TOTAL MAXIMUM DAILY LOADS

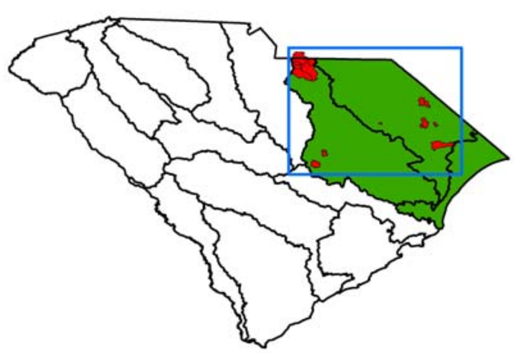
FOR

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 Diver Basin, South Carolina

Hydrologic Unit Codes: 03040202, 03040205, 03040201, and 03040204



Pee Dee River Basin

September 2005

SCDHEC Technical Report Number: 029-05

United States Environmental Protection Agency

Region 4 serving the southeast

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Loads (TMDLs) 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 Diver Basin. Subsequent actions must be consistent with this TMDL.

James D. Giattina, Director
Water Management Division

Date

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
AFO	Animal feeding operation
ASAE	American Society of Agricultural Engineers
BMP	Best management practice
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
cfs	Cubic feet per second
cfu	Colony-forming units
CWA	Clean Water Act
DMR	Discharge monitoring report
HUC	Hydrologic unit code
LA	Load allocation
LDC	Load duration curve
mg	Million gallons
mgd	Million gallons per day
ml	Milliliter
MOS	Margin of safety
MS4	Municipal separate storm sewer system
NC	North Carolina
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSFC	National Small Flows Clearinghouse
OSWD	Onsite wastewater disposal
PRG	Percent reduction goal
SC	South Carolina
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Caroline Department of Natural Resources
SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
UA	Urban area
UC	Urban cluster
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	Wasteload allocation
WQM	Water quality monitoring
WQS	Water quality standard
WWTP	Wastewater Treatment Plant

SECTION 1
INTRODUCTION

1.1 Background

Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require States to develop total maximum daily loads (TMDL) for water bodies not meeting designated uses where technology-based controls are in place. TMDLs establish the allowable loadings of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and in-stream water quality conditions, so States can implement water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of its water resources (USEPA 1991).

This report documents the data and assessment utilized to establish TMDLs for fecal coliform bacteria for certain water bodies in the Pee Dee River Basin in South Carolina (SC) in accordance with requirements of Section 303(d) of the CWA, Water Quality Planning and Management Regulations (40 CFR Part 130), USEPA guidance, and South Carolina Department of Health and Environmental Control (SCDHEC) guidance and procedures. States are required to submit all TMDLs to USEPA for review and approval. Once USEPA approves a TMDL, the water body may then be moved to Category 4a of a State's Integrated Water Quality Monitoring and Assessment Report, where it remains until compliance with water quality standards (WQS) is achieved (USEPA 2003).

The purpose of this TMDL report is to assist SCDHEC with establishing pollutant load allocations for impaired water bodies. TMDLs determine the pollutant loading a water body can assimilate without exceeding the WQS for that pollutant. TMDLs also establish the pollutant load allocation necessary to meet the WQS established for a water body based on the relationship between pollutant sources and in-stream water quality conditions. A TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources, and includes stormwater discharges regulated under the National Pollutant Discharge Elimination System (NPDES) as point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with model assumptions and data limitations.

SCDHEC included 16 water quality monitoring (WQM) stations from the 8-digit Hydrologic Unit Codes (HUC) 03040202, 03040205, 03040201, and 03040204 within the Pee Dee River Basin on the 2004 South Carolina §303(d) list for exceedances of fecal coliform bacteria WQS. Figures 1-1, 1-2, 1-3 are detailed orientation maps depicting the individual watersheds of the 303(d)-listed WQM stations not meeting the instantaneous fecal coliform WQSs of 400 colony-forming units (cfu)/100 milliliters (ml) for primary contact recreation.

The TMDLs in this report will affect water bodies in Lancaster, Chesterfield, Sumter, Florence, Horry, Marion, and Dillon Counties.

Figure 1-1 Hills Creek, Lynches River, North and South Branch of Wildcat Creek, and Flat Creek Watersheds

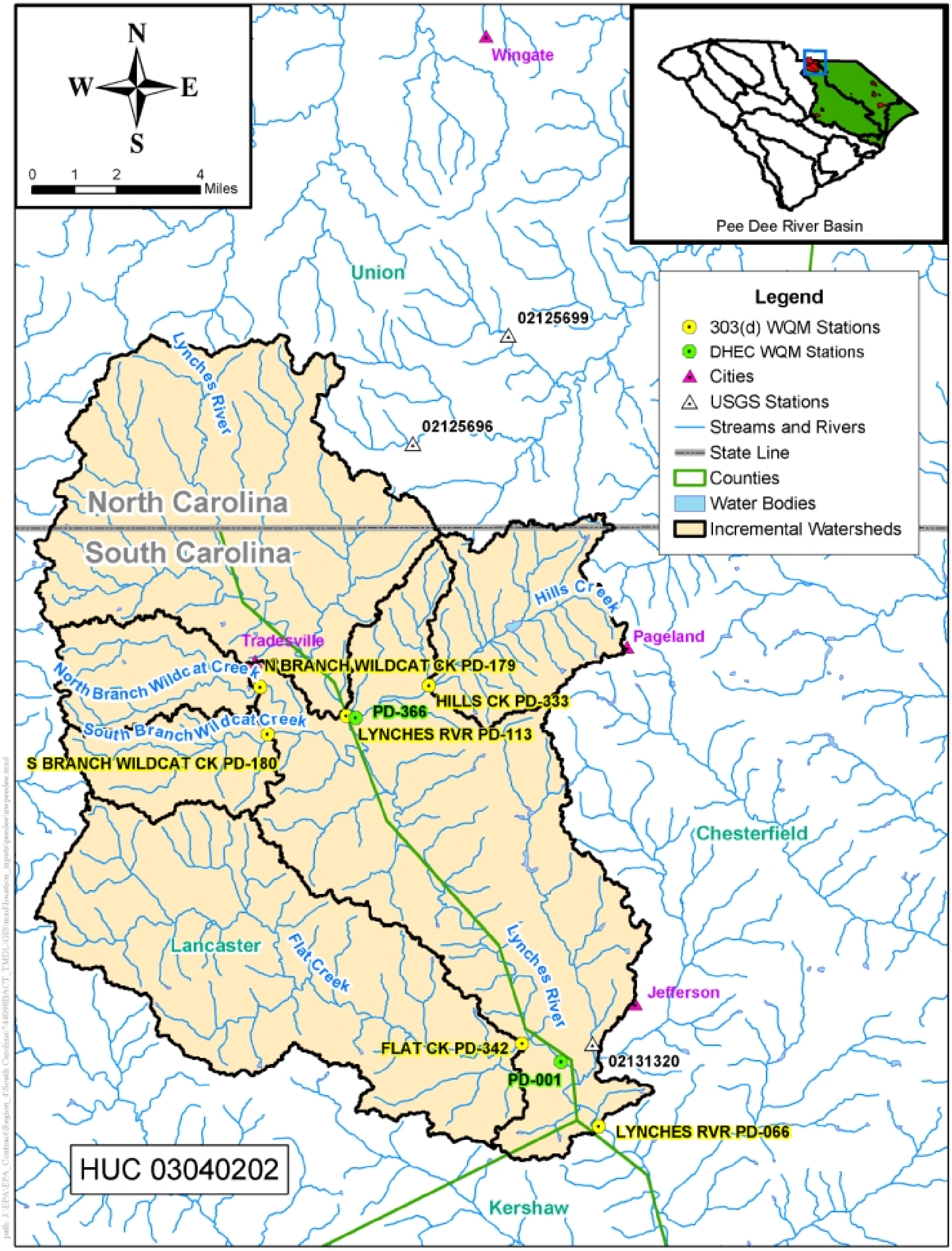


Figure 1-2 Turkey Creek and Nasty Branch Watersheds

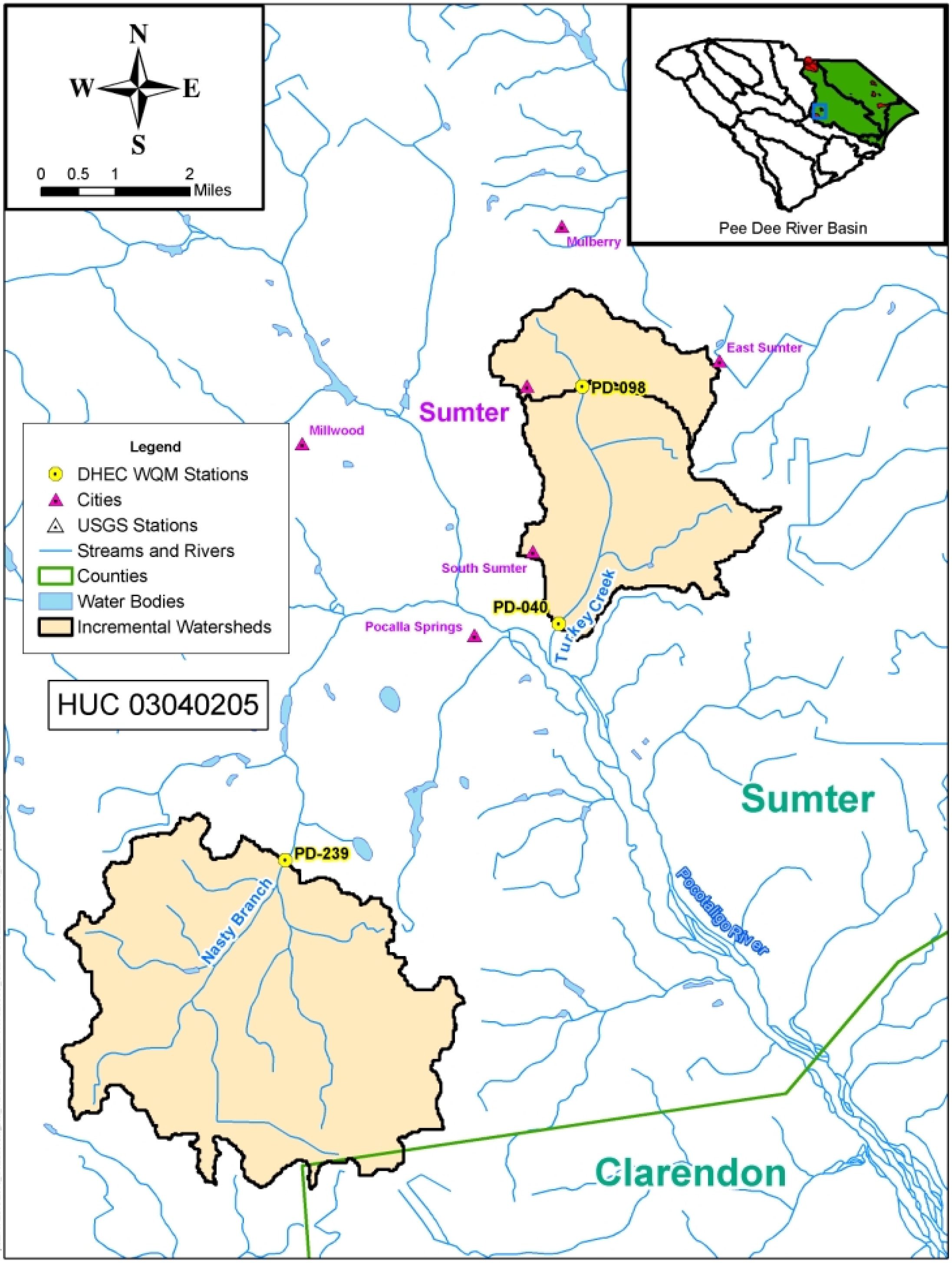
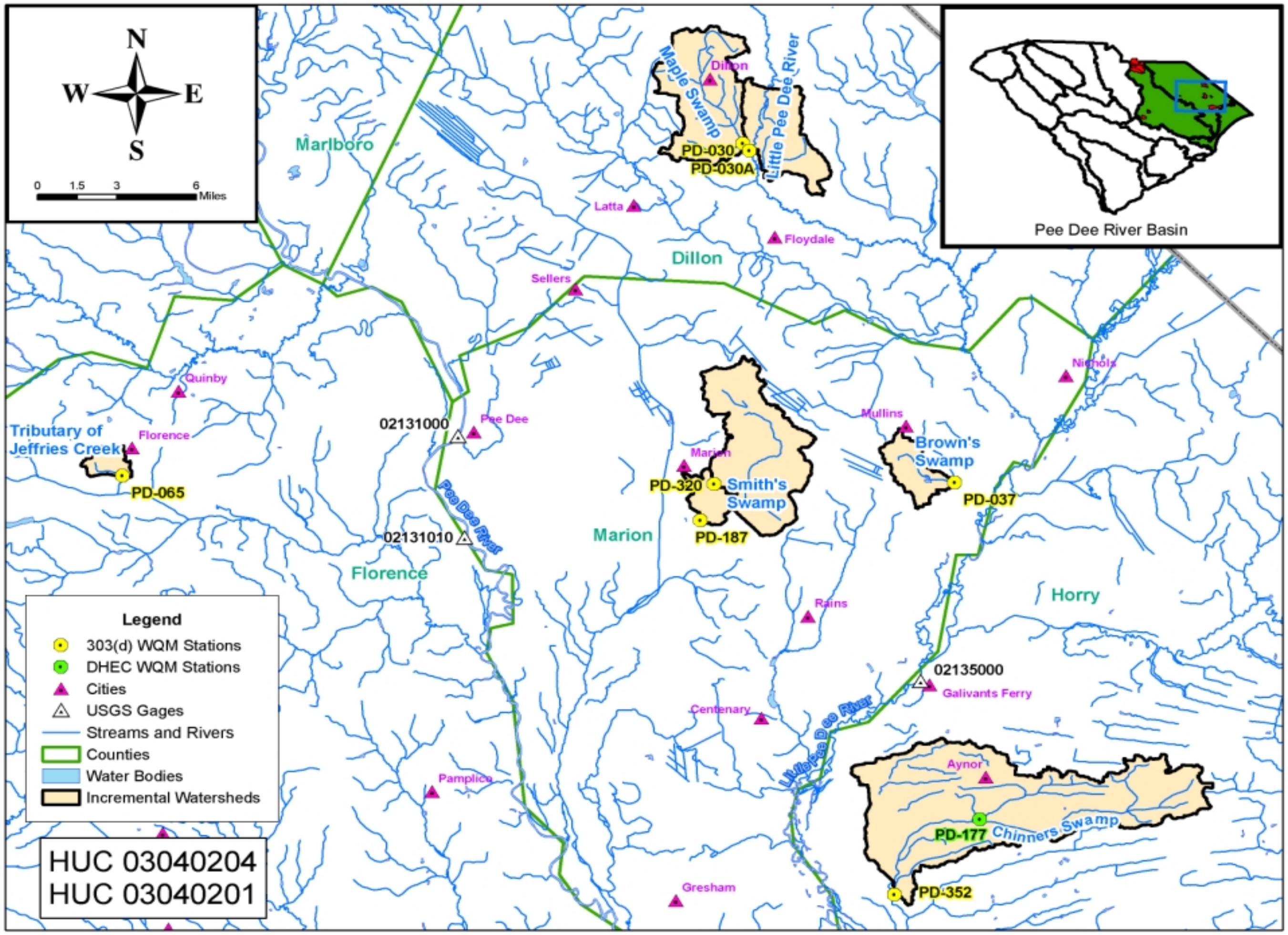


Figure 1-3 Gulley Branch, Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp Watersheds



The 303(d)-listed WQM stations associated with these water bodies are shown in Table 1-1 below and are generally listed upstream to downstream. The WQM stations are grouped by HUCs identified with 11 digits to further define their geographic location. The presence of fecal coliform bacteria in aquatic environments indicates the receiving water is contaminated with human or animal fecal material. Fecal coliform bacteria contamination is an indication that a potential health risk exists for individuals exposed to the water. Implementation of fecal coliform bacteria loading controls will be necessary to restore the primary contact recreation use designated for each water body listed in Table 1-1.

Table 1-1 Water Quality Monitoring Stations on 2004 303(d) List for Fecal Coliform in the Pee Dee River Basin

Water Body Name	SCDHEC WQM Stations	WQM Station Locations
HUC 03040202020		
Hills Creek	PD-333	Hills Creek at S-13-105
HUC 03040202030		
Lynches River	PD-113	Lynches River at SC 9 W of Pageland
North Branch	PD-179	North Branch Wildcat Creek at S-29-39 1 mi S of Tradesville
South Branch	PD-180	South Branch Wildcat Creek at S-29-39 2 mi S of Tradesville
HUC 03040202040		
Flat Creek	PD-342	Flat Creek at S-29-123
HUC 03040202050		
Lynches River	PD-066	Lynches River at S-28-42
HUC 03040205080		
Turkey Creek	PD-040	Turkey Creek at US 521
Turkey Creek	PD-098	Turkey Creek at Liberty St in Sumter above Santee Print Works
Nasty Branch	PD-239	Nasty Branch at S-43-251 7.5 mi SW of Sumter
HUC 03040201130		
Gulley Branch	PD-065	Gulley Branch at S-21-13, Timrod Park
Smith Swamp	PD-187	Smith Swamp at US 501 1.9 mi SSE of Marion
Smith Swamp	PD-320	Smith Swamp at S-34-19 1 mi E of Marion
HUC 03040204030		
Little Pee Dee River	PD-030A	Little Pee Dee River Below JCT with Maple SWP
Maple Swamp	PD-030	Maple Swamp at SC57
HUC 03040204070		
White Oak Creek	PD-037	White Oak Creek at S-34-31
HUC 03040204090		
Chinners Swamp	PD-352	Chinners Swamp at Gunters Island Rd off S-26-99

1.2 Watershed Description

1.2.1 General

Figure 1-4 depicts the Pee Dee and Lynches River Basins and highlights the 11-digit HUCs with WQM stations addressed in this report. The Pee Dee River Basin (also referred to as the Great Pee Dee River) encompasses 27 watersheds, and 3,425 square miles within SC, excluding the Lynches River and Black River Basins. The Pee Dee River flows across the Sandhills region to the Upper and Lower Coastal Plain regions and into the Coastal Zone region. Land use within the basin consists of 36.0 percent forested land, 23.0 percent agricultural, 19.6 percent scrub/shrub land, 16.5 percent forested wetlands (swamp), 2.5 percent urban land, 1.3 percent water, 1.0 percent nonforested wetlands (marsh), and 0.1 percent barren land. The urban land percentage comprises the Cities of Florence, Darlington, Bennettsville, and Dillon. In the Pee Dee River Basin, there are approximately 9,969 acres of lake waters and 1,522 acres of estuarine areas. The Pee Dee River flows across the North Carolina/South Carolina state line and accepts drainage from Thompson Creek, Crooked Creek, Cedar Creek, Three Creeks, and Black Creek. The Pee Dee River then accepts drainage from Jeffries Creek, Catfish Creek, the Lynches River Basin, the Little Pee Dee River, and the Black River Basin before draining into Winyah Bay (SCDHEC 2005).

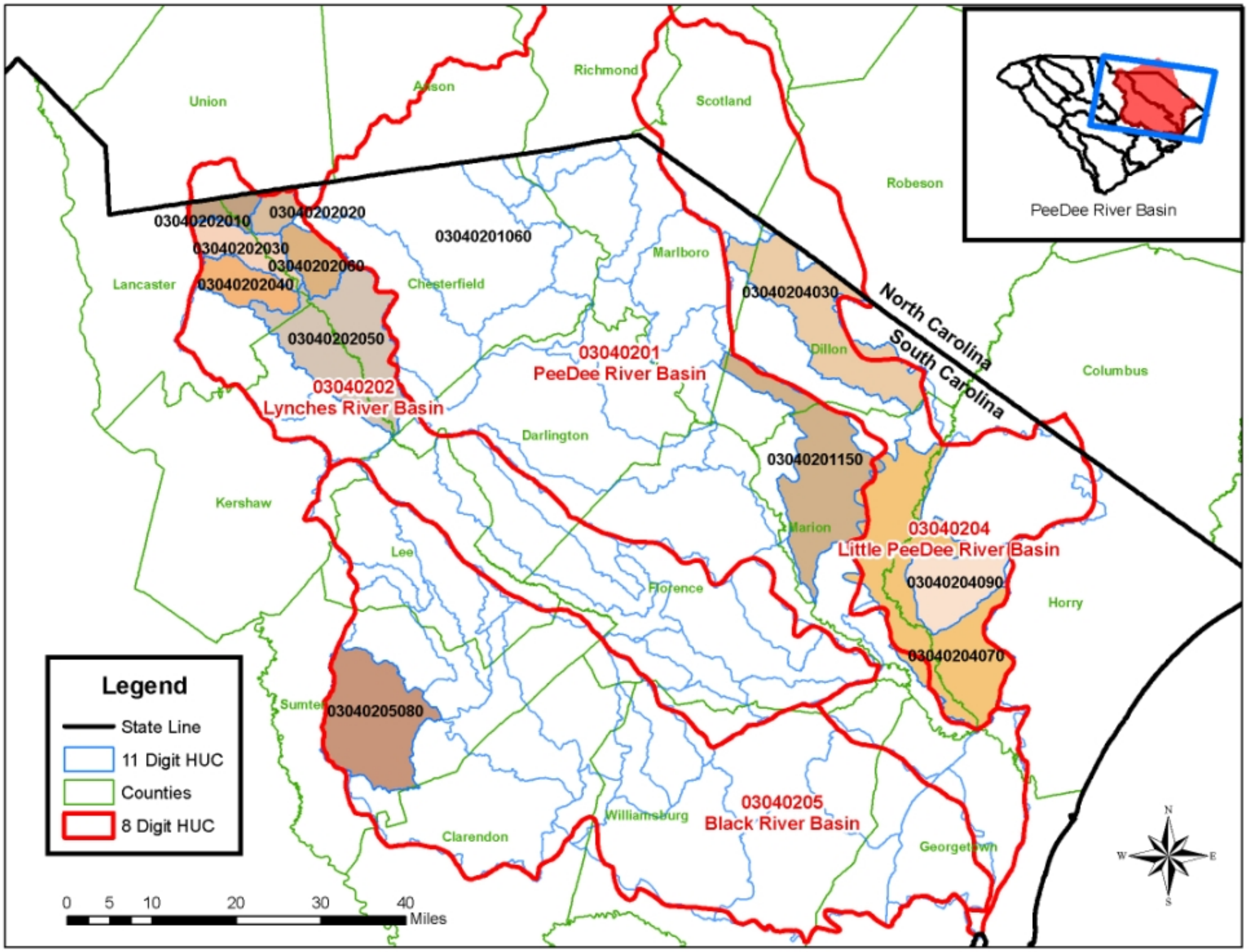
The Lynches River Basin encompasses 1,386.8 square miles with geographic regions that extend from the Piedmont to the Sandhills, and to the Upper and Lower Coastal Plains. The Lynches River Basin encompasses 17 watersheds and 887,524 acres, of which 45.0 percent is forested land, 30.3 percent is agricultural land, 16.8 percent is scrub/shrub land, 6.4 percent is forested wetlands (swamp), 0.7 percent is urban land, 0.4 percent is barren land, 0.3 percent is water, and 0.1 percent is nonforested wetlands (marsh). The urban land percentage comprises the City of Lake City. This predominantly rural area has approximately 1,624 stream miles and 1,310 acres of lake waters. The Lynches River originates in North Carolina (NC) and accepts drainage from Flat Creek, Fork Creek, the Little Lynches River, Sparrow Swamp, Big Swamp, and Lake Swamp before draining into the Pee Dee River (SCDHEC 2005).

1.2.2 Physiographic Regions

South Carolina is divided into six major land resource areas by the U.S. Department of Agriculture (USDA) Soil Conservation Service. The major land resource areas are physiographic regions that have soil, climate, water resources, and land uses in common. Physiographic regions that define the Pee Dee River Basin, including the Lynches River, are as follows:

The **Sandhills** area is composed of gently sloping to strongly sloping uplands with a predominance of sandy areas and scrub vegetation; elevations range from 250 to 450 feet.

Figure 1-4 Pee Dee River Basin: 8- and 11-Digit HUCs



The **Upper Coastal Plain** area is composed of gentle slopes with increased dissection and moderate slopes in the northwestern section that contain the State's major farming areas; elevations range from 100 to 450 feet.

The **Lower Coastal Plain** area is mostly nearly level and dissected by many broad, shallow valleys with meandering stream channels; elevations range from 25 to 125 feet.

The **Coastal Zone** is a mostly tidally influenced, nearly level area dissected by many broad, shallow valleys with meandering stream channels; most of the valleys terminate in tidal estuaries along the coast; elevations range from sea level to about 25 feet (SCDHEC 2001).

1.2.3 Soil Types

The dominant soil associations, or those soil series comprising, together, over 40 percent of the land area, were recorded for each watershed in percent descending order. The individual soil series for the Pee Dee River Basin are described as follows.

Alpin soil is well-drained and excessively drained, sandy with a loamy or sandy subsoil.

Aycock soil is nearly level to gently sloping, well-drained soil on Coastal Plain uplands, grayish brown in color and a very fine sandy loam.

Bonneau soil is deep, moderately well-drained with loamy subsoil on ridges.

Candor soil is well-drained soil that formed in sandy and loamy marine sediments on broad flats, narrow ridges, and side slopes.

Cantey soil is moderately well-drained with a loamy surface layer and clayey or loamy subsoil and poorly drained soil with a loamy surface layer and a clayey subsoil.

Chastain soil is poorly drained to well-drained and is clayey or loamy throughout and subject to flooding.

Coxville soil is deep, poorly drained in thick beds of clayey sediment, nearly level.

Dorovan soil is deep, level, very poorly drained, organic soil on floodplains adjacent to uplands.

Fuquay soil is well-drained, loamy, and sandy with clayey or loamy subsoil.

Goldsboro soil is moderately well to poorly drained with loamy subsoil on nearly level ridges and in shallow depressions.

Johnston soil is nearly level, moderately well-drained to very poorly drained, loamy throughout with a sandy surface layer on floodplains.

Lakeland soil is well-drained, sandy with loamy subsoil and excessively drained soil.

Levy soil is nearly level, very poorly drained, mucky throughout or loamy, and underlain with clayey layers, rarely or frequently flooded with fresh water.

Lynchburg soil is moderately well to poorly drained, with loamy subsoil, on nearly level ridges and in shallow depressions.

Meggett soil is poorly drained to very poorly drained, level to nearly level with a loamy to sandy surface layer and a loamy to clayey subsoil.

Nansemond soil formed in loamy Coastal Plain sediments on stream terraces and adjacent to small drainages, and is moderately well drained and rapidly permeable.

Noboco soil is well drained, sandy with loamy or clayey subsoil.

Norfolk soil is deep, well-drained, with loamy subsoil, nearly level and gently sloping elevated uplands.

Pelion soil is well-drained and moderately well-drained with a sandy surface layer and loamy subsoil, much of which has a fragipan in the subsoil.

Persanti soil formed in clayey marine sediment, and is deep, moderately well-drained, slowly permeable soil found on broad estuary terraces.

Rains soil is moderately well to poorly drained, with loamy subsoil, on nearly level ridges and in shallow depressions.

Rutledge soil is somewhat poorly drained to moderately well-drained, nearly level, sandy soil on ridges and poorly drained to very poorly drained, sandy soil in depressions.

Smithboro soil is deep, somewhat poorly drained, slowly permeable soil that formed in clayey marine sediment, found on the Coastal Plain on broad estuary terraces.

Tatum soil is dominantly sloping to steep, well-drained to excessively drained, with loamy subsoil, moderately deep or shallow to weathered rock.

Tawcaw soil is poorly drained to well drained, clayey or loamy throughout and subject to flooding.

Troup soil is well drained, sandy with loamy subsoil and excessively drained soil.

Wagram soil is well drained to very poorly drained, depressional to nearly level and gently sloping with a loamy to sandy surface layer and a clayey to loamy subsoil.

Woodington soil formed in loamy Coastal Plain sediments on stream terraces and upland flats on higher elevations and is poorly drained, moderately permeable.

Yauhannah soil is poorly drained to moderately well drained with loamy subsoil, on nearly level ridges and in shallow depressions.

Yemassee soil is poorly drained to moderately well drained with loamy subsoil, on nearly level ridges and in shallow depressions.

Yonges soil is moderately well-drained to poorly drained, nearly level with a sandy surface layer and predominantly loamy subsoil (SCDHEC 2001).

1.2.4 Slope and Erodibility

The definition of soil erodibility differs from that of soil erosion. Soil erosion may be more influenced by slope, rainstorm characteristics, cover, and land management than by soil properties. Soil erodibility refers to the properties of the soil itself, which cause it to erode more or less easily than others when all other factors are constant. This is an important characteristic because it allows for an understanding of whether any given soil type is prone to erosion and thus more or less likely to transport fecal coliform to receiving waters.

The soil erodibility factor, K, is the rate of soil loss per erosion index unit as measured on a unit plot, and represents an average value for a given soil reflecting the combined effects of all the soil properties that significantly influence the ease of soil erosion by rainfall and runoff if not protected. The K factor values closer to 1.0 represent higher soil erodibility and a greater need for best management practices (BMP) to minimize erosion and contain those sediments which do erode. The range of K-factor values in the Pee Dee River Basin is from 0.10 to 0.28 (SCDHEC 2001) suggesting that the soil is not highly prone to erosion during periods of stormwater runoff.

1.2.5 Rainfall

Normal yearly rainfall in the Pee Dee River area is 47.14 inches, according to SC historic climatological records. Data compiled from National Weather Service stations in the metropolitan locations of Pee Dee, Cheraw, McColl, Darlington, Florence (City and Airport), Dillon, Marion, and Georgetown were used to determine the general climate information for this portion of the State. The highest level of rainfall occurs in the summer with 15.64 inches; rain in the fall, winter, and spring, measures 9.77, 10.60, and 11.13 inches, respectively. The average annual daily temperature is 62.6 degrees Fahrenheit (°F). Summer temperatures average 78.6°F and fall, winter, and spring temperatures are 63.8°F, 45.7°F, and 62.5°F, respectively.

1.2.6 Land Use

Table 1-2 summarizes general land use categories and associated percentages for the contributing watersheds upstream of each 303(d)-listed WQM station. Land use/land cover data were derived from 1996 U.S. Geological Survey (USGS) Multi-Resolution Land Characteristic land use data (USGS 2005). Figures 1-5 and 1-6 depict the land use categories occurring within the watersheds described in this report. A summary of the land use characteristics for the watershed associated with each WQM station is provided below. Only major land use categories are identified in the narrative summaries below. For multiple WQM stations on the same water body, the acreage totals in Table 1-2 represent only the subwatershed associated with each WQM station below the next upstream station.

Upper Lynches River

There are six WQM stations within the upper Lynches River discussed in this report. Land use within the watersheds of these six stations is described below.

PD-333 Hills Creek at S-13-105

Hills Creek originates near the Town of Pageland and accepts the drainage of Mangum Branch, Cow Head Branch, and Conway Branch before flowing into the Lynches River. The watershed of WQM station PD-333 contains 10,214 acres. Land use/land cover in the watershed includes approximately 3 percent houses and business, 57 percent forest, 14 percent pastures, and 24 percent row crops.

PD-113 Lynches River at SC-9, West of Pageland

The watershed of WQM station PD-113 contains 33,011 acres. The Lynches River originates in NC, and accepts drainage originating in NC, including Polecat Creek (Otter Creek, Silver Run), Buffalo Creek (Raccoon Branch Creek), and Dead Pine Creek. Less than 1 percent of the watershed contains houses and businesses. Approximately 57 percent is covered by forest. Pastures and row-crops occupy 22 and 19 percent, respectively.

PD-179 North Branch of Wildcat Creek at S-29-39, 1 Mile South of Tradesville

The North (PD-179) and South (PD-180) Branches of Wildcat Creek combine before entering the Lynches River. The watershed of WQM station PD-179 contains 6,293 acres. Approximately 1 percent of the watershed is occupied by houses, businesses, and ancillary development. Forest occupies the largest land use with 63 percent followed by row-crops at 28 percent. Pastures occupy approximately 6 percent of the watershed.

PD-180 South Branch of Wildcat Creek at S-29-39, 2 Miles South of Tradesville

The watershed of WQM station PD-180 contains 6,222 acres. Less than 1 percent of the total area contains houses and businesses. Approximately 67 percent is forest. Pastures and row crops cover approximately 6 percent and 17 percent, respectively. Approximately 9 percent is classified as transitional land use, areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land development activities (USGS 2005a).

PD-342 Flat Creek at S-29-123

Flat Creek enters the Lynches River approximately two-thirds of a mile north of the town of Birdtown. The watershed of WQM station PD-342 contains 30,894 acres. Less than 1 percent of the total area contains houses and businesses. Approximately 63 percent is forest. Pastures and row crops cover approximately 2 percent and 14 percent, respectively. Woody wetlands encompass approximately 18 percent.

PD-066 Lynches River at S-28-42

The watershed of WQM station PD-066 contains 38,326 acres. Less than 1 percent of the total area contains houses and businesses. Approximately 53 percent is forest. Pastures and row crops cover approximately 3 percent and 15 percent, respectively. Woody wetlands encompass approximately 11 percent. Approximately 16 percent is classified as transitional land use, areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land development activities (USGS 2005a).

Tributaries to Pocotaligo River

There are three WQM stations within tributaries of the Pocotaligo River. Land uses within the watersheds of these three stations are described below.

PD-040 Turkey Creek at US 521

The watershed of WQM station PD-040 contains 4,395 acres and a portion of the urbanized areas in and around the City of South Sumter. Approximately 35 percent of the total area contains houses, businesses, and ancillary development. Approximately 37 percent is forest. Pastures and row crops cover approximately 2 percent and 19 percent, respectively. Woody wetlands encompass approximately 6 percent.

PD-098 Turkey Creek at Liberty Street in Sumter above Santee Print Works

The watershed of WQM station PD-098 contains 1,893 acres and a portion of the urbanized areas in and around the City of Sumter. Approximately 55 percent of the total area contains houses, businesses, and ancillary development. Approximately 27 percent is forest. Pastures and row crops cover approximately 3 percent and 9 percent, respectively.

PD-239 Nasty Branch at S-43-251, 7.5-Miles Southwest of Sumter

The watershed of WQM station PD-239 contains 11,160 acres. Less than 2 percent of the total area contains houses, businesses, and ancillary development. Forest covers approximately 48 percent and wooded wetlands 13 percent. Pastures and row crops cover approximately 6 percent and 31 percent, respectively.

Tributaries to Pee Dee River

There are three WQM stations within tributaries of the Pee Dee River addressed in this report. Land uses within the watersheds of these three stations are described below.

PD-065 Gulley Branch at S-21-13 in Timrod Park

The watershed of WQM station PD-065 contains 1,055 acres within the town of Florence. Approximately 82 percent of the total area contains houses, businesses, and ancillary development. Approximately 17 percent is forest. Pastures and row crops cover less than 1 percent combined.

PD-187 Smith Swamp at US 501, 1.9 Miles south-southeast of Marion

The watershed of WQM stations PD-187 contains 1,645 acres and drains the southeast portion of the town of Marion. Approximately 26 percent of the total area contains houses, businesses, and ancillary development. Approximately 18 percent is forest. Pastures and row crops cover approximately 8 and 33 percent, respectively. Woody wetlands encompass approximately 12 percent.

PD-320 Smith Swamp at S-34-19, 1-Mile East of Marion

The watershed of WQM station PD-320 contains 11,237 acres. The watershed contains a small airport and a lake surrounded by the Dusty Hills Golf Course. Approximately 4 percent of the total area contains houses, businesses, and ancillary development. Approximately 33 percent is forest. Pastures and row crops cover approximately 7 and 45 percent, respectively. Woody wetlands encompass approximately 10 percent.

Little Pee Dee River

There are four WQM stations within the Little Pee Dee River that are addressed in this report. Land uses within the watersheds of these four stations are described below.

PD-030A Little Pee Dee River below Confluence with Maple Swamp

The watershed of WQM station PD-030A contains 5,687 acres and drains the west side of the town of Dillon. Approximately 4 percent of the total area contains houses, businesses, and ancillary development. Approximately 30 percent is forest. Pastures and row crops cover approximately 1 percent and 23 percent, respectively. Woody wetlands comprise the largest percentage at 42 percent.

PD-030 Maple Swamp at SC 57

The watershed of WQM station PD-030 contains 8,886 acres and drains the town of Dillon. Approximately 16 percent of the total area contains houses, businesses, and ancillary development. Approximately 27 percent is forest. Pastures and row crops cover approximately 16 percent and 31 percent, respectively. Woody wetlands encompass approximately 8 percent.

PD-037 White Oak Creek at S-34-31

The watershed of WQM station PD-037 contains 2,450 acres and a portion of the town of Mullins. Approximately 16 percent of the total area contains houses, businesses, and ancillary development. Approximately 19 percent is forest. Pastures and row crops cover approximately 19 percent and 40 percent, respectively.

PD-352 Chinners Swamp at Gunters Island Road of S-26-99

The watershed of WQM station PD-352 contains 27,264 acres. Less than 2 percent of the total area contains houses, businesses, and ancillary development. Approximately 36 percent is forest. Wooded wetlands encompass 28 percent. Pastures and row crops cover approximately 4 and 30 percent, respectively.

Table 1-2 Land Use Summary for Watersheds of 303(d)-Listed WQM Stations in the Pee Dee River Basin

Description	Code	PD-333	PD-113	PD-179	PD-180	PD-342	PD-066	PD-040	PD-098
Open Water	11	56	48	17	3	25	65	2	0
Open Water Percent	11	0.55	0.15	0.27	0.05	0.08	0.17	0.05	0.01
Low Intensity Residential	21	158	88	25	1	3	155	626	489
Low Intensity Residential Percent	21	1.55	0.27	0.39	0.02	0.01	0.40	14.25	25.83
High Intensity Residential	22	34	0	2	0	0	17	276	249
High Intensity Residential Percent	22	0.33	0.00	0.03	0.00	0.00	0.04	6.27	13.14
High Intensity Commercial/Indust./Transportion	23	145	8	6	0	2	26	615	310
High Intensity Comm./Indust./Trans Percent	23	1.42	0.02	0.10	0.00	0.01	0.07	13.98	16.39
Bare Rock/Sand/Clay	31	8	21	7	1	14	11	1	4
Bare Rock/Sand/Clay Percent	31	0.08	0.06	0.11	0.02	0.05	0.03	0.03	0.23
Quarries/Strip Mines/Gravel Pits	32	0	0	0	0	0	257	0	0
Quarries/Strip Mines/Gravel Pits Percent	32	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.00
Transitional	33	0	484	121	620	984	6,150	0	0
Transitional Percent	33	0.00	1.46	1.92	9.96	3.18	16.05	0.00	0.00
Deciduous Forest	41	3,261	9,499	1,831	2,416	9,697	10,339	494	136
Deciduous Forest Percent	41	31.93	28.77	29.09	38.83	31.39	26.98	11.23	7.20
Evergreen Forest	42	1,247	5,422	1,141	924	5,342	5,608	635	197
Evergreen Forest Percent	42	12.21	16.42	18.13	14.85	17.29	14.63	14.46	10.40
Mixed Forest	43	1,350	3,766	1,008	817	4,352	4,264	476	182
Mixed Forest Percent	43	13.22	11.41	16.02	13.13	14.09	11.12	10.82	9.62
Pasture/Hay	81	1,454	7,226	347	372	740	1,311	85	62
Pasture/Hay Percent	81	14.23	21.89	5.51	5.98	2.40	3.42	1.94	3.28
Row Crops	82	2,452	6,352	1,760	1,058	4,294	5,737	829	165
Row Crops Percent	82	24.01	19.24	27.97	17.01	13.90	14.97	18.85	8.70
Other Grasses (Urban/recreational)	85	8	33	8	0	0	10	112	36
Other Grasses (Urban/recreational) Percent	85	0.08	0.10	0.13	0.00	0.00	0.03	2.55	1.89
Woody Wetlands	91	33	66	18	9	5,439	4,378	245	63
Woody Wetlands Percent	91	0.32	0.20	0.29	0.15	17.60	11.42	5.57	3.32
Emergent Herbaceous Wetlands	92	8	0	2	0	2	1	0	0
Emergent Herbaceous Wetlands Percent	92	0.08	0.00	0.03	0.00	0.01	0.00	0.00	0.01
Total Acres		10,214	33,011	6,293	6,222	30,894	38,326	4,395	1,893

Table 1-2 Land Use Summary for Watersheds of 303(d)-Listed WQM Stations in the Pee Dee River Basin (cont'd)

Description	Code	PD-239	PD-065	PD-187	PD-320	PD-030A	PD-030	PD-037	PD-352
Open Water	11	11	0	7	40	0	8	12	28
Open Water Percent	11	0.10	0.00	0.42	0.35	0.00	0.07	0.48	0.10
Low Intensity Residential	21	129	320	231	249	93	592	217	250
Low Intensity Residential Percent	21	1.16	30.31	14.02	2.21	1.63	6.65	8.86	0.92
High Intensity Residential	22	7	297	58	28	65	210	59	8
High Intensity Residential Percent	22	0.07	28.17	3.55	0.25	1.14	2.42	2.42	0.03
High Intensity Commercial/Indust./Transportation	23	13	243	141	135	43	630	108	162
High Intensity Commercial/Indust./Trans. Percent	23	0.12	23.06	8.60	1.21	0.75	7.09	4.39	0.59
Bare Rock/Sand/Clay	31	0	1	2	18	11	12	3	25
Bare Rock/Sand/Clay Percent	31	0.00	0.05	0.10	0.16	0.20	0.14	0.11	0.09
Quarries/Strip Mines/Gravel Pits	32	0	0	0	0	0	0	0	0
Quarries/Strip Mines/Gravel Pits Percent	32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transitional	33	30	0	0	0	0	0	0	26
Transitional Percent	33	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Deciduous Forest	41	1,786	45	81	917	361	516	95	1,972
Deciduous Forest Percent	41	16.01	4.23	4.94	8.16	6.34	5.75	3.88	7.23
Evergreen Forest	42	2,190	59	112	1,780	1,129	1,275	201	5,291
Evergreen Forest Percent	42	19.62	5.56	6.83	15.84	19.85	14.49	8.20	19.40
Mixed Forest	43	1,353	71	100	1,005	220	610	170	2,441
Mixed Forest Percent	43	12.12	6.72	6.10	8.94	3.88	6.84	6.93	8.95
Pasture/Hay	81	669	0	125	838	53	1,473	465	1,149
Pasture/Hay Percent	81	6.00	0.00	7.58	7.46	0.93	16.49	18.96	4.21
Row Crops	82	3,476	2	549	5,055	1,312	2,791	974	8,385
Row Crops Percent	82	31.14	0.16	33.38	44.99	23.08	31.39	39.75	30.75
Other Grasses (Urban/recreational)	85	12	4	38	50	8	67	14	14
Other Grasses (Urban/recreational) Percent	85	0.11	0.39	2.29	0.45	0.14	0.77	0.55	0.05
Woody Wetlands	91	1,484	14	200	1,119	2,391	702	132	7,512
Woody Wetlands Percent	91	13.29	1.34	12.18	9.96	42.05	7.93	5.40	27.55
Emergent Herbaceous Wetlands	92	1	0	0	3	0	0	1	2
Emergent Herbaceous Wetlands Percent	92	0.01	0.00	0.01	0.02	0.01	0.00	0.05	0.01
Total Acres		11,160	1,055	1,645	11,237	5,687	8,886	2,450	27,264

Figure 1-5 Land Use Map: Hills Creek, Lynches River, North and South Branch of Wildcat Creek, and Flat Creek Watersheds

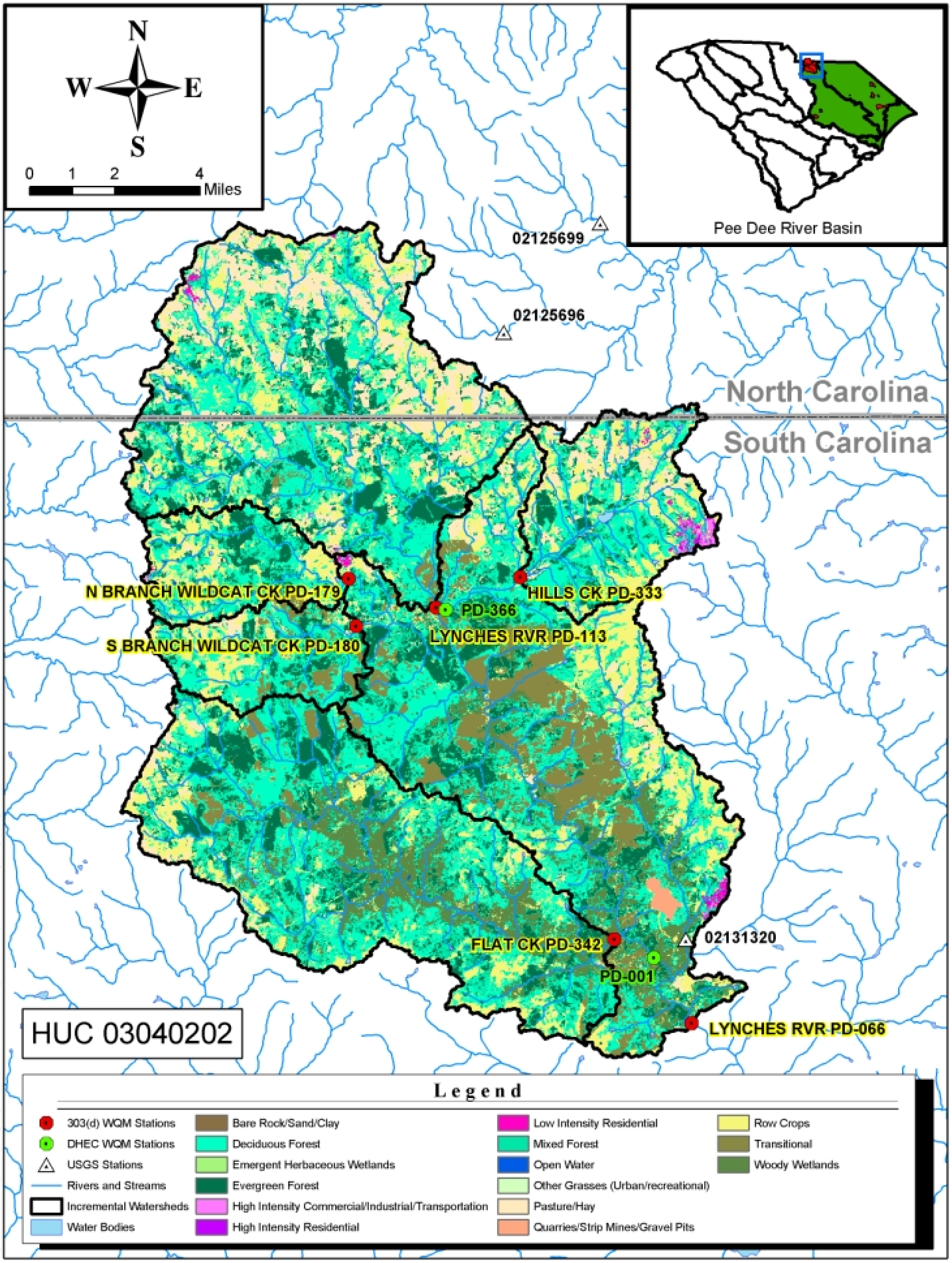


Figure 1-6 Land Use Map: Turkey Creek and Nasty Branch Watersheds

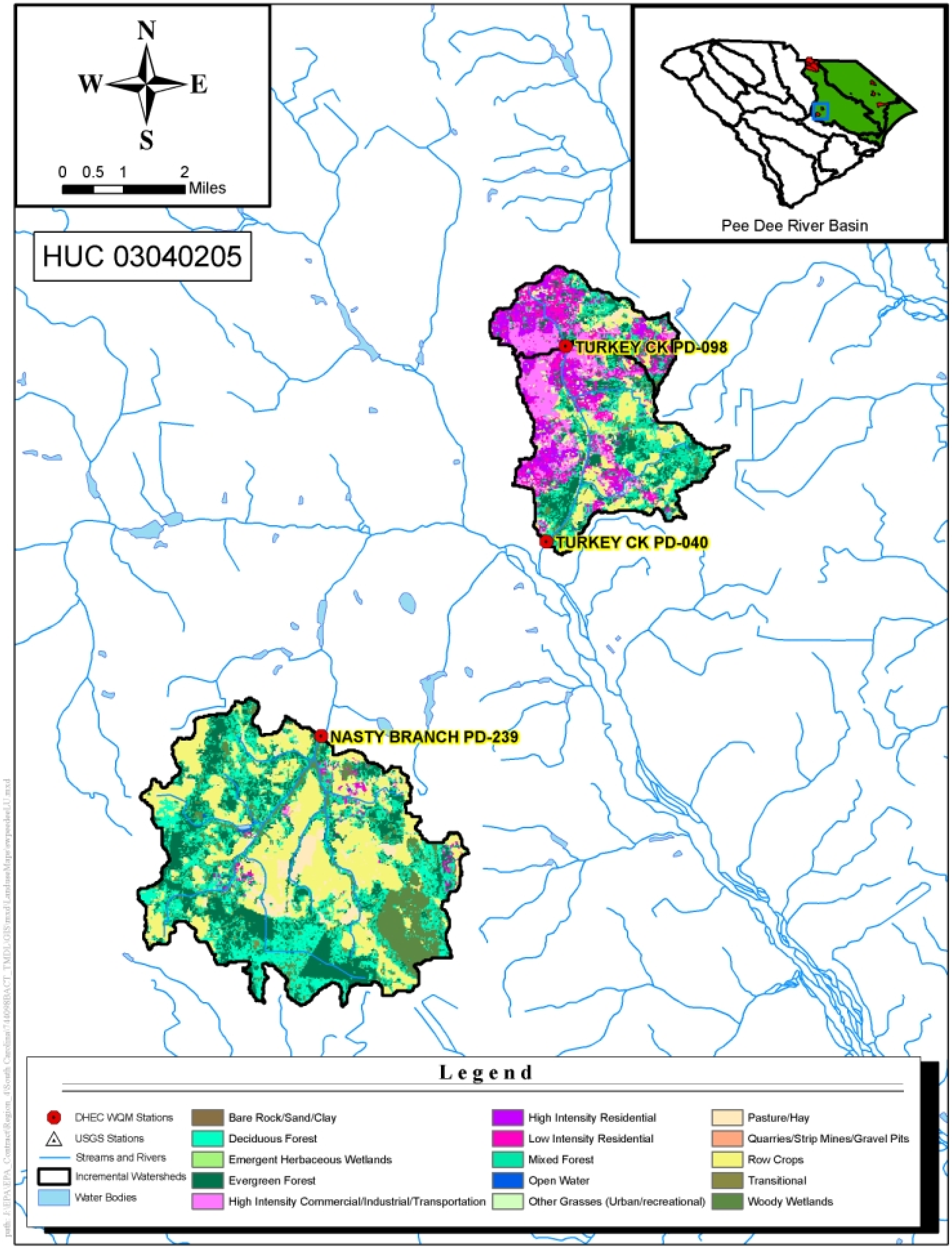
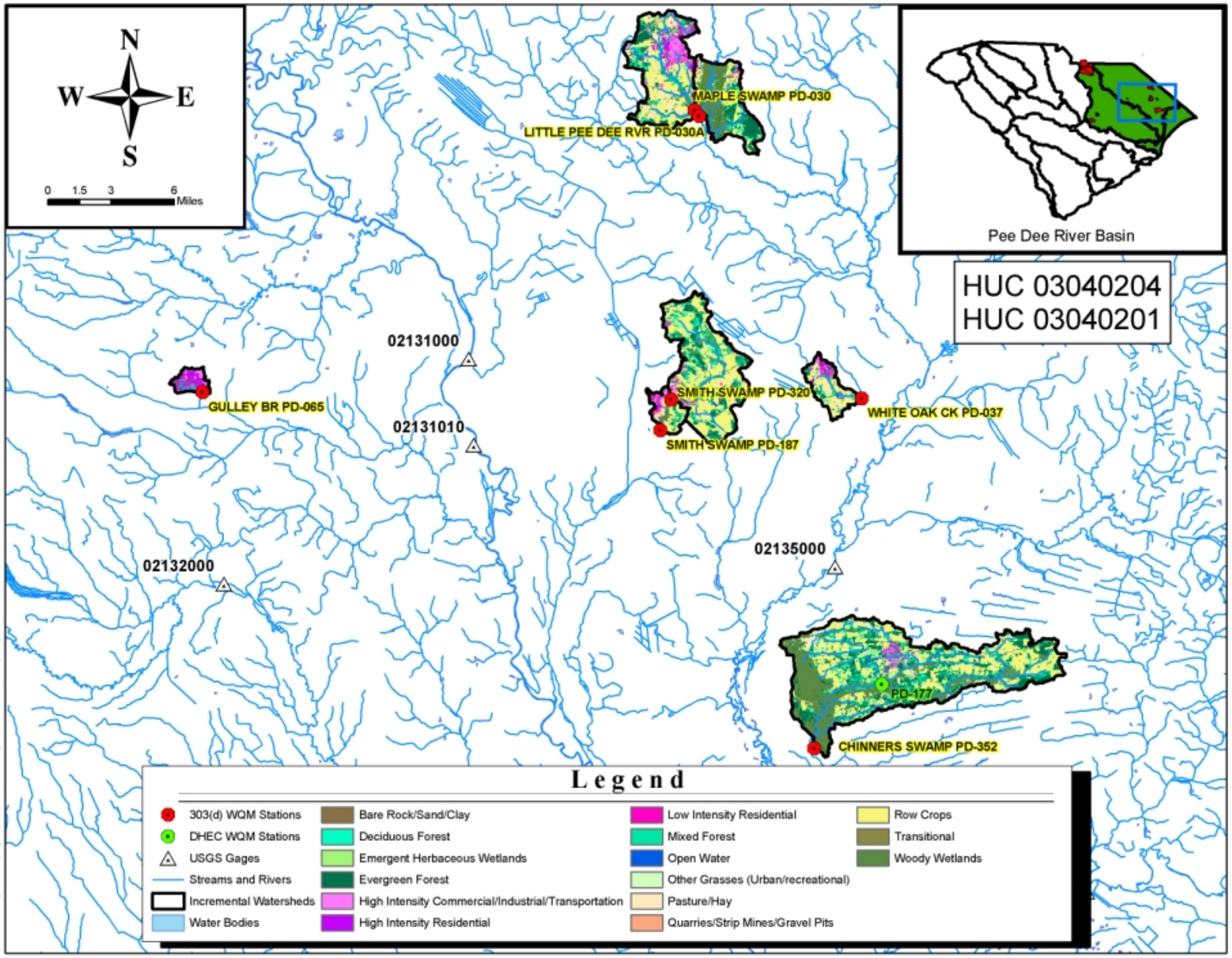


Figure 1-7 Land Use Map: Gulley Branch, Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp Watersheds



SECTION 2
WATER QUALITY ASSESSMENT

2.1 Water Quality Standards

Water quality standards for SC were promulgated in the South Carolina Pollution Control Act, Section 48-1-10 *et seq*. Chapter 61, R61-68 (SCDHEC 2001a). All water bodies in the Pee Dee River Basin are designated as freshwater. Waters of this class are defined in Regulation 61-68, §610, *Water Classifications and Standards,* and designated uses are described as follows:

> *Freshwater 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. These waters are suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. This class is also suitable for industrial and agricultural uses.* (SCDHEC 2001a)

South Carolina's numeric criteria for fecal coliform bacteria to protect for primary contact recreation use in freshwater are:

> *Not to exceed a geometric mean of 200 cfu/100ml, based on five consecutive samples during any 30-day period; nor shall more than 10 percent of the total samples during any 30-day period exceed 400 cfu/100ml.* (SCDHEC 2001a)

The State of South Carolina Integrated Report for 2004 identified the WQM stations requiring fecal coliform TMDLs (SCDHEC 2004). Fecal coliform bacteria monitoring data collected primarily by the SCDHEC Bureau of Water from 1998 through 2002 were used in the 2004 303(d) listing procedure. While SC WQSs stipulate two separate water quality criterion for assessing primary contact recreation, there are insufficient data available to calculate the 30-day geometric mean since most water quality samples are collected once a month. As a result, monitoring stations with greater than 10 percent of the samples exceeding 400 cfu/100 ml were considered impaired and were placed on the list for TMDL development. Targeting the instantaneous criterion of 400 cfu/100 ml as the water quality goal corresponds to the basis for 303(d) listing and will be protective of the geometric mean criterion.

The Lynches River and various tributaries contributing to WQM station PD-113 are interstate water bodies flowing from NC to SC. As with all interstate waters, the CWA requires that WQSs within the watershed of PD-113 be met at the NC/SC boundary line. None of the NC water bodies flowing to WQM station PD-113 are currently on the North Carolina Department of Environment and Natural Resources' 303(d) List for fecal coliform. The NC WQS for primary and secondary contact recreation in freshwater is defined in the NC Administrative Code (2004) as:

Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200 cfu/100ml based upon at least five consecutive samples examined during any 30 day period, nor exceed 400cfu/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the most probable number 5-tube dilution technique shall be used as the reference method.

2.2 Assessment of Existing Water Quality Data

Table 2-1 summarizes data supporting the decision to place the WQM stations targeted in this report on the SCDHEC 2004 303(d) list. Additional ambient fecal coliform data for each WQM station from 1990 to 2002 are provided in Appendix A. This larger dataset was used to develop the TMDL calculations (WLAs and LAs) and to calculate load reductions within each watershed. Ambient fecal coliform data were provided by SCDHEC and obtained from USEPA Storage and Retrieval Database (USEPA 2005).

Table 2-1 Fecal Coliform Bacteria Observed from 1998 through 2002

Station	Total Number of Samples	Maximum Concentration cfu/100 ml	Total Number of Samples > 400 cfu/100 ml	Percentage of Samples > 400 cfu/100 ml
PD-333	20	2,100	6	30%
PD-113	58	11,000	9	16%
PD-179	18	1,700	9	50%
PD-180	17	940	5	29%
PD-342	30	6,800	4	13%
PD-066	18	8,100	3	17%
PD-040	8	1,900	6	75%
PD-098	9	1,200	6	67%
PD-239	9	710	2	22%
PD-065	33	12,000	24	73%
PD-187	32	7,200	6	19%
PD-320	10	1,100	4	40%
PD-030A	10	1,100	2	20%
PD-030	17	1,600	2	12%
PD-037	15	3,900	5	33%
PD-352	23	900	4	17%

Fecal coliform data were for the most part collected only during May through October at some WQM stations (PD-333, PD-179, PD-180, PD-066, PD-239, PD-320, PD-030A, PD-030, and PD-037). The remaining WQM stations (PD-113, PD-342, PD-040, PD-098, PD-065, PD-187, and PD-352) were generally sampled 10 to 12 times per year. However, because bacteria load delivery mechanisms such as rainfall runoff occur over the course of the year, it is assumed that winter loading would be similar to that of those periods for which data do exist (SCDHEC 2003).

Between 12 and 75 percent of the samples collected at the 16 WQM stations from 1998 to 2002 exceeded the WQS for primary contact recreation. Three of 16 stations exceeded the WQS in more than 50 percent of the samples collected. Seventy-five percent of the samples collected at WQM station PD-040 (below the City of Sumter) in 1998 and 73 percent of the samples collected at WQM station PD-065 (below the Town of Florence) in 1998 and 2000 exceeded the 400 cfu/100 ml WQS. Potential sources of fecal coliform are discussed in Section 3 of this report.

Additional analyses were performed using fecal coliform data and precipitation data from the period 1994 through 2002 to develop a better understanding of the potential relationship between rainfall and elevated fecal coliform bacteria loads in individual WQM stations. Precipitation data from local National Oceanic and Atmospheric Administration (NOAA) weather stations were plotted against SCDHEC ambient fecal coliform data at each WQM station to evaluate the potential statistical relationship. Rainfall data for a 3-day period (2 days prior to and the day of each fecal coliform sample collection date) selected from weather stations proximal to each WQM station were averaged. Data from the NOAA weather monitoring stations at Columbia Metro Airport, Florence Regional Airport, Shaw Air Force Base/Sumter, downtown Greenville, Monroe Airport, NC, and Lumberton, NC were used to generate the plots (NOAA 2005). Plots for each WQM station and a map showing the location of the NOAA weather stations and their station identification numbers are provided in Appendix B. The names of individual weather monitoring stations are provided under each plot.

This comparison of fecal coliform concentration with the 3-day average rainfall was not possible for five of the WQM stations (PD-333, PD-179, PD-180, PD-066, and PD-352) because no rainfall occurred on any dates when the fecal coliform samples were recorded from these stations. Nor were plots prepared for WQM stations PD-113, PD-342 and PD-030A since only one rainfall event was measured in association with a fecal coliform sampling event. As a result, for this subset of WQM stations, it is difficult to demonstrate a correlation between rainfall and fecal coliform concentrations. However, some general conclusions could be derived from this data analysis:

- Nearly all ambient fecal coliform samples for the stations listed above were collected under dry conditions; the majority of fecal coliform samples exceeding the WQS occurred under dry weather conditions;

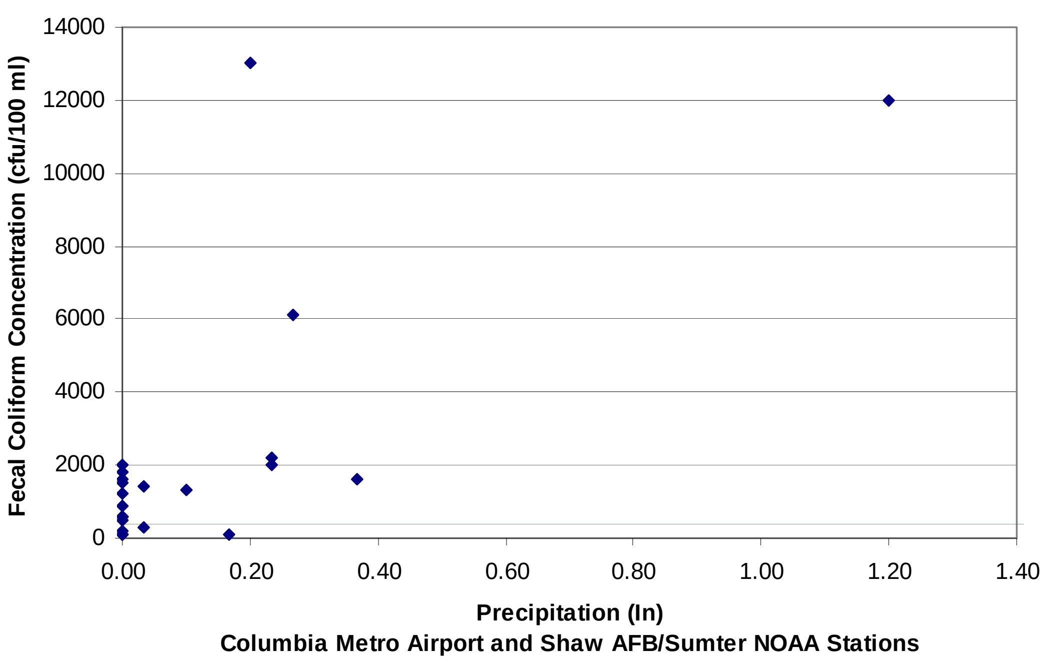
- It is difficult to discern a direct correlation between rainfall and fecal coliform concentrations at each WQM station without more localized precipitation data from within each watershed.

For WQM stations PD-040 and PD-239 there are a few instances where it appears that fecal coliform exceedances of the WQS are associated with peak runoff events. However, the highest fecal coliform densities occurred on days when no measurable rainfall was recorded.

The days on which measured rainfall resulted in elevated fecal coliform concentrations are limited because of small datasets. This lack of a relationship also suggests that fecal coliform may be associated with sources (point or nonpoint) that are not significantly affected by rainfall. Plots for these two stations (PD-040 and PD-239) showing a marginal relationship are provided in Appendix B.

Six other WQM stations (PD-098, PD-065, PD-187, PD-320, PD-030, and PD-037) appear to show a relationship between fecal coliform concentrations and precipitation. Higher fecal coliform concentrations at those six WQM stations appear to be associated with an increase in precipitation, indicating that fecal coliform loading is associated with surface runoff related to rainfall. Figure 2-1 for PD-098 is an example plot depicting higher fecal coliform concentrations in association with higher precipitation levels. A comparison of ambient fecal coliform data and NOAA precipitation data (26 data points) at WQM station PD-098 between 1995 and 2001 indicated 8 days in which the 3-day average rainfall exceeded 0.1 inch, and on 7 of those days, the fecal coliform measurement exceeded the WQSs. There were 13 other exceedances that occurred between 1995 and 2001; however, those occurred when there was no measurable rainfall recorded. This plot suggests a relationship between rainfall runoff and higher fecal coliform concentrations; although to fully determine this relationship, a continuous time series of precipitation would need to be evaluated. Plots for the remaining five stations, PD-065, PD-187, PD-320, PD-030, and PD-037, depicting a similar relationship, are also provided in Appendix B.

Figure 2-1 Comparison of Precipitation and Fecal Coliform Concentrations in Turkey Creek (PD-098)



Inferences from the comparison of fecal coliform concentration with rainfall data for five other WQM station are summarized below.

WQM Station PD-065 (Gulley Branch). For the period examined (1994 to 2001) there were numerous days in which fecal coliform concentrations exceeded the WQS (as high as 140,000 cfu/100 ml during a day when no rainfall occurred), although there is no apparent relationship between rainfall and fecal coliform exceedances. Fecal coliform concentrations appear very elevated at this station without regard to the occurrence of rainfall.

WQM Station PD-187 (Smith Swamp). For the period examined (1994 to 2001) there were approximately 8 days in which the 3-day average rainfall exceeded 0.1 inch, although there is little correlation between this rainfall and fecal coliform concentrations. This assessment suggests little or no relationship between wet weather conditions and higher fecal coliform concentrations at this station. Moreover, numerous fecal coliform samples exceeded the WQS when the 3-day average rainfall was less than 0.05 inches, including the single highest measurement (about 7,000 cfu/100 ml), further suggesting that wet weather events exert little influence on fecal coliform concentrations.

WQM Station PD-320 (Smith Swamp). For the period examined (1994 to 2001) there were numerous days in which the 3-day average rainfall exceeded 0.1 inch, although there is no apparent correlation between this rainfall and fecal coliform concentrations. Moreover, numerous fecal coliform samples exceeded the WQS when the 3-day average rainfall was less than 0.05 inches, including the single highest measurement (about 2,000 cfu/100 ml), further suggesting that wet weather events exert little influence on fecal coliform concentrations. During the single wettest day recorded (about 1.8 inches of rainfall) the measured fecal coliform counts were well below the WQS.

WQM Station PD-030 (Maple Swamp). For the period examined (1994 to 2001) there were approximately 5 days in which the 3-day average rainfall exceeded 0.1 inch, and two of the five fecal coliform measurements exceeded the WQS. However, there were approximately six WQS exceedances during days of no measurable rainfall, suggesting little or no relationship between wet weather conditions and elevated fecal coliform concentrations. The two highest fecal coliform densities (approximately 1,600 and 1,900 cfu/100 ml) occurred on days when no measurable rainfall was recorded.

WQM Station PD-037 (White Oak Creek). For the period examined (1994 to 2001) there were approximately 4 days in which the 3-day average rainfall exceeded 0.1 inch, and three of those fecal coliform measurements exceeded the WQS, although the day with the single highest rainfall measurement (about 1.8 inches) showed very low fecal coliform concentrations. This assessment suggests little or no relationship between wet weather conditions and higher fecal coliform concentrations at this station. There were approximately 8 days during which the WQS was exceeded when no measurable rainfall was recorded.

Relationships between fecal coliform exceedances at select WQM Stations

Fecal coliform data were also assessed to determine if any relationship existed between fecal coliform concentrations at select pairs of upstream and downstream WQM stations.

These data analyses could not be conducted for all WQM stations proximal to one another because the available fecal coliform data were not collected on the same date.

PD-333 and PD-113. Figure 2-2 is a plot showing fecal coliform data from the same dates for both Hills Creek (PD-333) and Lynches River (PD-113) based on data collected between 1990 and 2000. This plot is designed to show any potential relationship between exceedances occurring at the upstream WQM station (Hills Creek) and the downstream receiving water (Lynches River). This is an important part of the source assessment because it helps to explain contributions of fecal coliform from upstream sources. Based on this plot, of the 13 exceedances observed at Lynches River (PD-113), nine of the samples collected on the same day at the upstream station PD-333 exceeded the WQS. This shows a relationship between upstream fecal coliform and downstream fecal coliform concentrations. While there were no precipitation data to establish a specific relationship between rainfall runoff and fecal coliform concentrations at these two stations, Figure 2-2 demonstrates that upstream fecal coliform loading can have an effect on downstream fecal coliform concentrations.

PD-320 and PD-187. Figure 2-3 is a plot showing fecal coliform data from the same dates for both Smith Swamp upstream (PD-320) and Smith Swamp downstream (PD-187) based on data collected between 1990 and 2000. Based on this plot, of the 16 exceedances observed at Smith Swamp downstream (PD-187), nine of the samples collected on the same day at the upstream station PD-320 exceeded the WQS. This shows a direct relationship between upstream fecal coliform and downstream fecal coliform concentrations. There are only a few precipitation data points available to determine if a specific relationship exists between rainfall runoff and fecal coliform concentrations at these two stations. Figure 2-3 demonstrates that upstream fecal coliform loading can have an effect on downstream fecal coliform concentrations.

Figure 2-2 Comparison of Fecal Coliform Concentrations at PD-333 and PD-113

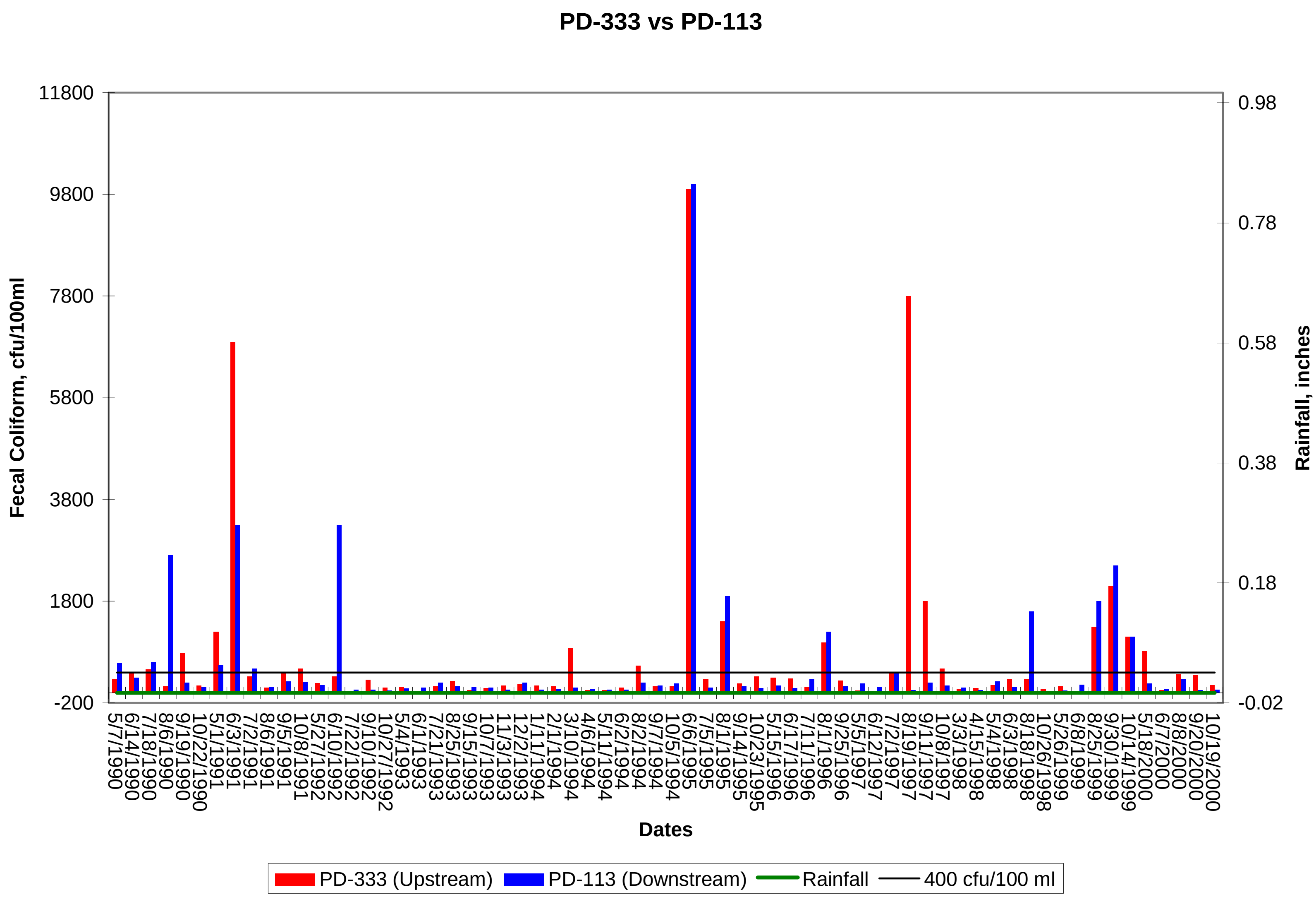
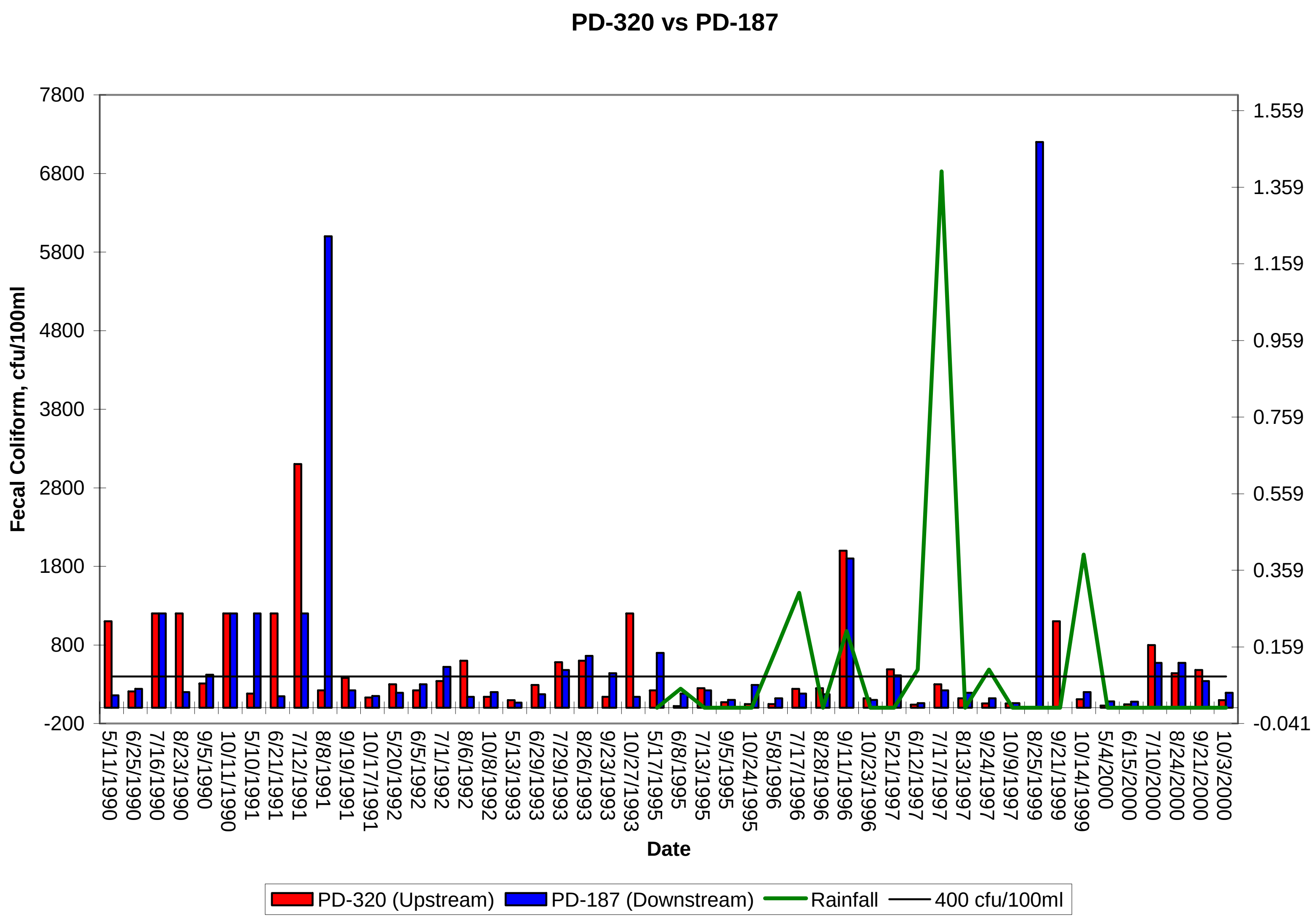


Figure 2-3 Comparison of Fecal Coliform Concentrations at PD-320 and PD-187



2.3 Establishing the Water Quality Target

40 CFR §130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards." For the WQM stations requiring TMDLs in this report, defining the water quality target is straightforward and dictated by the fecal coliform numeric criteria established for the protection and maintenance of the primary contact recreation use as defined in the SC WQSs (see Subsection 2.1). However, because available fecal coliform data were collected on an approximate monthly basis (see Appendix A) instead of five samples over 30 days, data for these TMDLs are analyzed and presented in relation to the instantaneous criterion of 400 cfu/100 ml, which requires that no more than 10 percent of the samples can exceed this numeric criterion. Therefore, the water quality target for each impaired WQM station will be expressed as: 380 cfu/100ml for the instantaneous criterion, which is 5 percent lower than the water quality criteria of 400 cfu/100ml. A 5 percent explicit MOS was reserved from the water quality criteria in developing the load duration curves (LDC). The instantaneous criterion was targeted as a conservative approach and should be protective of both the instantaneous and 30-day geometric mean fecal coliform bacteria standards.

This water quality target will be used to determine the allowable bacteria load derived by using the actual or estimated flow record multiplied by the instream fecal coliform criteria minus a 5 percent MOS. The line drawn through the allowable load data points is the water quality target which represents the maximum load for any given flow that still satisfies the WQS (SCDHEC 2003).

SECTION 3
POLLUTANT SOURCE ASSESSMENT

A source assessment characterizes known and suspected sources of pollutant loading to impaired water bodies. Sources within a watershed are categorized and quantified to the extent that information is available. Fecal coliform bacteria originate from warm-blooded animals and some plant life. Although fecal coliform bacteria are not harmful, they are present in mammal waste that also contains other harmful bacteria and viruses.

Sources of fecal coliform bacteria may be point or nonpoint in nature. Point sources are permitted through the NPDES program. NPDES-permitted facilities that discharge treated wastewater are required to monitor fecal coliform bacteria concentrations in accordance with its permit.

Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body at a single location. These sources may involve land activities that contribute fecal coliform bacteria to surface water as a result of stormwater runoff. The following discussion describes what is known regarding point and nonpoint sources of fecal coliform bacteria in the impaired watersheds.

This section describes potential fecal coliform sources in three groups of watersheds:

- Group I: Hills Creek, Lynches River, North Branch of Wildcat Creek, South Branch of Wildcat Creek, and Flat Creek;
- Group II: Turkey Creek and Nasty Branch; and
- Group III: Gulley Branch, Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp.

3.1 Group I: Hills Creek, Lynches River, North Branch of Wildcat Creek, South Branch of Wildcat Creek, and Flat Creek (HUC 03040202)

3.1.1 Point Source Discharges

There are two types of point sources discharging fecal coliform bacteria into the streams addressed in this report; they are continuous point sources and Municipal Separate Storm Sewer Systems (MS4). Continuous point source discharges such as wastewater treatment plants (WWTP), could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Stormwater Program, can also contain high fecal coliform bacteria concentrations and is discussed in Subsection 3.1.2. The following is a brief discussion of each type of point source discharge.

Continuous Point Sources

Table 3-1 lists three active NPDES point sources, Pageland Northwest WWTP, Buford High School WWTP and Jefferson WWTP, that discharge upstream of WQM stations PD-333, PD-179, and PD-066, respectively. Inactive permits that ceased discharging prior to 1998 or industrial dischargers with no fecal coliform limits are not included in Table 3-1. Figure 3-1 identifies the locations of the three point source dischargers as well as animal feeding operations (AFO) which are discussed later.

The Discharge Monitoring Report (DMR) from each NPDES WWTP was used to determine the number of permit violations for each. DMRs are produced monthly by the WWTP operator, and provide the geometric mean of all the fecal coliform analysis for that month and the maximum of the fecal coliform concentrations. The DMRs do not indicate how many fecal coliform analyses are required by the permit. Some permits require sampling once a month (small WWTPs) to three times per week (large WWTPs). NPDES permit violations occur when the monthly geometric mean concentration exceeded 200 cfu/100 ml or when the maximum of the individual concentrations exceed 400 cfu/100 ml. The DMR data for each WWTP are provided in Appendix C. For the most part, Table 3-1 indicates very few fecal coliform permit violations and, therefore, contributions of fecal coliform loading from these three WWTPs are considered insignificant.

Table 3-2 summarizes the existing load estimates for each NPDES WWTP. Existing point source loads were estimated by multiplying the monthly average flow rates by the monthly geometric mean of fecal coliform bacteria discharged and then by a unit conversion factor. The monthly flow rates and geometric mean fecal coliform values were extracted from the DMRs of each point source. The 90^{th} percentile value was used to express the estimated existing load in cfu per day.

Table 3-1 Permitted Facilities Discharging Fecal Coliform Bacteria

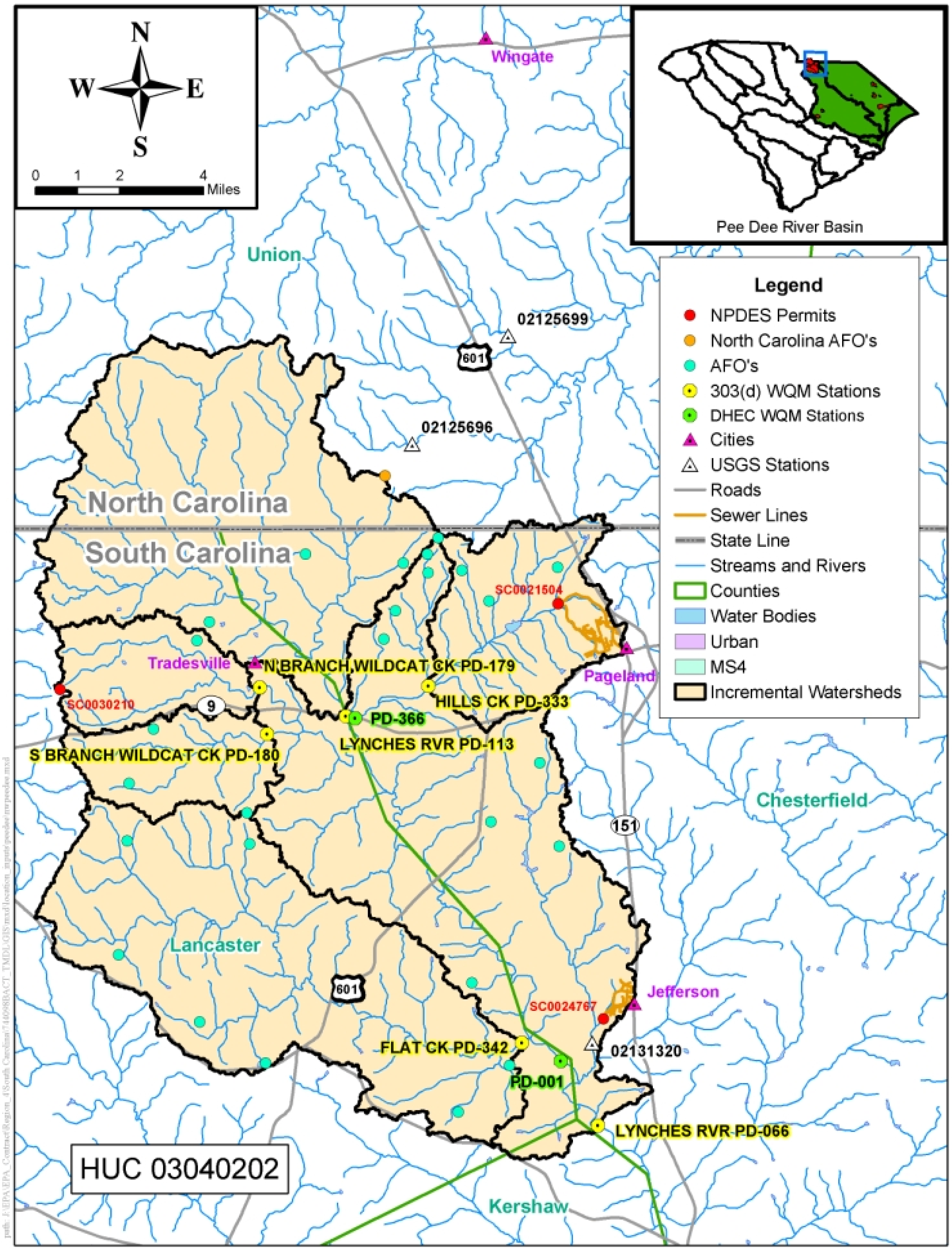
Water Quality Monitoring Station / Permittee	NPDES Permit Number	Receiving Water	Flow (mgd)	Number of Monthly Discharge Monitoring Reports*	Maximum Concentration cfu/100 ml	Monthly Average >200 cfu/100 ml	Maximum Daily Concentration >400 cfu/100 ml	Percent of Samples Exceeding Permit Limits
HUC 03040202020								
PD-333 Hills Creek at S-13-105								
Pageland / Northwest WWTF	SC0021504	Hills Creek	0.3	84	303	0	0	0
HUC 03040202030								
PD-179 North Branch Wildcat Creek at S-29-39								
Buford High School	SC0030210	N. Branch of Wildcat Creek	0.035	76	3000	1	1	3
HUC 03040202050								
PD-066 Lynches River at S-28-42								
Jefferson WWTP	SC0024767	Brazzell Branch	0.15	80	750	0	2	3

* Each DMR provides two fecal coliform values; the average of all samples for the month and the maximum of the samples.

Table 3-2 Estimated Existing Fecal Coliform Loading from NPDES Facilities (1998-2004)

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Receiving Water	90th percentile load (cfu/day)
HUC 03040202020			
PD-333 Hills Creek at S-13-105			
Pageland Northwest WWTP	SC0021504	Hills Creek	6.56E+09
HUC 03040202030			
PD-179 North Branch Wildcat Creek at S-29-39 1 Mile South of Tradesville			
Buford High School WWTP	SC0030210	North Branch of Wildcat Creek	9.16E+07
HUC 03040202050			
PD-066 Lynches River at S-28-42			
Jefferson WWTP	SC0024767	Brazzell Branch	1.21E+08

Figure 3-1 Locations of NPDES Dischargers, MS4s, and Animal Feeding Operations in Hills Creek, Lynches River, North and South Branches of Wildcat Creek, and Flat Creek Watersheds



3.1.2 Municipal Separate Storm Sewer Systems

In 1990 the USEPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local water bodies (SCDHEC 2002). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. A study under USEPA's National Urban Runoff Project indicated that average fecal coliform concentration from 14 watersheds in different areas within the U.S. was approximately 15,000 cfu/100 ml in stormwater runoff (USEPA 1983).

Phase II of the rule extends coverage of the NPDES stormwater program to certain small MS4s. Small MS4s are defined as an urban area (UA) that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Small MS4s serve populations of 50,000 to 99,999, and have an overall population density of 1,000 people per square-mile. The "suburbs" surrounding cities are typically classified as UAs for MS4 permitting purposes. Urbanized areas are identified on maps provided electronically by the U.S. Census Bureau at http://factfinder.census.gov/servlet/ReferenceMapFramesetServlet?_bm=y&-_lang=en. The U.S. Census Bureau map also identified urban clusters (UC), which are not automatically required to obtain MS4 permit coverage. There is no UA in the watersheds of PD-333 (Hills Creek) or PD-066 (Lynches River). The Town of Pageland, which is in the PD-333 watershed, is classified by the U.S. Census Bureau as a UC since the town is not near a UA and the population is less than 50,000. However, the Town of Pageland is not automatically required to have a Phase II MS4 permit. There are no urbanized areas designated as Phase I or Phase II MS4 within the Group I watersheds.

Sanitary sewer overflows (SSO) to streams, although infrequent, can be a major source of fecal coliform loading to streams. SSOs have existed since introduction of separate sanitary sewers, and most are caused by blockage of the pipes by grease and tree roots. SSOs are permit violations that must be addressed by the responsible NPDES permittee. Across the nation the reporting of SSOs has, within the last 6 years, been strongly encouraged by USEPA, primarily through enforcement and fines.

The Pageland Northwest WWTP (SC0021504) outfall and a portion of its collection system are located within the watershed of PD-333. This collection system reported two SSOs that reached Hills Branch. The first was approximately 60,000 gallons reported on January 17, 2003 and 200,000 gallons reported on December 8, 2004. The other SSOs that reached a waterbody were reported on February 7, March 10, and March 17, 2000, but were not quantified. No fecal coliform samples were collected at PD-333 (Hills Creek) near these dates, so the effect of these SSOs on fecal coliform concentrations is unknown. No SSOs were reported in the PD-179 (North Branch of Wildcat Creek), PD-180 (South Branch of

Wildcat Creek), PD-113 (Lynches River), PD-342 (Flat Creek), or PD-066 (Lynches River) watersheds.

There is no urbanized area designated as a Phase I or Phase II MS4 in the Lynches River watershed portion of Union County, NC. Additionally, there is no NPDES permitted WWTP discharge or wastewater collection system in this portion of the watershed.

3.1.3 Nonpoint Sources

Nonpoint sources include those that cannot be identified as entering the water body at a specific location. Because fecal coliform is associated with warm-blooded animals, nonpoint sources of fecal coliform may originate from both rural and urbanized areas.

Runoff from small urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria loading to streams. Water quality data collected from streams draining many of the unpermitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards. BMPs such as buffer strips and proper disposal of domestic animal waste may reduce fecal coliform bacteria loading to water bodies.

The following discussion highlights possible major nonpoint sources of fecal coliform. These sources include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems, and pets. The following subsections describe probable nonpoint sources of fecal coliform. Table 3-3 lists the WQM stations impaired from nonpoint sources of fecal coliform only, since the contributing watersheds do not contain an NPDES discharger with a fecal coliform limit.

Table 3-3 303(d) Listed WQM Stations Impaired by Nonpoint Sources Only

WQM Station	Stream Segments with No Upstream Active NPDES Fecal Coliform Discharge
PD-113	Lynches River at SC 9 W of Pageland
PD-180	South Branch Wildcat Creek at S-29-39 2 mi S of Tradesville
PD-342	Flat Creek at S-29-123

3.1.4 Wildlife

Fecal coliform bacteria are produced by warm blooded animals such as deer, feral hogs, wild turkey, raccoons, other small mammals, and avian species. The SC Department of Natural Resources (SCDNR) conducted a study in 2000 to estimate whitetail deer density based on suitable habitat (SCDNR 2000). This study assumed that deer habitat includes forests, croplands, and pastures. Table 3-4 lists the estimated deer population per square mile for each watershed. The deer density in each watershed is estimated at more than 45 deer per square-mile. According to a study conducted by Yagow (1999), fecal coliform production rate for deer is 347 x 10^6 cfu/head-day. Although only a portion of the fecal coliform produced by deer may enter into a water body, the large population of deer in the watersheds may be a significant source of fecal coliform loading.

Table 3-4 Estimated Deer Density by Watershed

Station	Estimated Deer Population per Square Mile
PD-333	> 45
PD-113	> 45
PD-179	> 45
PD-180	> 45
PD-342	> 45
PD-066	> 45

There are currently no available data for other wildlife and avian species known to inhabit these watersheds which could potentially contribute to the fecal coliform load. Given the representative statistics for deer population and the large amount of rural area (forest, cropland, and pasture) within these watersheds, wildlife may contribute a significant portion of the overall fecal coliform load.

3.1.5 Agricultural Activities and Domesticated Animals

Domesticated animals produce significant amounts of waste and are recognized as a source of fecal coliform loading. For example, according to a livestock study conducted by the American Society of Agricultural Engineers (ASAE 1998), the following fecal coliform production rates were estimated:

- cattle release approximately 100 billion fecal coliform per animal per day;
- chickens - 1.4 billion per animal per day, and
- turkeys - 1 billion per animal per day.

Manure generated by livestock in pastures or at AFOs, is typically used as fertilizer on crop lands, forests, and pastures, and is therefore a potential source of fecal coliform loading. The CWA does not regulate nonpoint source runoff from agriculture lands receiving agronomic applications of manure (CWA §502(14)). Furthermore, for the purposes of this pollutant source assessment, available data are not sufficient to estimate fecal coliform concentrations in stormwater runoff from land application fields. Stormwater leaving a concentrated animal feeding operation (CAFO) is regulated under the NPDES program; however, there are currently no NPDES-permitted CAFOs in SC. The SCDHEC maintains a statewide list of AFOs categorized by the type of facility (cattle, swine, poultry) and size which is defined by the specific number of animal units (large, medium, small).

Table 3-5 lists the turkey and poultry AFO facilities located by watershed, which was derived from the SCDHEC statewide list of AFOs. All the AFOs are classified as no discharge facilities. Table 3-6 lists the number of livestock permitted to be housed and the number of acres in each watershed permitted for land application of manure from AFO facilities. Figure 3-1, mentioned previously, presents the spatial distribution of specific AFO facilities upstream of each 303(d)-listed WQM station. WQM Station PD-342 (Flat Creek) contains the most livestock, in this case turkeys, of all the watersheds. In addition to the AFOs provided in Table 3-5, there may be other small farms throughout the watersheds with livestock that are not included in SCDHEC's AFO database.

Table 3-5 Animal Feeding Operations

NPDES	TYPE	DESIGN COUNT	AFO SIZE	COUNTY NAME	HUC CODE14
PD-333					
ND0000507	BROILERS	42000	medium	Chesterfield	03040202020010
ND0062634	TURKEY	20000	medium	Chesterfield	03040202020010
ND0066478	TURKEY	12000	small	Chesterfield	03040202020010
ND0072435	BROILERS	22000	small	Chesterfield	03040202020010
ND0082945	BREEDERS	44200	medium	Chesterfield	03040202020010
PD-113					
ND0062588	BROILERS	INACTIVE	large	Chesterfield	03040202010010
ND0062600	TURKEY	6000	small	Chesterfield	03040202010010
ND0075086	TURKEY	45000	medium	Lancaster	03040202010010
PD-179					
ND0075035	TURKEY	22500	medium	Lancaster	03040202030020
PD-180					
ND0064807	TURKEY	42000	medium	Lancaster	03040202030020
ND0074667	BROILERS	15200	small	Lancaster	03040202030020
PD-342					
ND0064840	TURKEY	16000	small	Lancaster	03040202040010
ND0074845	TURKEY	INACTIVE	large	Lancaster	03040202040010
ND0074870	TURKEY	25000	medium	Lancaster	03040202040010
ND0075159	TURKEY	22500	medium	Lancaster	03040202040010
ND0075761	TURKEY	32000	medium	Lancaster	03040202040010
ND0076261	TURKEY	25000	medium	Lancaster	03040202040010
ND0076309	TURKEY	25000	medium	Lancaster	03040202040010
ND0077763	TURKEY	25000	medium	Lancaster	03040202040010
PD-066					
ND0064483	TURKEY	23500	medium	Lancaster	03040202030010
ND0062774	BROILERS	86000	medium	Chesterfield	03040202060010
ND0064076	TURKEY	12000	small	Chesterfield	03040202060010
ND0069281	TURKEY	INACTIVE	medium	Chesterfield	03040202060010

There are approximately 4,800 acres permitted for animal waste application from poultry facilities within these watersheds. Table 3-6 provides a summary of the land application field acreage based on SCDHEC data within the watersheds of select WQM stations.

Table 3-6 AFO Waste Disposal

WQM Station Watershed	AFO Permitted Swine Capacity	AFO Permitted Turkey Capacity	AFO Permitted Poultry Capacity	Total Acres Available for AFO Waste Disposal
PD-333	-	32,000	108,200	826
PD-113	-	51,000	155,000	705
PD-179	-	22,500	-	478
PD-180	-	42,000	15,200	681
PD-342	-	333,000	-	1,535
PD-066	-	60,000	86,000	584

All these land application fields may not actually be in use; SCDHEC estimates represent a total number of permitted land application sites and not operating disposal sites. Improperly applied manure is a possible source of fecal coliform bacteria within the SC portion of the three watersheds. It is important to note that sufficient data are not available to adequately estimate fecal coliform concentrations in stormwater runoff from land application fields where manure is applied. These operations are permitted; therefore, problems are managed through SCDHEC enforcement mechanisms.

A potential source of fecal coliform can be stormwater runoff from uncovered animal waste stockpiles. It is a common practice among many dairy farmers in SC to land apply manure from freestall barns or outside lot areas daily (http://hubcap.clemson.edu/~blpprt/mini-pits.html). This practice avoids the capital costs of a manure storage facility. To avoid possible stream and groundwater contamination, a manure storage facility is needed to time the land application rates with the crop needs.

Cows produce a considerable amount of manure. A 1,000-pound beef or dairy cow produces approximately 11 tons and 15 tons of manure per year, respectively (OSU 1992). Assuming the average cow weighs 750 pounds and manure production is 12 tons per animal per year, 100 cows would produce approximately 2.5 tons per day. These statistics were used to estimate manure production from cattle for each watershed presented in Table 3-7. While there are no cattle AFOs listed in Table 3-5 within the Group I watersheds, there are small farms throughout these watersheds that have cattle. The number of cattle within each WQM station watershed was estimated by dividing the number of cattle in each county by the total acres of pasture land in each county. County agricultural census data, if available, were used to estimate the number of livestock for each watershed (USDA 2002). This cattle density value was then multiplied by the number of acres of pasture land in each watershed. It is not unusual for farmers to provide their cattle direct access to creeks. For many farmers these creeks are the only water source for their cattle. Therefore, fecal coliform loading deposited directly into the creeks by cattle could be a significant source to these watersheds.

Table 3-7 Estimated Tons of Manure by WQM Station

WQM Station	Number of Cattle and Calves in Watershed	Tons of Manure Deposited Daily in Watershed
PD-333	820	20
PD-113	2,345	58
PD-179	296	7
PD-180	317	8
PD-342	632	16
PD-066	816	20

3.1.6 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

Table 3-8 provides estimations of the number of onsite wastewater disposal (OSWD) systems (primarily septic systems) in each watershed based on U.S. Census data. The table also provides the density of the OSWD systems. The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census tract by the number of acres in each census tract. This density was then applied to the number of acres of each census tract within a WQM station watershed. Most census tracts are fully within a watershed. Census tracts crossing a watershed boundary required an additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all the OSWD systems for each whole or partial census tract. Since subdivisions are built on large land tracts (hundreds of acres) the number of OSWD systems per 100 acres is easier to visualize; therefore, the following equation was used to estimate the number of OSWD systems summarized in Table 3-8:

Average OSWD systems per 100 acres = (number of OSWD systems / number of acres in the watershed) x 100 acres

Table 3-8 OSWD System Density

Watershed	Onsite Wastewater Systems	Onsite Wastewater Systems per 100-acres
PD-333	315	3
PD-113	1,399	4
PD-179	181	3
PD-180	92	1
PD-342	516	2
PD-066	639	2

Each type of OSWD system (septic system, surface irrigation, and cesspools) has its unique problems. More than 95 percent of the OSWD systems in each watershed are septic systems (U.S. Census 2000). OSWD system failures are proportional to the adequacy of a State's minimum design criteria (Hall 2002). Failures include surface ponding or runoff of untreated waste prior to the effluent mixing with groundwater. Fecal coliform contaminated groundwater discharges to creeks through springs and seeps. Most studies estimated that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger would cause contamination of ground or surface water (University of Florida 1987). It has been estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-8 shows that none of the Group I watersheds exceed this guideline.

In 1995, the SCDHEC conducted a survey of 5-year-old conventional and modified OSWD systems, representing designs most commonly used in the State (SCDHEC 1995). A total of 649 systems were examined during the first 4 months of 1995. During that period, actual rainfall amounts met or exceeded the normal for the period. This allowed for examination of the systems under high stress conditions. Of the 649 systems examined, there were 47 OSWD systems (7.2%) characterized as malfunctioning (SCDHEC 1999). This number included systems that were discharging to the ground surface, backing up into a building, discharging via "straight pipe," or showing evidence of prior system repair or signs of periodic or seasonal failure. In comparison, the 1995 American Housing Survey conducted by the U.S. Census Bureau estimated that 10 percent of occupied homes with OSWD systems experienced malfunctions during the year nationwide (U.S. Census 1995).

The SCDHEC, Regulation 61-56 does not require a minimum lot size, but requires minimum setbacks, such as property lines that dictate the required size of each individual lot. The minimum setback distance to a surface water body is 50 linear feet. There is no single family residence requirement to reserve a backup area should the original system fail. According to the National Small Flows Clearinghouse (NSFC), SC does not require inspection of OSWD systems prior to sale of the property (NSFC 1996).

Dense residential subdivisions relying on OSWD systems are typically near sewered metropolitan areas. Failing OSWD systems may be contributing to fecal coliform WQS exceedances in these areas. Fecal coliform loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater springs and seeps.

3.1.7 Domestic Pets

Pets can be a major contributor of fecal coliform to streams. A study conducted by Weiskel *et al.* (1996) found that pets produce 450 million fecal coliform per animal per day. On average nationally, there are 0.58 dogs and 0.66 cats per household (American Veterinary Medical Association 2004). Using the U.S. Census data (U.S. Census Bureau 2000), dog and cat populations can be estimated for the counties as shown in Table 3-9.

Table 3-9 Estimated Numbers of Household Pets

County	Number of Households	Number of Dogs	Number of Cats	Tons of Dog Waste per Day
Chesterfield	19,369	11,234	12,784	2.4
Kershaw	20,188	11,709	13,324	2.5
Lancaster	25,846	14,991	17,058	3.1

A study in a Washington, D.C. suburb found that dogs produce approximately 0.42 pounds of fecal waste per day (Thorpe 2003). A comparable number for waste produced by cats was not available; therefore, only the estimated tons per day of dog waste produced is provided in Table 3-9. Fecal coliform from dogs and cats transported by runoff from urban and suburban areas can be a potential source of loading. These calculations were provided for informational purposes to demonstrate that pet populations are higher in urbanized areas and that they can be a significant source of fecal coliform.

It is difficult to derive the density of dogs and cats in each watershed from the estimated county totals in Table 3-9 given that the watersheds occupy a small percentage of land area in the three counties. The small number of households in the each watershed suggests that fecal coliform contributions from pets are negligible. The most important consideration in determining the contribution of pet waste to fecal coliform loading is the percentage of residential development within each watershed.

3.1.8 Group I: Summary of Fecal Coliform Sources within Hills Creek, Lynches River, North Branch of Wildcat Creek, South Branch of Wildcat Creek, and Flat Creek Watersheds

The following data and information were used to describe point and nonpoint sources of fecal coliform and to estimate existing fecal coliform loading at each WQM station.

- Watershed land use and land cover;
- Agricultural census data, including livestock populations;
- Households served by OSWD systems and OSWD densities;
- Animal feeding operations;
- Domestic pet census data;
- NPDES permitted point sources and discharge monitoring reports; and
- MS4 Urban Areas and Urban Clusters.

#1 PD-333 Hills Creek at S-13-105

Hills Creek originates near the Town of Pageland and accepts the drainage of Mangum Branch, Cow Head Branch, and Conway Branch before flowing into the Lynches River. The watershed for WQM station PD-333 contains 10,214 acres, and the estimated median flow is 10.4 cubic feet per second (cfs). Land use/land cover in the watershed includes approximately 3 percent residential and business, 57 percent forest, 14 percent pastures, and 24 percent row crops. Six out of the 20 water quality samples collected from 1998 through 2000 had concentrations of fecal coliform that exceeded the WQS. Four of these six monthly exceedances occurred from July through October 1999. Flow in Hills Creek was below the median flow for all four of these months.

Point sources. This watershed contains the west side of the Town of Pageland, which is classified as a UC. This watershed contains the Pageland Northwest WWTP (NPDES SC0021504) discharge. No fecal coliform permit violations were reported in 84 monthly DMRs. The collection system of the WWTP had two SSOs reported to have reached Hills Branch. The first was approximately 60,000 gallons reported January 17, 2003, and 200,000 gallons reported December 8, 2004. Other SSOs that reached a waterbody were reported on February 7, March 10, and March 17, 2000, but were not quantified. There were no water quality data collected synoptically with reported SSO incidents; however, SSOs are known to be associated with higher flows and could be contributing to fecal coliform exceedances.

Nonpoint sources. This watershed contains the west side of the Town of Pageland, which is classified as AUC. The PD-333 watershed contains five turkey and poultry AFOs (three medium broiler AFOs and two small turkey AFOs) permitted to house up to 140,200 animals. This represents a potential density of 3.1 turkeys/acre and 10.6 poultry/acre. In addition, there are about 820 cattle in the watershed, representing an approximate density of 0.08 cattle/acre, which produce 20 tons of manure per day. Both the poultry and the cattle densities appear to be higher than many of the surrounding watersheds in the Pee Dee River Basin, and, thus, could represent a potentially significant source of fecal coliform. The watershed also contains 826 acres of land that may be used for land application of manure from AFOs, which is about 0.08 percent of the total acreage of the watershed. This value appears to be higher than most of the surrounding watersheds. Deer density is estimated to exceed 45 per square-mile. While there are an estimated 315 OSWD systems in the watershed, the low density of three systems per 100 acres suggests that OSWDs are not a major source of fecal coliform in the watershed.

In summary, the most likely sources of elevated fecal coliform concentrations include leaking sewers, SSOs, wildlife, poultry AFOs, cattle with direct access to creeks, and land application of manure.

#2 PD-113 Lynches River at SC-9, West of Pageland

The Lynches River originates in Union County, NC and forms the boundaries for Lancaster and Chesterfield Counties, SC. The PD-113 watershed contains 33,011 acres and has a median flow rate of 33.5 cfs. Less than 1 percent of the watershed is designated as residential or business. Approximately 57 percent is covered by forest. Pastures and row-crops occupy 22 and 19 percent, respectively.

Fifty-eight water quality samples were collected at PD-113 with nine samples (16%) containing excessive fecal coliform. As with PD-333 noted above, water samples collected at PD-113 for the months of July through October-1999 all contained excessive fecal coliform. The estimated flow rates for these 3 months were all less than the median. Only two water samples collected from 2000 to 2002 contained excessive fecal coliform with the largest concentration recorded (11,000 cfu/100 ml) occurring on October 14, 2002.

Point sources. There are no continuous permitted NPDES discharges and no MS4 urbanized areas in the PD-113 watershed. As such, SSOs and leaking sewer pipes are not a factor in fecal coliform loading.

Nonpoint sources. A portion of the small town of Tradesville is located within this watershed, although it is primarily rural. The deer density is greater than 45 per acre, suggesting a potentially significant source of fecal coliform loading. The PD-113 watershed contains the most cattle (2,345) of the watersheds in this report. Four AFOs are upstream of PD-113 and are permitted to house 155,000 poultry (one AFO [ND0062588] which became inactive in February 1999) and 51,000 turkeys (two AFOs), representing densities of 1.5 and 4.7 birds per acre, respectively. There is one cattle AFO (155) in the upper reaches of the watershed located in Union County, NC. There are 705 acres available for land application of manure. While there are many OSWD systems (estimated to be 1,399) in the watershed, the average density of four systems per 100 acres suggests that OSWDs may not be the predominant source of fecal coliform loading.

Because there are no known point source discharges in the watershed, the primary sources of fecal coliform appear to be cattle with direct access to streams, pets, wildlife, AFO land application areas, and failing OSWD systems.

#3 PD-179 North Branch of Wildcat Creek at S-29-39, 1-Mile South of Tradesville

WQM Station PD-179 is approximately 1 mile south of the small town of Tradesville. The PD-179 watershed contains 6,293 acres. The estimated median flow rate is 6.3 cfs at this WQM station. Houses, businesses, and ancillary development occupy only approximately 1 percent of the watershed. Forest occupies the largest land use with 63 percent, followed by row-crops at 28 percent. Pastures occupy approximately 6 percent of the watershed.

Between 1998 through 2000, 50 percent of the 18 water samples collected at this station contained fecal coliform densities in excess of the WQS. Analysis of the LDC for this station suggests there are dry weather as well as wet weather sources of bacteria, although “moist” conditions are regarded as the critical hydrologic condition for this watershed.

Point sources. Buford High School WWTP discharges in the very upper reaches of this watershed. Two permit violations out of 76 monthly DMRs were reported for this WWTP. The violations occurred in February 2003, after the last date for data collected from PD-179. Point sources do not appear to be contributing a significant amount of fecal coliform to this stream.

Nonpoint sources. The deer density is greater than 45 per acre due to the rural nature of the watershed, which may represent a potentially significant source of fecal coliform loading. The PD-179 watershed contains 296 cattle, representing a density of 0.05 cattle per acre. There is only one AFO, which is permitted to house 22,500 turkeys, representing a fairly high density of 3.6 turkeys per acre. There are 478 acres available for land application of manure, representing a significant potential source of fecal coliform loading. This watershed contains 181 OSWD, a relatively low number, with an average density of three per 100 acres.

This WQM station consistently experiences high concentrations of fecal coliform. Sources of fecal coliform are primarily nonpoint sources such as cattle, pets, wildlife, AFO land application areas, with failing OSWD systems expected to be negligible. In addition, although fecal coliform excursions do not appear to be associated with precipitation, the critical condition is designated as "moist" and, thus, could be influenced by elevated stormwater runoff levels. While only 1 percent of the watershed for PD-179 is urbanized land use, the town of Tradesville is very close to the WQM station. As a result, urban runoff from Tradesville may be contributing to fecal coliform exceedances.

#4 PD-180 South Branch of Wildcat Creek at S-29-39, 2-Miles South of Tradesville

The watershed for WQM station PD-180 contains 6,222 acres. The estimated median flow rate is 6.3 cfs at this WQM station. Houses, businesses, and ancillary development occupy approximately only 1 percent of the watershed, while approximately 67 percent is forest. Pastures and row crops cover approximately 6 percent and 17 percent, respectively.

Between 1998 through 2000, 29 percent of the 17 water samples collected at this station contained fecal coliform concentrations in excess of the WQS.

Point sources. There are no continuous NPDES discharges and no MS4 permits in the PD-180 watershed. As such, SSOs and leaking sewer pipes are not a factor in fecal coliform loading.

Nonpoint sources. The deer density is greater than 45 per acre, which may represent a potentially significant source of fecal coliform loading. The PD-180 watershed contains 317 cattle, representing only 0.01 cattle per acre. There are two AFOs permitted to house 42,000 turkeys and 15,200 poultry, with respective densities of 6.8 turkeys per acre and 2.4 poultry per acre. This represents a potentially significant source of fecal coliform loading. There are 681 acres available for AFO land application, representing only 0.01 percent of the land area. This watershed contains only 92 OSWD systems, with an average density of one per 100 acres.

The absence of point source discharges within the watershed indicates that nonpoint sources of fecal coliform appear to originate from turkeys and poultry as well as wildlife, while cattle, pets, land application of manure, and failing OSWD systems appear to be negligible.

#5 PD-342 Flat Creek at S-29-123

The PD-342 watershed contains 30,894 acres. The estimated median flow rate is 31.1 cfs at this WQM station, with a range of 9.4 to 137.4 cfs. Houses, businesses, and ancillary development only occupy approximately 1 percent of the watershed, while approximately 63 percent is covered by forest. Pastures and row crops cover approximately 2 percent and 14 percent, respectively. Woody wetlands encompass approximately 18 percent.

Between 1998 through 2002, 13 percent or four of the 30 water samples collected at this station contained fecal coliform concentrations in excess of the WQS. The exceedances occurred randomly during the period but did coincide with flow rates near or below the median (31.1 cfs). The reason for these random spikes in the fecal coliform concentrations is unknown.

Point sources. There are no continuous NPDES discharges in the PD-342 watershed. As such, SSOs and leaking sewer pipes are not a factor in fecal coliform loading.

Nonpoint sources. The deer density is greater than 45 per acre, which may represent a potentially significant source of fecal coliform loading. The PD-342 watershed contains 632 cattle, representing a density of 0.02 cattle per acre. There are eight AFOs, which are permitted to house 333,000 turkeys, representing a decidedly high density of 11 turkeys per acre. The largest of these turkeys AFOs (ND0074845) became inactive in May 2004). Associated with the high turkey density, there are 1,535 acres set aside for AFO land application. This watershed contains 516 OSWD systems with an average density of 1.7 per 100 acres, suggesting negligible contributions from this source.

The absence of point sources indicates that nonpoint sources of fecal coliform include turkey AFOs, land application of manure, and wildlife, with negligible contributions from cattle, pets, and failing OSWD systems. Fecal coliform concentrations in this watershed do not appear related to precipitation which is substantiated by the designated hydrologic critical condition of “dry.”

#6 PD-066 Lynches River at S-28-42

WQM Station PD-066 is located approximately 2 miles south by southwest from the small town of Jefferson. The PD-066 watershed contains 38,326 acres. The estimated median flow rate is 143.2 cfs at this WQM station, with a range of 43.4 to 632.2 cfs. Less than 1 percent of the total area contains houses and businesses, while approximately 53 percent is forest. Pastures and row crops cover approximately 3 percent and 15 percent, respectively. Woody wetlands encompass approximately 11 percent.

Between 1998 through 2000, 17 percent or three out of the 18 water samples collected at this station contained fecal coliform densities above the WQS. The reason for observed random spikes in the fecal coliform concentrations is unknown.

Point sources. There are no Phase I or II MS4 designated urbanized areas within the watershed of WQM station PD-066. The town of Jefferson’s municipal WWTP discharges into this watershed. There were two violations reported out of 80 monthly DMRs. The two violations occurred during the months of August and September 1998 and did not coincide with WQS exceedances at PD-066.

Nonpoint sources. The deer density is greater than 45 per acre, which may represent a potentially significant source of fecal coliform loading. The PD-066 watershed contains 816 cattle, representing a density of 0.02 cattle per acre. There are four AFOs permitted to house 86,000 turkeys and 83,500 poultry. One of the medium-sized turkey AFOs (ND0069281) became inactive in April 2005. This represents a density of 1.6 turkeys per acre and 2.2 poultry per acre, which are acknowledged to be potentially significant sources of fecal coliform loading. There are 584 acres available for AFO land application, which is 0.02 percent of the land area. This watershed contains 639 OSWD systems with an average density of 1.7 per 100 acres, suggesting a minor contribution from failing systems.

Sources of fecal coliform loading could originate from nonpoint sources such as turkeys and land application from turkey AFOs. Other nonpoint sources include wildlife, cattle, pets, and failing OSWD systems (given their low density) which represent only a minor source of loading. The close proximity of the town of Jefferson upstream of WQM station PD-066 suggests that urban runoff may be contributing to fecal coliform exceedances.

Upstream Influences on Downstream Water Quality

Figures 3-1 and 1-5 are useful in providing a perspective on the geographic location of each WQM station in Group I as well as specific land use designations. PD-333 (mid=10.4 cfs) is an impaired WQM station on Hills Creek upstream of PD-113. However, another WQM station on Hills Creek, PD-366, immediately upstream of PD-113, fully supports the primary contact recreation use. Station PD-113 is located on the main stem of Lynches River slightly downstream of PD-366. This suggests that the Lynches River watershed is the major source of the fecal coliform loading at WQM station PD-113 rather than the Hills Creek watershed.

Flat Creek (PD-342) is upstream of WQM station PD-066 on the Lynches River. However, WQM station PD-001, which is fully supporting the primary contact recreation use, is farther upstream than WQM station PD-066 suggesting that the Flat Creek watershed (PD-342) is not contributing fecal coliform loadings at PD-066. Elevated levels of fecal coliform at PD-066 are more likely caused by inflow from Fork Creek, a Lynches River tributary downstream of PD-001, which includes the small town of Jefferson.

3.2 Group II: Turkey Creek and Nasty Branch (HUC 03040205)

There are three WQM stations (PD-040, PD-098, and PD-239) within tributaries of the Pocotaligo River.

3.2.1 Point Source Discharges

There are two types of point sources discharging fecal coliform bacteria into the streams addressed in this report; they are continuous point sources and MS4s. Continuous point source discharges such as WWTPs, could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. There are no continuous point sources discharging to receiving waters within the Group II watersheds. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Stormwater Program, can also contain high fecal coliform bacteria concentrations and is discussed in Subsection 3.2.2. The following is a brief discussion of the fecal coliform contributions from point sources within the Group II watersheds.

3.2.2 Municipal Separate Storm Sewer Systems

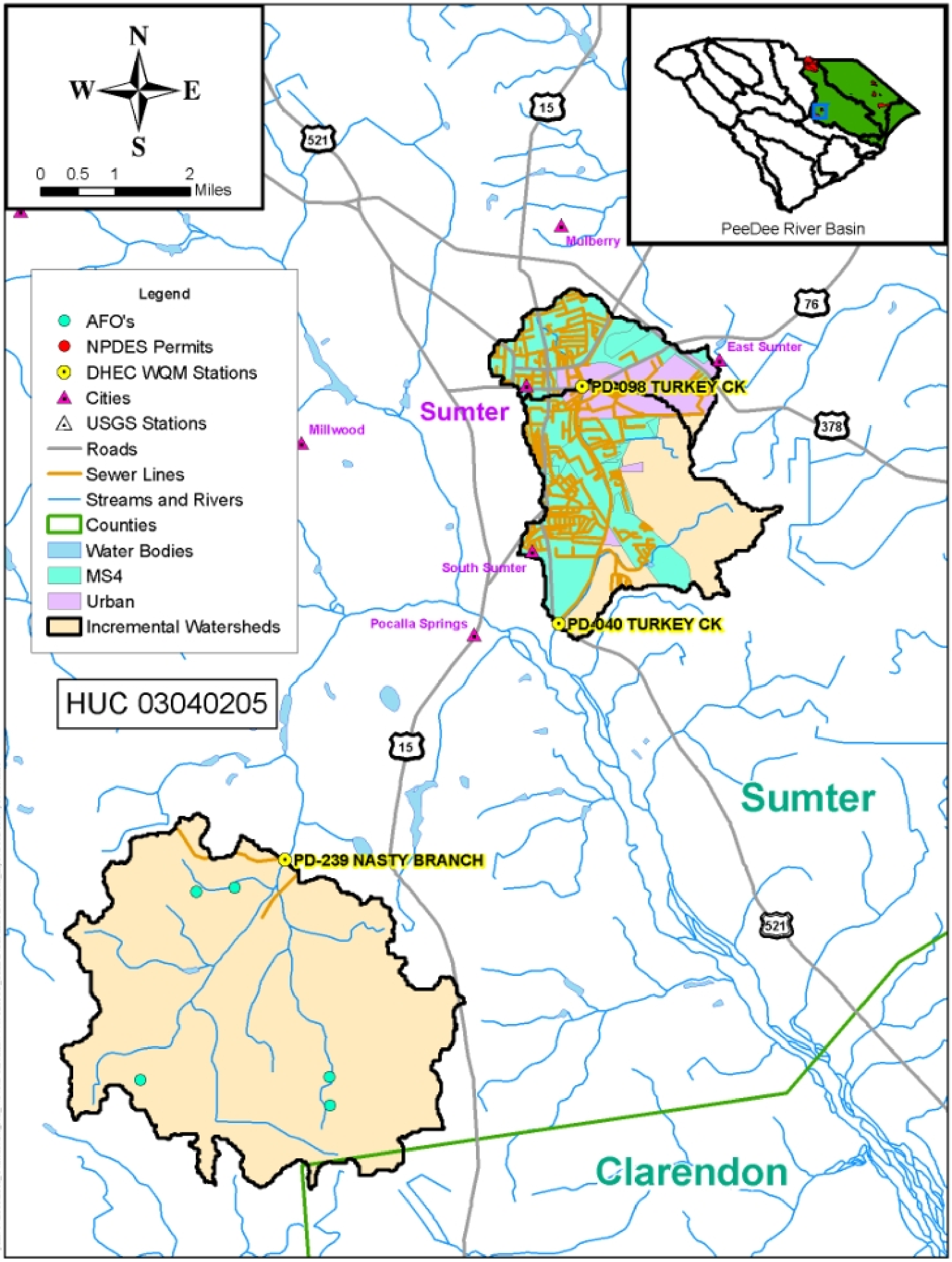
In 1990 the USEPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local water bodies (SCDHEC 2002). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. There are no Phase I MS4s within the Group II watersheds. A study under USEPA's National Urban Runoff Project indicated that average fecal coliform concentration from 14 watersheds in different areas within the U.S. was approximately 15,000 cfu/100 ml in stormwater runoff (USEPA 1983).

Phase II of the rule extends coverage of the NPDES stormwater program to certain small MS4s. Small MS4s are defined as a UA that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Small MS4s serve populations of 50,000 up to 99,999 and have an overall population density of 1,000 people per square-mile. The "suburbs" surrounding cities are typically classified as UAs for MS4 permitting purposes. Urban areas are identified on maps provided electronically by the U.S. Census Bureau at http://factfinder.census.gov/servlet/ReferenceMapFramesetServlet?_bm=y&-_lang=en. The U.S. Census Bureau map also identifies UCs, which are not automatically required to obtain MS4 permit coverage.

The Phase II MS4 regulations (Federal Register/Vol. 64, No. 235/Wednesday, December 8, 1999 /Rules and Regulations, pages 68722–68851) require operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the "maximum extent practicable," protect water quality, and satisfy appropriate water quality requirements of the CWA. Small MS4 stormwater programs must address the following minimum control measures:

- Public Education and Outreach;
- Public Participation/Involvement;
- Illicit Discharge Detection and Elimination;

Figure 3-2 Locations of NPDES Dischargers, MS4s, and Animal Feeding Operations in Turkey Creek and Nasty Branch Watersheds



- Construction Site Runoff Control;
- Post-Construction Runoff Control; and
- Pollution Prevention/Good Housekeeping.

SSOs to streams, although infrequent, can be a major source of fecal coliform loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of the pipes by grease and tree roots. SSOs are permit violations that must be addressed by the responsible NPDES permittee. Across the nation the reporting of SSOs has, within the last 6 years, been strongly encouraged by USEPA, primarily through enforcement and fines. Figure 3-2 above identifies the locations of the MS4 areas and the AFOs which are discussed later.

Portions of two of the three Group II watersheds are designated as an MS4 urbanized area. A large percentage of the watershed for WQM station PD-040 is urbanized and includes a sanitary sewer collection system. The MS4 area includes both the City of Sumter (including South Sumter) and Sumter County. These two governing entities have websites, but no references to the six Phase II requirements listed above were found. The PD-040 watershed containing this MS4 is heavily developed. Fecal coliform sources associated with MS4s are expected, including leaking sewers, SSOs, and pets, and wildlife.

PD-098 is also an MS4 urbanized area with a sanitary sewer collection system. The specific discharge location of SSOs was not reported. Therefore, the SSOs discussed above for PD-040 may have occurred within the PD-098 watershed.

3.2.3 Nonpoint Sources

Nonpoint sources include those that cannot be identified as entering the water body at a specific location. Because fecal coliform is associated with warm-blooded animals, nonpoint sources of fecal coliform may originate from both rural and urbanized areas.

Runoff from small urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria loading to streams. Water quality data collected from streams draining many of the un-permitted communities show existing loads of fecal coliform bacteria at levels greater than the State’s instantaneous standards. BMPs such as buffer strips and the proper disposal of domestic animal wastes may reduce fecal coliform bacteria loading to water bodies.

The following discussion highlights possible major nonpoint sources of fecal coliform. These sources include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems, and pets. The following subsections describe probable nonpoint sources of fecal coliform. Table 3-10 lists the three WQM stations impaired from nonpoint sources of fecal coliform only, since the contributing watersheds do not contain a continuous NPDES discharger with a fecal coliform limit.

Table 3-10 303(d) Listed WQM Stations Impaired by Nonpoint Sources Only

WQM Station	Stream Segments with No Upstream Active NPDES Fecal Coliform Discharge
PD-040	Turkey Creek at US 521
PD-098	Turkey Creek at Liberty St in Sumter above Santee Print Works
PD-239	Nasty Branch at S-43-251 7.5 mi SW of Sumter

3.2.4 Wildlife

Fecal coliform bacteria are produced by warm blooded animals such as deer, feral hogs, wild turkey, raccoons, other small mammals, and avian species. The SC DNR conducted a study in 2000 to estimate whitetail deer density based on suitable habitat (SCDNR 2000). This study assumed that deer habitat includes forests, croplands, and pastures. Table 3-11 lists the estimated deer population per square mile for each watershed. Each watershed contains an estimated density of 15 to 30 deer per square-mile. According to a study conducted by Yagow (1999), fecal coliform production rate for deer is 347 x 10^6 cfu/head-day. Although only a portion of the fecal coliform produced by deer may enter into a water body, the large population of deer in the watersheds may be a significant source of fecal coliform loading.

Table 3-11 Estimated Deer Density by Watershed

Station	Estimated Deer Population per Square Mile
PD-040	15 - 30
PD-098	15 - 30
PD-239	15 - 30

There are currently no available data for other wildlife and avian species known to inhabit these watersheds which could potentially contribute to the fecal coliform load. Given the representative statistics for deer population and the large amount of rural area (forest, cropland, and pasture) in the watersheds included in this report, wildlife may contribute a significant portion of the overall fecal coliform load.

3.2.5 Agricultural Activities and Domesticated Animals

Domesticated animals produce significant amounts of waste and are recognized as a source of fecal coliform loading. For example, according to a livestock study conducted by the ASAE (ASAE 1998), the following fecal coliform production rates were estimated:

- Cattle release approximately 100 billion fecal coliform per animal per day;
- pigs - 11 billion per animal per day, and
- chickens - 1.4 billion per animal per day.

Manure generated by livestock in pastures or at AFOs, typically used as fertilizer on crop lands, forests, and pastures, is therefore a potential source of fecal coliform loading. The CWA does not regulate nonpoint source runoff from agriculture lands receiving agronomic applications of manure (CWA §502(14)). Furthermore, for the purposes of this pollutant source assessment, sufficient data are not available to estimate fecal coliform concentrations in stormwater runoff from land application fields. Stormwater leaving a CAFO is regulated under the NPDES program; however, there are currently no NPDES-permitted CAFOs in SC. The SCDHEC currently maintains a statewide list of AFOs categorized by the type of facility (cattle, swine, poultry) and size which is defined by the specific number of animal units (large, medium, small).

Table 3-12 lists the poultry (broilers) and swine AFO facilities located in PD-239 which was derived from the SCDHEC statewide list of AFOs. All the AFOs are classified as no discharge facilities. Table 3-13 lists the number of livestock permitted to be housed and the number of acres in each watershed permitted for land application of manure from AFO facilities. All these AFOs are located in watershed PD-239. Figure 3-2, discussed previously, presents the spatial distribution of specific AFO facilities upstream of each 303(d)-listed WQM station. In addition to the AFOs listed in Table 3-12, there may be other small farms throughout the watershed with livestock that are not included in SCDHEC's AFO database.

Table 3-12 Animal Feeding Operations

NPDES	TYPE	DESIGN COUNT	AFO SIZE	COUNTY NAME	HUC CODE14
PD-239					
ND0068101	SWINE	200	small	Sumter	03040205080030
ND0070106	SWINE	12	small	Sumter	03040205080030
ND0070777	BROILERS	100000	medium	Sumter	03040205080030
ND0071188	BROILERS	48000	medium	Sumter	03040205080030
ND0071196	BROILERS	68000	medium	Sumter	03040205080030

There are approximately 342 acres permitted for animal waste land application from swine and poultry facilities within the watershed of PD-239. Table 3-13 provides a summary of the land application field acreage based on SCDHEC data within the PD-239 watershed.

Table 3-13 AFO Land Application

WQM Station Watershed	AFO Permitted Swine Capacity	AFO Permitted Turkey Capacity	AFO Permitted Poultry Capacity	Total Acres Available for AFO Land Application
PD-239	212	-	216,000	342

All these land application fields may not actually be in use; SCDHEC estimates represent a total number of permitted land application sites and not operating disposal sites. Improperly applied manure is a possible source of fecal coliform bacteria within this watershed. It is important to note that sufficient data are not available to adequately estimate fecal coliform concentrations in stormwater runoff from land application fields where manure is applied. These operations are permitted; therefore, problems are managed through SCDHEC enforcement mechanisms. There are few cows in these watersheds.

Cows produce a considerable amount of manure. A 1,000-pound beef or dairy cow produces approximately 11 tons and 15 tons of manure per year, respectively (OSU 1992). Assuming the average cow weighs 750 pounds and manure production is 12 tons per animal per year, 100 cows would produce approximately 2.5 tons per day. These statistics were used to estimate manure production from cattle for each watershed presented in Table 3-14. While there are no cattle AFOs listed in Table 3-12 within the Group II watersheds, there are small farms throughout these watersheds that have cattle. The number of cattle within each WQM station watershed was estimated by dividing the number of cattle in each county by the total acres of pasture land in each county. County agricultural census data, if available, were used to estimate the number of livestock for each watershed (USDA 2002). This cattle density value was then multiplied by the number of acres of pasture land in each watershed. It is not unusual for farmers to provide their cattle direct access to creeks. For many farmers these creeks are the only water source for their cattle. Therefore, fecal coliform loading deposited directly into the creeks by cattle could be a significant source to these watersheds.

Table 3-14 Estimated Tons of Manure by WQM Station

WQM Station	Number of Cattle and Calves in Watershed	Tons of Manure Deposited Daily in Watershed
PD-040	25	1
PD-098	18	0
PD-239	195	5

3.2.6 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

Table 3-15 provides estimations of the number of OSWD systems (primarily septic systems) in each watershed based on U.S. Census data. The table also provides the density of the OSWD systems. The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census tract by the number of acres in each census tract. This density was then applied to the number of acres of each census tract within a WQM station watershed. Most census tracts are fully within a watershed. Census tracts crossing a watershed boundary required an additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all the OSWD systems for each whole or partial census tract. Since subdivisions are built on large land tracts (hundreds of acres) the number of OSWD systems per 100 acres is easier to visualize; therefore, the following equation was used to estimate the number of OSWD systems summarized in Table 3-15:

Average OSWD systems per 100 acres = (number of OSWD systems / number of acres in the watershed) x 100 acres

Table 3-15 OSWD System Density

Watershed	Onsite Wastewater Systems	Onsite Wastewater Systems per 100-acres
PD-040	469	11
PD-098	59	3
PD-239	569	5

Each type of OSWD system (septic system, surface irrigation, and cesspools) has its unique problems. More than 95 percent of the OSWD systems in each watershed are septic systems (U.S. Census 2000). OSWD system failures are proportional to the adequacy of a State's minimum design criteria (Hall 2002). Failures include surface ponding or runoff of untreated waste prior to the effluent mixing with groundwater. Fecal coliform contaminated groundwater discharges to creeks through springs and seeps. Most studies estimated that the minimum lot size necessary to ensure against contamination is roughly one-half to one acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger would cause contamination of ground or surface water (University of Florida 1987). It has been estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-15 identifies one (PD-040) out of three watersheds with OSWD system densities greater than 6.25 septic systems per 100 acres. WQM Station PD-239 has an OSWD system density of five per 100 acres which could potentially contribute significant fecal coliform loadings.

In 1995, the SCDHEC conducted a survey of 5-year-old conventional and modified OSWD systems, representing designs most commonly used in the State (SCDHEC 1995). A total of 649 systems were examined during the first 4 months of 1995. During that period, actual rainfall amounts met or exceeded the normal for the period. This allowed for examination of the systems under high stress conditions. Of the 649 systems examined, there were 47 OSWD systems (7.2%) characterized as malfunctioning (SCDHEC 1999). This number included systems that were discharging to the ground surface, backing up into a building, discharging via "straight pipe," or showing evidence of prior system repair or signs of periodic or seasonal failure. In comparison, the 1995 American Housing Survey conducted by the U.S. Census Bureau estimated that 10 percent of occupied homes with OSWD systems experienced malfunctions during the year nationwide (U.S. Census 1995).

The SCDHEC, Regulation 61-56 does not require a minimum lot size, but requires minimum setbacks, such as property lines that dictate the required size of each individual lot. The minimum setback distance to a surface water body is 50 linear feet. There is no single family residence requirement to reserve a backup area should the original system fail. According to the NSFC, the SC does not require an inspection of OSWD systems prior to sale of the property (NSFC 1996).

Dense residential subdivisions relying on OSWD systems are typically near sewered metropolitan areas. Failing OSWD systems may be contributing to fecal coliform WQS exceedances in these areas. Fecal coliform loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater springs and seeps.

3.2.7 Domestic Pets

Pets can be a major contributor of fecal coliform to streams. A study conducted by Weiskel *et al.* (1996) found that pets produce 450 million fecal coliform per animal per day. On average nationally, there are 0.58 dogs and 0.66 cats per household (American Veterinary Medical Association 2004). Using the U.S. census data (U.S. Census Bureau 2000), dog and cat populations can be estimated for the counties as shown in Table 3-16.

Table 3-16 Estimated Number of Household Pets

County	Number of Households	Number of Dogs	Number of Cats	Tons of Dog Waste per Day
Clarendon	11,812	6,851	7,796	1.4
Sumter	42,648	24,736	28,148	5.2

A study in a Washington, D.C. suburb found that dogs produce approximately 0.42 pounds of fecal waste per day (Thorpe 2003). A comparable number for waste produced by cats was not available; therefore, only the estimated tons per day of dog waste produced is provided in Table 3-16. Fecal coliform from dogs and cats transported by runoff from urban and suburban areas can be a potential source of loading. These calculations were provided for informational purposes to demonstrate that pet populations are higher in urbanized areas and that they can be a significant source of fecal coliform.

It is difficult to derive the density of dogs and cats in each watershed from the estimated county totals in Table 3-16 given that the watersheds occupy a small percentage of land area in the three counties. Data for Sumter County, which includes both WQM stations PD-040 and PD-098, indicates 5.2 tons of dog waste produced per day, although PD-040 and PD-098 occupy only a small portion of the county's acreage. The large estimated population of dogs and cats in Sumter County is expected given the urbanized area and large number of households associated with the City of Sumter and the surrounding communities. Consequently, fecal coliform from domestic pets transported by runoff from urban and suburban areas in the watersheds can be a significant source of loading in urbanized areas.

3.2.8 Summary of Fecal Coliform Sources within Turkey Creek and Nasty Branch Watersheds

The following data and information were used to describe point and nonpoint sources of fecal coliform and to estimate existing fecal coliform loading at each WQM station.

- Watershed land use and land cover;

- Agricultural census data, including livestock populations;
- Households served by OSWD systems and OSWD densities;
- Animal feeding operations;
- Domestic pet census data;
- NPDES permitted point sources and discharge monitoring reports; and
- MS4 Urban Areas and Urban Clusters.

#7 PD-040 Turkey Creek at US 521 (upstream)

The PD-040 watershed contains 4,395 acres and a portion of the urbanized areas in and around the City of South Sumter. The estimated medium flow rate is 3.7 cfs at this WQM station, ranging from 0.2 to 27.8 cfs. The watershed is considerably more urbanized than those discussed above, with houses, businesses, and ancillary development occupying approximately 35 percent of the watershed, with approximately 37 percent covered by forest. Pastures and row crops cover approximately 2 percent and 19 percent, respectively. Woody wetlands encompass approximately 6 percent.

Eight water samples were collected at PD-040 in Turkey Creek during 1998, with six (75 percent) of the samples containing concentrations of fecal coliform in excess of the WQS. There is no clear correlation between fecal coliform concentrations and high or low flow rates. The three highest concentrations, 1,900, 1,900, and 1,400 cfu/100 ml, occurred in samples collected in May (5.6 cfs), June (5.2 cfs), and July (0.6 cfs), respectively.

Point sources. There is no continuous NPDES point source discharge in this watershed. However, there is an urbanized area designated as an MS4 and a sanitary sewer collection system within the watershed of WQM station PD-040. Fecal coliform sources associated with MS4s are expected, including leaking sewers, SSOs, and pets and wildlife.

The Sumter-Pocotaligo WWTP (SC0027707) collection system located partially within these watersheds, reported eight out of nine SSOs (420-1,000 gallons) reaching a receiving water body. SSOs are permit violations that must be addressed by the responsible NPDES permittee. Three of these SSOs discharged to ditches or canals draining to Turkey Creek (PD-040 and PD-098). These occurred on January 2, 2002 (500 gallons), March 1, 2002 (1,000 gallons), and June 12, 2002 (500 gallons). Instream water samples at the two stations were collected beginning 1998 through 2000. None of the eight SSOs reaching water bodies coincided with the dates instream water samples were collected at the two WQM stations in Turkey Creek.

Nonpoint sources. The deer density in this watershed ranges from 15 to 30 per acre, suggesting a relatively minor contribution of fecal coliform loading from wildlife. The PD-040 watershed is estimated to contain only 25 cattle, with a very low density of 0.01 cattle per acre. There are no cattle or poultry AFOs in the watershed or AFO land application areas. This watershed contains 469 OSWD systems with an average density of 11 per 100 acres, which is considered excessive and a potentially significant source of fecal coliform loading.

The watershed is regarded as one of the most degraded watershed of the 16 303(d)-listed watersheds in this report. Because of the SSOs and high OSWD system density, it is anticipated that human sources play a major role in fecal coliform loadings in this watershed. The potential relationship between fecal coliform concentrations and precipitation is marginal and exceedances occur under both wet and dry conditions.

#8 PD-098 Turkey Creek at Liberty Street in Sumter above Santee Print Works (downstream)

The PD-098 watershed contains 1,893 acres and a portion of the urbanized areas in and around the City of Sumter. The estimated median flow rate is 1.1 cfs (very low) at this WQM station, ranging from 0 to 8.3 cfs. Houses, businesses, and ancillary development are substantial, occupying approximately 55 percent of the watershed. Approximately 27 percent is forest. Pastures and row crops cover approximately 3 percent and 9 percent, respectively.

Nine water samples were collected at PD-098 in Turkey Creek during 1999. Six (67 percent) of the samples contained concentrations of fecal coliform exceeding the WQS. There is some correlation between excessive fecal coliform and wet weather since 100 percent of the samples collected during high flows exceeded the WQS.

Point sources. There is no continuous NPDES point source discharge in this watershed. However, as discussed in Subsection 3.2.2, the area is an urbanized area containing an MS4 and sanitary sewer collection system. The location of SSOs was not reported. Therefore, the SSOs discussed above for PD-040 may have contributed to fecal coliform loading in this watershed.

Nonpoint sources. The deer density ranges from 15 to 30 per acre, suggesting a relatively minor contribution of fecal coliform loading from wildlife. The PD-098 watershed is estimated to contain approximately 18-cattle, which is not regarded as significant. There are no AFOs in the watershed or AFO land application areas. This watershed contains 59 OSWD systems with an average density of three per 100 acres, which is much lower than PD-040 and is regarded as relatively minor. Because of the possibility of SSOs and moderate OSWD system density, it is anticipated that human sources may play a role in fecal coliform loadings in this watershed. Other nonpoint sources of fecal coliform include wildlife and pets. The relationship between fecal coliform concentrations and precipitation demonstrated a positive statistical correlation.

#9 PD-239 Nasty Branch at S-43-251, 7.5-Miles Southwest of Sumter

The PD-239 watershed contains 11,160 acres. The estimated median flow rate is 6.5 cfs at this station, ranging from 0.3 to 48.4 cfs. Less than 2 percent of the total area contains houses, businesses, and ancillary development. Forest covers approximately 48 percent and wooded wetlands 13 percent. Pastures and row crops cover approximately 6 percent and 31 percent, respectively.

Nine water samples were collected at PD-239 in Nasty Branch during 1999 and 2000. Two (22%) of the samples (August (0.3-cfs) and September (0.1-cfs) 1999) contained concentrations of fecal coliform in excess of the WQS. These flow rates are very low compared to the median.

Point sources. There is no continuous NPDES discharge or MS4 in the PD-239 watershed, therefore, SSOs, leaking sewer pipes, are not contributing to fecal coliform loading.

Nonpoint sources. The deer density ranges between 15 and 30 per acre suggesting a relatively minor contribution of fecal coliform loading from wildlife. There are five AFOs, which are permitted to house 212 swine and 216,000 poultry. There are 342 acres available for AFO land application, representing 0.03 percent of the land area. This watershed contains 569 OSWD systems with an average density of 5.1 per 100 acres, which is considered somewhat significant.

This watershed ranks in the middle relative to the other 15 303(d)-listed watersheds in this report. The absence of point source discharges indicates that nonpoint sources of fecal coliform are poultry AFOs, land application of manure, possible failing OSWD systems, wildlife, and cattle with direct access to creeks.

Upstream Influences on Downstream Water Quality

Figures 3-2 and 1-6 are useful in providing a perspective on the geographic location of each WQM stations in Group II as well as specific land use designations. PD-098 is upstream of PD-040. The similarity in land use and the proximity between these two WQM stations suggests that Turkey Creek upstream of PD-098 is contributing to the fecal coliform exceedances downstream at WQM station PD-040.

3.3 Group III: Gulley Branch ,Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp (HUCs 03040201, 03040204)

There are six WQM stations within the Little Pee Dee River that are addressed in this section of the report.

3.3.1 Point Source Discharges

There are two types of point sources discharging fecal coliform bacteria into the streams addressed in this report; they are continuous point sources and MS4s. Continuous point source discharges such as WWTPs, could result in discharge of elevated concentrations of fecal coliform bacteria if the disinfection unit is not properly maintained, is of poor design, or if flow rates are above the disinfection capacity. Stormwater runoff from MS4 areas, which is now regulated under the USEPA NPDES Stormwater Program, can also contain high fecal coliform bacteria concentrations and is discussed in Subsection 3.3.2. The following is a brief discussion of each type of point source discharge.

Continuous Point Sources

Table 3-17 lists two active NPDES point sources, Marion South Main Street WWTP (Smith Swamp) and Dillon Little Pee Dee WWTP (outfall 001) that discharge upstream of WQM stations PD-187 and PD-030A, respectively. Inactive permits that ceased discharging prior to 1998 or industrial dischargers with no fecal coliform limits are not included in Table 3-17. Figure 3-3 identifies the locations of the two point source discharges as well as AFOs which are discussed later.

The DMR from each NPDES WWTP was used to determine the number of permit violations for each NPDES WWTP. DMRs are produced monthly by the WWTP operator. Each monthly DMR provides the geometric mean of all the fecal coliform analysis for that month and the maximum of the fecal coliform concentrations. The DMR reports do not indicate how many fecal coliform analyses are required by the permit. Some permits require sampling once a month (small WWTPs) to three times per week (large WWTPs). NPDES permit violations occur when the monthly geometric mean concentration exceeded 200 cfu/100 ml or when the maximum of the individual concentrations exceed 400 cfu/100 ml. The DMR data for each WWTP are provided in Appendix C. Table 3-17 indicates 14 fecal coliform permit violations from the Smith Swamp discharge and four violations from the Little Pee Dee River discharge. Therefore, contributions of fecal coliform loading from these two WWTP are considered insignificant. However, the Smith Swamp discharge ceased its discharge in 1999. Since 1999, only two exceedances above the WQS have been recorded for this watershed.

Table 3-18 summarizes the existing load estimates for each NPDES facility. Existing point source loads were estimated by multiplying the monthly average flow rates by the monthly geometric mean of fecal coliform bacteria discharged and then by a unit conversion factor. The 90^{th} percentile value was used to express the estimated existing load in cfu per day. The monthly flow rates and geometric mean fecal coliform values were extracted from the DMRs of each point source.

Table 3-17 Permitted Facilities Discharging Fecal Coliform Bacteria

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Receiving Water	Flow (mgd)	Number of Monthly Discharge Monitoring Reports***	Maximum Concentration cfu/100 ml	Monthly Average >200 cfu/100 ml	Maximum Daily Concentration >400 cfu/100 ml	Percent of Samples Exceeding Permit Limits
HUC 03040201130								
PD-187 Smith Swamp at US 501 1.9 mi SSE of Marion								
Marion WWTP, South Main Street (inactive)	SC0020257*	Smith Swamp	3.85**	22	6900	1	2	14
HUC 03040204030								
PD-030A Little Pee Dee River Below JCT with Maple SWP								
Dillion - Little Pee Dee	SC0021776	Little Pee Dee River	4	76	>400	0	3	4

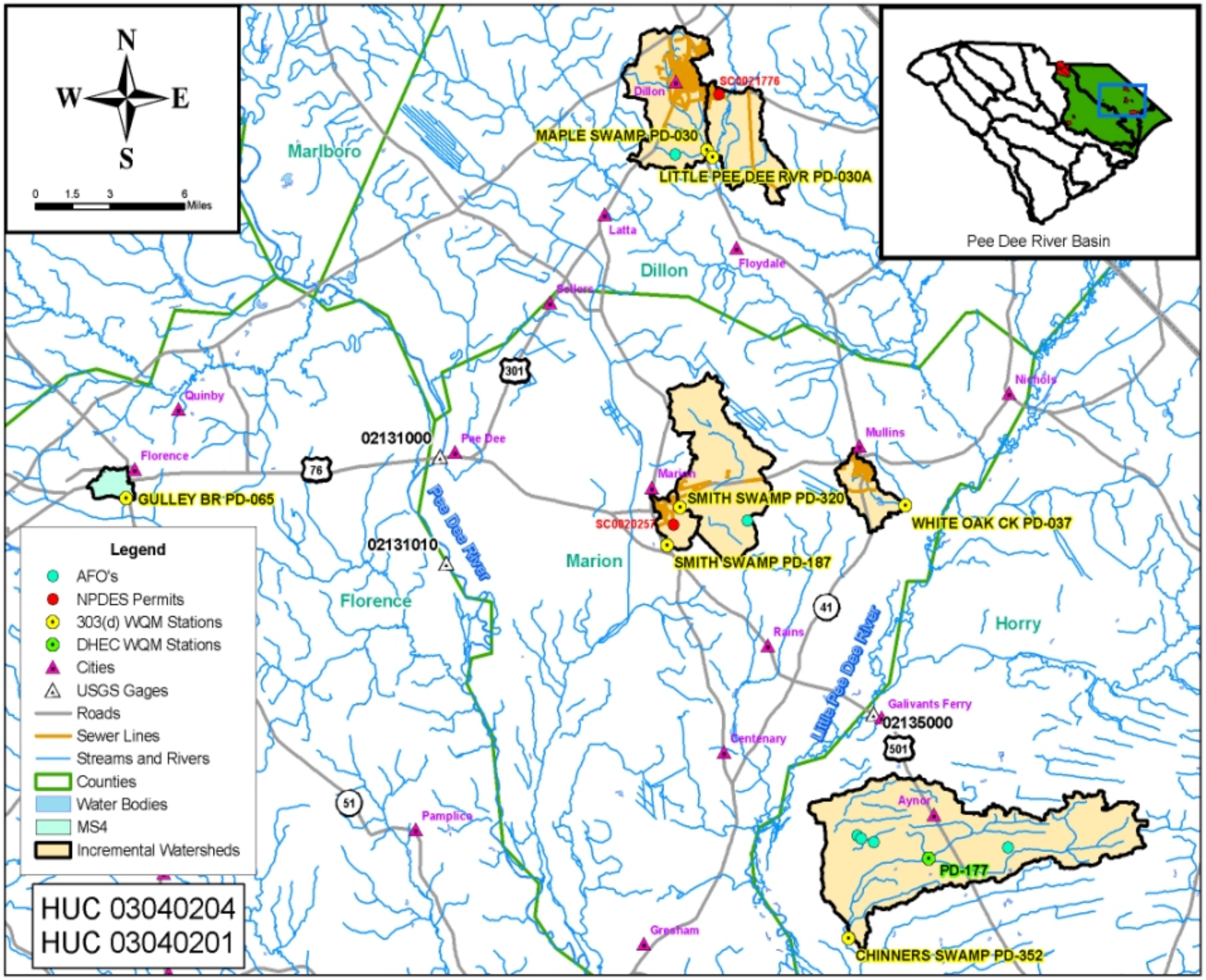
* Ceased Discharging in 1999.
** Maximum of Reported Monthly Average Flow Rates
*** Each DMR provides two fecal coliform values; the average of all samples for the month and the maximum of the samples.

Table 3-18 Estimated Existing Fecal Coliform Loading from NPDES Facilities (1998-2004)

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Receiving Water	90th percentile load (cfu/day)
HUC 03040201130			
PD-187 Smith Swamp at US 501, 1.9 Miles Southsoutheast of Marion			
Marion South Main Street WWTP	SC0020257*	Smith Swamp	6.56E+09
HUC 03040204030			
PD-030A Little Pee Dee River Below JCT with Maple SWP			
Dillion Little Pee Dee WWTP (Outfall 001)	SC0021776	Little Pee Dee River	8.36E+08

* Ceased Discharging in 1999.

Figure 3-3 Locations of NPDES Dischargers, MS4s, and Animal Feeding Operations in Gulley Branch, Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp Watersheds



3.3.2 Municipal Separate Storm Sewer Systems

In 1990 the USEPA developed rules establishing Phase I of the NPDES Stormwater Program, designed to prevent harmful pollutants from being washed by stormwater runoff into MS4s (or from being dumped directly into the MS4) and then discharged into local water bodies (SCDHEC 2002). Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or greater) to implement a stormwater management program as a means to control polluted discharges. Approved stormwater management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipal-owned operations, and hazardous waste treatment. There are no Phase I MS4s within the Group III watersheds. A study under USEPA's National Urban Runoff Project indicated that average fecal coliform concentration from 14 watersheds in different areas within the U.S. was approximately 15,000 cfu/100 ml in stormwater runoff (USEPA 1983).

Phase II of the rule extends coverage of the NPDES stormwater program to certain small MS4s. Small MS4s are defined as an urban area (UA) that is not a medium or large MS4 covered by Phase I of the NPDES Stormwater Program. Small MS4 have serve populations of 50,000 up to 99,999 and have an overall population density of 1,000 people per square-mile. The "suburbs" surrounding cities are typically classified as UAs for MS4 permitting purposes. Urban areas are identified on maps provided electronically by the U.S. Census Bureau at http://factfinder.census.gov/servlet/ReferenceMapFramesetServlet?_bm=y&-_lang=en. The U.S. Census map also identified UCs, which are not automatically required to obtain MS4 permit coverage.

The Phase II MS4 regulations (Federal Register/Vol. 64, No. 235 / Wednesday, December 8, 1999 / Rules and Regulations, pages 68722–68851) require operators of regulated small MS4s to obtain NPDES permits and develop a stormwater management program. Programs are designed to reduce discharges of pollutants to the "maximum extent practicable," protect water quality, and satisfy appropriate water quality requirements of the CWA.

SSOs to streams, although infrequent, can be a major source of fecal coliform loading to streams. SSOs have existed since the introduction of separate sanitary sewers, and most are caused by blockage of the pipes by grease and tree roots. SSOs are permit violations that must be addressed by the responsible NPDES permittee. Across the nation the reporting of SSOs has, within the last 6 years, been strongly encouraged by USEPA, primarily through enforcement and fines.

In the City of Florence, according to city staff, sewer pipes were discovered to be leaking wastewater into underground stormwater pipes during the early 1990s (City of Florence, SC 2005). These were repaired, but it is possible that new leaks have occurred. Therefore, leaking sewers may be a source of excessive fecal coliform into the PD-065 watershed. The watershed of WQM station PD-065 is heavily developed. It is likely the stormwater contains excessive concentrations of fecal coliform typical of this type of MS4. The City has been active in locating damaged sewers. On April 11, 2005, a house service line was found broken and discharging into an adjacent storm sewer. Water within this storm sewer eventually reached Gulley Branch. The service line was repaired that same day (City of Florence, SC 2005). There are no other MS4s in the Group III watersheds.

3.3.3 Nonpoint Sources

Nonpoint sources include those that cannot be identified as entering the water body at a specific location. Because fecal coliform is associated with warm-blooded animals, nonpoint sources of fecal coliform may originate from both rural and urbanized areas.

Runoff from small urban areas not permitted under the MS4 program is probably a significant source of fecal coliform bacteria into streams. Water quality data collected from streams draining many of the un-permitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards. BMPs such as buffer strips and the proper disposal of domestic animal wastes may reduce fecal coliform bacteria loading to water bodies.

The following discussion highlights possible major nonpoint sources of fecal coliform. These sources include wildlife, agricultural activities and domesticated animals, land application fields, urban runoff, failing OSWD systems, and pets. The following subsections describe probable nonpoint sources of fecal coliform. Table 3-19 lists the five WQM stations that are impaired from nonpoint sources of fecal coliform only, since the contributing watersheds do not contain an NPDES discharger with a fecal coliform limit.

Table 3-19 303(d) Listed WQM Stations Impaired by Nonpoint Sources Only

WQM Station	Stream Segments with No Upstream Active NPDES Fecal Coliform Discharge
PD-065	Gulley Branch at S-21-13, Timrod Park
PD-320	Smith Swamp at S-34-19 1 mi E of Marion
PD-030	Maple Swamp at SC57
PD-037	White Oak Creek at S-34-31
PD-352	Chinners Swamp at Gunters Island Rd off S-26-99

3.3.4 Wildlife

Fecal coliform bacteria are produced by warm-blooded animals such as deer, feral hogs, wild turkey, raccoons, other small mammals, and avian species. The SCDNR conducted a study in 2000 to estimate whitetail deer density based on suitable habitat (SCDNR 2000). This study assumed that deer habitat includes forests, croplands, and pastures. Table 3-20 lists the estimated deer population per square mile for each watershed. These watersheds contain a range in deer density from less than 15 per square-mile to 45 deer per square-mile. According to a study conducted by Yagow (1999), fecal coliform production rate for deer is 347×10^6 cfu/head-day. Although only a portion of the fecal coliform produced by deer may enter into a water body, the large population of deer in the watersheds may be a significant source of fecal coliform loading.

Table 3-20 Estimated Deer Density by Watershed

Station	Estimated Deer Population per Square Mile
PD-065	15 - 30
PD-187	15 - 30
PD-320	15 - 30
PD-030A	< 15
PD-030	< 15
PD-037	15 - 30
PD-352	30 - 45

There are currently no available data for other wildlife and avian species known to inhabit these watersheds which could potentially contribute to the fecal coliform load. Given the representative statistics for deer population and the large amount of rural area (forest, cropland, and pasture) in the watersheds included in this report, wildlife may contribute a significant portion of the overall fecal coliform load.

3.3.5 Agricultural Activities and Domesticated Animals

Domesticated animals produce significant amounts of waste and are recognized as a source of fecal coliform loading. For example, according to a livestock study conducted by the American Society of Agricultural Engineers (ASAE 1998), the following fecal coliform production rates were estimated:

- cattle release approximately 100 billion fecal coliform per animal per day; and
- pigs - 11 billion per animal per day.

Manure generated by livestock in pastures or at AFOs, which is typically used as fertilizer on crop lands, forests, and pastures, is a potential source of fecal coliform loading. The CWA does not regulate nonpoint source runoff from agriculture lands receiving agronomic applications of manure (CWA §502(14)). Furthermore, for the purposes of this pollutant source assessment, sufficient data are not available to estimate fecal coliform concentrations in stormwater runoff from land application fields. Stormwater leaving a CAFO is regulated under the NPDES program; however, there are currently no NPDES-permitted CAFOs in SC. The SCDHEC currently maintains a statewide list of AFOs categorized by the type of facility (cattle, swine, poultry) and size which is defined by the specific number of animal units (large, medium, small).

Table 3-21 lists the swine AFO facilities located by watershed, which was derived from the SCDHEC statewide list of AFOs. All the AFOs are classified as no discharge facilities. Table 3-22 lists the number of livestock permitted to be housed and the number of acres in each watershed permitted for land application of manure from AFO facilities. Figure 3-3, noted previously, presents the spatial distribution of specific AFO facilities upstream of each 303(d)-listed WQM station. WQM Station PD-030 (Maple Swamp) contains the most livestock, in this case swine, of all the watersheds. In addition to the AFO provided in Table 3-21, there may be other small farms throughout the watersheds with livestock that are not in SCDHEC's AFO database.

Table 3-21 Animal Feeding Operations

NPDES	TYPE	DESIGN COUNT	AFO SIZE	COUNTY NAME	HUC CODE14
PD-320					
ND0017809	SWINE	1670	medium	Marion	03040201150030
PD-030					
ND0076554	SWINE	5500	large	Dillon	03040204030060
PD-352					
ND0005037	SWINE	2860	large	Horry	03040204090010
ND0010618	SWINE	820	medium	Horry	03040204090010
ND0067903	SWINE	INACTIVE	small	Horry	03040204090010
ND0068047	SWINE	INACTIVE	small	Horry	03040204090010

There are approximately 380 acres permitted for land application of animal waste from swine AFO facilities within these watersheds. Table 3-22 provides a summary of the land application field acreage based on SCDHEC data within the watersheds of select WQM stations.

All these land application fields may not actually be in use; SCDHEC estimates represent a total number of permitted land application sites and not operating disposal sites. Improperly applied manure is a possible source of fecal coliform bacteria within the SC portion of the three watersheds. It is important to note that insufficient data are available to adequately estimate fecal coliform concentrations in stormwater runoff from land application fields where manure is applied. These operations are permitted; therefore, problems are managed through SCDHEC enforcement mechanisms.

Table 3-22 AFO Waste Disposal

WQM Station Watershed	AFO Permitted Swine Capacity	AFO Permitted Turkey Capacity	AFO Permitted Poultry Capacity	Total Acres Available for AFO Waste Disposal
PD-320	1,670	-	-	49
PD-030	5,500	-	-	308
PD-352	9,240	-	-	23

A potential source of fecal coliform can be stormwater runoff from uncovered animal waste stockpiles. It is a common practice among many dairy farmers in SC to land apply manure from freestall barns or outside lot areas daily (http://hubcap.clemson.edu/~blpprt/mini-pits.html). This practice avoids the capital costs of a manure storage facility. To avoid possible stream and groundwater contamination, a manure storage facility is needed to time the land application rates with the crop needs.

Cows produce a considerable amount of manure. A 1,000-pound beef or dairy cow produces approximately 11 tons and 15 tons of manure per year, respectively (OSU 1992). Assuming the average cow weighs 750 pounds and manure production is 12 tons per animal per year, 100 cows would produce approximately 2.5 tons per day. These statistics were used to estimate manure production from cattle for each watershed presented in Table 3-23. The highest estimate of manure production from cattle is approximately 10 tons per day (PD-352). Manure production from PD-065 and PD-030A is likely to be negligible. There are no cattle AFOs within the watersheds of this report. The number of cattle within each WQM station watershed was estimated by dividing the number of cattle in each county by the total acres of pasture land in each county. County agricultural census data, if available, were used to estimate the number of livestock for each watershed (USDA 2002). This cattle density value was then multiplied by the number of acres of pasture land in each watershed. It is not unusual for farmers to provide their cattle direct access to creeks. For many farmers these creeks are the only water source for their cattle. Therefore, fecal coliform loading deposited directly into the creeks by cattle could be a significant source to these watersheds.

Table 3-23 Estimated Tons of Manure by WQM Station

WQM Station	Number of Cattle and Calves in Watershed	Tons of Manure Deposited Daily in Watershed
PD-065	0	0
PD-187	40	1
PD-320	269	7
PD-030A	3	0
PD-030	83	2
PD-037	149	4
PD-352	399	10

3.3.6 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

Table 3-24 provides estimations of the number of OSWD systems (primarily septic systems) in each watershed based on U.S. Census data. The table also provides the density of the OSWD systems. The density of OSWD systems within each watershed was estimated by dividing the number of OSWD systems in each census tract by the number of acres in each census tract. This density was then applied to the number of acres of each census tract within a WQM station watershed. Most census tracts are fully within a watershed. Census tracts crossing a watershed boundary required an additional calculation to estimate the number of OSWD systems based on the proportion of the census tracking falling within each watershed. This step involved adding all the OSWD systems for each whole or partial census tract. Since subdivisions are built on large land tracts (hundreds of acres) the number of OSWD systems per 100 acres is easier to visualize; therefore, the following equation was used to estimate the number of OSWD systems summarized in Table 3-24:

Average OSWD systems per 100 acres = (number of OSWD systems / number of acres in the watershed) x 100 acres

Table 3-24 OSWD System Density

Watershed	Onsite Wastewater Systems	Onsite Wastewater Systems per 100-acres
PD-065	43	4
PD-187	95	6
PD-320	460	4
PD-030A	397	7
PD-030	395	5
PD-037	59	2
PD-352	941	3

Each type of OSWD system (septic system, surface irrigation, and cesspools) has its unique problems. More than 95 percent of the OSWD systems in each watershed are septic systems (U.S. Census 2000). OSWD system failures are proportional to the adequacy of a State's minimum design criteria (Hall 2002). Failures include surface ponding or runoff of untreated waste prior to the effluent mixing with groundwater. Fecal coliform contaminated groundwater discharges to creeks through springs and seeps. Most studies estimated that the minimum lot size necessary to ensure against contamination is roughly one-half to 1 acre (Hall 2002). Some studies, however, found that lot sizes in this range or even larger would cause contamination of ground or surface water (University of Florida 1987). It has been estimated that areas with more than 40 OSWD systems per square mile (6.25 septic systems per 100 acres) can be considered to have potential contamination problems (Canter and Knox 1986). Table 3-24 identifies one out of seven watersheds (PD-030A) with OSWD system densities greater than 6.25 septic systems per 100 acres. WQM Station PD-187 has an estimated OSWD system density of six per 100 acres, which may represent a substantial fecal coliform to the watershed.

In 1995, the SCDHEC conducted a survey of 5-year-old conventional and modified OSWD systems, representing designs most commonly used in the State (SCDHEC 1995). A total of 649 systems were examined during the first 4 months of 1995. During that period, actual rainfall amounts met or exceeded the normal for the period. This allowed for examination of the systems under high stress conditions. Of the 649 systems examined, there were 47 OSWD systems (7.2%) characterized as malfunctioning (SCDHEC 1999). This number included systems that were discharging to the ground surface, backing up into a building, discharging via "straight pipe," or showing evidence of prior system repair or signs of periodic or seasonal failure. In comparison, the 1995 American Housing Survey conducted by the U.S. Census Bureau estimated that 10 percent of occupied homes with OSWD systems experienced malfunctions during the year nationwide (U.S. Census 1995).

The SCDHEC, Regulation 61-56 does not require a minimum lot size, but requires minimum setbacks, such as property lines that dictate the required size of each individual lot. The minimum setback distance to a surface water body is 50 linear feet. There is no single family residence requirement to reserve a backup area should the original system fail. According to the NSFC, the SC does not require an inspection of OSWD systems prior to sale of the property (NSFC 1996).

Dense residential subdivisions relying on OSWD systems are typically near sewered metropolitan areas. Failing OSWD systems may be contributing to fecal coliform WQS exceedances in these areas. Fecal coliform loading from failing OSWD systems can be transported to streams in a variety of ways, including runoff from surface ponding or through groundwater springs and seeps.

3.3.7 Domestic Pets

Pets can be a major contributor of fecal coliform to streams. A study conducted by Weiskel *et al.* (1996) found that pets produce 450 million fecal coliform per animal per day. On average nationally, there are 0.58 dogs and 0.66 cats per household (American Veterinary Medical Association 2004). Using the U.S. census data (U.S. Census Bureau 2000), dog and cat populations can be estimated for the counties as shown in Table 3-25.

A study in a Washington, D.C. suburb found that dogs produce approximately 0.42 pounds of fecal waste per day (Thorpe 2003). A comparable number for waste produced by cats was not available; therefore, only the estimated tons per day of dog waste produced is provided in Table 3-25. Fecal coliform from dogs and cats transported by runoff from urban and suburban areas can be a potential source of loading. These calculations were provided for informational purposes to demonstrate that pet populations are higher in urbanized areas and that they can be a significant source of fecal coliform.

It is difficult to derive the density of dogs and cats in each watershed from the estimated county totals in Table 3-25 given that the watersheds occupy a small percentage of land area in the three counties. Station PD-065 is located in Florence County and is 82 percent urban. As shown on Table 3-25, approximately 5.7 tons of dog waste per day is produced in this county. However, PD-065 occupies only a small portion of the county's acreage.

Table 3-25 Estimated Number of Household Pets

County	Number of Households	Number of Dogs	Number of Cats	Tons of Dog Waste per Day
Dillon	11,199	6,495	7,391	1.4
Florence	47,147	27,345	31,117	5.7
Horry	131,384	76,203	86,713	16.0
Marion	15,402	8,933	10,165	1.9

3.3.8 Summary of Fecal Coliform Sources within Gulley Branch, Smith Swamp, Little Pee Dee River, Maple Swamp, White Oak Creek, and Chinners Swamp Watersheds (HUCs 03040201, 03040204)

The following data and information were used to describe point and nonpoint sources of fecal coliform and to estimate existing fecal coliform loading at each WQM station.

- Watershed land use and land cover;
- Agricultural census data, including livestock populations;
- Households served by OSWD systems and OSWD densities;
- Animal feeding operations;
- Domestic pet census data;
- NPDES permitted point sources and discharge monitoring reports; and
- MS4 Urban Areas and Urban Clusters.

#10 PD-065 Gulley Branch at S-21-13 in Timrod Park

The watershed of WQM station PD-065 contains 1,055 acres within the town of Florence. The estimated median flow rate is 1.5 cfs at this WQM station, ranging from 0.3 to 4.8 cfs. This is an urbanized watershed, with houses, businesses, and ancillary development occupying approximately 82 percent of the watershed. Approximately 17 percent is forest, while pastures and row crops cover less than 1 percent combined. Thirty-three water samples were collected at PD-065 in Gully Branch from 1998 through 2000. Twenty-four (73 percent) of the samples contained concentrations of fecal coliform in excess of the WQS.

Point sources. The City of Florence, within the PD-065 (Gulley Branch) watershed, is designated as an MS4. The City of Florence WWTP (SC0045462) reported 32 SSOs, with five SSOs reaching a waterbody, from March 2, 1999 through April 6, 2005. Most of the SSOs (31/32) were reported after February 2002. Twenty-two of the 32 SSOs occurred in 2004. The largest SSO to reach a waterbody (unknown) was 450,000 gallons on December 28, 2004.

A part of the City of Florence WWTP's collection system falls within the watershed of PD-065. Water samples collected at this station occurred from the beginning of 1998 through 2000. Table 2-1 shows 73 percent of the water samples collected at PD-065 were above the maximum daily fecal coliform WQS of 400 cfu/100 ml. SSOs or leaking sewers are contributing to the fecal coliform exceedances.

Nonpoint sources. The deer density ranges between 15 and 30 per acre. The PD-065 watershed contains no known cattle, and there are no AFOs or AFO land application areas. This watershed contains 43 OSWD systems with an average density of four per 100 acres, which could be significant.

Fecal coliform sources associated with MS4s are expected and include human sources of fecal coliform, including leaking sewers and SSOs. Domesticated pets could represent another source as well.

#11 PD-187 Smith Swamp at US 501, 1.9-Miles south-southeast of Marion

The PD-187 watershed contains 1,645 acres and drains the southeast portion of the Town of Marion. The estimated median flow rate is 18.9 cfs at this WQM station, ranging from 4.3 to 61.5 cfs. Approximately 26 percent of the total area contains houses, businesses, and ancillary development, while approximately 18 percent is forest. Pastures and row crops cover approximately 8 and 33 percent, respectively. Woody wetlands encompass approximately 12 percent.

Thirty-two water samples were collected at PD-187 from 1998 through 2000. Six (19%) of the samples contained concentrations of fecal coliform exceeding the WQS. Five of six WQS exceedances occurred in July, August, or September (lower flow months).

Point sources. The Marion Main Street WWTP (SC0020257), which stopped discharging to Smith Swamp in October 1999, reported two SSOs on September 16 and 22, 1999 that reached an unknown waterbody. A water sample was collected at PD-187 that contained 600 cfu/100 ml and may be related to these SSOs. In 1999, the WWTP discharge was moved to the Pee Dee River to obtain less stringent permit limits. Although the town is not large enough to automatically qualify for Phase II MS4 coverage, leaking sewers or SSOs may be contributing to the WQS exceedances.

Nonpoint sources. There is no Phase II MS4 in the PD-187 watershed. The Town of Marion is a UC area. Nevertheless, stormwater runoff from the most densely populated part of these UCs most probably contains excessive fecal coliform. The deer density ranges between 15 and 30 per acre. The PD-187 watershed contains approximately 40 cattle, which represents a low density of 0.02 cattle per acre. There are no AFOs or AFO land application areas. This watershed contains 95 OSWD systems with an average density of six per 100 acres, representing a potentially significant source.

In summary, fecal coliform sources typical of urban areas are expected and include human sources of fecal coliform such as leaking sewers, SSOs, and failing septic systems. Pets and wildlife may also represent a potential source of fecal coliform loading.

#12 PD-320 Smith Swamp at S-34-19, 1-Mile East of Marion

The watershed of WQM station PD-320 contains 11,237 acres. The estimated median flow rate is 91.7 cfs at this WQM station, ranging from 20.8 to 298.2 cfs. Houses, businesses, and ancillary development occupy only about 4 percent of the watershed. Approximately 33 percent is forest. Pastures and row crops cover approximately 7 and 45 percent, respectively. Woody wetlands encompass approximately 10 percent.

Ten water samples were collected at PD-320 from 1999 through 2000. Four (40%) contained concentrations of fecal coliform exceeding the WQS, with exceedances occurring in September 1999 and July, August, and September 2000 (low flow months). The PD-320 flow rates were estimated to be below 50 cfs on all the dates of exceedances in 2000. The estimated flow rate on the day of the September 1999 sample was 128 cfs, which is slightly above the average flow.

Point sources. There are no NPDES dischargers in this watershed, no UAs, and therefore, no Phase I or II MS4s in this watershed. The Marion Main Street WWTP reported two SSOs on September 16 and 22, 1999 that reached an unknown waterbody. A water sample was collected at PD-320 on September 21, 1999 that contained 1,100 cfu/100 ml and may be related to these SSOs. Although the town is not large enough to automatically qualify for Phase II MS4 coverage, leaking sewers or SSOs may be contributing to the WQS exceedances.

Nonpoint sources. The Town of Marion is a UC area and as a result, stormwater runoff from the most densely populated part of this UC probably contains excessive fecal coliform. The deer density ranges between 15 and 30 per acre, suggesting only a moderate contribution to fecal coliform loading. The PD-320 watershed is estimated to contain 269 cattle, representing a density of 0.02 cattle per acre. There is one swine AFO registered to house up to 1,670 animals, representing a density of 0.15 swine per acre (moderate potential contribution). There are 49 acres registered for AFO land application, which is minor. This watershed contains 460 OSWD systems with an average density of four per 100 acres, which may be a moderate source of fecal coliform loading.

In summary, human-derived fecal coliform sources typical of developed areas are expected, including SSOs and failing septic systems. Non-human sources such as swine, wildlife, and pets are expected to be low to moderate in this watershed. There appears to be no potential relationship between precipitation and fecal coliform loadings in this watershed, and the critical hydrologic condition for this watershed appears to be “dry.”

#13 PD-030A Little Pee Dee River below Confluence with Maple Swamp

The watershed of WQM station PD-030A contains 5,687 acres and drains the east side of the Town of Dillon. The estimated median flow rate is quite high at 1,065 cfs at this WQM station, ranging from 228.2 to 4,661.7 cfs. Houses, businesses, and ancillary development occupy only about 4 percent of the watershed, with approximately 30 percent covered by forest. Pastures and row crops cover approximately 1 percent and 23 percent, respectively. Woody wetlands comprise the largest percentage at 42 percent.

Ten water samples were collected at PD-030A from 1999 through 2000. Two (20%) contained concentrations of fecal coliform in excess of the WQS. Exceedances occurred in August 1999 and July 2000. Flow rates at PD-030A on these dates were significantly below the median flow rate. There are no MS4s in the PD-030A watershed. The Town of Dillon is a UC due to its size and isolation.

Point sources. No SSOs were reported within the PD-030A watershed. The small town of Dillon's WWTP discharges into this watershed. There were three permit violations reported out of 76 monthly DMRs. The three violations occurred during the months of August 1998, September 1999, and June 2000, but did not coincide with WQS exceedances at PD-030A.

Nonpoint sources. The deer density is less than 15 per acre, suggesting only a minor contribution to fecal coliform loadings. The PD-030A watershed is estimated to contain three cattle, which is negligible. There are no AFOs or AFO land application fields in this watershed. This watershed contains 397 OSWD systems with an average density of seven per 100 acres, which may be excessive. The close proximity of the Town of Dillon upstream of WQM station PD-030A suggests that urban runoff may be contributing to fecal coliform exceedances.

In summary, fecal coliform sources are expected to be from a combination of failing OSWD systems, and non-human sources such as livestock, wildlife, and pets.

#14 PD-030 Maple Swamp at SC 57

The watershed of WQM station PD-030 contains 8,886 acres and drains the Town of Dillon. The estimated median flow rate is 27 cfs at this WQM station, ranging from 5.8 to 118.1 cfs. Houses, businesses, and ancillary development occupy approximately 16 percent of the watershed, with approximately 27 percent covered by forest. Pastures and row crops cover approximately 16 percent and 31 percent, respectively. Woody wetlands encompass approximately 8 percent.

There were 17 water samples collected at PD-030 from 1998 through 2000. Two (12%) of the samples contained excessive concentrations of fecal coliform. The exceedances occurred in August 1998 and July 2000. Flow rates at PD-030 on these dates were estimated to be greatly below the median flow rate. There are no MS4s in the PD-030 watershed. The Town of Dillon is a UC due to its size and isolation.

Point sources. There are no WWTPs in this watershed, and no SSOs were reported within the PD-030 watershed. There are numerous sewer lines near Dillon, although it is not known whether leakages could have contributed to fecal coliform loading.

Nonpoint sources. The deer density is less than 15 per acre, suggesting only a minor contribution to fecal coliform loadings. The PD-030 watershed is estimated to contain 83 cattle, which represents a density of only 0.01 cattle per acre. There is one large swine AFO in this watershed that is registered to house 5,500 animals, representing a density of 0.62 swine per acre. There are 320 acres registered for AFO land application of waste in this watershed, which is not expected to be a major contribution. This watershed contains 395 OSWD systems with an average density of five per 100 acres, which is moderate to high. The close proximity of the Town of Dillon upstream of WQM station PD-030 suggests that urban runoff may be contributing to fecal coliform exceedances.

This watershed has the lowest percentage of WQS exceedances of the 16 watersheds discussed in this report. Fecal coliform sources may include some unreported leaking sewer lines, failing septic systems, and runoff from the single swine AFO. Contributions from wildlife and pets are considered negligible.

#15 PD-037 White Oak Creek at S-34-31

The watershed of WQM station PD-037 contains 2,450 acres and a portion of the Town of Mullins. The estimated medium flow rate is 7.7 cfs at this WQM station, ranging from 1.6 to 33.7 cfs. Houses, businesses, and ancillary development occupy approximately 16 percent of the watershed, while approximately 19 percent is covered by forest. Pastures and row crops cover approximately 19 percent and 40 percent, respectively.

There were 15 water samples collected at PD-037 from 1998 through 2000. Five (33%) of the samples contained concentrations of fecal coliform in excess of the WQS, all of which occurred during 1998 and 1999. Exceedances did not clearly correlate with high or low flow rates.

Point sources. There are no Phase I or II MS4s in the PD-037 watershed. The Town of Mullins is regarded as a UC. No SSOs were reported for the town. Nevertheless, stormwater runoff from the most densely populated part of this UC most probably contains excessive fecal coliform.

Nonpoint sources. The deer density falls between 15 and 30 per acre, representing a moderate potential source of fecal coliform loading. The PD-037 watershed is estimated to contain 149 cattle, representing 0.06 cattle per acre (low to moderate). There are no AFOs or AFO land application areas in this watershed. This watershed contains 59 OSWD systems with an average density of two per 100 acres, which is considered to be minor.

Fecal coliform sources may include a combination of nonpoint sources including stormwater runoff from the Town of Mullins, failing septic systems, and both pets and wildlife.

#16 PD-352 Chinners Swamp at Gunters Island Road of S-26-99

The watershed of WQM station PD-352 contains 27,264 acres. The estimated median flow rate is 41.2 cfs at this WQM station, ranging from 9.4 to 134.1 cfs. Houses, businesses, and ancillary development occupy less than 2 percent of the watershed, while approximately 36 percent is covered by forest. Wooded wetlands encompass 28 percent. Pastures and row crops cover approximately 4 and 30 percent, respectively.

There were 23 water samples collected at PD-352 during 1998, 2001 and 2002. Four (17%) of the samples contained concentrations of fecal coliform in excess of the WQS, all of which occurred in May and September 1998 and 2001 (low flow conditions).

Point sources. There are no Phase I or II MS4s in the PD-352 watershed. The small Town of Aynor lies within the watershed. No SSOs were reported for this town, which may not be sewered.

Nonpoint sources. Due to the rural nature of the watershed, the deer density falls between 30 and 45 per acre (fairly significant contribution). The PD-352 watershed is estimated to contain 399 cattle, representing a low density of 0.01 cattle per acre. There is one large, one medium, and two small swine AFOs in this watershed registered to house a combined total of 3,470 animals. The two smallest swine AFOs (ND0067903 and ND0068047) became inactive in March of 1999 and January 1998, respectively. This represents a density of 0.34 swine per acre, which may constitute a significant source of fecal coliform loading. Twenty-three acres is registered for AFO waste land application in this watershed, which is considered minor. This watershed contains 941 OSWD systems with an average density of three per 100 acres, which may represent a significant source.

In summary, OSWD systems may represent the major source of fecal coliform loadings, and swine AFOs may also contribute substantially to elevated concentrations. Wildlife and cattle may also contribute fecal coliform loadings.

Upstream Influences on Downstream Water Quality

Figures 3-3 and 1-7 are useful in providing a perspective on the geographic locations for each of the WQM stations in Group III as well as specific land use designations. PD-320 is upstream of PD-187. The similarity in land use and the proximity between these two WQM stations suggests that Smith Swamp upstream of PD-320 is contributing to the fecal coliform exceedances downstream at WQM station PD-187.

PD-030 (Maple Swamp) is upstream of PD-030A (Little Pee Dee River). The multiple human and non-human sources from the PD-030 watershed are contributing to the fecal coliform exceedances measured downstream at WQM station PD-030A.

Overall Summary by Watershed

Based on the information and data presented and analyzed in this report, the following inferences can be made regarding the sources (point and nonpoint) and magnitude of fecal coliform contributions to the 303(d)-listed WQM stations listed in this report. Table 3-26 lists the WQM stations in increasing percentages of WQS exceedances.

The exceedances are compared to four columns listing some of the potential significant sources of fecal coliform. The last three WQM stations (PD-098, PD-065, and PD-040) listed in Table 3-26 display the highest percentage of (most frequent) nonsupport of the primary contact recreation use. All three of these watersheds contain have two common characteristic – UAs with central sewer collection systems and designation as an MS4. Since agricultural activities (livestock and land application fields) are not present in these three watersheds, it suggests that human sources are the primary category of fecal coliform loading occurring, with minor contributions coming from pets and wildlife.

Most of the other watersheds were dominated by nonpoint sources of non-human fecal coliform loading (*e.g.*. poultry, swine or cattle AFOs or land application of AFO wastes, wildlife and pets) or human-derived fecal coliform (*e.g.*, OSWD systems). In the more forested watersheds it is expected that wildlife may contribute elevated concentrations of fecal coliform. WQM stations PD-030, PD-187, PD-333, and D-320 have urban areas not classified as MS4s. As stated above runoff from small urban areas not permitted under the MS4 program can be a significant source of fecal coliform bacteria loading to streams. Water quality data collected from streams draining many of the un-permitted communities show existing loads of fecal coliform bacteria at levels greater than the State's instantaneous standards

Table 3-26 WQM Stations Sorted According to Percent Exceedances

Station	Total Number of Samples	Total Number of Samples > 400 cfu/100 ml	Percentage of Samples > 400 cfu/100 ml	MS4	Runoff from Urban Land Use	AFO Waste Disposal in acres	Number of OSWD Systems	Number of Cattle
PD-030	17	2	12%	-	yes	308	395	83
PD-342	30	4	13%	-		1,535	516	632
PD-113	58	9	16%	-		705	1,399	2,345
PD-066	18	3	17%	-		584	639	816
PD-352	23	4	17%	-		23	941	399
PD-187	32	6	19%	-	yes	-	95	40
PD-030A	10	2	20%	-		-	397	3
PD-239	9	2	22%	-		342	569	195
PD-180	17	5	29%	-		681	92	317
PD-333	20	6	30%	-	yes	826	315	820
PD-037	15	5	33%	-		-	59	149
PD-320	10	4	40%	-	yes	49	460	269
PD-179	18	9	50%	-		478	181	296
PD-098	9	6	67%	yes		-	59	18
PD-065	33	24	73%	yes		-	43	0
PD-040	8	6	75%	yes		-	469	25

SECTION 4
TECHNICAL APPROACH AND METHODOLOGY

A TMDL is defined as the total quantity of a pollutant that can be assimilated by a receiving water body while achieving the WQS. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

TMDL = Σ WLA + Σ LA + MOS

The objective of the TMDL is to estimate allowable pollutant loads and to allocate these loads to the known pollutant sources in the watershed so the appropriate control measures can be implemented and the WQS achieved. 40 CFR § 130.2 (1) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform, TMDLs are expressed as cfu per day where possible or as percent reductions, and represent the maximum one-day load the stream can assimilate while still attaining the WQS.

4.1 Using Load Duration Curves to Develop TMDLs

LDCs are graphical analytical tools that illustrate the relationships between stream flow and water quality and assist in decision making regarding this relationship. Flow is an important factor affecting the loading and concentration of fecal coliform. Both point and nonpoint source loads of pollutants to streams may be affected by changes in flow regime. Given an understanding of the potential loading mechanisms of fecal coliform, and how those mechanisms relate to flow conditions, it is possible to infer and quantify the major contributing sources of pollutants to a stream by examining the relationship between flow and pollutant concentration or load. Of critical importance is that the incremental watershed LDC approach makes effective use of existing data. The lack of instream flow data at most water quality monitoring locations would typically be identified as a significant data gap for application of watershed and water quality models. However, since the incremental watershed LDC approach makes use of drainage area ratio-based flow estimates, the lack of flow information at these locations is not limiting. The incremental watershed approach also allows for assessment of land use, soil, and source contribution differences between observation points. The fecal coliform TMDLs presented in this report are designed to be protective of typical flow conditions. The following discussion provides an overview of the approach used to develop LDCs and TMDL calculations. Results and calculations are presented in Section 5.

4.2 Explanation of Steps used to Perform TMDL Calculations

The following discussion provides a summary of the steps involved in the calculation of the key components of the fecal coliform TMDLs presented in Section 5 of this report.

Step 1: Develop Flow Percentiles for each WQM Station. Direct flow measurements are not available for all of the WQM stations addressed in this report. This information, however, is vitally important to understanding the relationship between water quality and stream flow. Therefore, to characterize flow, in some cases flow data were derived from a flow estimation model for each relevant watershed. Flow data to support development of flow duration curves will be derived for each SCDHEC WQM station from USGS daily flow records (USGS 2005b) in the following priority:

i) In cases where a USGS flow gage coincides with, or occurs within one-half mile upstream or downstream of a SCDHEC WQM station and simultaneous daily flow data matching the water quality sample date are available, these flow measurements will be used.

ii) If flow measurements at the coincident gage are missing for some dates on which water quality samples were collected, gaps in the flow record will be filled, or the record extended, by estimating flow based on measured streamflows at a nearby gage. First, the most appropriate nearby stream gage is identified. All flow data are first log-transformed to linearize the data because flow data are highly skewed. Linear regressions are then developed between 1) daily streamflow at the gage to be filled/extended; and 2) streamflow at all gages within 93 miles (150 kilometers) that have at least 300 daily flow measurements on matching dates. The station with the strongest flow relationship, as indicated by the highest correlation coefficient (r-squared value), is selected as the index gage. R-squared indicates the fraction of the variance in flow explained by the regression. The regression is then used to estimate flow at the gage to be filled/extended from flow at the index station. Flows will not be estimated based on regressions with r-squared values less than 0.25, even if that is the best regression. This value was selected based on familiarity with using regression analysis in estimating flows. In some cases, it will be necessary to fill/extend flow records from two or more index gages. The flow record will be filled/extended to the extent possible based on the strongest index gage (highest r-squared value), and remaining gaps will be filled from successively weaker index gages (next highest r-squared value), and so forth.

iii) In the event no coincident flow data are available for a WQM station, but flow gage(s) are present upstream and/or downstream, flows will be estimated for the WQM station from an upstream or downstream gage using a watershed area ratio method derived by delineating subwatersheds, and relying on the Natural Resources Conservation Service runoff curve numbers and antecedent rainfall condition. Drainage subbasins will first be delineated for all impaired 303(d)-listed WQM stations, along with all USGS flow stations located in the 8-digit HUCs with impaired streams. All USGS gage stations upstream and downstream of the subwatersheds with 303(d)-listed WQM stations will be identified.

Step 2: Develop Flow Duration Curves. Flow duration curves serve as the foundation of LDC TMDLs. Flow duration curves are graphical representations of the flow regime of a stream at a given site. The flow duration curve is an important tool of hydrologists, utilizing the historical hydrologic record from stream gages to forecast future recurrence frequencies.

Flow duration curves are a type of cumulative distribution function. The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. The observed flow values are first ranked from highest to lowest, then, for each observation, the percentage of observations exceeding that flow is calculated. The flow rates for each 5^{th} percentile for each WQM station are provided in Appendix D. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa, which is numbered from 0 to 100 percent, and may or may not be logarithmic. The lowest measured flow occurs at an exceedance frequency of 100 percent, indicating that flow has equaled or exceeded this value 100 percent of the time, while the highest measured flow is found at an exceedance frequency of 0 percent. The median flow occurs at a flow exceedance frequency of 50 percent.

While the number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than 1 year of observations, and encompasses inter-annual and seasonal variations. Ideally, the drought and flood of record are included in the observations. For this purpose, the long term flow gaging stations operated by the USGS are ideal.

A typical semi-log flow duration curve exhibits a sigmoidal shape, bending upward near a flow duration of 0 percent and downward at a frequency near 100 percent, often with a relatively constant slope in between. However, at extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantitation. The extreme high flow conditions ($<10^{th}$ percentile) and low flow conditions (>95 percentile) are not considered in development of these TMDLs. The overall slope of the flow duration curve is an indication of the flow variability of the stream.

Flow duration curves can be subjectively divided into several hydrologic condition classes. These hydrologic classes facilitate the diagnostic and analytical uses of flow and LDCs. The hydrologic classification scheme utilized in the development of these TMDLs is presented in Table 4-1.

Table 4-1 Hydrologic Condition Classes

Flow Duration Interval	Hydrologic Condition Class*
0-10%	High flows
10-40%	Moist Conditions
40-60%	Mid-Range Conditions
60-90%	Dry Conditions
90-100%	Low Flows

Source: Cleland 2003.

Step 3: Estimate Current Point Source Loading. In SC, NPDES permittees that discharge treated sanitary wastewater must meet the state WQS for fecal coliform bacteria at the point of discharge (see discussion in Section 2). However, for TMDL analysis it is necessary to understand the relative contribution of WWTPs to the overall pollutant loading and their general compliance with required effluent limits. The fecal coliform load for continuous point source dischargers was estimated by multiplying the monthly average flow rates by the monthly geometric mean using a conversion factor. The data were extracted from each point source's DMR from 1998 through 2004. The 90^{th} percentile value of the monthly loads was used to express the estimated existing load in counts/day. The current pollutant loading from each permitted point source discharge as summarized in Section 3 was calculated using the equation below.

*Point Source Loading = monthly average flow rates (mgd) * geometric mean of corresponding fecal coliform concentration * unit conversion factor*

Where:

unit conversion factor = 37,854,120 100-ml/million gallons (mg)

Step 4: Estimate Current Loading and Identify Critical Conditions. It is difficult to estimate current nonpoint loading due to lack of specific water quality and flow information that would assist in estimating the relative proportion of non-specific sources within the watershed. Therefore, existing instream loads were used as a conservative surrogate for nonpoint loading. It was calculated by multiplying the concentration by the flow matched to the specific sampling date. Then using the hydrologic flow intervals shown in Table 4-1, the 90^{th} percentile nonpoint loading within each of the intervals would then represent the nonpoint loading estimate for that interval. Existing loads have been estimated using a regression-based relationship developed between observed fecal coliform loads and flow or flow exceedance percentile.

In many cases, inspection of the LDC will reveal a critical condition related to exceedances of WQSs. For example, criteria exceedances may occur more frequently in wet weather, low flow conditions, or after large rainfall events. The critical conditions are such that if WQSs were met under those conditions, WQSs would likely be met overall. Given that the instantaneous fecal coliform criterion indicates that no more than 10 percent of samples should exceed 400 cfu/100 ml, it is appropriate to evaluate existing loading as the 90^{th}

percentile of observed fecal coliform concentrations. Together with the MOS, the reduction calculated in this way should ensure that no more than 10 percent of samples will exceed the criterion.

Existing loading is calculated as the 90th percentile of measured fecal coliform concentrations under each hydrologic condition class multiplied by the flow at the middle of the flow exceedance percentile. For example, in calculating the existing loading under dry conditions (flow exceedance percentile = 60-90%), the 75th percentile exceedance flow is multiplied by the 90th percentile of fecal coliform concentrations measured under the 60-90th percentile flows. The “high flow” or “low flow” hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are typically available to reliably estimate loads under these conditions. This methodology results in multiple estimates of existing loading. However, TMDLs are typically expressed as a load or concentration under a single scenario. Therefore, these TMDLs will assume that if the highest percent reduction associated with the difference between the existing loading and the LDC (TMDL) is achieved, the WQS will be attained under all other flow conditions.

Step 5: Develop Fecal Coliform Load Duration Curves (TMDL). Load duration curves are based on flow duration curves, with the additional display of historical pollutant load observations at the same location, and the associated water quality criterion or criteria. In lieu of flow, the ordinate is expressed in terms of a fecal coliform load (cfus/day). The curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 ml) expressed in terms of a load through multiplication by the continuum of flows historically observed at the site. The points represent individual paired historical observations of fecal coliform concentration and flow. Fecal coliform concentration data used for each WQM station are provided in Appendix A. The fecal coliform load (or the y-value of each point) is calculated by multiplying the fecal coliform WQS by the instantaneous flow (cfs) from the same site and time, with appropriate volumetric and time unit conversions.

TMDL (cfu/day) = WQS * flow (cfs) * unit conversion factor

Where: WQS = 400 cfu/100ml

*unit conversion factor = 24,465,525 ml*s / ft^3*day*

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured flow, in other words, the percent of historical observations that equal or exceed the measured flow. It should be noted that the site daily average stream flow is often used if an instantaneous flow measurement is not available. Fecal coliform loads representing exceedance of water quality criteria fall above the water quality criterion line.

Step 6: Develop LDCs with MOS. An LDC depicting slightly lower estimates than the TMDL is developed to represent the TMDL with MOS. An explicit MOS is defined for each TMDL by establishing an LDC using 95 percent of the TMDL value (5 percent of the

400 cfu/100 ml instantaneous water quality criterion) to slightly reduce assimilative capacity in the watershed, thus providing a 5 percent MOS. The MOS at any given percent flow exceedance, therefore, is defined as the difference in loading between the TMDL and the TMDL with MOS.

Step 7: Calculate WLA. As previously stated, the pollutant load allocation for point sources is defined by the WLA. A point source can be either a wastewater (continuous) or stormwater (MS4) discharge. Stormwater point sources are typically associated with urban and industrialized areas, and recent USEPA guidance includes permitted stormwater discharges as point source discharges and, therefore, part of the WLA.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading will vary with flow condition. TMDLs can be expressed in terms of maximum allowable concentrations, or as different maximum loads allowable under different flow conditions, rather than single maximum load values. This concentration-based approach meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs "in terms of mass per time, toxicity, or other appropriate measures" and is consistent with USEPA's *Protocol for Developing Pathogen TMDLs* (USEPA 2001).

WLA for WWTP. Wasteload allocations may be set to zero in cases of watersheds with no existing or planned continuous permitted point sources. For watersheds with permitted point sources, wasteloads may be derived from NPDES permit limits. A WLA may be calculated for each active NPDES wastewater discharger using a mass balance approach as shown in the equation below. The permitted average flow rate used for each point source discharge and the water quality criterion concentration are used to estimate the WLA for each wastewater facility. All WLA values for each subwatershed are then summed to represent the total WLA for the watershed.

*WLA (cfu/day) = WQS * flow * unit conversion factor*

Where: WQS = 400 cfu/100ml

flow (mgd) = permitted flow or design flow (if unavailable)

unit conversion factor = 37,854,120 100-ml/mg

WLA for MS4s. Because a WLA for each MS4 cannot be calculated as an individual value, WLAs for MS4s are expressed as a percent reduction goal (PRG) derived from the LDC for nonpoint sources. The method for estimating the percent reduction of fecal coliform loading is described in Step 8.

Step 8: Calculate LA. Load allocations can be calculated under different flow conditions as the water quality target load minus the WLA. The LA is represented by the area under the LDC but above the WLA. The LA at any particular flow exceedance is calculated as shown in the equation below.

LA = TMDL – MOS - ∑WLA

However, to express the LA as an individual value, the LA is derived using the equation above but at the median point of the hydrologic condition class requiring the largest percent reduction as displayed in the LDCs provided in Appendix E. Thus, an alternate method for expressing the LA is to calculate a PRG for fecal coliform. Load allocations are calculated as percent reductions from current estimated loading levels required to meet water quality criteria.

Step 9: Estimate WLA Load Reduction. The WLA load reduction was not calculated because it was assumed that the continuous dischargers (NPDES permitted WWTPs) are adequately regulated under existing permits and, therefore, no WLA reduction would be required. For the MS4 permittees, the percent reduction was assumed to be the same as the nonpoint load reduction.

Step 10: Estimate LA Load Reduction. After existing loading estimates are computed for the three different hydrologic condition classes described in Step 2, nonpoint load reduction estimates for each WQM station are calculated by using the difference between estimated existing loading (Step 5) and the LDC (TMDL). This difference is expressed as a percent reduction, and the hydrologic condition class with the largest percent reduction is selected as the critical condition and the overall PRG for the LA.

Results of all these calculations are discussed in Section 5.

SECTION 5
TMDL CALCULATIONS

5.1 Results of TMDL Calculations

The calculations and results of the TMDLs for the 303(d)-listed WQM stations in the Pee Dee River Basin are provided in this section. The methods for deriving these results are specified in Section 4. The Lynches River and various tributaries contributing to WQM station PD-113 are interstate water bodies. The TMDLs established in Section 5.7 of this report for WQM station PD-113 are achievable if WQS for fecal coliform are met at the state line.

5.2 Critical Conditions and Estimated Loading

USEPA regulations at 40 CFR 130.7(c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Available instream WQM data were evaluated with respect to flows and magnitude of water quality criteria exceedance using LDCs. Load duration curve analysis involves using measured or estimated flow data, instream criteria, and fecal coliform concentration data to assess flow conditions in which water quality exceedances are occurring (SCDHEC 2003). The goal of flow weighted concentration analysis is to compare instream observations with flow values to evaluate whether exceedances generally occur during low or high flow periods (SCDHEC 2003).

To calculate the fecal coliform load at the WQS, the instantaneous fecal coliform criterion of 400 cfu/100 ml is multiplied by the flow rate at each flow exceedance percentile, and a unit conversion factor ($24{,}465{,}525\ ml*s\ /\ ft^3*day$). This calculation produces the maximum fecal coliform load in the stream without exceeding the instantaneous standard over the range of flow conditions. The allowable fecal coliform loads at the WQS establish the TMDL and are plotted versus flow exceedance percentile as an LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a fecal coliform load.

To estimate existing loading, the loads associated with individual fecal coliform observations are paired with the flows estimated at the same site on the same date. Fecal coliform loads are then calculated by multiplying the measured fecal coliform concentration by the estimated flow rate and a unit conversion factor of $24{,}465{,}525\ ml*s\ /\ ft^3*day$. The associated flow exceedance percentile is then matched with the measured flow from the tables provided in Appendix D. The observed fecal coliform loads are then added to the LDC plot as points. These points represent individual ambient water quality samples of fecal coliform. Points above the LDC indicate the fecal coliform instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the WQS.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading, and load reductions required to meet the TMDL water quality target, can also be calculated under different flow conditions. The difference between existing loading and the water quality target is used to calculate the loading reductions required. Given that the instantaneous fecal coliform criterion indicates that no more than 10 percent of samples should exceed 400 cfu/100 ml, it is appropriate to evaluate existing loading as the 90th percentile of observed fecal coliform concentrations. Together with the MOS, the reduction calculated in this way should ensure that no more than 10 percent of samples will exceed the criterion.

Existing loading is calculated as the 90th percentile of measured fecal coliform concentrations under each hydrologic condition class multiplied by the flow at the middle of the flow exceedance percentile. For example, in calculating the existing loading under dry conditions (flow exceedance percentile = 60-90 percent), the 75th percentile exceedance flow is multiplied by the 90th percentile of fecal coliform concentrations measured under 60-90th percentile flows.

After existing loading and percent reductions are calculated under each hydrologic condition class, the critical condition for each TMDL is identified as the flow condition requiring the largest percent reduction. However, the "high flow" (<10th percentile flow exceedance) or "low flow" (> 90th percentile flow exceedance) hydrologic conditions will not be selected as critical conditions because these extreme flows are not representative of typical conditions, and few observations are available to reliably estimate loads under these conditions. In the example shown in Table 5-1 for WQM station PD-333, the critical condition occurs under "Moist Conditions," when a 93 percent loading reduction is required to meet the WQS.

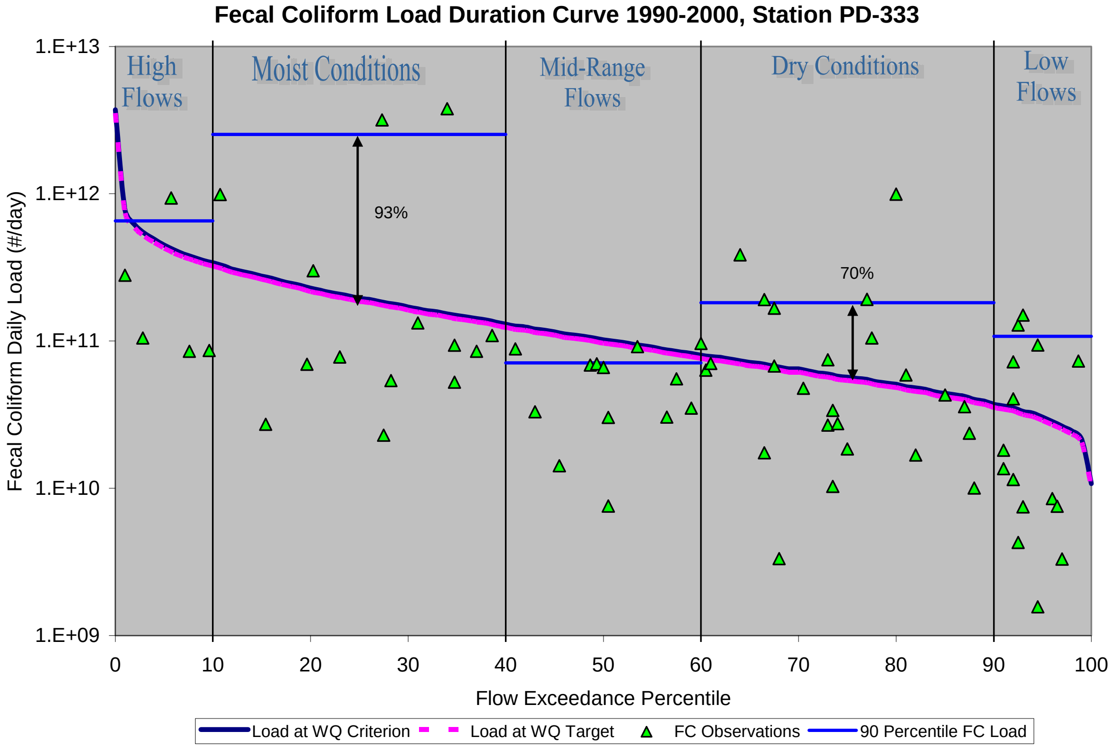
Table 5-1 Estimated Existing Fecal Coliform Loading for Station PD-333 (Hills Creek with Critical Condition Highlighted

Hydrologic Condition Class*	Estimated Existing Loading (cfu/100 ml)	Percent Reduction Required
High Flows	6.54E+11	NA
Moist Conditions	2.53E+12	93%
Mid-Range Conditions	7.10E+10	NA
Dry Conditions	1.82E+11	70%
Low Flows	1.08E+11	NA

* Hydrologic Condition Classes are derived from Cleland 2003.

The LDC for WQM station PD-333 shown in Figure 5-1 indicates actual fecal coliform loads are exceeding the instantaneous load of the WQS during "moist" and "dry" flow conditions. LDCs similar to Figure 5-1 for all of the 303(d)-listed WQM stations in this report used to estimate existing loading and identify critical conditions are provided in Appendix E. The LDCs were developed for the time period from January 1990 through October 2002 if data were available.

Figure 5-1 Estimated Fecal Coliform Load and Critical Conditions, Station PD-333 (Hills Creek)



The existing instream fecal coliform load (actual or estimated flow multiplied by observed fecal coliform concentration) is compared to the allowable load for that flow. Any existing loads above the allowable LDCs represent an exceedance of the WQS. For a low flow loading situation, there are typically observations in excess of criteria at the low flow side of the chart. For a high flow loading situation, observations in excess of criteria at the high flow side of the chart are typical. For water bodies impacted by both point and nonpoint sources, the "nonpoint source critical condition" would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load, while the "point source critical condition" would typically occur during low flows, when treatment plant effluents would dominate the base flow of the impaired water. Based on these characteristics, critical conditions for each WQM station are summarized in Table 5-2.

Table 5-2 Summary of Critical Conditions for each WQM Station as derived from Load Duration Curves

SCDHEC WQM Station	Moist Conditions	Mid-Range Conditions	Dry Conditions
PD-333	✱		
PD-113	✱		
PD-179	✱		
PD-180	✱		
PD-342			✱
PD-066	✱		
PD-040		✱	
PD-098	✱		
PD-239	✱		
PD-065		✱	
PD-187			✱
PD-320			✱
PD-030A			✱
PD-030		✱	
PD-037		✱	
PD-352			✱

The existing load for each WQM station was derived from the critical condition line depicted on the LDCs described above and provided in Appendix E. Estimated existing loading is derived from the 90th percentile of observed fecal coliform loads corresponding to the critical condition identified at each WQM station identified in Table 5-2. This estimated loading is indicative of loading from all sources including continuous point source dischargers, leaking sewer lines, MS4s, SSOs, failing OSWD systems, land application fields, wildlife, pets, and livestock. The total estimated existing load for each station is provided in Table 5-3.

Table 5-3 Estimated Existing Loading at each WQM Station

SCDHEC WQM Station	90th Percentile Load Estimation (cfu/day)	Flow Exceedance Percentile
PD-333	2.53E+12	25
PD-113	3.15E+12	25
PD-179	7.76E+11	25
PD-180	2.31E+11	25
PD-342	3.72E+11	75
PD-066	1.36E+13	25
PD-040	1.37E+11	50

SCDHEC WQM Station	90th Percentile Load Estimation (cfu/day)	Flow Exceedance Percentile
PD-098	4.31E + 11	75
PD-239	1.63E+11	25
PD-065	1.51E+12	50
PD-187	2.54E+11	75
PD-320	1.33E+12	75
PD-030A	1.05E+13	75
PD-030	6.61E+11	50
PD-037	7.54E+11	50
PD-352	3.08E+11	75

5.3 Waste Load Allocation

Table 5-4 summarizes the WLA of the NPDES-permitted facilities within the watershed of each WQM station. The WLA for each facility is derived from the following equation:

WLA = WQS * flow * unit conversion factor (#/day)

Where: WQS = 400 cfu/100ml

flow (cfs) = permitted flow

unit conversion factor = 37,854,120 100-ml/mg

Table 5-4 Wasteload Allocations (WLA) for NPDES Permitted Facilities

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Flow (mgd)	Load (cfu/day)
HUC 3050106020			
PD-333 Hills Creek at S-13-105			
Pageland Northwest WWTP	SC0021504	0.3	4.54E+09
HUC 3040202030			
PD-179 North Branch Wildcat Creek at S-29-39 1 Mile South of Tradesville			
Buford High School WWTP	SC0030210	0.035	5.30E+08
HUC 3040202050			
PD-066 Upper Lynches River			
Jefferson WWTP	SC0024767	0.15	2.27E+09
HUC 3040204030			
PD-030A Little Pee Dee River Below JCT with Maple SWP			
Dillon Little Pee Dee WWTP (Outfall 001)	SC0021776	4.0	6.06E+10

* Ceased Discharging in 1999.

When there are no NPDES WWTPs discharging into the contributing watershed of a WQM station, then the WLA for continuous point sources is zero. See Subsection 4/2 (Step 7) and Section 5.7 for an explanation of how the WLA for NPDES dischargers is depicted in a LDC.

The cities of Sumter and Florence are the only MS4s within the watersheds of this report. Because of insufficient data, it is not possible to express a WLA for MS4s as a load or concentration; therefore, the WLA is expressed as a PRG. Each MS4 was assigned a PRG equal to the PRG identified in the LA for each WQM station. The PRGs that will serve as a component of the WLA are provided in Table 5-5. When multiple WQM stations fall under one MS4 jurisdiction, multiple PRGs can occur. In these cases the highest PRG is selected as the overall reduction requirement incorporated into the TMDL of each station. For example, by reviewing the LDCs in Appendix E, Stations PD-098 and PD-040 have PRGs of 94 and 75 percent, respectively. Therefore, using a conservative approach, the highest reduction goal of 94 percent is selected and incorporated into the TMDLs (see Table 5-5) for WQM stations PD-098 and PD-040. The PRGs in this TMDL report apply also to the fecal coliform WLAs attributable to those areas of the watershed which are covered or will be covered under NPDES MS4 permits. Compliance by those municipalities within the terms of their individual MS4 permits will fulfill any obligations they have toward implementing TMDLs for fecal coliform.

Table 5-5 WLA for MS4 Entities in Turkey Creek and Gulley Branch Watersheds

MS4 Entity	WQM Stations	Percent Reduction Goal
Sumter	PD-098, PD-040	94
Florence	PD-065	99

5.4 Load Allocation

As discussed in Section 3, nonpoint source fecal coliform loading to the receiving streams of each WQM station originate from a number of different sources. For a select group of WQM stations (Table 3-3, Table 3-10, and Table 3-19) nonpoint sources of fecal coliform loading is the sole reason the primary contact recreation use is not supported. As discussed in Section 4, nonpoint source loading was estimated and depicted for all flow conditions using LDCs (See Figure 5-1 example and Appendix E). Figure 5-1, the LDC for PD-333, displays the relationships between the TMDL water quality target, the MOS, and the PRG that can serve as an alternative for expressing the LA. The data analysis and the LDCs demonstrate that exceedances at many of the WQM stations are the result of nonpoint source loading such as failing OSWD systems, leaking sewer lines, cattle in streams, and fecal loading from land application fields, wildlife and pets transported by runoff events. The LAs, calculated as the difference between the TMDL, MOS, and WLA, for each WQM station are presented in Table 5-6. Where MS4s are present then the LA is not calculated and is expressed as a PRG.

5.5 Seasonal Variability

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Seasonal variation was accounted for in these TMDLs by using more than 5 years of water quality data (1990-2002) whenever possible and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

5.6 Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs include an MOS. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable fecal coliform pollutant loading to ensure WQSs are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit.

For the explicit MOS the water quality target was set at 380 cfu/100 ml for the instantaneous criterion, which is 5 percent lower than the water quality criterion of 400 cfu/100 ml. The net effect of the TMDL with MOS is that the assimilative capacity of the watershed is slightly reduced. These TMDLs incorporates an explicit MOS by using a curve representing 95 percent of the TMDL as the average MOS. The MOS at any given percent flow exceedance, therefore, can be defined as the difference in loading between the TMDL and the TMDL with MOS. For consistency, the explicit MOS at each WQM station will be expressed as a numerical value derived from the same critical condition as the largest load reduction goal at the respective 25th, 50th, or 75th flow exceedance percentile (see Table 5-6).

There are other conservative elements utilized in these TMDLs that can be recognized as an implicit MOS such as:

- The use of instream fecal coliform concentrations to estimate existing loading; and
- The highest PRG for nonpoint sources, based on the LDC used.

This conservative approach to establishing the MOS will ensure that both the 30-day geometric mean and instantaneous fecal coliform bacteria standards can be achieved and maintained.

5.7 TMDL Calculations

The fecal coliform TMDLs for the 303(d)-listed WQM stations covered in this report were derived using LDCs. A TMDL is expressed as the sum of all WLAs (point source loads), LAs (nonpoint source loads), and an appropriate MOS, which attempts to account for uncertainty concerning the relationship between effluent limitations and water quality.

This definition can be expressed by the following equation:

$$TMDL = \Sigma\, WLA + \Sigma\, LA + MOS$$

For each WQM station the TMDLs presented in this report are expressed in cfus per day or as a percent reduction. The TMDLs are presented in fecal coliform counts to be protective of both the instantaneous, per day, and geometric mean, per 30-day, criteria. To express a TMDL as an individual value, the LDC is used to derive the LA, the MOS, and the TMDL based on the median percentile of the critical condition (*i.e.*, the median percentile of the hydrologic condition class requiring the greatest percent reduction to meet the instantaneous criterion which is the water quality target). The WLA component of each TMDL is the sum of all WLAs within the contributing watershed of each WQM station which is derived from each NPDES facilities' maximum design flow and the permitted 1-day maximum concentration of 400 cfu/100 ml. When MS4s do not exist in the contributing watershed, the LDC and the simple equation of:

$$Average\ LA = average\ TMDL - MOS - \sum WLA$$

can provide an individual value for the LA in cfu per day which represents the area under the TMDL target line and above the WLA line. Percent reductions necessary to achieve the water quality target are also provided for all WQM stations as another acceptable representation of the TMDL. Like the LA, the percent reduction is derived from the median percentile of the critical condition (*i.e.*, the median percentile of the hydrologic condition class requiring the greatest percent reduction to meet the instantaneous criterion which is the water quality target). Table 5-6 summarizes the TMDLs for each WQM station, and Figures 5-2 through 5-17 present the LDCs for each station depicting the TMDL, MOS, and WLA (if applicable).

Table 5-6 TMDL Summary for Select WQM Stations in Pee Dee River Basin (HUCs 03040202, 03040205, 03040201, 03040204)

SCDHEC WQM Station	WLAs (cfu/ day)	MS4 WLA (Percent reduction)	LA (cfu/day or % reduction)	MOS	TMDL (cfu/day or % reduction)	Percent reduction
Lynches River HUC 03040202020						
PD-333	4.54E+09	NA	1.80E+11	9.74E+09	1.95E+11	93
Upper Lynches River HUC 03040202030						
PD-113	0	NA	5.99E+11	3.15E+10	6.30E+11	81
PD-179	5.30E+08	NA	1.13E+11	5.97E+09	1.19E+11	85
PD-180	0	NA	1.12E+11	5.92E+09	1.18E+11	51
Upper Lynches River HUC 03040202040						
PD-342	0	NA	1.62E+11	8.51E+09	1.70E+11	57
Upper Lynches River HUC 03040202050						
PD-066	2.27E+09	NA	2.56E+12	1.35E+11	2.69E+12	81
Tributary to Pocotaligo River HUC 03040205080						
PD-040	0	94	3.44E+10	1.81E+09	3.62E+10	75
PD-098	0	94	2.70E+10	1.42E+09	2.84E+10	94
PD-239	0	NA	1.54E+11	8.12E+09	1.62E+11	5
Tributary to Pee Dee River HUC 03040201130						
PD-065	0	99	1.39E+10	7.34E+08	1.47E+10	99
PD-187	0	NA	8.74E+10	4.60E+09	9.20E+10	66
PD-320	0	NA	4.22E+11	2.22E+10	4.44E+11	68
Little Pee Dee River HUC 03040204030						
PD-030A	6.06E+10	NA	4.90E+12	2.61E+11	5.22E+12	53
PD-030	0	NA	2.51E+11	1.32E+10	2.64E+11	62
Little Pee Dee River HUC 03040204070						
PD-037	0	NA	7.16E+10	3.77E+09	7.54E+10	91
Little Pee Dee River HUC 03040204090						
PD-352	0	NA	1.90E+11	9.98E+09	2.00E+11	39

Figure 5-2 TMDL for PD-333 Hills Creek

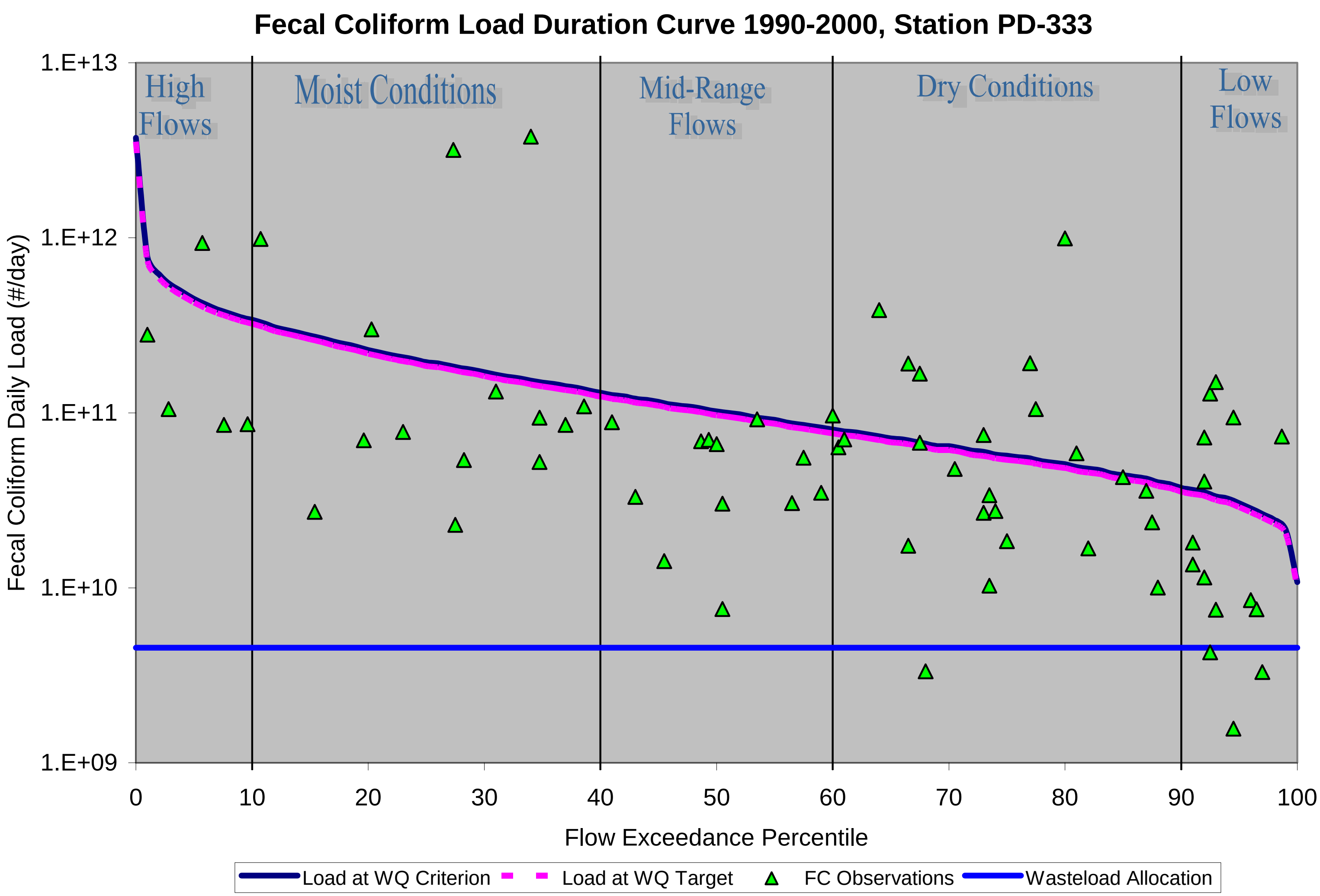


Figure 5-3 TMDL for PD-113 Lynches River

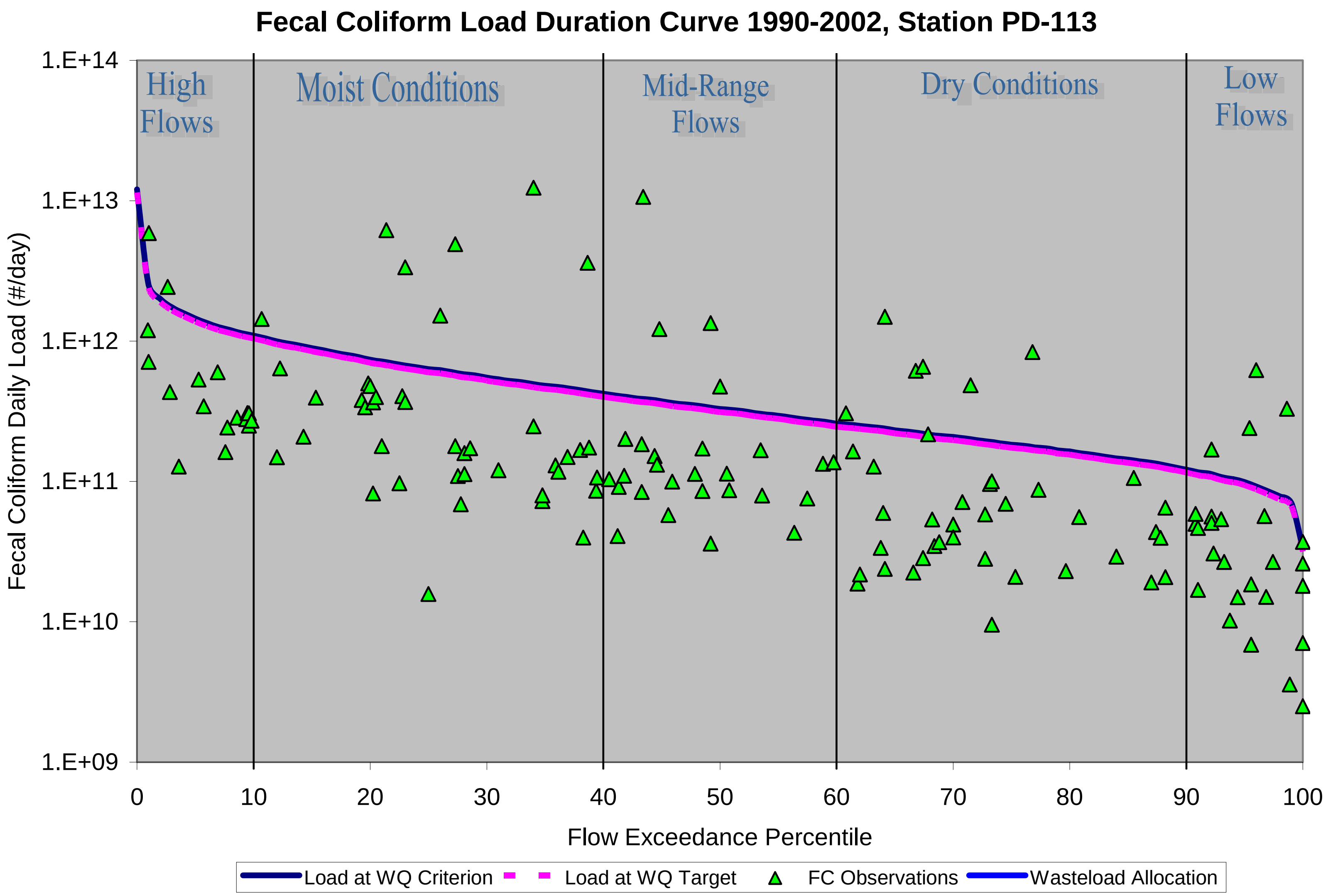


Figure 5-4 TMDL for PD-179 North Branch Wildcat Creek

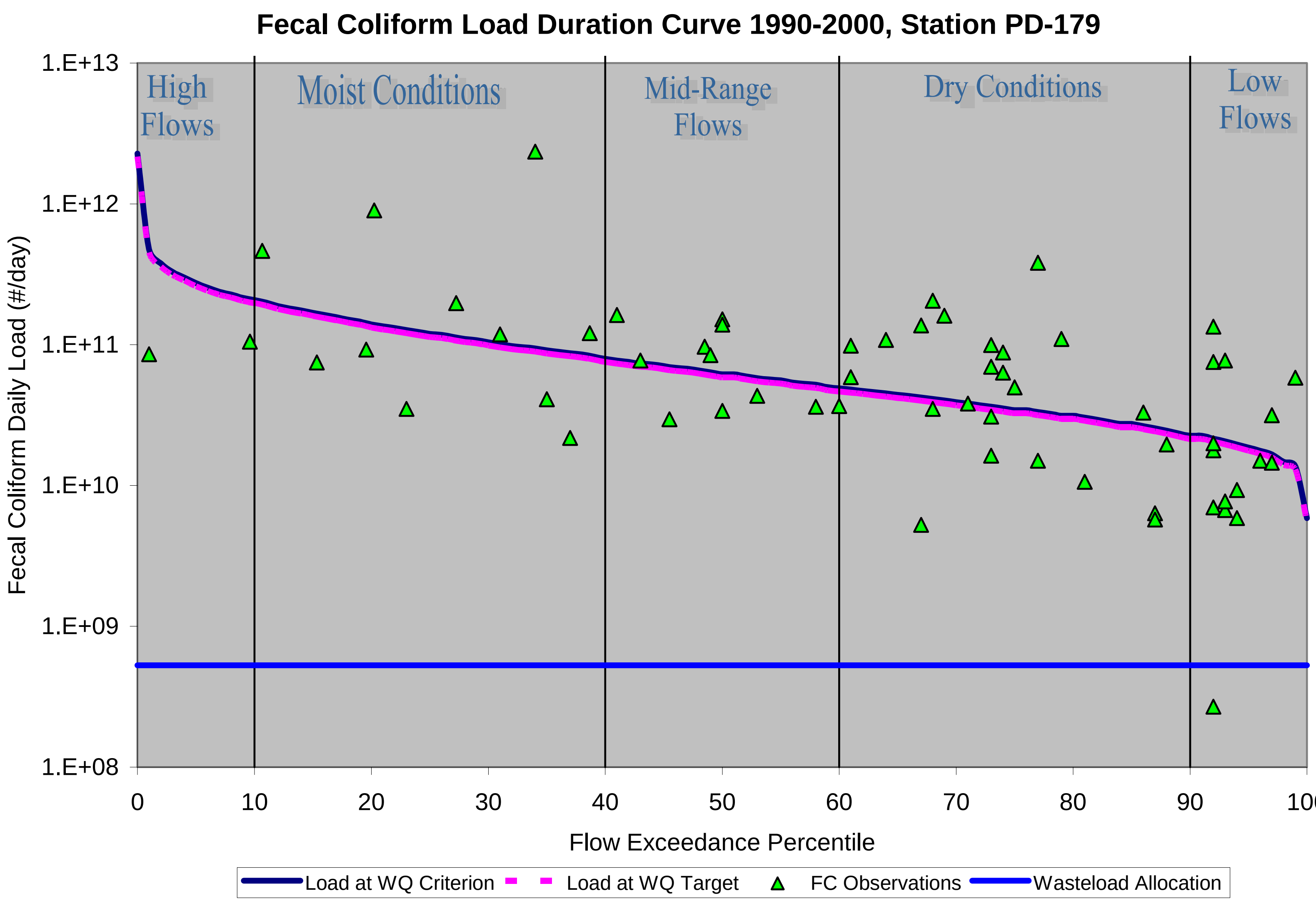


Figure 5-5 TMDL for PD-180 South Branch Wildcat Creek

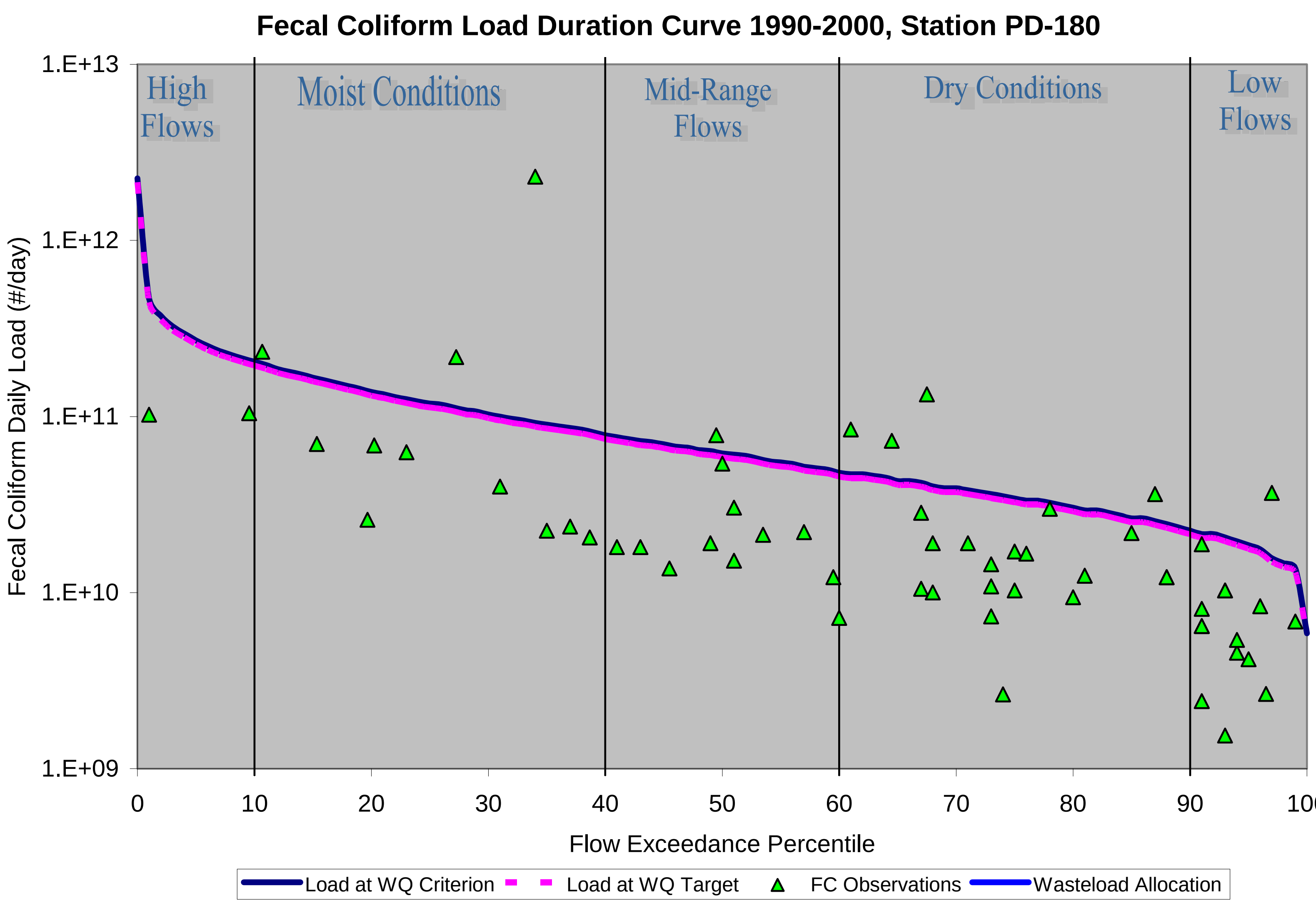


Figure 5-6 TMDL for PD-342 Flat Creek

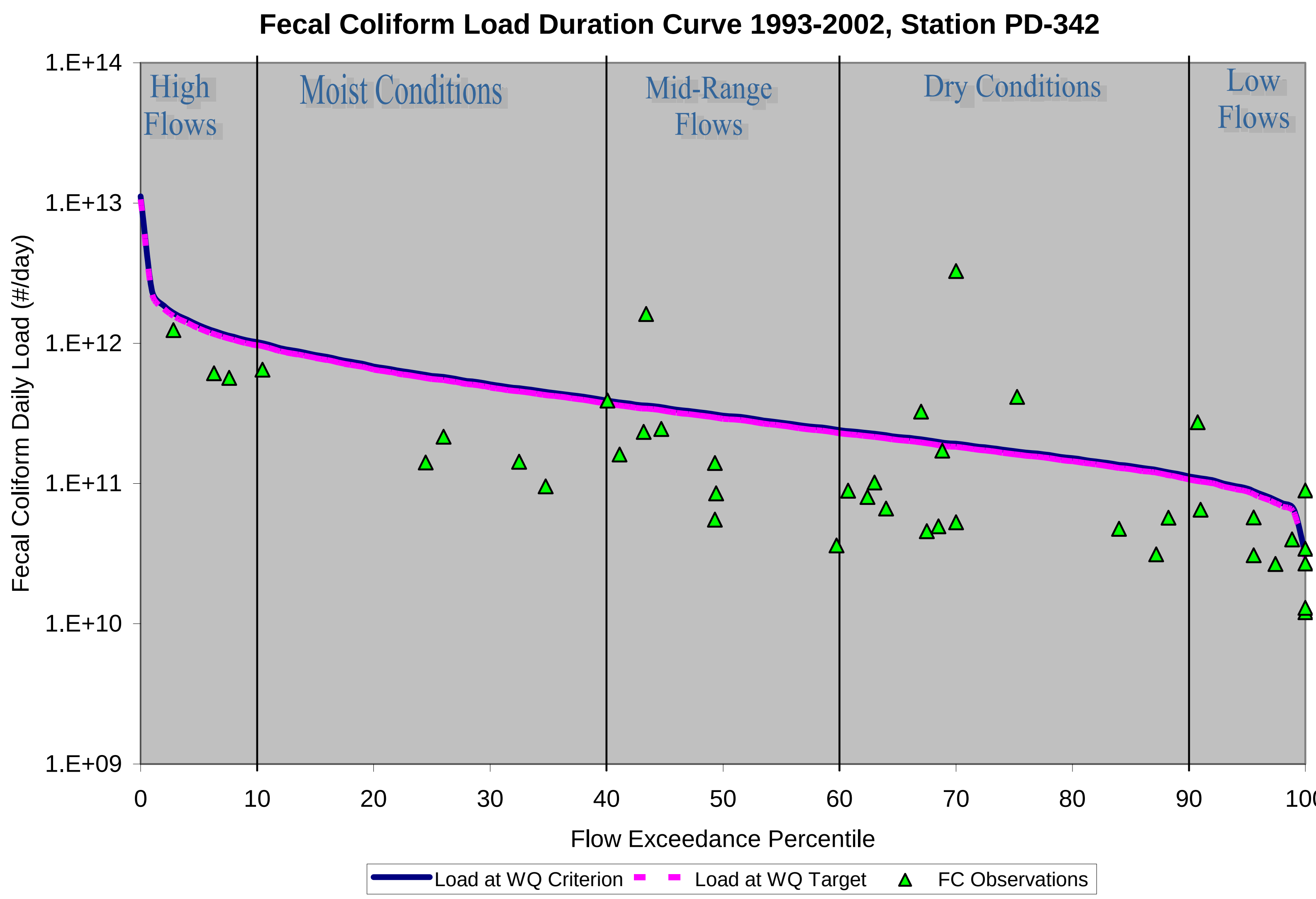


Figure 5-7 TMDL for PD-066 Lynches River

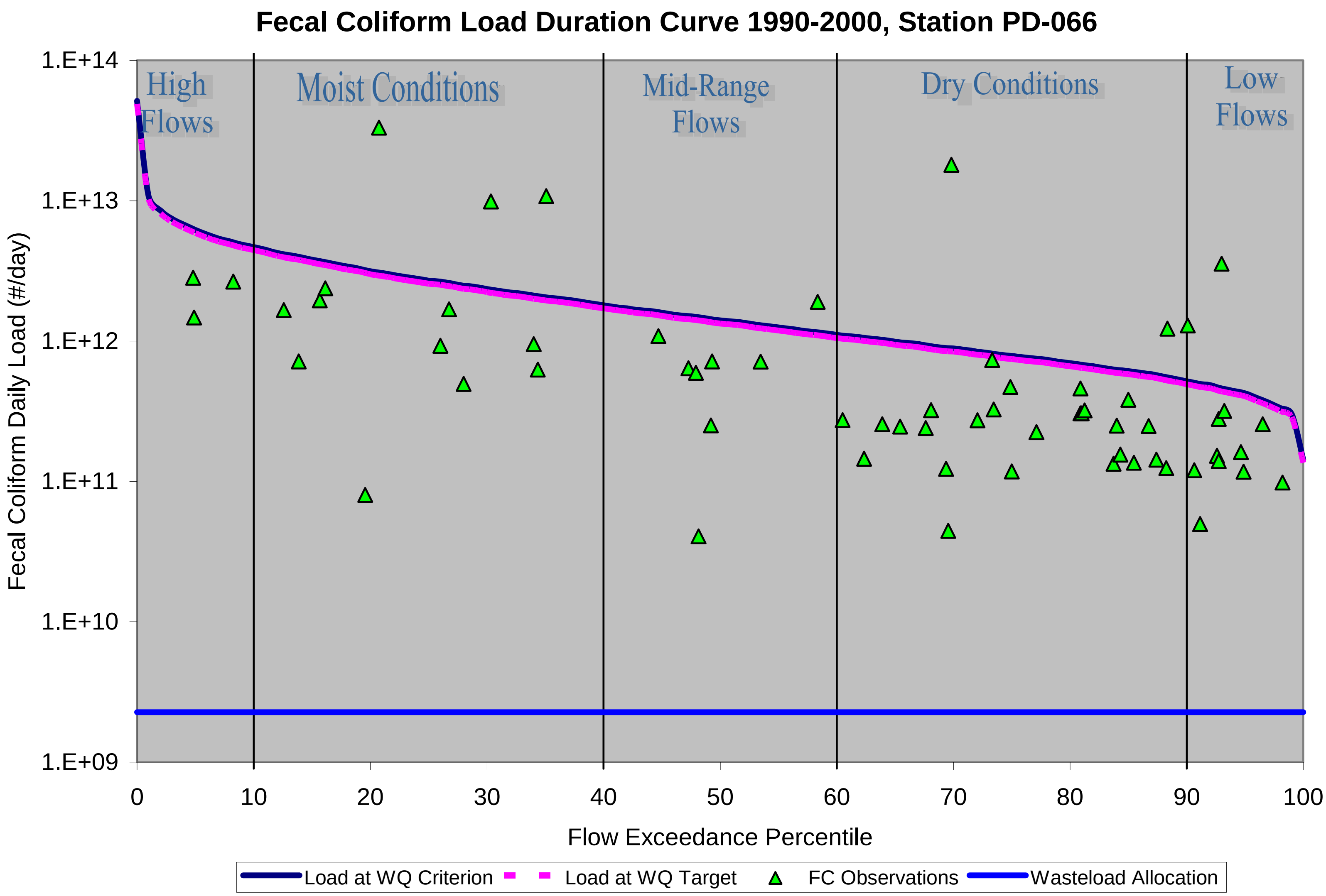


Figure 5-8 TMDL for PD-040 Turkey Creek

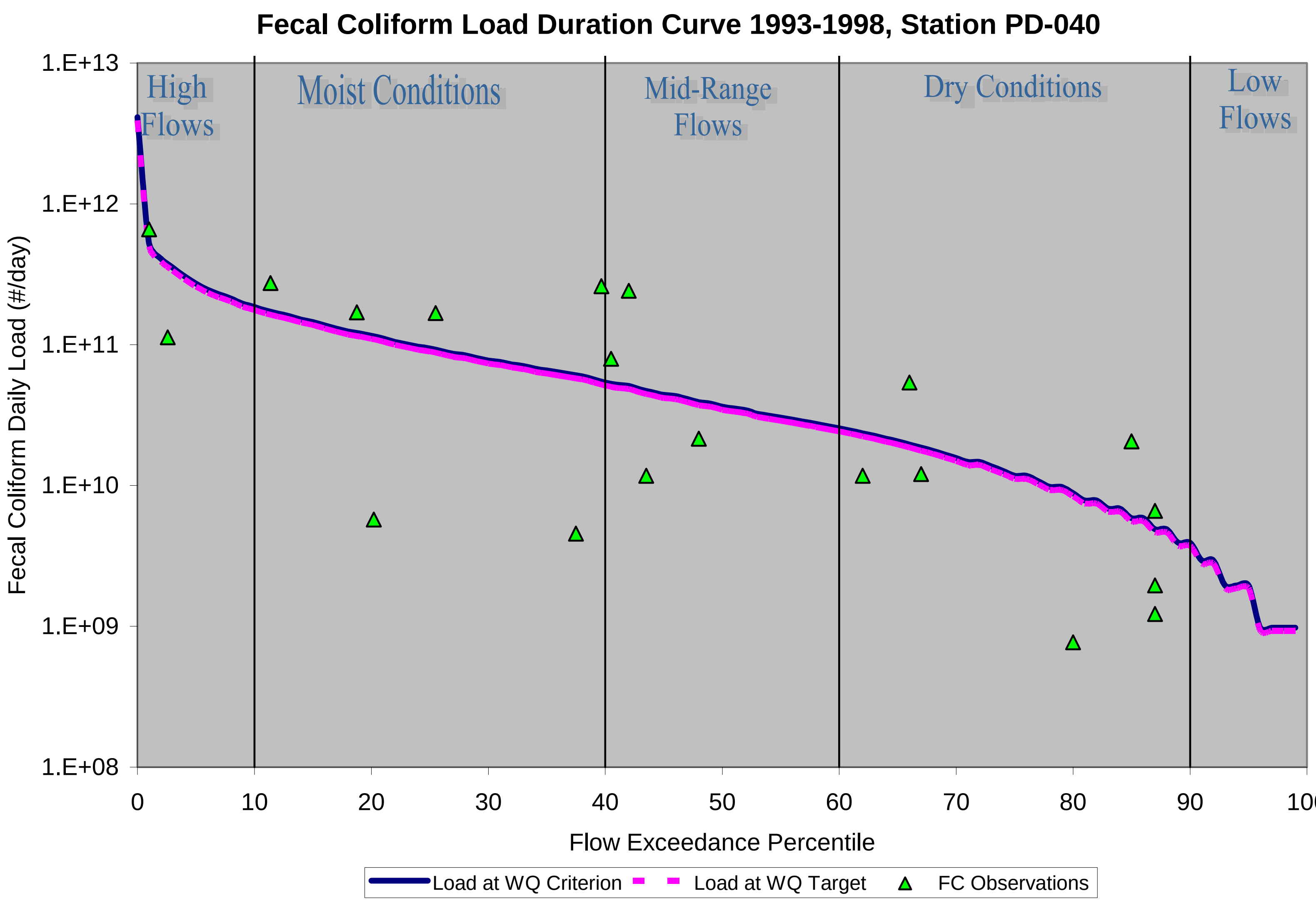


Figure 5-9 TMDL for PD-098 Turkey Creek

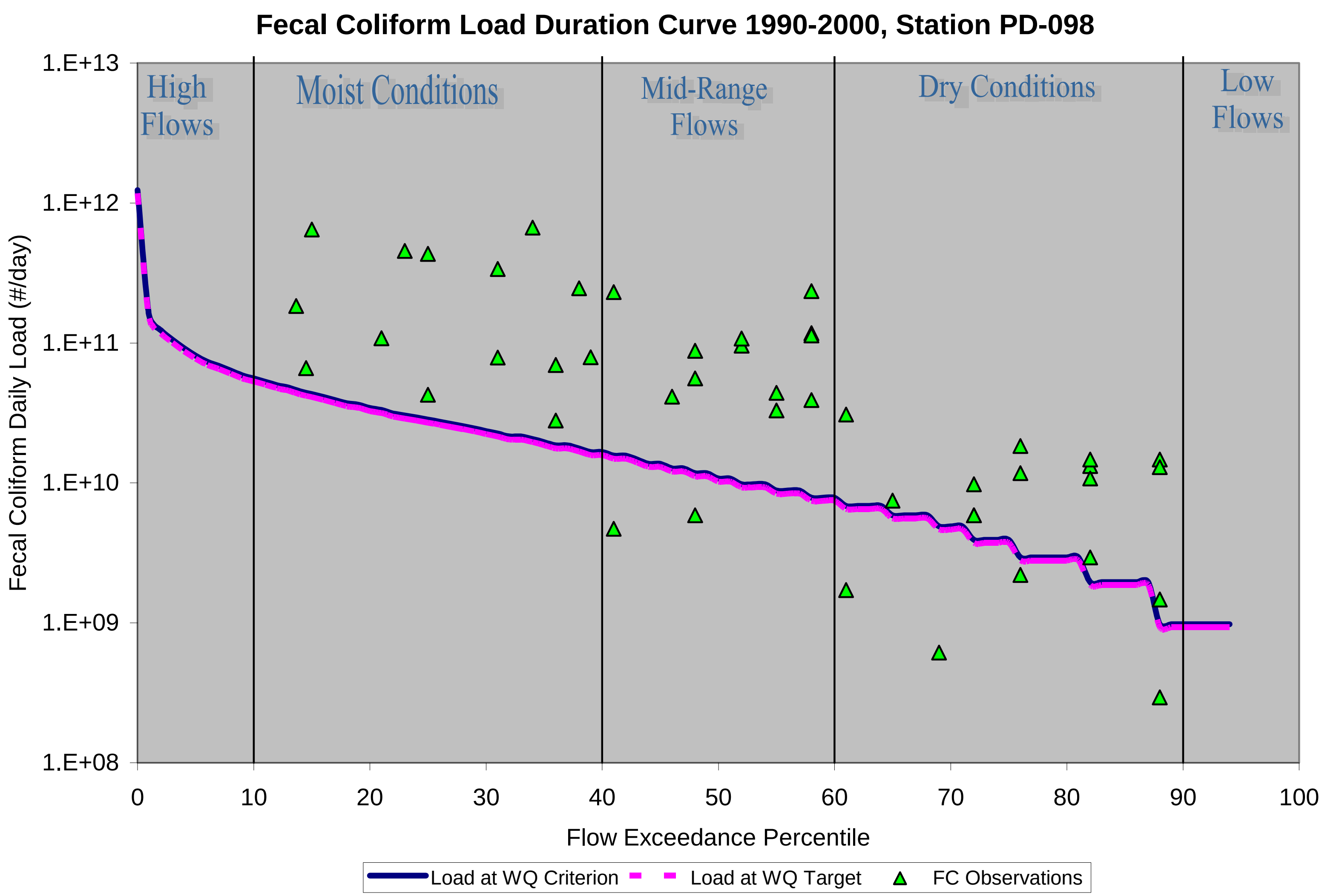


Figure 5-10 TMDL for PD-239 Nasty Branch

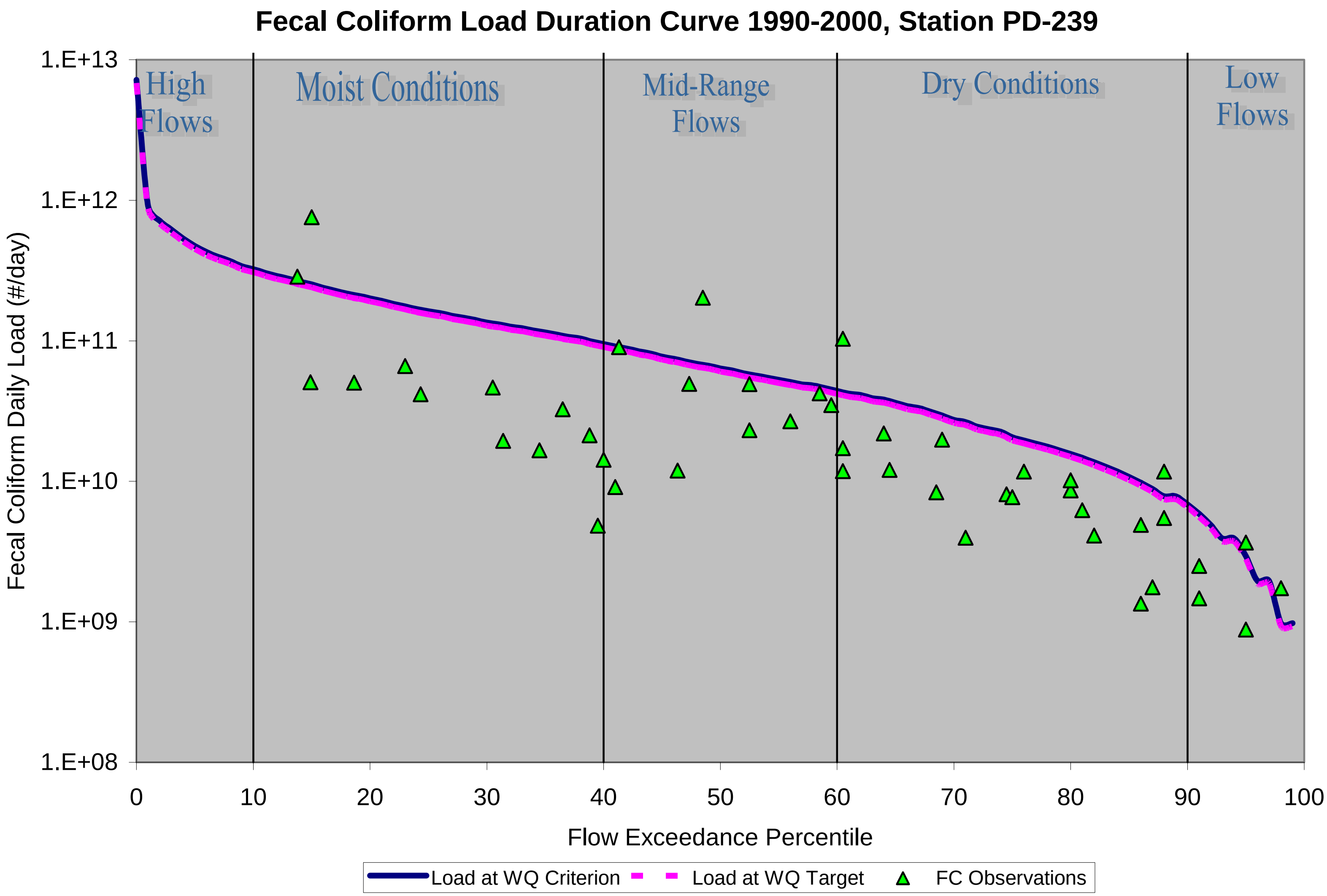


Figure 5-11 TMDL for PD-065 Gulley Branch

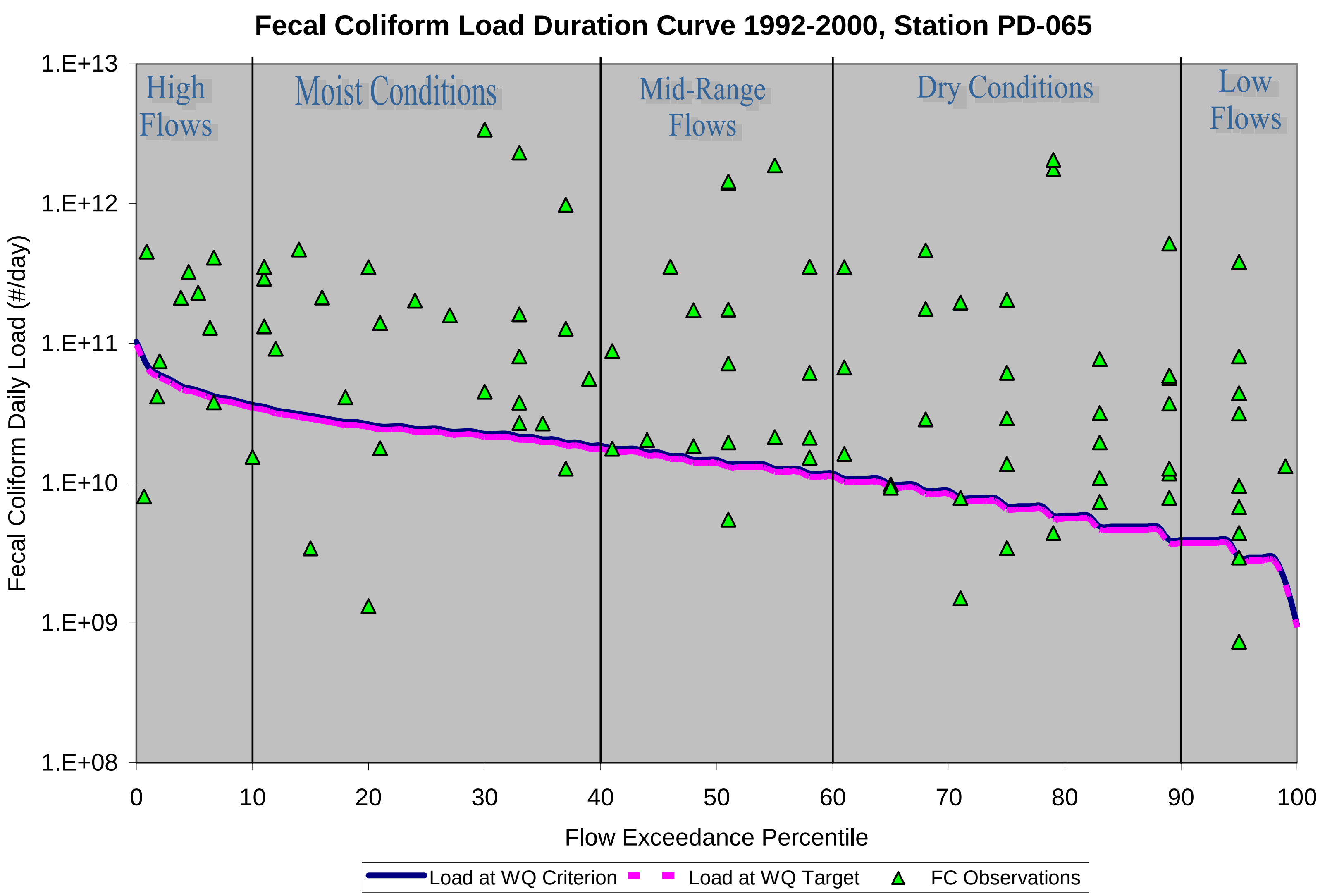


Figure 5-12 TMDL for PD-187 Smith Swamp

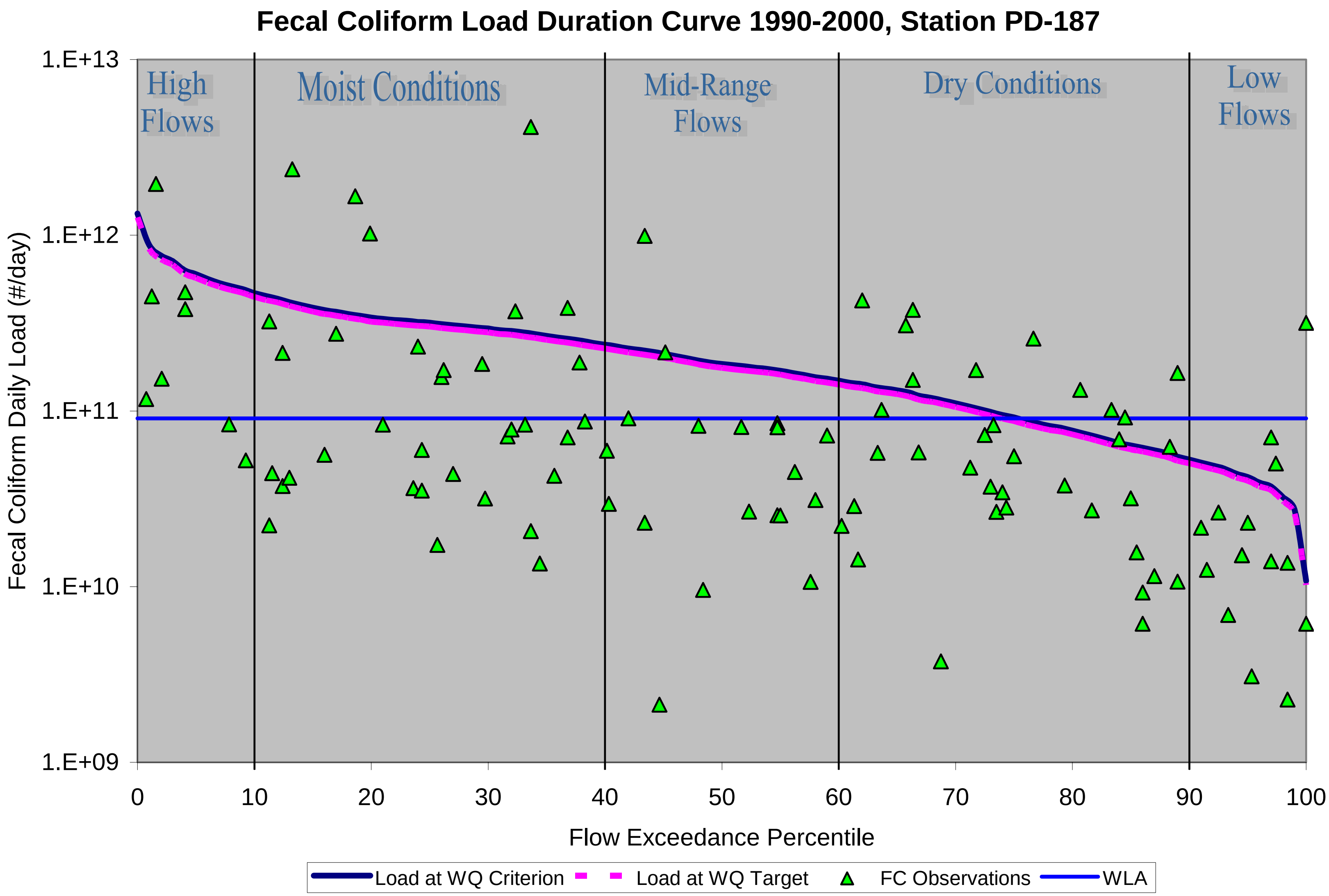


Figure 5-13 TMDL for PD-320 Smith Swamp

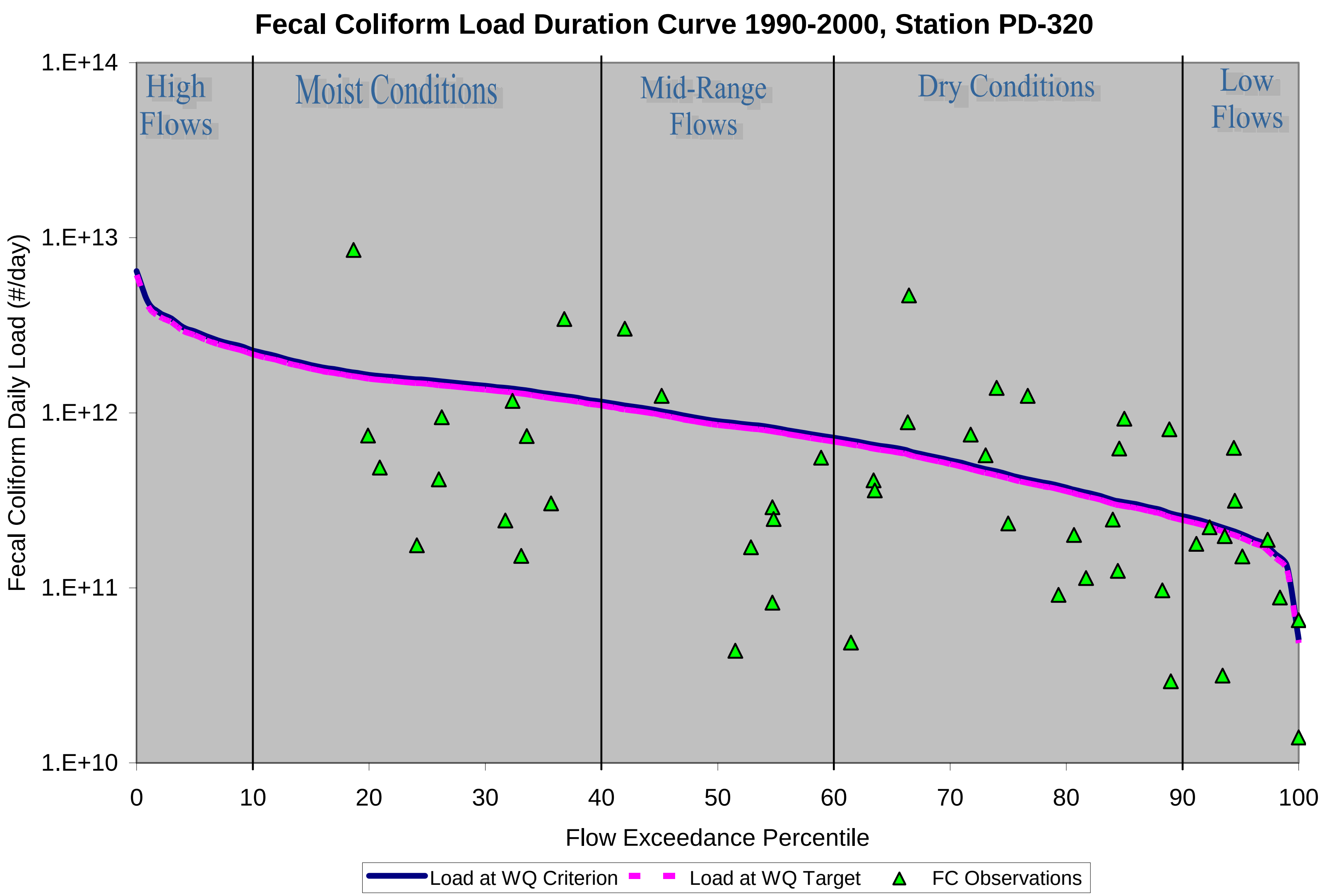


Figure 5-14 TMDL for PD-030A Little Pee Dee River

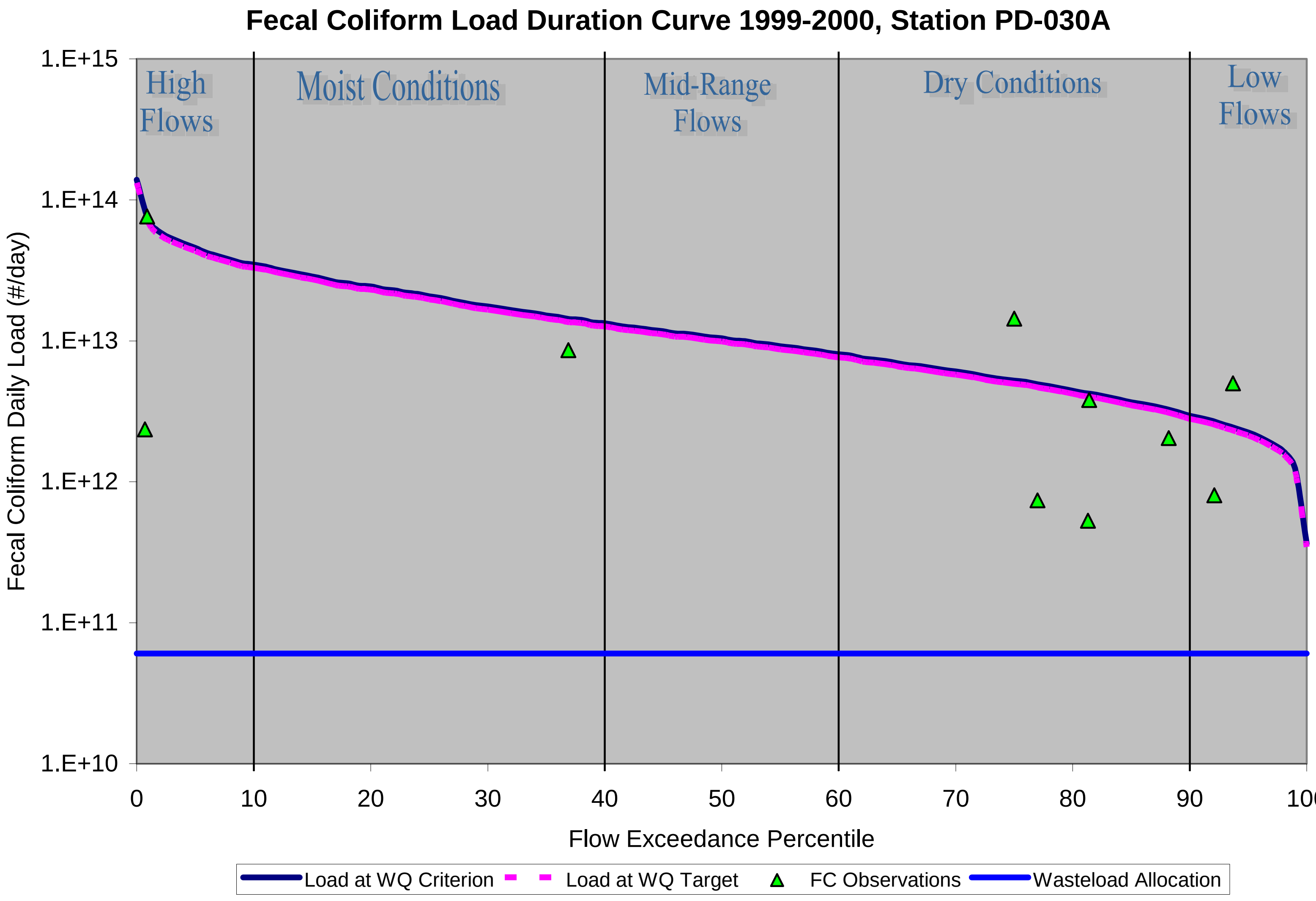


Figure 5-15 TMDL for PD-030 Maple Swamp

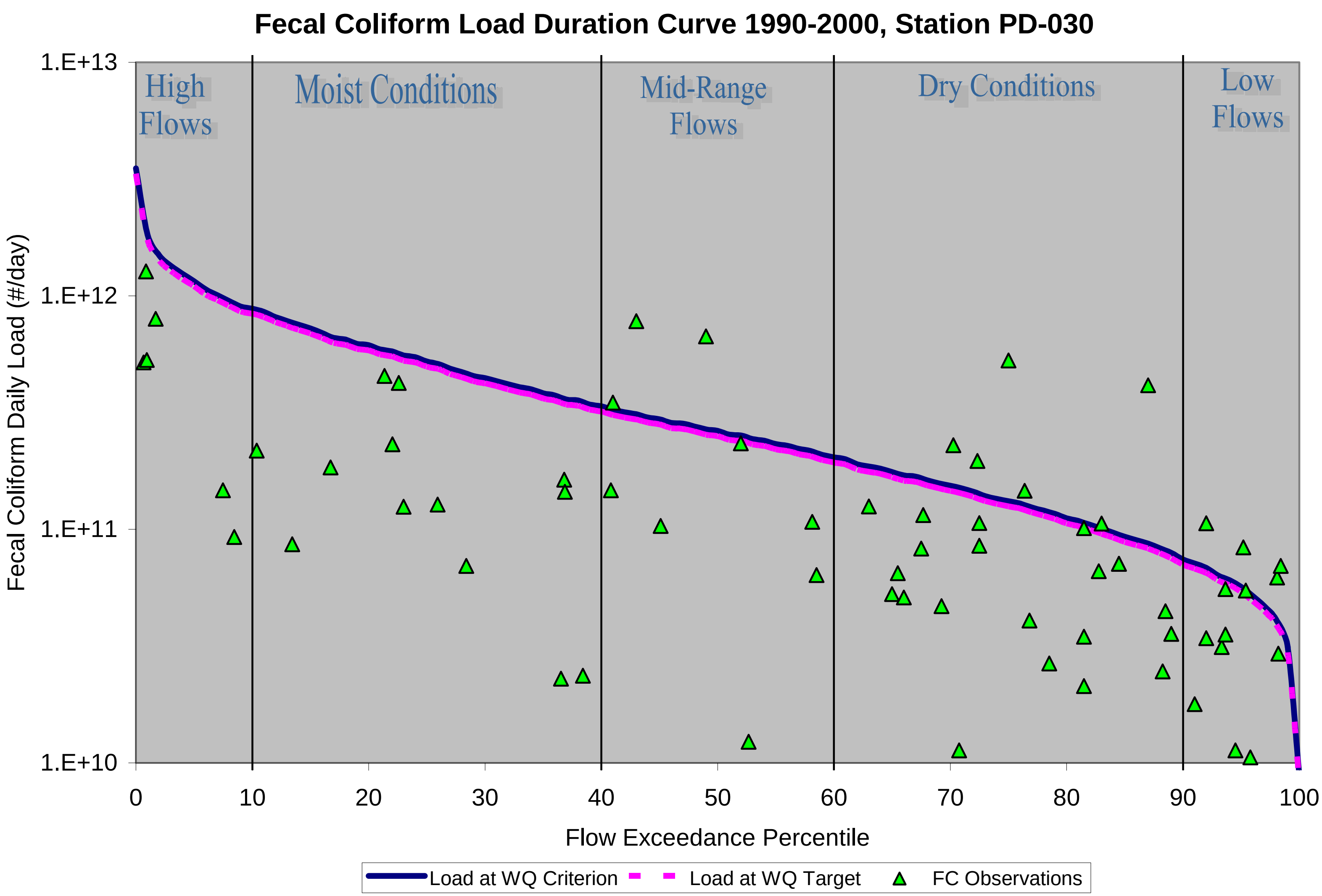


Figure 5-16 TMDL for PD-037 White Oak Creek

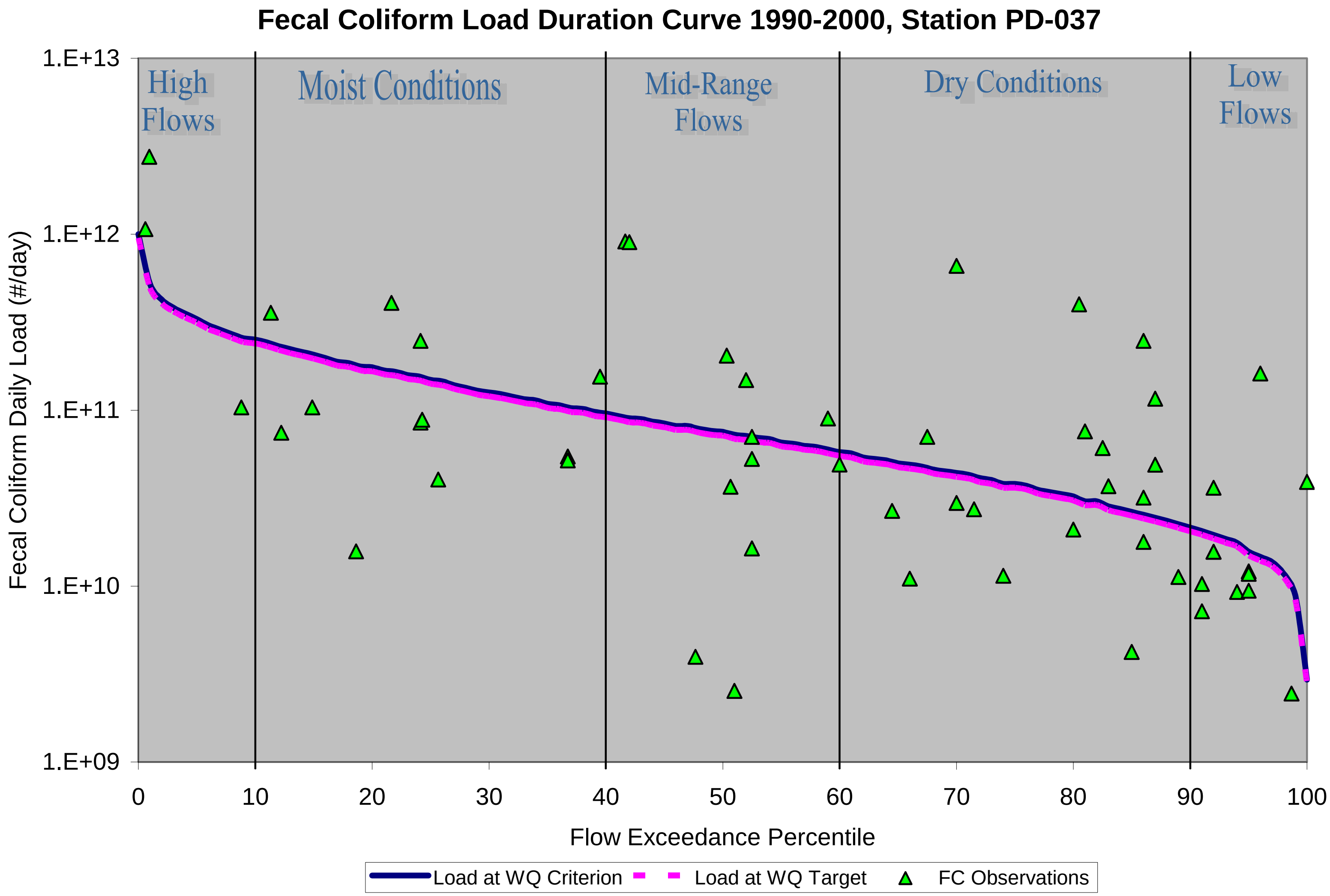
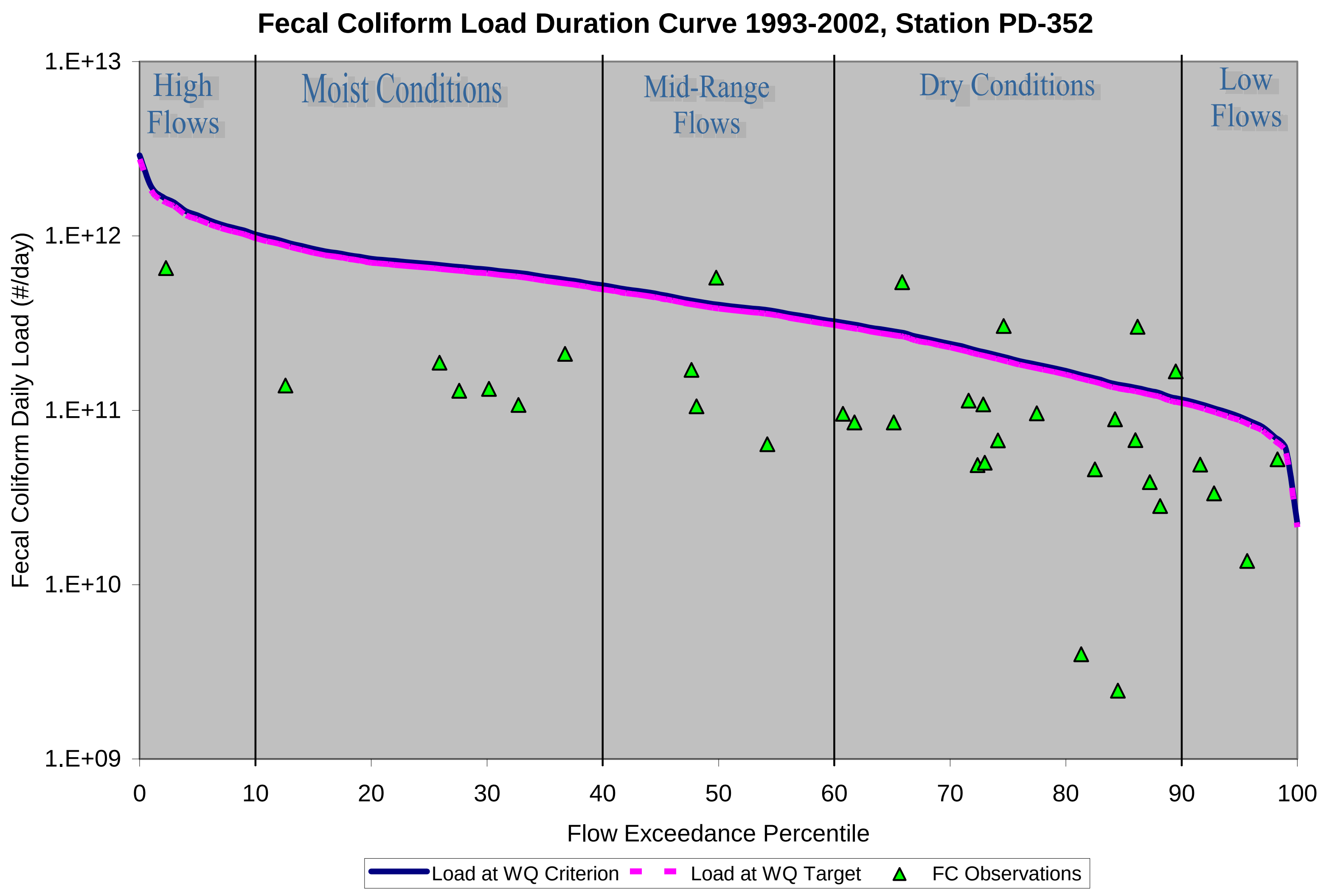


Figure 5-17 TMDL for PD-352 Chinners Swamp



SECTION 6
REFERENCES

American Veterinary Medical Association 2004. Veterinary market statistics, 2004.

ASAE 1998. American Society of Agricultural Engineers Standards, 45th edition. Standards, engineering, practices, data.

Canter and Knox 1986. Canter, L.W., and R.C. Knox Septic Tank System Effects on Ground Water Quality. Chelsea, MI: Lewis Publishers. 1986

City of Florence, SC 2005. Phone conversation with Forrest Wittington, Utility Department Manager.

Cleland 2003. *TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet-Weather Assessments*. Water Environment Federation National TMDL Science and Policy Conference 2003. Chicago, IL.

Hall 2002. Selden Hall, Washington State Department of Health, Wastewater Management Program Rule Development Committee, Issue Research Report - Failing Systems, June 2002.

NOAA 2005. National Oceanic and Atmospheric Administration, National Climatic Data Center. http://www.ncdc.noaa.gov/cgi-bin/res40.pl?page=gsod.html

NSFC 1996. – National Small Flows Clearinghouse, Summary of State Regulations, 1996. http://www.nesc.wvu.edu/nsfc/pdf/summaries/SOUTHCAROLINA.pdf

OSU 1992. Ohio Livestock Manure And Wastewater Management Guide, Bulletin 604. http://ohioline.osu.edu/b604/b604_2.html

SCDHEC 1995. SC Department of Health and Environmental Control. Final Report – 1995 Systems Performance Survey.

SCDHEC 1999. A Technical Evaluation of Onsite Wastewater Disposal in South Carolina, Onsite Wastewater Technical Committee, SC Department of Health and Environmental Control, 1999.

SCDHEC 2001. Water Quality Assessment Report, Broad River Basin, Technical Report No. 001-01. SCDHEC, Bureau of Water June, 2001.

SCDHEC 2001a. Water Classifications and Standards (Regulation 61-68) and Classified Waters (Regulation 61-69) for the State of SC. Office of Environmental Control, Columbia, SC.

SCDHEC 2002. South Carolina Department of Health and Environmental Control. Onsite Septic System Inspector Training Pilot Program Feasibility Study Report, 2002.

SCDHEC 2003. Total Maximum Daily Load Development for Twelve Mile Creek Watershed, SC. South Carolina Department of Health and Environmental Control, Bureau of Water, June 19, 2003.

SCDHEC 2004. South Carolina DHEC. State of South Carolina Integrated Report for 2004, Part I: Listing of Impaired Waters.

SCDHEC 2005. Broad River Basin website, http://www.scdhec.gov/eqc/water/shed/bd_main.html.

SCDNR 2000. South Carolina Department of Natural Resources. South Carolina Deer Density Map.

Strange 2003. Tommy Strange, Harvest Information Program, Waterfowl Project, S.C. Department of Natural Resources.

Thorpe 2003. The Water Line Newsletter. "The Scoop on Poop". Spring 2003, Volume 7, No. 2. http://www.lmvp.org/Waterline/spring2003/scoop.htm

University of Florida 1987. Institute Of Food And Agricultural Sciences, University Of Florida, Florida Cooperative Extension Service, No. 31, December, 1987.

U.S. Census Bureau 1995. American Housing Survey.

U.S. Census Bureau 2000

USDA 2002, Census of Agriculture, National Agricultural Statistics Service, United States Department of Agriculture.

USEPA 1983. Final Report of the Nationwide Urban Runoff Program. U.S. Environmental Protection Agency, Water Planning Division.

USEPA 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Office of Water, EPA 440/4-91-001.

USEPA 2001. 2001 Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, EPA 841-R-00-002.

USEPA 2003. Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d) and 305(b) of the Clean Water Act, TMDL -01-03 - Diane Regas-- July 21, 2003.

USEPA 2005. 2005 Storage and Retrieval (STORET) Database. http://www.epa.gov/storet/. January 2005

USGS 2005. Multi-Resolution Land Characteristics Consortium. http://www.mrlc.gov/index.asp

USGS 2005a. National Land Cover Dataset (NLCD). http://landcover.usgs.gov/classes.asp#barren

USGS 2005b. USGS Daily Streamflow Data. http://waterdata.usgs.gov/nwis/sw

Weiskel, et al., 1996. Weiskel P.A., B.L. Howes, and G.R. Heufelder. Coliform contamination of a coastal embayment: sources and transport pathways. Environ. Sci. Technol. 30:1872-1881.

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

APPENDIX A
SCDHEC FECAL COLIFORM DATA – 1990 - 2002

APPENDIX B
PLOTS COMPARING PRECIPITATION AND FECAL COLIFORM CONCENTRATIONS

APPENDIX C
NPDES PERMIT DISCHARGE MONITORING REPORT DATA

APPENDIX D
ESTIMATED FLOW EXCEEDANCE PERCENTILES

APPENDIX E
LOAD DURATION CURVES – ESTIMATED LOADING AND CRITICAL CONDITIONS