South Carolina
Department of Health and Environmental Control

Total Maximum Daily Load Development for Hanging Rock and Lick Creeks: Stations PD-328 and PD-329 Fecal Coliform Bacteria

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Bureau of Water

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Abstract

Hanging Rock and Lick Creeks (03040202-070-030) in Lancaster County, South Carolina, are small streams that are impaired for primary contact recreational uses by fecal coliform bacteria. Lick Creek is a tributary of Hanging Rock Creek, which is a tributary of the Little Lynches River. The Lick Creek watershed is 49 % forest, 22 % cropland, and 12 % built-up and has an area of 18 km^2. Hanging Rock watershed above the confluence with Lick Creek is 62 % forest, 21 % cropland and has an area of 55 km^2. There is one permitted discharger in the watershed, the Town of Kershaw's wastewater treatment facility. The area has numerous turkey growing operations and many fields where the manure is applied. During the 1996-2000 assessment period, 80 % of samples at PD-329 and 15 % of samples at PD-328 exceeded the water quality standard of 400 cfu/100ml.

This TMDL was developed using a regional application of EPA's BASINS, a GIS-based water quality modeling software. The principal source of fecal coliform loading to the streams was determined to be runoff from pasture land. The total maximum daily loads (TMDL) for these two creeks for fecal coliform bacteria were determined to be 4.13×10^{12} cfu /30-days (Lick Creek) and 1.55×10^{13} cfu /30-days (Hanging Rock Creek). These TMDL values would require a reduction of 84 % and 67 % in the current loads to the creeks, respectively, to meet standards. Several TMDL implementation strategies to bring about these reductions are suggested.

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1.0 INTRODUCTION:

1.1 Background

Levels of fecal coliform bacteria can be elevated in water bodies as the result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop total maximum daily loads (TMDLs) for water bodies that are not meeting designated uses under technology-based pollution controls. The TMDL process establishes 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 that states can establish water quality-based controls to reduce pollution and restore and maintain the quality of water resources (USEPA 1991).

1.2 Watershed Description

The watershed of Hanging Rock and Lick Creeks is in Lancaster and Kershaw Counties, in the lower Piedmont region of South Carolina (Figure 1). Hanging Rock Creek drains into the Little Lynches River southeast of the town of Kershaw. Portions of the towns of Heath Springs and Kershaw are in the watershed. Approximately 3300 people lived in the watershed in 2000. Only the part of the watershed upstream of monitoring station PD-328 is included in this TMDL. All of the watershed covered by this TMDL is in Lancaster County.

Lick Creek has one monitoring station (PD-329) and Hanging Rock Creek has a station (PD-328) just downstream of the confluence with Lick Creek. Descriptions of the monitoring locations are given in Table 1. The Town of Kershaw has a wastewater treatment facility on Lick Creek just upstream of PD-329. The treatment plant is permitted to discharge 0.8 mgd (3.03×10^6 l/day) of wastewater at a maximum geometric mean concentration of 200 fecal coliform counts (cfu)/100 ml of fecal coliform bacteria. The area of the Lick Creek watershed is 17.5 km^2 (6.8 mi^2). The drainage area of the Hanging Rock Creek watershed to the USGS gauging station is 60.4 km^2 (23.3 mi^2).

The watershed is divided into three sub-watersheds in order to adequately model it. The sub-watershed below the USGS gauge was not included in the model. The other three sub-watersheds are predominantly forest (Table 2; Figure 2), according to the MRLC database made in the early 1990s. Cropland is the second ranking land use in the upper Hanging Rock and Lick Creek sub-watersheds. Wetlands are the second ranking land use in the small sub-watershed ending at the USGS gauge. Pasture and built-up land uses constitute most of the remaining land uses. There are also numerous turkey growing operations in the watershed area (Table 3).

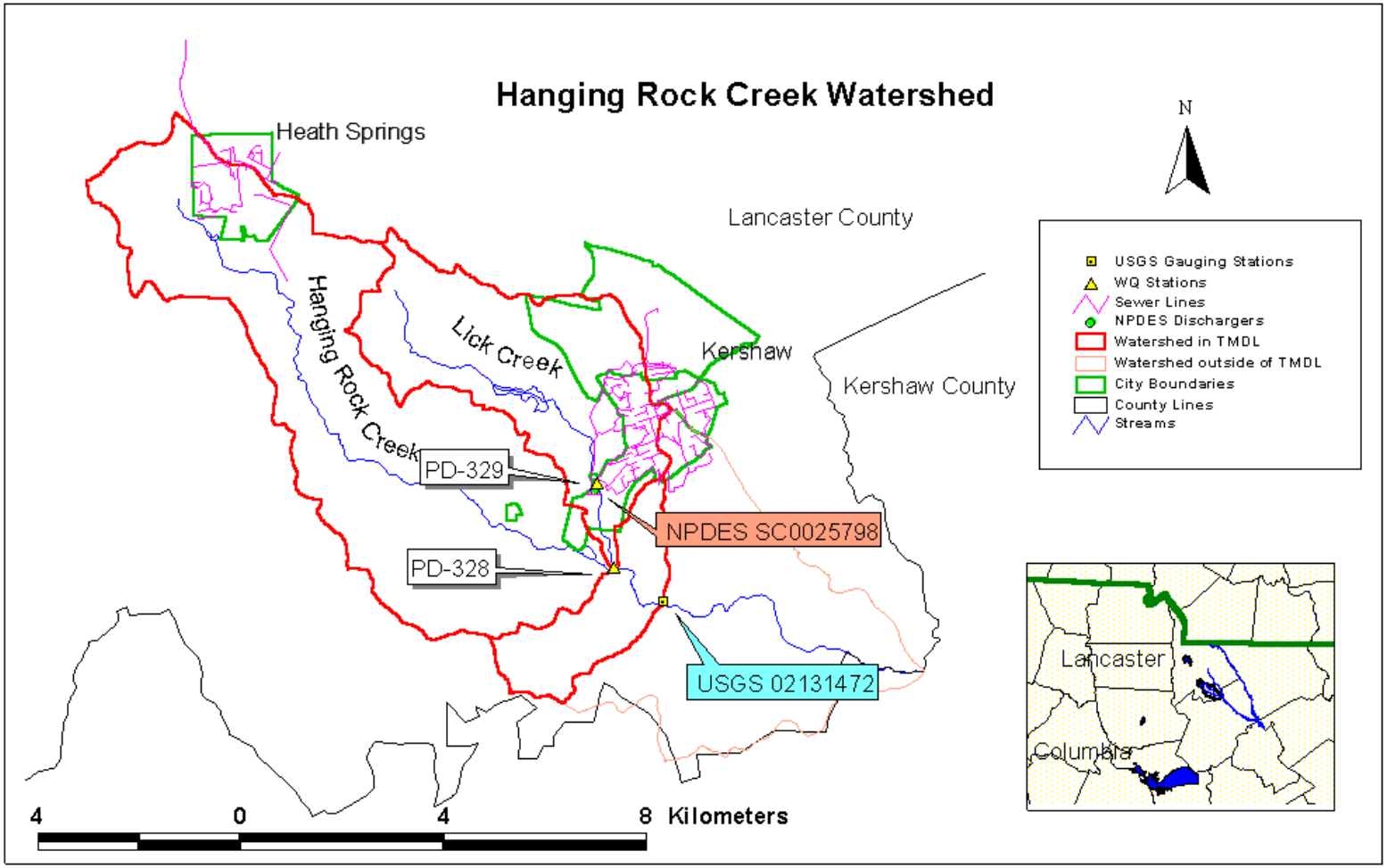


Figure 1. Map of the Hanging Rock Creek watershed, Lancaster County.

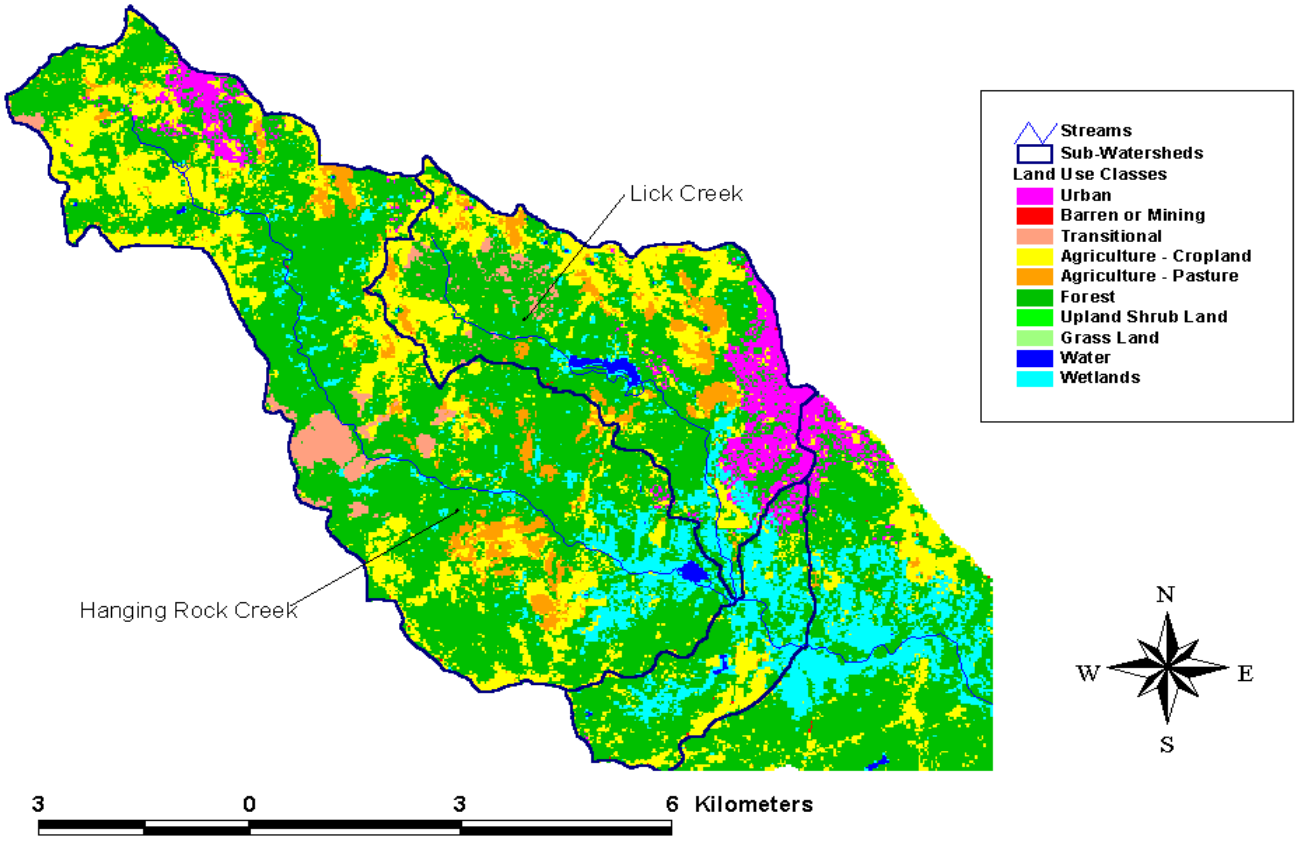


Figure 2. Land use in the Hanging Rock Creek watershed, Lancaster County, SC.

1.3 Water Quality Standard

The impaired stream segments, Hanging Rock and Lick Creeks, are designated as Class Freshwater. Waters of this class are described as follows:

> "Freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses." (R.61-68)

South Carolina's standard for fecal coliform in Freshwater is:

> "Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml."(R.61-68).

Table 1. Descriptions of water quality monitoring stations in the Hanging Rock Creek watershed.

Station ID	Location Description	% Violations	Period of Data
PD-328	Hanging Rock Creek at S-29-764	15	1996-2000
PD-329	Lick Creek at S-29-13	80	1996-2000

Table 2. Land use in the Hanging Rock Creek watershed by sub-watershed.

		Area (hectares)					
Land Use Name		**Hanging Rock Creek upper**		**Lick Creek**		**Hanging Rock Creek above gauge**	
Water		10.6	0.3%	17.8	1.0%	2.6	0.5%
Built-up		86.2	2.3%	**205.2**	**11.7%**	18.8	3.6%
Transitional		114.6	3.0%	37.6	2.1%	0.0	0.0%
Forest		**2336.6**	**62.1%**	**860.5**	**49.2%**	**295.5**	**56.0%**
Pasture/Hay		190.6	5.1%	124.9	7.1%	0.4	0.1%
Row Crops		**780.5**	**20.8%**	**383.7**	**21.9%**	**67.4**	**12.8%**
Wetlands		234.6	6.2%	102.6	5.9%	**142.2**	**27.0%**
Totals		**3760.1**	**99.8%**	**1749.1**	**99.0%**	**527.3**	**99.9%**

Table 3. Animal feeding operations with fields permitted to receive animal wastes in the Hanging Rock Creek watershed.

Permit Number	Type of Livestock	Number of Birds	Total # of Fields	# of Fields in WS
ND0063991	Turkeys	16,000	13	6
ND0064025	Turkeys	45,000	52	52
ND0075078	Turkeys	45,000	78	1
ND0075248	Turkeys	22,520	77	10
ND0075841	Turkeys	45,000	15	8
ND0076261	Turkey poults	12,500	10	2
ND0077232	Turkeys	22,500	20	3
ND0077437	Turkeys	25,000	18	2

2.0 WATER QUALITY ASSESSMENT

An assessment of water quality in 2002 found that Hanging Rock Creek and its tributary Lick Creek did not meet the water quality standard for fecal coliform (Table 1). The data, collected from 1996 through 2000, showed that more than 10 % of samples from water quality monitoring stations PD-329 and PD-328 exceeded the 400 fecal coliform counts (cfu) / 100 ml criteria. These two creeks were also on the 1998 and 2000 303(d) lists. This assessment is based the percentage of samples that exceed the criteria during a five year period. If no more than 10% of the samples collected over the five year period are greater than the standard, the water body is considered meeting the recreational use standard. Waters with more than 10 percent of samples greater than 400 cfu/ 100 ml are considered impaired and listed for fecal coliform bacteria on South Carolina's 303(d) list.

A comparison of fecal coliform concentrations and flow at both stations (Figure 3) shows that fecal coliform bacteria have a similar relationship to flow at both stations, though PD-329 (Lick Creek) has higher concentrations. PD-329 is on a tributary just upstream of PD-328. Sampling station PD-329 on Lick Creek has a much higher percentage of standard violations than PD-328, which is on Hanging Rock Creek just below the confluence with Lick Creek. The higher concentration of fecal coliform in Lick Creek than in Hanging Rock Creek at PD-328, indicates that the upper Hanging Rock Creek is diluting the more concentrated fecal coliform bacteria in Lick Creek.

Comparison of the flow with fecal coliform concentrations indicates no simple relationship (Figure 3). Fecal coliform can be high at any flow, indicating that there are sources of fecal coliform bacteria that involve runoff and other sources that are continual such as failing septic systems and cattle-in-streams. Precipitation data (Winnsboro) for the day of and day prior to sampling and fecal coliform concentration are shown in Appendix F Tables F-4 and F-5. Fecal coliform data for both stations are provided in Appendix A.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria enter surface waters from both point and nonpoint sources. Poorly treated municipal sewage has been a major source of fecal coliform, but with improved treatment and enforcement is not usually the case now. All point sources must have a NPDES permit. In South Carolina, the effluent from NPDES dischargers that treat sanitary wastewater must meet the state standard for fecal coliform.

Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters. Some sources are related to land use activities that accumulate fecal coliform on the land surface, which then runs off during storm events. Other sources are more or less continuous. Potential nonpoint sources of fecal coliform bacteria are: wildlife, land application of manure, grazing animals, failing septic systems, urban storm runoff, and leaking or overflowing sewer collection systems**.**

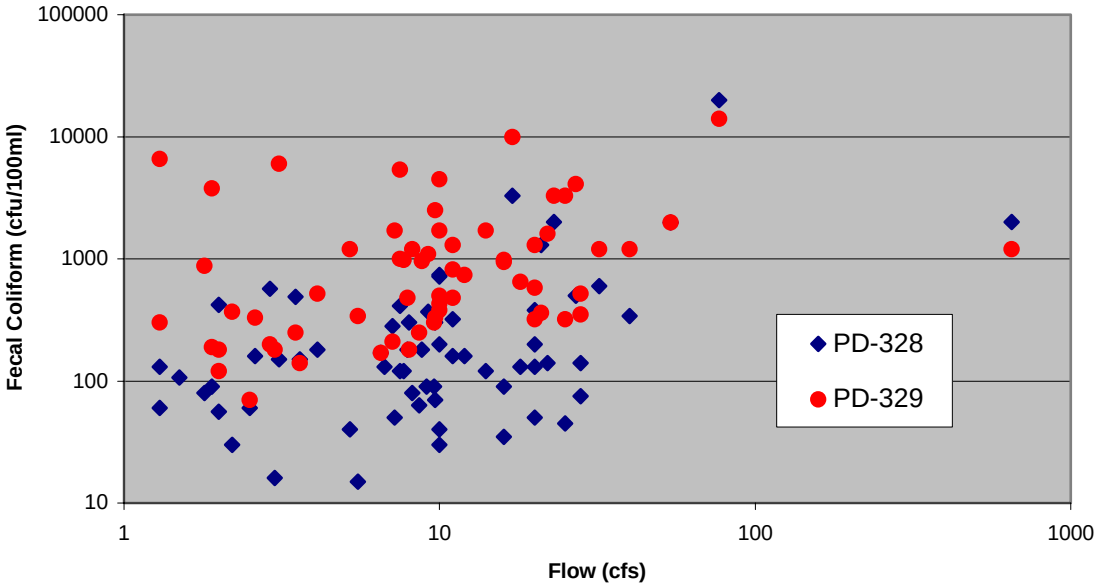


Figure 3. Comparison of observed flow at USGS 02131472 with fecal coliform concentrations in Hanging Rock (PD-328) and Lick (PD-329) Creeks.

3.1 Point Sources in the Hanging Rock Creek Watershed

There is one point source in this largely rural watershed. The town of Kershaw operates a wastewater treatment plant on Lick Creek (NPDES # SC0025798), just upstream of monitoring

station, PD-329. The plant is permitted to discharge 0.8 mgd (3.0×10^6 l/day) of wastewater. The discharge data from this facility (Appendix B) indicates that it is not a significant contributor to the impairment of Lick and Hanging Rock Creeks. Though the facility has had violations of its permit in the past it has not had a violation since February 1996.

3.2 Nonpoint Sources in Hanging Rock Creek Watershed

3.2.1 Wildlife

Wildlife (mammals and birds) contribute a low level of fecal coliform to surface waters. Wildlife wastes are carried into nearby streams by runoff during rainfall. Deer are used as a surrogate for all wildlife. The SC Department of Natural Resources (Charles Ruth, DNR Deer Project Supervisor, personal communication, 2000) has estimated a density of 45 deer/mi^2 for this area. Deer habitat includes forest, cropland, and pasture land. Deer are assumed to be distributed evenly throughout their habitat and the population uniform during the modeling period. Wildlife are in most situations the only contributors of fecal coliform bacteria to forest land which usually has the lowest loading rates per unit of area of any land uses. Wildlife, represented by deer, contribute to forest, crop, and pasture lands. Wildlife is the only fecal coliform source for forested lands.

3.2.2 Land Application of Manure

This region has numerous turkey growing operations (Table 3). The numbers of animals and fields are the quantities permitted, not necessarily present or in use. Poultry and turkey litter in this area is mostly (> 90%) applied to pasture and hay lands (Ann Christie, NRCS Lancaster County Conservationist, personal communication, 2003). Loading for these sources was estimated from the number of birds, acreage of cropland and pasture, and percentage of fields in the sub-basin using the spreadsheet tool provided in Watershed Characterization System (WCS). Runoff from pasture lands was the predominant source of fecal coliform loading to both Lick and Hanging Rock Creeks.

3.2.3 Grazing Animals

Livestock such as cattle, goats, and horses spend much of their time grazing on pasture land. Runoff from rainfall washes some of the manure deposited in the pastures into nearby streams. Livestock population estimates are based on the Census of Agriculture 1997 and NRCS (Ann Christie, NRCS Lancaster County conservationist, personal communication, 2003).

Cattle and other livestock that are allowed access to streams deposit manure directly into the streams. Manure deposited in streams can be a significant source of fecal coliform bacteria. Loading from this source was estimated from the number of beef cattle and the percentage of time they spend in streams using the spreadsheet tool in WCS. Assumptions for these calculations are that beef cattle are not confined, have access to streams, and they spend 0.25 % of the time in the streams (EPA Region 4 personal communication, 2002). Estimated loading values from cattle-in-streams is provided in Table 4. Cattle with access to streams were estimated to be the second largest source of fecal coliform bacteria.

3.2.4 Failing Septic Systems

Using a GIS we estimated the populations and number of households with septic systems and other non-sewered wastewater treatments from 1990 census data and the watershed boundaries. The 1990 census is the most up-to-date data available. Based on Horsley and Witten (1996) the average waste flow per person was assumed to be 70 gal/capita/day. Septic systems were assumed to have a failure rate of 30 % (Schueler, 1999). Other assumptions were that all wastewater reached the stream and the concentration of fecal coliform in that wastewater was 10^4 cfu/100ml (Horsley and Witten, 1996). The 1990 census indicated that over 50 people in the watershed had 'other' waste treatment (not sewered or on septic systems). These houses may have a higher potential for contributing fecal coliform to Hanging Rock or Lick Creeks. Some of these houses may have wastewater piped directly into a creek or indirectly through ditches or overland. The estimated values from failing septic systems are given in Table 4. Calculations for these loading rates are provided in Appendix F Tables F-1 and F-2.

Table 4. Load estimates to model for cattle-in-streams and failing septic systems.

Failing Septic Systems

Sub-WS		**FC Load**
		(cfu/30days)
Hanging Rock Creek upper		3.3E+10
Lick Creek		7.5E+10

Cattle-in-Streams

Sub-WS		**FC Load**
		(cfu/30days)
Hanging Rock Creek upper		5.3E+11
Lick Creek		4.8E+11

4.0 MODELING

Watersheds with varied land uses and numerous potential sources of pollutants typically require a complex model to ascertain the affect of source loadings on in-stream water quality. This relationship must be understood to some degree in order to develop an effective TMDL. In this section, the numerical modeling techniques that have been developed to simulate fecal coliform bacteria fate and transport in the watershed are discussed as applied to the Hanging Rock Creek watershed.

4.1 Model Selection

The US EPA has assembled a variety of tools to use in the development of TMDLs. The Hanging Rock Creek watershed is a relatively large basin with primarily agricultural and some urban land uses that have the potential to cause impairment of water quality. The GIS based dynamic modeling tool - Watershed Characterization System or WCS (USEPA - Region 4, 2001), was used for this watershed. WCS, which is a version of BASINS (US EPA, 1998), has additional source loading calculation tools, updated data, and is focused on a given state. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display and analyze GIS information including land use, land type, point source discharges, soil types, population, and stream characteristics. The WCS was used to identify and summarize the sources of fecal coliform bacteria in the watershed, as well the other factors that affect its fate and transport.

Information collected using WCS was used in a series of spreadsheet applications designed to compute fecal coliform bacteria loading rates in the watershed from varying land uses including urban, agricultural, and forestry as described in Section 3.0. Computed loading rates were used in a hydrologic and water quality model, NPSM (Non-Point Source Model which is built around Hydrologic Simulation Program Fortran or HSPF), to simulate the deposition and transport of fecal coliform bacteria, and the resulting water quality response. NPSM simulates nonpoint source runoff as well as the transport and flow of pollutants in stream reaches. A necessary feature of NPSM is its ability to integrate both point and nonpoint sources of fecal coliform bacteria and determine the in-stream water quality response.

4.2 Model Set Up

The Hanging Rock Creek watershed was delineated into three sub-watersheds to characterize the fecal coliform bacteria contributions to the two streams and to calibrate the model (see Figure 1). The lower sub-watershed was used to calibrate hydrology only. Watershed delineation was based on the RF1 stream coverage and elevation data. In addition, sub-division of the watershed allows for management and load reduction alternatives to be varied by sub-watershed. A continuous simulation period from January 1, 1988, to December 31, 1998, was used in the analysis. The period from January 1, 1988, to December 31, 1988, was used to allow the model results to stabilize. The period from January 1, 1989, to December 31, 1998, was used to identify the critical condition period from which to develop the TMDL.

An important factor driving model results is the precipitation data contained in the meteorological file used in the simulations. The pattern and intensity of rainfall affects the build-up and wash-off of fecal coliform bacteria from the land into the streams, as well as the dilution potential of the stream. Weather data from the Winnsboro meteorological station were used in all simulations. This station is some distance from the watershed (Figure 4), which may contribute to difficulties in calibrating the model. Because rainfall tends to be highly variable over relatively short distances, flow amounts, flow peaks, and flow durations predicted based on the rain gauge may be quite

different than observed in the watershed.

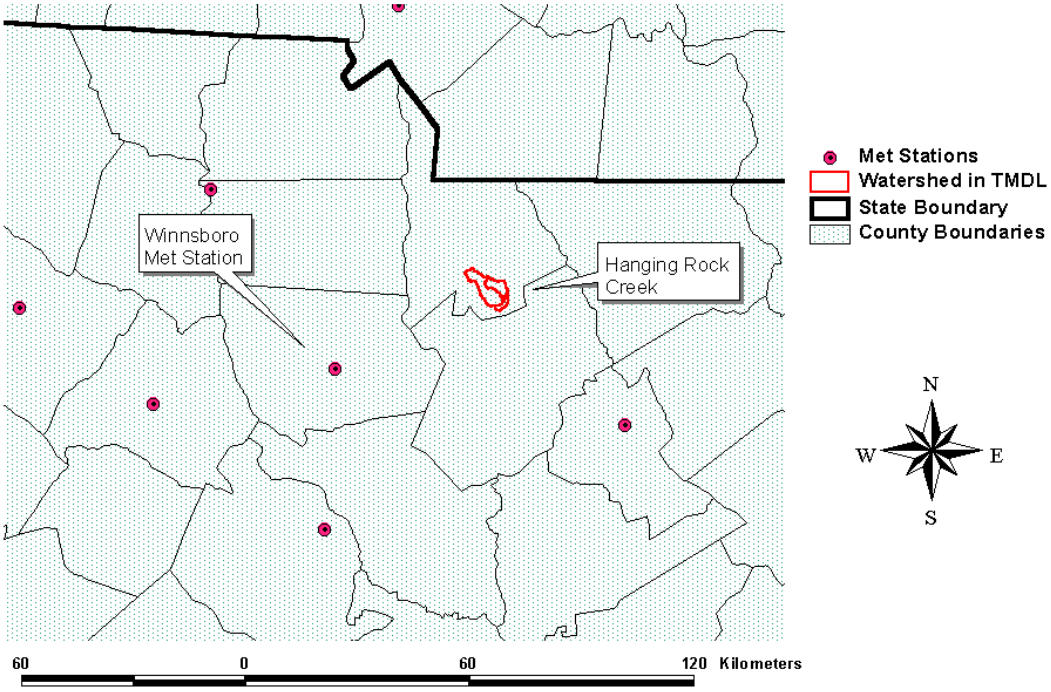


Figure 4. Location of meteorological station in relation to watershed.

4.3 Model Calibration

Calibration of the watershed model is a two-step process; first the hydrology and then water quality. Water balances and stream hydrographs from the model are compared to water balances and stream hydrographs from a USGS gauge. By adjusting model parameters in the Data Editor module (Pwater and Iwater), the model response can be changed. The model was adjusted until the water balances averaged over the 10-year (1989-98) period were within recommended error ranges (Appendix C). For some years the errors are quite large but it was not possible to get all yearly water balances within the error ranges. A comparison of predicted and observed hydrographs for 1997, which is the year of the critical periods, is also shown in Appendix C. The match between the hydrographs is acceptable given the use of weather data from outside of the watershed. Parameters such as evapo-transpiration rates, infiltration, upper and lower zone storage, groundwater storage and recession, and interflow discharge rates control the movement and storage of water in the watershed. Hanging Rock Creek has a flow gauge 1.6 km downstream of PD-328 (USGS 02131472). The hydrology component of the model was calibrated to this gauge.

Water quality was monitored at 2 stations in the Hanging Rock Creek watershed. Calibration of the model was based on both stations: PD-328 on Hanging Rock Creek just downstream of its confluence with Lick Creek and PD-329 on Lick Creek some 2 km upstream of the confluence. Model calibration results for 1997 are shown in Appendix D. Other years show better and worse agreement. Results show that the model adequately simulates fecal coliform bacteria in response to rainfall events and suspected inputs. Calibration was hampered by the limited observed data: no data during the winter and most samples collected during low flow. At times, a high observed value is not simulated in the model due to lack of rainfall at the meteorological station as compared to the rainfall occurring in the watershed, or an unknown source that is not included in the model.

4.4 Critical Conditions

EPA regulations at 40 CFR 130.7(c)(1) require that TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that established uses of the stream (in this case primary contact recreation) are protected. The selection of a critical environmental condition sometimes corresponds to a specific stream flow condition. However, for this TMDL the critical period is the 30-day period for which the model predicts the largest violation of the geometric mean standard (EPA 1991) and the geometric mean flow is between the 10^{th} and 90^{th} percentiles. Basing the TMDL on this critical period ensures that the standard can be met throughout the period of simulation.

5.0 MODELING RESULTS

5.1 Critical Conditions

The critical conditions for Hanging Rock and Lick Creeks were determined from the plot of the 30-day geometric mean 10-year simulation of fecal coliform and the comparison to 30-day running geometric mean flow. The critical periods are given in Table 5. These critical periods were chosen because the geometric mean fecal coliform concentration for this date was the highest peak occurring while geometric mean flow was between the 10^{th} and 90^{th} percentiles during the period of simulation, that is between 8.2 and 87.6 cfs. The mean flow for the 1989-98 period was 51.2 cfs. The model seems to be especially sensitive to low flows, sometimes generating irrational numbers at very low flow rates. Basing this TMDL on these very low flow events would make the TMDL unnecessarily conservative and protective. Choosing the critical period from among these less extreme flow periods should produce a TMDL that is adequately conservative and has achievable reductions in load. In addition, recreational use of creeks is unlikely during high flow events and may be unsafe due to fast moving and deep water.

Table 5. Critical periods for Hanging Rock and Lick Creeks.

Station	Stream	Beginning Date	Peak Date
PD-329	Lick Creek	June 2, 1997	July 1, 1997
PD-328	Hanging Rock Creek	May 26, 1997	June 24, 1997

5.2 Model Uncertainty

There are several sources of uncertainty in the Hanging Rock Creek model. These include the rainfall data from outside the watershed, limited water quality data, especially during high flow conditions and during the cool seasons, inherent variability in fecal coliform sampling; and little hard information on sources like failing leaking septic systems, leaking sewer lines, and sanitary sewer overflows. These uncertainties should be considered in evaluating the recommendations in this TMDL.

5.3 Existing Load

Estimated existing loads from runoff to Hanging Rock and Lick Creeks are provided in Table 6. Existing loads from all sources are summarized in Table 7. The loads in Table 6 were summed from the daily loads for each sub-watershed by land use for the 30-day critical period Appendix F Tables F-3 and F-4. The existing load values presented before were assembled in Table 7. The model The loads include both point and nonpoint sources because of the wastewater treatment plant on Lick Creek. As indicated below the primary source of fecal coliform bacteria loading to both creeks is runoff. Most of the runoff load comes from pasture land, which receives significant applications of turkey manure. Cattle with access to the creeks are the second most important source.

Table 6. Existing loads from runoff by landuse for Lick (PD-329) and Hanging Rock (PD-328) Creeks (cfu/30-days).

Landuse		**PD-329**	**PD-328**
Cropland		1.11E+12	3.25E+12
Pasture		1.79E+13	3.49E+13
Developed		6.87E+12	6.88E+12
Total Runoff		2.59E+13	4.52E+13

Table 7. Existing loads in Hanging Rock (PD-328) and Lick (PD-329) Creeks (cfu/30-days).

Source		PD-329	PD-328
WWTP		1.81E+11	1.81E+11
Runoff		2.59E+13	4.52E+13
Cattle-in-streams		4.85E+11	1.01E+12
Failing Septic Systems		7.49E+10	1.08E+11
Total		2.66E+13	4.65E+13

6.0 TOTAL MAXIMUM DAILY LOAD

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

$$TMDL = 3\ WLAs + 3\ LAs + MOS$$

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

Achieving a peak value of 190 cfu/100ml (standard of 200 minus 10 margin of safety) for the critical period did not meet the second part of South Carolina's standard for water quality as determined from the individual daily concentrations from the model output for the critical period. Much lower geometric mean values were required in order to meet the second part of the standard (no more than 10 % of samples may exceed 400 cfu/100ml); these are for PD-329, 136 cfu/100ml and PD-328, 117 cfu/100ml. Daily fecal coliform concentrations for the critical period predicted for the TMDL load are given Appendix E.

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

6.1 Waste Load Allocations

The wasteload allocation for both Hanging Rock and Lick Creeks is 1.81E+11 cfu/30days. The wasteload allocations are the same as the existing loads.

6.2 Load Allocations

Load allocations were determined initially by reducing loads into the model until the critical peak concentration was reduced to the target concentration (190 cfu/100 ml; standard of 200 minus MOS of 10). As indicated above a lower critical peak was required to meet the second part of the standard. Loadings from failing septic systems, cattle-in-streams, and from runoff were summed for the 30-day critical period. The load allocation for Lick Creek (PD-329) is 3.95×10^{12} cfu/30-days and for Hanging Rock Creek (PD-328) the load allocation is 1.53×10^{13} cfu/30-days.

6.3 Margin of Safety

The margin of safety determined from the geometric mean is quite large for these two TMDLs. The MOS for PD-329 is 64 cfu/100ml and for PD-328 it is 83 cfu/ 100ml. However, as the 10 % criteria of the standard was the determining factor for these TMDLs, the MOS for both impaired stations is really implicit, the margin of safety being provided by conservative modeling assumptions.

6.4 TMDL

TMDL = ΣWLA + ΣLA + MOS

Waterbody	Stations	Existing Load	WLA	LA	Target Load	MOS	TMDL	Reduc-tion %
Lick Creek	PD-329	2.66E+13	1.81E+11	3.95E+12	4.13E+12	Implicit	4.13E+12	84%
Hanging Rock Creek	PD-328	4.65E+13	1.81E+11	1.53E+13	1.55E+13	Implicit	1.55E+13	67%

The target loading value is the load to the creek that it can receive and meet the water quality standard. It is simply the TMDL minus the MOS. The target loading for Lick Creek requires a reduction of 84 % from the current load of 2.7×10^{13} cfu/30-days and for Hanging Rock Creek a reduction of 67 % from 4.6×10^{13} cfu/30-days.

7.0 IMPLEMENTATION

As discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina* (SCDHEC,1998), South Carolina has several tools available for implementing this nonpoint source TMDL. Specifically, SCDHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. In addition, SCDHEC will work with the existing agencies in the area to provide nonpoint source education in the Hanging Rock Creek watershed. Local sources of nonpoint source

education and assistance include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Lancaster County Soil and Water Conservation Services, and the South Carolina Department of Natural Resources. Clemson Extension Service offers a 'Farm-A-Syst' package to farmers. Farm-A-Syst allows the farmer to evaluate practices on their property and determine the nonpoint source impact they may be having. It recommends best management practices (BMPs) to correct nonpoint source problems on the farm. NRCS can provide cost share money to land owners installing BMPs.
SCDHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions which threaten the quality of waters of the state. In addition, other interested parties (universities, local watershed groups, etc.) may apply for section 319 grants to install BMPs that will reduce fecal coliform loading to Hanging Rock Creek. TMDL implementation projects are given highest priority for 319 funding.

In addition to the resources cited above for the implementation of this TMDL in the Hanging Rock Creek watershed, Clemson Extension has developed a Home-A-Syst handbook that can help urban or rural homeowners reduce sources of NPS pollution on their property. This document guides homeowners through a self-assessment, including information on proper maintenance practices for septic tanks. SCDHEC also employs a nonpoint source educator who can assist with distribution of these tools as well as provide additional BMP information.

Using existing authorities and mechanisms, these measures will be implemented in the Hanging Rock Creek watershed in order to bring about a 67 – 84 % reduction in fecal coliform bacteria loading to Hanging Rock and Lick Creeks. DHEC will continue to monitor, according to the basin monitoring schedule, the effectiveness of implementation measures and evaluate stream water quality as the implementation strategy progresses.

8.0 REFERENCES

Horsley & Witten, Inc. 1996. Identification and Evaluation of Nutrient and Bacterial Loadings to Maquoit Bay, Brunswick, and Freeport, Maine. Casco Bay Estuary Project, Portland, ME.

SCDHEC. 2000. Watershed Water Quality Assessment: Pee Dee River Basin. Technical Report No. 015-00.

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

Schueler, T. R. 1999. Microbes and Urban Watersheds: Concentrations, Sources, and Pathways. Watershed Protection Techniques 3(1): 554-565.

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

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

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

US Geological Survey. 1999. Water-Resources Data South Carolina Water Year 1999. United States Geological Survey.

APPENDIX A Fecal Coliform Data

Fecal Coliform Bacteria Concentrations (cfu/100ml) in Hanging Rock Creek at SR-29-764, PD-328

Date	Time	FC (cfu/ 100ml)
5/25/89	1243	50
6/21/89	1310	1300
7/6/89	1224	90
8/1/89	1212	45
9/19/89	1330	370
10/12/89	1455	75
5/7/90	1446	35
6/14/90	1227	180
7/18/90	1310	40
8/6/90	1217	60
9/19/90	1406	30
10/23/90	1235	2000
6/3/91	1330	500
7/2/91	1045	740
8/6/91	1240	130
9/5/91	940	130
10/8/91	1323	90
6/10/92	1300	3300
7/22/92	1305	280
8/25/92	1320	170
9/10/92	1201	490
10/27/92	1210	70
5/4/93	1302	1980
6/1/93	1350	2000
7/21/93	1000	150
8/25/93	1410	60
9/15/93	1310	140

Date	Time	FC (cfu / 100ml)
10/7/93	1345	80
5/11/94	1333	320
6/2/94	1400	40
8/2/94	1338	120
9/7/94	1440	160
10/5/94	1355	200
5/18/95	1335	90
6/6/95	1400	20000
7/5/95	1340	160
8/1/95	1124	120
9/14/95	1317	80
10/23/95	1343	200
5/15/96	1315	720
6/17/96	1414	50
7/11/96	1340	107
9/25/96	1350	120
5/5/97	1400	140
6/12/97	1245	410
7/2/97	1340	130
8/19/97	1310	300
9/11/97	1345	300
10/8/97	1107	570
5/4/98	1310	340
6/3/98	1230	140
7/6/98	1425	15
8/18/98	1235	180
9/22/98	1330	380
10/26/98	1345	30
7/28/99		56
8/25/99		< 1
9/30/99		600
10/14/99		180

Date	Time	FC (cfu / 100ml)
5/18/00		90
6/7/00		420
7/12/00		150
8/8/00		130
9/20/00		160
10/19/00		38

Fecal Coliform Bacteria Concentrations (cfu/100ml) in Lick Creek at SR-29-13, PD-329

Date	Time	FC (cfu/ 100ml)
5/25/89	1300	320
6/21/89	1226	360
7/6/89	1210	940
8/1/89	1158	320
9/19/89	1300	1100
10/12/89	1511	350
5/7/90	1435	980
6/14/90	1246	520
7/18/90	1327	500
8/6/90	1234	70
9/19/90	1345	370
10/23/90	1220	1200
5/1/91	1407	3300
6/3/91	1300	4100
7/2/91	1020	4500
8/6/91	1225	1300
Date	Time	FC (cfu /

		100ml)
9/5/91	930	650
10/8/91	1245	300
5/27/92	1245	1300
6/10/92	1240	10000
7/22/92	1320	210
8/25/92	1300	170
9/10/92	1215	250
10/27/92	1220	330
5/4/93	1334	1980
6/1/93	1415	3300
7/21/93	1020	6000
8/25/93	1350	6600
10/7/93	1410	340
5/11/94	1401	880
6/2/94	1425	480
8/2/94	1352	1200
9/7/94	1500	1700
10/5/94	1419	740
6/6/95	1430	14000
7/5/95	1355	820
8/1/95	1135	980
9/14/95	1340	1200
10/23/95	1358	430
5/15/96	1340	1700
6/17/96	1430	1700
9/25/96	1406	1000
5/5/97	1411	520
6/12/97	1315	5400
7/2/97	1355	8
8/19/97	1325	180
9/11/97	1400	2500
10/8/97	1120	200
5/4/98	1330	1200
6/3/98	1330	1600
7/6/98	1450	340

Date	Time	FC (cfu / 100ml)
8/18/98	1257	960
9/22/98	1350	580
10/26/98	1405	380
7/28/99		120
8/25/99		3800
9/30/99		1200
10/14/99		480
5/18/00		190
6/7/00		180
7/12/00		140
8/8/00		300
9/20/00		330
10/19/00		35

Appendix B Town of Kershaw WWTP Data

Town of Kershaw Wastewater Treatment Plant DMR Data									
SC0025798									
		Mean loading				Loading based			
		for 1989-98:				on Permit Limits:			1.82E+11
									(cfu/30 days)
		3.73E+10							
		(cfu/30 days)				Flow Limit:		0.8	mgd
						FC Limit:		200	(cfu/100 ml)
Sample		Flow (50050)			Fecal Coliform (74055)				FC Loading
Date		Monthly	Weekly		Mean	Maximum			Monthly
		Mean	Mean						Loading
		Monthly (mgd)			Monthly (cfu/100ml)				(cfu/30 days)
1/31/89		0.265	0.34		2366	2366			7.12E+11
2/28/89		0.299	0.518		0.5	1			1.70E+08
4/30/89		0.421	0.711		53	70			2.53E+10
5/31/89		0.392	0.714		63.2	80			2.81E+10
6/30/89		0.326	0.44		548	1000			2.03E+11
7/31/89		0.458	0.799		660	6600			3.43E+11
8/31/89		0.381	0.45		793	1533			3.43E+11
9/30/89		0.35	0.553		20	40			7.95E+09
10/31/89		0.546	0.818		332	1100			2.06E+11
11/30/89		0.291	0.488		62.4	390			2.06E+10
12/31/89		0.372	0.553		30	50			1.27E+10
1/31/90		0.329	0.496		104	120			3.89E+10
2/28/90		0.385	0.651		1004	4200			4.39E+11
3/31/90		0.362	0.419		128	1630			5.26E+10
4/30/90		0.276	0.323		14.142	20			4.43E+09
6/30/90		0.289	0.304		1	1			3.28E+08
7/31/90		0.27	0.292		16.75	40			5.14E+09
8/31/90		0.328	0.474		0	13			0.00E+00
9/30/90		0.265	0.379		16	50			4.82E+09
10/31/90		0.315	0.825		35	40			1.25E+10
12/31/90		0.364	0.634		221	515			9.14E+10
1/31/91		0.432	0.737		34	45			1.67E+10
2/28/91		0.418	0.77		0	40			0.00E+00
3/31/91		0.38	0.894		0	20			0.00E+00
4/30/91		0.224	0.25		20	40			5.09E+09
5/31/91		0.254	0.27		20.4	105			5.88E+09
6/30/91		0.145	0.185		32	100			5.27E+09
7/31/91		0.137	0.177		0	6			0.00E+00
8/31/91		0.155	0.308		3	3			5.28E+08
9/30/91		0.111	0.242		54	73			6.81E+09

Sample		Flow (50050)			Fecal Coliform (74055)			FC Loading
Date		Monthly	Weekly		Mean	Maximum		Monthly
		Mean	Mean					Loading
		Monthly (mgd)			Monthly (cfu/100ml)			(cfu/30 days)
10/31/91		0.148	0.194		33.3	33.3		5.60E+09
2/29/92		0.169	0.218		0	3		0.00E+00
3/31/92		0.313	0.34		25	100		8.89E+09
4/30/92		0.31	0.335		24	30		8.45E+09
5/31/92		0.27	0.308		10	16		3.07E+09
6/30/92		0.297	0.327		10	33		3.37E+09
7/31/92		0.215	0.224		29.1	16		7.11E+09
8/31/92		0.231	0.264		0	10		0.00E+00
9/30/92		0.2	0.248		8	10		1.82E+09
10/31/92		0.243	0.267		6	6		1.66E+09
11/30/92		0.35	0.45		0	0		0.00E+00
12/31/92		0.253	0.272		0	0		0.00E+00
1/31/93		0.42	0.598		29	42		1.38E+10
2/28/93		0.329	0.357		15.5	22		5.79E+09
3/31/93		0.387	0.402		85	85		3.74E+10
4/30/93		0.41	0.473		78	300		3.63E+10
5/31/93		0.269	0.282		37	468		1.13E+10
6/30/93		0.194	0.222		55	150		1.21E+10
7/31/93		0.142	0.143		0	6		0.00E+00
8/31/93		0.127	0.146		82.2	104		1.19E+10
9/30/93		0.195	0.211		47	92		1.04E+10
10/31/93		0.174	0.194		4.5	5		8.89E+08
11/30/93		0.221	0.244		11	13		2.76E+09
12/31/93		0.27	0.297		6	10		1.84E+09
1/31/94		0.349	0.368		80	106		3.17E+10
2/28/94		0.328	0.373		48	231		1.79E+10
3/31/94		0.24	0.293		16	49		4.36E+09
4/30/94		0.278	0.358		20	52		6.31E+09
5/31/94		0.172	0.289		18	53		3.52E+09
6/30/94		0.338	0.389		21	23		8.06E+09
7/31/94		0.321	0.357		62	138		2.26E+10
8/31/94		0.495	0.829		34	96		1.91E+10
9/30/94		0.368	0.452		14	92		5.85E+09
10/31/94		0.428	0.491		8	8		3.89E+09
11/30/94		0.394	0.418		8	15		3.58E+09
12/31/94		0.334	0.46		16	26		6.07E+09
1/31/95		0.383	0.453		17	17		7.39E+09
2/28/95		0.344	0.464		18	---		7.03E+09
3/31/95		0.291	0.366		30	50		9.91E+09
4/30/95		0.208	0.232		13	22		3.07E+09
5/31/95		0.217	0.246		23.4	108		5.77E+09
6/30/95		0.297	0.311		132	138		4.45E+10
7/31/95		0.247	2.69		277	500		7.77E+10
8/31/95		0.23	0.293		486	508		1.27E+11

Sample		Flow (50050)			Fecal Coliform (74055)			FC Loading
Date		Monthly	Weekly		Mean	Maximum		Monthly
		Mean	Mean					Loading
		Monthly (mgd)			Monthly (cfu/100ml)			(cfu/30 days)
9/30/95		0.229	0.256		554	1365		1.44E+11
10/31/95		0.231	0.332		37.3	1390		9.78E+09
11/30/95		0.274	0.326		695	760		2.16E+11
12/31/95		0.242	0.284		37	40		1.02E+10
1/31/96		0.24	0.28		454	1250		1.24E+11
2/29/96		0.244	0.279		296	1511		8.20E+10
4/30/96		0.241	0.295		106	106		2.90E+10
5/31/96		0.212	0.244		93	146		2.24E+10
6/30/96		0.28	0.354		37	446		1.18E+10
7/31/96		0.237	0.268		10	10		2.69E+09
8/31/96		0.345	0.374		23	86		9.01E+09
9/30/96		0.285	0.44		42	45		1.36E+10
10/31/96		0.227	0.303		47	150		1.21E+10
3/31/96		0.263	0.283		28	132		8.36E+09
11/30/96		0.302	0.328		65	327		2.23E+10
12/31/96		0.285	0.336		7	95		2.27E+09
1/31/97		0.372	0.477		14	82		5.91E+09
2/28/97		0.407	0.468		6	27		2.77E+09
4/30/97		0.376	0.699		7	236		2.99E+09
5/31/97		0.345	0.508		65	272		2.55E+10
3/31/97		0.406	0.455		23	154		1.06E+10
6/30/97		0.235	0.298		2	9		5.34E+08
7/31/97		0.346	0.52		18	154		7.07E+09
8/31/97		0.365	0.447		1	0		4.15E+08
9/30/97		0.327	0.412		17	277		6.31E+09
10/31/97		0.422	0.504		10	331		4.79E+09
11/30/97		0.481	0.748		12	259		6.55E+09
12/31/97		0.517	0.67		159	386		9.34E+10
1/31/98		0.757	0.891		6	54		5.16E+09
2/28/98		0.89	1.06		72	22		7.28E+10
3/31/98		0.845	0.982		5	50		4.80E+09
4/30/98		0.814	0.996		8.18	195		7.56E+09
5/31/98		0.537	0.585		16	354		9.76E+09
7/31/98		0.409	0.425		35	272		1.63E+10
8/31/98		0.42	0.47		17	68		8.11E+09
9/30/98		0.445	0.475		12.1	281		6.11E+09
11/30/98		0.427	0.481		6	190		2.91E+09
10/31/98		0.458	0.581		3	136		1.56E+09
12/31/98		0.459	0.501		2.09	40		1.09E+09
1/31/99		0.593	0.647		7	13		4.71E+09
2/28/99		0.551	0.663		4.3	359		2.69E+09
3/31/99		0.491	0.503		12	163		6.69E+09

Sample		Flow (50050)			Fecal Coliform (74055)			FC Loading
Date		Monthly	Weekly		Mean	Maximum		Monthly
		Mean	Mean					Loading

		Monthly (mgd)			Monthly (cfu/100ml)			(cfu/30 days)
4/30/99		0.504	0.554		76	163		4.35E+10
5/31/99		0.556	0.642		16.3	190		1.03E+10
6/30/99		0.389	0.42		46	200		2.03E+10
7/31/99		0.439	0.466		18	125		8.97E+09
8/31/99		0.426	0.438		55	200		2.66E+10
9/30/99		0.444	0.552		5	155		2.52E+09
10/31/99		0.461	0.52		10	90		5.24E+09
11/30/99		0.41	0.419		41	200		1.91E+10
12/31/99		0.463	0.468		3.4	30		1.79E+09
1/31/00		0.554	0.735		34	150		2.14E+10
2/29/00		0.595	0.648		48.2	150		3.26E+10
3/31/00		0.534	0.571		40.6	175		2.46E+10
4/30/00		0.506	0.542		8	20		4.60E+09
5/31/00		0.483	0.492		22	155		1.21E+10
6/30/00		0.518	0.541		9	125		5.29E+09
7/31/00		0.496	0.535		1.5	5		8.45E+08
8/31/00		0.528	0.548		4	110		2.40E+09
9/30/00		0.643	0.712		6	35		4.38E+09
10/31/00		0.513	0.587		6	55		3.50E+09
11/30/00		0.467	0.516		13.2	200		7.00E+09
12/31/00		0.51	0.538		16	400		9.27E+09
1/31/01		0.501	0.515		8	65		4.55E+09
2/28/01		0.51	0.535		25	130		1.45E+10
3/31/01		0.542	0.612		9	105		5.54E+09
4/30/01		0.555	0.602		13	90		8.19E+09
5/31/01		0.485	0.518		16	185		8.81E+09
6/30/01		0.574	0.623		13	180		8.47E+09
7/31/01		0.533	0.567		2.9	200		1.76E+09
8/31/01		0.536	0.549		51	190		3.10E+10
9/30/01		0.446	0.538		39	190		1.98E+10
10/31/01		0.379	0.409		7.4	75		3.18E+09
11/30/01		0.385	0.393		10.2	45		4.46E+09
12/31/01		0.379	0.39		5.6	40		2.41E+09
1/31/02		0.42	0.467		2.7	15		1.29E+09
2/28/02		0.423	0.47		6.2	60		2.98E+09

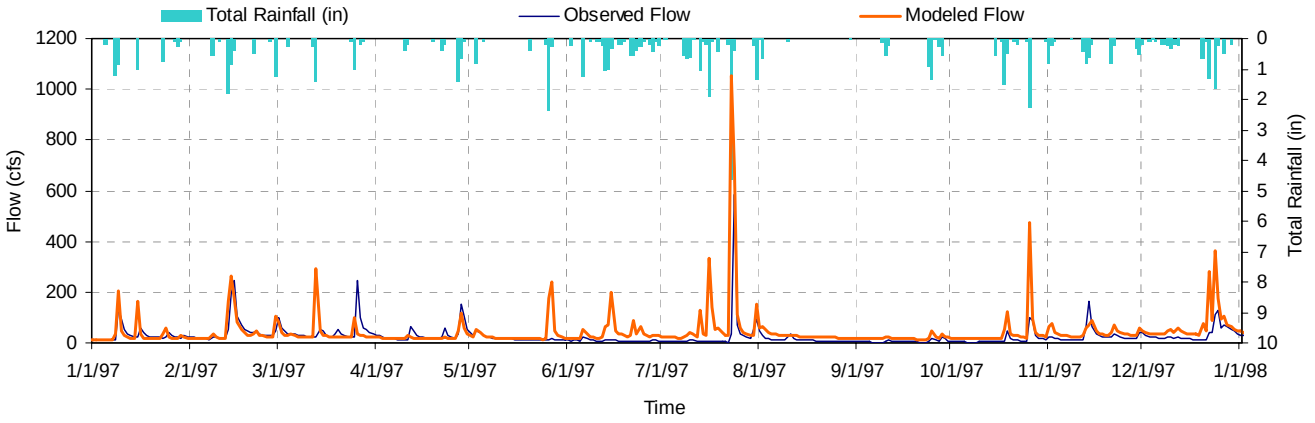
Appendix C Hydrologic Calibration

Hanging Rock Creek Model Hydrologic Calibration 1/16/03

	Run: Date	Time
Model File:	**WQcalib.prj**	**1/16/03** **14:21**
Weather Station:	**Winnsboro**	

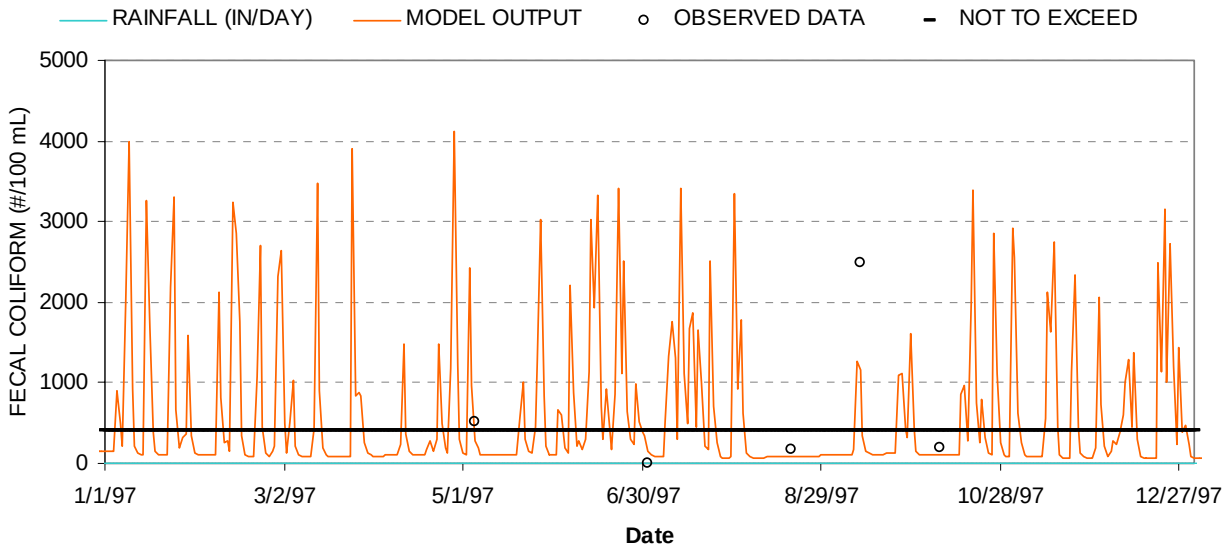
		Water Balance Errors						
Year		Total (+/- 10 %)	50% Lowest (+/- 10 %)	10% Highest (+/- 15 %)	Summer (+/- 30 %)	Fall (+/- 30 %)	Winter (+/- 30 %)	Spring (+/- 30 %)
1989		-35	-6	-38	-80	-49	-49	-2
1990		-0.7	42	-11	66	-10	-25	23
1991		-4	19	-17	-38	-0.9	8	1
1992		16	23	26	56	11	3	11
1993		-21	-31	-23	56	-22	-14	-69
1994		-54	-31	-52	-99	-65	-45	-8
1995		-7	34	-17	37	3	-41	16
1996		-2	15	-2	9	-11	-2	-2
1997		41	56	46	67	51	-2	38
1998		33	62	32	86	33	-5	39
Mean		-3.37	18.3	-5.6	16	-5.99	-17.2	4.7

Graph of model predicted flow, observed flow, and rainfall in Hanging Rock Creek at USGS gauging station.

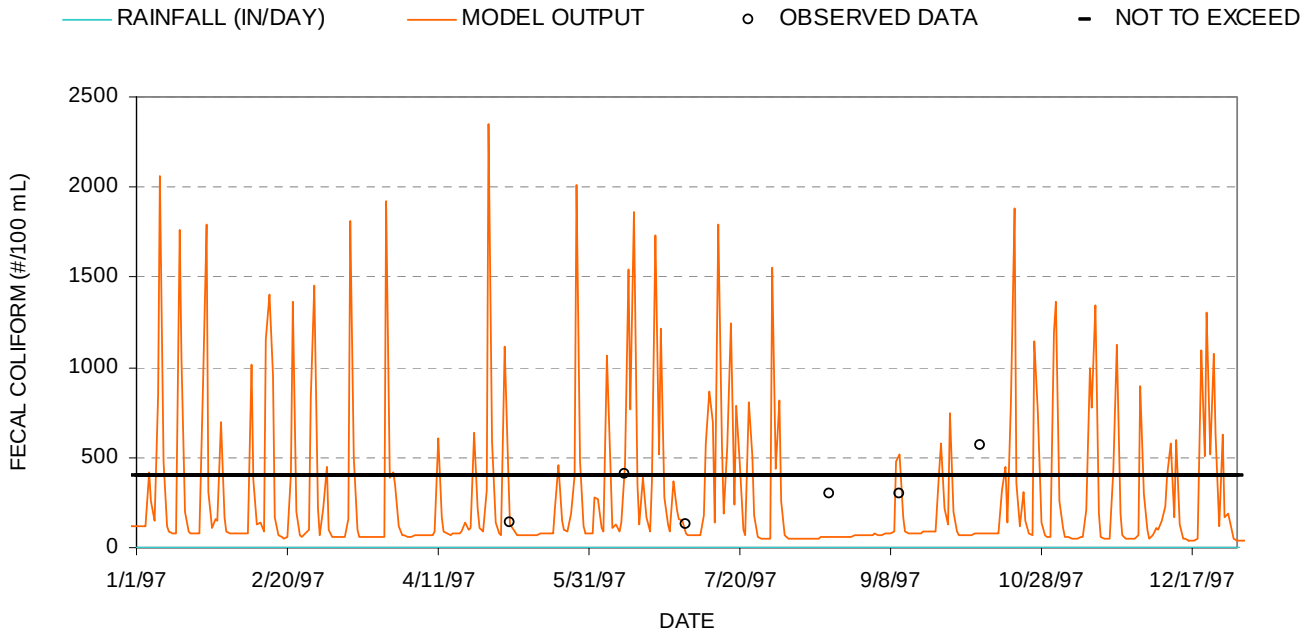


Appendix D Water Quality Calibration

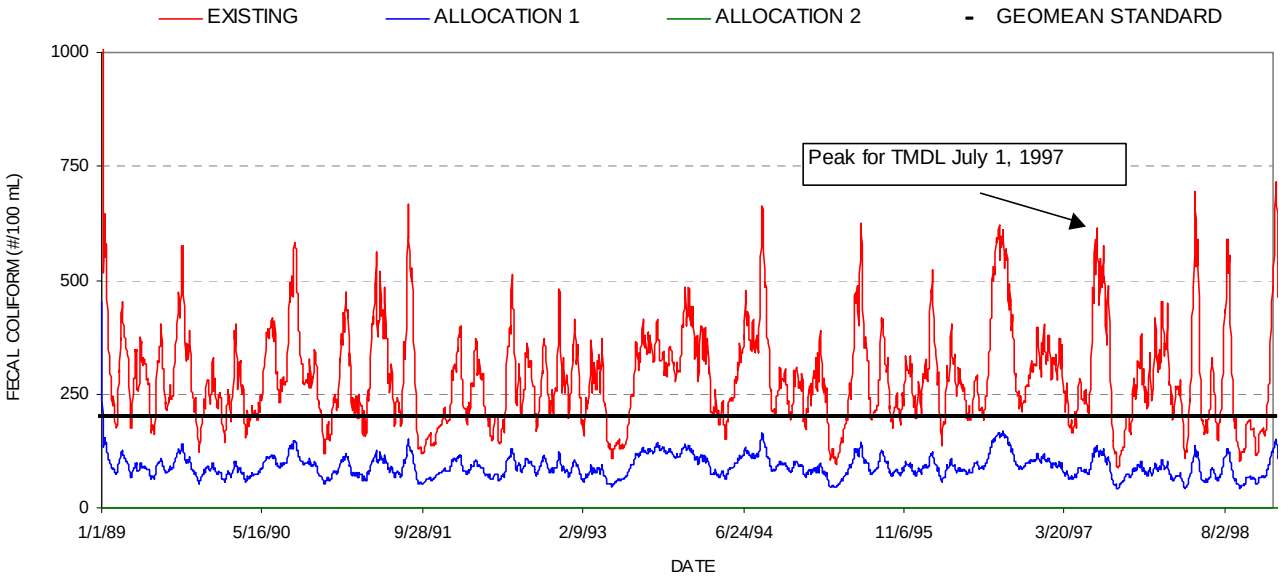
Plot of water quality calibration for Lick Creek at PD-329 for 1997.



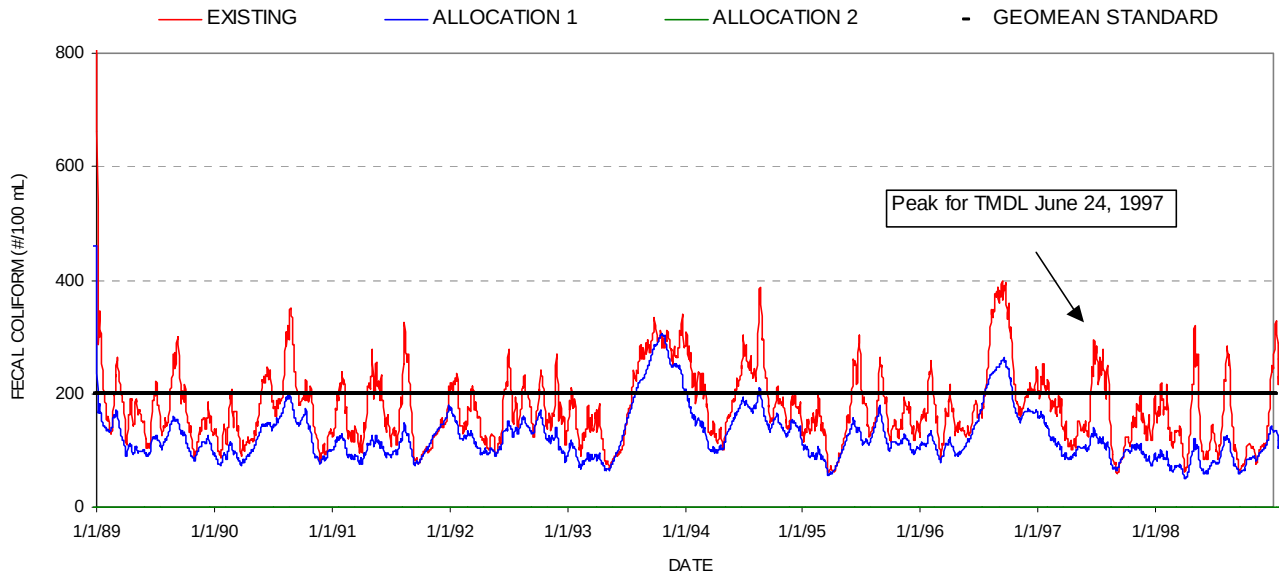
Plot of water quality calibration for Hanging Rock Creek at PD-328 for 1997.



Appendix E Geomean Plots and Daily TMDL Fecal Coliform Concentrations



30-day geometric mean plot for PD-329 showing existing load, TMDL load, and critical peak.



30-day geometric mean plot for PD-328 showing existing load, TMDL load, and critical peak.

Daily Fecal Coliform Concentrations showing compliance with Standard at PD-329

Date	Model Predicted Fecal Coliform Conc (cfu/100ml)
6/2/97	145.9
6/3/97	137.0
6/4/97	68.7
6/5/97	56.3
6/6/97	352.2
6/7/97	153.3
6/8/97	66.2
6/9/97	78.3
6/10/97	60.7
6/11/97	84.5
6/12/97	224.7
6/13/97	**445.6**
6/14/97	291.7
6/15/97	**454.5**
6/16/97	120.2
6/17/97	77.8
6/18/97	180.7
6/19/97	97.2
6/20/97	58.4
6/21/97	159.8
6/22/97	**491.5**
6/23/97	184.4
6/24/97	371.9
6/25/97	118.1
6/26/97	78.3
6/27/97	68.0
6/28/97	198.9
6/29/97	116.0
6/30/97	94.7
7/1/97	87.0

Daily Fecal Coliform Concentrations showing compliance with Standard at PD-328

Date	Model Predicted Fecal Coliform Conc (cfu/100ml)
5/26/97	200
5/27/97	336
5/28/97	95
5/29/97	58
5/30/97	56
5/31/97	57
6/1/97	58
6/2/97	113
6/3/97	92
6/4/97	64
6/5/97	60
6/6/97	392
6/7/97	108
6/8/97	61
6/9/97	66
6/10/97	59
6/11/97	69
6/12/97	147
6/13/97	**443**
6/14/97	296
6/15/97	336
6/16/97	82
6/17/97	68
6/18/97	133
6/19/97	67
6/20/97	53
6/21/97	169
6/22/97	**446**
6/23/97	120
6/24/97	365

Appendix F Miscellaneous Tables and Figures

Table F-1 Calculation of Septic System Loads

Existing Loading was calculated by multiplying FC Loading Rate from FCLES Spreadsheet by
Sub-Watershed # 1 0.8
Sub-Watershed # 2 1.0

Upper Hanging Rock Creek Watershed (PD-328) consists of Sub-watersheds: 1and 2
Lick Creek Watershed (PD-329) consists of Sub-watershed: 2

Assume a typical septic overcharge flow rate of:						70	gal/day/ person	**(Horsely & Witten, 1996)**	
SEPTICS AS A POINT SOURCE Includes houses listed by Census 1990 as having 'other' than sewage or septic systems									
Sub-water	**# people on septics**	**Density**	**# failing**	**Tot. # people**	**Septic flow**	**Septic flow**	**FC rate**	**Septic flow**	
shed		**capita/house**	**septics**	**served**	**(gal/day)**	**(mL/hr)**	**(#/hr)**	**(cfs)**	
001	172	2.95	17.5	51.6	3612	569,643	5.70E+07	5.60E-03	
002	316	2.53	37.4	94.7	6626	1,044,897	1.04E+08	1.03E-02	
003	239	2.56	28.0	71.7	5019	791,538	7.92E+07	7.78E-03	
004	265	2.55	31.2	79.5	5565	877,647	8.78E+07	8.63E-03	
Total:	992								
House wastewater treatment data from US Census 1990.									
see Septic System Data.xls for Hanging Rock Creek									

Table F-2 Calculation of initial Cattle-in-Stream Loads

Existing Loading was calculated by multiplying FC Loading Rate from FCLES Spreadsheet by
Sub-Watershed # 1 0.5
Sub-Watershed # 2 1

Upper Hanging Rock Creek Watershed (PD-328) consists of Sub-watersheds: 1and 2
Lick Creek Watershed (PD-329) consists of Sub-watershed: 2

This sheet contains information related to the direct contribution of cattle fecal coliform bacteria to streams.

The direct contribution of fecal coliform from cattle to a stream can be represented as a direct source in the model. Required input for direct sources in NPSM are flow (cfs) and loading rate (#/hr).

It is assumed that only beef cattle are grazing and therefore have access to streams. They have access to streams based on information in the Cattle Farming worksheet.

Assume the following:

Beef Cattle Waste: 46 (lbs/animal/day)

The density of cattle manure (including urine) is approximately the density of water: 62.4 (lbs/cubic foot)

CATTLE AS A DIRECT SOURCE

All Months	# grazing beef cattle	# grazing dairy cattle	# beef cattle in streams	# dairy cattle in streams	FC Loading Rate (#/hr)	Waste Flow (cfs)
001	181	0	0	0	1.96E+09	3.89E-06
002	83	0	0	0	8.99E+08	1.79E-06
003	84	0	0	0	9.10E+08	1.81E-06
004	28	0	0	0	3.03E+08	6.02E-07

Table F-3 Calculation of Existing Load by Land Use for upper Hanging Rock Creek Sub-Watershed (cfu/30 days)

Sub-Watershed		Agriculture				Pasture				Developed					
										Pervious			ImPervious		
Date		1	2	3		1	2	3		1	2	3	1	2	3
5/26/97		7.35E+11				6.27E+12				1.22E+09			1.31E+09		
5/27/97		1.58E+11				1.22E+12				4.79E+08			6.42E+08		
5/28/97		7.62E+09				1.84E+09				8.40E+07			1.58E+07		
5/29/97		4.08E+09				9.88E+08				5.11E+07			4.92E+06		
5/30/97		2.31E+09				5.59E+08				3.44E+07			2.21E+06		
5/31/97		1.41E+09				3.40E+08				2.55E+07			1.19E+06		
6/1/97		9.53E+08				2.31E+08				2.10E+07			7.22E+05		
6/2/97		3.32E+09				1.86E+10				3.37E+07			5.19E+08		
6/3/97		1.20E+09				2.90E+08				2.47E+07			5.26E+07		
6/4/97		8.52E+08				2.06E+08				2.07E+07			8.43E+06		
6/5/97		6.55E+08				1.58E+08				1.79E+07			3.09E+06		
6/6/97		8.78E+10				6.92E+11				3.16E+08			1.40E+09		
6/7/97		7.22E+09				1.75E+09				9.76E+07			4.27E+07		
6/8/97		4.22E+09				3.66E+09				5.92E+07			4.51E+07		
6/9/97		2.25E+09				5.45E+08				4.18E+07			7.91E+07		
6/10/97		1.52E+09				1.41E+09				3.04E+07			5.33E+07		
6/11/97		9.64E+08				2.33E+08				2.59E+07			8.74E+07		
6/12/97		5.37E+09				2.65E+10				5.45E+07			6.87E+08		
6/13/97		1.50E+11				1.23E+12				4.40E+08			1.06E+09		
6/14/97		4.59E+11				3.85E+12				7.87E+08			7.22E+08		
6/15/97		1.20E+11				8.59E+11				5.45E+08			6.83E+08		
6/16/97		9.97E+09				2.41E+09				1.05E+08			2.06E+07		
6/17/97		7.51E+09				1.60E+10				7.67E+07			2.95E+08		
6/18/97		1.17E+10				5.00E+10				9.53E+07			4.33E+08		
6/19/97		3.70E+09				8.96E+08				6.19E+07			1.28E+08		
6/20/97		2.21E+09				5.36E+08				4.38E+07			1.46E+07		
6/21/97		2.70E+10				2.13E+11				9.54E+07			9.63E+08		
6/22/97		1.98E+11				1.64E+12				4.66E+08			8.55E+08		
6/23/97		6.94E+09				1.66E+10				8.93E+07			3.36E+08		
6/24/97		1.15E+11				9.15E+11				3.11E+08			6.97E+08		
Totals		**2.14E+12**		**###**		**1.70E+13**		**###**		**5.75E+09**			**1.69E+10**		**#####**

Table F-4 Calculation of Existing Load by Land Use for Lick Creek Sub-Watershed (cfu/30 days)

				Developed	
Date		**Agriculture**	**Pasture**	**Perv**	**ImPerv**
		(cfu/30 days)			
5/26/97		6.81E+11	1.14E+13	6.19E+11	6.73E+11
5/27/97		1.54E+11	2.50E+12	1.76E+11	3.32E+11
5/28/97		3.22E+09	1.04E+09	1.88E+08	8.19E+09
5/29/97		1.74E+09	5.61E+08	1.14E+08	2.53E+09
5/30/97		1.00E+09	3.22E+08	7.67E+07	1.14E+09
5/31/97		6.21E+08	2.00E+08	5.67E+07	6.13E+08
6/1/97		4.30E+08	1.38E+08	4.66E+07	3.71E+08
6/2/97		2.79E+09	3.87E+10	5.38E+09	2.66E+11
6/3/97		5.65E+08	1.83E+08	5.50E+07	2.70E+10
6/4/97		4.03E+08	1.30E+08	4.60E+07	4.33E+09
6/5/97		3.11E+08	1.00E+08	3.98E+07	1.59E+09
6/6/97		8.39E+10	1.39E+12	1.25E+11	7.18E+11
6/7/97		3.40E+09	1.11E+09	2.17E+08	2.21E+10
6/8/97		2.13E+09	5.46E+09	2.34E+08	2.33E+10
6/9/97		1.06E+09	3.46E+08	9.29E+07	4.07E+10
6/10/97		7.74E+08	2.13E+09	1.17E+08	2.74E+10
6/11/97		4.58E+08	1.48E+08	5.76E+07	4.48E+10
6/12/97		4.32E+09	5.62E+10	7.85E+09	3.52E+11
6/13/97		1.43E+11	2.41E+12	2.08E+11	5.44E+11
6/14/97		4.22E+11	7.06E+12	3.54E+11	3.73E+11
6/15/97		1.02E+11	1.57E+12	1.87E+11	3.53E+11
6/16/97		4.66E+09	1.51E+09	2.32E+08	1.06E+10
6/17/97		4.39E+09	2.97E+10	3.62E+09	1.52E+11
6/18/97		8.68E+09	1.02E+11	7.90E+09	2.23E+11
6/19/97		1.74E+09	5.65E+08	3.21E+08	6.60E+10
6/20/97		1.04E+09	3.38E+08	9.73E+07	7.49E+09
6/21/97		2.49E+10	4.09E+11	3.04E+10	4.95E+11
6/22/97		1.83E+11	3.06E+12	2.36E+11	4.41E+11
6/23/97		4.29E+09	3.28E+10	7.99E+09	1.73E+11
6/24/97		1.02E+11	1.66E+12	1.02E+11	3.59E+11
Totals		**1.11E+12**	**1.79E+13**	**1.28E+12**	**5.58E+12**
					6.87E+12

Table F-5 Comparison of Precipitation at Winnsboro with FC Conc at PD-328

		Precipitation	
OBS WQ DATA		Prior Day	Same Day
DATE	DATA	(in)	
5/25/89	50	0	0
6/21/89	1300	1.4	0.9
7/6/89	90	0	0
8/1/89	45	0	0.5
9/19/89	370	0	0
10/12/89	75	0	0
5/7/90	35	0	0
6/14/90	180	0	0
7/18/90	40	0.4	0
8/6/90	60	0.2	1.4
9/19/90	30	0	0
10/23/90	2000	2	0.7
6/3/91	500	0	0
7/2/91	740	0	0
8/6/91	130	0.04	0.61
9/5/91	130	0	0
10/8/91	90	0.1	0
6/10/92	3300	0.2	0
7/22/92	280	0	1.9
8/25/92	170	0	0
9/10/92	490	0	0
10/27/92	70	0	0
5/4/93	1980	0	0.8
6/1/93	2000	0	0
7/21/93	150	0	0
8/25/93	60	0	0
9/15/93	140	0	0
10/7/93	80	0	0
5/11/94	320	0	0
6/2/94	40	0	0.2
8/2/94	120	0	0
9/7/94	160	0	0
10/5/94	200	0	0
5/18/95	90	0	0
6/6/95	20000	1.2	1.6
7/5/95	160	0	0.5
8/1/95	120	0	0
9/14/95	80	0	0
10/23/95	200	0	0
5/15/96	720	0	0
6/17/96	50	0	0

7/11/96	107	0	0
9/25/96	120	0	0
5/5/97	140	0	0.1
6/12/97	410	0.08	0.22
7/2/97	130	0	0.05
8/19/97	300	0	0
9/11/97	300	0.57	0.26
10/8/97	570	0	0
5/4/98	340	0.26	0.02
6/3/98	140	0.45	0
7/6/98	15	0	0
8/18/98	180	0.1	0
9/22/98	380	0	0.7
10/26/98	30	0	0

Table F-6 Comparison of Precipitation at Winnsboro with FC Conc at PD-329

		Precipitation	
OBS WQ DATA		Prior Day	Same Day
DATE	DATA	(in)	
5/25/89	320	0	0
6/21/89	360	1.4	0.9
7/6/89	940	0	0
8/1/89	320	0	0.5
9/19/89	1100	0	0
10/12/89	350	0	0
5/7/90	980	0	0
6/14/90	520	0	0
7/18/90	500	0.4	0
8/6/90	70	0.2	1.4
9/19/90	370	0	0
10/23/90	1200	2	0.7
5/1/91	3300	0	0
6/3/91	4100	0	0
7/2/91	4500	0	0
8/6/91	1300	0.04	0.61
9/5/91	650	0	0
10/8/91	300	0.1	0
5/27/92	1300	0	0
6/10/92	10000	0.2	0
7/22/92	210	0	1.9
8/25/92	170	0	0
9/10/92	250	0	0
10/27/92	330	0	0

5/4/93	1980	0	0.8
6/1/93	3300	0	0
7/21/93	6000	0	0
8/25/93	6600	0	0
10/7/93	340	0	0
5/11/94	880	0	0
6/2/94	480	0	0.2
8/2/94	1200	0	0
9/7/94	1700	0	0
10/5/94	740	0	0
6/6/95	14000	1.2	1.6
7/5/95	820	0	0.5
8/1/95	980	0	0
9/14/95	1200	0	0
10/23/95	430	0	0
5/15/96	1700	0	0
6/17/96	1700	0	0
9/25/96	1000	0	0
5/5/97	520	0	0.1
6/12/97	5400	0.08	0.22
7/2/97	8	0	0.05
8/19/97	180	0	0
9/11/97	2500	0.57	0.26
10/8/97	200	0	0
5/4/98	1200	0.26	0.02
6/3/98	1600	0.45	0
7/6/98	340	0	0
8/18/98	960	0.1	0
9/22/98	580	0	0.7
10/26/98	380	0	0

Appendix G Public Notification

The following notice was published in the Lancaster (SC) News on May 11, 2003 and was sent to persons whom had requested to be notified of the availability of TMDLs:

PUBLIC NOTICE

AVAILABILTY OF PROPOSED TOTAL MAXIMUM DAILY LOADs FOR WATERS AND POLLUTANTS OF CONCERN IN THE STATE OF SOUTH CAROLINA

Hanging Rock and Lick Creeks in Lancaster County

Section 303(d)(1) of the Clean Water Act (CWA), 33 U.S.C. § 1313(d)(1)(C), and the implementing regulation of the US Environmental Protection Agency (EPA, 40 C.F.R. § 130.7(c) (1), require the establishment of total maximum daily loads (TMDLs) for waters identified as impaired pursuant to § 303(d)(1)(A) of the CWA. Each of these TMDLs is to be established at a level necessary to implement applicable water quality standards with seasonal variations and a margin of safety, to account for lack of knowledge concerning the relationship between effluent limitations and water quality. At this time, the South Carolina Department of Health and Environmental Control (DHEC) has developed proposed TMDLs for the § 303(d)(1)(A) waters:

Hanging Rock and Lick Creeks, Lancaster County, Fecal Coliform Bacteria, HUC 03040202-070-030.

Upon review of any public comment and revision, if necessary, the Department will submit these TMDLs to EPA for approval as final TMDLs.

Persons wishing to comment on the proposed TMDLs or to offer new data regarding the proposed TMDLs are invited to submit the same in writing no later than June 15, 2003, to:

South Carolina Department of Health and Environmental Control
Bureau of Water
2600 Bull St.
Columbia, S.C. 29201
Attn: Mark Giffin

Mr. Giffin's phone number is 803-898-4203. His E-mail address is giffinma@dhec.sc.gov. Persons may also contact Ms Kathy Stecker at 803-898-4011.

Copies of individual TMDLs can be obtained from the Bureau of Water web site: http://www.scdhec.net/water/ or by calling, writing, or e-mailing Mr. Giffin at the address above. The administrative record, including technical information, data and analyses supporting the proposed TMDLs, are available for review. Requests to review this information must be submitted in writing to DHEC's Freedom of Information Office at 2600 Bull Street, Columbia, SC 29201 or requests can be submitted via FAX to the Freedom of Information Office at 803-898-3816. Reproduction of documents is available at a cost of $0.25 per page.