TOTAL MAXIMUM DAILY LOADS

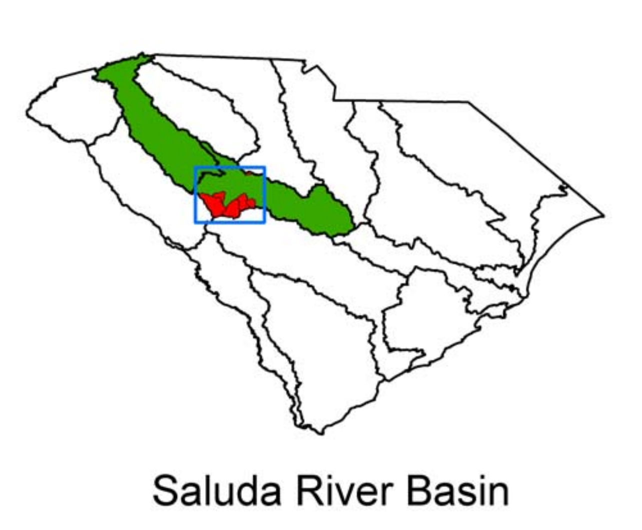
FOR

FECAL COLIFORM

FOR

LITTLE SALUDA RIVER, CLOUDS CREEK, CAMPING CREEK, AND HOLLOW CREEK WATERSHEDS, SOUTH CAROLINA

HYDROLOGIC UNIT CODE: 03050109 (S-050, S-123, S-255, S-324, S-290, S-306)



September 2005

SCDHEC Technical Report Number: 027-05

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 Load (TMDL) for Fecal Coliform for Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek in the Saluda River Basin. Subsequent actions must be consistent with this TMDL.

______________________________ ______________________________

James D. Giattina, Director Date
Water Management Division

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ACRONYMS AND ABBREVIATIONS

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
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 Carolina Department of Natural Resources
SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
USC	United States Code
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

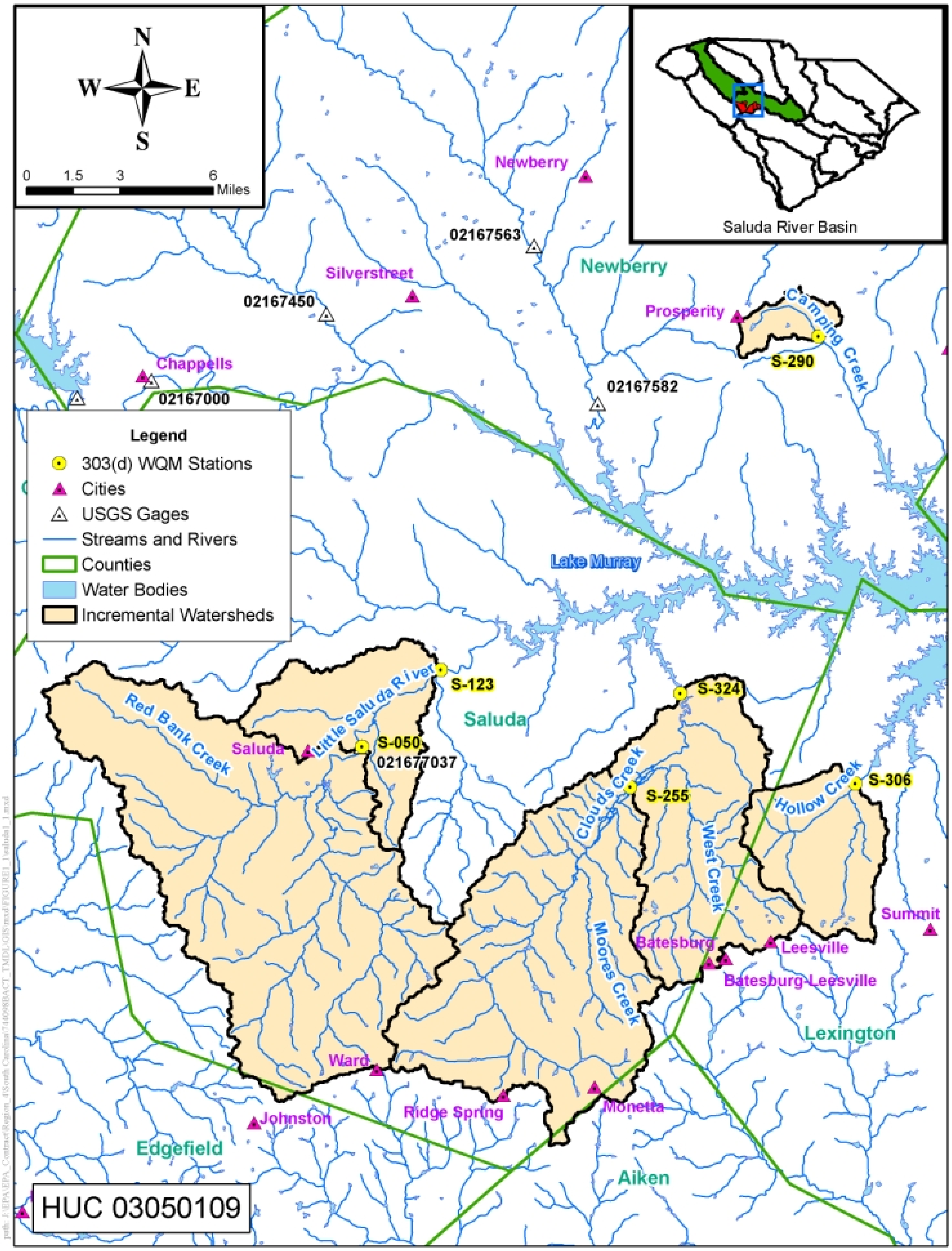
Section 303(d) of the Clean Water Act (CWA) and U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 Code of Federal Regulations [CFR] Part 130) require States to develop total maximum daily loads (TMDL) for water bodies not meeting designated uses where 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 Saluda River Basin 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 (SC) 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 6 water quality monitoring (WQM) stations from the 8-digit Hydrologic Unit Code (HUC) 03050109 within the Saluda River Basin on the 2004 South Carolina §303(d) list for exceedances of fecal coliform bacteria WQS. Figure 1-1 is an orientation map showing the locations of the 303(d)-listed WQM stations that are 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 Newberry, Saluda, and Lexington Counties.

Figure 1-1 Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek Watersheds



The six 303(d)-listed WQM stations associated with these water bodies are shown in Table 1-1 below, 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 HUC 03050109 of the Saluda River Basin

Water Body Name	SCDHEC WQM Stations	WQM Station Locations
HUC 03050109170		
Little Saluda River	S-050	Little Saluda River at US 378 East of Saluda
Little Saluda River	S-123	Little Saluda River at S-41-39, 5.2-Miles Northeast of Saluda
HUC 03050109180		
Clouds Creek	S-255	Clouds Creek at S-41-26, 4 mi. NW Batesburg
Clouds Creek	S-324	Clouds Creek at US 378
HUC 03050109190		
Camping Creek	S-290	Camping Creek S-36-202 below Georgia-Pacific
HUC 03050109200		
Hollow Creek	S-306	Hollow Creek at S-32-54

1.2 Watershed Description

General. There are approximately 2,416.2 stream miles in the Saluda River Basin. The Saluda River Basin encompasses 21 11-digit HUCs and 2,519 square miles within SC. The South Saluda River merges with the North Saluda River to form the Saluda River, which discharges into Lake Greenwood. Clouds Creek drains into Little Saluda River which, together with Saluda River, flows out of Lake Greenwood and the Bush River to form the headwaters of Lake Murray. Camping Creek enters on the northern shore of Lake Murray, and Hollow Creek enters midlake on the southern shore of the lake (SCDHEC 1998). Of the approximate 1.6 million acres within the Saluda River Basin, 67.4 percent is forested, 16.2 percent is agricultural, 8.4 percent is urban, 3.4 percent is scrub/shrub land, 3.9 percent is open water, 0.5 percent is barren land, and 0.2 percent is forested wetland (SCDHEC 1998).

The SCDHEC WQM stations addressed in this report are located in four different 11-digit HUCs of the Saluda River Basin (HUCs 03050109170, 03050109180, 03050109190, 03050109200). The majority of the Little Saluda River watershed (HUC 03050109170) is located within Saluda County, with a small portion extending into Edgefield County. Growth within this watershed is limited by lack of water and sewer infrastructure. Recent connections into the Edgefield County Water and Sewer Authority's Regional Sewer Collection System, however, should provide more potential for future growth. The Clouds

Creek watershed (HUC 03050109180) is located mostly within Saluda County, with part of the watershed extending into Aiken and Lexington County. There is low potential for growth in this watershed, and a majority of the area does not have water or sewer service. Camping Creek lies within the Saluda River/Lake Murray watershed (HUC 03050109190), located entirely within Newberry County. The upper lake region in Newberry County is primarily rural, although there is continual growth in areas surrounding Lake Murray. The Hollow Creek watershed (HUC 03050109200) is located mostly within Lexington County, with a small portion extending into Saluda County (SCDHEC 1998). Similar to Clouds Creek watershed, there is a low potential for growth in the Hollow Creek watershed.

Physiographic Regions. SC has been 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. The physiographic regions that define the Saluda River Basin are the Blue Ridge, Piedmont, Sand Hills, and Upper Coastal Plain regions.

The Blue Ridge is an area of dissected (separated by erosion into many closely spaced valleys), rugged mountains with narrow valleys dominated by forest; elevations range from 1,000 to 3,300 feet. The Piedmont consists of gently rolling to hilly slopes with narrow stream valleys dominated by forests, farms, and orchards; elevations range from 375 to 1,000 feet. Sand Hills is an area of gently sloping to strongly sloping uplands with a predominance of sandy areas and scrub vegetation; elevations range from 250 to 450 feet. The Upper Coastal Plain is an area of gentle slopes with increased dissection and moderate slopes in the northwest section that contains the state's major farming areas; elevations range from 100 to 450 feet (SCDHEC 1998).

Soil Types. The dominant soil associations, or those soil series composing, together, over 40 percent of the land area, were recorded for each watershed in percent descending order. The individual soil series for the Saluda River Basin are described as follows (SCDEHC 1998):

- Appling soil is well drained, deep soil, brownish to red, firm clay in the main part of the subsoil, found on narrow to broad ridges.
- Ashe soil is shallow to moderately deep, well drained to excessively drained in steep areas.
- Cecil soil is deep, well drained, gently sloping to sloping soil with red subsoil.
- Davidson soil is deep, gently sloping to strongly sloping, well drained to somewhat poorly drained with a loamy surface layer and a clayey subsoil.
- Georgeville soil is gently sloping to sloping, well-drained and moderately well-drained.
- Hayesville soil is moderately shallow to deep, well drained in gently sloping to steep areas, with red to yellow-brown subsoil.
- Helena soil is gently sloping to sloping, moderately well-drained to well-drained.
- Herndon soil is gently sloping to sloping, well-drained and moderately well-drained.

- Hiwassee soil is well-drained, moderately sloping with a moderately deep clayey subsoil.
- Lakeland soil is well-drained, sandy soil with a loamy subsoil and excessively drained soil.
- Louisburg soil is well-drained to excessively drained, shallow to deep, mainly red to yellowish-brown, friable to firm sandy clay loam to clay on narrow ridges and side slopes.
- Madison soil is well-drained, moderately sloping with a moderately deep clayey subsoil.
- Pacolet soil is well drained, moderately steep with a moderately deep clayey subsoil.
- Tatum soil is predominantly sloping to steep, well-drained to excessively drained, with a loamy subsoil, moderately deep or shallow to weathered rock.
- Wilkes soil is predominantly strongly sloping to steep, and well-drained.

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 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, 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. The K factor reflects 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 that erode. The range of K factor values in the Saluda River Basin are from 0.22 to 0.43 (SCDHEC 1998), suggesting that the soil types are not highly prone to erosion during periods of stormwater runoff.

Rainfall. Normal yearly rainfall in the Saluda River Basin during the period 1971 to 2000 ranges from 47.8 inches in Saluda to 48.01 inches in Batesburg (SC Department of Natural Resources [SCDNR] 2005).

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. For watersheds with multiple WQM stations, acreages for the downstream station only represent the subwatershed areas that are below the next upstream station within the watershed associated with the particular 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). Figure 1-2 depicts land use categories occurring within the watersheds described in this report. A summary of the major land use characteristics for the watershed associated with each WQM station is provided below.

S-050 – Little Saluda River at U.S. 378 East of Saluda and S-123 – Little Saluda River at S-41-39, 5.2 Miles Northeast of Saluda

The confluence of Mine Creek and Red Bank Creek forms the headwaters of Little Saluda River. The River flows through the Saluda Reservoir near the Town of Saluda and joins Big Creek to form an arm of upper Lake Murray (SCDHEC 1998). There are two WQM stations along the Little Saluda River, the upstream station (S-050) and the downstream station (S-123). The predominant soil types consist of an association of the Herndon-Tatum-Helena-Georgeville series. The K factor of the soil averages 0.43, the highest in the Saluda River Basin, and the slope of the terrain averages 7 percent, with a range of 2-25 percent.

The watershed for WQM station S-050 contains 27,934 acres. Approximately 70 percent of the watershed is forested, and this watershed includes little residential area (less than 1 percent). Pastures and row crops comprise approximately 8 and 19 percent, respectively.

The watershed for WQM station S-123 contains 12,777 acres. More than half of this watershed consists of forested area (56 percent), and approximately 2 percent consists of residential area. Row crops and pastures are the second and third most dominant land use in this watershed, which comprise approximately 25 and 15 percent, respectively.

S-255 – Clouds Creek at S-41-26, 4 miles NW Batesburg and S-324 – Clouds Creek at U.S. 378

The Clouds Creek watershed originates near the Town of Ridge Spring. The watershed encompasses a total of 124.7 stream miles where Clouds Creek flows through Asbill Pond and then later discharges into Little Saluda River (SCDHEC 1998). There are two WQM stations along Clouds Creek, the upstream station (S-255) and the downstream station (S-324). The predominant soil types consist of an association of the Appling-Herndon-Tatum-Lakeland-Helena series. The K factor of the soil averages 0.24 and the slope of the terrain averages 7 percent, with a range of 2 to 25 percent.

The watershed for WQM station S-255 contains 38,618 acres. Approximately 60 percent of this is forested and 6 percent consists of wetlands. Row crops are the second most dominant land use, comprising approximately 24 percent of this watershed, with the remainder consisting mostly of pasture land.

The watershed for WQM station S-324 contains 22,879 acres. Of this, more than 70 percent is forested area and approximately 3 percent is woody wetlands. Similar to WQM station S-255, there is very little residential area (approximately 2 percent). Row Crops and pasture land comprise the majority of the remaining watershed, with approximately 15 and 5 percent, respectively.

S-290 – Camping Creek S-36-202 Below Georgia-Pacific

Camping Creek lies in the Saluda River/Lake Murray watershed and discharges into midlake on the northern shore of Lake Murray (SCDHEC 1998). There are two WQM stations along Camping Creek, the upstream site (S-290), which is included in this TMDL report, and a downstream site, which is not impaired by fecal coliform bacteria and currently fully supports all aquatic life uses. The predominant soil types consist of an association of the Tatum-Georgeville-Herndon-Lakeland series. The K factor of the soil averages 0.28 and the slope of the terrain averages 8 percent, with a range of 2-25 percent.

The watershed for WQM station S-290 contains 2,460 acres and consists mostly of forested area (approximately 69 percent). The second and third most dominant land uses are row crops and pasture, comprising approximately 12 and 9 percent of this watershed, respectively. The remaining watershed consists mostly of residential and commercial/industrial/transportation area.

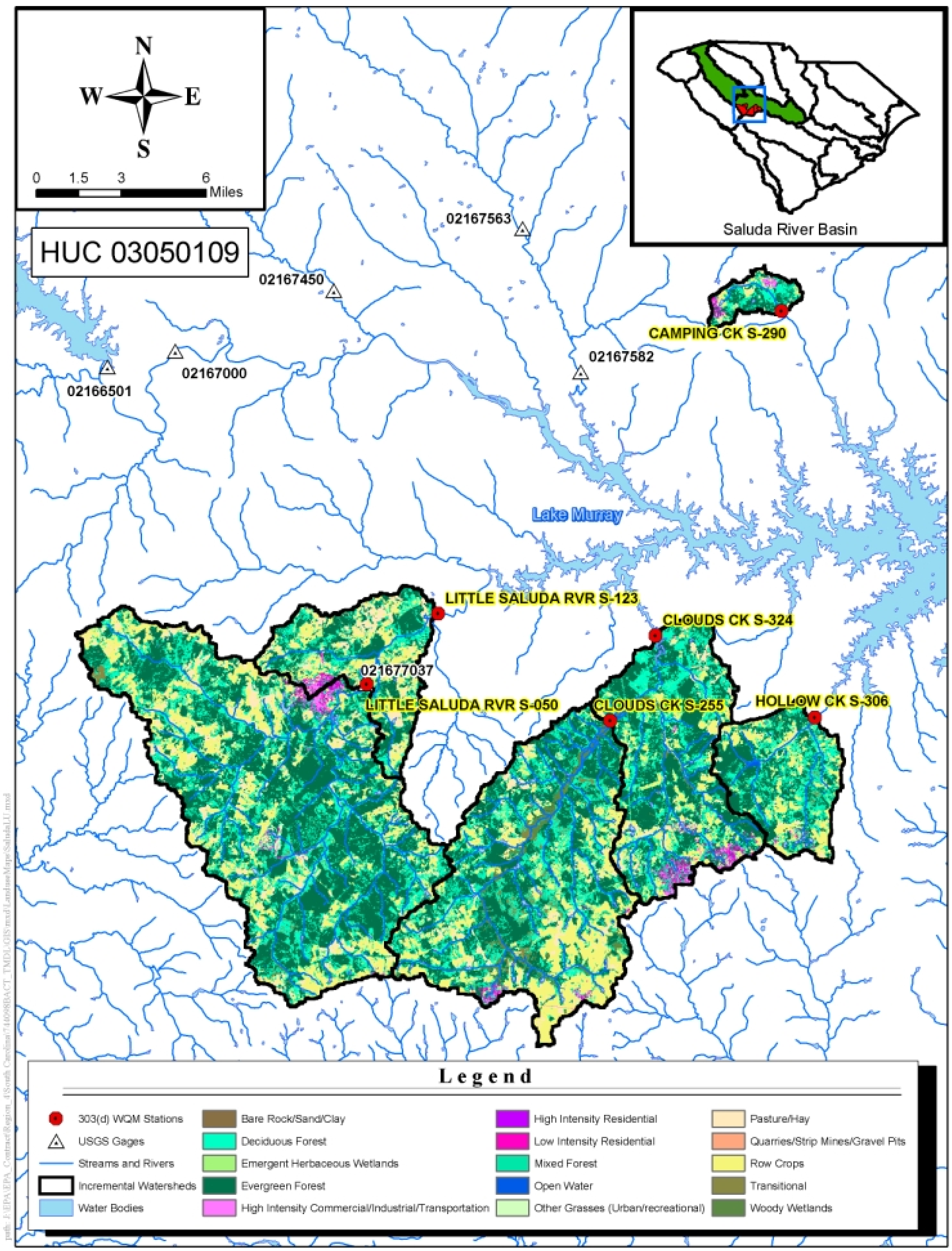
S-306 – Hollow Creek at S-32-54

The Hollow Creek watershed accepts drainage from Caney Branch and Little Creek before draining into the middle region of Lake Murray (SCDHEC 1998). The predominant soil types consist of an association of the Appling-Lakeland-Tatum-Georgeville series. The K factor of the soil averages 0.24 and the slope of the terrain averages 7 percent, with a range of 2-25 percent. The watershed for WQM station S-306 is dominated by forested area, comprising approximately 70 percent of the watershed. Row crops are the second most dominant land use (approximately 22 percent) and the remaining watershed consists mostly of pasture land

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

Description	Code	S-050	S-123	S-255	S-324	S-290	S-306
Open Water	11	212	23	249	145	16	206
Open Water Percent	11	0.37	0.18	0.65	0.64	0.65	1.82
Low Intensity Residential	21	428	157	187	539	91	37
Low Intensity Residential Percent	21	0.74	1.23	0.48	2.36	3.69	0.33
High Intensity Residential	22	29	30	19	41	11	1
High Intensity Residential Percent	22	0.05	0.23	0.05	0.18	0.46	0.01
High Intensity Commercial/Industrial/Transportation	23	256	108	87	286	88	16
High Intensity Commercial/Industrial/Transportation Percent	23	0.44	0.85	0.23	1.25	3.59	0.14
Bare Rock/Sand/Clay	31	42	23	17	21	13	13
Bare Rock/Sand/Clay Percent	31	0.07	0.18	0.04	0.09	0.52	0.12
Quarries/Strip Mines/Gravel Pits	32	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
Transitional	33	280	1	667	0	0	59
Transitional Percent	33	0.48	0.01	1.73	0.00	0.00	0.52
Deciduous Forest	41	9,598	1,889	6,042	4,388	523	2,148
Deciduous Forest Percent	41	16.57	14.79	15.65	19.18	21.25	19.01
Evergreen Forest	42	24,054	3,945	12,877	9,354	843	4,132
Evergreen Forest Percent	42	41.52	30.87	33.34	40.88	34.28	36.57
Mixed Forest	43	6,857	1,317	4,480	2,820	319	1,579
Mixed Forest Percent	43	11.84	10.31	11.60	12.33	12.97	13.97
Pasture/Hay	81	4,367	1,889	2,187	1,123	232	466
Pasture/Hay Percent	81	7.54	14.79	5.66	4.91	9.42	4.13
Row Crops	82	11,034	3,234	9,354	3,506	291	2,506
Row Crops Percent	82	19.05	25.31	24.22	15.32	11.83	22.18
Other Grasses (Urban/recreational)	85	200	40	33	38	17	4
Other Grasses (Urban/recreational) Percent	85	0.34	0.31	0.09	0.16	0.69	0.03
Woody Wetlands	91	556	119	2,357	580	16	117
Woody Wetlands Percent	91	0.96	0.93	6.10	2.53	0.63	1.04
Emergent Herbaceous Wetlands	92	21	1	62	38	0	14
Emergent Herbaceous Wetlands Percent	92	0.04	0.01	0.16	0.17	0.01	0.13
Total Acres		57,934	12,777	38,618	22,879	2,460	11,299

Figure 1-2 Land Use Map: Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek 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 Saluda 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/100 ml, 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/100 ml*. (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 is expected to be protective of the geometric mean criterion as well.

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. Ambient fecal coliform data were obtained from SCDHEC and 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
S-050	28	3,000	10	36%
S-123	57	1,200	10	18%
S-255	23	600	4	17%
S-324	23	600	3	13%
S-290	48	100,000	11	23%
S-306	23	110,000	15	65%

Some of the fecal coliform data were generally collected only during May through October (S-050 and S-255), while other stations were mostly sampled throughout the year (S-123, S-324, S-290, and S-306). 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 periods for which data do exist (SCDHEC 2003).

Between 13 and 65 percent of the samples collected at the 6 WQM stations from 1998 to 2002 exceeded the WQS for primary contact recreation. WQM station S-306 (Hollow Creek) exceeded the 400 cfu/100 ml WQS in 65 percent of the samples collected, and WQM station S-050 (Little Saluda River upstream) exceeded the WQS in more than 35 percent of the samples collected. 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 conditions under which bacteria loads can be transported to streams in each watershed. 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 whether any relationship between fecal coliform exceedances and rainfall could be discerned. Rainfall data for a 3-day period (2 days prior to and the day of each fecal coliform sample) selected from weather stations proximal to each WQM station were averaged. Data from the NOAA weather monitoring stations Greenwood Airport, Anderson County Airport, and Columbia Metro Airport were used (NOAA 2005). A map showing the location of these weather stations and their station identification numbers are provided in Appendix B.

A variety of general conclusions were derived from this data assessment, such as:

- Most ambient fecal coliform samples were collected under dry conditions;
- A large number of fecal coliform samples exceeded the WQS even under dry weather conditions;
- Fecal coliform exceedances of the WQS at some of the 303(d)-listed WQM stations are associated with wet weather (peak runoff) events.

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

WQM Station S-050 (Little Saluda River Upstream). For the period examined (47 data points) there were only 4 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates only two fecal coliform measurements exceeded the WQS. The maximum fecal coliform value of 3,000 cfu/100 ml occurred on August 13, 1998 when measured rainfall was 0.3 inches.

WQM Station S-123 (Little Saluda River Downstream). For the period examined (93 data points) there were approximately 8 days in which the 3-day average rainfall exceeded 0.1 inch, and on those dates only one fecal coliform measurement exceeded the WQS. This suggests there is no relationship between wet weather conditions and higher fecal coliform concentrations. However, 14 fecal coliform samples exceeded the WQS when the 3-day average rainfall was less than 0.05 inches suggesting that wet weather events have a limited influence on fecal coliform concentrations. The maximum fecal coliform measurement of 3,000 cfu/100 ml occurred on October 5, 1994; however, there was no precipitation recorded on that date.

WQM Station S-255 (Clouds Creek Upstream). For the period examined (45 data points) there were 11 days in which the 3-day average rainfall exceeded 0.2 inches resulting in only two fecal coliform measurements exceeding the WQS. Three other exceedances of the WQS occurred when less than 0.17 inches of rain were recorded. The maximum fecal coliform density measured was 600 cfu/100 ml on October 8, 1996.

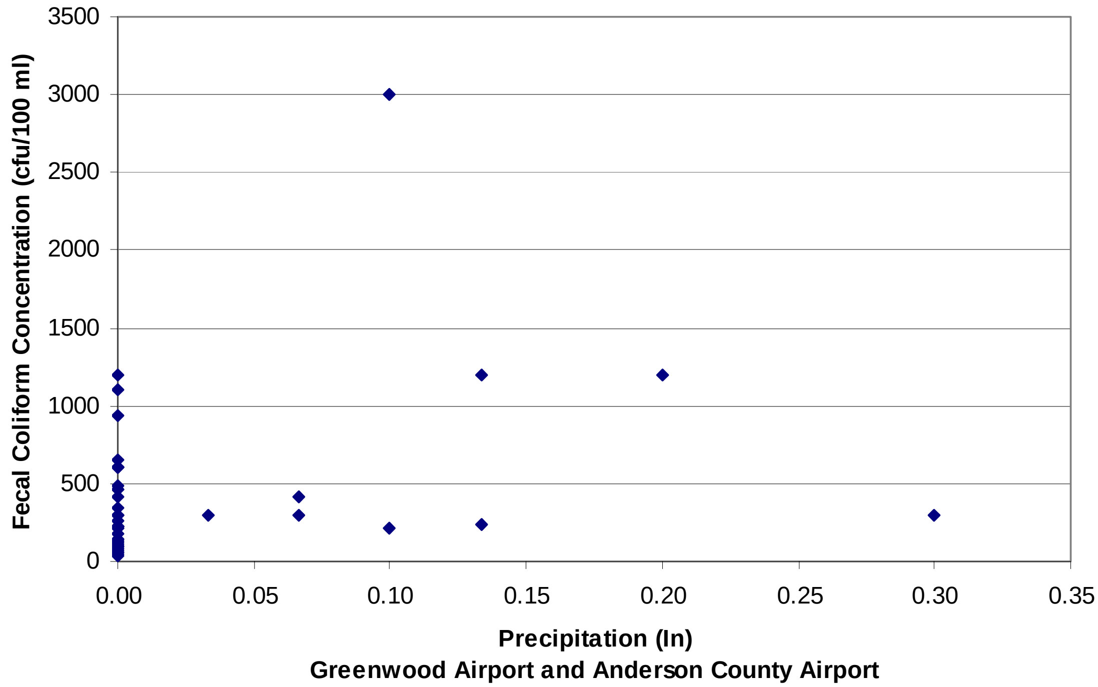
WQM Station S-324 (Clouds Creek Downstream). For the period examined (22 data points) there were 5 days in which the 3-day average rainfall exceeded 0.3 inches, resulting in three fecal coliform measurements exceeding the WQS. This suggests that wet weather may be associated with high fecal coliform concentrations. The maximum fecal coliform density measured was 600 cfu/100 ml on May 6, 2002. Maximum measured densities at this WQM station were several orders of magnitude below those measured at other stations.

WQM Station S-290 (Camping Creek). For the period examined (91 data points) there were 22 days in which the 3-day average rainfall exceeded 0.1 inch, resulting in 16 fecal coliform measurements exceeding the WQS. The maximum fecal coliform measurement of 100,000 cfu/100 ml occurred on July 16, 1996 and October 5, 1999, and the 3-day average rainfall was 0.17 and 0.13 inches, respectively. These statistics suggest that high fecal coliform concentrations are unlikely to be associated with wet weather events.

WQM Station S-306 (Hollow Creek). For the period examined (34 data points) there were 6 days in which rainfall exceeded 0.1 inch, resulting in four fecal coliform measurements exceeding the WQS. However, 17 fecal coliform samples exceeded the WQS when the 3-day average rainfall was less than 0.10 inches suggesting that wet weather events have a limited influence on fecal coliform concentrations.

In summary, the data discussed above indicated that fecal coliform WQS exceedances from three of the WQM stations (S-050, S-324, S-290) appear to correlate with days during which measurable precipitation occurred, indicating that fecal coliform exceedances are associated with rainfall. No such relationship appears to be evident for two other stations (S-123, S-306). It is unclear whether S-255 shows such a relationship. The lack of such a relationship suggests that fecal coliform exceedances may be associated with point or nonpoint sources that are not significantly affected by rainfall. Figure 2-1 is an example plot of WQM station S-050 (Little Saluda River upstream) showing the apparent relationship between fecal coliform exceedances and precipitation. Plots for WQM stations S-324 and S-290 are provided in Appendix B; no plots for any other station are shown. Subsection 3.3 provides a more detailed discussion of fecal coliform sources by watershed and the affect dry and wet weather conditions have on fecal coliform loading.

Figure 2-1 Comparison of Precipitation and Fecal Coliform Concentrations for WQM Station S-050 Little Saluda River



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 generally collected on a monthly basis (see Appendix A) instead of at least five samples over a 30-day period, 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/100 ml for the instantaneous criterion, which is 5 percent lower than the water quality criteria of 400 cfu/100 ml. A 5 percent explicit MOS was reserved from the water quality criteria in developing the load duration curves. 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 (SCDHEC 2003).

This water quality target will be used to determine the allowable bacteria load which is derived by using the actual or estimated flow record multiplied by the instream fecal coliform criteria minus 5 percent, representing the 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 themselves are not pathogenic, they are present in mammalian waste that also contains other harmful microorganisms such as bacteria and viruses.

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

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.

3.1 Point Source Discharges

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 carrying fecal coliform bacteria is another type of point source currently regulated under the USEPA NPDES Stormwater Program. However, there are currently no Municipal Separate Storm Sewer Systems (MS4) permits in the watersheds discussed in this report and therefore only continuous point source discharges are addressed. The following is a brief discussion of point source discharges in the Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek watersheds.

3.1.1 Continuous Point Sources

Table 3-1 lists three NPDES dischargers located upstream of three of the six WQM stations. These NPDES facilities are shown in Figure 3-1. Two of these facilities, SC0038237, Eastover WWTP No. 1 (S-255) and SC0044741, Newberry Co. W&SA Plant No. 2 (S-290), are no longer discharging and are, therefore, not considered current sources of fecal coliform loading. Wastewater from Eastover WWTP No. 1 is pumped to a facility outside of the watershed since it became inactive (Eastover Town Hall 2005). For the Newberry County Water and Sewer Authority facility, the process was changed in part by incorporating water from an adjoining facility to help evaporate the wastewater effluent, thereby allowing the effluent discharge to be discontinued (Newberry County W&SA 2005).

Discharge Monitoring Reports (DMR) were used to determine the number of fecal coliform analyses performed from 1998 through 2004, the maximum concentration during this period, the number of violations occurring when the monthly geometric mean concentration exceeded 200 cfu/100 ml, and the number of violations when a daily concentration exceeded 400 cfu/100 ml. The DMR data for each WWTP are provided in Appendix C. For the most part, these data indicate occasional fecal coliform permit violations occurring at the facilities located in the watersheds listed in Table 3-1. For example, SC00022381, Saluda WWTP, had no monthly violations between 1998 and 2004. The Saluda WWTP did have two violations of the daily maximum permit limit in both 1998 and 2004. Likewise, SC0044741, Newberry Co. W&SA WWTP No. 2, had no monthly violations between 1998 and 2001, and only one violation of the daily maximum permit limit in 1998. Between 1998 and 2001, SC0038237, Eastover WWTP No. 1, had 12 monthly violations and eight daily maximum violations.

Eastover Plant No. 1 has not discharged since April 2002, and Newberry Co. W&SA Plant No. 2 has not discharged since March 2001. Nevertheless, SC0038237, Eastover WWTP No. 1, may have contributed to fecal coliform exceedances reported between 1998 and the date the discharge became inactive at WQM station S-255.

Some NPDES permits only require monitoring and reporting. For those permits, USEPA's permit compliance system database was used to determine the maximum monthly average flow rate for each WWTP. Where permit Fact Sheets were available, the design flow of the WWTP was used. Inactive permits or industrial dischargers are not included in Table 3-1, because they do not contribute fecal coliform loading.

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

Sanitary sewer overflows (SSO), typically associated with urban growth areas, are also a potential source of fecal coliform loading to streams. SSOs are generally caused by inadequate operation, maintenance, and management of wastewater collection systems and are known to frequently occur during periods of high flows (e.g. from stormwater) when wastewater treatment capability may be overwhelmed. Documentation of SSO incidents were reviewed and local water and sewer agencies (e.g. Lexington County Joint Water and Sewer Commission, Saluda County Water and Sewer Authority and Prosperity Water and Sewer Authority) were verbally interviewed to identify possible historical SSO incidents and to ascertain whether leaking sewer lines are a potential source of fecal coliform in the Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek watersheds.

No reported SSOs were identified in these watersheds for the time period in question (approximately 1990 to 2002). There are currently no sewer lines located in the Hollow Creek watershed (see Figure 3-1) and sewer lines would therefore not be a potential source of fecal coliform to this watershed. Each of the local agencies interviewed reported no known leakage in the sewer lines within any of these watersheds (Lexington County Joint Water and Sewer Commission 2005; Batesburg-Leesville Water Plant 2005; Saluda County Water and Sewer Authority 2005; Newberry Water and Sewer Authority; Prosperity Water and Sewer Authority). Therefore, contribution of fecal coliform from SSOs or leaking sewer lines is likely to be a negligible source within the Little Saluda River, Clouds Creek, and Camping Creek watersheds.

Figure 3-1 Locations of NPDES Dischargers and Animal Feeding Operations in Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek Watersheds

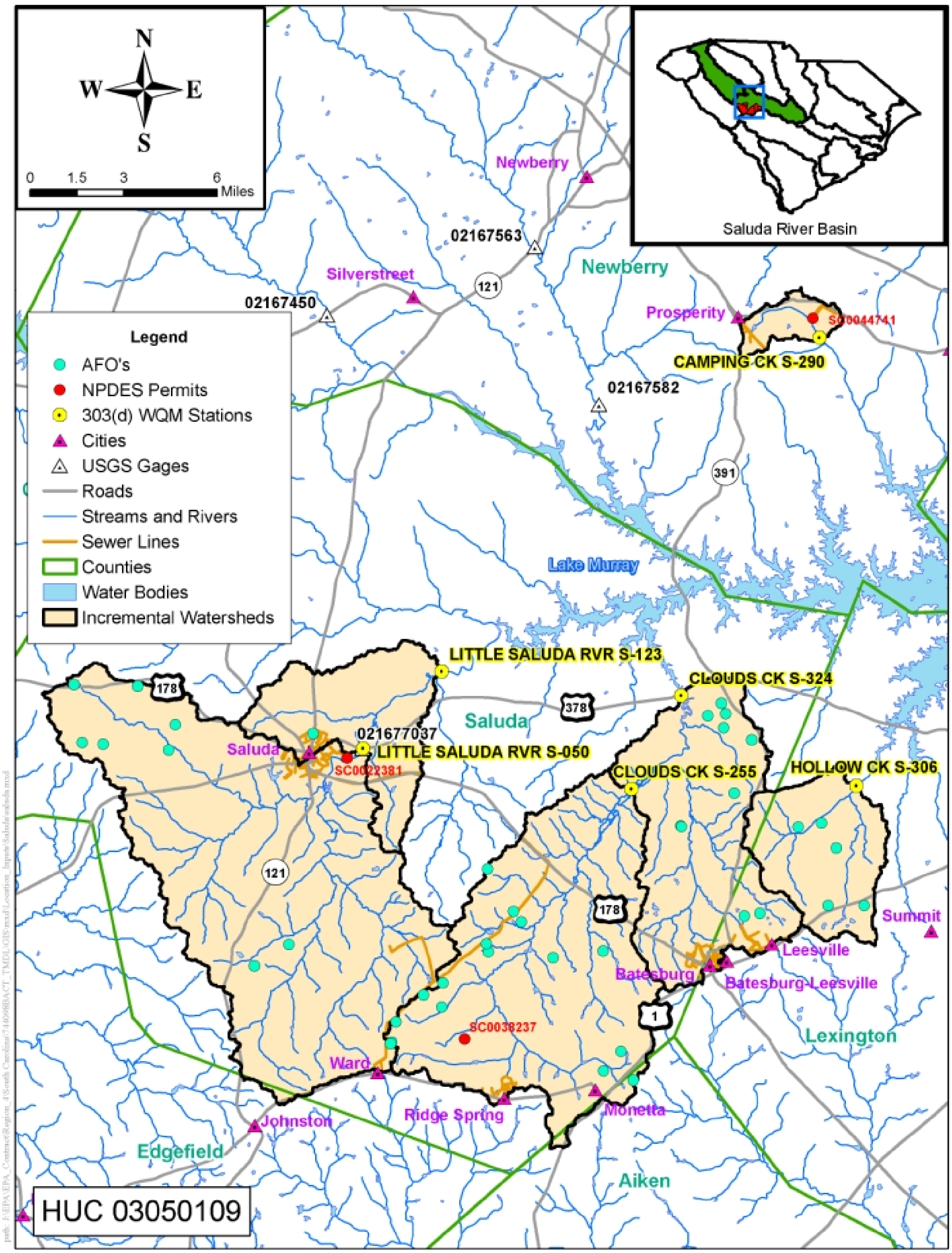


Table 3-1 Permitted Facilities Discharging Fecal Coliform Bacteria

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Receiving Water	Flow (mgd)	Number of 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 03050109170								
S-050 Little Saluda River at US 378 East of Saluda								
Town of Saluda	SC0022381	Little Saluda River	0.465	84	5700	0	4	5%
HUC 03050109180								
S-255 Clouds Creek at S-41-26, 4 mi. NW Batesburg								
Eastover Plant No. 1 (Inactive - 3/31/02)	SC0038237	Clouds Creek	0.019*	50	3300	12	8	40%
HUC 03050109190								
S-290 Camping Creek S-36-202 below Georgia-Pacific								
Newberry Co. W&SA Plant No. 2 (Inactive 3/3/01)	SC0044741	Camping Creek	0.10*	39	6000	0	1	3%

* Maximum of Reported Average Monthly Flows
**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 03050109170			
S-050 Little Saluda River at US 378 East of Saluda			
Town of Saluda	SC0022381	Little Saluda River	6.91E+08
HUC 03050109180			
S-255 Clouds Creek at S-41-26, 4 mi. NW Batesburg			
Eastover Plant No. 1 (Inactive - 3/31/02)	SC0038237	Clouds Creek	2.35E+08
HUC 03050109190			
S-290 Camping Creek S-36-202 below Georgia-Pacific			
Newberry Co. W&SA Plant No. 2 (Inactive 3/3/01)	SC0044741	Camping Creek	2.38E+06

3.2 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. The following discussion highlights possible major nonpoint sources contributing fecal coliform in each watershed. These sources include wildlife, agricultural activities and domesticated animals, urban runoff, failing onsite wastewater disposal (OSWD) systems, and pets. The following subsections describe probable nonpoint sources of fecal coliform. Table 3-3 lists the 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. Although WQM stations S-255 and S-290 contain NPDES point source dischargers upstream, these WWTPs are no longer discharging since March of 2002 and 2001, respectively. Therefore, any potential impairment during more recent years is expected to be associated with nonpoint discharges only. In addition, since there were only a few excursions associated with the WWTP discharge in the Camping Creek watershed, impairment in this watershed during the period at which this WWTP was discharging is considered to be mostly associated with nonpoint sources of fecal coliform as well.

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

WQM Station	Streams with No NPDES Fecal Coliform Discharge
S-324	Clouds Creek
S-306	Hollow Creek

A study under USEPA's National Urban Runoff Project indicated that average fecal coliform concentration from 14 watersheds in different areas within the United States was approximately 15,000 cfu/100 ml in stormwater runoff (USEPA 1983). Runoff from urban areas not permitted under the MS4 program may be a significant source of fecal coliform bacteria in 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.

3.2.1 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 3-4 lists the estimated deer density per square mile for each watershed. 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 some of the watersheds may be a significant source of fecal coliform loading.

Table 3-4 Estimated Deer Density by Watershed

Station	Estimated Deer Density per Square Mile
S-050	15 - 45
S-123	15 - 30
S-255	< 15 - 30
S-324	< 15
S-290	> 45
S-306	< 15

Approximately 70,000 ducks, mostly wood ducks, green-winged teal, mallards, and ringnecks, wintered in SC in January 2003 (Strange 2003). This is substantially lower than the long-term average of 200,000 (Strange 2003). There are currently no wildlife management areas along the Saluda River, and there are 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 in some of these watersheds.

3.2.2 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;
- horses - 400 million per animal per day;
- pigs - 11 billion per animal per day;
- chickens - 1.4 billion per animal per day;
- turkeys - 1 billion per animal per day; and
- sheep - 12 billion per animal per day.

Manure generated by livestock in pastures or at animal feeding operations (AFO) which is 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)). 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 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). Insufficient data are available to estimate fecal coliform levels in stormwater runoff from the AFO land application fields.

Table 3-5 lists the dairy, turkey, broilers, poultry, and stockyard AFO facilities located in each HUC derived from the SCDHEC statewide list of AFOs. All of the AFOs are classified as no discharge facilities. No AFO facilities are located in Camping Creek watershed (HUC 03050109190). Three small dairy facilities and a stockyard are located in the Little Saluda River watershed (HUC 03050109170), and one small swine facility is located in the Hollow Creek watershed (HUC 03050109200). All the remaining facilities are poultry operations.

Table 3-5 Animal Feeding Operations

NPDES	AFO TYPE	DESIGN COUNT	AFO SIZE	COUNTY NAME	HUC CODE10
HUC 03050109170					
ND0016390	BROILERS	68000	medium	Saluda	03050109170010
ND0061921	DAIRY	165	small	Saluda	03050109170010
ND0063223	TURKEY	31000	medium	Saluda	03050109170010
ND0067261	TURKEY	15000	small	Saluda	03050109170010
ND0082236	BROILERS	135000	large	Saluda	03050109170010
ND0069159	DAIRY	200	medium	Saluda	03050109170020
ND0073466	DAIRY	130	small	Saluda	03050109170020
ND0060950	STOCKYARD	850	NA	Saluda	03050109170030
HUC 03050109180					
ND0006211	BROILERS	160000	large	Saluda	03050109180010
ND0016403	BROILERS	25000	small	Saluda	03050109180010
ND0019097	BROILERS	80000	medium	Saluda	03050109180010
ND0019101	BROILERS	19400	small	Saluda	03050109180010
ND0066711	BROILERS	74000	medium	Saluda	03050109180010
ND0067601	BROILERS	22400	small	Aiken	03050109180010
ND0068390	BROILERS	115000	medium	Saluda	03050109180010
ND0070815	BROILERS	110400	medium	Saluda	03050109180010
ND0071005	BROILERS	100000	medium	Saluda	03050109180010
ND0073261	BROILERS	65000	medium	Saluda	03050109180010
ND0076023	BROILERS	122000	medium	Saluda	03050109180010
ND0076210	BROILERS	139000	large	Saluda	03050109180010
ND0082589	BROILERS	92000	medium	Saluda	03050109180010
ND0082872	BROILERS	90000	medium	Saluda	03050109180010
ND0063231	BROILERS	104000	medium	Saluda	03050109180020
ND0065986	BROILERS	64000	medium	Saluda	03050109180020
ND0066974	BROILERS	89000	medium	Saluda	03050109180020
ND0068071	BROILERS	112000	medium	Saluda	03050109180020
ND0072664	BROILERS	57000	medium	Saluda	03050109180020
ND0072729	BROILERS	58500	medium	Lexington	03050109180020
ND0073199	BROILERS	51000	medium	Saluda	03050109180020
ND0073776	BROILERS	90000	medium	Saluda	03050109180020
ND0080608	BROILERS	48000	medium	Saluda	03050109180020
ND0081485	BROILERS	48300	medium	Lexington	03050109180020
HUC 03050109200					
ND0005819	BROILERS	48000	medium	Lexington	03050109200010
ND0069124	LAYERS	20000	small	Lexington	03050109200010
ND0080861	POULTRY	60000	medium	Lexington	03050109200010
ND0081451	BROILERS	67500	medium	Lexington	03050109200010

While Table 3-5 and Figure 3-1 present the spatial distribution of specific AFO facilities upstream of each 303(d)-listed WQM station, the following information is provided to summarize the estimated manure production and potential contributions of fecal coliform loading for different livestock. County agricultural census data, if available, were used to estimate the number of livestock for each watershed (USDA 2002).

Cattle: Between 1997 and 2002 the number of cattle farms in Saluda County decreased by about 28 percent from 527 to 378 based on the USDA census data (USDA 2002). The number of cattle in Saluda County decreased about 5 percent from 28,038 to 26,667 during the same 5-year period. Between 1997 and 2002 the number of cattle in Lexington County decreased by 24 percent from 12,897 to 9,804. 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 3-6. 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. This cattle density value was then multiplied by the number of acres of pasture land in each watershed. SCDHEC has verified that cattle throughout these watersheds have direct access to the creeks. For many farmers these creeks are the only water source for their cattle. Therefore, fecal coliform loading from cattle, whether deposited directly into the creeks or transported from land by rainfall runoff, is likely to be significant in Little Saluda River (S-050 and S-123) and Clouds Creek (S-324 and S-255) watersheds. Although the numbers of cattle within Camping Creek (S-290) and Hollow Creek (S-306) watersheds are relatively small, contributions of fecal coliform loading from cattle may still be significant due to the relatively small size of these watersheds.

Table 3-6 Estimated Tons of Manure by WQM Station

WQM Station	Number of Cattle and Calves in Watershed	Tons of Manure Deposited Daily in Watershed
S-050	3,715	92
S-123	1,603	40
S-255	1,846	46
S-324	941	23
S-290	131	3
S-306	375	9

Poultry: According to USDA census data in 2002, there were 675,344 layers, 2,811,918 broilers and 95,004 turkeys in Saluda County (USDA 2002). In Table 3-5 above, poultry facilities include turkeys, broilers, and layers. According to Table 3-5, all of the AFOs in Clouds Creek watersheds (S-255 and S-324) are poultry facilities. The majority of AFOs in the Little Saluda River and Hollow Creek watersheds are also poultry facilities. In a report by the SC Water Resources Center, on the lower Broad River in SC the spatial relationships of human, cattle, poultry, and hogs to fecal coliform concentrations in the major watersheds of SC were evaluated (Allen and Lu 1998). There was little correlation between the location of poultry farms to instream fecal coliform concentrations above the WQSs. This may be related to the fact that poultry do not have nor need access to water bodies for drinking water.

However, there is significant acreage within some of the watersheds dedicated to land application of poultry litter and cattle manure. There are approximately 2,880 acres of land application fields registered by SCDHEC for poultry and dairy operations in the Little Saluda River watershed (HUC 03050109170). There are approximately 3,550 acres of land application fields registered by SCDHEC for poultry operations in the Clouds Creek watershed (HUC 03050109180). There are only 62 acres of land application fields registered by SCDHEC for poultry operations in Camping Creek watershed HUC 030500109190). In the Hollow Creek watershed (HUC 03050109200) there are approximately 870 acres of land application fields registered by SCDHEC for poultry operations. All these land application fields may not actually be in use; SCDHEC estimates represent a total number of permitted land application sites not operating disposal sites. Improperly applied manure is a possible source of fecal coliform bacteria in watersheds with application fields. These operations are permitted; therefore, problems are managed through SCDHEC enforcement mechanisms. The magnitude of fecal coliform loading from poultry facilities is unknown; however, the high number of poultry in Saluda County suggests that land application of poultry litter is a potential source of fecal coliform loading in Little Saluda River, Clouds Creek, and Hollow Creek watersheds.

Swine: According to USDA census data in 2002, there were only 1,542 hogs and pigs in Saluda County (USDA 2002). In 1997 there were 3,397 hogs and pigs in Lexington County (USDA 2002). 1997 census data were used when 2002 data were not available. While there are no swine AFOs located in any of the watersheds, it is assumed some small farms with swine are located in Little Saluda River and Clouds Creek watersheds. However, it is difficult to discern the magnitude of fecal coliform loading from swine within a given watershed since they are not evenly distributed throughout Saluda or Lexington Counties. Unlike cattle, swine typically do not have direct access to creeks. The combination of these factors suggests that fecal coliform loading from swine is negligible in the Little Saluda River and Clouds Creek watersheds.

3.2.3 Failing Onsite Wastewater Disposal Systems and Illicit Discharges

Table 3-7 provides estimations of the number of OSWD systems (primarily septic systems) in each watershed based on U.S. Census data. The table also estimates 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 3-7:

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

Table 3-7 OSWD Systems Summary

Monitoring Station	OSWD Systems	OSWD Systems per 100-acres
S-050	1414	2
S-123	853	7
S-255	761	2
S-324	1473	6
S-290	81	3
S-306	563	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 is 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). Among the six monitoring stations, Table 3-7 identifies Little Saluda River (S-123) to be the only one with OSWD system densities greater than 6.25 septic systems per 100 acres.

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).

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 (NFSC), 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.

3.2.4 Domestic Pets

Pets can be a major contributor of fecal coliform to streams. On average nationally, there are 0.58 dogs per household 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 listed in Table 3-8.

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 3-8. A study conducted by Weiskel *et al.* found that pets produce 450 million fecal coliform per animal per day (Weiskel 1996). 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. However, given the small percentage of land area covered by the Camping Creek and Hollow Creek watersheds in Newberry and Lexington Counties, respectively, it is difficult to derive the density of dogs from the estimated county totals in Table 3-8. Furthermore, with such a small number of households in the Little Saluda River and Clouds Creek watersheds, it is assumed that the fecal coliform loading contribution from pets is negligible.

Table 3-8 Estimated Number of Household Pets

County	Number of Households	Number of Dogs	Number of Cats	Tons of Dog Waste per Day
Saluda	7,127	4,134	4,704	0.9
Lexington	83,240	48,279	54,938	10.1
Newberry	14,026	8,135	9,257	1.7

3.3 Summary of Fecal Coliform Sources and WQM Stations on Impaired Streams

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;
- Watershed soil characteristics;
- Agricultural census data, including livestock populations;
- Households served by OSWD systems and OSWD system failure rates;
- AFOs;
- Domestic pet census data; and
- NPDES permitted point sources and discharge monitoring reports.

Based on the foregoing 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.

3.3.1 Little Saluda River

Little Saluda River is located in Saluda County and includes two WQM stations within HUC 03050109170.

WQM Station S-050, Little Saluda River (upstream)

The watershed for WQM station S-050 contains 27,934 acres and the estimated median flow is 82.8 cubic feet per second (cfs). The urban land use (~1 percent) within the watershed associated with the cities of Saluda and Ward is insignificant but includes OSWD systems, sanitary sewer lines, and a small population of domestic pets. The watershed is largely forested (~70 percent), and approximately 27 percent is pasture land and row crops combined. There are an estimated 3,715 head of cattle in this watershed, several poultry facilities, approximately 2,800 acres of land application fields and an estimated deer density of 15 to 45 individuals per square mile. Thus, there are a number of non-human sources including wildlife, livestock and potentially land application fields that are most likely significant sources of fecal coliform loading.

Twenty-eight water samples were collected from this watershed from 1998 through 2001. Analysis indicated that 36 percent of the water samples contained fecal coliform concentrations above the WQS. DMR data from the one active NPDES discharger in this watershed clearly indicates that the WWTP is not a contributing source of fecal coliform. In addition, review of SSO records and interviews with local agencies indicated that there are currently no known sources from SSOs or leaking sewer lines. While there are an estimated 1,414 OSWD systems in the watershed the low density of two systems per 100 acres suggest that OSWDs are not a major source of fecal coliform in the watershed.

Fecal coliform sources within this watershed could include a combination of failing OSWD systems, waste from birds and wildlife, and cattle watering in creeks. In addition, precipitation and resulting elevated runoff levels could also influence fecal coliform loading as well.

WQM Station S-123, Little Saluda River (downstream)

The watershed for WQM station S-123 is similar to S-050. Its estimated median flow is 71.3 cfs and urban land use is minimal within this watershed (~2 percent) with a high percentage of forest (~46 percent), and approximately 40 percent pastureland and row crops combined. The estimated density of OSWD systems within the watershed is significant. There are currently no known sources from SSOs or leaking sewer lines. There are an estimated 1,603 head of cattle in this watershed, land application fields and an estimated deer density of 15 to 30 individuals per square mile. Thus, as with upstream station S-050, there are a number of non-human sources including wildlife and livestock that are most likely significant sources of fecal coliform loading. Domestic pets are not expected to be a major source due to the low number of households in the watershed.

Fifty-seven water samples were collected from this watershed from 1998 through 2002. Analysis indicated that 18 percent of the water samples contained fecal coliform concentrations above the WQS. There are no active NPDES dischargers in this watershed, and an estimated 853 OSWD systems in the watershed, with an estimated density of seven systems per 100 acres

Fecal coliform sources within this watershed include a combination of failing OSWD systems, waste from birds and wildlife, and cattle or other livestock watering in the creek.

Summary of upstream vs. downstream stations in the Little Saluda River watershed. By way of overall summary between the upstream and downstream stations within this watershed, as discussed later in the document (Section 5) the critical hydrologic conditions are mid-range to dry conditions for the upstream station (S-050), while the critical condition for the downstream station (S-123) occurred during moist conditions. Possible explanations for this discrepancy may be due to difference in land use. For example, there are more AFOs and higher concentrations of wildlife due to more forested habitat, and wildlife and livestock are known to stand in creeks during hot summer days when flows are lower. Possible explanations for the downstream critical conditions (moist) there is more pastureland/row crops and only one known AFOs, and therefore waste would presumably be much more diffuse and prone to wash into the receiving water during rainfall events.

3.3.2 Clouds Creek Watershed

The Clouds Creek watershed drains 62,543 acres and includes two WQM stations within HUC 03050109180.

WQM Station S-255, Clouds Creek (upstream)

WQM station S-255 in the Clouds Creek watershed has an estimated median flow of 39.4 cfs and urban land use is minimal within this watershed (~1 percent). This watershed is also composed of a high percentage of forest (~60 percent), with approximately 30 percent pastureland and row crops combined. The urban land use within the watershed associated with the town of Ridge Spring includes OSWD systems and a small population of domestic pets, however overall these are considered insignificant sources. Domestic pets are not expected to be a major source due to low human population density. There are currently no known sources of fecal coliform from SSOs and leaking sewer lines. There are an estimated 1,846 head of cattle in this watershed, several poultry facilities, approximately 3,500 acres of land application fields, and deer density ranging from 15 to 30 individuals per square mile. There are a number of non-human sources potentially contributing to fecal coliform loading, including wildlife and livestock.

Twenty-three water samples were collected from this watershed from 1990 through 2001. Analysis indicated that 17 percent of the water samples contained fecal coliform concentrations above the WQS. There are an estimated 761 OSWD systems in the watershed however the low density of two systems per 100 acres suggests that OSWDs are not a major source of fecal coliform in the watershed.

It is noted that the maximum measured densities at this WQM station were several orders of magnitude below those measured at stations in the Little Saluda watersheds. It is possible that these lower fecal coliform densities are in part attributable to the relatively few anthropogenic inputs at WQM station S-255.

Fecal coliform sources within this watershed could include a combination of failing OSWD systems, manure from land application fields, waste from birds and wildlife, and cattle or other livestock watering in the creek.

WQM Station S-324, Clouds Creek (downstream)

WQM station S-324 in the Clouds Creek watershed has an estimated median flow of 62.8 cfs, and the urban land use is slightly higher within this watershed (~4 percent). This watershed is composed of a high percentage of forest (~73 percent), and includes pastureland and row crops (~20 percent combined). There are an estimated 941 head of cattle in this watershed, several poultry facilities, land application fields, and a deer density of less than 15 individuals per square mile. As with the above WQM stations, there are a number of nonhuman sources including wildlife, livestock, and land application fields potentially contributing to fecal coliform loading. Domestic pets are not expected to be a major source due to relatively low human population density.

Twenty-three water samples were collected from this watershed from 2001 to 2002. Analysis indicated that 13 percent of the water samples contained fecal coliform concentrations above the WQS. There are no active NPDES dischargers in this watershed, and an estimated 1,473 OSWD systems in the watershed, with an estimated density of six systems per 100 acres. In addition, there are currently no known sources of SSOs or leaking sewer lines within the watershed.

It is noted that the maximum measured fecal coliform concentrations at this WQM station were several orders of magnitude below those measured in the Little Saluda River and Hollow Creek watersheds. As with WQM station S-255, it is possible that these lower fecal coliform densities are in part attributable to the relatively few anthropogenic inputs at WQM Station S-324.

Fecal coliform sources within this watershed could include a combination of failing OSWD systems, manure from land application fields, waste from birds and wildlife, and cattle or other livestock watering in the creek. The highest fecal coliform loading appears to be associated with high precipitation.

Summary of upstream vs. downstream stations in the Clouds Creek watershed. By way of overall summary between the upstream and downstream stations within this watershed, as discussed later in the document (Section 5) the critical hydrologic conditions are dry conditions for the upstream station (S-255), while the critical condition for the downstream station (S-324) occurred during moist conditions. Similar to the Little Saluda River watershed, possible explanations for this discrepancy may be due to differences in land use. For example, there are more agricultural activities and wildlife due to more forested habitat, and there is an inactive WWTP (with approximately 40 percent exceedance prior to its closure in 2002). Excursions from WWTP discharges tend to be associated with lower flows due to minimal dilution under these hydrologic conditions. Possible explanations for the downstream critical conditions (moist) there is more residential area (approximately 3 percent) may be associated with elevated stormwater flows. The downstream WQM station is well below the upstream station and thus any fecal coliform loading would be expected to be much lower at the downstream station due to die-off, dilution, and other factors.

3.3.3 Camping Creek Watershed

The Camping Creek watershed drains 150,881 acres and includes one WQM station within HUC 03050109190.

WQM Station S-290, Camping Creek S-36-202 below Georgia-Pacific

WQM station S-290 in the Camping Creek watershed has an estimated median flow of 2.5 cfs. The urban land use (~8 percent) within the watershed includes very few OSWD systems and an insignificant population of domestic pets. With the remaining land use of the watershed being forest (68 percent), pastures, and row crops (20 percent combined), there are a number of nonhuman sources also contributing to fecal coliform loading. The estimated cattle population in the watershed is insignificant at only 131 cattle. The estimated deer density is more than 45 per square-mile. There are a number of non-human sources potentially contributing to fecal coliform loading, including wildlife and livestock. Domestic pets are not expected to be a major source due to relatively number of households.

Forty-eight water samples were collected from this watershed from 1990 through 2001. Analysis indicated that 23 percent of the water samples contained fecal coliform concentrations above the WQS. There is one inactive NPDES discharger in this watershed, and an estimated 81 OSWD systems in the watershed, with an estimated density of three systems per 100 acres. OSWDs are considered a minor source of fecal coliform due to the relatively low density. No point sources have been active in the watershed since the WWTP facility closed in March 2001. As indicated by the DMRs, the last WQS excursion associated with this WWTP was observed in Dec 1998. There are also currently no known sources of fecal coliform from SSOs or leaking sewer lines. Therefore fecal coliform loading is likely associated predominantly with nonpoint sources.

A brief review of the overall fecal coliform database (Appendix A) during the past ten years or so clearly shows wide fluctuations in water quality over time, including recent years. For example, during 1997 the highest fecal coliform value observed was 530 cfu/100 ml, and in 2001 the highest value observed was 460 cfu/100 ml, while between the years 1997 and 2001 there were numerous WQS excursions including values of 100,000, 40,000, and 20,000 (twice) cfu/100, in addition to several other elevated values as well.

Fecal coliform sources within this watershed could include a combination of failing OSWD systems, fecal waste from birds and wildlife, and cattle watering in the creek. Fecal coliform loading appears to generally increase with increased precipitation in this watershed.

3.3.4 Hollow Creek Watershed

The Hollow Creek watershed drains 14,169 acres and includes one WQM station within HUC 03050109200.

WQM Station S-306, Hollow Creek at S-32-54

WQM station S-306 in the Hollow Creek watershed has an estimated median flow of 11.6 cfs. The urban land use is minimal within this watershed (<1 percent). This watershed is composed of a high percentage of forest (~70 percent), and with less extensive pastureland and row crops combined (~26 percent). There are only an estimated 375 head of cattle in this watershed, with a projected deer density of less than 15 individuals per square mile. As with the above WQM stations, there are a number of non-human sources potentially contributing to fecal coliform loading, including land application fields, wildlife and livestock. Domestic pets are not expected to be a major source due to relatively low human population density.

Twenty-three water samples were collected from this watershed from 1992 through 2002. Analysis indicated that 65 percent of the water samples contained fecal coliform concentrations above the WQS. There are no active NPDES dischargers in this watershed, and an estimated 563 OSWD systems in the watershed, with an estimated density of five systems per 100 acres, which is below the guideline of 6.25 systems per 100 acres proposed by Canter and Knox (1986). There are currently no known sources of fecal coliform from SSOs or leaking sewer lines.

Fecal coliform sources within this watershed could include a combination of failing OSWD systems, waste from birds and wildlife, and cattle watering in the creek.

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

Load duration curves (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. 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 2005) 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 (<10th percentile) and low flow conditions (>90th 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 90th percentile value of the monthly loads was used to express the estimated existing load in cfu/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 (million gallons per day [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 90^{th} 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 75^{th} percentile exceedance flow is multiplied by the 90^{th} percentile of fecal coliform concentrations measured under the 60-90^{th} 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 (cfu/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/100 ml

*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. However, as noted above, there is no MS4 discharge in the three watersheds of concern. Therefore, point source discharges would be confined exclusively to the presence of WWTP discharges.

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 /100 ml

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

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

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 percent reduction goal (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.

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 Saluda River basin are provided in this section. The methodology for deriving these results is specified in Section 4.

5.2 Identifying Critical Conditions and Estimating Current 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 (see discussion in Step 4) . 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 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 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 S-050, while similar load reductions are required under all the hydrologic condition classes, the critical condition occurs under "Mid-Range Conditions," when a 68 percent loading reduction is required to meet the WQS.

Table 5-1 Estimated Existing Fecal Coliform Loading for Station S-050, with Critical Condition Highlighted

Hydrologic Condition Class*	Estimated Existing Loading (cfu/100 ml)	Percent Reduction Required
High Flows	1.48E+12	NA
Moist Conditions	2.37E+12	46%
Mid-Range Conditions	2.43E+12	68%
Dry Conditions	1.46E+12	68%
Low Flows	3.33E+11	NA

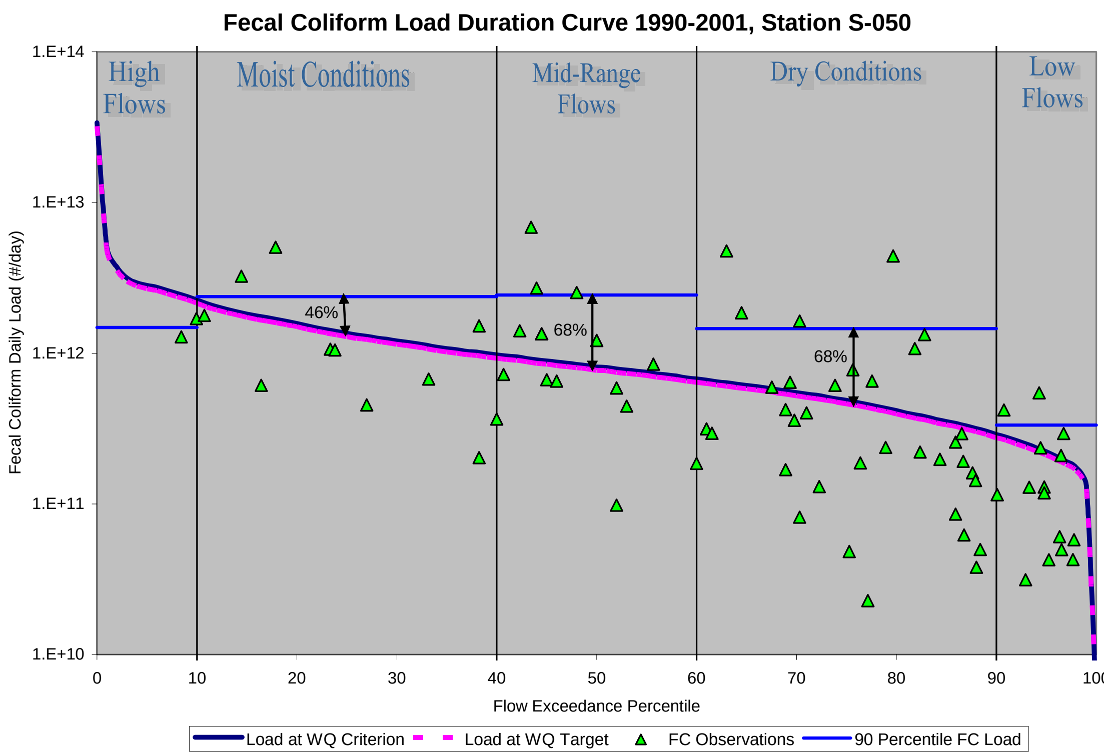
*Hydrologic Condition Classes are derived from Cleland 2003

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 S-050, while similar load reductions are required under all the hydrologic condition classes, the critical condition

occurs under "Mid-Range Conditions," when a 68 percent loading reduction is required to meet the WQS. Although this calculated load reduction is identical to that calculated for the dry hydrologic, the mid-range condition was selected because it occurs during higher flows and therefore results in a higher fecal coliform load.

The LDC for WQM station S-050 shown in Figure 5-1 shows estimated existing fecal coliform loads, and indicates that actual fecal coliform loads are exceeding the instantaneous load of the WQS during all flow conditions (characterized as moist, mid-range, and dry conditions). The 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 1990 through 2002 if data were available.

Figure 5-1 Estimated Fecal Coliform Load and Critical Conditions for Station S-050 (Little Saluda Upstream)



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.

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.

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
S-050		✱	
S-123	✱		
S-255			✱
S-324	✱		
S-290		✱	
S-306			✱

The individual flow exceedance percentiles for each WQM station are shown on Table-5-3. Based on Table 5-2, critical conditions for WQM stations S-123, S-255 and S-324 are moist conditions, S-050 and S-290 are mid-range conditions, and S-306 is a dry condition. Estimated loadings are indicative of loading from all sources including continuous point source dischargers, SSOs, failing OSWD systems, wildlife, domestic 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
S-050	2.43E+12	50
S-123	3.46E+12	25
S-255	2.36E+11	75
S-324	1.56E+12	25
S-290	4.53E+11	50
S-306	3.68E+12	75

5.3 Waste Load Allocation

Table 5-4 summarizes the WLA of the NPDES-permitted facilities within the watershed of each WQM station, based on the flow and estimated fecal coliform load shown for each facility. The WLA for each facility is derived from the following equation:

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

Where: WQS = 400 cfu /100 ml

flow (cfs) = permitted flow

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

Table 5-4 Wasteload Allocations for NPDES Permitted Facilities

Water Quality Monitoring Station / Permittee	NPDES Permit Number	Flow (mgd)	Load (cfu/day)
HUC 03050109170			
S-050 Little Saluda River at US 378 East of Saluda			
Town of Saluda	SC0022381	0.465	7.04E+09

* Maximum of reported monthly average flow rates

When multiple NPDES facilities occur within a watershed, individual WLAs are summed and the total WLA for continuous point sources is included in the TMDL calculation for the corresponding WQM station. 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 Subsection 5.7 for an explanation of how the WLA for NPDES dischargers is calculated using LDCs.

5.4 Load Allocation

As discussed in Section 3, nonpoint source fecal coliform loading to the receiving streams of each WQM station emanate from a number of different sources. For a select group of WQM stations (Table 3-3) 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 and Appendix E). Figure 5-1, the LDC for S-050, 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, cattle in streams, and fecal loading from wildlife and domestic 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 5-5.

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 5-5).

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:

$$\textbf{\textit{TMDL}} = \Sigma\ \textbf{\textit{WLA}} + \Sigma\ \textbf{\textit{LA}} + \textbf{\textit{MOS}}$$

For each WQM station the TMDLs presented in this report are expressed in cfu per day or as a percent reduction. The TMDLs are presented in fecal coliform cfu 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. The LDC and the simple equation of:

$$\textit{Average LA} = \textit{average TMDL} - \textit{MOS} - \sum \textit{WLA}$$

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 5-5 summarizes the TMDLs for each WQM station, and Figures 5-2 through 5-7 present the LDCs for each station depicting the TMDL, MOS, and WLA (if applicable).

Table 5-5 TMDL Summary for WQM Stations in Little Saluda River, Clouds Creek, Camping Creek, and Hollow Creek Watersheds

SCDHEC WQM Station	WLAs (counts/ day)	LA (counts/day or % reduction)	MOS	TMDL (cfu/day or % reduction)	Percent reduction
HUC 03050109170					
S-050	7.04E+09	7.63E+11	4.05E+10	8.10E+11	68
S-123	0	1.20E+12	6.29E+10	1.26E+12	65
HUC 03050109180					
S-255	0	1.50E+11	7.88E+09	1.58E+11	37
S-324	0	1.05E+12	5.54E+10	1.11E+12	33
HUC 03050109190					
S-290	0	2.32E+10	1.22E+09	2.45E+10	95
HUC 03050109200					
S-306	0	4.37E+10	2.30E+09	4.60E+10	99

Figure 5-2 TMDL for S-050 Little Saluda River (upstream)

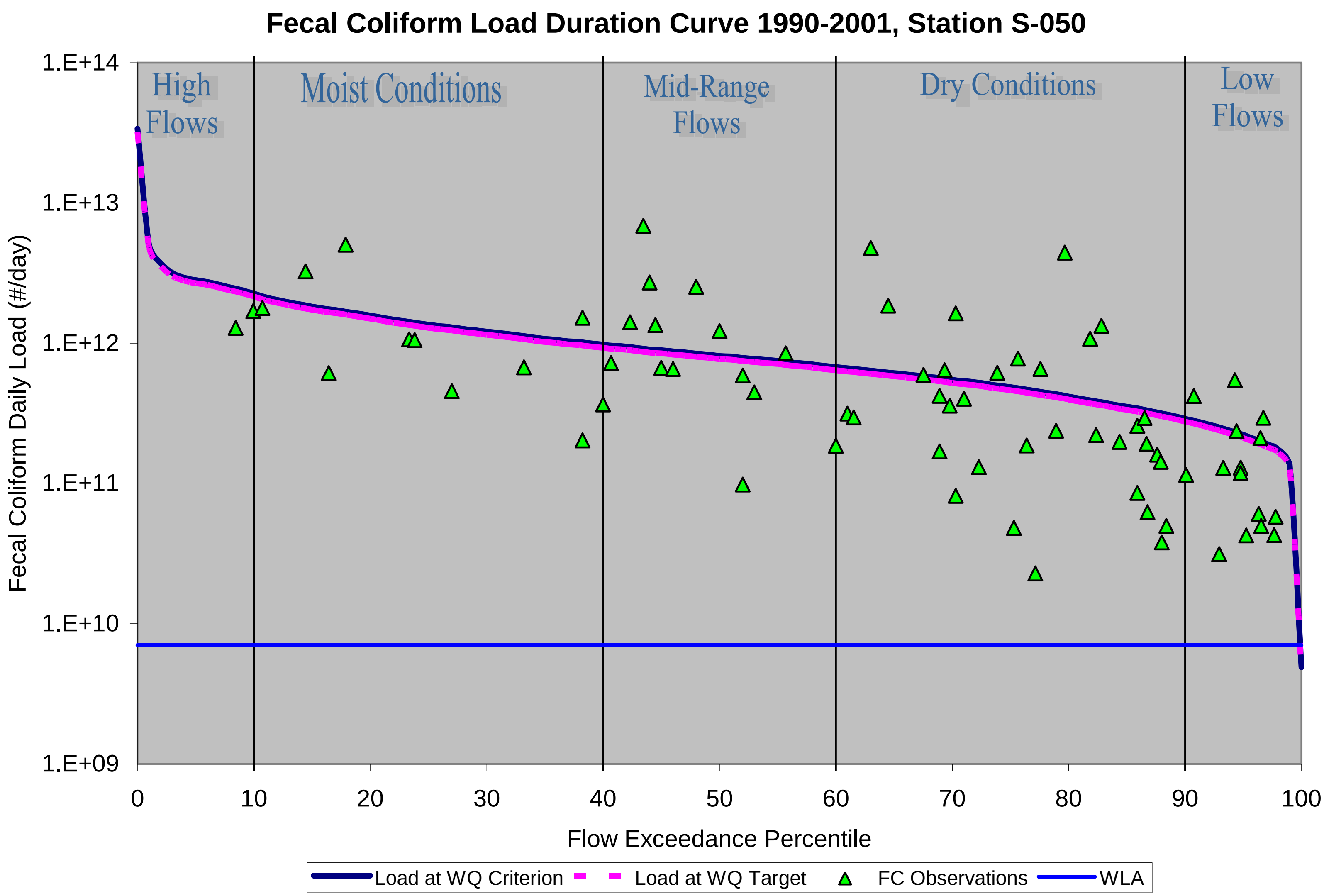


Figure 5-3 TMDL for S-123 Little Saluda River

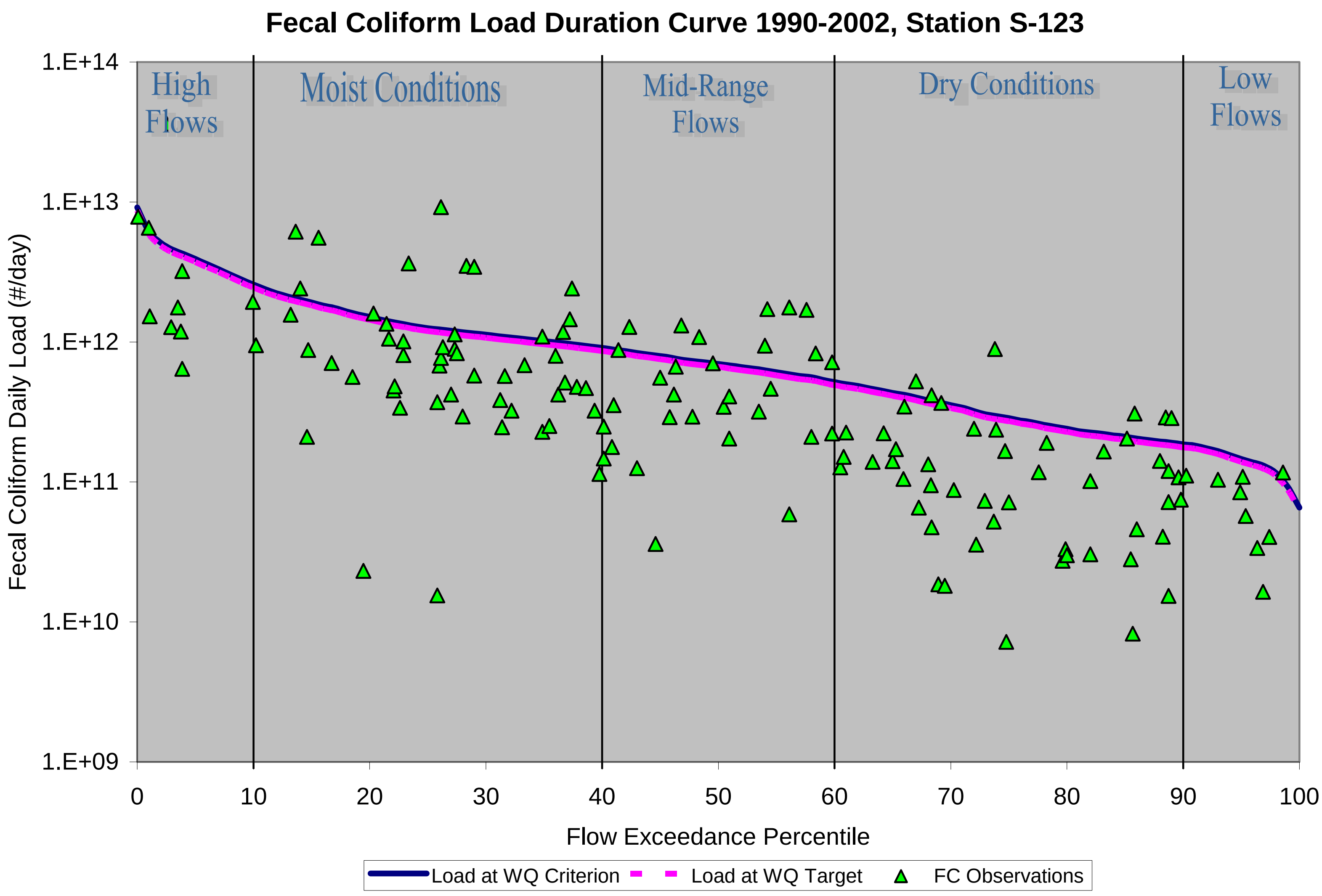


Figure 5-4 TMDL for S-255 Clouds Creek

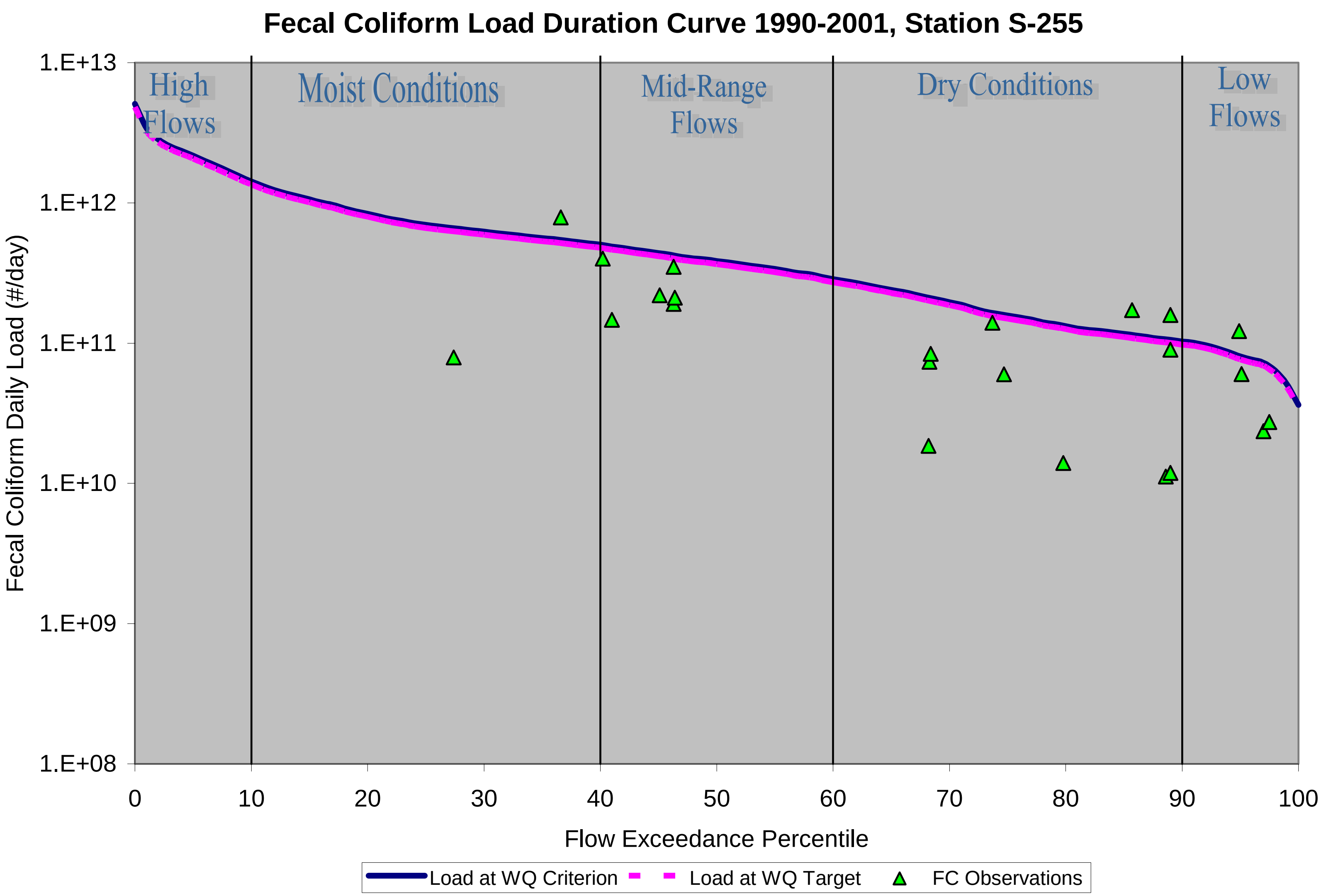


Figure 5-5 TMDL for S-324 Clouds Creek

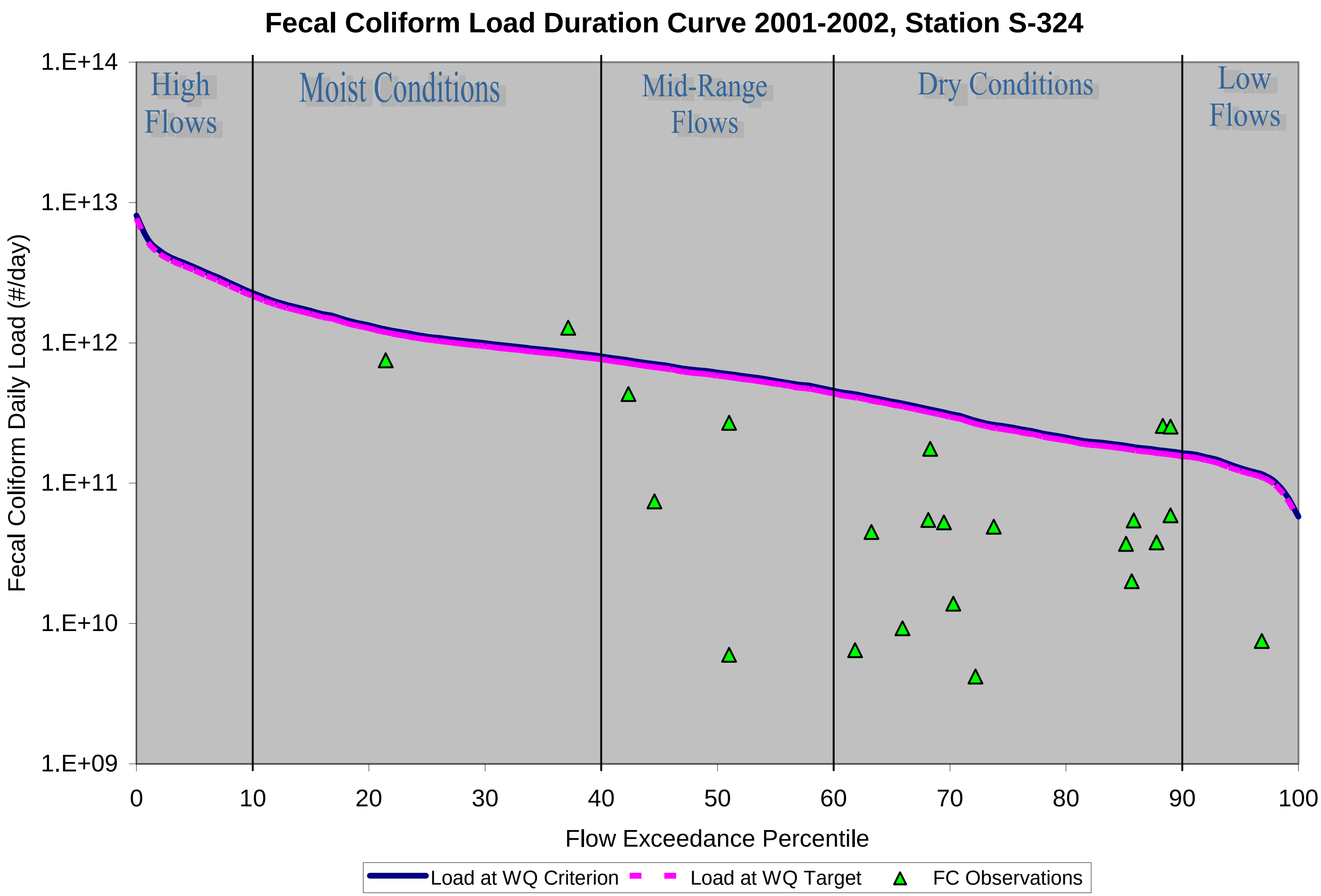


Figure 5-6 TMDL for S-290 Camping Creek

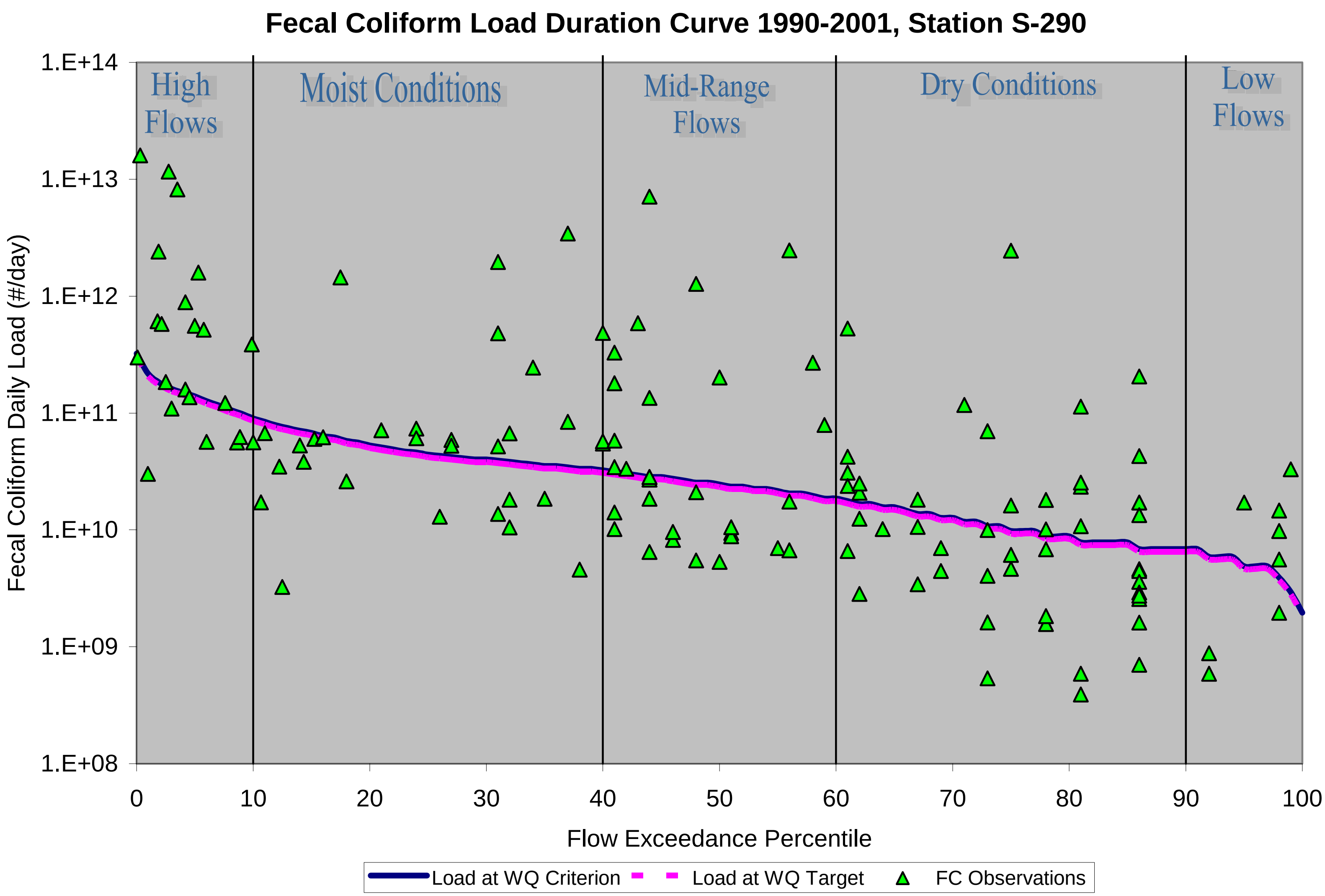
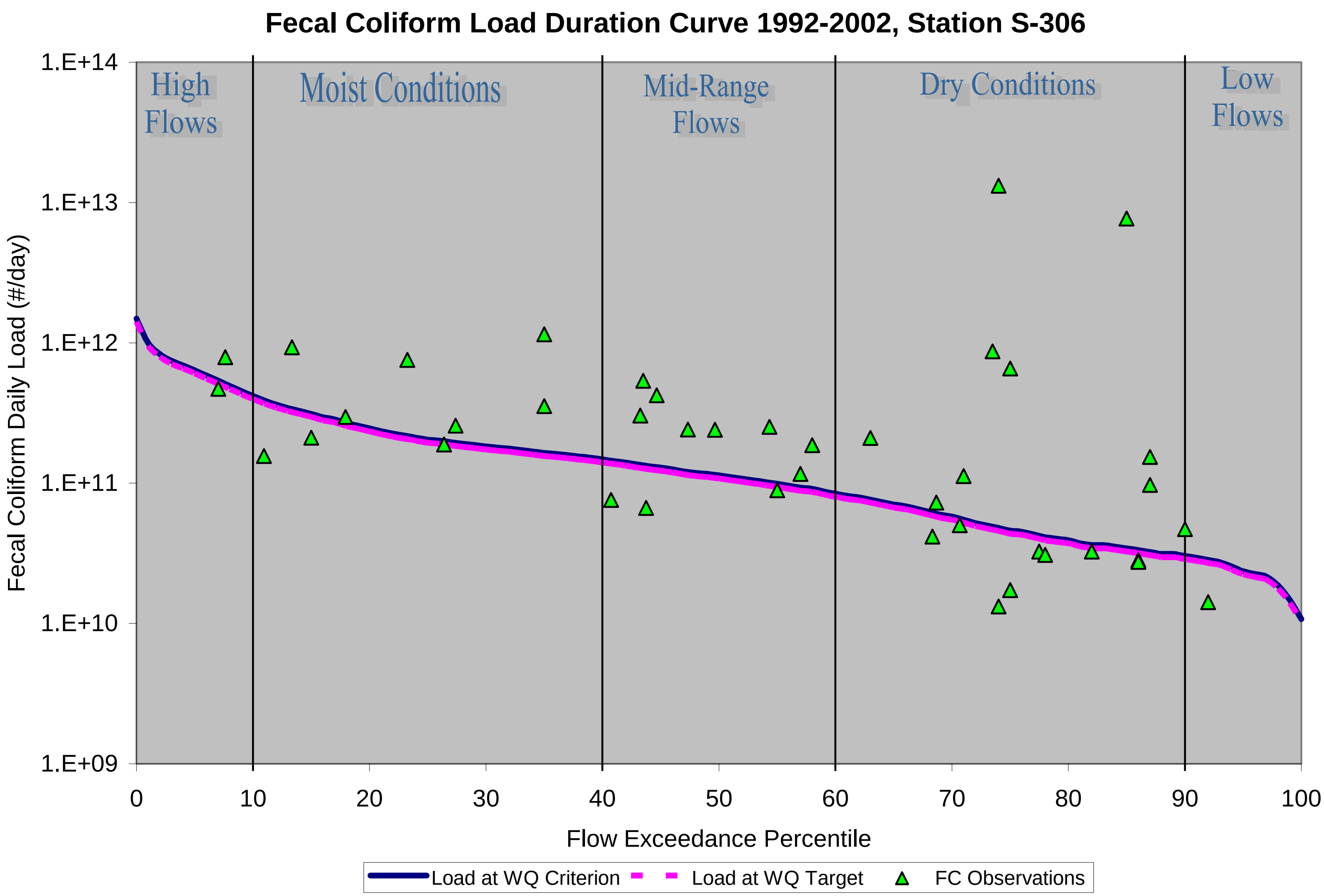


Figure 5-7 TMDL for S-306 Hollow Creek



SECTION 6
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APPENDIX A
FECAL COLIFORM DATA – 1990 - 2002

APPENDIX B
ESTIMATED FLOW EXCEEDANCE PERCENTILES

APPENDIX C
NPDES PERMIT DISCHARGE MONITORING REPORT DATA

APPENDIX D
PLOTS COMPARING PRECIPITATION AND FECAL COLIFORM CONCENTRATIONS

APPENDIX E
LOAD DURATION CURVES – ESTIMATED LOADING AND CRITICAL CONDITIONS