South Carolina
Department of Health and Environmental Control

Total Maximum Daily Load Development for Fishing Creek and Tributaries (Stations: CW-005, CW-006, CW-008, CW-029, CW-096, CW-212, CW-224, CW-225, CW-227, CW-233, and CW-234) for Fecal Coliform Bacteria (HUC 03050103)

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Bureau of Water

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DHEC
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South Carolina Department of Health and Environmental Control

Executive Summary

The Clean Water Act requires that water bodies that are impaired must be listed under section 303(d) of the act. Waters that are placed on the 303(d) list must have a Total Maximum Daily Load (TMDL) determined for the pollutant of concern. The State of South Carolina has placed Fishing Creek and its tributaries on the list at eleven locations, because of impairment by fecal coliform bacteria. Fishing Creek is impaired at water quality monitoring station CW-029, CW-005, CW-225, CW-224, CW-008, and CW-233. Tributaries that are impaired are Tools Fork (CW-212), Wildcat Creek (CW-006 and CW-096), Neelys Creek (CW-227), and Tinkers Creek (CW-234). Concentrations of fecal coliform exceeded the standard of 400 cfu/100ml for more than 10% of the samples from each of these stations. Fishing Creek (HUC 03050103-050, -060, and -070) is a Piedmont stream that drains a watershed of 747 km^2 (288 mi^2) that is predominantly forested, but has a significant amount of agricultural land use, particularly in cattle pasture. The watershed has a relatively small but growing urban or built-up area, mostly in the upper Fishing Creek and Wildcat Creek sub-watersheds.

Fishing Creek, and its tributaries Tools Fork, Hope Branch, and Neelys Creek have seven active wastewater treatment facilities that have NPDES permits to discharge wastewater containing fecal coliform bacteria. The discharge from these facilities meets the standard indicating that they are not the cause of the impairment of these streams. Nonpoint sources were determined to be responsible for impairment of these streams. Runoff from both urban and agricultural areas is the principal source of fecal coliform bacteria in the Fishing Creek watershed. Other significant sources may include failing septic systems, leaking and overflowing sanitary sewers, and animals especially cattle defecating directly into streams.

The proposed TMDLs represent reductions to the existing loading of 48 % overall to Fishing Creek. The reductions are directed primarily at runoff from urban and pasture lands, failing septic systems, leaking or overflowing sanitary sewers, and livestock with uncontrolled access to streams.

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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 Fishing Creek watershed is a 747 km^2 (288 mi^2) watershed, located in York and Chester Counties, SC. Fishing Creek drains into the Catawba River just downstream of the Fishing Creek Hydroelectric Station and Fishing Creek Reservoir (Figure 1) near Great Falls, SC. Fishing Creek has several named tributaries that are part of this TMDL: Wildcat Creek, which drains part of Rock Hill and its tributary Tools Fork Creek, Tinkers Creek and its tributary Neelys Creek. More detailed maps of the upper parts of Tools Fork Creek and Fishing Creek are presented in Figure 2. The Fishing Creek watershed also has two other important tributaries that were not sampled: South Fork Fishing Creek and Taylors Creek.

The Fishing Creek watershed is in the Piedmont region of South Carolina. Soils in the watershed are principally clay and clay-loam soils. The Lloyd-Cecil-Enon, Cecil-Pacolet-Appling, and Iredell-Mecklenburg-Davidson soil associations account for over 85 % of the area within the watershed.

Land use in the Fishing Creek watershed (Table 1; Figure 3) is predominantly forest (65%)**;** the remaining is cropland (13%), pasture land (14%), and urban (5.3%) (based on National Land Cover Data or sometimes MRLC). Much of the forested land is abandoned agricultural land that is scrubby hardwoods or pine tree farms. Land use in the sub-watersheds varies widely. Land use in the small upper Tools Fork Creek watershed is predominantly agricultural (56%; pasture - 34.5% and row crops 21.2 %), with a large forested area (39%) (Appendix C). The upper part of Wildcat Creek is 40% urban or built-up, while the South Fork Fishing Creek is only 0.5% urban. The Wildcat Creek sub-watershed is 47% forest, the South Fork Fishing Creek is 57% forest; but the Fishing Creek ‘Mouth’ is over 80% forest. Land use in the upper Fishing Creek sub-watershed has changed since the NLCD data was collected with the transformation of approximately

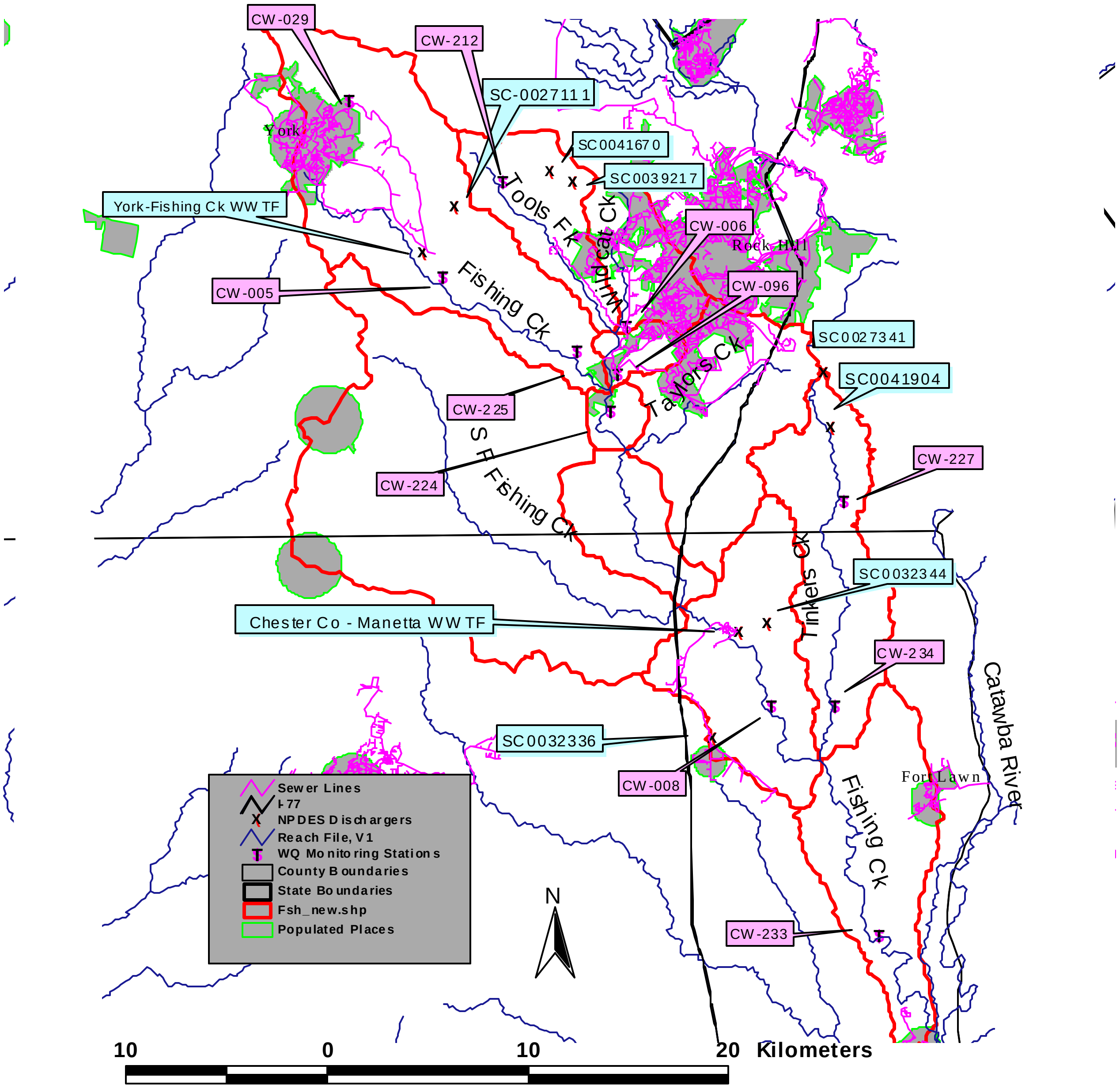

Figure 1. Fishing Creek watershed in SC with WQ monitoring stations and NPDES dischargers.

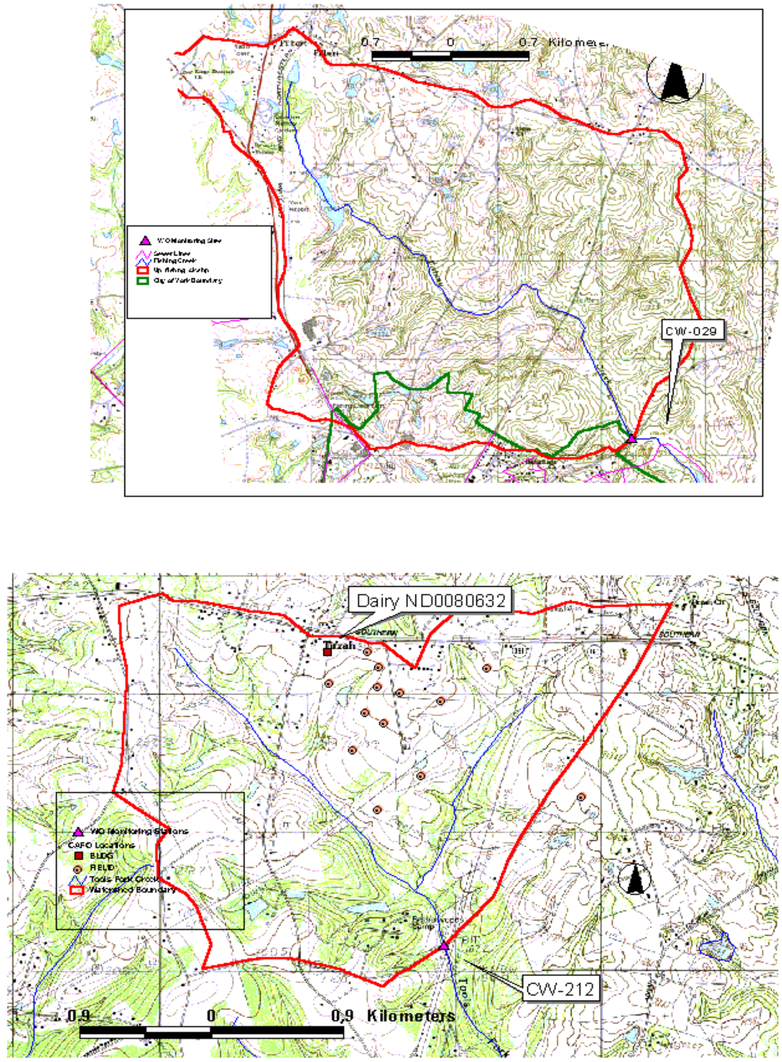

Figure 2. Maps of the upper Fishing Creek (top) and Tools Fork Creek (bottom) watersheds.

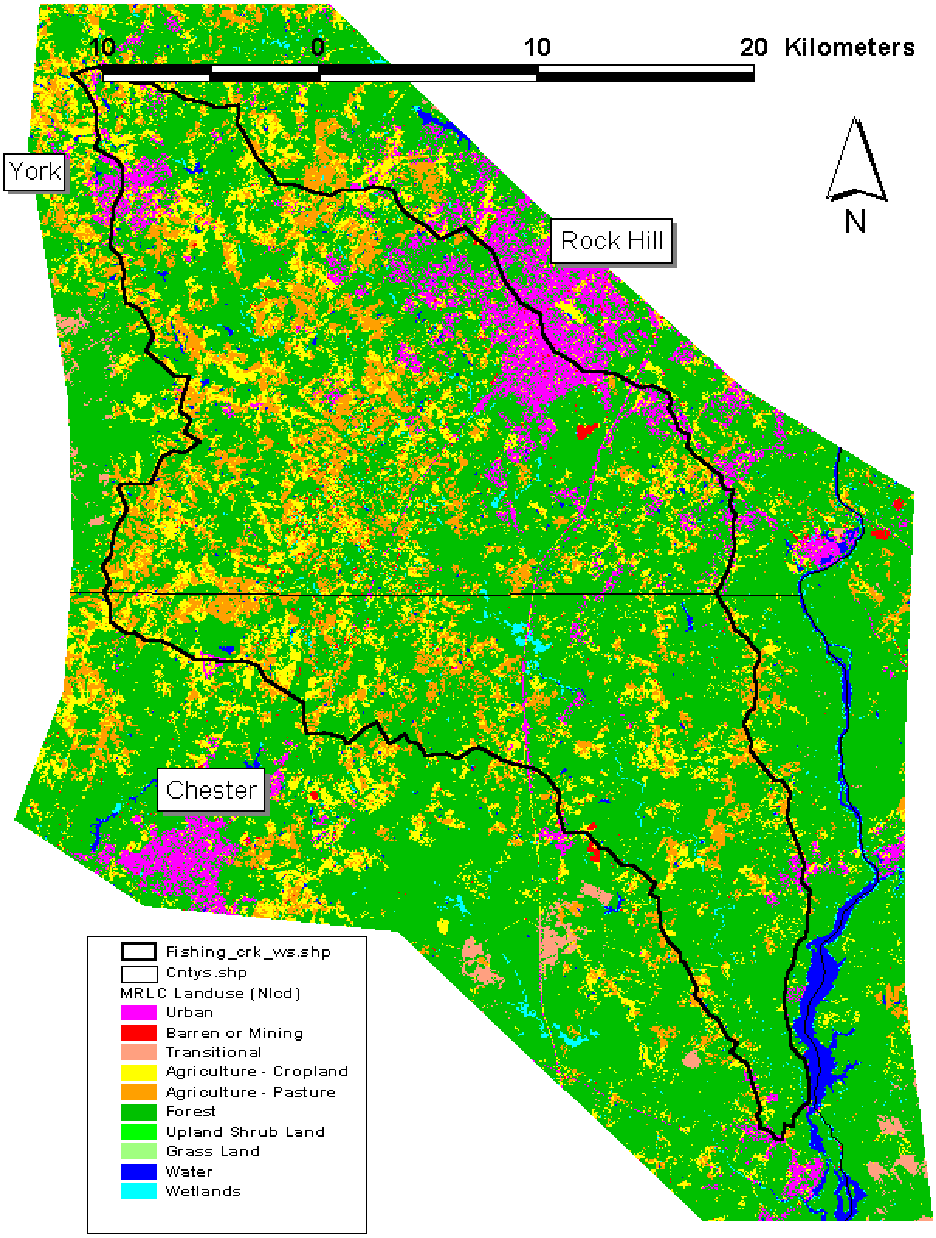

Figure 3. Land use in the Fishing Creek watershed from National Land Cover Data.

100 hectares of agricultural land to urban uses (Appendix B). The city of Rock Hill covers much of the Wildcat Creek and Taylor Creek sub-watersheds. This area is growing rapidly and housing developments are replacing farmland in the area around Rock Hill.

1.3 Water Quality Standard

The impaired streams, Fishing Creek and its tributaries, are designated as Class Freshwater. Waters of this class are described as follows:

> AFreshwaters 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)

The South Carolina standard for fecal coliform in Freshwater is:

> ANot 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).

2.0 WATER QUALITY ASSESSMENT

The Watershed Water Quality Management Strategy Catawba Basin (SCDHEC 1999b) was used to identify these stream stations as impaired and for listing these water bodies on the 2000 South Carolina 303(d) list. Fishing Creek and the tributaries were also included on the 1998 303(d) list. Waters in which no more than 10% of the samples collected over a five-year period are greater than 400-cfu/100 ml (cfu, counts, colonies, or # are equivalent units for this TMDL) are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10 percent of samples greater than 400 cfu/100 ml are considered impaired and listed for fecal coliform bacteria on the South Carolina 303(d) List. The impaired water bodies are described in Table 2. Table 2 also gives the percentages of samples that exceeded the standard during the assessment period (1994-1998) and the mean value for this period. Tools Fork at Station CW-212, which is near Rock Hill, had the highest mean concentration of fecal coliform bacteria and the second highest percentage of violations. Wildcat Creek (CW-006), which is in Rock Hill, had the highest percentage of violations and the third highest concentration for the assessment period. Fecal coliform data for the stations that are included in this TMDL 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 NPDES permittees that discharge sanitary wastewater must meet the state standard for fecal coliform at the point of discharge.

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 run off during storm events. Other sources are more or less continuous. Potential nonpoint sources of fecal coliform bacteria include animals, manure application, failing septic systems, and leaking sanitary sewers.

3.1 Point Sources

There are seven active point sources in the Fishing Creek watershed (Table 3). None are in the upper Fishing Creek or upper Tools Fork Creek sub-watersheds. There are also two point sources that stopped discharging during the ten-year period that was modeled. The largest discharger is the York-Fishing Creek facility on the upper part of Fishing Creek, accounting for 75 % of the waste load in Fishing Creek. This facility has a permitted discharge of 2.0 mgd (7570 m^3/d), however had an average discharge of 1.08 mgd (4088 m^3/d) during the 1989-98 period. The average load for this period was 8.9 $x\ 10^8$ cfu/day. The DMR based load will be used to determine the existing load in the model. The discharger with the second largest load on Fishing Creek is the Chester County – Lando-Manetta WWTF, which has a permitted flow limit of 0.5 mgd (1890 m^3/d). The fecal coliform load from this discharger averaged 2.47 $x\ 10^8$ cfu/day for 1989-98. For allocation runs of the model and determination the TMDL, the permitted flow for each of these two facilities and fecal coliform limit of 200 cfu/100ml monthly average were used to calculate the wasteload. Load based on permit limits will be used in the model for the other dischargers, which are all small (< 0.05 mgd).

The DMR data for the York and Chester wastewater facilities indicate that their treated wastewater regularly meets the standard. A review of DMR data from all the other facilities also indicates that their discharges have met the water quality standards. Therefore the point sources are not apparently a cause of the impairment at any of the locations. The wastewater facilities other than York-Fishing Creek and Chester-Manetta are very small so that their wasteloads are almost insignificant; altogether accounting for less than three per cent of the total wasteload. The total waste load from all of the point sources at permit limits is 1.98 $x\ 10^{10}$ cfu/day.

3.2 Nonpoint Sources

3.2.A upper Fishing Creek sub-watershed

3.2.A.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 or deposited directly into streams. Loading of fecal coliform bacteria from wildlife is considered background and is the primary source for forest land.

For this TMDL a concentration of 30 cfu/ 100ml was used for the background fecal coliform load.

Table 1. Land use distributions in the Fishing Creek watershed by sub-watersheds.

Sub-watershed	Whole Watershed	Fishing Creek Mouth	Tinkers Creek	Fishing Creek bl SF F C	Fishing Creek bl Taylor	Taylor Creek	S Fork Fishing Creek	Fishing Creek bl Wildcat	Wildcat Creek bl Tools	Wildcat Creek Head	Tools Fork	Fishing Creek Head
Land Use Class												
Built-up	9,870.2	360.6	496.2	372.5	48.7	2,451.8	274.1	52.3	414.8	2,834.0	944.2	1,620.9
	5.3%	2.0%	2.9%	2.1%	0.6%	13.6%	0.5%	2.6%	17.4%	39.7%	9.9%	5.1%
Forest	120,180.0	14,478.7	12,663.8	13,894.1	5,941.8	12,793.6	30,461.7	1,435.2	1,491.1	3,336.0	5,471.4	18,212.4
	65.1%	80.6%	74.4%	78.6%	75.3%	70.9%	57.3%	70.6%	62.7%	46.7%	57.2%	57.5%
Pasture-Hay	25,670.8	1,298.7	1,622.5	1,235.4	830.0	894.2	12,003.3	349.3	112.3	256.6	1,729.0	5,339.4
	13.9%	7.2%	9.5%	7.0%	10.5%	5.0%	22.6%	17.2%	4.7%	3.6%	18.1%	16.8%
Row Crops	23,604.8	1,533.1	1,932.1	1,880.7	629.8	1,194.7	9,033.1	138.5	261.8	353.8	1,071.8	5,575.4
	12.8%	8.5%	11.4%	10.6%	8.0%	6.6%	17.0%	6.8%	11.0%	5.0%	11.2%	17.6%
Wetlands	2,056.7	184.0	97.8	146.6	399.6	167.2	508.8	30.3	53.3	49.4	128.2	291.5
	1.1%	1.0%	0.6%	0.8%	5.1%	0.9%	1.0%	1.5%	2.2%	0.7%	1.3%	0.9%
Totals	184,559.5	17,955.1	17,022.5	17,683.6	7,893.5	18,047.8	53,160.4	2,033.1	2,377.2	7,136.2	9,561.2	31,688.8

Table 2. Sampling station descriptions and statistics of fecal coliform bacteria samples during the 1994-98 assessment period.

Station Description	Stations	% Violations	Mean Fecal Coliform Conc. (cfu/100ml)	Number of Samples
Fishing Creek at SC-49	CW-029	33	486	56
Fishing Creek at S-46-347 (dws of York)	CW-005	25	684	56
Fishing Creek at S-46-503 (ups of confluence with Wildcat Creek	CW-225	59	873	29
Tools Fork Creek at S-46-195	CW-212	80	1897	25
Wildcat Creek at S-46-650 (in Rock Hill)	CW-006	81	1170	27
Wildcat Creek at S-46-998 (dws end of stream and of Rock Hill)	CW-096	31	883	29
Fishing Creek at S-46-163 (dws of confluence with Wildcat Creek)	CW-224	50	1214	26
Fishing Creek at SC-223 (dws of South Fork Fishing Creek)	CW-008	25	687	56
Neelys Creek S-46-997 (ups of confluence with Tinkers Creek)	CW-227	20	354	25
Tinkers Creek at S-12-599 (ups of confluence with Fishing Creek)	CW-234	25	307	8
Fishing Creek at S-12-77 (ups of confluence with Catawba River)	CW-233	29	864	7

3.2.A.2 Untreated Wastewater Inputs

Using a GIS, we compared the census layer to the sewer line file and estimated the number of persons without access to municipal sewer lines to be 819 (2000 Census). Based on Horsley and Witten (1996) the average waste flow per person was assumed to be 70 gal/capita/day. The average household consisted of 2.63 persons. Septic systems were assumed to have a failure rate of 5 % (Schueler, 1999), at the low end of the range. 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). This source contributes 1.09×10^9 cfu/day to the upper Fishing Creek.

3.2.A.3 Urban Storm Runoff

Urbanized or developed land typically generates an increased loading for pollutants relative to forest and other undeveloped land uses. Dogs, cats, and other pets are a primary source of fecal coliform deposited on the urban landscape. Storm runoff washes some of this fecal material into streams directly or through the storm sewers. This source is estimated by the ›simple method› of

Table 3. Point source dischargers in the Fishing Creek watershed.

Discharger Name	NPDES Number	Receiving Stream	Flow (mgd)	Load (cfu/day)	Comments
York-Fishing Creek WWTP	SC0038156	Fishing Creek	2.0	1.51×10^{10}	Active
Utilities of SC – Country Oaks SD	SC0039217	Tools Fork	0.02	1.51×10^{8}	Active
Adnah Road MHP	SC0041670	Tributary to Tools Fork	0.04	3.03×10^{8}	Active
McAfee Mobile Home Park	SC0027111	Hope Branch	0.018	1.36×10^{8}	Active
Edgemore Community Assoc.	*SC0032344*	*Hicklin Branch*	*0.012*	*0*	*Inactive 6/1/1997*
Chester-Manetta Plant	SC0001741	Fishing Creek	0.5	3.79×10^{9}	Active
Lewisville Middle School	*SC0032336*	*Tributary to Fishing Creek*	*0.01*	*0*	*Inactive 12/10/1997*
Neelys Creek Homes Inc.	SC0041904	Neelys Creek	0.008	6.06×10^{7}	Active
Jack Nelson Enterprises	SC0027341	Neelys Creek Tributary	0.012	9.08×10^{7}	Active
Totals			2.62	1.98×10^{10}	

Note: All loads are based on permit limits. The loads for Edgemore Community Assoc. and Lewisville Middle School prior to 1997 were 9.08×10^{7} and 7.57×10^{7} cfu/day, respectively. The loads used in the model for existing conditions for York – Fishing Creek and Chester - Manetta were 8.9×10^{8} and 2.47×10^{8} cfu/day, respectively; based on DMR data.

Schueler (1987) using a concentration for fecal coliform from the literature (USEPA, 2001). Storm runoff is the largest contributor to the load going into Fishing Creek by far (95 %).

3.2.A.4 Pasture Land Runoff

The land use data indicate there is 158 hectares of pasture/hay land in this watershed. However, most of the grassland in this area is not actively used as pasture land any more. Based on a drive-by site assessment, approximately 25 % or 36 hectares of the pasture land are estimated to be used for stock.

3.2.B upper Tools Fork Creek sub-watershed

3.2.B.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 or deposited directly into the streams. Loading of fecal coliform bacteria from wildlife is considered background and is the primary source for forest land. For this TMDL a concentration of 30 cfu/ 100ml was used for the background fecal coliform load.

3.2.B.2 Agricultural Activities

In this small headwater watershed agriculture is the principal activity. Runoff from pastures where cattle graze is the major source of fecal coliform loading. Other agricultural sources include runoff from croplands where manure has been applied and manure directly discharged by cattle standing in streams. This watershed has a single large dairy that has a permit for 300 dairy cattle. The load of fecal coliform bacteria from pasture runoff was estimated to be 1.89×10^{11} cfu/day. For this TMDL fecal coliform bacteria will be expressed as cfu (colony forming units), which are equivalent to counts or #. Runoff from pasture land was estimated to be the principal source of fecal coliform bacteria in Tools Fork Creek, accounting for 76 % of the load.

Manure deposited directed into streams and ponds by livestock is the second largest source of fecal coliform in this watershed. Loading from this source is estimated from the number of dairy cattle and the percentage of time they spend in streams. The loading was estimated to be 4.54×10^{10} cfu/day or 18 % of the total.

3.2.B.3 Untreated Wastewater Inputs

Using the GIS, the 2000 census block database was compared to the watershed boundary and a population of 342 and the number of households of 139 was estimated. All houses in this watershed use on-site waste treatment because there are no sewers. 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 5 % (Schueler, 1999) or 7 failing septic systems. This failure rate is at the low end of the range reported by Schueler. 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). This source in the upper Tools Fork Creek is a minor contributor to the fecal coliform loading to the creek (4.73×10^{8} cfu/day).

3.2.C Fishing Creek watershed

3.2.C.1 Wildlife

Fecal coliform bacteria can also originate in forested areas. Generally the sources are wild animals such as deer, raccoons, wild turkeys, waterfowl, etc. Streams draining forested land usually have the lowest fecal coliform concentrations of any streams. Controls of these sources will be limited to land management BMPs, although forested areas are not specifically targeted in this TMDL.

The Department of Natural Resources in South Carolina estimated a deer density of about 45 deer per square mile of deer habitat (personal communication, Charles Ruth, Deer Project Supervisor, DNR, 2/22/01). Deer habitat includes the forest, cropland and pastureland uses. Using the provided deer density and the area of deer habitat available in the watershed, the total estimated number of deer in the watershed is calculated at 12,000. The fecal coliform production rate for deer was estimated by linear interpolation using the rate for other animals, such as turkey and cattle, which are available in Metcalf & Eddy (1991). The interpolation was conducted based on each animal weight. This method gives a rate of 5×10^8 cfu/animal/day for deer. Using this rate and the assumption of equally distributed population of deer between forest and agricultural land uses, the fecal coliform accumulation rates were determined to be 2.47×10^6 cfu/acre/day, which represents background fecal coliform loading.

3.2.C.2 Land Application of Manure and Sludge

Agricultural land frequently is a source of fecal coliform bacteria. Runoff from pastures, animal operations, the improper land application of animal wastes, and animals with access to creeks are all sources of fecal coliform. A table of fecal coliform bacteria production rates for livestock and other animals is presented in Appendix E. Agricultural Best Management Practices or BMPs such as buffer strips, alternative watering sources, limiting livestock access to creeks, and the proper land application of animal wastes reduce fecal coliform loading to water bodies.

There are eight turkey operations are located within the watershed; which are permitted for a total of 312,000 turkeys. More than half of these turkeys are in the South Fork Fishing Creek sub-watershed. The watershed has one layer facility, which is permitted for 22,000 chickens. Also several dairy farms with some 600 cattle are located in Fishing Creek basin. Litter from these operations is applied primarily to pasture land; but also to cropland in the Fishing Creek watershed. Operators are required to follow their Poultry Waste Management Plans for the application of litter and manure. All of these animal operations have ND or no discharge permits. The fecal coliform spreadsheet tool of WCS was used to calculate the amount of fecal coliform deposited on agricultural land.

The Fishing Creek watershed also receives applications of Class B sludge or bio-solids (defined as having less than 2×10^6 mpn/g of fecal coliform bacteria) from domestic wastewater treatment plants. Recipients of the sludge are required to obtain a permit and must meet certain criteria in regard to application rate, setback from streams, etc. At present, the location of fields receiving sludge, dates of applications, and quantities are not readily available. However, SCDHEC has funded a 319-grant proposal that will set up a GIS-based database to track these applications.

Runoff from pastures where cattle graze is the major source of fecal coliform loading in the upper Tools Fork Creek watershed. The load of fecal coliform bacteria from pasture runoff was estimated to be 1.89×10^{11} cfu/day. Runoff from pasture land was estimated to be the principal source of fecal coliform bacteria in Tools Fork Creek, accounting for 76 % of the load.

3.2.C.3 Grazing Animals

In addition to the confined animal operations are numerous grazing livestock. Based on the 1997 USDA census, we estimated that 9344 beef cattle, 605 dairy cattle, and perhaps 70 horses are found in the watershed. Livestock, except for the dairy cattle, are not usually confined and so are grazing in the pastures most of the time. Manure deposited by the cattle onto the pastureland is a potential source of nonpoint source pollution. Fecal coliform were estimated to accumulate on pastureland at the rates between 5.1×10^7 and 2.48×10^9 cfu/acre /day.

Loading of fecal coliform bacteria from cattle defecating directly into streams was estimated from the agricultural census of cattle, literature values of fecal coliform concentrations in manure, and the assumption that only a small number of cattle would defecate in or near the stream (personal communication, EPA Region 4, 2000). The estimated loadings from the cattle-in-streams were treated as continuous sources for input into the model by sub-watershed (Table 4).

Manure deposited directed into streams and ponds, by livestock is the second largest source of fecal coliform in the upper Tools Fork Creek watershed. The loading was estimated to be 4.54×10^{10} cfu/day or 18 % of the total.

3.2.C.4 Failing Septic Systems

Using the septic system tool in WCS, we estimated the number of persons using on-site septic systems. Because of a lack of data several assumptions were made: an average waste flow of 70 gal/capita-day (Horsley and Witten, 1996), an average of 2.6 persons per household, a failure rate of 20 % (EPA), that all the wastewater reached the stream, and the concentration of fecal coliform was 10^4 cfu/100ml (Horsley and Witten, 1996). Loading from failing septic systems was combined with estimated loading for leaking and overflowing sewers and entered into the model as continuous sources by sub-watersheds (Table 5).

3.2.C.5 Urban Storm Runoff

In addition to the point sources of fecal coliform bacteria loading to watersheds from urban areas, there is more generalized increased loading from urban areas relative to forested land. Sources of fecal coliform bacteria in urban areas include pets, particularly dogs. Much of the increase in loading from these areas is due simply to the increase in impervious surfaces and resulting increase in runoff. The accumulation rate for the built-up land was 1.0×10^9 cfu/acre/day for both the pervious and impervious fractions; 65% of built-up land was assumed to be pervious. Rock Hill extends into Wildcat (both sub-watersheds 046 and 047), Taylors, and Tools Fork Creeks. The other sizable urban area is part of the Town of York in the upper Fishing Creek sub-watershed. Much of the countryside adjacent to these towns is converted into low and medium density housing.

3.2.C.6 Leaking and Overflowing Sewers

Other potential sources of fecal coliform bacteria in the Fishing Creek watershed include direct discharges, leaking sanitary sewers, and overflows of sanitary sewers. There is no information on direct discharges. However, in this watershed sanitary sewers are located along the lower Tools Fork, Wildcat, Taylors, and the upper part of Fishing Creek (Figure 4). Wastewater from the Town of York is conveyed in several sewer lines to a treatment plant on the upper Fishing Creek.

Table 4. Livestock-in-streams loading rates for fecal coliform and flow for model input.

Sub-watershed Name	Sub-watershed number	Fecal Coliform Loading Rate (cfu/hr)	Flow Rate (cfs)
Fishing Creek Mouth	40	4.56E+08	9.058E-07
Tinkers Creek	41	5.18E+08	1.028E-06
Fishing Creek	42	4.33E+08	8.606E-07
Fishing Creek	43	2.47E+08	4.906E-07
Fishing Creek	44	9.43E+07	1.872E-07
Taylors Creek	45	3.14E+07	6.24E-08
Wildcat Creek	46	3.03E+07	6.024E-08
Wildcat Creek	47	6.93E+07	1.377E-07
Tools Fork Creek	48	7.32E+08	1.47E-06
Fishing Creek Head	49	1.44E+09	2.864E-06
S F Fishing Creek	50	3.60E+09	7.145E-06

Table 5. Fecal coliform loading and flow from septic systems by sub-watershed.

Sub-watershed Name	Sub-watershed number	Fecal Coliform loading (cfu/hr)	Flow (cfs)
Fishing Creek Mouth	40	2.28E+08	2.24E-02
Tinkers Creek	41	3.97E+08	3.91E-02
Fishing Creek	42	2.58E+08	2.54E-02
Fishing Creek	43	2.17E+08	2.14E-02
Fishing Creek	44	6.00E+08	5.90E-02
Taylors Creek	45	7.20E+07	7.07E-03
Wildcat Creek	46	7.09E+07	6.97E-03

Wildcat Creek	47	1.78E+08	1.75E-02
Tools Fork Creek	48	3.48E+08	3.42E-02
Fishing Creek Head	49	1.10E+09	1.08E-01
S F Fishing Creek	50	1.48E+09	1.45E-01

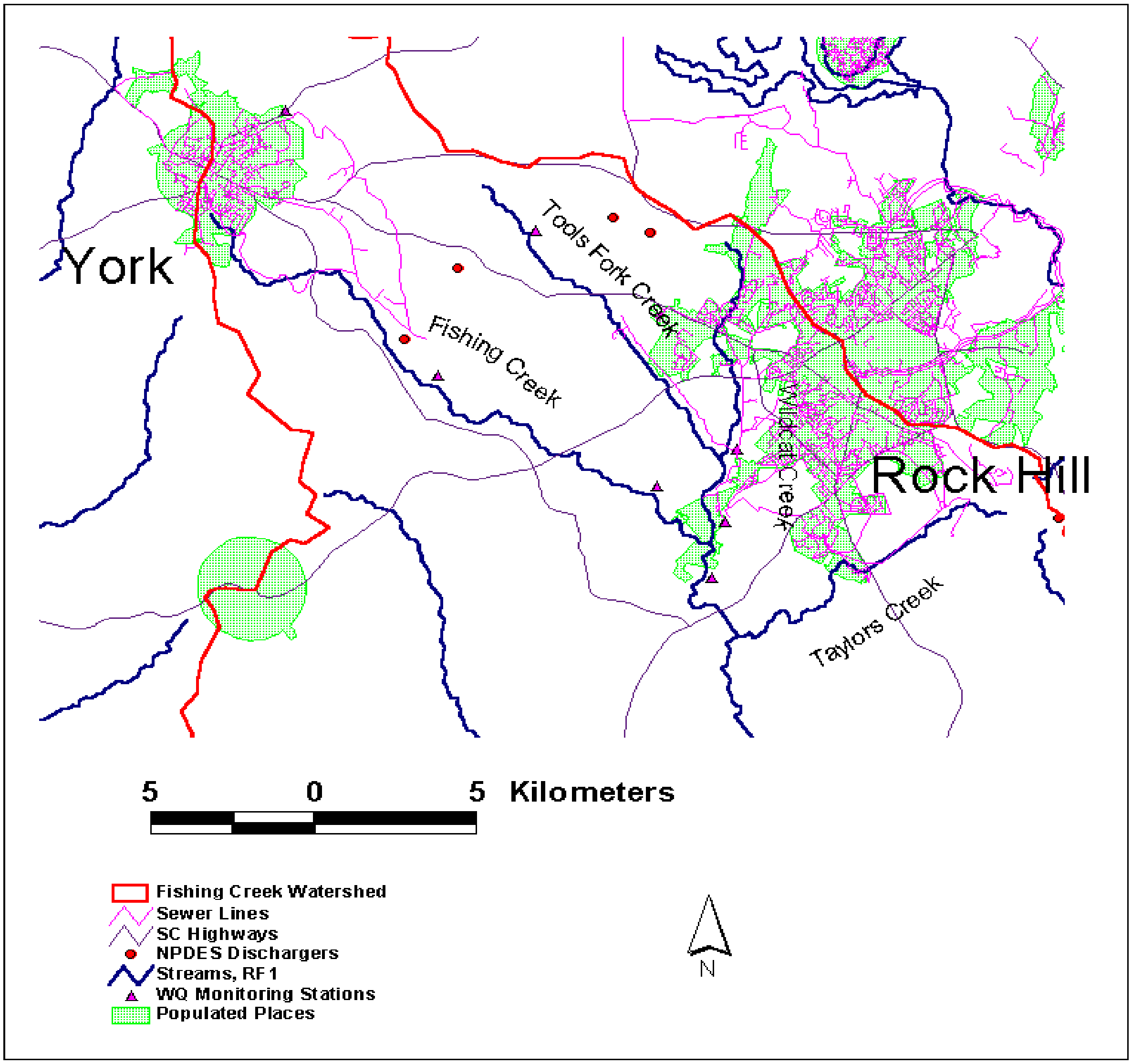

Figure 4. Location of sewer lines along creeks in the Fishing Creek watershed.

Wastewater from the part of Rock Hill in the Fishing Creek drainage is treated at a facility that discharges directly into the Catawba River. Leaks or overflows from the sewer lines along these streams would be potential sources of pollution. The water quality sampling station on Tools Fork (CW-212) and the upper station on Wildcat Creek (CW-006) have very high frequencies of standard violations (Table 2). However the Wildcat Creek station (CW-096) downstream of the confluence with Tools Fork has a substantially lower rate of violations. It is not possible with the available data to separate leaking or overflowing sewers from failing septic systems, or 'general' urban runoff. For modeling purposes these possible sources are considered part the continuous source loading.

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 Fishing Creek watershed.

4.1 upper Fishing and Tools Fork Creeks

TMDLs for these two stream segments were developed using a simple mass balance approach as suggested in the USEPA (2001) Protocol for Developing Pathogen TMDLs. The estimated loads were added up to calculate the existing load. These two sub-watersheds are too small to obtain valid results from the model (NPSM) used for the other stream segments. These TMDLs were calculated using the warm season estimated flow. The average flow for the upper Fishing Creek, which is not gauged, was calculated from the generation coefficient determined for an adjacent gauged stream, Rocky Creek (USGS 02147500). Calculations and spreadsheets are presented in Appendices B and C.

4.2 Fishing Creek

4.2.1 Model Selection

The US EPA has assembled a variety of tools to use in the development of TMDLs. The Fishing Creek watershed is a relatively large basin with significant land uses with 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 all streams except the two small sub-watersheds (upper Fishing Creek and upper Tools Fork Creek). 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.

4.2.2 Model Set Up

The Fishing Creek watershed was delineated into eleven sub-watersheds in order to characterize the relative fecal coliform bacteria contributions from the significant contributing sub-watersheds (see Figure 1). The two separately identified sub-watersheds are included in these sub-watersheds. Watershed delineation was based on the RF1 stream coverage and elevation data. In addition, this discretization 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 Lockhart meteorological station were used in the simulations for all sub-watersheds but the two most southern ones (040 and 042), which used Winnsboro. Both of these stations are outside of the watershed, which may contribute to difficulties in calibrating the model such as matching peak flows during the summer and using computed data to replace missing data.

4.2.3 Model Calibration

The calibration of the watershed model is a two-step process; first the hydrology and then water quality. The simulated stream hydrograph is compared to the measured stream hydrograph from a reliable source such as a U.S. Geological Survey (USGS) stream gauging station. By adjusting model parameters in the Data Editor module (Pwater and Iwater), the model response can be changed. The model is considered to be calibrated hydrologically when the most of the simulated peaks match the measured peaks and the baselines are the same. Parameters such as evapotranspiration 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. Fishing Creek does not have a flow gauge, so the hydrology parameter values determined for the Rocky Creek model were used. The Rocky Creek watershed borders the

Fishing Creek watershed on its western side and is similar in size, soils, slope, and land uses. The USGS gauge (USGS 02147500) on Rocky Creek 2.5 km upstream of its confluence with the Catawba River near Great Falls was used to calibrate the Rocky Creek flow model.

Water quality was monitored at 11 stations in the Fishing Creek watershed, though only nine stations are included in this TMDL. Calibration of the model was based on 3 stations: CW-225 in the Fishing Creek headwater reach; CW-008 in Fishing Creek below South Fork Fishing Creek; and CW-233 in the lowest Fishing Creek reach. The model output was also checked at the two upstream stations. Model calibration results are shown in Appendix D. Results show that the model adequately simulates fecal coliform bacteria in response to rainfall events and suspected inputs. Often 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. A comparison of simulated water quality concentrations and observed concentrations for sampling stations in the watershed are shown in Appendix D.

4.2.4 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 30-day period for which the model predicts the largest violation of the geometric mean standard (EPA 1991) and the flow during the period is closest to the stream average. Basing the TMDL on this period ensures that the standard can be met throughout the period of simulation. For the upper Fishing and Tools Fork Creeks, the critical conditions were determined to be the average for warm season (May – October).

5.0 MODELING RESULTS

5.1 Existing Conditions

An examination of the model output indicates that the primary sources of fecal coliform loading to Fishing Creek are nonpoint sources related to agricultural and urban activities. Existing loading from nonpoint sources to the Fishing Creek watershed are presented in Table 6.

5.2 Critical Conditions

The critical condition for Fishing Creek was determined from the plot of the 10-year simulation of fecal coliform and the comparison of average flow for the 30-day period to the average flow for Fishing Creek (1989-98) (Appendix E). The critical period for this TMDL was the 30-day period prior to and including August 22, 1994 (July 24-August 22). This critical period was chosen

Table 6. Existing loads to the Fishing Creek watershed by compliance point (sampling station).

Stations on Fishing Creek	Names of impaired Streams	Sub-watersheds Included	Loading from Runoff	Loading from other Sources	Total Existing NPS Load	Point Sources Loads	Total Existing Load
CW-005 & CW-225	Fishing Creek	049	9.16E+13	1.83E+12	9.35E+13	3.41E+10	9.35E+13
CW-006	Wildcat Creek	047	1.64E+13	1.78E+11	1.65E+13	0	1.65E+13
CW-096	Wildcat Creek	046, 047, & 048	6.36E+13	1.03E+12	6.47E+13	3.88E+09	6.47E+13
CW-224	Fishing Creek	045, 046, 047, 048, & 049	1.57E+14	2.94E+12	1.60E+14	3.80E+10	1.60E+14
CW-008	Fishing Creek	042, 043, 044, 045, 046, 047, 048, 049, & 050	4.17E+14	7.92E+12	4.25E+14	4.54E+10	4.25E+14
CW-227 & CW-234	Neeleys Creek & Tinkers Branch	041	3.34E+13	6.59E+11	3.40E+13	1.08E+09	3.40E+13
CW-233	Fishing Creek	All	4.64E+14	9.07E+12	4.73E+14	4.65E+10	4.73E+14

because the mean flow for this 30-day period was closest to the mean flow for Fishing Creek for the period of simulation. The mean flow for the 1989-98 period was 242 cfs. Extremes in flow, especially low flows, can affect the concentration of fecal coliform. Basing this TMDL on the maximum fecal coliform concentration during the 10-year period would probably result in a required reduction of greater than 99.9 %. Recreational use of creeks is unlikely during high flow events and may be unsafe due to fast moving and deep water. In addition to basing decisions on the 30-day geometric means during the critical period; the percentage of predicted daily values exceeding the 400 cfu/100 ml standard was also calculated (Appendix G).

5.3 Model Uncertainty

There are several sources of uncertainty in the Fishing Creek model. These include the rainfall data from outside the watershed, limited water quality data - especially during high flow conditions, inherent variability in fecal coliform sampling, and little or no information on sources like failing or leaking septic systems and sanitary sewer overflows. These uncertainties should be considered in evaluating the recommendations in this TMDL.

6.0 TMDL

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.

For most pollutants, TMDLs are expressed on a mass-loading basis (e.g., kilograms per day). For bacteria, however, TMDLs can be expressed in terms of organism counts or cfu (colony forming units) or the resulting concentration, in accordance with 40 CFR 130.2(l). For this document loading will be expressed as cfu/30-days, which is the length of the critical period.

6.1 Wasteload Allocations

There are now seven active wastewater dischargers with permits to discharge fecal coliform bacteria in the Fishing Creek drainage (Table 7). The York Fishing Creek Wastewater Treatment Plant (SC0038156) is the largest discharger of wastewater in the watershed. This facility in the upper Fishing Creek sub-watershed is permitted for a flow of 2.0 mgd (3.1 cfs) and accounts for 76 % of the permitted wasteload into the watershed. The Chester County - Manetta WWTP (SC0001741), which discharges into the lower Fishing Creek, is the second largest discharger in the basin. The waste load from all the seven facilities is 5.85×10^{11} cfu/30 days. Because the permits for these facilities are already at the water quality standard, no reductions are required from these facilities.

Table 7. Wasteload Allocations (WLA) for Fishing Creek.

Discharger Name	**NPDES Number**	**WS#**	**Receiving Stream**	**Flow (mgd)**	**Load (cfu/30 days)**
York-Fishing Creek WWTP	SC0038156	049	Fishing Creek	2.000	4.54E+11
Utilities of SC – Country Oaks SD	SC0039217	048	Tools Fork	0.020	4.54E+09
Adnah Road MHP	SC0041670	048	Tributary to Tools Fork	0.040	9.08E+09
McAfee Mobile Home Park	SC0027111	049	Hope Branch	0.018	4.09E+09
Chester-Manetta Plant	SC0001741	042	Fishing Creek	0.500	1.14E+11
Neelys Creek Homes Inc.	SC0041904	041	Neelys Creek	0.008	1.82E+09
Jack Nelson Enterprises	SC0027341	041	Neelys Creek Tributary	0.012	2.73E+09
Totals				2.598	5.90E+11

6.2 Load Allocation

Nonpoint sources were arranged into two groups for the model. Sources that accumulate on the land and are then washed into streams or ponds are under 'Loading from Runoff' in Table 8.
Other 'direct' non-point sources such as failing septic systems, leaking sewers, overflowing sewers, and cattle in-streams, which may reach surface waters without rainfall, are listed as 'Loading from other Sources'. In the last column loading to Fishing Creek from the nonpoint sources (load allocation) is provided.

The loading presented in Table 8 represents one scenario where reductions were applied equally to loading from runoff (agricultural and built-up) and to the 'other source' loading. Reductions are applied differently to the sub-watersheds because more reductions are required in the upper sub-watersheds; 69 % in Fishing Creek headwaters (049), 80 % in the upper Wildcat Creek (047), while an overall 48 % reduction is required for whole watershed. Other reduction scenarios are possible so long as the water quality standard can be met at the compliance points. Plots of 30-day geometric mean existing and predicted TMDL fecal coliform bacteria are presented in Appendix F.

Table 8. Existing and TMDL non-point source loads to Fishing Creek by compliance point (cfu/30 days).

Stations in Fishing Creek Watershed	Names of Impaired Streams	Sub-watersheds Included	Existing Runoff Load	Existing Load from other Non-Point Sources	Existing Total Non-Point Source Load	TMDL - Total Load Allocation	Total Reduction	Percent Reduct-ion
CW-029	upper Fishing Creek	NA	2.52E+12	3.27E+10	2.66E+12	4.2E+11	2.24E+12	84.2%
CW-005 & CW-225	Fishing Creek	049	9.16E+13	1.83E+12	9.35E+13	2.86E+13	6.49E+13	69.1%
CW-212	upper Tools Fork Creek	NA	6.27E+12	1.38E+12	7.65E+12	1.96E+11	7.45E+12	97.4%
CW-006	Wildcat Creek	047	1.64E+13	1.78E+11	1.65E+13	3.39E+12	1.32E+13	79.5%
CW-096	Wildcat Creek	046, 047, & 048	6.36E+13	2.79E+12	6.64E+13	1.38E+13	5.26E+13	79.2%
CW-224	Fishing Creek	045, 046, 047, 048, & 049	1.57E+14	2.94E+12	1.60E+14	4.41E+13	1.16E+14	72.3%
CW-008	Fishing Creek	042, 043, 044, 045, 046, 047, 048, 049, & 050	4.17E+14	7.92E+12	4.25E+14	2.28E+14	1.97E+14	46.3%
CW-227 & CW-234	Neelys Creek & Tinkers Branch	041	3.34E+13	6.59E+11	3.40E+13	1.04E+13	2.37E+13	69.5%
CW-233	Fishing Creek	All	4.64E+14	9.07E+12	4.73E+14	2.48E+14	2.25E+14	47.5%

Note: Percent reduction refers to the reduction in the actual loading.

Reductions of 84 % were recommended for the upper Fishing Creek (above CW-029); and 97 % for the upper part of Tools Fork Creek (above CW-212). The reduction in the upper Fishing Creek is similar to that recommended for sub-watershed 049 of which it is a part. The reduction for the upper part of the Tools Fork basin is much higher than that required for sub-watershed 048 of which it is a part. Fecal coliform bacteria in the upper Fishing Creek was determined to be primarily of an urban nature. On the other hand fecal coliform bacteria in the upper Tools Fork Creek were attributed primarily to runoff from a livestock operation.

6.3 Margin of Safety

There are two basic methods for incorporating the margin of safety or MOS (USEPA 1991): 1) implicitly incorporate the MOS using conservative model assumptions to develop allocations, or 2) explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations. For this TMDL the MOS is explicit through the use of a 25 cfu/100 ml margin. Further safety is added by using a 10-year simulation period and by making conservative assumptions in developing the model. Several conservative assumptions were used in this model. For the allocation the point sources, discharge was assumed to be the maximum permitted limits. Other conservative assumptions are that all failing septic systems discharge directly into streams, and that all impervious land is directly connected to the stream network.

6.4 Total Maximum Daily Loads

Total maximum daily loads for fecal coliform for the seven stream reaches (nine compliance points) are the sums of the WLA, the LA, and the MOS (Table 9). The TMDLs represent 25 - 97 % reductions from the existing loads to the stream reaches. The greatest reduction in loading from nonpoint sources is required in the upper Tools Fork Creek sub-watershed (Appendix C).

6.5 Seasonal Variability

The model simulation covered a 10-year continual period so that all seasons were included. The simulation period included both wet and dry years. Monthly varying values were used for evapo-transpiration, roughness coefficients, and interception storage capacity.

7.0 IMPLEMENTATION

South Carolina has several tools available to reduce loading of fecal coliform bacteria due to agricultural activities as discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina*. 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 Fishing Creek watershed. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS) and the South Carolina Department of Natural Resources. Clemson Extension

Table 9. TMDL components for Fishing Creek watershed.

Compliance Point	**Sub-watersheds by Number**	**Sub-watersheds by Name**	**WLA (cfu/30 days)**	**LA (cfu/30 days)**	**MOS (cfu/30 days)**	**TMDL (cfu/30 days)**	**Target (cfu/30 days)**
CW-029	NA	upper Fishing Creek	0.0	4.2E+11	6.0E+10	4.8E+10	4.2E+11
CW-005 & CW-225	049	Fishing Creek above Wildcat Creek	4.58E+11	2.86E+13	4.09E+12	3.31E+13	2.91E+13
CW-212	NA	upper Tools Fork Creek	0.0	1.96E+11	6.6E+10	2.62E+11	1.96E+11
CW-006	047	Wildcat Creek	0.00E+00	3.39E+12	4.84E+11	3.87E+12	3.39E+12
CW-096	046, 047, 048	Wildcat Creek	1.32E+10	1.38E+13	1.97E+12	1.58E+13	1.38E+13
CW-224	045, 046, 047, 048, 049	Fishing Creek below Wildcat Creek	4.71E+11	4.41E+13	6.31E+12	5.09E+13	4.46E+13
CW-008	042, 043, 044, 045, 046, 047, 048, 049, 050	Fishing Creek below South Fork Fishing Creek	5.85E+11	2.28E+14	3.26E+13	2.61E+14	2.29E+14
CW-227 & CW-234	041	Neelys & Tinkers Creeks	4.54E+09	1.04E+13	1.48E+12	1.19E+13	1.04E+13
CW-233	All	lower Fishing Creek	5.90E+11	2.48E+14	3.54E+13	2.84E+14	2.49E+14

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. Fencing cattle out of streams and restoring a adequate stream buffer have been shown to reduce pollution entering streams. NRCS can provide cost share money to land owners installing BMPs. SCDHEC employs a nonpoint source educator who can also provide BMP information.

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 Fishing Creek.

SCDHEC will work with existing agencies in the region to provide nonpoint source education in the Fishing Creek watershed to reduce pollution from built-up areas. Local sources of nonpoint source education include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the York and Chester County Soil and Water Conservation Districts, and the South Carolina Department of Natural Resources. In addition, 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. In built-up areas, failing septic systems should be repaired or replaced. Also, maintenance of sanitary sewers and prevention of sewer overflows (from blockages) should be emphasized.

Using existing authorities and mechanisms, these measures will be implemented in the Fishing Creek Watershed in order to bring about a reduction in fecal coliform bacteria loading to Fishing Creek. The reductions will be targeted at urban sources and livestock sources.

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. This TMDL may be revised if additional monitoring data and better modeling tools become available.

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