categories are generally not used in the development of a TMDL due to their infrequency. Accordingly, the TMDLs for the seven (7) WQM stations in the JCT Watershed were based on the flow recurrence interval between 10% and 90% and excludes extreme high and low flow conditions; flows that are characterized as 'Low' or 'High.' The critical conditions for the JCT Watershed pathogen impaired segments are listed in Table 13. This data indicates that for WQM Station PD-231, moist conditions result in larger bacteria loads and is therefore the critical condition for that station. The following flow conditions result in larger bacteria loads, and are therefore the critical conditions, for the other six (6) WQM stations in the JCT Watershed: **a)** mid-range flow conditions for PD-256; **b)** moist conditions for PD-065; **c)** moist conditions for PD-230; **d)** dry conditions for RS-07205; **e)** mid-range flow conditions for PD-035; and, **f)** mid-range flow conditions for PD-167.

Table 13. Percent Reduction Necessary to Achieve Target Load by Hydrologic Category

WQM Station	Waterbody	Moist Conditions	Mid-Range Flow	Dry Conditions
PD-256	Jeffries Creek	20	59	50
PD-065	Gulley Branch	90	83	89
PD-230	Middle Swamp	73	35	23
RS-07205	Polk Swamp	16	NRN	53
PD-035	Jeffries Creek	NRN	66	58
PD-231	Jeffries Creek	45	NRN	NRN
PD-167	Willow Creek	61	64	6

Highlighted cells indicate critical condition
NRN = no reduction needed. Existing load below target load

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 development document. The existing load under the critical condition, described in Section 5.1 above 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 the seven (7) WQM stations in the JCT Watershed are provided in Appendix D.

5.3 Waste Load Allocation

The 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 is one active permitted domestic discharger of *E. coli* and other FC bacteria in the JCT Watershed. The facility is the Commander Nursing Center, which is discharging in the Willow Creek Watershed (Figure 6) (see Section 3.1.1 of this TMDL development document). The nursing center is permitted under the SCDHEC's NPDES Permit No. SC0034703 to discharge *E. coli* from its WWTF to Little Willow Creek, and ultimately to Willow Creek. To determine the WLA for the nursing center, the average permitted flow for the WWTF was multiplied by an allowable permitted maximum concentration of 349 MPN/100mL and a unit conversion factor. The WLA for the nursing center, based on a permitted daily maximum of 349 MPN/100 mL, is presented in Table 14. The WLA for the nursing center is 330 million counts per day (3.30E+08 MPN/day) based on a permitted average design flow of 0.025 MGD.

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 are required to meet the prescribed loading for *E. coli* based on permitted flow and an allowable permitted maximum concentration of 349MPN/100mL.

Table 14. Average Permitted Flow and *E. coli* WLA for the NPDES Wastewater Discharge in the Jeffries Creek and Tributaries Watershed

Impaired Station Watershed	Permitted Facility	Permit Number	Permitted Flow (MGD)	WLA *E. coli* (MPN/day)
PD-167	Commander Nursing Center	SC0034703	0.025	3.30E+08

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 SCS & SCR and regulated under SC *Water Pollution Control Permits* Regulation 122.26(b)(14) & (15) (SCDHEC, 2010. Illicit discharges, including SSOs, are not covered under any NPDES permit and are subject to enforcement mechanisms. All areas defined as "Urbanized Area" by the US Census are required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater. Figure 8 shows the urbanized areas in the JCT Watershed. Other non-urbanized areas may be required under the NPDES Phase II Stormwater Regulations to obtain a permit for the discharge of stormwater.

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 15 presents the reduction needed for each impaired segment in the JCT Watershed. The reduction percentages in these TMDLs also apply to the FC or *E. coli* waste load attributable to those areas of the watershed that are covered or will be covered under NPDES MS4 permits.

Table 15. Percent Reduction Necessary to Achieve Target Load

WQM Station	Waterbody	% Reduction
PD-256	Jeffries Creek	59
PD-065	Gulley Branch	90
PD-230	Middle Swamp	73
RS-07205	Polk Swamp	53
PD-035	Jeffries Creek	66
PD-231	Jeffries Creek	45
PD-167	Willow Creek	64

As appropriate information is made available to further define the pollutant contributions for the permitted MS4, an effort can 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.

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 these TMDLs. 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 16. There may be other unregulated MS4s located in the JCT 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, these entities will be required to meet load reductions prescribed in the WLA component of these TMDLs. 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 take into account the seasonal variability in watershed loading. The variability in these TMDLs is accounted for by using a 10-year hydrological and water quality sampling data set.

5.6 Margin of Safety

The 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). Target loads are therefore 95% of the assimilative capacity (i.e.,TMDL) of the waterbody. 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 derived from an established relationship between FC bacteria and *E. coli* WQS in freshwaters determined during the 2009 PIS.

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 organism counts (or resulting concentration), in accordance with 40 CFR 130.2(l). Only the instantaneous water quality criterion was targeted for the JCT 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 segment 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 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 16. Total Maximum Daily Loads for the Jeffries Creek and Tributaries Watershed
Loads are expressed as FC bacteria or *E. coli* count/day

	Existing Load (count/day)		TMDL (count/day)		Margin of Safety (MOS) (count/day)		Waste Load Allocation (WLA)				Load Allocation (LA)		
							Continuous Source[3] (count/day)		Non-Continuous Sources[4,5] (%Reduction)	Non-Continuous SCDOT[5] (%Reduction)	Load Allocation (count/day)		% Reduction to Meet LA[5]
March 2016 Total Maximum Daily Loads													
Station	FC (cfu/day)[1]	*E. coli* (MPN/day)[2]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)	(Percent)	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)
PD-256	---	4.71E+11	---	2.01E+11	---	1.01E+10	---	See Note Below	59	0[7]	---	1.91E+11	59
PD-230	---	1.50E+12	---	4.31E+11	---	2.16E+10	---	See Note Below	73	73[7]	---	4.10E+11	73
RS-07205	8.13E+10	---	4.07E+10	3.55E+10	2.03E+09	1.77E+09	See Note Below	See Note Below	53	53[7]	3.86E+10	3.37E+10	53
PD-035	---	2.57E+12	---	9.14E+11	---	4.57E+10	---	See Note Below	66	66[7]	---	8.68E+11	66
PD-231	4.15E+12	---	2.39E+12	2.09E+12	1.19E+11	1.04E+11	See Note Below	See Note Below	45	45[7]	2.27E+12	1.98E+12	45
PD-167	---	7.16E+11	---	2.70E+11	---	1.35E+10	---	3.30E+08	64	0[6]	---	2.56E+11	64
March 2016 Total Maximum Daily Loads (Revised from September 2005)													
Station	FC (cfu/day)[1]	*E. coli* (MPN/day)[2]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)	(Percent)	FC (cfu/day)	*E. coli* (MPN/day)[8]	(Percent)
PD-065	---	1.15E+11	---	1.19E+10	---	5.93E+08	---	See Note Below	90	90[7]	---	1.13E+10	90

Table Notes:

1. Existing fecal coliform loads were determined from the 90 percentile instream fecal coliform concentrations and stream flows during critical flow conditions. Fecal coliform concentrations were determined as part of the Department's water quality monitoring program.
2. Existing *E. coli* loads were determined from the 90 percentile instream *E. coli* concentrations and stream flows during critical flow conditions. *E. coli* concentrations were determined during the Department's 2009 Pathogen Indicator Study.
3. WLAs are expressed as a daily maximum. Existing and future continuous discharges are required to meet the prescribed loading for the pollutant of concern. For the purposes of NPDES permitting, continuous discharges may be required to meet a loading equivalent of FC bacteria, based upon permitted flow and an allowable permitted maximum FC bacteria concentration of 400 cfu/100ml, until such time that *E. coli* limits are incorporated into individual permits. *E. coli* limits will be developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100ml.
4. 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.
5. Percent reduction applies to existing instream FC bacteria or *E. coli.*
6. As long as the conditions within the SCDOT MS4 area remain the same the Department deem the current contributions from SCDOT negligible and no reduction of FC bacteria or *E. coli* is necessary. SCDOT must continue to comply with the provisions of its approved NPDES stormwater permit.
7. By implementing the best management practices that are prescribed in either the SCDOT annual SWMP or the SCDOT MS4 Permit to address fecal coliform or *E. coli,* the SCDOT will comply with these TMDLs and its applicable WLA to the MEP as required by its MS4 permit.
8. Expressed as *E. coli* (MPN/day). Loadings are developed by applying a conversion factor to values calculated for FC bacteria. This conversion is derived from an established relationship between FC bacteria and *E. coli* water quality standards in freshwaters.

Table 16 indicates the percentage reduction or water quality standard required for each watershed (or reach) in the JCT 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 FC bacteria or *E. coli* prescribed load reductions must be targeted from all sources, including NPDES permitted and nonpoint sources.

Based on the available information at this time, the portions of the JCT Watershed that drain directly to a regulated MS4 and that drain 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, the regulated MS4 is assigned the same percent reduction as the non-regulated sources in the watershed. Compliance with the MS4 permit in regards to this TMDL development 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 development document.

6.0 IMPLEMENTATION

The implementation of both point (i.e., WLA) and non-point (i.e., LA) source components of the TMDLs are necessary to bring about the required reductions in FC bacteria or *E. coli* loading to Jeffries Creek and tributaries in order to achieve water quality standards. Using existing authorities and mechanisms, an implementation plan providing information on how point and non point sources of pollution are being abated or may be abated in order 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 development document. As the implementation strategy progresses, the 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 *CWA's* primary point source control program is the NPDES. Point sources can be broken down into continuous and non-continuous point sources. Some examples of a continuous point source are WWTFs and industrial facilities. Non-continuous point sources are related to stormwater and include MS4, construction activities, etc. Current and future NPDES discharges in the referenced watersheds are required to comply with the load reductions prescribed in the 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 JCT Watershed are subject to the LA and not the WLA of the TMDL development 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 JCT Watershed would be the establishment and administration of a program of BMPs. BMPs 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 FC bacteria or *E. coli* loading to Jeffries Creek and tributaries. TMDL implementation projects are given highest priority for 319 funding. *CWA* §319 grants are not available for implementation of the WLA component of this TMDL but may be available for the LA component within permitted MS4

jurisdictional boundaries. Additional resources are provided in Section 7.0 of this TMDL development document.

The SCDHEC will also work with the existing agencies in the area to provide nonpoint source education in the JCT Watershed. Local sources of nonpoint source education and assistance include the Natural Resource Conservation Service (NRCS), the Barnwell, Bamberg, and Colleton County Soil and Water Conservation Services, the Clemson University Cooperative Extension Service, and the South Carolina Department of Natural Resources.

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

6.1 Implementation Strategies

The strategies presented in this document for implementation of the referenced TMDLs 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 for the referenced watersheds while demonstrating consistency with the assumptions and requirements of the TMDLs. Application of certain strategies provided within may be voluntary and are not a substitute for actual NPDES permit conditions.

6.1.1 Continuous Point Sources

Continuous point source WLA reductions will be implemented through NPDES permits. Existing and 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 TMDLs. FC Loadings are developed based upon permitted flow and an allowable permitted maximum concentration of 400 cfu/100 mL. *E. coli* loadings are developed based upon permitted flow and an allowable permitted maximum *E. coli* concentration of 349 MPN/100 mL.

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 SWMP or any other plan is TMDL and watershed specific. Hence, it is expected that NPDES permit holders 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 staff (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 C which provides additional information as it relates to evaluating the effectiveness of an MS4 Permit as it related to compliance with approved TMDLs. For the SCDOT, existing and future NPDES MS4 permittees, compliance with terms and conditions of its NPDES permit is effective implementation of the WLA to the MEP and demonstrates consistency with the assumptions and requirements of the TMDLs. 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 these TMDLs 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 TMDLs by MS4s is expected to take one or more permit iteration. Achieving the WLA reduction for the TMDLs 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 criterion depending on the type of NPDES MS4 permit that applies. 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 web sites, 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. These discharges enter 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 USEPA 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 for instance. If not already in place, an ordinance prohibiting non-stormwater discharges into a MS4 with appropriate enforcement procedures may also 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: http://www.scdhec.com/environment/ocrm/pubs/docs/SW/BMP_Handbook/Erosion_prevention.pdf

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/good housekeeping is also a key element of stormwater management programs. Generally this requires the MS4 entity to examine and alter their programs or activities to ensure reductions in pollution are occurring. It is recommended that a plan be developed to prevent or reduce pollutant runoff from municipal operations into the storm sewer system and it is encouraged to include employee training on how to incorporate and document pollution prevention/good housekeeping techniques. To minimize duplication of effort and conserve resources, the MS4 operator can use training materials that are available from the USEPA or relevant organizations (USEPA, 2005).

MS4 communities are encouraged to utilize partnerships when developing and implementing a stormwater management program. Watershed associations, educational organizations, and state, county, and city governments are all examples of possible partners with resources that can be shared. For additional information on partnerships contact the SCDHEC Watershed Manager for the waterbody of concern online at: http://www.scdhec.gov/HomeAndEnvironment/Water/Watersheds/Contacts/ For additional information on stormwater discharges associated with MS4 entities please see the SCDHEC's NPDES web page online at http://www.scdhec.gov/environment/water/swnpdes.htm as well as the USEPA NPDES website online at http://cfpub.epa.gov/npdes/home.cfm?program_id=6 for information pertaining to the National Menu of BMPs, Urban BMP Performance Tool, Outreach Documents, etc.

Clemson Carolina Clear and the Florence Darlington Stormwater Consortium are currently two organizations working cooperatively with regulated MS4s in the JCT watershed to address permit requirements and reduce FC bacteria or *E. coli* loadings from non-continuous point sources.

6.1.3 Wildlife

Suggested forms of implementation for wildlife will vary widely due to geographic location and species. There are many forms of acceptable wildlife BMPs in practice and development at the present time. For example, contiguous forested areas could be set up and managed to keep wildlife from bedding down and defecating near surface waters. This management practice relies on concentrating wildlife away from water bodies to minimize their impact to pollutant loading. Additionally, contributions from wildlife could be reduced in protected areas by developing a management plan which would allow hunting access during certain seasons. Although this strategy might not work in all situations, it would decrease FC bacteria or *E. coli* loading from wildlife in areas where wildlife may be a significant contributor to the overall watershed. According to the 2011 NLCD, the Jeffries Creek Watershed is 48.87 percent forest or otherwise vegetated (non-cultivated); and, the Willow Creek Watershed is 70.99 percent forest or otherwise vegetated (non-cultivated). On October 29th and November 19th in 2015, and on January 7th and 11th in 2016, the SCDHEC conducted site visits in the JCT Watershed to assess pollutant sources potentially contributing to water quality impairment in the watershed. All potential pollutant sources in the watershed found during the 2015 and 2016 site visits are identified in Tables Ap-1 through Ap-6 (see Appendix E). During the potential pollutant source assessment visits, the department found evidence of wild game in the Jeffries Creek Watershed. This was evidenced by the presence of hunt clubs in Reach 1 of the watershed (Figures F-1 and F-2).

According to the SCDNR 2008 study, the estimated population of deer in Darlington and Florence Counties in the areas of the JCT Watershed range from less than fifteen (15) deer per square mile to thirty (30) to forty-five (45) deer per square mile (see Section 3.2.1 of this TMDL development document) (SCDNR 2008). While the SCDHEC did not find any actual deer in the JCT Watershed during the 2015 and 2016 potential pollutant source assessment visits, the evidence of their presence was ample throughout the watershed in the form of deer stands. Deer stands were found in both the Jeffries Creek Watershed and in the Willow Creek Watershed (e.g., Figures F-3, F-4, F-5, and F-6).

Deterrents may also be used to keep wildlife away from docks and lawns in close proximity to surface waters. Non-toxic spray deterrents, decoys, eagles, kites, noisemakers, scarecrows, and plastic owls are a

sample of what is currently available. During the SCDHEC's potential pollutant source assessment visits in 2015 and 2016, the department found waterfowl the JCT Watershed. Ducks in ponds were found in both the Jeffries Creek Watershed and in the Willow Creek Watershed (e.g., Figures F-7, F-8, F-9, and F-10). Many waterfowl species are deterred by foreign objects on lawns and the planting of a shrub buffer along greenways adjacent to impoundments may also be effective.

In addition, homeowners and the hunting community should be educated on the impacts of feeding wildlife or planting wildlife food plots in close proximity to surface waters. Please check local and federal laws before applying deterrents or harassing wildlife. Additional information may be obtained from the "Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water" bulletin provided by the USEPA (2001).

6.1.4 Agricultural Activities

Suggested forms of implementation for agricultural activities will vary based on the activity of concern. 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. Therefore, for BMPs to be effective, the transport mechanism of the pollutant, FC bacteria or *E. coli,* needs to be identified. For livestock in the referenced watersheds, 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. During the potential pollutant source assessment visits in 2015 and 2016, the SCDHEC found several cattle pastures throughout the JCT Watershed (e.g., Figures F-11, F-12, F-13, and F-14).

During the potential pollutant source assessment visits in 2015 and 2016, the SCDHEC also found numerous hobby farms within the JCT Watershed. Horses were found throughout the JCT Watershed (e.g., Figures F-15, F-16, F-17, and F-18). A donkey was found in the Willow Creek Watershed, and a pony was found in Reach 6 of the Jeffries Creek Watershed (Figures F-19 and F-20). Hogs were found in the Willow Creek Watershed ((Figures F-21 and F-22). Goats were found in Reach 3 and Reach 5 of the Jeffries Creek Watershed, and in the Willow Creek Watershed (e.g., Figure F-23, F-24, and F-25). And, chickens were found in Reach 5 of the Jeffries Creek Watershed, and in the Willow Creek Watershed (e.g., Figure F-26 and F-27).

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% (ASABE 1997). An indirect result of this was a 77% reduction in stream bank erosion by providing an alternative to accessing the stream directly for water supply.

For row crop farms in the referenced watersheds, many common practices exist to reduce FC bacteria or *E. coli* contributions. Unstabilized soil directly adjacent to surface waters can contribute to FC bacteria or *E. coli* loading during periods of runoff after rain events. Agricultural field borders and filter strips (vegetative buffers) can provide erosion control around the border of planted crop fields. These borders can provide food for wildlife, may possibly be harvested (grass and legume), and also provide an area where farmers can turn around their equipment (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 runoff concentrations from 2.0E+7 to an immeasurable amount once filtered through the buffer. A buffer of this width was also shown to reduce phosphorous and nitrogen concentrations by 75%.

The agricultural BMPs listed above are 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 JCT Watershed. Education should be provided to local farmers on these methods as well as acceptable manure spreading and holding (stacking sheds) practices.

For additional information on accepted agricultural BMPs you can obtain a copy of the "Farming for Clean Water in South Carolina" handbook by contacting Clemson University Cooperative Extension Service at

(864) 656-1550. In addition, Clemson Extension Service offers a 'Farm-A-Syst' package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. You can access Farm-A-Syst by going onto the Clemson Extension Service website: http://www.clemson.edu/waterquality/FARM.HTM.

NRCS provides financial and technical assistance to help South Carolina landowners address natural resource concerns, promote environmental quality, and protect wildlife habitat on property they own or control. The cost-share funds are available through the 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. EQIP also assists eligible small-scale farmers who have historically not participated in or ranked high enough to be funded in previous sign ups. Please visit www.sc.nrcs.usda.gov/programs/ for more information, including eligibility requirements.

Also available through NRCS, the Grassland Reserve Program (GRP) is a voluntary program offering landowners the opportunity to protect, restore and enhance grasslands on their property. NRCS and the Farm Service Agency (FSA) coordinate implementation of the GRP, which helps landowners restore and protect grassland, rangeland, pastureland, shrubland and certain other lands and provides assistance for rehabilitating grasslands. The program will conserve vulnerable grasslands from conversion to cropland or other uses and conserve valuable grasslands by helping maintain viable grazing operations. A grazing management plan is required for participants. NRCS has further information on their website for the GRP as well as additional programs such as the Conservation Reserve Program, Conservation Security Program, Farm and Ranch Lands Protection Program, etc. You can visit the NRCS website by going to: www.sc.nrcs.usda.gov/programs/.

6.1.5 Leaking Sanitary Sewers and Illicit Discharges

Leaking sanitary sewers and illicit discharges, although illegal and subject to enforcement, may be occurring in regulated or unregulated portions of the JCT Watershed at any time. 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.

The SCDHEC recognizes illicit discharge detection and elimination activities are conducted by regulated MS4 entities as 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 the SCDHEC to work with the MS4 entities to recognize FC bacteria or *E. coli* load reductions as they are achieved. The 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, the 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 water 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 wells, groundwater, and surface water bodies, where people get their drinking water and recreate. Pumping a septic tank is probably the single most important thing that can be done to protect the system. If the buildup of solids in the tanks becomes too high and solids move to the drainfield, this could clog and strain the system to the point where a new drainfield will be needed.

The SCDHEC's Office of Coastal Resource Management (OCRM) has created a toolkit for homeowners and local governments which includes tips for maintaining septic systems. These septic system Do's and Don'ts's are as follows:

Do's:

- Conserve water to reduce the amount of wastewater that must be treated and disposed of by your system. Doing laundry over several days will put less stress on your system.
- Repair any leaking faucets or toilets. To detect toilet leaks, add several drops of food dye to the toilet tank and see if dye ends up in the bowl.
- Divert down spouts and other surface water away from your drainfield. Excessive water keeps the soil from adequately cleansing the wastewater.
- Have your septic tank inspected yearly and pumped regularly by a licensed septic tank contractor.

Don'ts:

- Don't drive over your drainfield or compact the soil in any way.
- Don't dig in your drainfield or build anything over it, and don't cover it with a hard surface such as concrete or asphalt.
- Don't plant anything over or near the drainfield except grass. Roots from nearby trees and shrubs may clog and damage the drain lines.
- Don't use your toilet as a trash can or poison your system and the groundwater by pouring harmful chemicals and cleansers down the drain. Harsh chemicals can kill the bacteria that help purify your wastewater.

For additional information on how septic systems work, how to properly plan and maintain a septic system, or to link to the OCRM toolkit mentioned above, please visit the SCDHEC Environmental Health Onsite Wastewater page at the following link: http://www.scdhec.gov/health/envhlth/onsite_wastewater/septic_tank.htm

6.1.7 Urban Runoff

Urban runoff is surface runoff of rainwater created by urbanization outside of regulated areas which may pick up and carry pollutants to receiving waters. Pavement, compacted areas, roofs, reduced tree canopy and open space increase runoff volumes that rapidly flow into receiving waters. This increase in volume and velocity of runoff often causes stream bank erosion, channel incision and sediment deposition in stream channels. In addition, runoff from these developed areas can increase stream temperatures that along with the increase in flow rate and pollutant loads negatively affect water quality and aquatic life (USEPA 2005). This runoff can pick up FC bacteria or *E. coli* along the way. Many strategies currently exist to reduce FC loading from urban runoff and the USEPA nonpoint source pollution website provides extensive resources on this subject, which can be accessed online at: http://www.epa.gov/nps/urban.html.

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).

Some additional urban BMPs that can be adopted in public parks are doggy dooleys and pooch patches. Doggy dooleys are disposal units, which act like septic systems for pet waste, and are installed in the

ground where decomposition can occur (USEPA, 2001). This requires that pet owners place the waste into the disposal units. During the SCDHEC potential pollutant source assessment visits in 2015 and 2016, unattended dogs were found throughout the JCT Watershed (e.g., Figures F-28, F-29, F-30, and F-31).

Although the JCT Watershed is primarily rural in nature, many of the urban runoff practices discussed in this section can be applied to individual households in the watersheds. Education should be provided to individual homeowners in the referenced watersheds on the contributions to FC bacteria or *E. coli* 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 Runoff Pollution homepage at http://www.scdhec.gov/environment/water/npspage.htm.

Clemson Extension's Home-A-Syst handbook can also help homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment of their property and can be accessed online at: http://www.clemson.edu/waterquality/HOMASYS.HTM

Some organizations currently supporting with educational/outreach activities to reduce FC bacteria or *E. coli* loadings from urban runoff within the Jefferies Creek Watershed are Clemson University Carolina Clear and the Florence/Darlington Stormwater Consortium and Keep Florence Beautiful. In addition, the Lucas Park Homeowner's Association and Timrod Park Neighborhood Association are cooperators for the ongoing Lucas and Timrod Park Restoration Project, which is currently underway.

7.0 RESOURCES FOR POLLUTION MANAGEMENT

This section provides a listing of available resources to aid in the mitigation and control of pollutants. There are examples from across the nation, most of which are easily accessible on the world wide web.

7.1 General for Urban and Suburban Stormwater Mitigation

- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft. 2002. EPA842-B-02-003. Available at: http://www.epa.gov/owow/nps/urbanmm/index.html
- Stormwater Management Volume Two: Stormwater Technical Manual. Massachusetts Department of Environmental Management. 1997. Available at: http://www.mass.gov/dep/brp/stormwtr/stormpub.htm
- Fact Sheets for the six (6) minimum control measures for storm sewers regulated under Phase I or Phase II. Available at: http://cfpub1.epa.gov/npdes/stormwater/swfinal.cfm?program_id=6
- A Current Assessment of Urban Best Management Practices. 1992. Metropolitan Washington Council of Governments. Washington, DC
- Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. 1987. Metropolitan Washington Council of Governments. Washington, DC
- 2004 Stormwater Quality Manual. Connecticut Department of Environmental Protection 2004. Available at: http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm
- Stormwater Treatment BMP New Technology Report. California Department of Transportation. 2004. SW-04-069-.04.02 Available at: http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-04-069.pdf

- Moonlight Beach Urban Runoff Treatment facility: Using Ultraviolet Disinfection to Reduce Bacteria Counts. Rasmus, J. and K. Weldon. 2003. StormWater, May/June 2003. Available at http://www.forester.net/sw_0305_moonlight.html
- Operation, Maintenance, and Management of Stormwater Management Systems. Livingston, Shaver, Skupien, and Horner. August 1997. Watershed Management Institute. Call: (850) 926-5310.
- Model Ordinances to Protect Local Resources – Stormwater Control Operation and Maintenance. USEPA Webpage: http://www.epa.gov/owow/nps/ordinance/stormwater.htm
- Stormwater O & M Fact Sheet Preventive Maintenance. USEPA 1999. 832-F-99-004. Available at: http://www.epa.gov/owm/mtb/prevmain.pdf
- The MassHighway Stormwater Handbook. Massachusetts Highway Department. 2004. Available at: http://166.90.180.162/mhd/downloads/projDev/swbook.pdf
- University of New Hampshire Stormwater Center: Dedicated to the protection of water resources through effective stormwater management. Available at: http://www.unh.edu/erg/cstev/index.htm#
- USEPA's Stormwater website: http://www.epa.gov/region1/topics/water/stormwater.html

7.2 Illicit Discharges

- Illicit Discharge Detection and Elimination Manual - A Handbook for Municipalities. 2003. New England Interstate Water Pollution Control Commission. Available at: http://www.neiwpcc.org/PDF_Docs/iddmanual.pdf
- Model Ordinances to Protect Local Resources – Illicit Discharges. USEPA webpage: http://www.epa.gov/owow/nps/ordinance/discharges.htm

7.3 Pet Waste

- National Management Measure to Control Non Point Source Pollution from Urban Areas – Draft. USEPA 2002. EPA 842-B-02-2003. Available from: http://www.epa.gov/owow/nps/urbanmm/index.html
- Septic Systems for Dogs? Nonpoint Source News-Notes 63. Pet Waste: Dealing with a Real Problem in Suburbia. Kemper, J. 2000. New Jersey Department of Environmental Protection. Available from: http://www.state.nj.us/dep/watershedmgt/pet_waste_fredk.htm
- Stormwater Manager's Resource Center. Schueler, T., Center for Watershed Protection, Inc. http://www.stormwatercenter.net
- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA, Office of Water 1993. Washington, DC.
- National Menu of Best Management Practices for Stormwater Phase II. USEPA. 2002. Available at: http://www.epa.gov/npdes/menuofbmps/menu.htm
- Welcome to NVRC'S Four Mile Run Program. NVRC 2001. Available at: http://www.novaregion.org/fourmilerun.htm

- Boston's ordinance on dog waste. City of Boston Municipal Codes, Chapter XVI. 16-1.10A Dog Fouling. Available at: http://www.amlegal.com/boston_ma/

- Pet Waste and Water Quality. Hill, J.A., and D. Johnson. 1994. University of Wisconsin Extension Service. http://cecommerce.uwex.edu/pdfs/GWQ006.PDF

- Long Island Sound Study. Pet Waste Poster. USEPA. Available at: http://www.longislandsoundstudy.net/pubs/misc/pet.html

- Source Water Protection Practices Bulletin: Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. USEPA. 2001. EPA 916-F-01-027. Available at: http://www.epa.gov/safewater/protect/pdfs/petwaste.pdf

7.4 Wildlife

- An example of a bylaw prohibiting the feeding of wildlife: Prohibiting Feeding of Wildlife. Town of Bourne Bylaws Section 3.4.3. Available at: http://www.townofbourne.com/Town%20Offices/Bylaws/chapter__3.htm

- Integrated Management of Urban Canadian Geese. M Underhill. 1999. Conference Proceedings, Waterfowl Information Network.

- Urban Canadian Geese in Missouri. Missouri Conservationist Online. Available at: http://www.conservation.state.mo.us/conmag/2004/02/20.htm

7.5 Septic Systems

- National Management Measures to Control Nonpoint Source Pollution from Urban Areas – Draft. Chapter 6. New and Existing Onsite Wastewater Treatment Systems. USEPA 2002. EPA842-B-02-003. Available at: http://www.epa.gov/owow/nps/urbanmm/index.html

- Septic Systems. USEPA Webpage: http://cfpub.epa.gov/owm/septic/home.cfm

7.6 Field Application of Manure

- Conservation Standard Practice-Irrigation Water Management. Number 449. United States Department of Agriculture (USDA) Natural Resources Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html

- Conservation Standard Practice-Filter Strip. Number 393. USDA Natural Resources Conservation Service (NRCS). 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html

- Buffer Strips: Common Sense Conservation. USDA Natural Resource Conservations Service. No Date. Website. Available at: http://www.nrcs.usda.gov/feature/buffers/

- Conservation Standard Practice-Riparian Forest Buffer. Number 391. USDA Natural Resource Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html

- Conservation Standard Practice-Riparian Herbaceous Cover. Number 390 USDA Natural Resource Conservation Service. 2003. Available at:

http://www.nrcs.usda.gov/technical/Standards/nhcp.html

7.7 Grazing Management

- Conservation Standard Practice-Stream Crossing. Number 578. USDA Natural Resource Conservation Service. 2003. Available at: http://www.nrcs.usda.gov/technical/Standards/nhcp.html
- Guidance Specifying Management Measures for Nonpoint Source Pollution in Coastal Waters. Chapter 2. Management Measures for Agricultural Sources. Grazing Management. USEPA. Available at: http://www.epa.gov/owow/nps/MMGI/Chapter2/ch2-2e.html

7.8 Animal Feeding Operations and Barnyards

- National Management Measures to Control Nonpoint Source Pollution from Agriculture. USEPA 2003. Report: EPA 841-B-03-004. Available at: http://www.epa.gov/owow/nps/agmm/index.html
- Livestock Manure Storage. Software designed to asses the threat to ground and surface water from manure storage facilities. USEPA. Available at: http://www.epa.gov/seahome/manure.html
- National Engineering Handbook Part 651. Agricultural Waste Management Field Handbook. NRCS. Available At: http://www.wcc.nrcs.usda.gov/awm/awmfh.html
- Animal Waste Management. NRCS website: http://www.wcc.nrcs.usda.gov/awm/
- Animal Waste Management Software. A tool for estimating waste production and storage requirements. Available at: http://www.wcc.nrcs.usda.gov/awm/awm.html
- Manure Management Planner. Software for creating manure management plans. Available at: http://www.agry.purdue.edu/mmp/
- Animal Feeding Operations Virtual Information Center. USEPA website: http://cfpub.epa.gov/npdes/afo/virtualcenter.cfm

7.9 Federal Agriculture Resources: Program Overviews, Technical Assistance, and Funding

- USDA-NRCS assists landowners with planning for the conservation of soil, water, and natural resources. Local, state, and federal agencies and policymakers also rely on NRCS expertise. Cost shares and financial incentives are available in some cases. Most work is done with local partners. The NRCS is the largest funding source for agricultural improvements. To find out about potential funding, see: http://www.ma.nrcs.usda.gov/programs/. To pursue obtaining funding, contact a local NRCS coordinator. Contact information is available at: http://www.ma.nrcs.usda.gov/contact/employee_directory.html
- NRCS provides a wealth of information and BMP fact sheets tailored to agricultural and conservation practices through the NRCS Electronic Field Office Technical Guide at: http://efotg.nrcs.usda.gov/efotg_locator.aspx?map=SC
- The 2002 USDA Farm Bill (http://www.nrcs.usda.gov/programs/farmbill/2002/) provides a variety of programs related to conservation. Information can be found at:

http://www.nrcs.usda.gov/programs/farmbill/2002/products.html. The following programs can be linked to from the USDA Farm Bill website:

- Conservation Security Program (CSP): http://www.nrcs.usda.gov/programs/csp/
- Conservation Reserve Program (CRP): http://www.nrcs.usda.gov/programs/crp/
- Wetlands Reserve Program (WRP): http://www.nrcs.usda.gov/programs/wrp/
- Environmental Quality Incentives Program (EQIP): http://www.nrcs.usda.gov/programs/eqip/
- Grassland Reserve Program (GRP): http://www.nrcs.usda.gov/programs/GRP/
- Conservation of Private Grazing Land Program (CPGL): http://www.nrcs.usda.gov/programs/cpgl/
- Wildlife Habitat Incentives Program (WHIP): http://www.nrcs.usda.gov/programs/whip/
- Farm and Ranch Land Protection Program (FRPP): http://www.nrcs.usda.gov/programs/frpp/
- Resource Conservation and Development Program (RC&D): http://www.nrcs.usda.gov/programs/rcd/

- CORE4 Conservation Practices. The common sense approach to natural resource conservation. USDA-NRCS (1999). This manual is intended to help USDA-NRCS personnel and other conservation and nonpoint source management professionals implement effective programs using four core conservation practices: conservation tillage, nutrient management, pest management, and conservation buffers, available at: http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf

- County soil survey maps are available from NRCS at: http://soils.usda.gov

- Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. USEPA, Office of Water (1993). Developed for use by State Coastal Nonpoint Pollution Control Programs, Chapter 2 of this document covers erosion control, animal feeding operation management, grazing practices, and management of nutrients, pesticides, and irrigation water, available at:: http://www.epa.gov/owow/nps/MMGI/Chapter2/index.html.

- Farm-A-Syst is a partnership between government agencies and private business that enables landowners to prevent pollution on farms, ranches, and in homes using confidential environmental assessments, available at: http://www.uwex.edu/farmasyst/

- State Environmental Laws Affecting South Carolina Agriculture: A comprehensive assessment of regulatory issues related to South Carolina agriculture has been compiled by the National Association of State Departments, available at: http://www.nasda-hq.org/nasda/nasda/Foundation/state/states.htm

- Waterborne Pathogens in Agricultural Wastewater. Rosen, B. H., 2000. USDA, NRCS, Watershed Science Institute. Available at: ftp://ftp-fc.sc.egov.usda.gov/WSI/pdffiles/Pathogens_in_Agricultural_Watersheds.pdf

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). 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.

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

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

CDC, n.d. *E. coli (Escherichia coli) General Information.* [Online] Available at: http://www.cdc.gov/ecoli/general/index.html [Accessed 17 April 2013].

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.

Nadakavukaren, A. 1995. Our Global Environment: A Health Perspective. Waveland Press, Inc. 4th ed. Prospect Heights, IL.

National Land Cover Data (NLCD) Set. 2006. Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, Vol. 77(9):858-864.

SCDHEC. 1998. Implementation Plan for Achieving Total Maximum Daily Load Reductions from Nonpoint Sources for the State of South Carolina.

SCDHEC. 2008. *Water Classifications and Standards* (Regulation 61-68). Bureau of Water. Columbia, SC

SCDHEC. 2012. Classified Waters (Regulation 61-69). Bureau of Water. Columbia, SC

South Carolina Department of Health and Environmental Control. Bureau of Water. 2014. State of South Carolina Section §303(d) List for 2014. http://www.scdhec.gov/HomeAndEnvironment/Docs/tmdl_14-303d.pdf

SCDHEC. 2002. *Standards for the Permitting of Agricultural Animal Facilities* (Regulation 61-43). Bureau of Water. Columbia, SC

SCDHEC. 2011. *Water Pollution Control Permits* (Regulation 61-9) Office of Environmental Quality Control, Columbia, SC.

SCDHEC. 2007. Watershed Water Quality Assessment: Pee Dee River Basin. Technical Report No. 005-07. Bureau of Water, Columbia, SC.

SCDNR. 1997. Farming for Clean Water in South Carolina.

SCDNR. 2008. Deer Density Map. http://www.dnr.sc.gov/wildlife/deer/deermap.html

Starr, C., Taggart, R. 1992. Biology: The Unity and Diversity of Life. Wadsworth Publishing Company, Inc. 6th ed. Belmont, CA.

Stormwater Program (Phase II); Municipal Sewer Systems and Construction Sites. 64 Federal Register 235 (8 December 1999), pp. 68837.

Tchobanoglous, G., Schroeder, E. D. 1987. Water Quality Characteristics Modeling and Modification. Volume I. Addison-Wesley Publishing Company, Inc. pp 768.

United States Department of Agriculture (USDA). 2014. Census of Agriculture. South Carolina. County Levels. Available at http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/South_Carolina/st45_2_011_011.pdf

United States Environmental Protection Agency (USEPA). 1983. Final Report of the Nationwide Urban Runoff Program, Vol 1. Water Planning Division, US Environmental Protection Agency, Washington, DC.

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 http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_petwaste.pdf

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

United States Environmental Protection Agency (USEPA), Region IV. 2005. Total Maximum Daily Loads for Fecal Coliform for Hills Creek, Lynches River, North and South Branch of Wildcat Creek, Flat Creek, Turkey Creek, Nasty Branch, Gulley Branch, Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp of the Pee Dee River Basin, South Carolina. SCDHEC Technical Report Number: 029-05.

US Geological Survey. 2007. Water-Resources Real-time Data South Carolina Water Year. United States Geological Survey. Available at http://waterdata.usgs.gov/nw

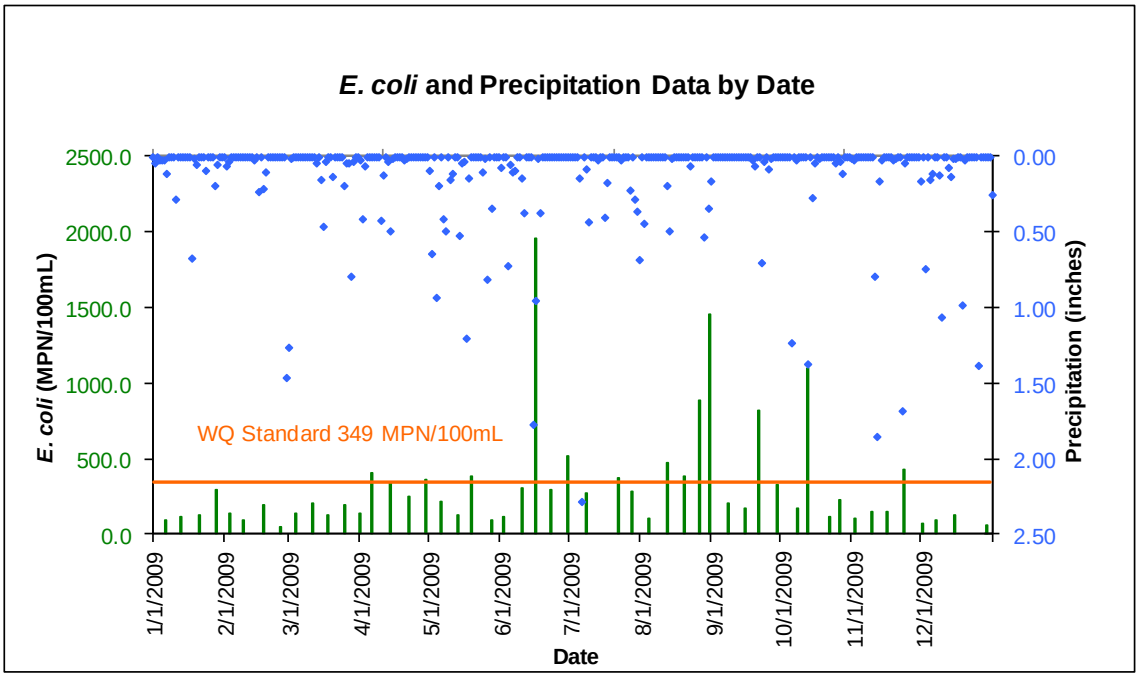
Water Quality Planning and Management, Title 40 Code of Federal Regulations, Pt. 130.2(i). 2006 ed.

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

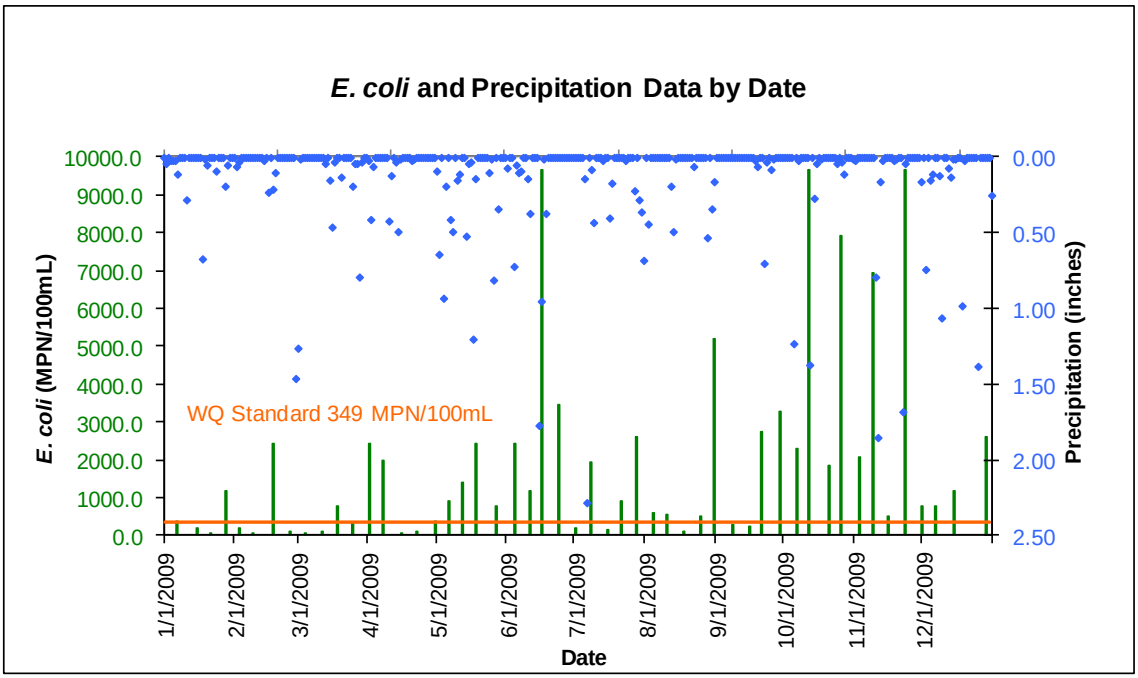
Yagow, G. 1999. Unpublished monitoring data. Mountain Run TMDL Study. Submitted to Virginia Department of Environmental Quality. Richmond, Virginia.

APPENDIX A
ADDITIONAL RAIN CHARTS BY STATION

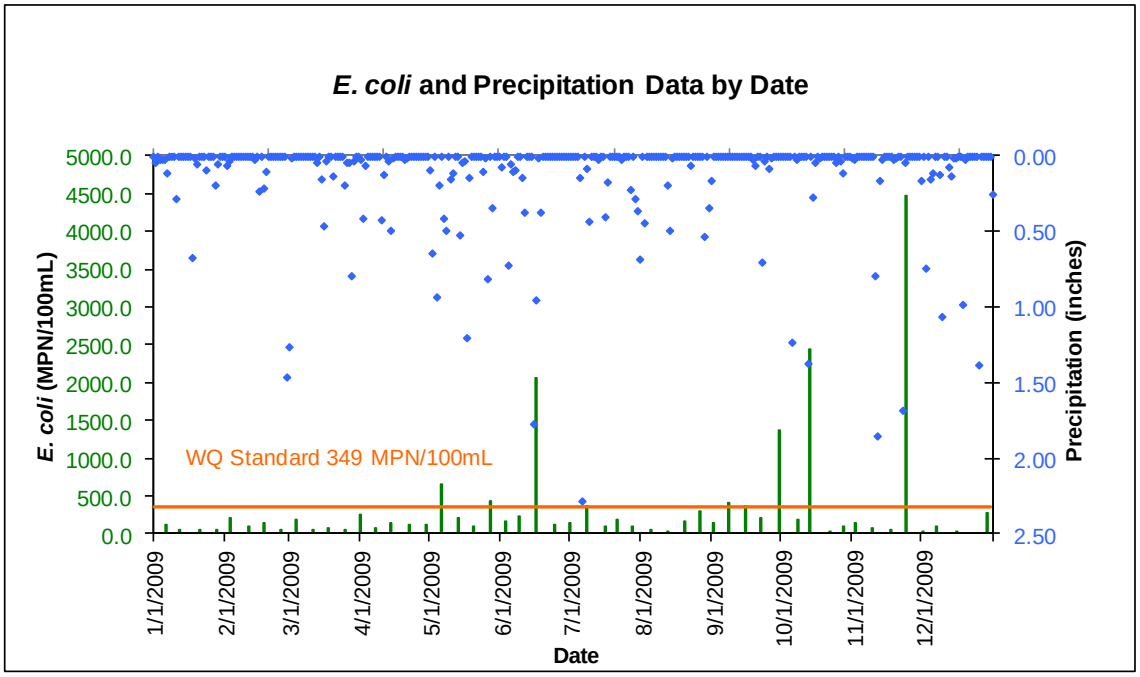
Precipitation and *E. coli* Data by Date for Monitoring Station PD-256



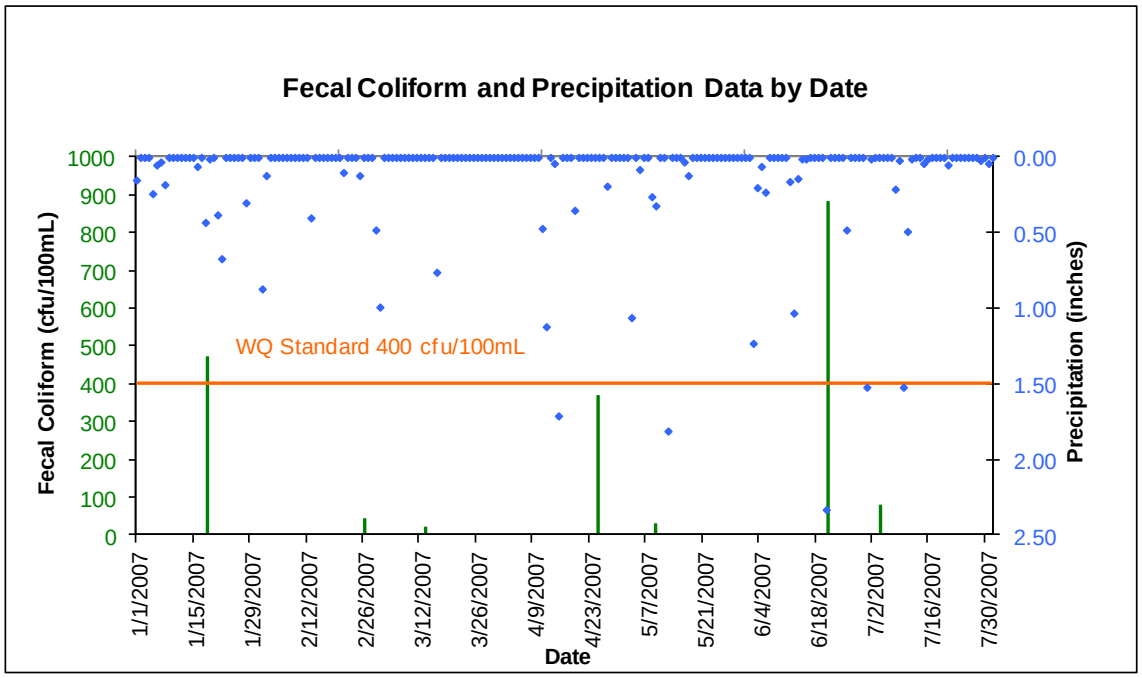
Precipitation and *E. coli* Data by Date for Monitoring Station PD-065



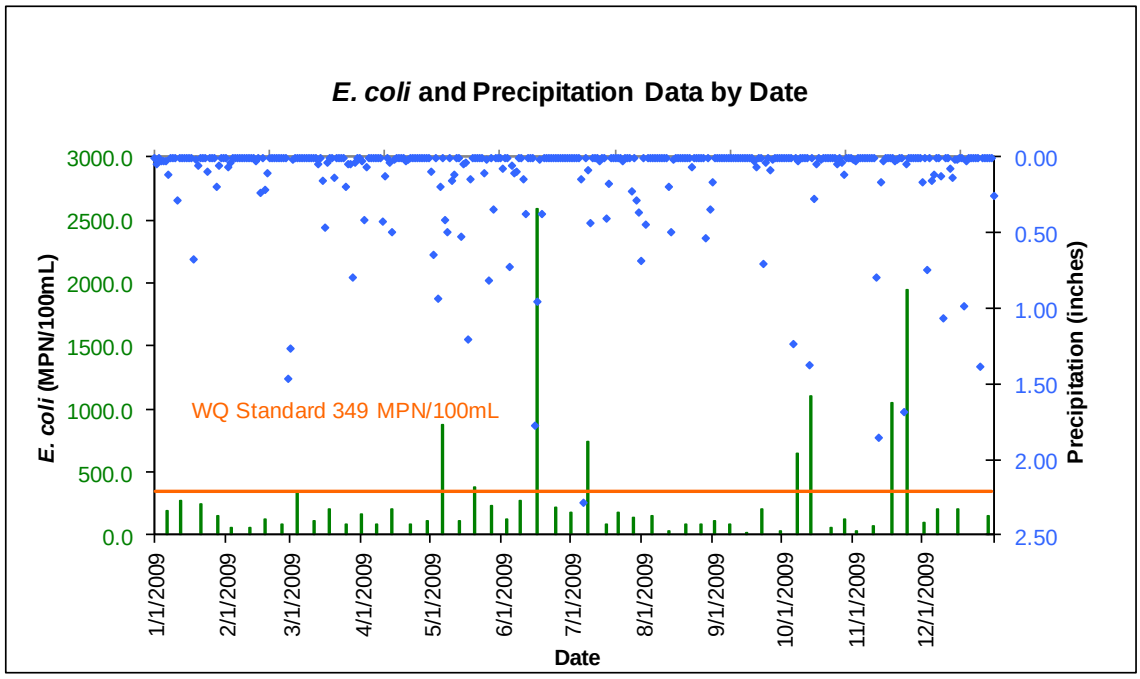
Precipitation and *E. coli* Data by Date for Monitoring Station PD-230



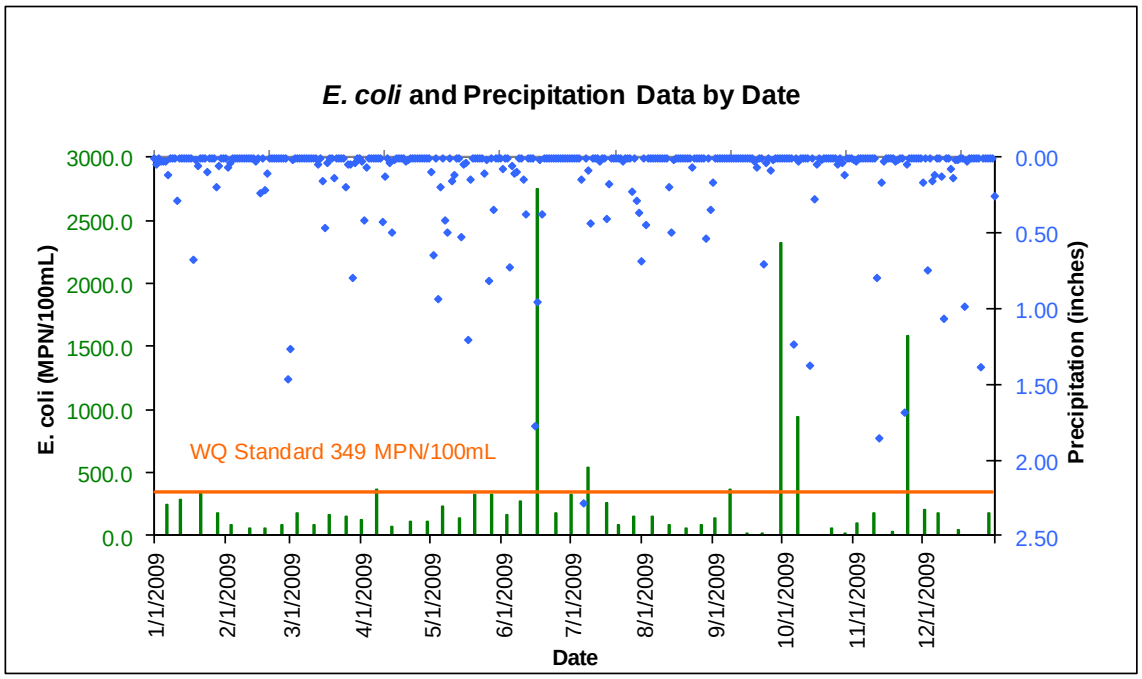
Precipitation and FC Data by Date for Monitoring Station RS-07205



Precipitation and *E. coli* Data by Date for Monitoring Station PD-035

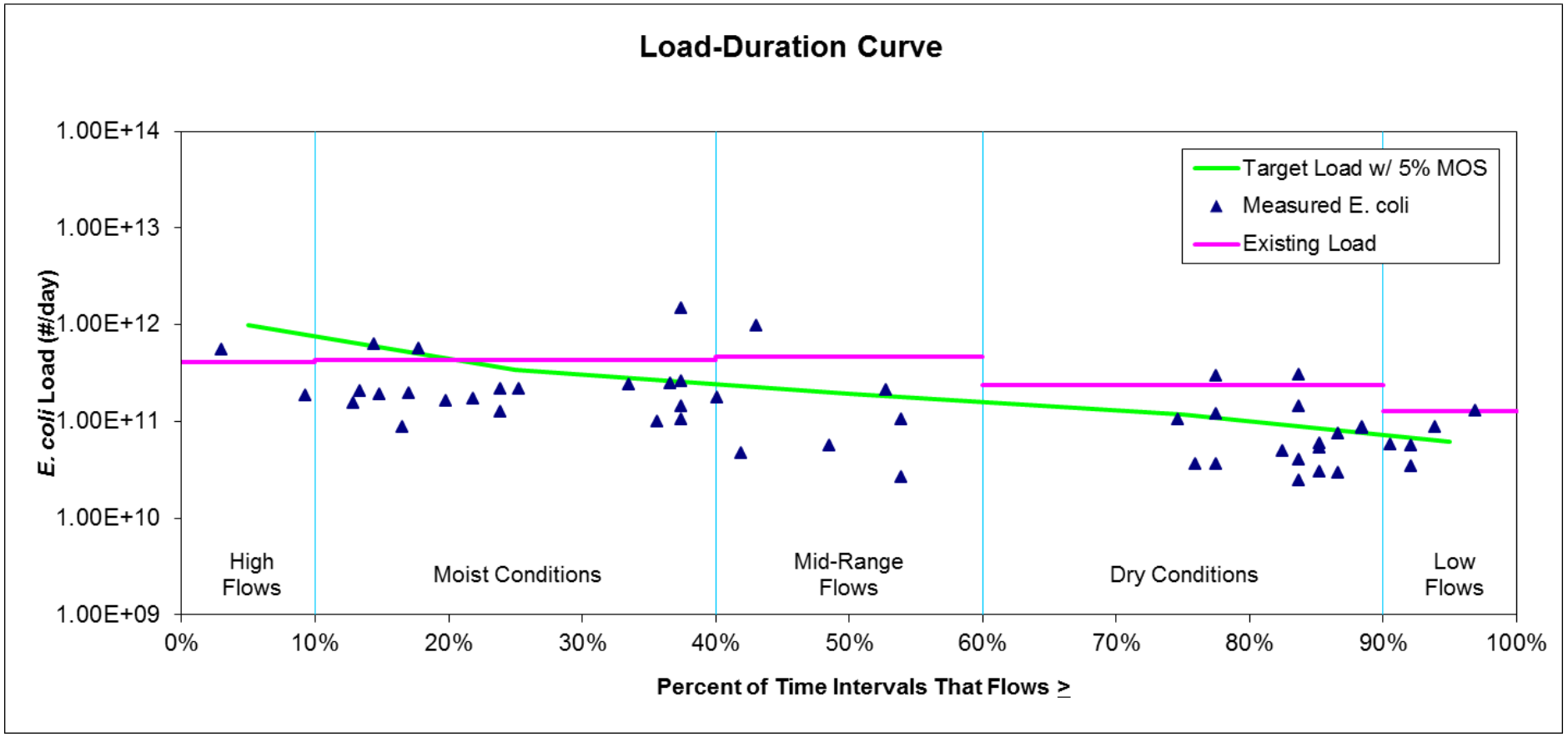


Precipitation and *E. coli* Data by Date for Monitoring Station PD-167

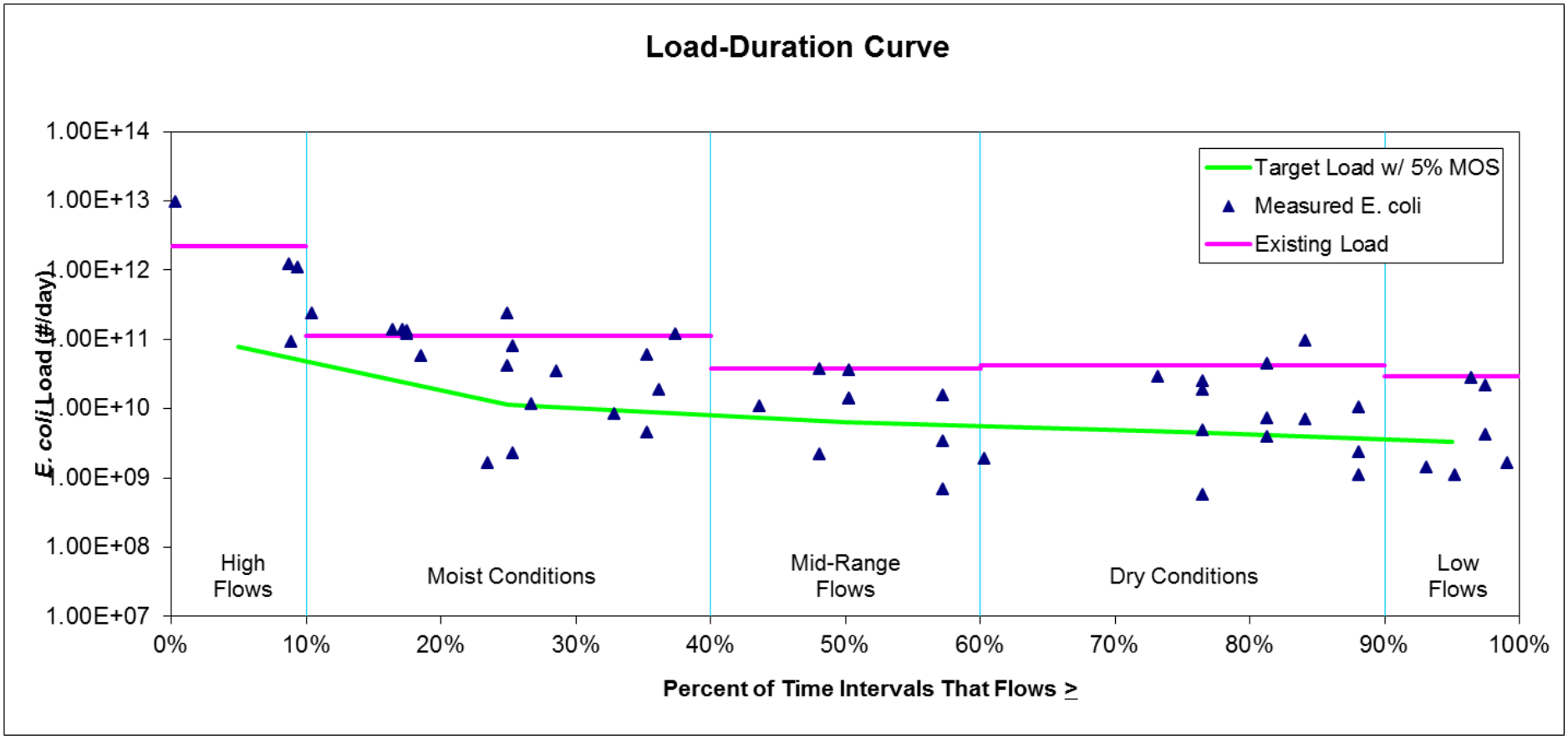


APPENDIX B
ADDITIONAL LOAD-DURATION CURVES BY STATION

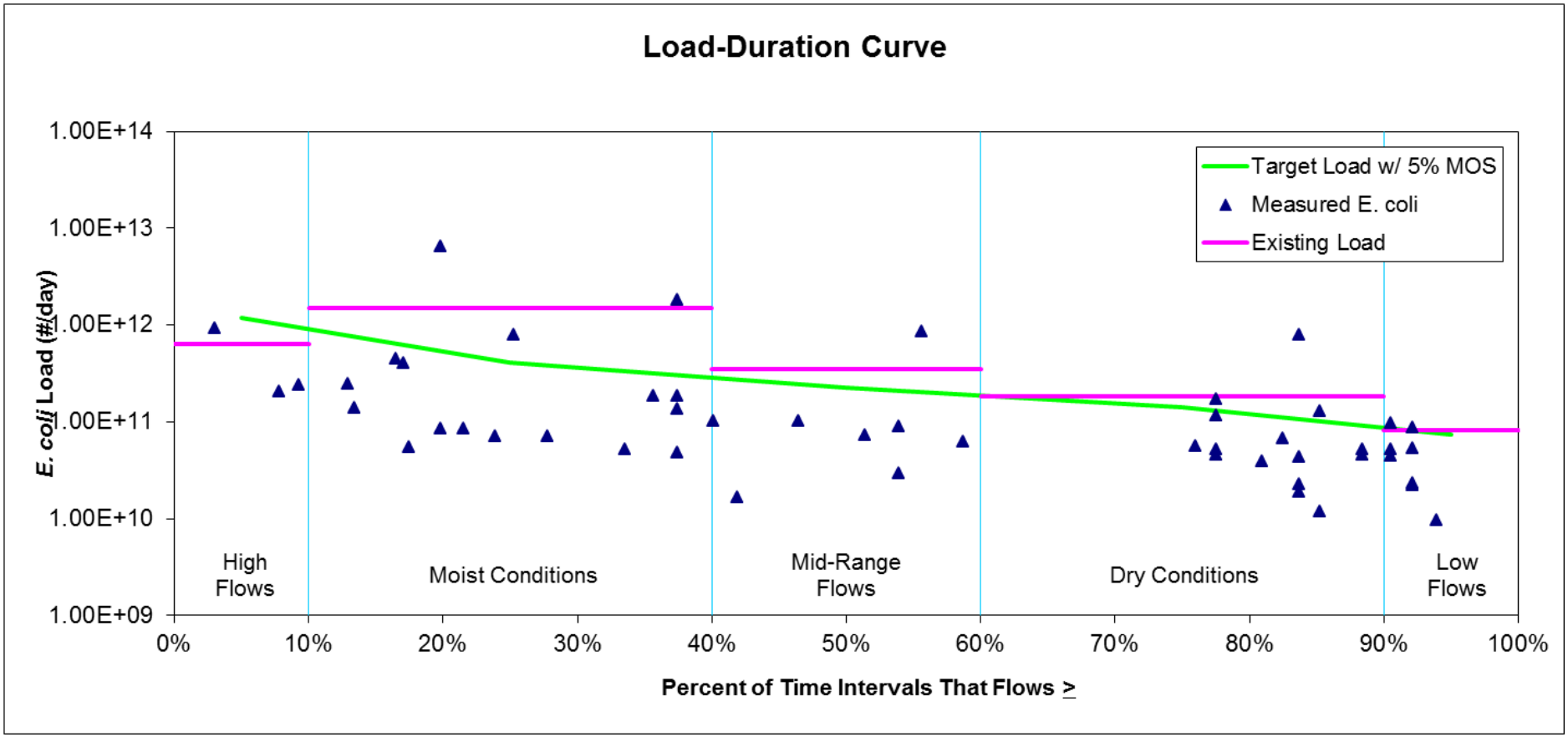
Load Duration Curve for Reach 1 of the Jeffries Creek Watershed, WQM Station PD-256



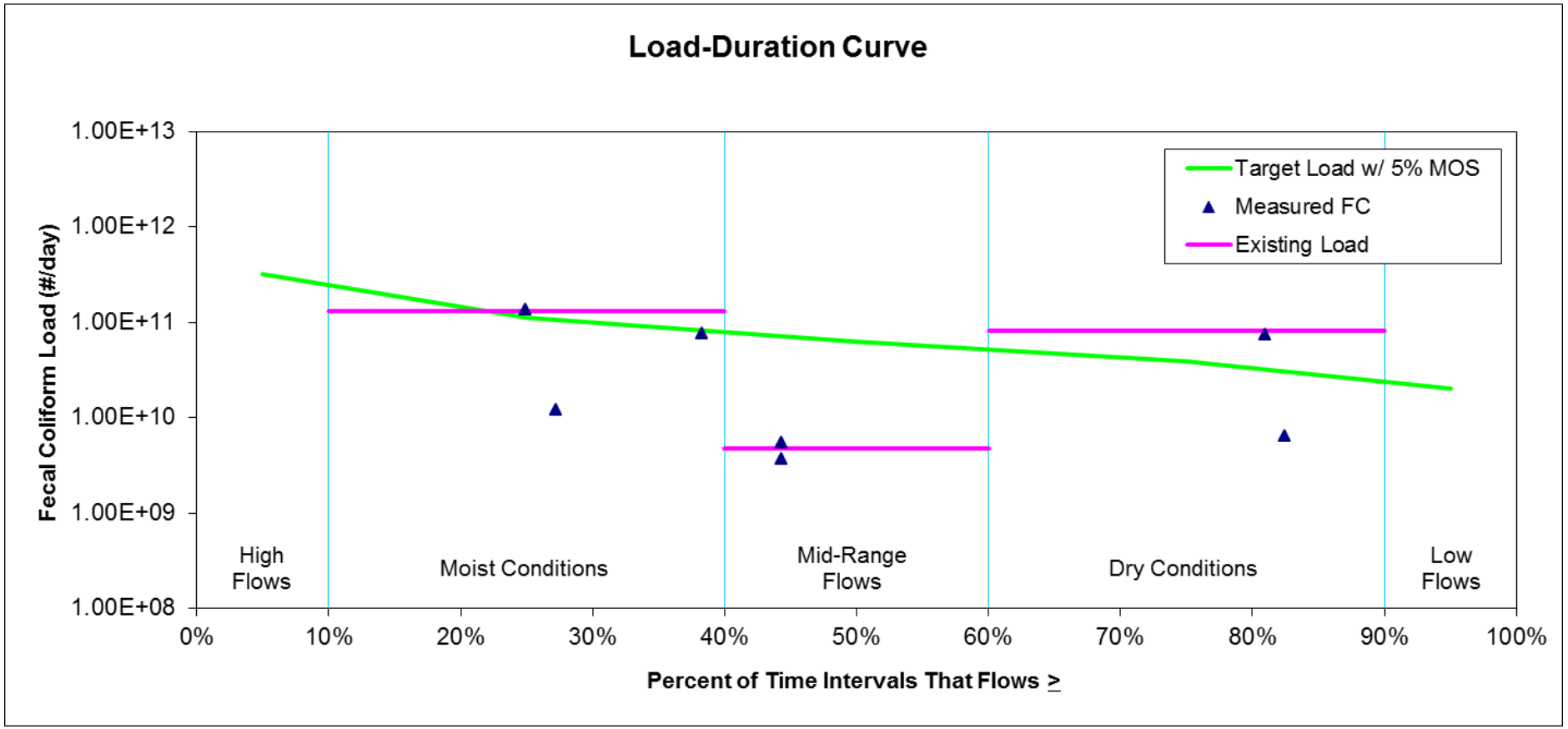
Load Duration Curve for Reach 2 of the Jeffries Creek Watershed, WQM Station PD-065



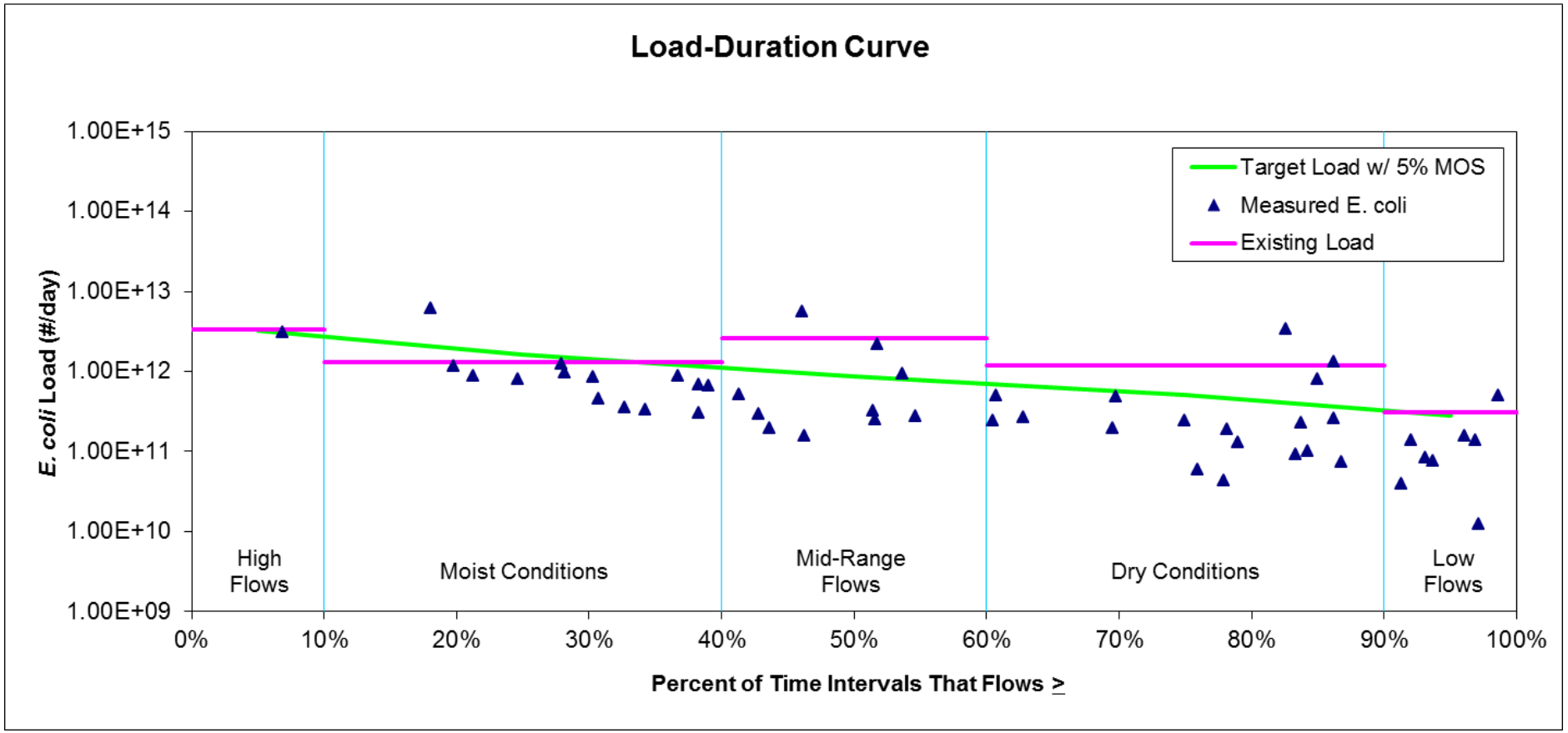
Load Duration Curve for Reach 3 of the Jeffries Creek Watershed, WQM Station PD-230



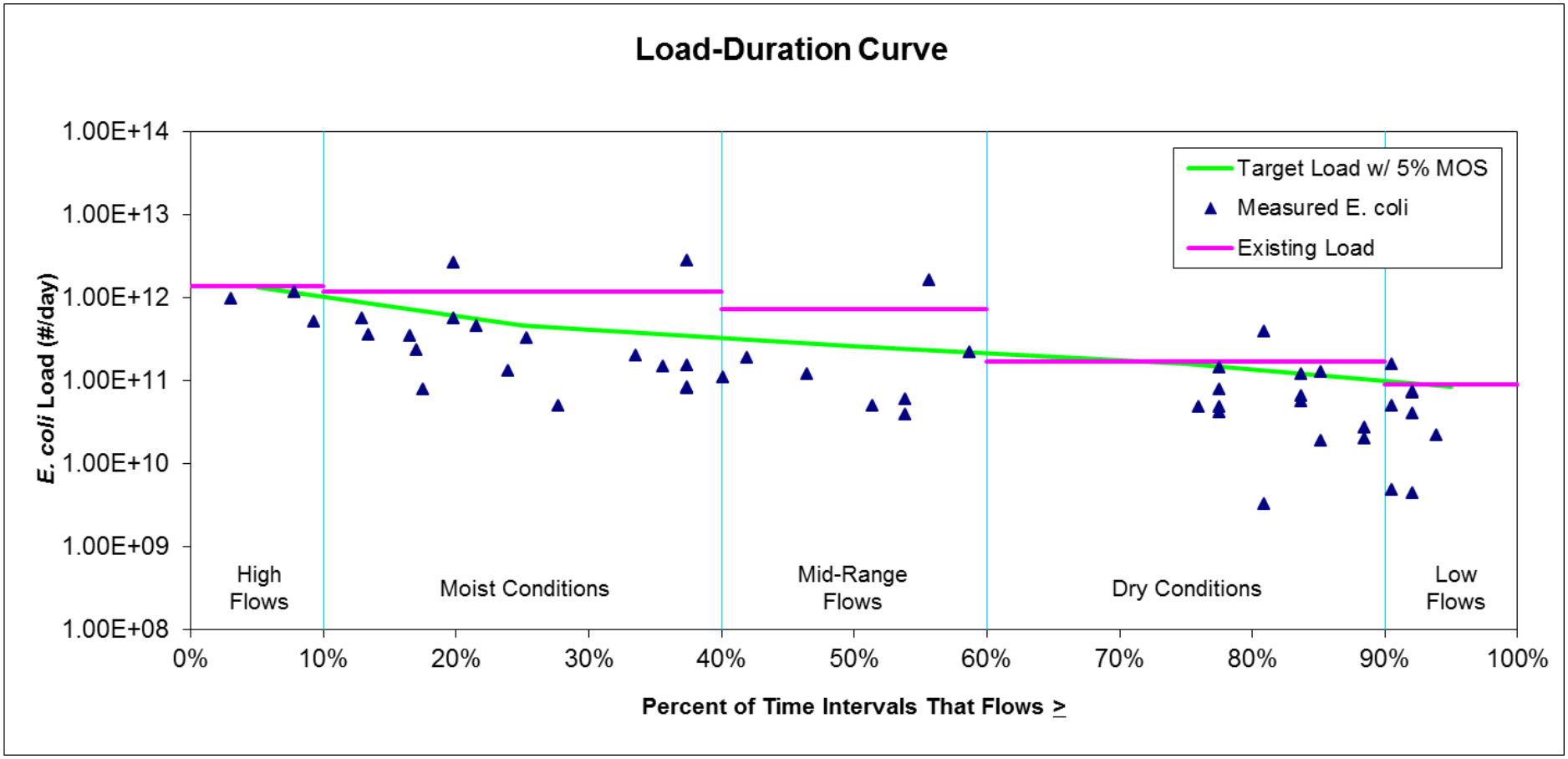
Load Duration Curve for Reach 4 of the Jeffries Creek Watershed, WQM Station RS-07205



Load Duration Curve for Reach 5 of the Jeffries Creek Watershed, WQM Station PD-035



Load Duration Curve for the Willow Creek Watershed, WQM Station PD-167



Appendix C

EVALUATING THE PROGRESS OF MS4 PROGRAMS

Evaluating the Progress of MS4 Programs:
Meeting the Goals of TMDLs and Attaining Water Quality Standards

Bureau of Water

August 2008

Described below are potential approaches that may be used by MS4 permit holders. These are recommendations and examples only, as the 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

5. Links:

- Evaluating the Effectiveness of Municipal Stormwater Programs. September 2007. EPA 833-F-07-010
- The BMP database - http://www.bmpdatabase.org/BMPPerformance.htm (this link is specifically to the BMP performance page, and lot more)
- USEPA's STORET data warehouse - http://www.epa.gov/storet/dw_home.html
- USEPA, Region 5: STEPL – Spreadsheet tool for estimating pollutant loads http://it.tetratech-ffx.com/stepl/
- Measurable goals guidance for Phase II Small MS4 - http://cfpub.epa.gov/npdes/stormwater/measurablegoals/index.cfm
- Environmental indicators for sotrmwater program- http://cfpub.epa.gov/npdes/stormwater/measurablegoals/part5.cfm
- National menu of stormwater best management practices (BMPs) - http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm
- SCDHEC – BOW: 319 grant program has attempted to calculate the load reductions for the following BMPs:

    - Septic tank repair or replacement
    - Removing livestock from streams (cattle, horses, mules)
    - Livestock fencing
    - Waste Storage Facilities (aka stacking sheds)
    - Strip cropping
    - Prescribed grazing
    - Critical Area Planting
    - Runoff Management System
    - Waste Management System
    - Solids Separation Basin
    - Riparian Buffers

Appendix D
DATA TABLES

E. coli WQS Exceedence Summary for Impaired Station PD-256 by Date

Date	*E. coli* (MPN/mL)
1/6/2009	93.3
1/13/2009	118.4
1/21/2009	133.3
1/28/2009	290.9
2/3/2009	139.6
2/9/2009	94.8
2/18/2009	195.6
2/25/2009	49.6
3/4/2009	141.4
3/11/2009	204.6
3/18/2009	128.1
3/25/2009	193.5
4/1/2009	143.0
4/6/2009	**410.6**
4/14/2009	344.8
4/22/2009	250.1
4/29/2009	**365.4**

Date	*E. coli* (MPN/mL)
5/6/2009	214.3
5/13/2009	127.4
5/19/2009	**387.3**
5/28/2009	90.6
6/2/2009	121.0
6/10/2009	307.6
6/16/2009	**1953.6**
6/23/2009	293.2
6/30/2009	518.4
7/8/2009	268.0
7/22/2009	**372.8**
7/28/2009	281.2
8/4/2009	108.8
8/12/2009	**468.8**
8/20/2009	**384.4**
8/26/2009	**889.6**
8/31/2009	**1461.6**

Date	*E. coli* (MPN/mL)
9/8/2009	208.0
9/15/2009	168.6
9/21/2009	**825.6**
9/29/2009	326.4
10/8/2009	171.2
10/12/2009	**1102.0**
10/22/2009	115.2
10/26/2009	230.4
11/2/2009	104.8
11/9/2009	147.2
11/16/2009	151.6
11/23/2009	**434.4**
12/1/2009	69.2
12/7/2009	91.2
12/15/2009	128.0
12/29/2009	63.8

___ WQS Exceeded

90th Percentile *E. coli* Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-256	136.4	415.4	817.0	666.9	682.9	50

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-256	123.39	42.43	23.57	14.73	7.66

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-256	4.12E+11	4.31E+11	4.71E+11	2.40E+11	1.28E+11

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-256	1.00E+12	3.44E+11	1.91E+11	1.19E+11	6.21E+10

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-256	N/A	8.70E+10	2.80E+11	1.21E+11	N/A

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-256	N/A	20	59	50	N/A

E. coli WQS Exceedence Summary for Impaired Station PD-065 by Date

Date	*E. coli* (MPN/mL)
1/6/2009	**366.0**
1/15/2009	201.3
1/21/2009	39.9
1/28/2009	**1203.3**
2/3/2009	186.0
2/9/2009	42.2
2/18/2009	**2419.6**
2/25/2009	98.7
3/4/2009	45.0

Date	*E. coli* (MPN/mL)
3/11/2009	115.3
3/18/2009	**770.1**
3/25/2009	325.5
4/1/2009	**2419.6**
4/7/2009	**1986.3**
4/15/2009	68.8
4/22/2009	116.0
4/30/2009	**360.9**
5/6/2009	**920.8**

Date	*E. coli* (MPN/mL)
5/12/2009	**1413.6**
5/18/2009	**2419.6**
5/27/2009	**770.1**
6/4/2009	**2419.6**
6/11/2009	**1203.3**
6/16/2009	**9678.4**
6/24/2009	**3465.6**
7/1/2009	211.2
7/8/2009	**1953.6**

___ WQS Exceeded

E. coli WQS Exceedence Summary for Impaired Station PD-065 by Date (Continued)

Date	*E. coli* (MPN/mL)
7/15/2009	145.6
7/21/2009	**912.8**
7/28/2009	**2595.2**
8/4/2009	**593.2**
8/10/2009	**575.6**
8/18/2009	120.4
8/25/2009	**533.2**
8/31/2009	**5198.8**

Date	*E. coli* (MPN/mL)
9/8/2009	305.2
9/16/2009	236.4
9/21/2009	**2746.8**
9/29/2009	**3265.6**
10/7/2009	**2276.8**
10/12/2009	**9678.4**
10/21/2009	**1844.4**
10/26/2009	**7945.2**

Date	*E. coli* (MPN/mL)
11/3/2009	**2068.8**
11/9/2009	**6931.6**
11/16/2009	**525.6**
11/23/2009	**9678.4**
12/1/2009	**771.2**
12/7/2009	**782.0**
12/15/2009	**1163.6**
12/29/2009	**2595.2**

___ WQS Exceeded

90th Percentile *E. coli* Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-065	9678.4	3376.3	1960.1	3046.6	3006.2	51

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-065	9.54	1.39	0.78	0.58	0.40

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-065	2.26E+12	1.15E+11	3.75E+10	4.31E+10	2.98E+10

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-065	7.74E+10	1.13E+10	6.33E+09	4.69E+09	3.28E+09

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-065	N/A	1.03E+11	3.11E+10	3.84E+10	N/A

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-065	N/A	90	83	89	N/A

E. coli WQS Exceedence Summary for Impaired Station PD-230 by Date

Date	E. coli (MPN/mL)
1/6/2009	125.8
1/12/2009	62.0
1/21/2009	58.6
1/28/2009	53.8
2/3/2009	209.8
2/11/2009	109.8
2/18/2009	142.1
2/25/2009	46.5
3/4/2009	198.9
3/11/2009	56.5
3/18/2009	71.7
3/25/2009	53.8
4/1/2009	248.1
4/7/2009	74.9
4/14/2009	151.5
4/22/2009	121.1
4/29/2009	115.3
5/6/2009	**648.8**
5/13/2009	201.4
5/20/2009	108.1
5/27/2009	**435.2**
6/3/2009	172.5
6/9/2009	224.7
6/16/2009	**2068.8**
6/24/2009	132.4
7/1/2009	134.4
7/8/2009	**373.2**
7/16/2009	92.4
7/21/2009	188.4
7/28/2009	98.4
8/5/2009	58.0
8/12/2009	43.6
8/20/2009	168.8
8/26/2009	293.2
9/1/2009	138.0
9/8/2009	**420.0**
9/15/2009	**363.2**
9/22/2009	204.8
9/30/2009	**1379.2**
10/8/2009	198.0
10/13/2009	**2452.4**
10/22/2009	38.8
10/28/2009	110.0
11/2/2009	138.4
11/9/2009	69.2
11/17/2009	63.2
11/24/2009	**4479.6**
12/1/2009	20.8
12/7/2009	98.4
12/16/2009	34.4
12/29/2009	276.4

___ WQS Exceeded

90th Percentile *E. coli* Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-230	178.8	1216.8	513.2	429.1	366.2	51

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-230	146.87	50.50	28.06	17.53	9.12

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-230	6.42E+11	1.50E+12	3.52E+11	1.84E+11	8.17E+10

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-230	1.19E+12	4.10E+11	2.28E+11	1.42E+11	7.40E+10

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-230	N/A	1.09E+12	1.25E+11	4.19E+10	N/A

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-230	N/A	73	35	23	N/A

Fecal Coliform WQS Exceedence Summary for Impaired Station RS-07205 by Date

Date	FC (cfu/mL)
1/18/2007	**470**
2/26/2007	44
3/13/2007	20

Date	FC (cfu/mL)
4/25/2007	370
5/9/2007	30
6/21/2007	**880**

Date	FC (cfu/mL)
7/4/2007	80

___ WQS Exceeded

90th Percentile FC Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
RS-07205	NS	450	29	800	NS	7

NS = No samples

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-07205	34.80	11.97	6.65	4.16	2.16

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-07205	NM	1.32E+11	4.72E+09	8.13E+10	NM

NM = Not measured

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-07205	3.24E+11	1.11E+11	6.18E+10	3.86E+10	2.01E+10

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-07205	N/A	2.05E+10	NRN	4.27E+10	N/A

NRN = no reduction needed. Existing load below target load.

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
RS-07205	N/A	16	NRN	53	N/A

NRN = no reduction needed. Existing load below target load.

E. coli WQS Exceedence Summary for Impaired Station PD-035 by Date

Date	*E. coli* (MPN/mL)
1/6/2009	198.9
1/12/2009	275.5
1/21/2009	248.1

Date	*E. coli* (MPN/mL)
1/28/2009	159.7
2/3/2009	63.8
2/11/2009	55.4

Date	*E. coli* (MPN/mL)
2/18/2009	127.4
2/25/2009	88.4
3/4/2009	344.8

E. coli WQS Exceedence Summary for Impaired Station PD-035 by Date (Continued)

Date	FC (cfu/mL)
3/11/2009	107.6
3/18/2009	201.4
3/25/2009	88.2
4/1/2009	162.4
4/7/2009	88.2
4/14/2009	201.4
4/22/2009	93.2
4/29/2009	116.2
5/6/2009	**875.2**
5/13/2009	114.5
5/20/2009	**387.3**
5/27/2009	235.9
6/3/2009	133.3
6/9/2009	275.5
6/16/2009	**2595.2**
6/24/2009	215.6
7/1/2009	182.8
7/8/2009	**740.0**
7/16/2009	91.2
7/21/2009	180.8
7/28/2009	145.6
8/5/2009	159.6
8/12/2009	39.2
8/20/2009	91.2
8/26/2009	81.2
9/1/2009	111.6
9/8/2009	84.4
9/15/2009	16.4
9/22/2009	201.6
9/30/2009	29.6
10/7/2009	**646.4**
10/13/2009	**1102.0**
10/22/2009	64.4
10/28/2009	129.2
11/2/2009	39.8
11/9/2009	72.4
11/17/2009	**1045.2**
11/24/2009	**1953.6**
12/1/2009	99.6
12/7/2009	208.4
12/16/2009	211.6
12/29/2009	159.6

___ WQS Exceeded

90th Percentile *E. coli* Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-035	344.8	267.3	983.0	783.1	363.1	51

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-035	397.75	202.49	107.03	62.55	34.35

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-035	3.36E+12	1.32E+12	2.57E+12	1.20E+12	3.05E+11

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-035	3.23E+12	1.64E+12	8.68E+11	5.07E+11	2.79E+11

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-035	N/A	NRN	1.71E+12	6.91E+11	N/A

NRN = no reduction needed. Existing load below target load.

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-035	N/A	NRN	66	58	N/A

NRN = no reduction needed. Existing load below target load.

Fecal Coliform WQS Exceedence Summary for Impaired Station PD-231 by Date

Date	FC (cfu/mL)
1/17/2008	250
2/19/2008	**590**
3/27/2008	44
4/24/2008	44
5/13/2008	**800**
6/12/2008	46
7/28/2008	62
8/21/2008	150
9/15/2008	120
10/8/2008	97
11/24/2008	120
12/10/2008	100
1/15/2009	220

Date	FC (cfu/mL)
2/11/2009	59
3/3/2009	**800**
4/29/2009	68
5/7/2009	360
6/2/2009	88
7/15/2009	120
8/5/2009	170
10/7/2009	**530**
12/3/2009	230
1/5/2010	190
3/4/2010	110
5/6/2010	100
7/1/2010	320

Date	FC (cfu/mL)
11/23/2010	40
1/19/2011	360
3/8/2011	250
5/4/2011	76
7/13/2011	140
9/14/2011	48
11/15/2011	25
2/8/2012	180
4/4/2012	96
8/7/2012	110
10/3/2012	270
12/12/2012	46

____ WQS Exceeded

90th Percentile FC Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-231	NS	695	360	310	134	38

NS = No samples

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-231	479.66	244.19	129.07	75.44	41.43

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-231	NM	4.15E+12	1.14E+12	5.72E+11	1.36E+11

NM = Not measured0

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-231	4.46E+12	2.27E+12	1.20E+12	7.01E+11	3.85E+11

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-231	N/A	1.88E+12	NRN	NRN	N/A

NRN = no reduction needed. Existing load below target load.

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-231	N/A	45	NRN	NRN	N/A

NRN = no reduction needed. Existing load below target load.

E. coli WQS Exceedence Summary for Impaired Station PD-167 by Date

Date	*E. coli* (MPN/mL)
1/6/2009	248.1
1/12/2009	290.9
1/21/2009	344.8

Date	*E. coli* (MPN/mL)
1/28/2009	178.5
2/3/2009	82.0
2/11/2009	65.7

Date	*E. coli* (MPN/mL)
2/18/2009	54.8
2/25/2009	83.6
3/4/2009	184.2

E. coli WQS Exceedence Summary for Impaired Station PD-167 by Date (Continued)

Date	*E. coli* (MPN/mL)
3/11/2009	90.8
3/18/2009	163.2
3/25/2009	151.5
4/1/2009	127.4
4/7/2009	**371.4**
4/14/2009	78.9
4/22/2009	115.3
4/29/2009	108.1
5/6/2009	238.2
5/13/2009	142.2
5/20/2009	328.2
5/27/2009	325.5
6/3/2009	172.5
6/9/2009	272.3
6/16/2009	**2746.8**
6/24/2009	174.8
7/1/2009	329.2
7/8/2009	**541.6**
7/16/2009	265.2
7/21/2009	86.4
7/28/2009	147.6
8/5/2009	153.6
8/12/2009	86.4
8/20/2009	64.4
8/26/2009	92.4
9/1/2009	143.6
9/8/2009	**363.6**
9/15/2009	16.4
9/22/2009	16.4
9/30/2009	**2317.6**
10/7/2009	**943.6**
10/22/2009	53.6
10/28/2009	8.0
11/2/2009	104.8
11/9/2009	174.6
11/17/2009	39.2
11/24/2009	**1587.2**
12/1/2009	208.4
12/7/2009	185.6
12/16/2009	44.0
12/29/2009	182.8

___ WQS Exceeded

90th Percentile *E. coli* Concentrations (#/100 mL)

Hydro Category Range	High Flow 0-10	Moist Cond. 10-40	Mid Range 40-60	Dry Flow 60-90	Low Flow 90-100	Samples
PD-167	334.2	841.8	925.0	353.3	353.1	50

Mid Point Hydrologic Category Flow (cfs)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-167	165.52	56.91	31.62	19.76	10.28

Existing Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-167	1.35E+12	1.17E+12	7.16E+11	1.71E+11	8.88E+10

Target Load (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-167	1.34E+12	4.61E+11	2.56E+11	1.60E+11	8.30E+10

Load Reduction Necessary (#/day)

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-167	N/A	7.11E+11	4.59E+11	1.08E+10	N/A

% Load Reduction Necessary

Hydro Categ (Mid-Point)	High Flow (5)	Moist Cond. (25)	Mid Range (50)	Dry (75)	Low Flow (95)
PD-167	N/A	61	64	6	N/A

Appendix E

POTENTIAL POLLUTANT SOURCE IDENTIFICATION

Table Ap-1. Potential FC and *E. coli* Pollutant Sources in Reach 1 of the Jeffries Creek Watershed (WQM Station PD-256)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-256	Cattle	Calvary Road	Darlington	Northwest	34.30995	-80.06818	10/29/2015	Pastured cattle
PD-256	Cattle	US 15	Darlington	Northwest	34.33082	-80.07819	10/29/2015	Pastured cattle
PD-256	Dogs	Dewitt Circle	Darlington	Southeast	34.20820	-79.89694	10/29/2015	Unattended dog in yard
PD-256	Dogs	Pine Grove Drive	Darlington	Southeast	34.21404	-79.87296	10/29/2015	Unattended dog in yard
PD-256	Dogs	Windburn Drive	Darlington	Southeast	34.21387	-79.87623	10/29/2015	Unattended dog in yard
PD-256	Ducks	King Drive	Darlington	Southeast	34.20748	-79.89227	10/29/2015	Ducks in a stream-fed pond
PD-256	Horses	US 15	Darlington	Northwest	34.33255	-80.08018	10/29/2015	Horse in pasture near stream
PD-256	Horses	Dewitt Circle	Darlington	Southeast	34.21388	-79.90348	10/29/2015	Pastured horses near Jeffries Creek
PD-256	Turtles	West Hampton Pointe Drive	Florence	Southeast	34.18737	-79.85724	10/29/2015	Turtle in a stream-fed pond

Table Ap-2. Potential FC and *E. coli* Pollutant Sources in Reach 3 of the Jeffries Creek Watershed (WQM Station PD-230)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-230	Deer	East Howe Springs Road	Florence	East	34.13998	-79.73594	1/7/2016	Deer stand on edge of field
PD-230	Goats	Oliver Road	Florence	South	34.12108	-79.84857	11/19/2015	Pastured goats
PD-230	Herons	SC 340	Darlington	Northwest	34.18827	-79.94020	10/29/2015	Blue heron near pond
PD-230	Herons	Whitehall Shores Road	Florence	Northwest	34.18289	-79.89074	11/19/2015	Heron in Oakdale Lake
PD-230	Horses	James Turner Road	Florence	East	34.13061	-79.79730	11/19/2015	Pastured horses near Aligator Branch
PD-230	Horses	Blitsgel Drive	Florence	Northwest	34.18924	-79.90615	11/19/2015	Pastured horses
PD-230	Horses	Garner Road	Florence	West	34.13238	-79.86620	11/19/2015	Pastured horse

Table Ap-3. Potential FC and *E. coli* Pollutant Sources in Reach 4 of the Jeffries Creek Watershed (WQM Station RS-07205)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
RS-07205	Dogs	County Route S-21-24	Florence	North	34.22998	-79.67597	1/11/2016	Unattended dog in yard
RS-07205	Horses	County Route S-21-24	Florence	North	34.23057	-79.67967	1/11/2016	Pastured horses
RS-07205	Horses	John C. Calhoun Road	Florence	West	34.22087	-79.72338	1/11/2016	Pastured horses near Adams Branch

Table Ap-4. Potential FC and *E. coli* Pollutant Sources in Reach 5 of the Jeffries Creek Watershed (WQM Station PD-035)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-035	Cattle	SC 327	Florence	Northeast	34.16420	-79.64152	1/11/2016	Pastured cattle
PD-035	Cattle	Claussen Road	Florence	Southeast	34.13412	-79.65776	1/11/2016	Pastured cattle
PD-035	Chickens	Claussen Road	Florence	Southeast	34.14043	-79.69048	1/11/2016	Chickens and peacocks in a pen
PD-035	Deer	SC 51	Florence	Central	34.15736	-79.73362	1/11/2016	Deer stand in a field near Jeffries Creek
PD-035	Deer	SC 327	Florence	Northeast	34.17144	-79.64628	1/11/2016	Deer stand on edge of field
PD-035	Dogs	Justine Road	Florence	Northeast	34.16114	-79.64793	1/11/2016	Unattended dog in yard
PD-035	Ducks	Justine Road	Florence	Northeast	34.16244	-79.65074	1/11/2016	Duck in a stream-fed pond
PD-035	Ducks	Tommy Drive	Florence	Northeast	34.16706	-79.66986	1/11/2016	Ducks in a stream-fed pond
PD-035	Ducks	Claussen Road	Florence	Southeast	34.14041	-79.69043	1/11/2016	Ducks in a yard
PD-035	Goats	Claussen Road	Florence	Southeast	34.13777	-79.68190	1/11/2016	Pastured goats near Cane Branch
PD-035	Goats	Claussen Road	Florence	Southeast	34.14032	-79.69007	1/11/2016	Goat in a pen
PD-035	Horses	South McCurdy Road	Florence	Central	34.18833	-79.70294	1/11/2016	Pastured horses
PD-035	Horses	Claussen Road	Florence	Southeast	34.13413	-79.65868	1/11/2016	Pastured horses
PD-035	Peacocks	Claussen Road	Florence	Southeast	34.14043	-79.69048	1/11/2016	Peacock and chickens in a pen

Table Ap-5. Potential FC and *E. coli* Pollutant Sources in Reach 6 of the Jeffries Creek Watershed (WQM Station PD-231)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-231	Deer	Carter Corner Road	Florence	East	34.16389	-79.58209	1/11/2016	Deer stand near Boggy Branch
PD-231	Deer	Liberty Chappel Road	Florence	East	34.16954	-79.58222	1/11/2016	Deer stand in field
PD-231	Deer	East Palmetto Street	Florence	Northeast	34.19971	-79.60153	1/11/2016	Deer stand in woods
PD-231	Dogs	Bailey Lane	Florence	Northwest	34.21233	-79.64294	1/11/2016	Unattended dog in yard
PD-231	Dogs	Fore Road	Florence	Northwest	34.21154	-79.65544	1/11/2016	Unattended dog in yard
PD-231	Dogs	Fore Road	Florence	Northwest	34.20776	-79.65579	1/11/2016	Unattended dog in yard
PD-231	Ducks	Bailey Lane	Florence	Northwest	34.21230	-79.64300	1/11/2016	Ducks in a stream-fed pond
PD-231	Game	County Route S-21-24	Florence	Northeast	34.21764	-79.61706	1/11/2016	Sign for hunting club
PD-231	Game	Bethel Road	Florence	South	34.15308	-79.58909	1/11/2016	Hunting club near Moore Branch
PD-231	Ponies	Fore Road	Florence	Northwest	34.21154	-79.65544	1/11/2016	Pony in yard with a dog

Table Ap-6. Potential FC and *E. coli* Pollutant Sources in the Willow Creek Watershed (WQM Station PD-167)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-167	Cats	Cato Road	Florence	Northwest	34.10145	-79.72666	11/19/2015	Unattended cats in yard
PD-167	Cattle	Four Seasons Road	Florence	Central	34.10184	-79.66529	11/19/2015	Cow in pasture
PD-167	Cattle	Cato Road	Florence	Northwest	34.10116	-79.72680	11/19/2015	Pastured cattle
PD-167	Cattle	Flowers Road	Florence	Northwest	34.11130	-79.69327	1/7/2016	Cattle in pasture with dogs and horses
PD-167	Cattle	SC 51	Florence	Northwest	34.09939	-79.70105	1/7/2016	Pastured cattle near Little Willow Creek
PD-167	Cattle	Allen Road	Florence	South	34.03961	-79.67480	1/7/2016	Cow in pasture with horses
PD-167	Cattle	Francis Marion Road	Florence	South	34.04552	-79.65473	1/7/2016	Cattle in pasture near ducks in a pond
PD-167	Cattle	SC 51	Florence	South	34.04606	-79.66319	1/7/2016	Pastured cattle near stream-fed pond
PD-167	Chickens	Delosh Road	Florence	Central	34.08143	-79.66728	1/7/2016	Chickens in a pen with hogs
PD-167	Chickens	Delosh Road	Florence	Central	34.08100	-79.66743	1/7/2016	Unattended chicken in road
PD-167	Chickens	SC 327	Florence	Central	34.07070	-79.67338	1/7/2016	Chickens in a pen near a Carolina Bay
PD-167	Chickens	Cato Road	Florence	Northwest	34.10116	-79.72680	11/19/2015	Unattended chickens in yard

Table Ap-6 (Continued). Potential FC and *E. coli* Pollutant Sources in the Willow Creek Watershed (WQM Station PD-167)

Reach Station	Source	Vicinity of Road/Street	County	Location in Watershed	Latitude	Longitude	Date Observed	Source Notes
PD-167	Deer	SC 327	Florence	Northeast	34.11384	-79.63263	1/7/2016	Deer stand on edge of field
PD-167	Deer	Wickerwood Road	Florence	Northeast	34.11335	-79.64677	1/7/2016	Deer stand in woods
PD-167	Deer	Wickerwood Road	Florence	Northeast	34.11078	-79.65124	1/7/2016	Deer stand on edge of field
PD-167	Deer	Flowers Road	Florence	Northwest	34.11564	-79.68176	1/7/2016	Deer stand in a clearing
PD-167	Deer	Allen Road	Florence	South	34.03951	-79.67299	1/7/2016	Deer stand on edge of field
PD-167	Deer	East Armfield Road	Florence	South	34.05898	-79.61393	1/7/2016	Deer stand in field
PD-167	Deer	SC 51	Florence	South	34.05012	-79.66719	1/7/2016	Deer stand in woods
PD-167	Dogs	Megan Road	Florence	Central	34.09087	-79.66140	1/7/2016	Unattended dogs in yard
PD-167	Dogs	Megan Road	Florence	Central	34.08706	-79.65767	1/7/2016	Unattended dog in road near Willow Creek
PD-167	Dogs	Flowers Road	Florence	Northwest	34.11130	-79.69327	1/7/2016	Dogs in pasture with cattle and horses
PD-167	Dogs	Java Road	Florence	Northwest	34.11169	-79.75726	11/19/2015	Unattended dogs in yard
PD-167	Donkeys	Branch Road	Florence	Northwest	34.10060	-79.70152	11/19/2015	Pastured donkey near Little Willow Creek
PD-167	Ducks	Francis Marion Road	Florence	South	34.04552	-79.65473	1/7/2016	Ducks in a stream-fed pond
PD-167	Goats	Jordan road	Florence	Central	34.06982	-79.65434	1/7/2016	Pastured goats near Cypress Creek
PD-167	Goats	Branch Road	Florence	Northwest	34.09789	-79.70965	11/19/2015	Pastured goats
PD-167	Hogs	Delosh Road	Florence	Central	34.08143	-79.66728	1/7/2016	Hogs and chickens near Willow Creek
PD-167	Hogs	Cato Road	Florence	Northwest	34.10117	-79.72680	11/19/2015	Hog in a pen near Little Willow Creek
PD-167	Horses	Jordan road	Florence	Central	34.06834	-79.65441	1/7/2016	Horse in a pasture
PD-167	Horses	SC 327	Florence	Central	34.07081	-79.67308	1/7/2016	Horse in pasture near Carolina Bay
PD-167	Horses	Wickerwood Road	Florence	Northeast	34.11037	-79.63746	1/7/2016	Pastured horses
PD-167	Horses	Branch Road	Florence	Northwest	34.10060	-79.70152	11/19/2015	Pastured horses
PD-167	Horses	Cato Road	Florence	Northwest	34.10015	-79.72496	11/19/2015	Pastured horses
PD-167	Horses	Flowers Road	Florence	Northwest	34.11130	-79.69327	1/7/2016	Horses in pasture with cattle and dogs
PD-167	Horses	Hewitt Cemetery Road	Florence	Northwest	34.09907	-79.71785	11/19/2015	Pastured horses near Little Willow Creek
PD-167	Horses	Poor Farm Road	Florence	Northwest	34.09353	-79.72584	11/19/2015	Pastured horses
PD-167	Horses	SC 51	Florence	Northwest	34.09939	-79.70105	1/7/2016	Pastured horses
PD-167	Horses	SC 51	Florence	Northwest	34.12312	-79.71878	1/7/2016	Pastured horses
PD-167	Horses	Allen Road	Florence	South	34.03961	-79.67480	1/7/2016	Horses in pasture with a cow
PD-167	Horses	Francis Marion Road	Florence	South	34.04341	-79.65691	1/7/2016	Pastured horses near stream-fed pond

Appendix F

SOURCE ASSESSMENT PICTURES

Figure F-1

Sign for a hunting club (location: 34.21764 N, -79.61706 W) on County Route S-21-24 in Florence County. Found in Reach 6 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

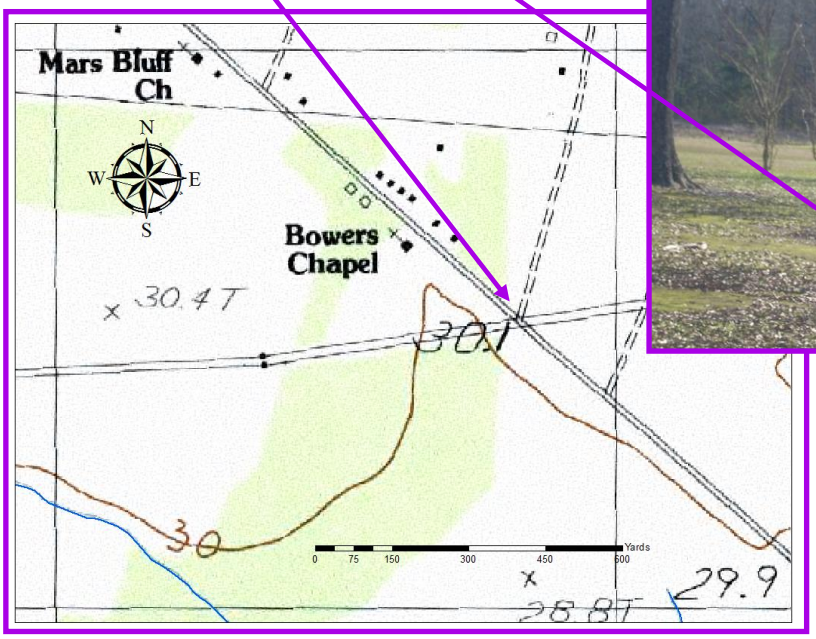


Figure F-2

Hunting club near Moore branch (location: 34.15308 N, -79.58909 W) on Bethel Road in Florence County. Found in Reach 6 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

Figure F-3

Deer stand in a field near Jeffries Creek (location: 34.15736 N, -79.73362 W) on SC 51 in Florence County. Found in Reach 5 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

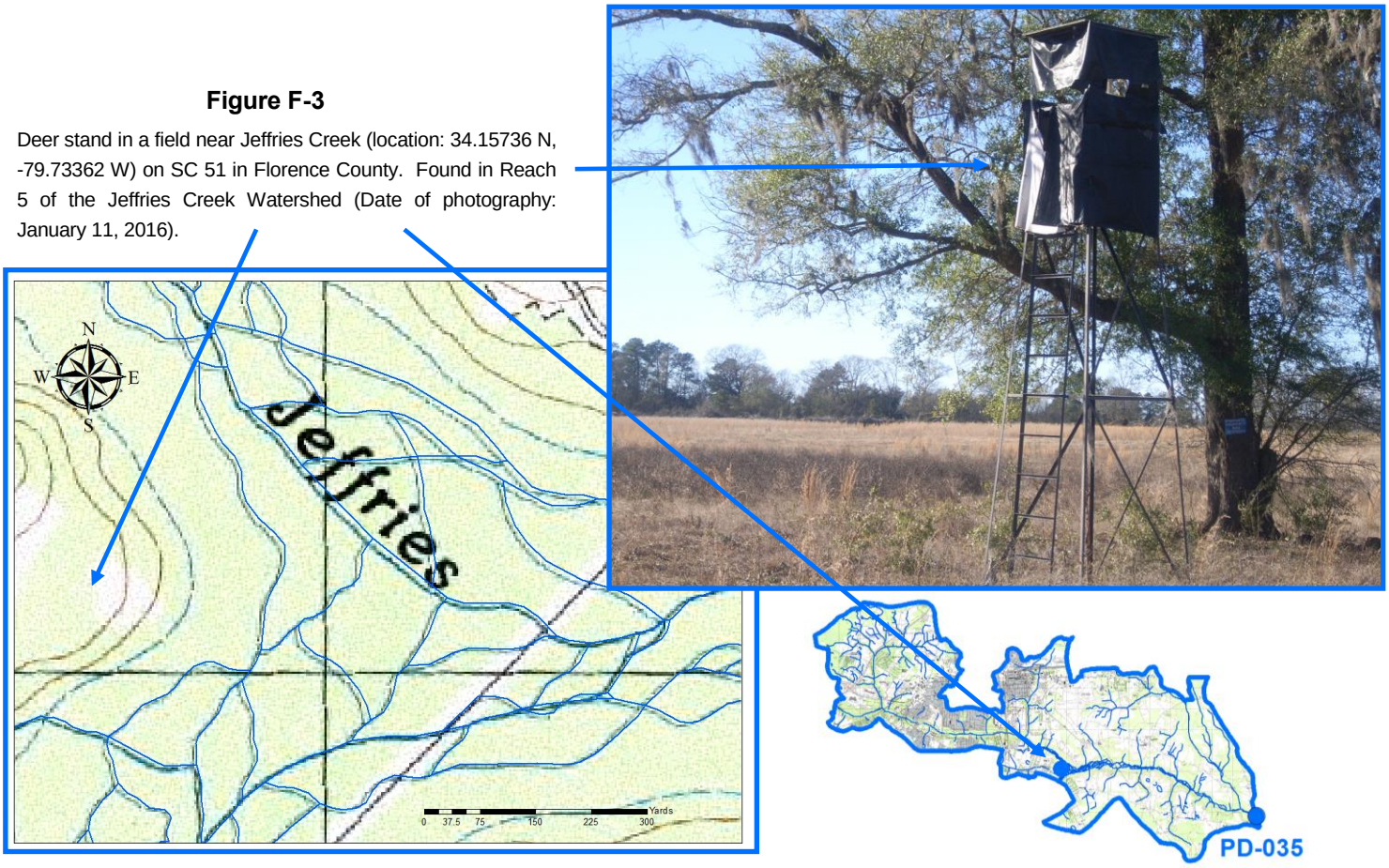


Figure F-4

Deer stand on edge of field (location: 34.17144 N, -79.64628 W) on SC Route 327 in Florence County. Found in Reach 5 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

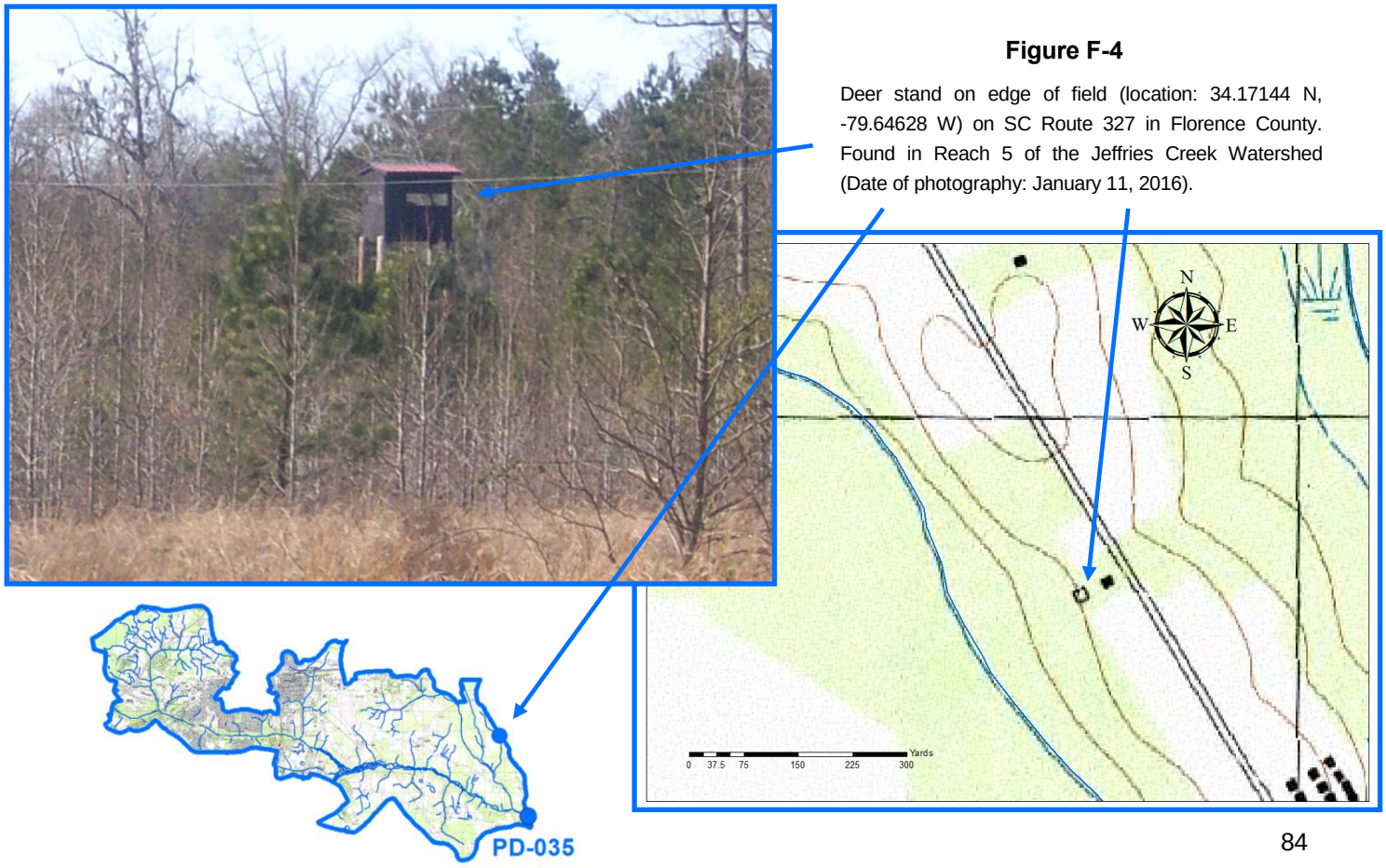


Figure F-5

Deer stand near Boggy Branch (location: 34.16389 N, -79.58209 W) on Carter Corner Road in Florence County. Found in Reach 6 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

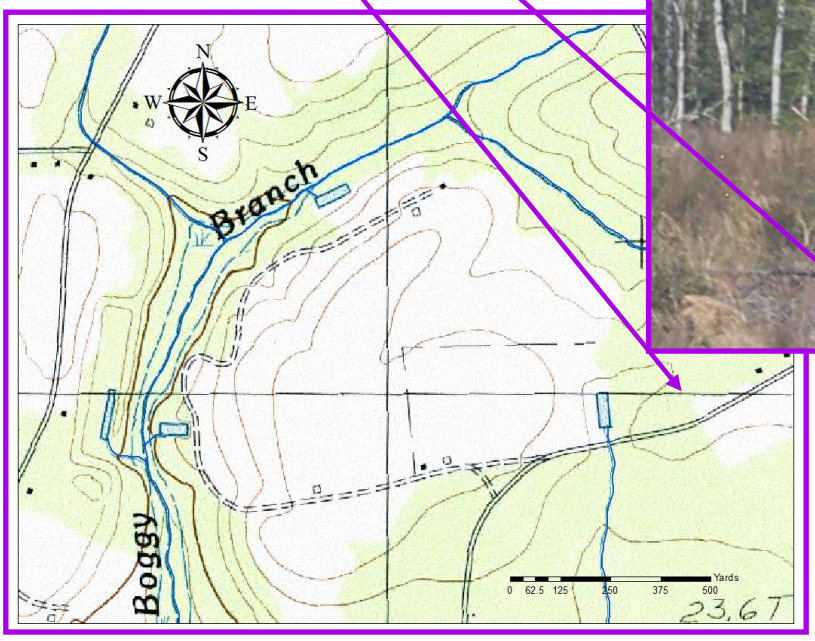


Figure F-6

Deer stand in woods (location: 34.11335 N, -79.64677 W) on Wickerwood Road in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).

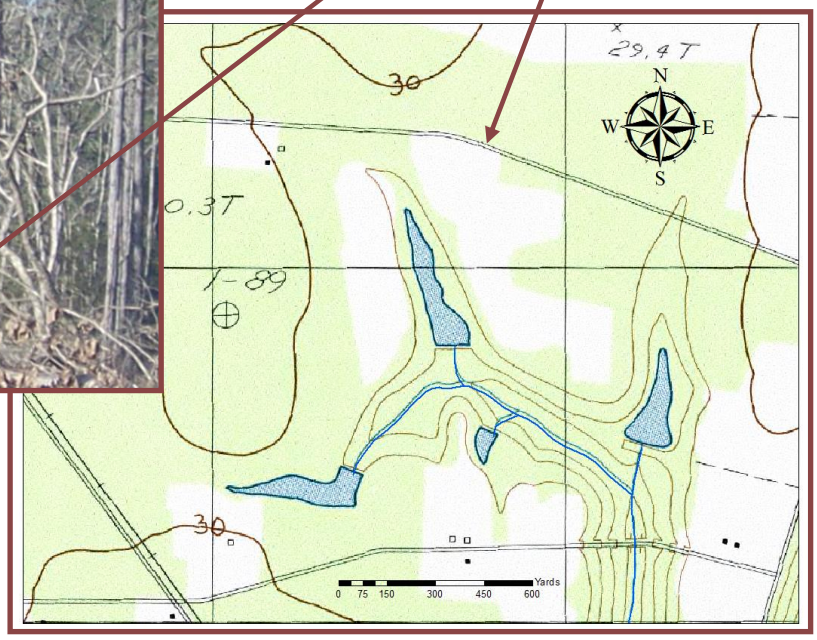


Figure F-7

Ducks in a stream-fed pond (location: 34.20748 N, -79.89227 W) on King Drive in Darlington County. Found in Reach 1 of the Jeffries Creek Watershed (Date of photography: October 29, 2015).

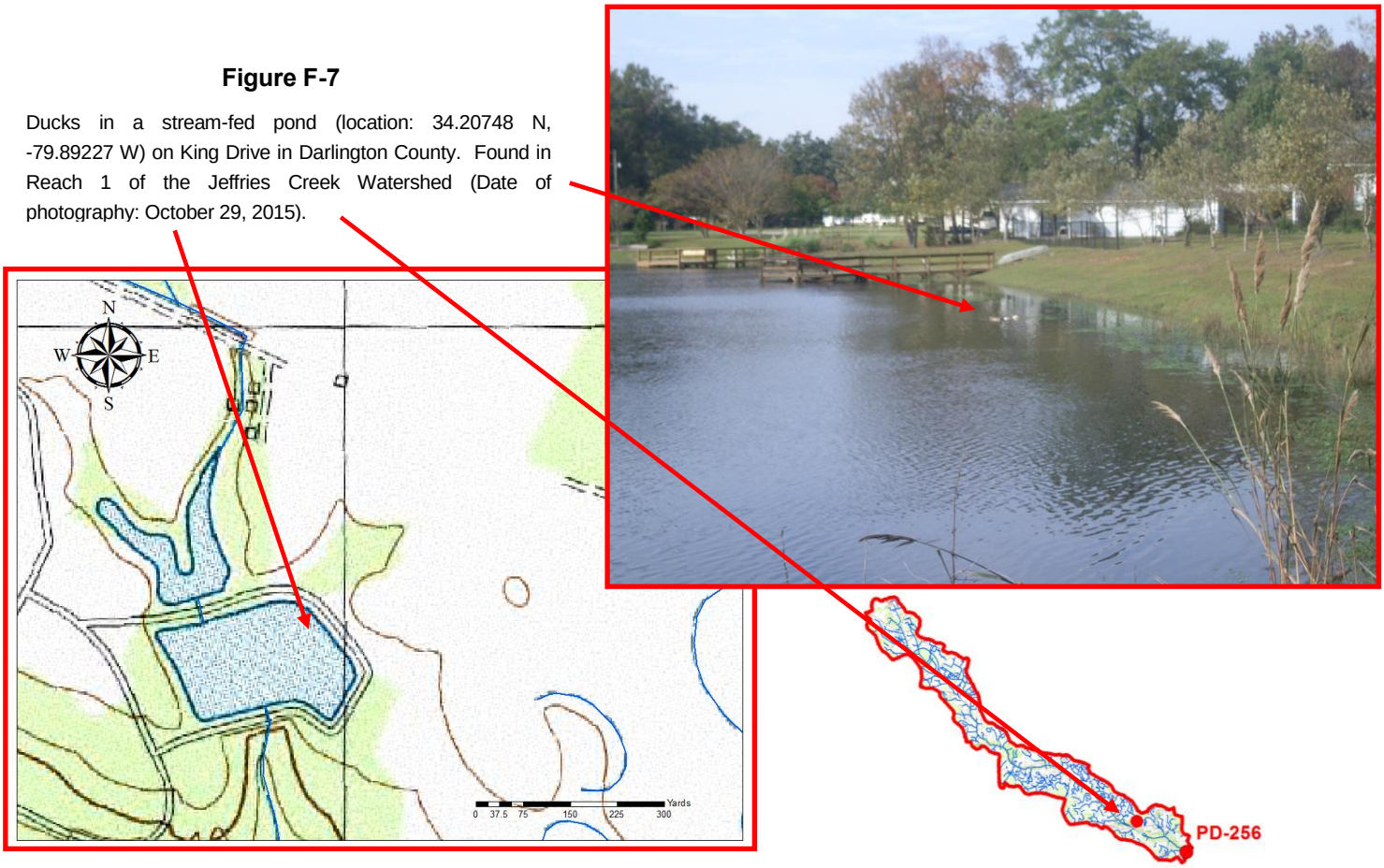


Figure F-8

Ducks in a stream-fed pond (location: 34.16706 N, -79.66986 W) on Tommy Drive in Florence County. Found in Reach 5 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

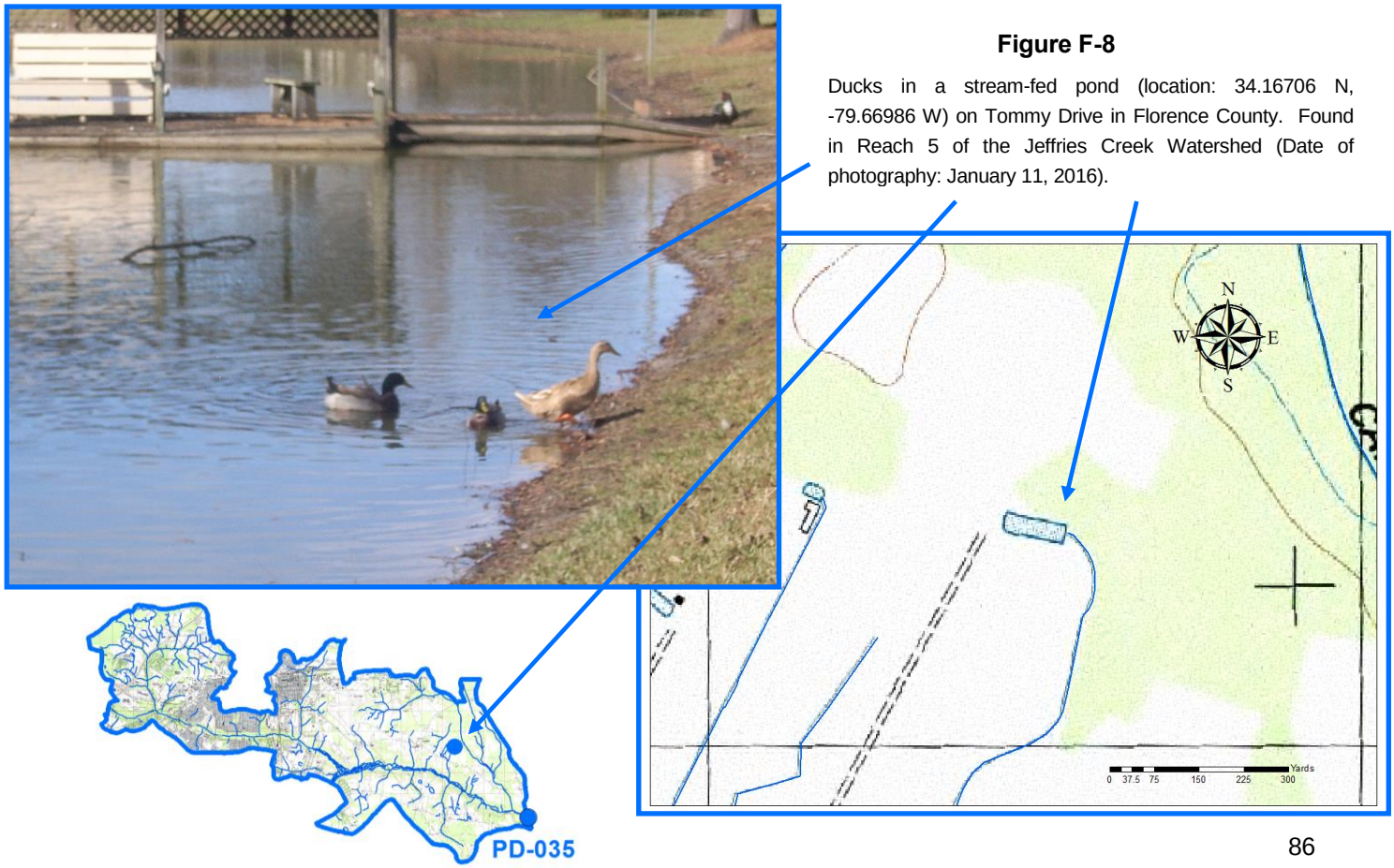


Figure F-9

Ducks in a stream-fed pond (location: 34.21230 N, -79.64300 W) on Bailey Lane in Florence County. Found in Reach 6 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

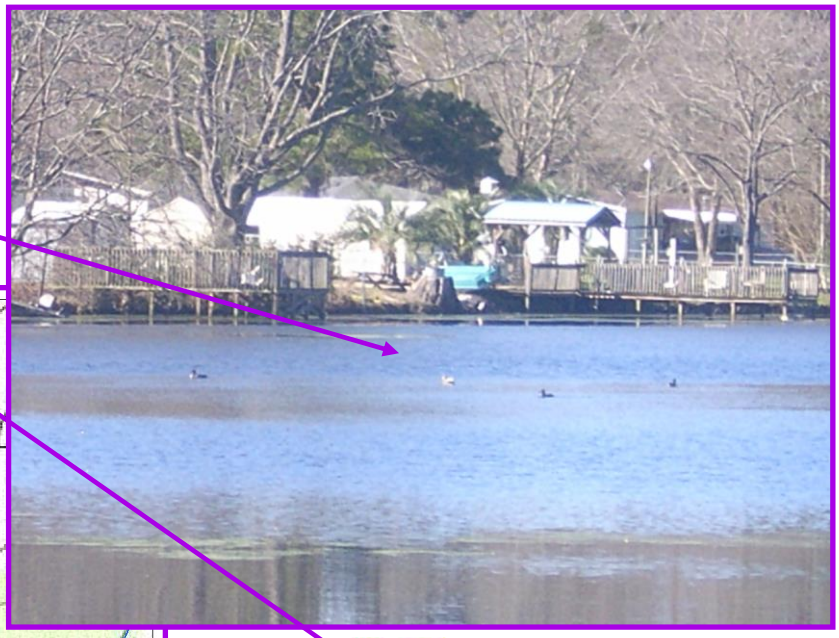
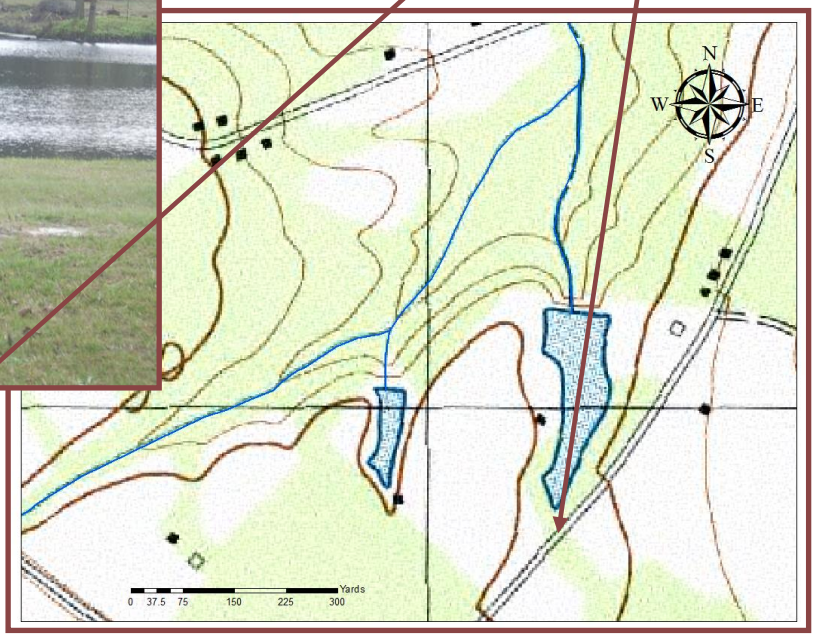


Figure F-10

Ducks in a stream-fed pond (location: 34.04552 N, -79.65473 W) on Francis Marion Road in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).



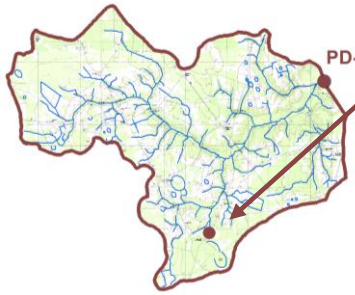


Figure F-11

Pastured cattle (location: 34.30995 N, -80.06818 W) on Calvary Road in Darlington County. Found in Reach 1 of the Jeffries Creek Watershed (Date of photography: October 29, 2015).

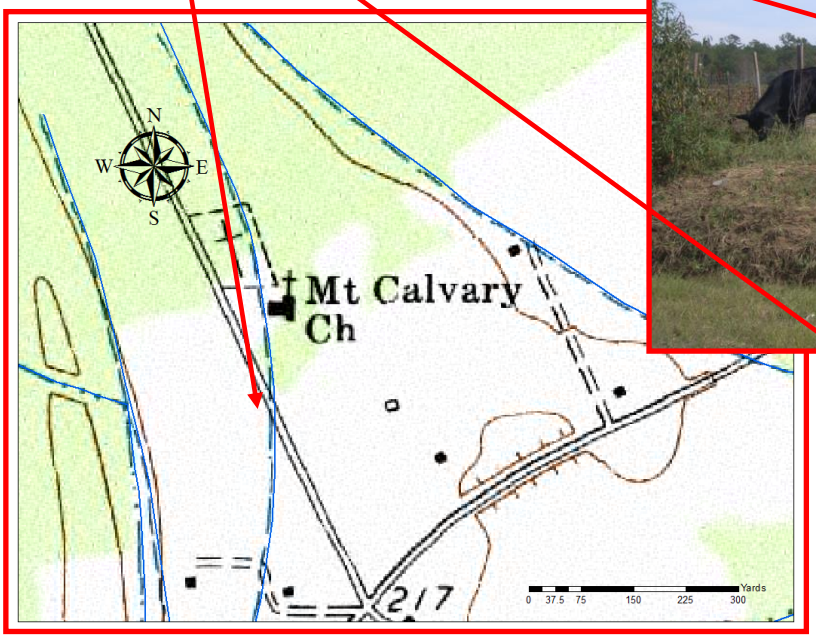


Figure F-12

Pastured cattle (location: 34.13412 N, -79.65776 W) on Claussen Road in Florence County. Found in Reach 5 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

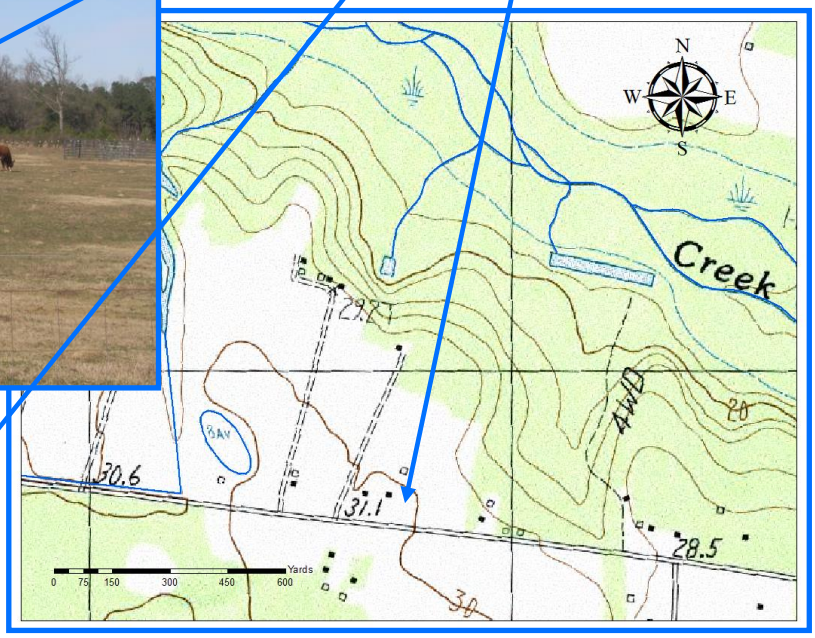
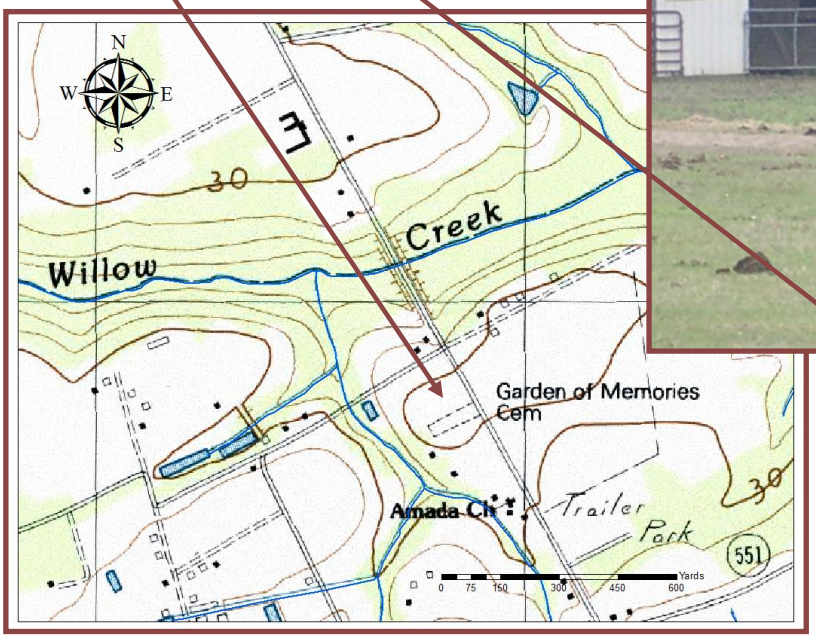


Figure F-13

Pastured cattle near Little Willow Creek (location: 34.09939 N, -79.70105 W) on SC Route 51 in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).



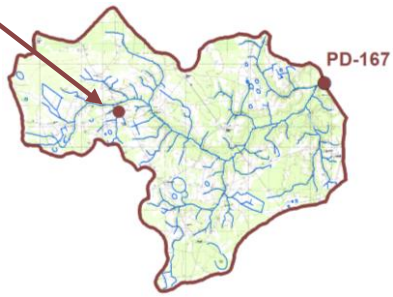


Figure F-14

Pastured cattle near a stream-fed pond (location: 34.04606 N, -79.66319 W) on SC Route 51 in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).

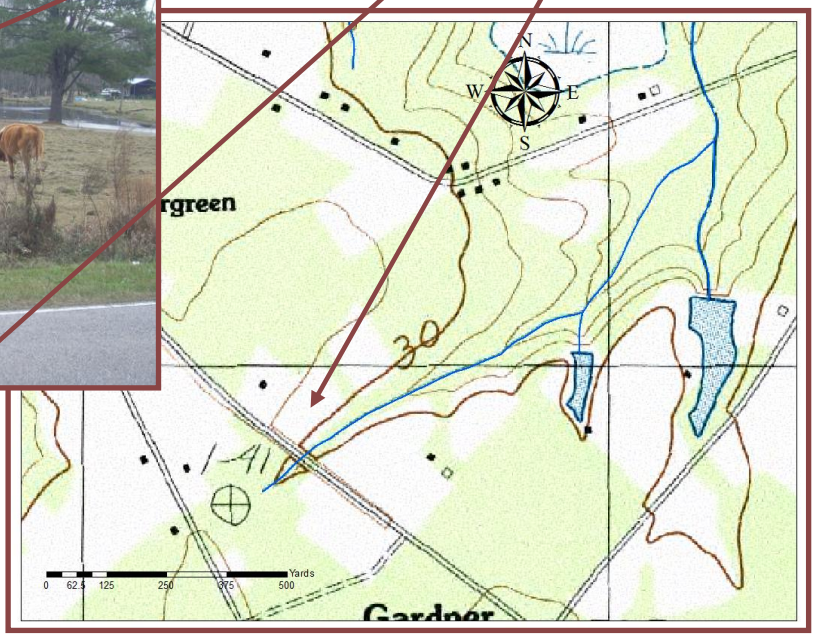


Figure F-15

Pastured horses near Jeffries Creek (location: 34.21388 N, -79.90348 W) on Dewitt Circle in Darlington County. Found in Reach 1 of the Jeffries Creek Watershed (Date of photography: October 29, 2015).

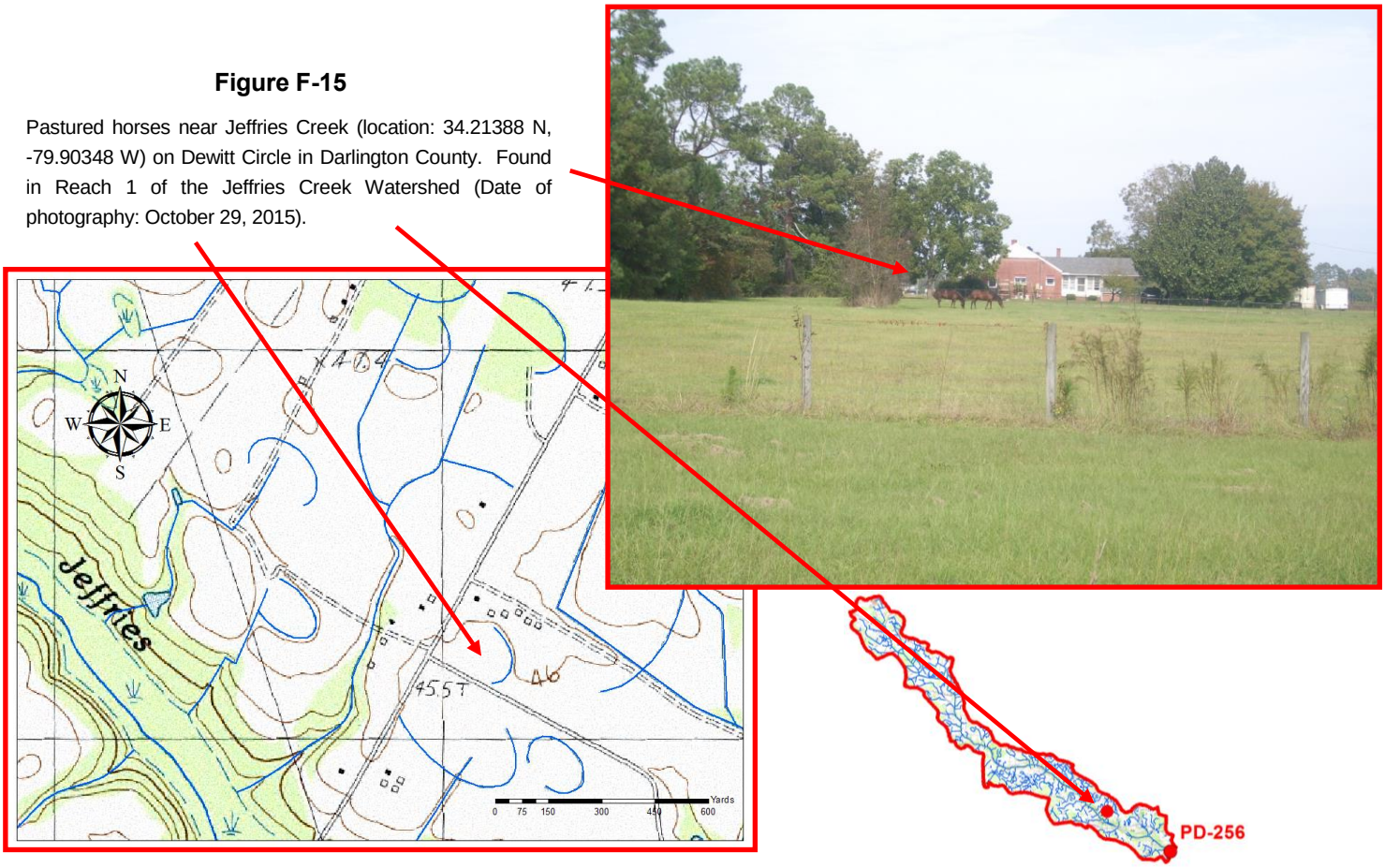


Figure F-16

Pastured horses near Alligator Branch (location: 34.13061 N, -79.79730 W) on James Turner Road in Florence County. Found in Reach 3 of the Jeffries Creek Watershed (Date of photography: November 19, 2015).

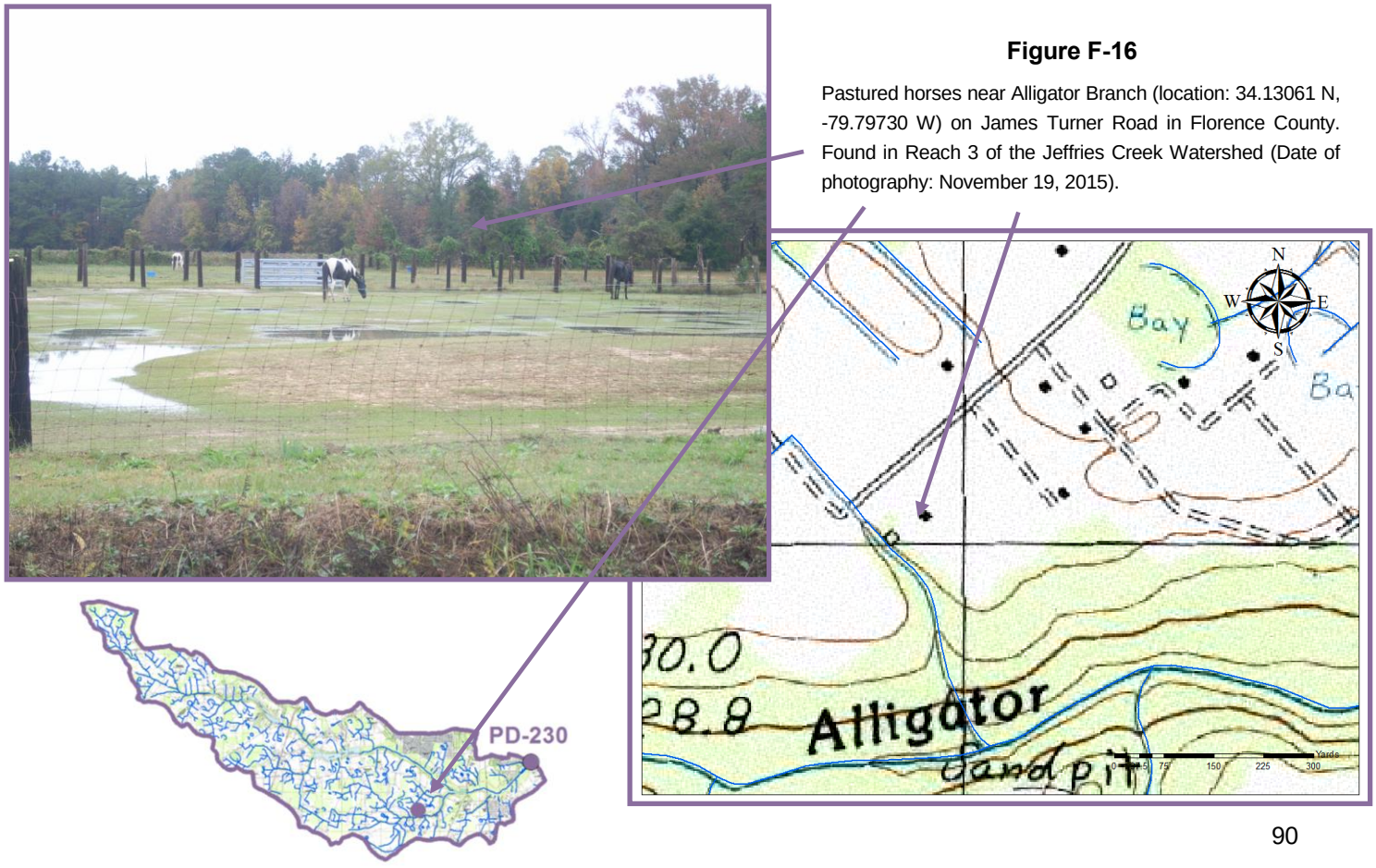
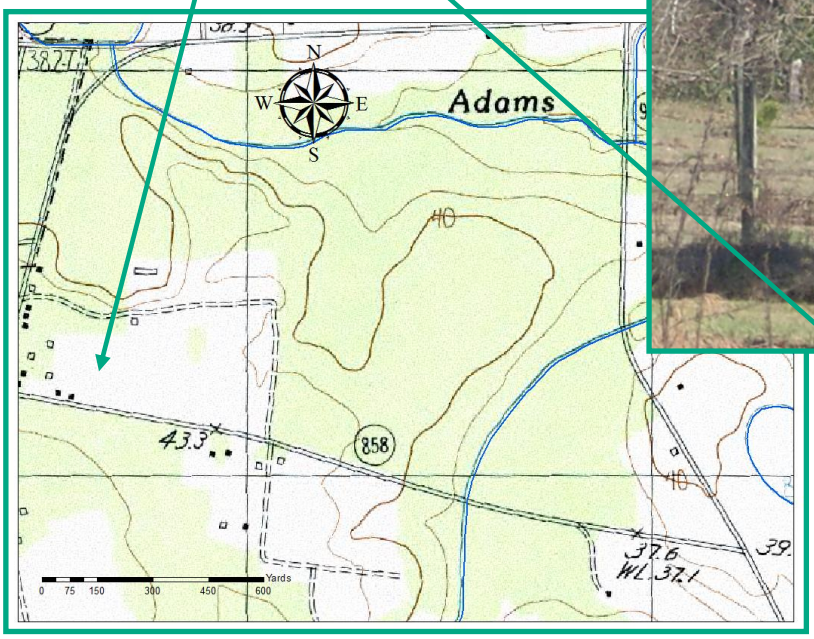


Figure F-17

Pastured horses near Adams branch (location: 34.22087 N, -79.72338 W) on John C. Calhoun Road in Florence County. Found in Reach 4 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).



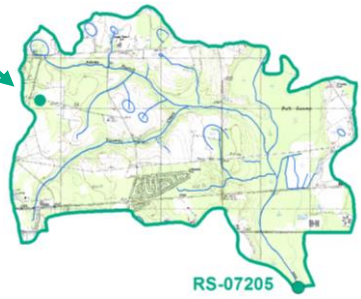


Figure F-18

Pastured horses near Little Willow Creek (location: 34.09907 N, -79.71784 W) on Hewitt Cemetery Road in Florence County. Found in the Willow Creek Watershed (Date of photography: November 19, 2015).

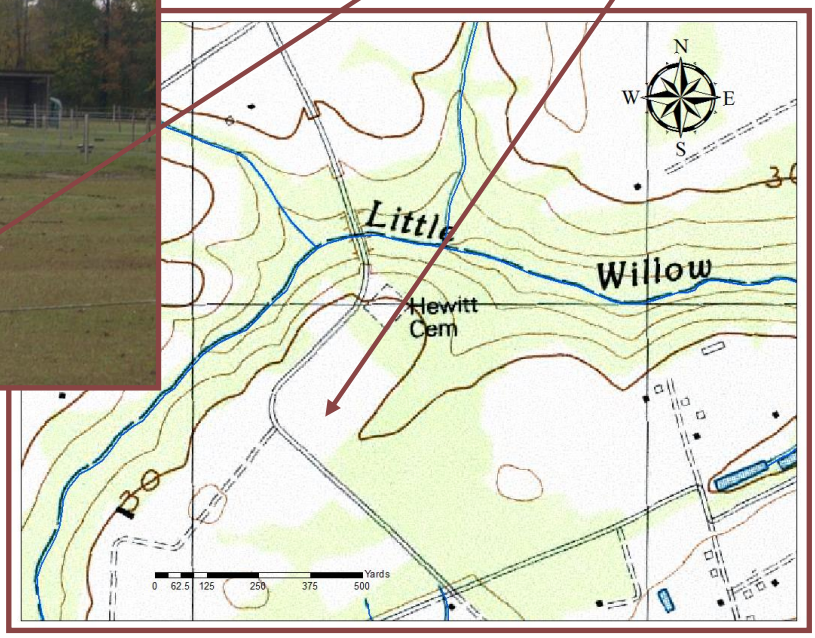
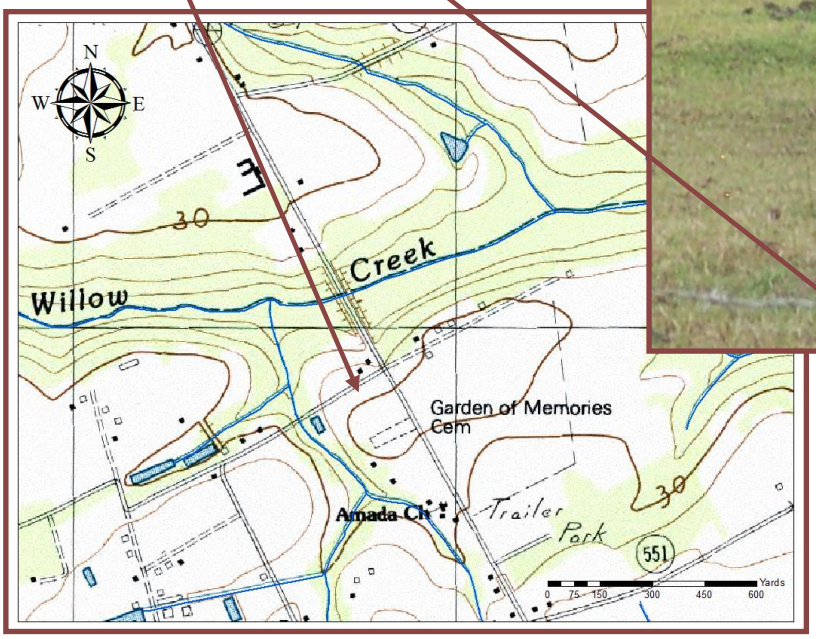


Figure F-19

Donkey in a pasture near Little Willow Creek (location: 34.10060 N, -79.70152 W) on Branch Road in Florence County. Found in the Willow Creek Watershed (Date of photography: November 19, 2015).



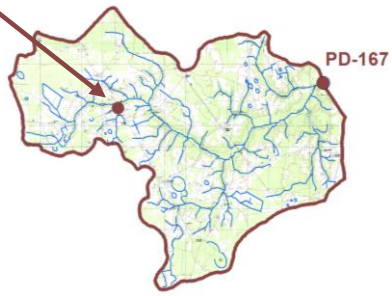


Figure F-20

Pony in yard with a dog (location: 34.21154 N, -79.65544 W) on Fore Road in Florence County. Found in Reach 1 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

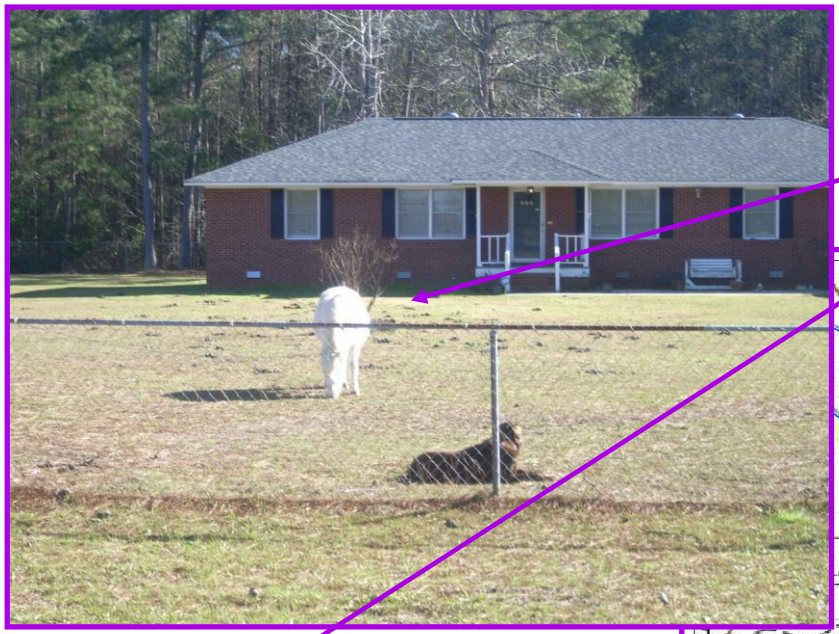
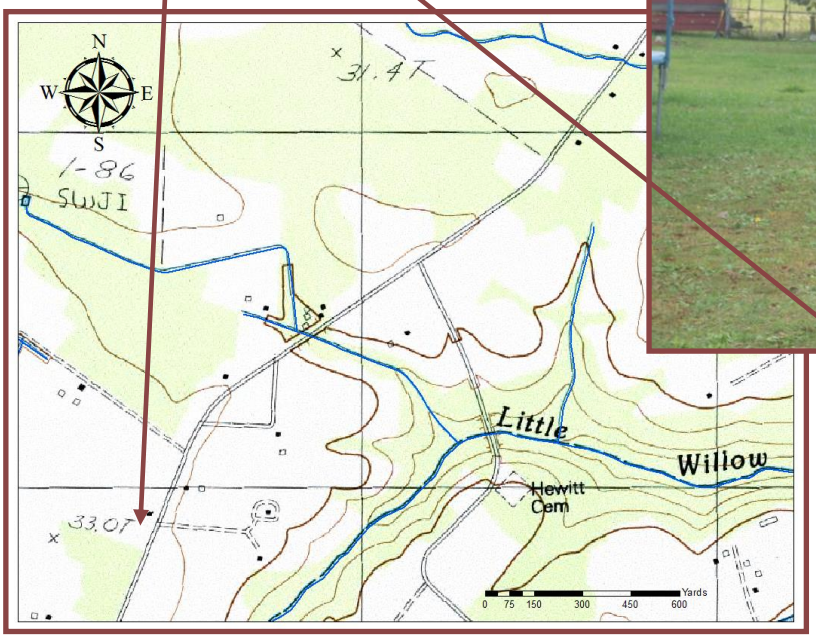


Figure F-21

Hog in a pen near Little Willow Creek (location: 34.10117 N, -79.72680 W) on Cato Road in Florence County. Found in the Willow Creek Watershed (Date of photography: November 19, 2015).



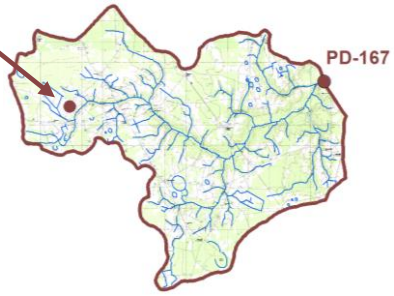


Figure F-22

Hogs and chickens near Willow Creek (location: 34.08143 N, -79.66728 W) on Delosh Road in Florence County. Found in Willow Creek Watershed (Date of photography: January 7, 2016).

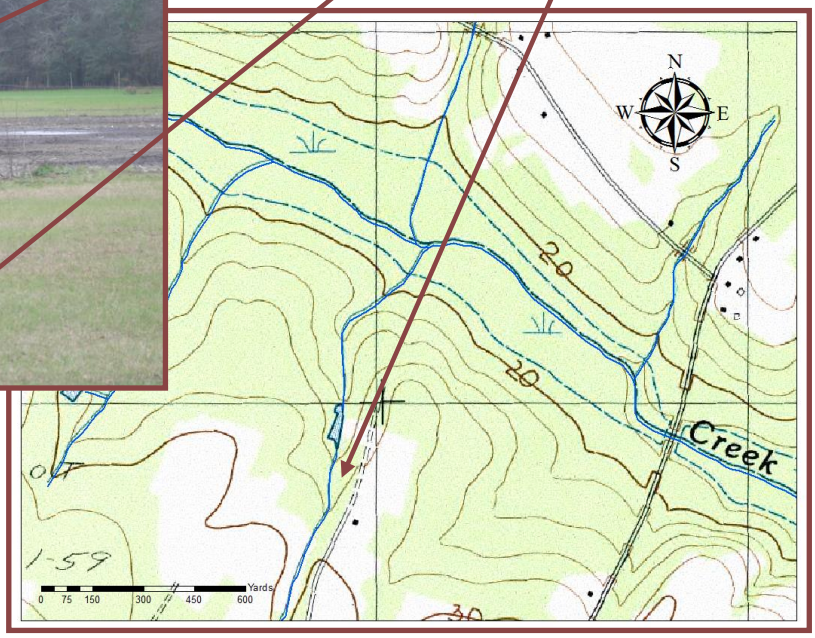
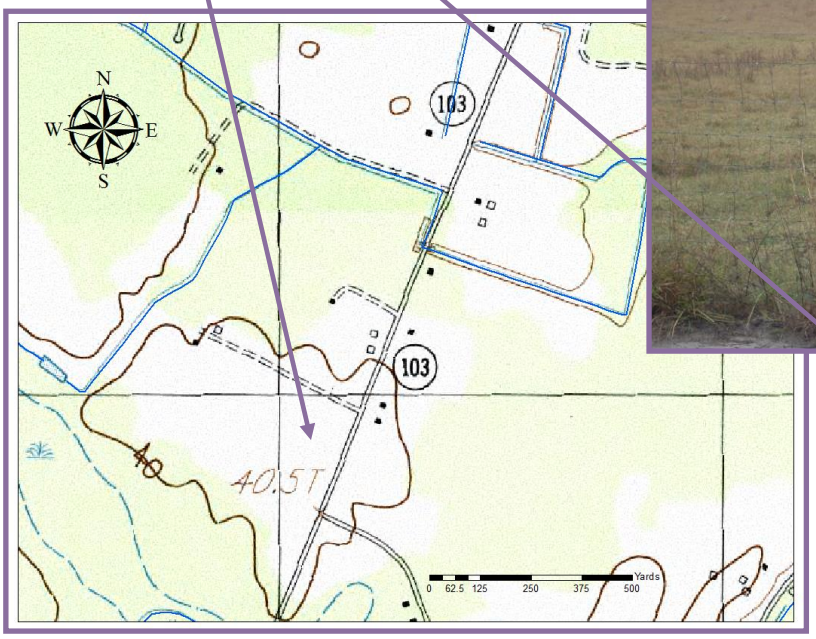


Figure F-23

Pastured goats (location: 34.12108 N, -79.84857 W) on Oliver Road in Florence County. Found in Reach 3 of the Jeffries Creek Watershed (Date of photography: November 19, 2015).



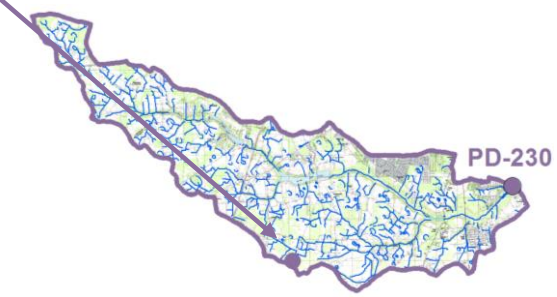


Figure F-24

Pastured goats near Cane Branch (location: 34.13777 N, -79.68190 W) on Claussen Road in Florence County. Found in Reach 5 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

Figure F-25

Pastured goats near Cypress Creek (location: 34.06982 N, -79.65435 W) on Jordan Road in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).

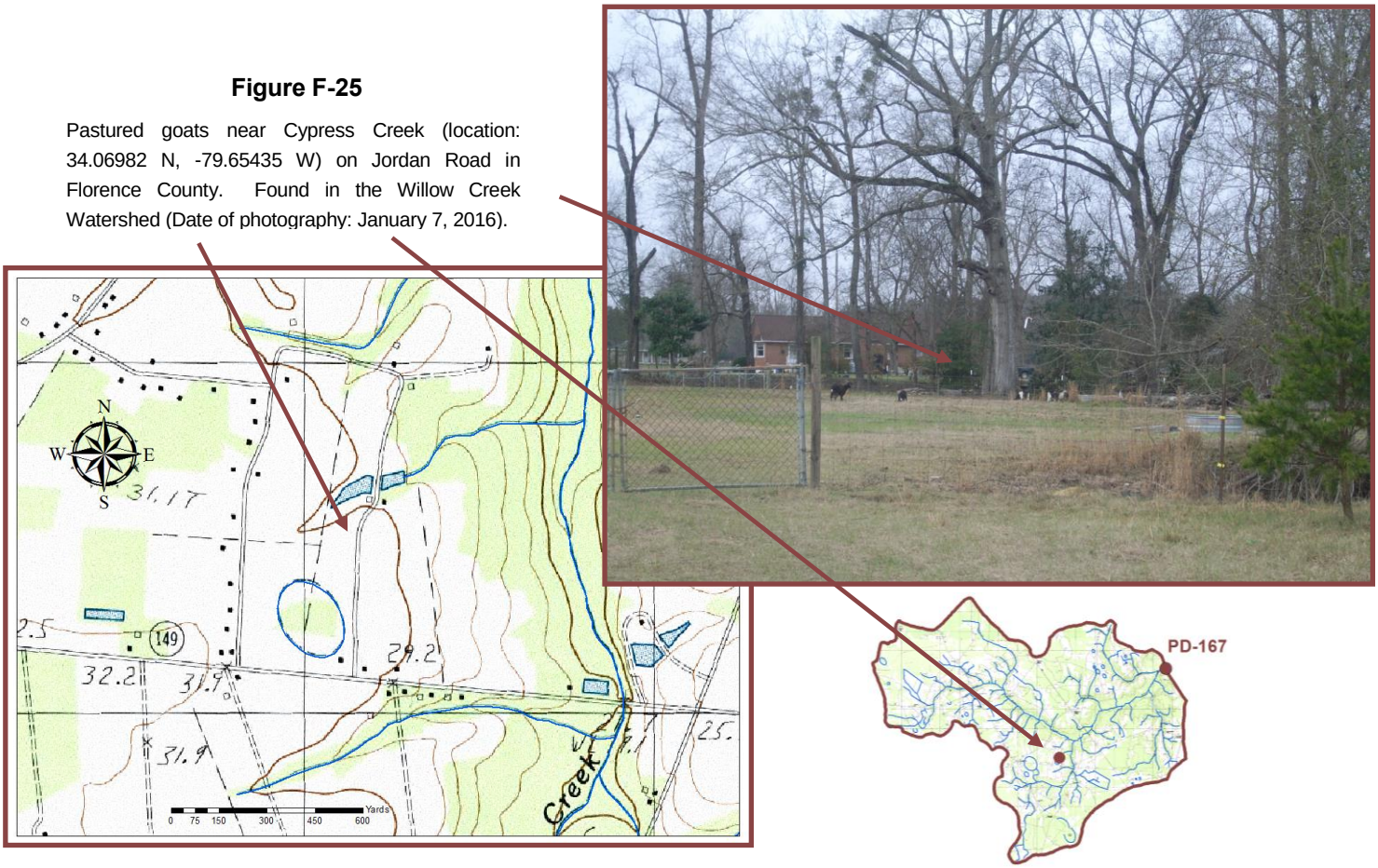


Figure F-26

Chickens and peacocks in a pen (location: 34.14043 N, -79.69048 W) on Claussen Road in Florence County. Found in Reach 5 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

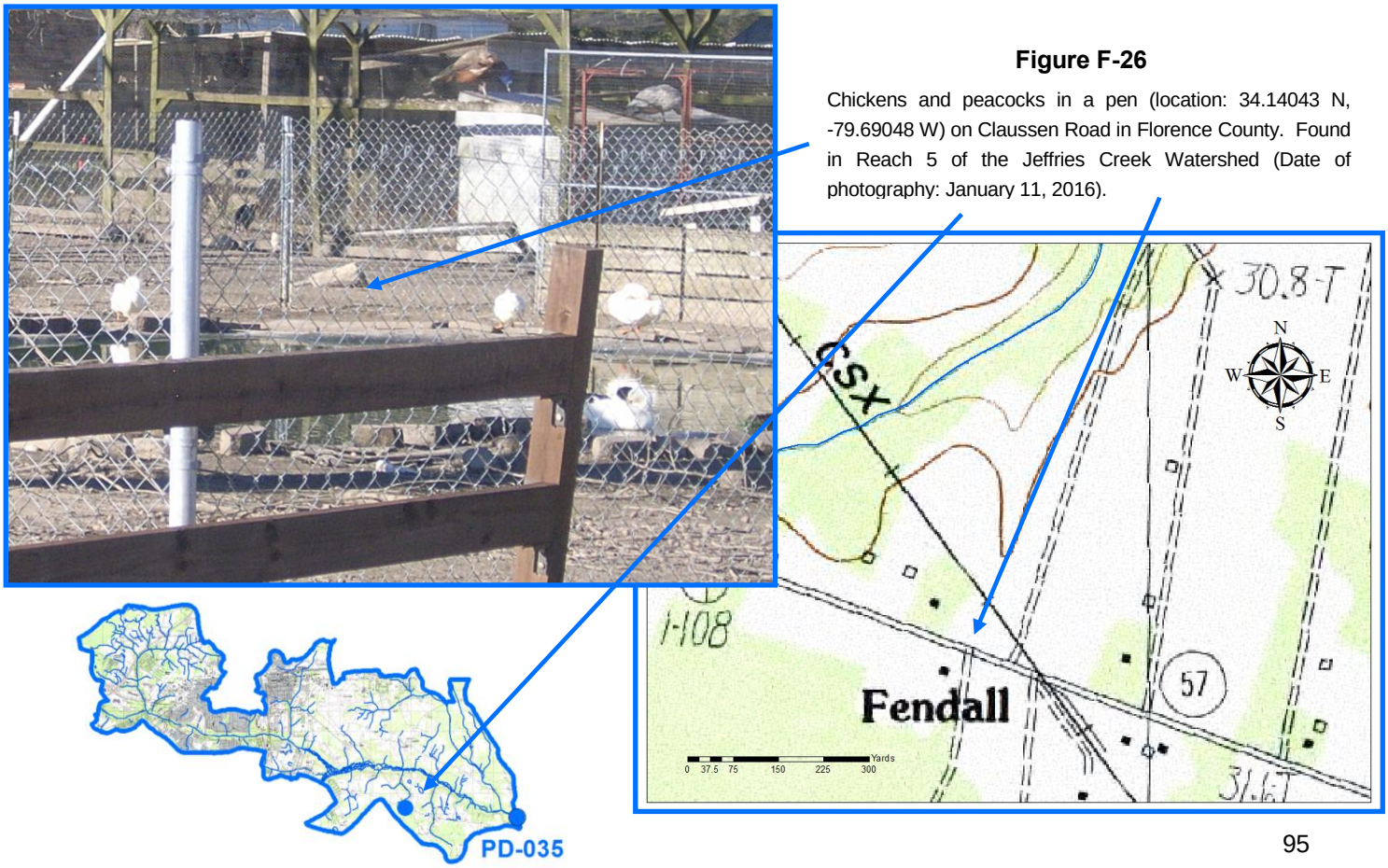
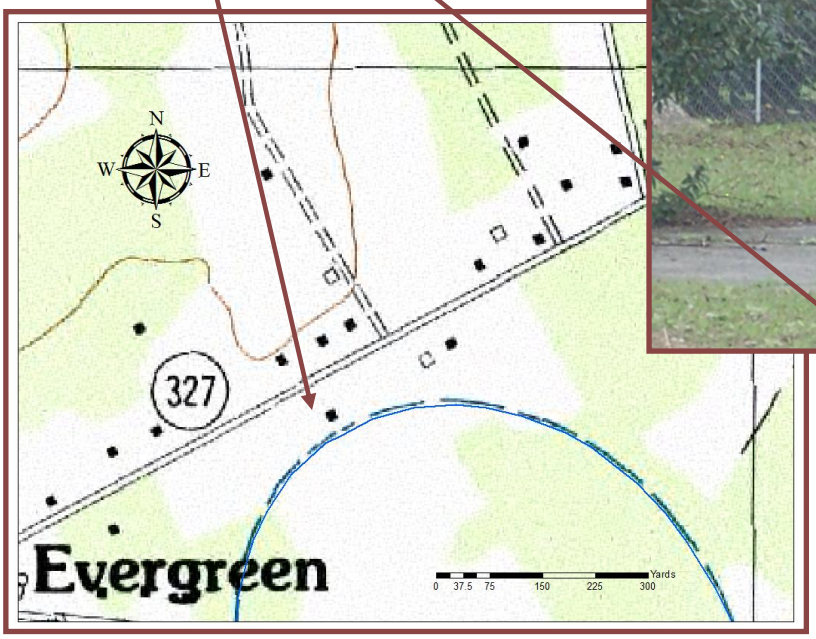


Figure F-27

Chickens in a pen near a Carolina Bay (location: 34.07070 N, -79.67338 W) on SC Route 327 in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).



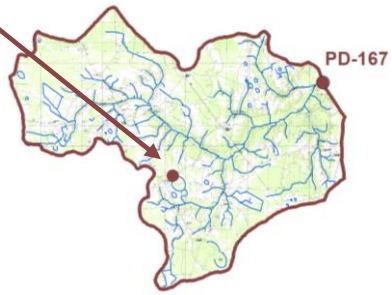


Figure F-28

Unattended dog in yard (location: 34.21387 N, -79.87623 W) on Windburn Drive in Darlington County. Found in Reach 1 of the Jeffries Creek Watershed (Date of photography: October 29, 2015).

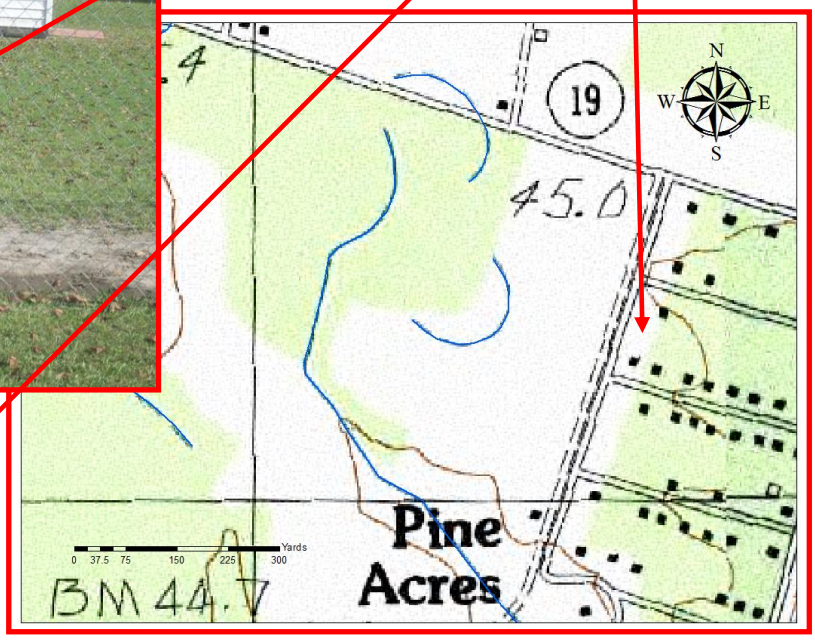
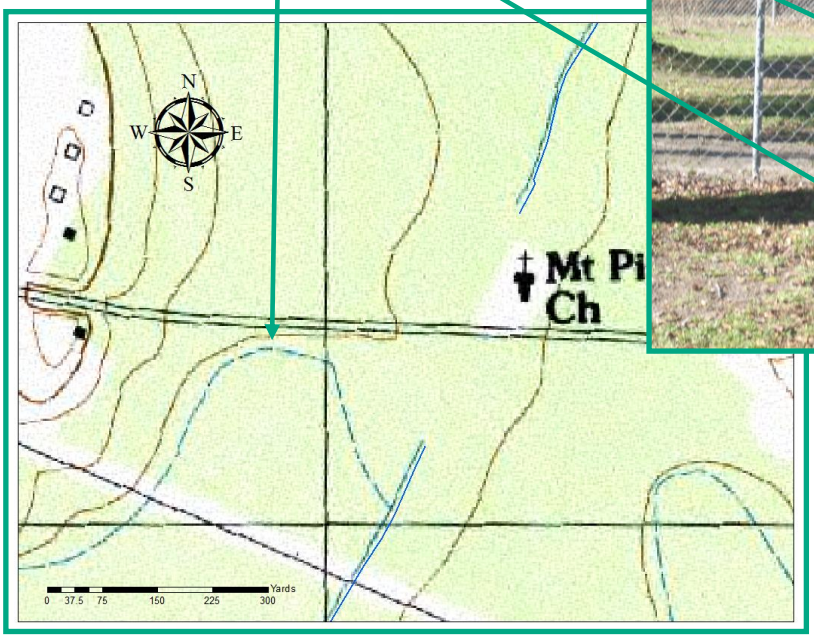


Figure F-29

Unattended dog in yard (location: 34.22998 N, -79.67597 W) on County Route S-21-24 in Florence County. Found in Reach 4 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).



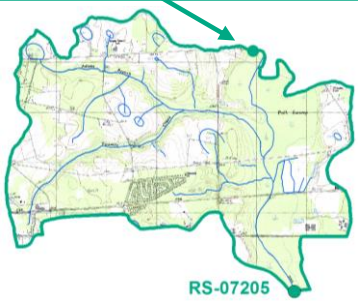
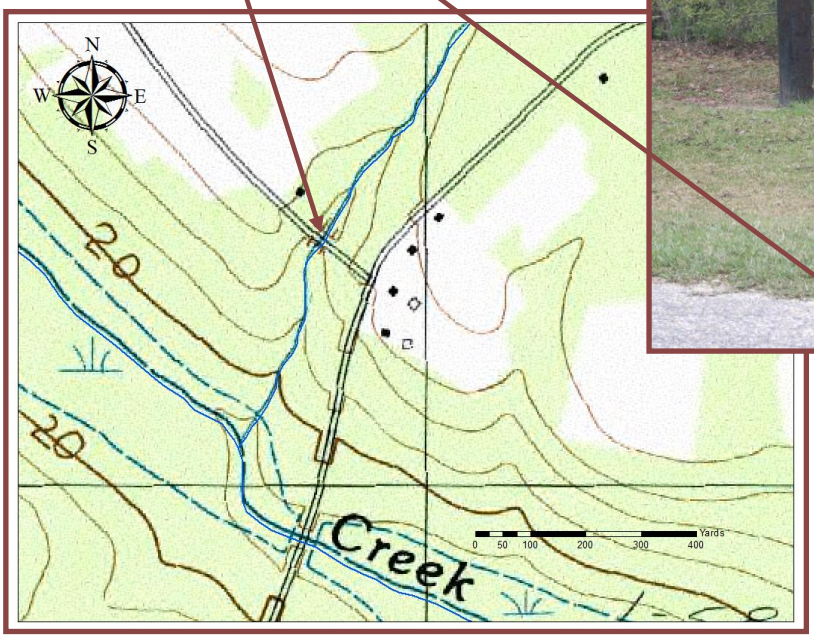


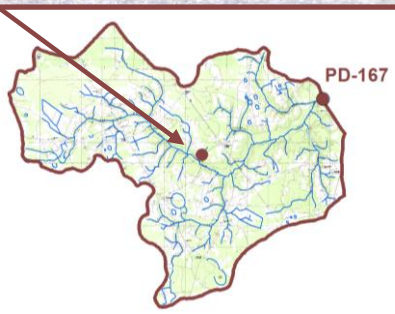
Figure F-30

Unattended dog in yard (location: 34.21233 N, -79.64294 W) on Bailey Lane in Florence County. Found in Reach 6 of the Jeffries Creek Watershed (Date of photography: January 11, 2016).

Figure F-31

Unattended dog in road near Willow Creek (location: 34.08706 N, -79.65767 W) on Megan Road in Florence County. Found in the Willow Creek Watershed (Date of photography: January 7, 2016).





Responsiveness Summary
Jeffries Creek and Tributaries *E. coli* TMDLs Document

In response to the SCDHEC's March 25, 2016 public notice for the Jeffries Creek and Tributaries *E. coli* TMDLs document, the Department received comments from the City of Florence, SC, and the Florence/Darlington Stormwater Consortium (a Service of Clemson Extension). Below are those comments, and the Department's responses to those comments.

Comments from the City of Florence

Comment 1: General

"Gulley Branch" is known as "Gully Branch" in most documentation related to this watershed. Please change reference.

Response 1

The Department is aware of the "Gully Branch" reference in other documentation related to the Jeffries Creek Watershed; however, the Department chose the "Gulley Branch" reference in the JCT Watershed TMDL development document, consistent with the spelling in South Carolina's *Classified Waters* regulations *(R.61-69),* and consistent with the spelling in the State's 2004 §303(d) list of impaired waterbodies.

Comment 2: General

A definitions section and acronyms list would be beneficial. Giving an initial introduction/definition to key terms (TMDL, Margin of Safety, Load Allocation, Point Source, etc) would get the reader familiar with key information prior to reading document. The acronym list would provide a quick reference for the reader.

Response 2

The Department appreciates your comment regarding the abbreviations/acronyms key. DHEC staff will be discussing the possibility developing such a key for future TMDL documents.

Comment 3: General

Acronyms need to be defined with the first use and then only the acronym should be used from that point forward. No need to define multiple times throughout document.

Response 3

The TMDL development document has been revised to ensure that acronyms are defined only with the first use in both the abstract for the TMDL development document and the TMDL development document proper.

Comment 4: General

Be consistent with the use of numbers and parenthesis. Either six or six (6), not back and forth between the two.

Response 4

The Department has amended the TMDL development document to consistently use numbers and parentheses.

Comment 5: General

Be consistent with case throughout the document. Several locations use "we"(1st Person) rather than the Department or the City (3rd Person).

Response 5

The Department has amended the TMDL development document to consistently use “the Department” or “the City.”

Comment 6: General

Round unnecessary decimals. Only use decimals to the hundredth and tenth when they add value to the statement. Is it acceptable to say 98 acres rather than 98.12 acres? Or a 75.5%reduction rather than 75.56% reduction. Fewer numbers improves flow of reading.

Response 6

In the case of the percent reductions of pollutants needed to achieve the TMDLs, the Department does, indeed, round unnecessary decimals (e.g., Table 15, pg. 34; and, Table 16, pg. 36). And, in the case of the percent of samples exceeding the WQS at the WQM Stations, unnecessary decimals are rounded (i.e., Table 7, pg. 18). In these cases, there are no relationships between each entry in the tables. However, in those cases where there are zero-sum relationships between entities, as in the case of categories of land uses within a whole TMDL project development watershed, the Department rounds both the acres of those land use categories and the areal percentages of those land use categories to two significant digits (e.g., Table 2a, pg. 5). And, in reference to the acres of each Reach in the whole JCT Watershed, the Department rounds those acres to two significant digits.

Comment 7: General

Consider information repeated multiple times. Is repeating important information good or is it simply repetitive?

Response 7

The TMDL development document is a large document, and many parts of the document are independent of other parts. Often times information is repeated to provide a foundation for discussion in these independent parts. This allows some sections to be read without referencing other sections of the document.

Comment 8: General

“TMDLs vs TMDL” – Be consistent with plural usage. Both TMDL and TMDLs are technically accurate, but be consistent throughout the document.

Response 8

TMDLs were developed for seven (7) impaired water quality monitoring stations in the TMDL development document. The Department used “TMDLs” (plural usage) to refer to the TMDLs collectively. A TMDL document may include multiple “TMDLS” or a single “TMDL”, depending on the number of impaired locations requiring a reduction in order to meet the applicable water quality standard.

Comment 9: General

Don't start sentences with prepositions - "and", "but", etc.

Response 9

This comment was considered by the Department and determined to be editorial in nature. There are no hard and fast grammatical rules against using “and” or “but” to begin a sentence.

And, to use such may provide a smooth transition between sentences, and is a matter of writing style. No changes were made in the document as result of this comment.

Comment 10: General

The TMDL uses flow information from Columbia and parts of North Carolina. Was consideration given to utilizing the now deactivated USGS Gage 02131110 to derive flow data for Reaches 1 and 3? This seems a much more appropriate and accurate measure of the flows within this watershed.

Response 10

The Department evaluated USGS Gage 02131110 to derive flow data for developing TMDLs in the TMDL development document. However, the gage did not provide an adequate period of record. The gage provided only three years and one month of flow data. The Department prefers at least ten (10) years of flow data. Furthermore, the Department chose USGS gages "…based primarily on the size of the drainage area to the downstream gage, and secondarily on the general land use in the drainage area." (See pg. 29, paragraph 8 of the document). The USGS gage at Mays Store, NC (Gage Number: 0208925200), with a drainage area of 57.7 square miles, is similar in size to Reach 1 and Reach 3 of the Jeffries Creek Watershed (34.00 square miles and 40.57 square miles, respectively). Based on the NLCD, the land use in the drainage area for the Mays Store, NC gage is similar to the land use in Reach 1 and Reach 3 of the Jeffries Creek Watershed. And, the drainage area for the gage lies in the same ecoregion (i.e., the Southeastern Plains) as the two reaches.

Comment 11: Page iii:

"…conditions of its NPDES permit is effective implementation…" should be revised to "…conditions of its NPDES permit is considered effective implementation…"

Response 11

As it pertains to compliance with the conditions of an NPDES permit, "…is effective implementation…", the Department has discussed this internally, and believes this language should not be changed. This language is relevant to all MS4s and should provide all MS4s a greater level of comfort that TMDLs do not result in additional requirements, outside of the terms of conditions of their MS4 permit.

Comment 12: Page 11:

Figure is incorrectly labeled as PD-256, revise to PD-035.

Response 12

Figure 3e in the TMDL development document (pg. 11) has been revised to PD-035.

Comment 13: Page 15, Section 1.3.2.2:

Specific references to the 319 Grant for Gulley (sic) Branch TMDL watershed. While the City of Florence appreciates the acknowledgement of the project being undertaken within the watershed, it is not clear why this is being included as part of the TMDL. The goals of the project are to reduce bacteria to the MEP. However, the effectiveness of the project will be determined through future monitoring. Having this implementation referenced in the TMDL seems unnecessary. Reference to the Watershed Plan (Plan) is acceptable. Since the full implementation of the plan is contingent on several factors within the watershed, and, as acknowledged in the Plan itself, is a living document that can be modified as project and monitoring warrants, it is extremely assumptive to include only one of the several planned projects in the Plan. References, if necessary for the TMDL, should be limited to the fact that the City has developed a plan to be implemented to reduce bacterial loading within the watershed, and should stop short of identifying individual projects. [That is], is the TMDL going to be revised once the next project from the Plan is implemented?

Response 13

Section 1.3.2 *(CWA §319 Load Reduction Project in the Gulley Branch TMDL Watershed)* in the TMDL development document was included to summarize any *CWA §319* grant activity relative to the existing Gulley Branch TMDL, which is currently being revised in this document. Section 1.3.2.2 *(The Timrod Park Restoration Project)* of the document was included to summarize any work in the Gulley Branch TMDL Watershed pursuant to a *CWA §319* grant, at the time of the TMDL revision. Section 1.3.2.2 was not included to critique the efficacy of the LTPRP within the watershed nor does discussion of the CWA *§319* project result in any additional requirements for the grantee. Section 1.3.2.2 was included to only summarize project work ongoing at the time of the Gulley Branch TMDL revision and to acknowledge ongoing efforts in the watershed to reduce pathogen contributions from NPS runoff. While the Department has no plans to revise this document in the immediate future, TMDL documents may be revised at any time, if additional information becomes available and deemed appropriate by the Department.

On page 15, Section 1.3.2.2., the first sentence of the final paragraph has been changed from "The City of Florence has until November 4, 2017 to complete the LTPRP." The sentence now reads: "It is expected that work will continue on the LTPRP through 2017."

Comment 14: Page 15, Table 6:

Table should be after Section 1.3.1, not 1.3.2.

Response 14

This comment was considered by the Department and determined to be editorial in nature. After referring to Table 6 on page 14 of the TMDL development document, there was not enough room for the table on page 14. However, there was room on page 14 to begin Section 1.3.2. Therefore, Table 6 was placed on page 15 after the completion of Section 1.3.2. However, in response to these comments, the Department moved Table 6 to the top of page 15 and before the completion of Section 1.3.2.

Comment 15: Page 15:

"[T]he Lucas Park" "the Timrod Park" should be "Lucas Park" and "Timrod Park", "the" is not necessary.

Response 15

"[T]he" has been removed from "the Timrod Park" and "the Lucas Park" in the TMDL development document.

Comment 16: Page 15:

City should be capitalized in all references to the City of Florence Project.

Response 16

"City" in all references to the City of Florence Project has been capitalized.

Comment 17: Page 17, Section 3.0, first sentence:

This has been explained several times previously in the document. Is it necessary to reiterate it again?

Response 17

As with the SCDHEC's response to the City of Florence's Comment 7, The TMDL development document is a large document, and many parts of the document are independent of other parts. Often times information is repeated to provide a foundation for discussion in these independent

parts. In addition, this allows some sections to be read without referencing other sections of the document.

Comment 18: Page 18, RS-07205 data:

It is recognized through the developed of TMDLs throughout the State, that often times RS data for one sampling year is included in the development of TMDLs. While this practice has been questioned in the past to the accuracy of inclusion in TMDLs, the Department recognizes it as usable data in the development of these documents. This comment is directed as an objection to inclusion of this data. Throughout the TMDL document, and specifically with respect to changes of loading to PD-065, the document recognizes changes in baseline through monitoring periods. If data has improved for PD-065, there is the potential that baseline has also changed for RS-07205. This does place undue burden on the MS4 communities to allocate resources to enact a monitoring program where one may not be necessary to refute the validity of this data.

Response 18

South Carolina has an extensive network of water quality monitoring stations and federal *Clean Water Act* (CWA) does not specify how many stations or a minimum sample size are required for a waterbody. Nor is there a minimum sampling requirement for the development of the 303(d) list or TMDLs.RS-07205 was sampled as a "random" or "probability-based" component of the statewide ambient monitoring strategy in 2007. The goal of "random" monitoring is to sample a location once/month for one year only. There are currently no plans to visit this location in the future. Despite the site currently being inactive, data collected at the location in 2007 demonstrated impairment for FC bacteria. §303(d) of the CWA and USEPA *Water Quality Planning and Management* Regulations (40 CFR Part 130) require states to develop TMDLs water bodies that are included on the §303(d) list of impaired waters.

The Department may in some cases, depending on the circumstances, determine that a particular dataset is not sufficiently representative to calculate a percent reduction. However, the limited data that are available at RS-07205 show impairment, and it is not possible to project that the baseline has changed or no reduction is needed simply based on trends in a different sub-watershed (PD-065). Downstream sites that receive drainage from the RL-07205 sub-watershed would be more indicative of upstream conditions. It is notable that percent reductions at PD-035 (66%) and PD-231 (45%) are similar to the calculated reduction at RS-07205 (53%). On this basis, we conclude the data and percent reductions at RS-07205 are representative, and the TMDL should stand as proposed.

Comment 19: Page 18, first paragraph under Table 8:

This is repetitive information from the last paragraph on page 18. Remove.

Response 19

WQM stations addressed in this TMDL development document are listed on South Carolina's 2014 §303(d) list as impaired for freshwater recreational use due to *E. coli* Bacteria. The first two sentences in the paragraph under Table 8 on page 18 of the document makes the connection between *E. coli,* a pathogen indicator, "full body contact" recreation, and "risk to public health." As such, the Department does not deem the first two sentences of the paragraph to be repetitive. The last two sentences of the paragraph are repetitive and have been removed.

Comment 20: Page 20, Section 3.1.2:

Town of Quinby is an existing MS4.

Response 20

The TMDL development document has been revised to note that the Town of Quinby is an existing small MS4 (see pg. 20, paragraph 3; and, pg. 22, paragraph 3 of the document).

Comment 21: Page 26:

"The poultry operation is considered according to Section 122.23…" Is considered what?

Response 21

"The poultry operation is considered according to Section 122.23…" in paragraph one on page 26 of the TMDL development document has been revised to "The poultry operation is regulated according to Section 122.23…"

Comment 22: Page 27, Section 3.2.5, first sentence:

Remove "however."

Response 22

The Department removed “however” from the first sentence in Section 3.2.5 on page 27 of the TMDL development document.

Comment 23: Page 29, Paragraphs 3 and 4:

Remove "however" from last sentence.

Response 23

This comment was considered by the Department and determined to be editorial in nature. The Department did not remove "however" from last sentences in paragraphs 3 and 4 on page 29 of the TMDL development document. “However” at the beginning of a sentence may be used to introduce a statement that contrast, or seems to contrast, something that has previously been said.

Comment 24: Page 29, Paragraph 6:

If you are taking percentages to two decimal places you are representing exact percentages, but the text uses the words "approximately" and "about". These two relationships are in conflict with each other.

Response 24

The TMDL development document has been revised to remove “approximately” in reference to percentages taken to two decimal places, particularly those percentages that are part of zero-sum relationships.

Comment 25: Page 30, Paragraph 1:

If you are taking percentages to two decimal places you are representing exact percentages, but the text uses the word "approximately". These two relationships are in conflict with each other.

Response 25

As with the SCDHEC’s response to the City of Florence’s Comment 24, the TMDL development document has been revised to remove “approximately” in reference to percentages taken to two decimal places.

Comment 26: Page 33, Section 5.3:

Waste load Allocation title, capitalize "load."

Response 26

The word “load” has been capitalized in the title for Section 5.3 on page 33 of the TMDL development document.

Comment 27: Page 25, First Paragraph:

The last sentence seems out of place. This is discussed on Page 21, so is not necessary here and is out of context with the rest of the section.

Response 27

Section 3.2.1 of the TMDL development document discusses wildlife as significant nonpoint source contributors of *E. coli* and other FC bacteria in the Jeffries Creek and Tributaries watersheds. The last sentence of the first paragraph in that section merely quantifies the number of deer in a portion of Reach 1 of the Jeffries Creek Watershed. The Department does not believe that the sentence is out of context with the rest of the section.

Comment 28: Pages 39-40:

This section outlines the six MCMs as required by the Phase II NPDES Permit. Provide sub-headings of the six MCMs as you are allocating one paragraph to each MCM. This will help distinguish the requirements of each MCM to the layman as well as potential new MS4s within the TMDL coverage area.

Response 28

In providing Section 6.1.2 (Implementation Strategies for Non-Continuous Point Sources) in the TMDL development document (pgs. 38 – 40), the Department did not intend to provide comprehensive details on such strategies. However, the reader is directed to Section 7.0 of the document for resources on implementation strategies, including the six MCMs (minimum control measures) required for MS4s covered under a Phase II NPDES Permit.

Comment 29: Page 52-54:

The charts show a WQ Standard of both 349 cnt/100mL and 349 cfu/100mL. This should be cfu/100mL consistently. Please revise.

Response 29

Where necessary, the Department revised the Precipitation and *E. coli* Bacteria/FC Bacteria Data charts for all seven (7) TMDL development watersheds (pg. 18, and pgs. 52 – 54). The appropriate unit for FC Bacteria is cfu, and the appropriate unit for *E. coli* Bacteria is MPN.

Comments from the Florence/Darlington Stormwater Consortium

According to the Consortium, their comments "…are in reference to the TMDL for the Jeffries Creek Watershed and Tributaries, and in regard to the connection to the [NPDES general permit for storm water discharges from Small MS4s] and its public education and involvement measures of compliance."

Comment 1:

The FDSC would like to [be] listed as a potential partner in working with local audiences to minimize the risk of bacteria and *E. coli* inputs to stormwater.

Response 1

The TMDL development document encourages MS4 communities to utilize partnerships when developing and implementing a stormwater management program (see Section 6.1.2, paragraph 3, pg. 40 of the document). The document notes that watershed associations, educational organizations, and state, county, and city governments are all examples of possible partners with resources that can be shared. And, the document direct the reader to contact the SCDHEC Watershed Manager for the waterbody of concern for additional information on partnerships. The Watershed Manager for the Pee Dee River Basin is going to add the FDSC to the list of watershed organizations on the Department's website.

On page 40, Section 6.1.2, *Non-Continuous Point Sources*, the following language has been added: “Clemson Carolina Clear and the Florence Darlington Stormwater Consortium are currently two organizations working cooperatively with regulated MS4s in the JCT watershed to address permit requirements and reduce FC bacteria or *E. coli* loadings from non-continuous point sources”.

On page 45, Section 6.1.7, *Urban Runoff*, the following language has been added: Some organizations currently supporting with educational/outreach activities to reduce FC bacteria or *E. coli* loadings from urban runoff within the Jefferies Creek Watershed are Clemson University Carolina Clear, the Florence/Darlington Stormwater Consortium and Keep Florence Beautiful. In addition, the Lucas Park Homeowner’s Association and Timrod Park Neighborhood Association are cooperators for the ongoing Lucas and Timrod Park Restoration Project, which is currently underway.

Comment 2:

As related to the TMDL, the FDSC has held numerous programs in the Jeffries Creek Watershed relating to treating stormwater, rainwater harvesting, and management of dog waste. Examples include rain barrel sale based at Timrod Park, rain garden installation with educational signage and subsequent volunteer work days at Timrod Park, dog waste station grants to neighborhoods and MS4 parks, and distribution of dog waste disposal information and portable bag dispensers through the Florence Area Humane Society and at public events such as Canines in Costume for a Cause held at Timrod Park.

Response 2

The Department acknowledges the efforts of the FDSC in regard to connection to the public education and involvement measures.

Comment 3:

Previous conversations with SC DHEC have included the potential to estimate pollutant loading reduction based on outreach efforts in a watershed. The consortium feels that this possibility, and the more important possibility of demonstration installations leading to measurable changes in pollutant loading, would be best measured by a river gage within the Jeffries Creek Watershed. We understand that SC DHEC relied on gaging stations in North Carolina and in Columbia, SC, with similar watershed sizes and land use to develop the load-duration curve. In consideration of ongoing projects, the ability to determine the success of education and demonstration efforts, and for overall improved watershed management, the consortium would like to suggest the installation of a river gage at PD-035 and/or PD-231, which would also allow managers to assess contributions of Jeffries Creek to the Pee Dee River.

Response 3

The Department developed TMDLs for impaired locations in the JCT Watershed using existing, readily available data. At this time, the Department has no plans to deploy additional resources for the purpose of installing an instream flow gaging station. The Department understands the value/importance of collecting instream flow data in the JCT watershed. The United Stated Geological Survey (USGS) gaging stations may be installed cooperatively by interested parties. The Department recommends the FDSC or any other interested party to contact USGS-SC Water Science Center at (803) 750-6181 regarding the feasibility of installing a flow gaging station in the JCT Watershed.

Comment 4:

Relating to Figure 5, the consortium would like to request that this graph be modified to show Fecal Coliform results as a point (representing the individual result of that sample), and that precipitation be shown as either a daily accumulation (bar) or line (if data is consistently recorded) with a non-inverted axis. This important connection between rainfall and bacteria count could be an important tool in outreach and building awareness if provided in a larger space such as full page landscape.

Response 4

The Department believes that Figure 5 in the TMDL development document is an appropriate presentation of the relationship between precipitation and FC Bacteria by date for WQM Station PD-231 in Reach 6 of the Jeffries Creek Watershed. The Department believes that the representation of precipitation by a bar or line would be overwhelming in the graph, since the precipitation events are much more numerous than the FC Bacteria monitoring events. Also, the Department believes that the inverted axes for FC Bacteria (primary horizontal axis) and precipitation (secondary horizontal axis) best shows the relationship between these two variables, particularly since the two variables share the same time line.

Comment 5:

The opportunity to receive 319(h) funding to implement load allocation reductions (not wasteload allocations), as documented in this TMDL is mentioned in Section 6.0 Implementation. The consortium understands that use of these funds is limited for permitted MS4 areas in that it can not be used to treat stormwater discharging to waterways. This section may need further clarification on how 319(h) may be applicable within an MS4 if it is unrelated to stormwater discharges per the permittee, as well as incorporating text clarifying the requirement of a watershed based plan to prioritize the proposed projects for 319(h) use.

Response 5

Restated differently, regulated MS4s are subject to the WLA component of a TMDL; therefore, Section 319 funding is unavailable to implement the WLA component of the TMDL as described in the JCT Watershed TMDL document. Section 319 funding is available for BMPs that are not required under an NPDES MS4 permit and covered under LA component of a TMDL. Section 3.2 of the TMDL describes FC bacteria and *E. coli* sources that are considered part of the TMDL LA. BMPs to reduce loadings from those sources are eligible for funding.

The Department appreciates the request for greater guidance regarding Section 319 funding within MS4 areas. The Department believes each MS4 jurisdictional area is unique and additional details regarding opportunities for Section 319 funding in specific MS4 areas would be best provided by contacting either the Department's NPS Coordinator. See: http://www.scdhec.gov/HomeandEnvironment/BusinessesandCommunities-GoGreen/EnvironmentalGrantsandLoans/319NonpointSourcePollutionGrants/ or, the appropriate watershed manager, See: http://www.scdhec.gov/HomeAndEnvironment/Water/Watersheds/Contacts/