Total Maximum Daily Load – Allison Creek
(Hydrologic Unit Code 0305010115)
Station CW-249
Fecal Coliform Bacteria

November 2006
Bureau of Water

SCDHEC Technical Document Number: 007-07

PROMOTE PROTECT PROSPER
South Carolina Department of Health
and Environmental Control

Abstract

The Allison Creek watershed is a tributary of the Catawba River located within York County in the Piedmont region of South Carolina (HUC 0305010115). Water quality monitoring station CW-249 (Allison Ck at S-46-114) is listed on the 2004 and draft 2006 303(d) list as impaired for recreational uses due to exceeding the fecal coliform standard. The primary land uses in the Allison Creek watershed above station CW-249 are forested (59.89%) and agriculture (32.85%). There is one permitted point source in the watershed, but it does not discharge waste containing fecal coliform. There are 3 permitted animal feeding operations within the watershed. Probable sources of fecal coliform bacteria in the swamp are wildlife, livestock, and possibly failing septic systems.

The TMDL and existing load for the Allison Creek watershed was developed using the load-duration curve methodology. The TMDL for station CW-249 is $3.12*10^{11}$ cfu/day. To reach the TMDL, existing load must be reduced by 81%. This can likely be achieved through nonpoint source education and agricultural BMPs.

Table of Contents

Tables and Figures

1.0 INTRODUCTION

1.1 Background

A Total Maximum Daily Load (TMDL) is a written plan and analysis to determine the maximum pollutant load a waterbody can receive and still meet applicable water quality standards. The TMDL process includes estimating pollutant loadings from all sources, linking pollutant sources to their impacts on water quality, allocation of pollutant loads to each source and establishment of control mechanisms to achieve water quality standards (US EPA, 1999). TMDLs are required to be developed for each waterbody and pollutant combination on the State 303(d) list by 40 CFR 130.31(a) (US EPA, 1999).

1.2 Watershed Description

The Allison Creek watershed is located within York County in the Upper Piedmont region of South Carolina. The Allison Creek watershed is a sub-watershed of the Catawba River Basin and is represented by the 12-digit hydrologic unit code (HUC) 030501011506 (Figure 1). The watershed encompasses a portion of the Town of Clover. Allison Creek originates near the Town of Clover and is joined by Morris Branch, Calabash Branch (Walker Branch), Grist Branch, Johnson Branch (Rock Branch), and Big Branch before forming an arm of Lake Wylie near the City of York.

There are two SC DHEC ambient water quality monitoring stations on Allison Creek, CW-171 (Allison Creek at US 321, 3.1 mi S of Clover) and CW-249 (Allison Creek at S-46-114). Station CW-171 was listed on the 1998, 2000 and 2002 303(d) lists as impaired for recreational uses due to exceeding the fecal coliform standard. A fecal coliform TMDL for CW-171 was approved in September 2003 (SC DHEC, 2003). Monitoring at station CW-249 began in 2001. Station CW-249 has been listed on the 2004 and draft 2006 303(d) lists as impaired for recreational uses due to exceeding the fecal coliform standard.

Figure 1. Location of the Allison Creek Watershed

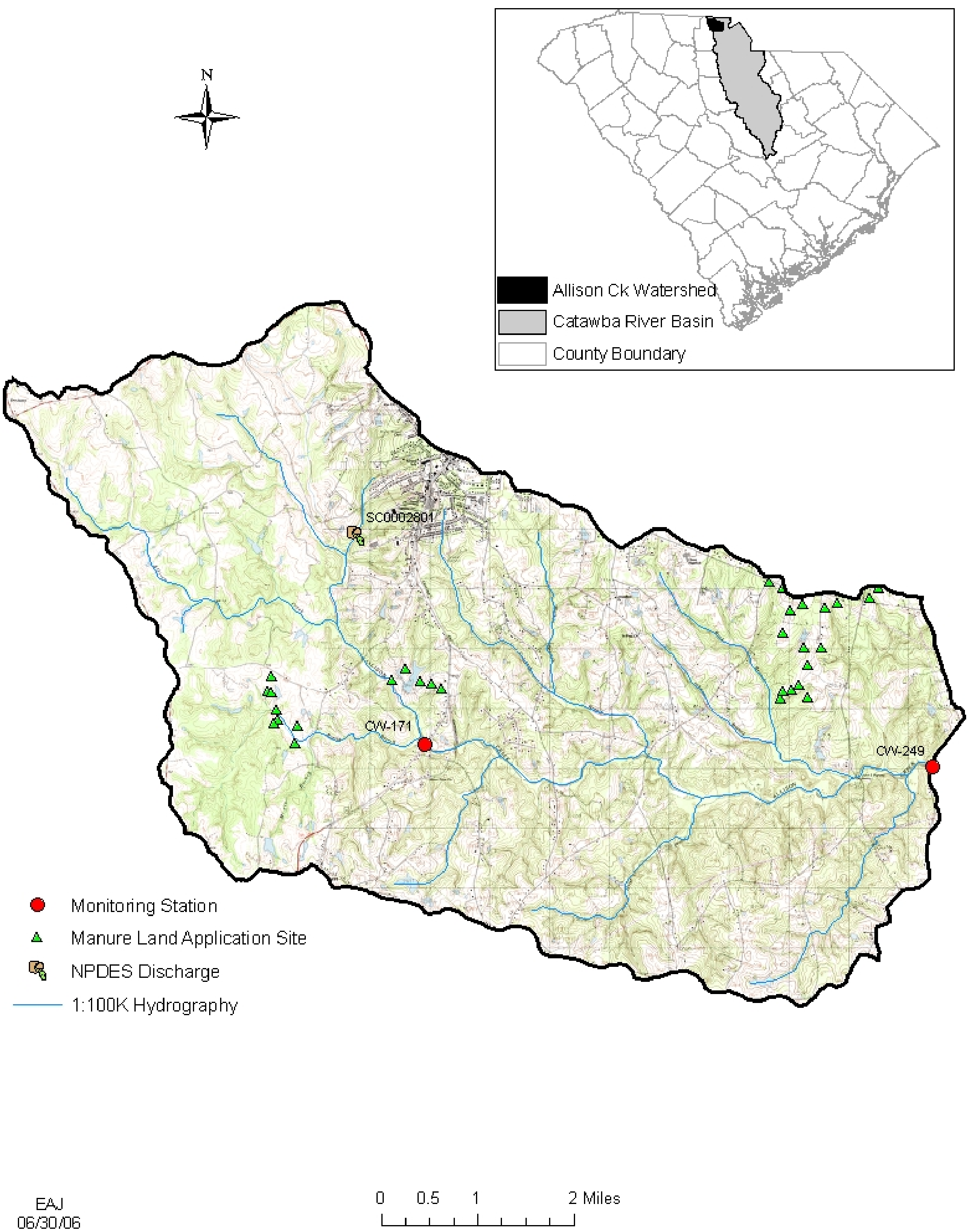
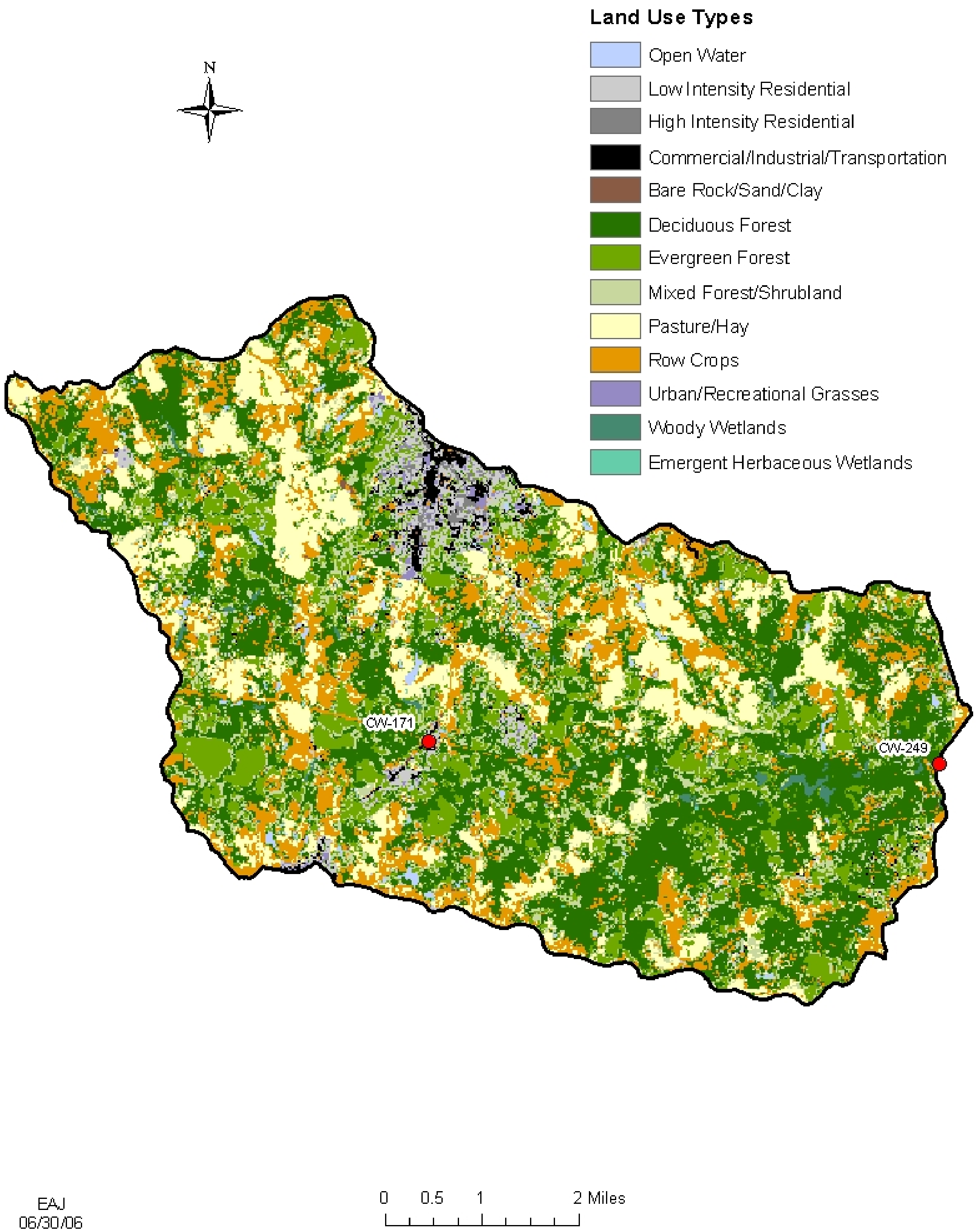


Figure 2. Land Use Within the Allison Creek Watershed



The primary land use in the Allison Creek watershed above station CW-249 is forest, with nearly sixty percent of the area designated as evergreen, deciduous or mixed forest by the United States Geological Survey (USGS) 1992 National Land Cover Dataset (NLCD) (Vogelmann, 2001). About one-third of the watershed area is agricultural with 16.25% designated as row crops and 16.60% designated as pasture/hay (Table 1).

Table 1. Land Use Summary

Land Use	Station CW-249	
	Area (mi^2)	Percent
Evergreen Forest	6.38	15.86
Mixed Forest	4.38	10.90
Deciduous Forest	13.32	33.13
Total Forested	***24.08***	***59.89***
Row Crops	6.53	16.25
Pasture/Hay	6.67	16.60
Total Agricultural	***13.20***	***32.85***
Low Intensity Residential	1.36	3.39
High Intensity Residential	0.13	0.33
Commercial/Industrial/Transportation	0.48	1.19
Total Developed	***1.97***	***4.91***
Woody Wetlands	0.28	0.70
Emergent Herbaceous Wetlands	0.05	0.12
Total Wetlands	***0.33***	***0.82***
Open Water	0.33	0.81
Bare Rock/Sand/Clay	0.10	0.25
Urban/Recreational Grasses	0.20	0.47
Total Other	***0.63***	***1.53***

1.3 Water Quality Standard

Water quality standards are based on the classification of the waterbody and are designed to protect the designated uses of that classification. Allison Creek is designated as Freshwaters (FW) by R.61-69, Classified Waters (SC DHEC, 2004a). Freshwaters are defined as:

> "freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements for 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" (SC DHEC, 2004c pg. 25).

The fecal coliform standard for FW includes a geometric mean and a single sample standard. The geometric mean standard is 200cfu/100mL, based on five consecutive samples during any 30-day period. The single sample standard is no more than 10% of samples in any 30-day period exceeding 400cfu/100mL (SC DHEC, 2004c).

2.0 WATER QUALITY ASSESSMENT

Assessment of water quality data collected in 2001-2004 at water quality monitoring station CW-249 indicates that this location is impaired for recreational use. Monitoring station CW-249 has been listed on the 2004 and draft 2006 303(d) list (SC DHEC 2004b, SC DHEC 2006). Waters in which no more than 10% of the samples collected over a five year period are greater than the single sample standard of 400 cfu/100mL are considered to comply with the South Carolina water quality standard for fecal coliform bacteria. Waters with more than 10% of samples exceeding the single sample standard are considered impaired. During the assessment period for the 2004 303(d) list, 48% of samples exceeded the standard. Thirty-nine percent of samples exceeded the standard during the 2006 303(d) assessment period (Table 2). Fecal coliform, precipitation and turbidity sample data is available in Appendix A.

Table 2. Data Summary for 2004-2006 303(d) List

303(d) List Year	Years Included	# Samples	Geometric Mean (cfu/100mL)	Maximum (cfu/100mL)	Minimum (cfu/100mL)	% Samples Exceeding Standard (400 cfu/100mL)
2004	1998-2002	21	352	16,000	70	48%
2006	2000-2004	41	362	16,000	65	39%

Fecal coliform values at station CW-249 are positively correlated to precipitation and sample turbidity (Figures 3&4). In general, fecal coliform counts increase with increasing rainfall or turbidity. Precipitation is measured at National Weather Service Cooperative site Fort Mill 4 NW, which is located at the outlet of HUC 0305010115 approximately 8 miles southeast of the monitoring station. Precipitation data for each sample date is available in Appendix A. A graph of daily precipitation plotted with fecal coliform concentrations is available in Appendix B. Turbidity samples are taken simultaneously with fecal coliform samples. Turbidity is a measurement of the scattering of light through a water sample due to suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms (APHA, 1995). The positive correlation implicates nonpoint sources of pollution related to rainfall runoff. Heavy rain can wash fecal matter that has collected on the land surface into the stream, increasing fecal coliform counts. The rain would also cause increased turbidity levels by suspending particles in the stream and by the sediment-laden runoff.

Figure 3. Relationship of Fecal Coliform with Precipitation

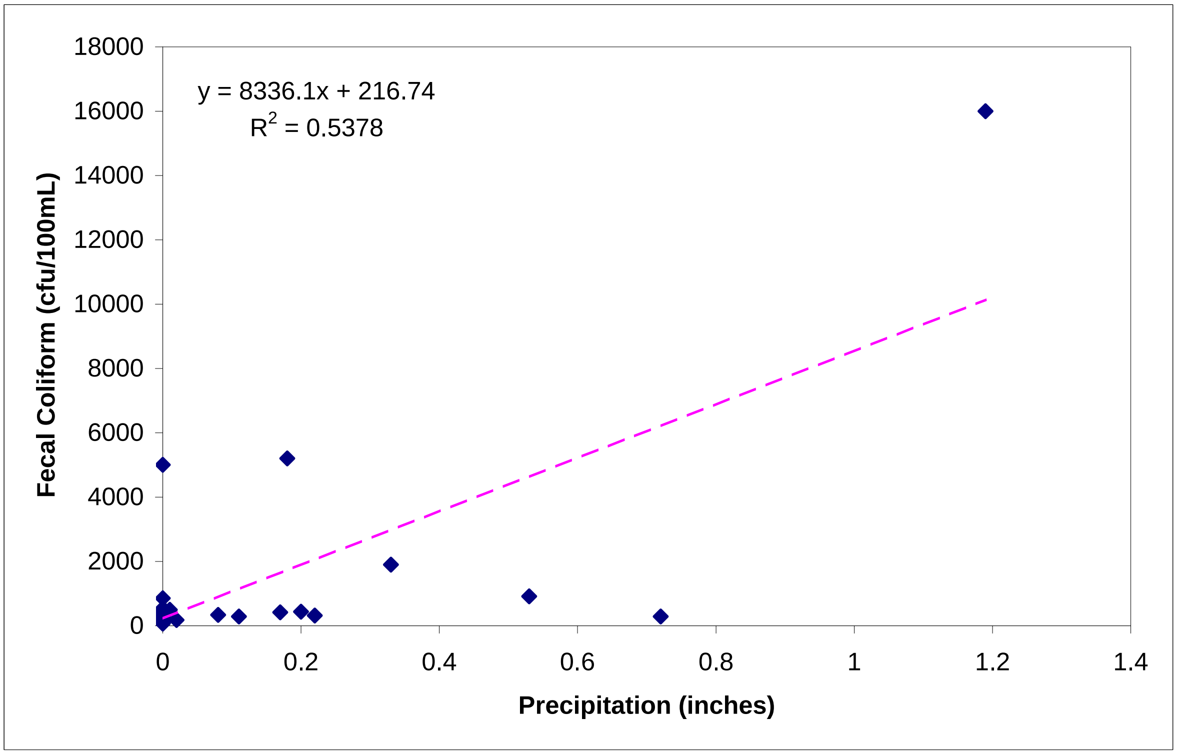
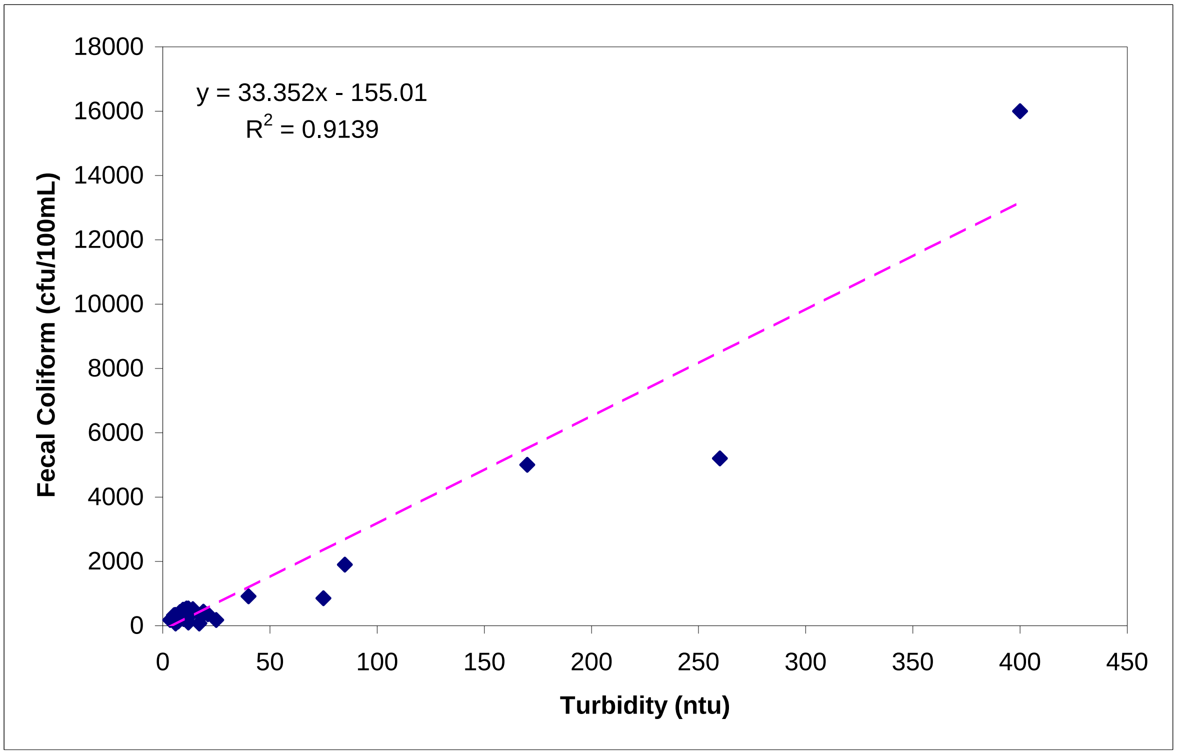


Figure 4. Relationship of Fecal Coliform with Turbidity



3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Surface waters may be contaminated by fecal coliform bacteria that originate from both point and nonpoint sources. Point sources are facilities, such as wastewater treatment plants and factories that have NPDES permits and discharge wastewater through a pipe or similar structure. Historically, poorly treated or untreated point sources of waste were a major source of fecal coliform bacteria. The Clean Water Act has remedied this problem. All point sources must have a NPDES permit and are required to treat wastewater to a satisfactory level. In South Carolina, NPDES permittees that discharge sanitary wastewater must meet the state standards for fecal coliform at the point of discharge.

3.1 Point Sources

3.1.1 Continuous Point Sources

There is one permitted discharger above the monitoring station within the Allison Creek watershed, North Safety Products, SC0002801 (Figure 1). This facility discharges to an unnamed tributary of Allison creek. The facility discharges process wastewater that does not contain domestic wastes and is not expected to contain fecal coliform bacteria. This discharge is not a source of fecal coliform bacteria to Allison Creek.

3.1.2 Intermittent Point Sources

The Allison Creek watershed has no designated Municipal Separate Storm Sewer System (MS4). However, there maybe industrial or construction activities going on at any time that could produce stormwater runoff. Industrial facilities that have the potential to cause or contribute to a violation of a water quality standard are covered by the NPDES Storm Water Industrial General Permit (SCR000000). Construction activities are covered by the NPDES Storm Water Construction General Permit from DHEC (SCR100000). Where the construction has the potential to affect water quality of a water body with a TMDL, the Storm Water Pollution Prevention Plan (SWPPP) for the site must address any pollutants of concern and adhere to any wasteload allocations in the TMDL.

3.2 Nonpoint Sources

3.2.1 Wildlife

Wildlife can be a significant source of fecal matter, and therefore fecal coliform. Wildlife wastes are carried into nearby streams by runoff during rainfall events or by direct deposition. Wildlife in this area includes deer and small mammals as well as a variety of birds. The Department of Natural Resources deer density map estimates 15-30deer/mi^2 in the upper reaches of the watershed and 30-45 deer/mi^2 in the lower portion of the watershed (SC DNR, 2000). Water birds may also be a contributor to fecal coliform load in Allison Creek. Although wildlife is possibly a source in the watershed, any control of the source would be difficult to implement and not likely to have the desired results.

3.2.2 Agricultural Activities

Agricultural activities that involve livestock or animal wastes are potential sources of fecal coliform contamination of surface waters. Fecal matter can enter the waterway by rainfall runoff from the land or by direct deposition into the stream.

3.2.2.1 Agricultural Animal Facilities

Owners/operators of most commercial animal growing operations are required by R. 61-43, Standards for the Permitting of Agricultural Animal Facilities, to obtain permits for the handling, storage, treatment (if necessary) and disposal of the manure, litter and dead animals generated at their facilities (SC DHEC 2002). The requirements of R. 61-43 are designed to protect water quality; therefore, we have a reasonable assurance that facilities operating in compliance with this regulation should not contribute to downstream water quality impairments.

While there are currently no confined animal feeding operations (CAFOs) in South Carolina, there are three permitted animal feeding operations (AFOs) within the watershed, which apply manure to approximately 30 fields, or manure utilization units, within the watershed (Figure 1). These operations include a turkey brooder facility with design capacity of 36,000 birds (ND0065404). The manure from the facility is applied by dry spreader to roughly 220 acres of fescue. The second permit (ND0015512) is for a dairy farm with a design capacity of 200 cattle. Manure from the dairy facility is applied by spray irrigation to approximately 200 acres of pastureland. The remaining permit (ND0013340) is for a small (10 hog design capacity) swine feeding operation. The manure from this facility is applied by spray irrigation. These facilities are routinely inspected for compliance with their permits. Permitted agricultural facilities that operate in compliance with their permit are not considered to be a source of impairment.

3.2.2.2 Grazing Animals

Pasture cattle and other grazing animals can contribute to fecal coliform contamination through runoff or direct deposition of manure. Runoff from rainfall may wash manure deposited on pastureland to nearby streams. Cattle and other livestock that are allowed access to streams may deposit manure directly into the waterbody. Defecation directly into a waterbody by cattle can be a very significant source of fecal coliform bacteria, as a single beef or dairy cow can produce $1.0*10^{11}$ organisms/day (ASAE, 1998). Pasture cattle facilities are not permitted through SC DHEC, but according to the 2002 Census of Agriculture, there are a total of 19,211 cattle and calves in York county (USDA, 2002). Assuming that cattle are evenly distributed across pastureland in the county, an estimate of the number of cattle in the watershed can be obtained by comparing the area of pasture/hay land use of the county to the area of pasture/hay land use within the watershed. This method gives a total of 1,960 cattle within the watershed.

3.2.3 Failing Septic Systems

Failed septic tanks can contribute to bacterial contamination of downstream waterbodies (US EPA, 2001). A portion of the watershed is within the Clover town limits and has sewer service. The remainder of the watershed is likely served by private septic tanks. A rough estimate of the population and number of households with septic systems was derived by comparing the GIS coverage of sewage lines with the 2000 census block coverage. Census blocks within the watershed that were intersected by sewer lines were considered to be on public sewer. All other blocks were considered to have private septic systems. Using this method, about 28% of the total population within the watershed is served by public sewer. The remaining 72% of the population, approximately 6,500 people in 2,500 households, use private septic tanks. The precise failure rate of these septic systems is unknown.

3.2.4 Urban Runoff

Urban and suburban stormwater runoff from streets, parking lots and lawns can contribute a large bacterial load to receiving waters (Gaffield, 2003). However, there is very little urban development within the watershed. A portion of the Town of Clover is the only urbanized area within the watershed. The Town of Clover is not currently under MS4 coverage. Total developed land within the watershed is less than two square miles. Due to the small size of the urban area, loading from this source is most likely insignificant at this time.

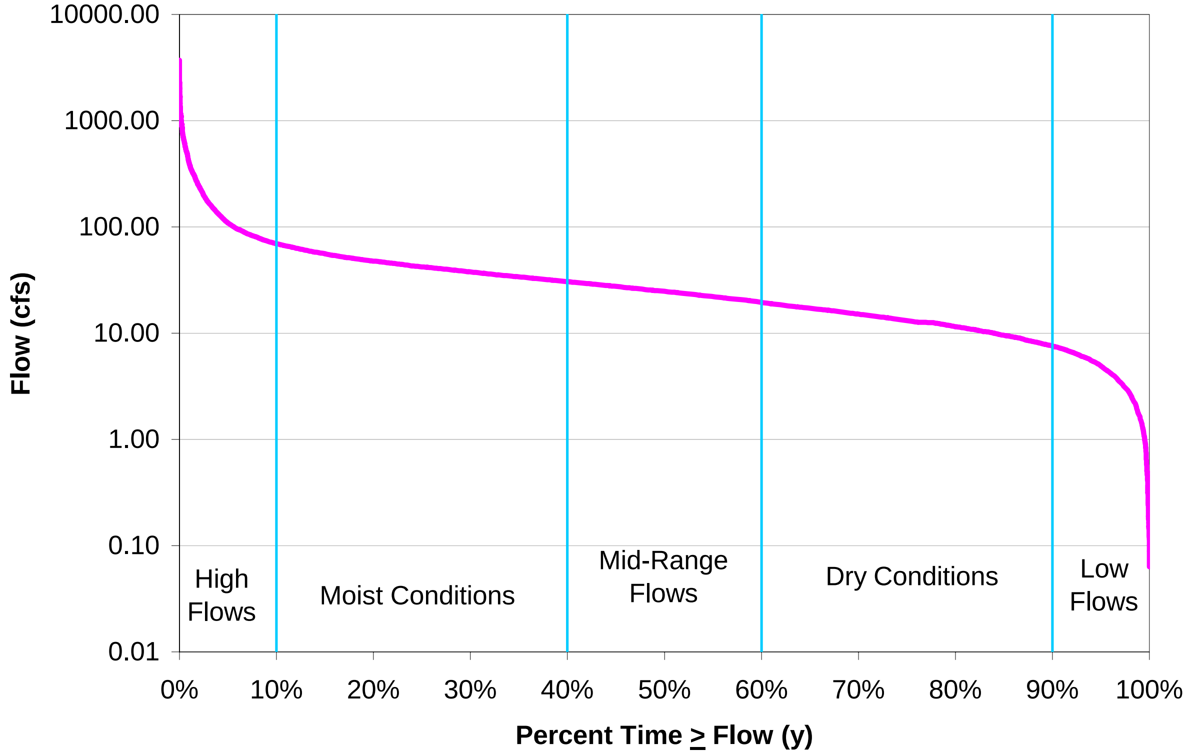
4.0 METHODS

The TMDL for the Allison Creek watershed was developed using the load-duration curve methodology. Load-duration curves were developed as a method of calculating TMDLs that apply to all hydrologic conditions. The load-duration curve method uses the cumulative frequency distribution of stream flow and pollutant concentration data to estimate the existing and the total maximum daily loads for a waterbody.

4.1 Flow-Duration Curve

The first step in the load-duration methodology is the development of a flow-duration curve. Flow-duration curves are used for a variety of management purposes including water-use planning and characterization of erosion and sedimentation problems (Fan and Li, 2004). Flow-duration curves provide a graphic representation of the cumulative frequency of historic flow data over a time period (Cleland, 2003). Flow-duration curves are typically generated from long-term continuous-record flow-gauging USGS stations. There is not a USGS gauge within the Allison Creek watershed. Long Creek, in Gaston county North Carolina is a comparable, nearby gauged stream with a similar sized drainage area, land uses and topography. Data from the Long Creek gage (USGS 0214400) near Bessemar City, NC for the period of record (01/01/1953 – 12/31/2004) was used to generate the flow-duration curve. Daily mean streamflow data was retrieved from http://sc.water.usgs.gov/. The Allison Creek watershed is slightly larger than the USGS gage drainage area. Daily flow data was adjusted to account for the difference in drainage area by multiplying the daily flow rates from Long Creek by the ratio of Allison Creek drainage area to that of Long Creek (1.266). The flow-duration curve points are found by ranking the daily flow from highest to lowest and calculating the percent of days these flows were exceeded. These points are then plotted on a semi-log plot with flow on the y-axis and percent on the x-axis to form the curve (Figure 3). Low values of x correspond to the highest flows or flood conditions (flows rarely exceed these values) and high values correspond to the lowest flows, which are nearly always exceeded (drought conditions) (Cleland, 2002).

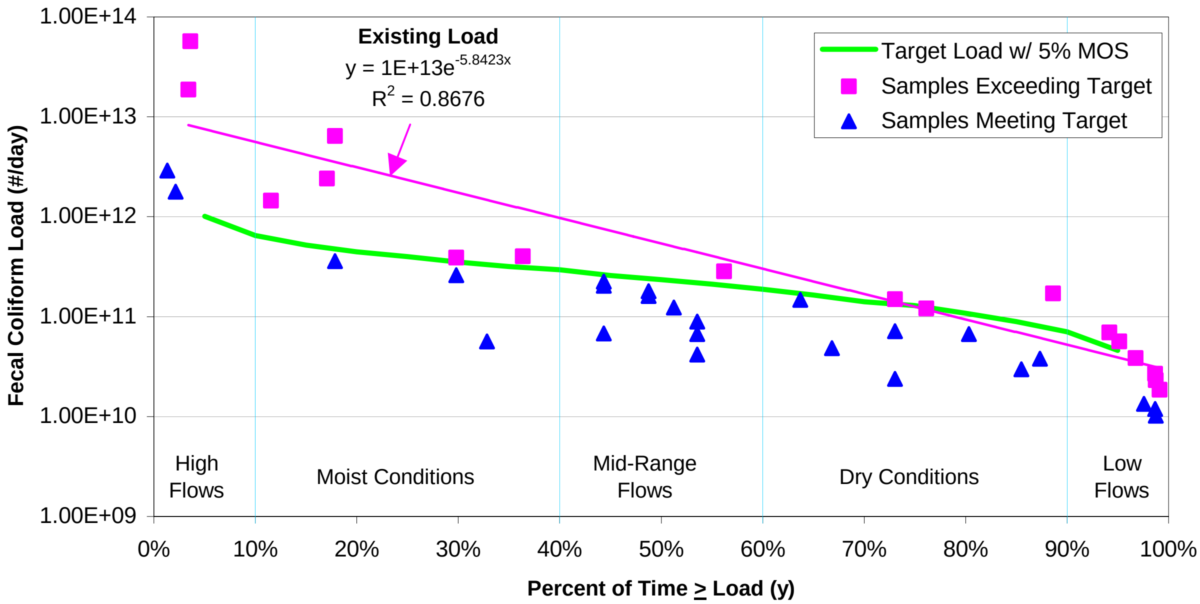
Figure 3. Flow-Duration Curve



4.2 Load-Duration Curve

After development of the flow-duration curves, load-duration curves are created by combining flow duration data with water quality data (Cleland, 2002). Points for this plot are calculated by multiplying daily stream flows by the water quality standard concentration and a conversion factor to get daily load. These values were calculated at 5% flow intervals from 5%-95% and plotted on semi-log scale with y being the daily load of fecal coliform and x being the percent of time the flow is exceeded and hence the percent of time the load is exceeded. The curve was calculated using the instantaneous water quality standard with a 5% margin of safety, which equals 380 cfu/100mL (Figure 4).

Figure 4. Load-Duration Curve



4.3 Existing Load Calculation

To calculate the average existing load for development of the TMDL, the water quality sample values are plotted on the load-duration curves. Water quality monitoring data for the period of record, 2001-2004, was used for calculation of this fecal coliform TMDL. Data used in TMDL development is listed in Appendix A. Daily loads for each water quality sample were calculated by multiplying the sample concentration by the flow on that date and a conversion factor. The flows used for this calculation are those calculated for the flow-duration curve. Flows were not recorded during sample collection. Daily loads are then plotted on the load-duration curve with y being the sample load and x being the percentile corresponding to that day's flow. A line is then fit through the sample loads that exceed the margin of safety standard, in this case an exponential function provided the best fit (Figure 4).

5.0 DEVELOPMENT OF THE TMDL

5.1 Critical Conditions

Critical conditions are the "worst-case" environmental conditions for exceedance of water quality standards and which occur at an acceptable frequency (US EPA, 1999). Load-duration curves allow for visualization of critical conditions. If high samples values are mainly confined to a specific flow range, the critical conditions for establishing the TMDL can be targeted to that flow range. This information can also be used to target potential sources. For example exceedances that occur at low flows could indicate point source contributions, while exceedances at higher flows would be more indicative of non-point sources (Cleland, 2003). Many of the more extreme fecal coliform standard violations in Allison Creek occur within the high flow and moist conditions ranges. This is in agreement with the positive correlation between fecal coliform and turbidity. High flows due to runoff, which cause increased turbidity, are related to high fecal coliform counts. Although the more extreme violations occur in the high flow ranges, standard violations occurred over much of the total range of flows. Critical conditions for this TMDL are taken to be the flow range between the 5th and 95th percentile, incorporating all but the most extreme flows. This is considered appropriate because the standards are based on not more than 10% exceedance and loading occurring at extreme flows is unlikely to be controllable. Seasonal variation is taken into account since all but the most extreme flows are represented in the calculations.

5.2 Wasteload Allocation

The wasteload allocation (WLA) is the portion of the TMDL allocated to point sources (US EPA, 1999).

5.2.1 Continuous Point Sources

There is no continuous point source WLA for this TMDL because this watershed has no NPDES facilities that discharge wastes expected to contain fecal coliform bacteria.

5.2.2 Intermittent Point Sources

Intermittent point sources include all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction instead of a numeric loading due to the uncertain nature of stormwater discharge volumes and recurrence intervals. Stormwater discharges are required to meet the percentage reduction or the existing instream standard for pollutant of concern, whichever is less restrictive. The percent reduction applied is the same as that applied to the existing load, 81%.

5.3 Existing Load

The line fit to the exceedance data is used to calculate existing load. The equation of the fitted line is applied at 5% intervals for the 5^{th} to 95^{th} percentile flows and the resultant loads averaged to determine an average existing load at critical conditions (Appendix D). The average existing load for station CW-249 is $1.55*10^{12}$ cfu/day (Table 3).

5.4 Margin of Safety

A margin of safety (MOS) allows for an accounting of the uncertainty in the relationship between pollutant loads and receiving water quality (US EPA, 1999). Incorporation of a MOS can be done either explicitly within the TMDL calculation or implicitly by using conservative assumptions (US EPA, 1999). The margin of safety component of the TMDL for Allison Creek is calculated explicitly. Five percent or 20 cfu/100mL of the water quality standard (400 cfu/100mL) is reserved in the TMDL calculation as a margin of safety. Again, loads were calculated for the 5^{th} to 95^{th} percentile and averaged (Appendix D). This results in an average margin of safety load of $1.56*10^{10}$ cfu/day (Table 3). Conservative assumptions in the modeling process also contribute to the margin of safety.

5.5 Calculation of the TMDL

A TMDL represents the loading capacity (LC) of a waterbody, which is the maximum loading a waterbody can receive without exceeding water quality standards (US EPA, 1999). The TMDL is the sum of the wasteload allocations (WLA) for point sources, the load allocation (LA) for non-point sources and natural background, and a margin of safety (MOS). The TMDL can be represented by the equation:

TMDL = LC = WLA + LA + MOS (US EPA, 2001).

The TMDL was calculated as the water quality standard concentration, converted to load and averaged over the 5^{th} to 95^{th} percentile flows. This gives a loading capacity of $3.12*10^{11}$ cfu/day (Appendix D). Since the existing load for the station is greater than the calculated loading capacity or TMDL, a reduction in existing loading is required to meet water quality standards. Percent reduction is calculated as:

$$\frac{\text{Existing Load - Load Allocation}}{\text{Existing Load}}*100\,.$$

This calculation results in an 81% load reduction at station CW-249 to consistently meet the instantaneous water quality criteria for fecal coliform (Table 3). By meeting the instantaneous standard it is assumed the geometric mean criteria will also be consistently met.

Table 3. TMDL Components for Allison Creek

Station ID	TMDL (cfu/day)	MOS (cfu/day)	WLA		LA (cfu/day)	Existing Load (cfu/day)	% Reduction to Meet Load Allocation[3]
			Continuous Sources[1] (cfu/day)	Intermittent Sources[2] (% Reduction)			
CW-249	$3.12*10^{11}$	$1.56*10^{10}$	n/a	81%	$2.96*10^{11}$	$1.55*10^{12}$	81%

Table Notes:

1. WLA is expressed as total monthly average.
2. Percent reduction applies to all NPDES-permitted stormwater discharges, including current and future MS4, construction and industrial discharges covered under permits numbered SCS & SCR. Stormwater discharges are expressed as a percentage reduction due to the uncertain nature of stormwater discharge volumes and recurrence intervals. Stormwater discharges are required to meet percentage reduction or the existing instream standard for pollutant of concern, whichever is less restrictive.
3. Percent reduction applies to existing load.

A TMDL for station CW-171, which is above CW-24, in the watershed (Figure 1), was completed in 2003. At station CW-171 a reduction of 67% was needed to consistently meet the instantaneous water quality criteria for fecal coliform. This finding is consistent with the current finding. It would be expected that a station further down in the watershed would receive more non-point source loading and therefore require a greater percent reduction from current load to meet standards.

6.0 IMPLEMENTATION

As discussed in the *Implementation Plan for Achieving Total Maximum Daily Load Reductions From Nonpoint Sources for the State of South Carolina* (SC DHEC, 1998), South Carolina has several tools available for implementing this nonpoint source TMDL. Specifically, SC DHEC's animal agriculture permitting program addresses animal operations and land application of animal wastes. There are also a number of voluntary measures available to interested parties. SC DHEC will work with the existing agencies in the area to provide nonpoint source education in the Allison Creek Watershed. Local sources of nonpoint source education and assistance include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the York 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 agricultural nonpoint source problems. NRCS can provide cost share money to land owners installing BMPs.

SC DHEC is empowered under the State Pollution Control Act to perform investigations of and pursue enforcement for activities and conditions that 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 Allison 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 Allison 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. SC DHEC 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 voluntary mechanisms, these measures will be implemented in the Allison Creek watershed in order to bring about an 81% reduction in fecal coliform bacteria loading to Allison Creek. SC 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.

7.0 REFERENCES

American Public Health Association, American Water Works Association and Water Environment Association (APHA). 1992. Standard Methods for the Examination of Water and Wastewater (19th ed.): Washington, D.C., American Public Health Association, p. 2-8 to 2-11.

American Society of Agricultural Engineers (ASAE). 1998. ASAE Standards, 45th Edition. Standards, Engineering Practices, Data.

Cleland, B.R. 2002. "TMDL Development from the "Bottom Up" – Part II: Using Duration Curves to Connect the Pieces." National TMDL Science and Policy 2002 – WEF Specialty Conference. Phoenix, AZ. November 2002.

Cleland, B.R. 2003. "TMDL Development from the "Bottom Up" – Part III: Duration Curves and Wet Weather Assessments." National TMDL Science and Policy 2003 – WEF Specialty Conference, Chicago, IL. November 2003.

Fan, C. and Li, J. 2004. "A Modelling Analysis of Urban Stormwater Flow Regimes and their Implication for Stream Erosion." *Water Quality Research Journal of Canada Vol 39, No 4*: 356-361.

Gaffield, S.J., Goo, R.L., Richards, L.A., Jackson, R.J. 2003. "Public Health Effects of Inadequately Managed Stormwater Runoff." *American Journal of Public Health Vol 93, No. 9*: 1527-1533.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 1998. Implementation Plan for Achieving Total Maximum Daily Load Reductions from Nonpoint Sources for the State of South Carolina.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 2002. Standards for the Permitting of Agricultural Animal Facilities (R.61-43). Effective June 28,2002. [Electronic Version]; 105pp.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 2003. Total Maximum Daily Load Development for Allison Creek: Station CW-171, Fecal Coliform Bacteria. Technical Report No. 011-03. Approved September 19,2003. [Electronic Version]; 20pp.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 2004a. Classified Waters (R.61-69). Amended May 28, 2004. Printed April 2005; 36pp.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 2004b. State of South Carolina Section 303(d) List for 2004. Approved September 23, 2004. Printed February 2005; 30pp.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 2004c. Water Classifications & Standards (R.61-68). Amended June 25, 2004. Printed April 2005; 56pp.

South Carolina Department of Health and Environmental Control (SC DHEC) Bureau of Water. 2006. Draft State of South Carolina Section 303(d) List for 2006. [Electronic Version]; 47pp.

South Carolina Department of Natural Resources (SC DNR). 2000. SC Deer Density 2000. Retrieved from www.dnr.sc.gov/wildlife/deer March 21, 2006.

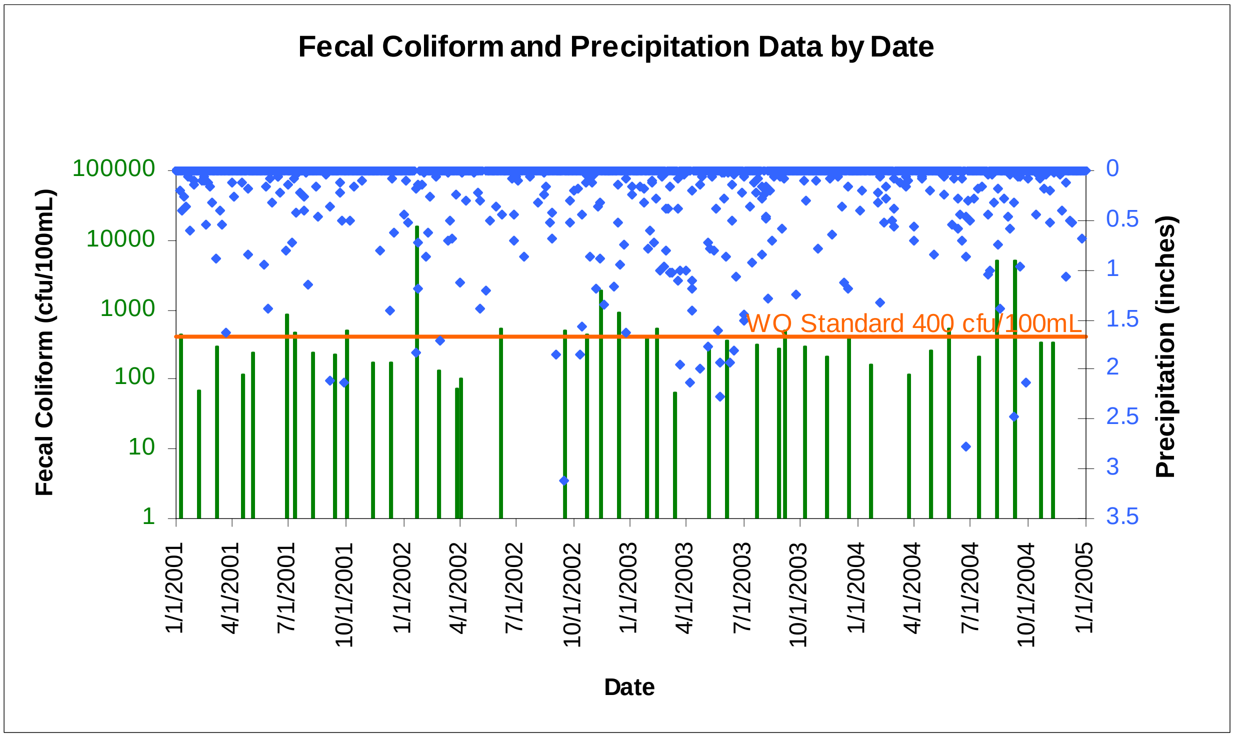
United States Department of Agriculture, National Agricultural Statistics Service (USDA). 2002. 2002 Census of Agriculture. Retrieved from www.nass.usda.gov/Census_of_Agriculture/index.asp July 7,2006.

United States Environmental Protection Agency (US EPA). 1999. Draft Guidance for Water Quality-based Decisions: The TMDL Process. Second Edition. Office of Water, EPA 841-D-99-001.
United States Environmental Protection Agency (US EPA). 2001. Protocol for Developing Pathogen TMDLs. First Edition. Office of Water, EPA 841-R-00-002.
Vogelmann, J.E., S.M. Howard, L. Yang, C.R. Larson, B.K. Wylie, N. Van Driel, 2001. Completion of the 1990s National Land Cover Data Set for the Conterminous United States from Landsat Thematic Mapper Data and Ancillary Data Sources, Photogrammetric Engineering and Remote Sensing, 67:650-652.

APPENDIX A – WATER QUALITY DATA, 2001-2004

Sample Date	Fecal Coliform (cfu/100mL)	Precipitation (inches)	Turbidity (NTU)
1/8/2001	440	0.2	19
2/5/2001	70	0	6
3/6/2001	300	0	18
4/17/2001	120	0	6.3
5/2/2001	240	0	5.1
6/27/2001	860	0	75
7/10/2001	480	0	11
8/6/2001	240	0	9.7
9/11/2001	220	0	7.9
10/2/2001	500	0	9.4
11/13/2001	180	0	3.4
12/12/2001	180	0.02	25
1/23/2002	16000	1.19	400
2/25/2002	130	0	7.2
3/27/2002	75	0	17
4/2/2002	100	0	12
6/5/2002	540	0	11
9/17/2002	500	0.01	11
10/23/2002	430	0	8
11/13/2002	1900	0.33	85
12/11/2002	920	0.53	40
1/27/2003	390	0	10
2/12/2003	540	0	12
3/12/2003	65	0	17
5/5/2003	290	0.72	9
6/3/2003	360	0	21
7/21/2003	320	0.22	9.8
8/26/2003	280	0	12
9/4/2003	500	0	10
10/7/2003	290	0.11	6.4
11/12/2003	210	0	4.2
12/17/2003	420	0.17	12
1/22/2004	160	0	6.6
3/23/2004	120	0	6
4/27/2004	260	0	9
5/26/2004	520	0	14
7/14/2004	210	0	9.7
8/12/2004	5200	0.18	260
9/9/2004	5000	0	170
10/19/2004	340	0.08	5.8
11/9/2004	330	0	5.3

APPENDIX B – DAILY PRECIPITATION VERSUS FECAL COLIFORM



APPENDIX C – LOADING CALCULATIONS

Loading Capacity	
Target: 400 cfu/100ml	
% Exceeded	Load
5%	1.07E+12
10%	6.81E+11
15%	5.47E+11
20%	4.71E+11
25%	4.21E+11
30%	3.72E+11
35%	3.34E+11
40%	3.10E+11
45%	2.73E+11
50%	2.48E+11
55%	2.23E+11
60%	1.98E+11
65%	1.73E+11
70%	1.49E+11
75%	1.36E+11
80%	1.14E+11
85%	9.41E+10
90%	7.43E+10
95%	4.83E+10
Average	**3.12E+11**

Margin of Safety	
Target: 20 cfu/100ml	
% Exceeded	Load
5%	5.33E+10
10%	3.41E+10
15%	2.74E+10
20%	2.35E+10
25%	2.11E+10
30%	1.86E+10
35%	1.67E+10
40%	1.55E+10
45%	1.36E+10
50%	1.24E+10
55%	1.11E+10
60%	9.91E+09
65%	8.67E+09
70%	7.43E+09
75%	6.81E+09
80%	5.70E+09
85%	4.71E+09
90%	3.72E+09
95%	2.42E+09
Average	**1.56E+10**

Existing Load	
$Y=1*10^{13}e^{-5.8423x}$	
% Exceeded	Load
5%	7.51E+12
10%	5.60E+12
15%	4.18E+12
20%	3.12E+12
25%	2.33E+12
30%	1.74E+12
35%	1.30E+12
40%	9.71E+11
45%	7.25E+11
50%	5.42E+11
55%	4.04E+11
60%	3.02E+11
65%	2.25E+11
70%	1.68E+11
75%	1.26E+11
80%	9.38E+10
85%	7.01E+10
90%	5.23E+10
95%	3.91E+10
Average	**1.55E+12**

APPENDIX D – PUBLIC PARTICIPATION

NOTICE OF AVAILABILITY OF INITIAL DRAFT TMDL
ALLISON CREEK WATERSHED
YORK COUNTY

Pollutant of Concern: Fecal Coliform Bacteria. Allison Creek Watershed: Hydrologic unit 030501011506. A Map of this watershed is available on the Internet at: www.scdhec.gov/water/shed/cat_main.html.
Persons wishing to submit views and information on this draft total maximum daily load are invited to make these submissions in writing no later than 5:00pm October 23, 2006, to: S.C. Dept. of Health and Environmental Control, Bureau of Water, 2600 Bull St, Columbia, S.C. 29201, Attn: Matt Carswell, or via e-mail to carsweme@dhec.sc.gov. Persons may also contact Ms. Erica Johnson at Johnsoea@dhec.sc.gov. The purpose of TMDLs is to calculate the amount of pollutant reduction necessary for an impaired waterbody to achieve and maintain water quality standards. Comments will be considered in development of the final draft TMDL and addressed in a responsiveness summary to be provided to all commenters. Copies of individual TMDLs can be obtained from the Bureau of Water web site: http://www.scdhec.gov/water or by calling, writing, or e-mailing at the address above. 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 TMDL for waters identified as impaired.