Total Maximum Daily Load Horse Creek
(Hydrologic Unit Code: 03060106060, -030, -040 & -050)
Stations SV-069, SV-072, SV-073 & SV-250
Fecal Coliform Bacteria

September 28, 2005

SCDHEC Technical Report Number: 007-06

Abstract

Total Maximum Daily Loads (TMDLs) have been developed for the Horse Creek Watershed, which are tributaries of the Savannah River in Aiken and Edgefield Counties, SC. Sand River, Little Horse Creek and Horse Creek were listed South Carolina's 303(d) list in 2004. Two of these sites have been listed since 1998. The locations are water quality monitoring station SV-069, Sand River at old US 1 1.2 Mi SE Warrenville; SV-073, Little Horse Creek at SC 421; SV-072, Horse Creek at S-02-145; and SV-250, Horse Creek at SC 125 1.5 Mi SW Clearwater. During the assessment period for the 2004 303(d) list (1998-2002), 11 % of samples at SV-069, 11 % at SV-073, 41% at SV-072, and 17 % at SV-250 exceeded the water quality standard. The watershed of Horse Creek is mostly forest, non-urban transitional, and urban around the Cities of Aiken and North Augusta. There is one point source of fecal coliform bacteria in the watershed. The Cities of Aiken and North Augusta as well as adjacent developed areas have been designated as a Municipal Separate Storm Sewer System (MS4). The probable sources of fecal coliform bacteria in Horse Creek are urban runoff, sewer leaks, sanitary sewer overflows, failing septic tanks, and cattle in creek.

The load-duration curve methodology was used to calculate the existing loads and the TMDL loads for the creek. Existing loads and TMDL loads are presented in Table Ab-1. In order to reach the target loads for Horse Creek, reductions in the existing loads to the creek of 11% to 47% will be necessary. Resources and several TMDL implementation strategies to bring about these reductions are suggested.

Table Ab-1. Total Maximum Daily Loads for Horse Creek Watershed at impaired stations.

Station ID	Existing Waste Load Continuous (cfu/day)	TMDL WLA Continuous[1] (cfu/day)	TMDL WLA MS4[2]	Existing Load (cfu/day)	TMDL LA (cfu/day)	MOS (cfu/day)	TMDL (cfu/day)	Percent Reduction[3]
SV-069	NA	NA	47%	2.88E+11	1.53E+11	8.06E+09	1.61E+11	47%
SV-073	NA	NA	11%	5.48E+11	4.90E+11	2.58E+10	5.16E+11	11%
SV-072	2.62E+08	2.62E+08	30%	2.16E+12	1.52E+12	8.01E+10	1.60E+12	30%
SV-250	NA	NA	43%	2.86E+12	1.63E+12	8.60E+10	1.72E+12	43%

Table Notes:
1. WLA is expressed as total monthly average.
2. MS4 expressed as percent reduction equal to LA reduction.
3. Percent reduction applies to LA and MS4 components when an MS4 is in the watershed.

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INTRODUCTION

1.1 Background

Fecal coliform bacteria is widely used as an indicator of pathogens in surface waters and wastewater. Acute gastrointestinal illnesses affect millions of people in the United States and cause billions of dollars of costs each year (Gaffield et al, 2003). Of these illnesses many are caused by contaminated drinking water. Untreated stormwater runoff has been associated with a number of disease outbreaks, most notably the outbreak in Milwaukee that caused many deaths.

Though occurring at low levels from natural sources, the concentration of fecal coliform bacteria can be elevated in water bodies as the result of pollution. Sources of fecal coliform bacteria are usually diffuse or nonpoint source, such as stormwater runoff, failing septic systems, and leaking sewers. Occasionally, the source of the pollutant is a point source. 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 Horse Creek watershed in Aiken and Edgefield Counties is in the Southeastern Plains of western South Carolina (Figure 1). Horse Creek is a tributary of the Savannah River downstream of Lake Thurmond. Portions of the Cities of Aiken and North Augusta are in the watershed. Approximately 54000 people live in the Horse Creek watershed in 24000 households (2000 US Census). These TMDLs include those parts of the watersheds upstream of four water quality stations. Information about the watersheds is given in Table 1.

Table 1. Horse Creek water quality monitoring site descriptions.

Watershed	Station ID	Sampling Station Description	Drainage Area (km^2)	(mi^2)	Population
Sand River	SV-069	Sand River at Old US 1	37.3	14.4	13400
Little Horse Creek	SV-073	Little Horse Creek at SC 421	119.4	46.1	11600
Horse Creek	SV-072	Horse Creek at S-02-145	379.7	146.6	46900
Horse Creek	SV-250	Horse Creek at SC 125	407.7	157.4	54200

Forest is the principal land use in the watershed; 63 % of the watershed above station SV-250 (entire Horse Creek watershed) was forest in 1992 (Table 2 and Figure2). Undeveloped transitional made up 13 % and urban landuse made up 13 % of this watershed. The highest percentage of transitional landuse (14.5%) was documented in the Little Horse Creek watershed. This suggests that parts of the Horse Creek Watershed is experiencing a movement from less open pasture to a more forested land.

Figure 1. Map of Horse Creek watershed, Savannah Basin.

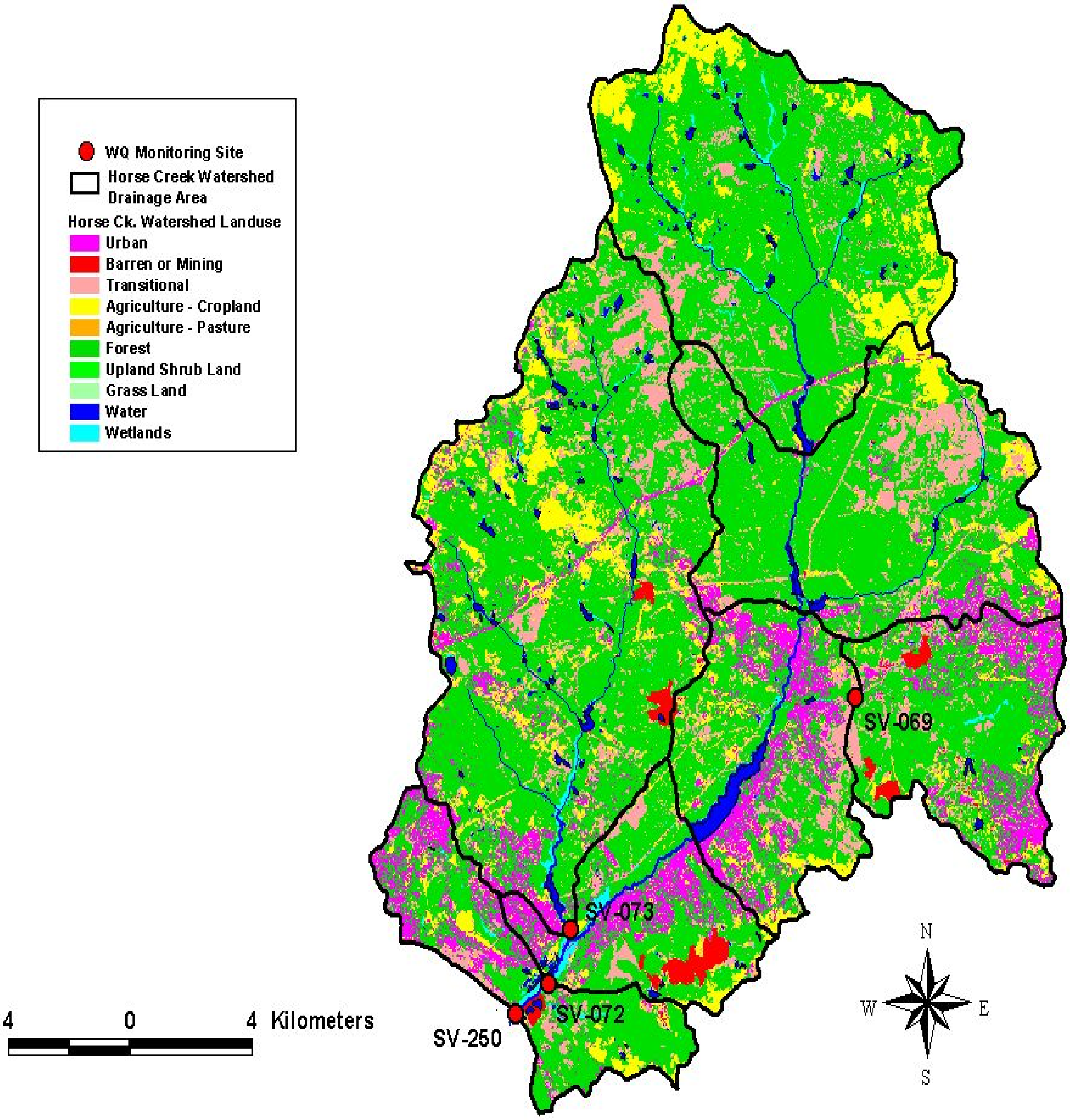


Figure 2. Map showing land uses in the Horse Creek watershed.

These land use data are from the National Land Cover Data 1992 (NLCD 1992) (Figure 2; Table 2). Note the most heavily urbanized area was above station SV-069 (Sand River); this watershed drains a significant portion of the City of Aiken.

1.3 Water Quality Standard

The impaired stream segments of Horse Creek 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).

Primary contact recreation is not limited to large streams and lakes. Even streams that are too small to swim in, will allow small children the opportunity to play and immerse their hands and faces. Essentially all perennial streams should therefore be protected from pathogen impairment.

Table 2. Land uses in Horse Creek watershed by water quality monitoring station.

Land Use Class		Area (hectares)				Percentage			
		SV-069	SV-072	SV-073	SV-250	SV-069	SV-072	SV-073	SV-250
Transitional (33)		480.2	4985.2	1727.0	5272.4	13.0%	13.1%	14.5%	12.9%
Water (11)	**Water**	9.6	466.2	176.4	479.61	0.3%	1.2%	1.5%	1.2%
Developed (21-23)	Residential Low Density	483.1	2012.8	447.75	2393.46				
	Residential High Density	80.6	400.1	77.31	490.14				
	Commercial, Industrial, & Transportation	195.8	837.5	150.84	929.07				
	Urban	**759.5**	**3250.4**	**675.9**	**3812.7**	20.4%	8.6%	5.7%	9.4%
	Quarries/Mines	91.2	357.2	91.4	397.8	2.4%	0.9%	0.8%	1.0%
	Barren	32.6	113.7	30.5	123.8	0.9%	0.3%	0.3%	0.3%
Forest (41-43)	Forest Deciduous	122.1	3755.7	1242.9	4005.5				
	Forest Evergreen	1674.5	15615.6	4756.7	16596.7				
	Forest Mixed	303.1	4895.2	1742.7	5252.5				
	Forest	**2099.7**	**24266.5**	**7742.3**	**25854.66**	56.5%	63.9%	64.8%	63.4%
Pasture (81)	**Pasture**	36.4	559.0	155.7	632.0	1.0%	1.5%	1.3%	1.6%
Cropland	**Cropland**	83.5	3259.4	1171.8	3414.78				
(61,82-84)									
		83.5	**3259.4**	**1171.8**	**3414.8**	2.2%	8.6%	9.8%	8.4%
Wetlands (91-92)	Woody Wetlands	28.3	434.8	121.5	481.9				
	Emergent Herbaceous Wetlands	0.8	45.3	16.56	46.9				
	Wetlands	**29.1**	**480.1**	**138.1**	**480.1**	0.8%	1.3%	1.2%	1.3%
Total for Watershed		**3621.8**	**37737.7**	**11909.0**	**40467.8**	**97.5%**	**99.4%**	**99.9%**	**99.5%**

2.0 WATER QUALITY ASSESSMENT

The Horse Creek Watershed has four water quality monitoring stations (Table 1 and Figure 1). An assessment of water quality data collected from 1998 through 2002 for the 2004 303(d) list at these stations indicated that all were impaired for recreational use. Sand River (SV-069) and Horse Creek (SV-072) have been placed on the 303(d) list of impaired waters since 1998; Downstream Horse Creek (SV-250) first appeared on the 2002 303(d) list. Little Horse Creek (SV-073) first appeared on the list in 2004. Waters in which no more than 10% of the samples collected over a five year period are greater than 400 fecal coliform counts or cfu/100 ml 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 for fecal coliform bacteria and placed on South Carolina's 303(d) list. Descriptive statistics for data collected since 1990 at these locations is provided in Appendix A Table A-4. All of the data is provided in Appendix A Tables A-1 and A-2.

Water quality has generally degraded in Horse Creek at these locations since the 1998 assessment. In particular, the percentage of samples exceeding the standard of 400 cfu/100ml has increased from 13 % during the 1992-1996 period to 41 % during the 1998-2002 period (Table 3). It is only fair to note that the Horse Creek tributary locations (Sand River and Little Horse Creek) only marginally exceeded the same criterion during the 2004 303(d) assessment at 11%.

Table 3. Changes in percentage of standard violations by 303(d) list and site.

		Percent of Standard Violations			
303(d) List	**Time Period**	**SV-069**	**SV-072**	**SV-073**	**SV-250**
1998	1992-1996	**15%**	**13%**	8%	3%
2000	1994-1998	**12%**	10%	8%	0%
2002	1996-2000	7%	**24%**	10%	**13%**
2004	1998-2002	**11%**	**41%**	**11%**	**17%**

While fecal coliform bacteria was related to turbidity in Sand River (SV-069; Figures 4), the relationship was not evident in Little Horse Creek or mainstem of Horse Creek (SV-072, SV-073 & SV-250; Figures 5, 6 & 7). The association with turbidity indicates that fecal coliform is being washed into the creek with runoff. Note that Sand River drains a significant portion of the City of Aiken (urban landuse). In Little Horse Creek and mainstem Horse Creek, however, the major sources of fecal coliform appear to be a combination runoff and continuous, such as livestock in the stream, failing septic systems, illicit discharges, or leaking sewers (in areas where sewer service is available.

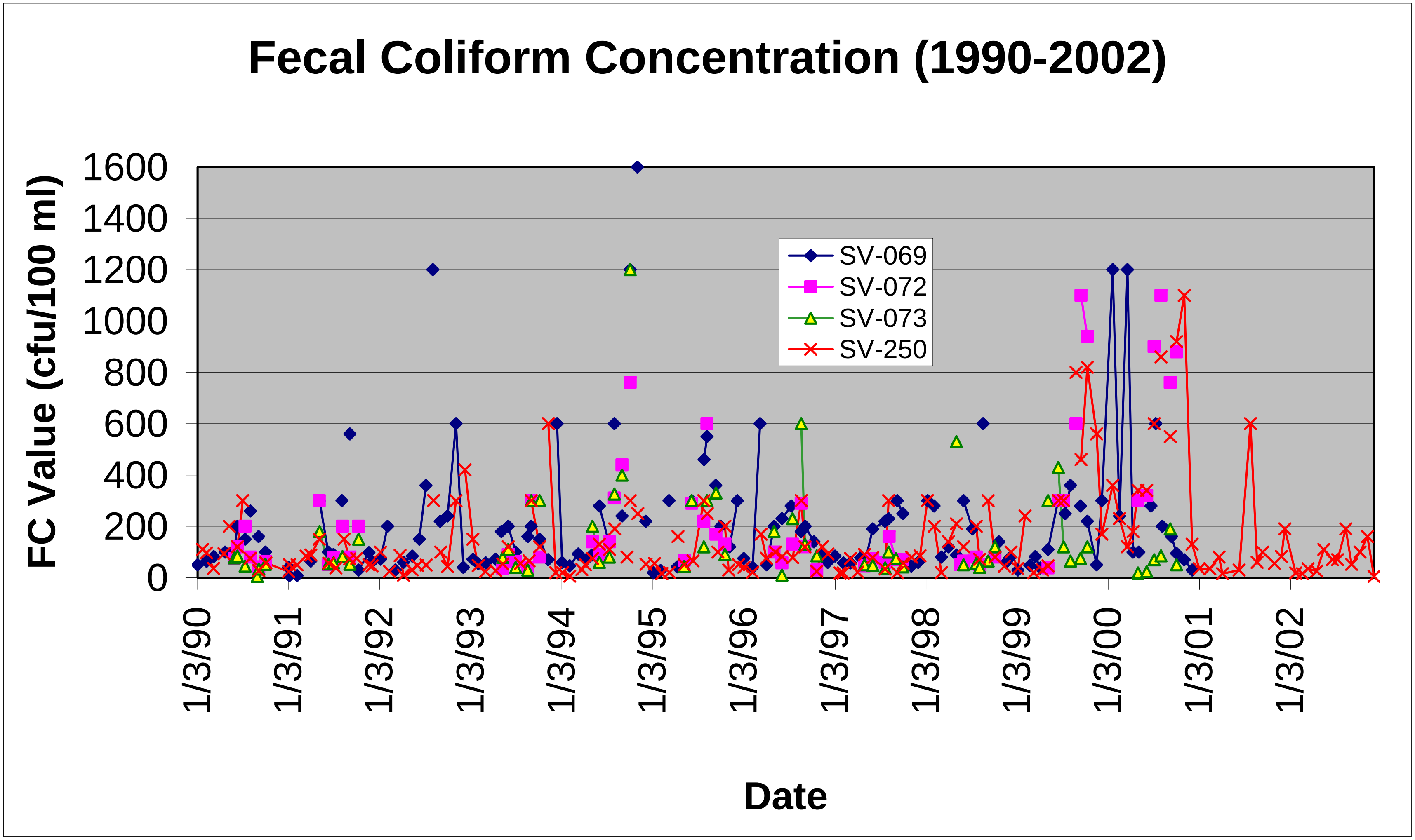


Figure 3. Fecal coliform concentrations in Horse Creek at four locations over time.

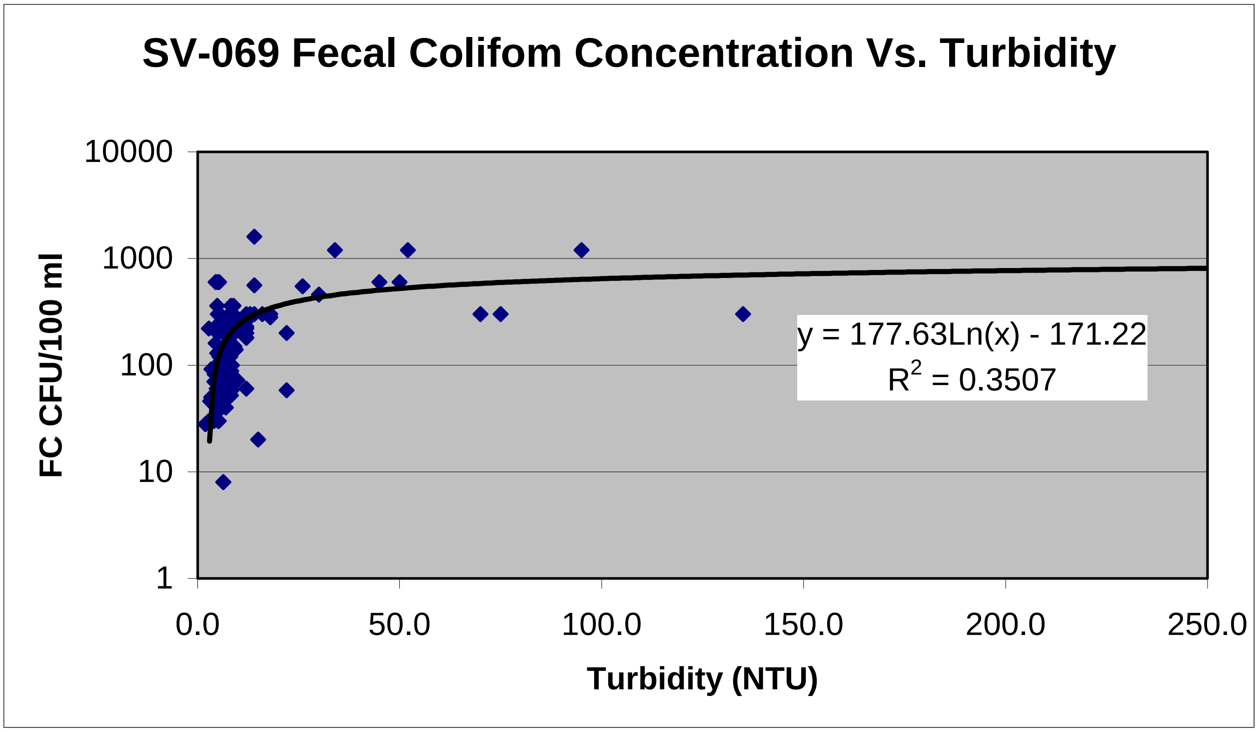


Figure 4. Comparison of turbidity and fecal coliform concentrations in Sand River.

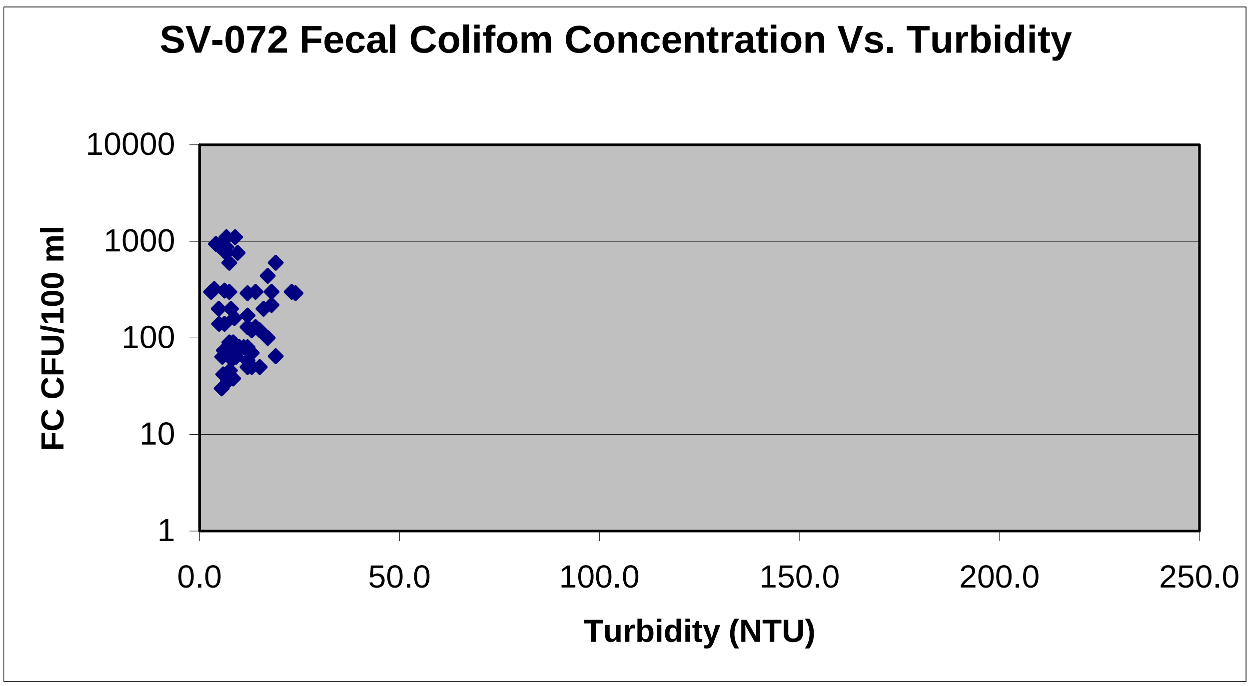


Figure 5. Comparison of turbidity and fecal coliform concentrations in Horse Creek.

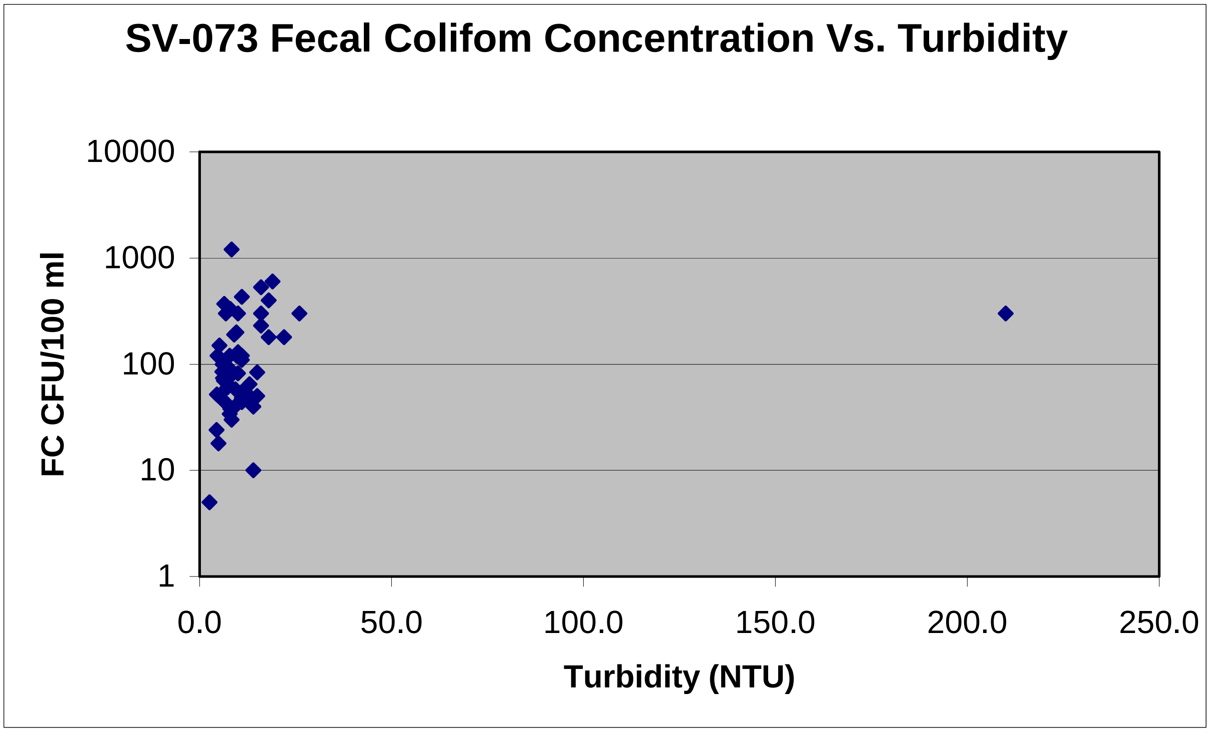


Figure 6. Comparison of turbidity and fecal coliform concentrations in Little Horse Creek.

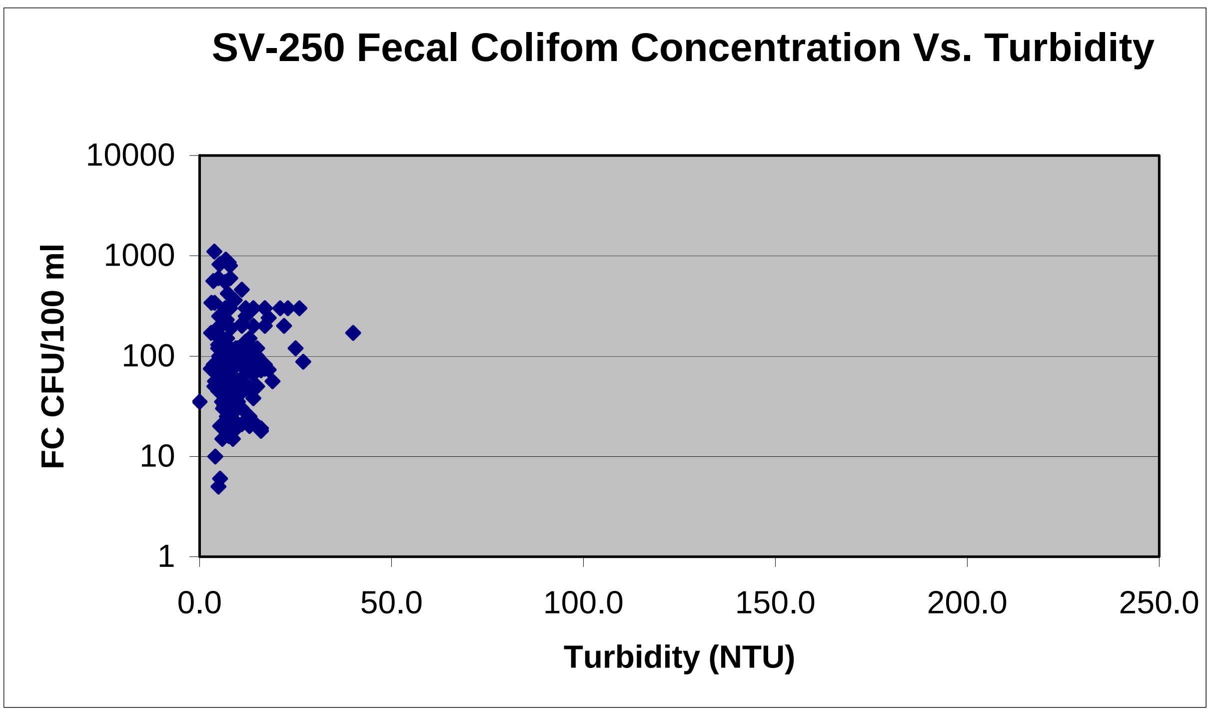


Figure 7. Comparison of turbidity and fecal coliform concentrations in Horse Creek.

There is not a simple relationship between precipitation and fecal coliform concentration in the watershed (Appendix B; Figures B-1 through B-4). Fecal coliform concentrations show some increase with rainfall, as measured in nearby Aiken 4 NE (cooperative monitoring station); but the relationship is not clear. This pattern also suggests that there are both continuous sources of fecal coliform bacteria such as leaking sewers or livestock in the stream and rainfall associated sources, such as runoff from pasture land or land application of waste.

3.0 SOURCE ASSESSMENT AND LOAD ALLOCATION

Fecal coliform bacteria are used by the State of South Carolina as the indicator for pathogens in surface waters. Pathogens, which are usually difficult to detect, cause disease and make full body contact recreation in lakes and streams risky. Indicators such as fecal coliform bacteria, enteroccoci, or E. *Coli* are easier to measure, have similar sources as pathogens, and persist a similar or longer length of time in surface waters. These bacteria are not in themselves usually disease causing.

There are many sources of pathogen pollution in surface waters. In general these sources may be classified as point and nonpoint sources. With the implementation of technology-based controls, pollution from point sources, such as factories and wastewater treatment facilities, has been greatly reduced. These point sources are required by the Clean Water Act to obtain a NPDES permit. In South Carolina NPDES permits require that dischargers of sanitary wastewater must meet the state standard for fecal coliform at the point of discharge. Municipal and private sanitary wastewater treatment facilities may occasionally be sources of pathogen or fecal coliform bacteria pollution. However, if these facilities are discharging wastewater that meets their permit limits, they are not causing the impairment. If one of these facilities is not meeting its permit limits, enforcement of the permit limit is required. A TMDL is not necessary for this purpose. Pathogen or fecal coliform TMDLs are therefore essentially nonpoint source TMDLs even though the TMDL may include a wasteload allocation for a point source.

3.1 Point Sources in the Horse Creek Watershed

3.1.1 Continuous Point Sources

Currently there is one NPDES discharger or point source in the Horse Creek watershed that has a permit to discharge wastewater containing fecal coliform bacteria. GTX/Castlewood Mobile Home Estates (SC0032638) is permitted to discharge 0.0173 MGD of treated sanitary wastewater into Horse Creek upstream of SV-072 and above the confluence with Little Horse Creek. Effluent data reported by the discharger (Appendix C) document fecal coliform exceedences during the 1990-2002 time-frame. While this facility may have contributed to the impairment of Horse Creek at downstream of SV-072, it should be noted that most fecal coliform bacteria excursions occurred prior to 1995; the current 303d list of impaired waters is based on 1998-2002 data. In addition, WWTP facility operation/maintenance was transferred to GTX Properties in January 2003. District SCHDEC staff have indicated the facility has operated more efficiently since that time. A precursory review of more current effluent data (2003-2004) revealed no additional excursions of the fecal coliform standard.

The Cities of Aiken and North Augusta have sewage collection systems that are partly in the Horse Creek watershed. In addition, there are numerous satellite collection systems in the watershed, particularly along the main stem of Horse Creek. Sewage collection systems typically are placed adjacent to waterways. At these locations, there is a potential for collection system leaks which could result in elevated instream concentrations of fecal coliform bacteria. Sanitary sewer overflows (SSOs) are also a potential source, particularly after periods of intense rainfall. This source is associated with infrequent events, limited in duration and likely to have an insignificant long-term impact on recreational use. Identified collection system and/or SSO problems are addressed by SCDHEC through compliance and enforcement mechanisms. Note that the City of Aiken has extensive collection system coverage in the Sand River Watershed (upstream of SV-069). From Jan. 1, 1998-December 31, 2002, SCDHEC documented a minimum of nine SSOs in the watershed for an estimated total of 2450 gallons of sanitary wastewater released at various locations.

A windshield survey of the watershed was conducted on May 26, 2005. As a part of the site visit, SCDHEC staff met with representatives of the City of North Augusta, Aiken County and the SC Dept. of Transportation. The purpose of meeting with local officials was to gain better knowledge of potential sources of fecal coliform bacteria in the watershed. Stakeholders emphasized that numerous satellite collection system problems may have contributed to historically elevated fecal coliform levels in the watershed. Many of these small collection systems are old have not been properly maintained. Beginning October 2003, general permit coverage has been in place for satellite sewer systems statewide. Permit requirements are outlined in R.61-9 and address proper operation, maintenance and compliance. Since that time, satellite sewer systems with identified permit violations have been addressed by SCDHEC through compliance/enforcement mechanisms.

3.1.2 Intermittent Point Sources

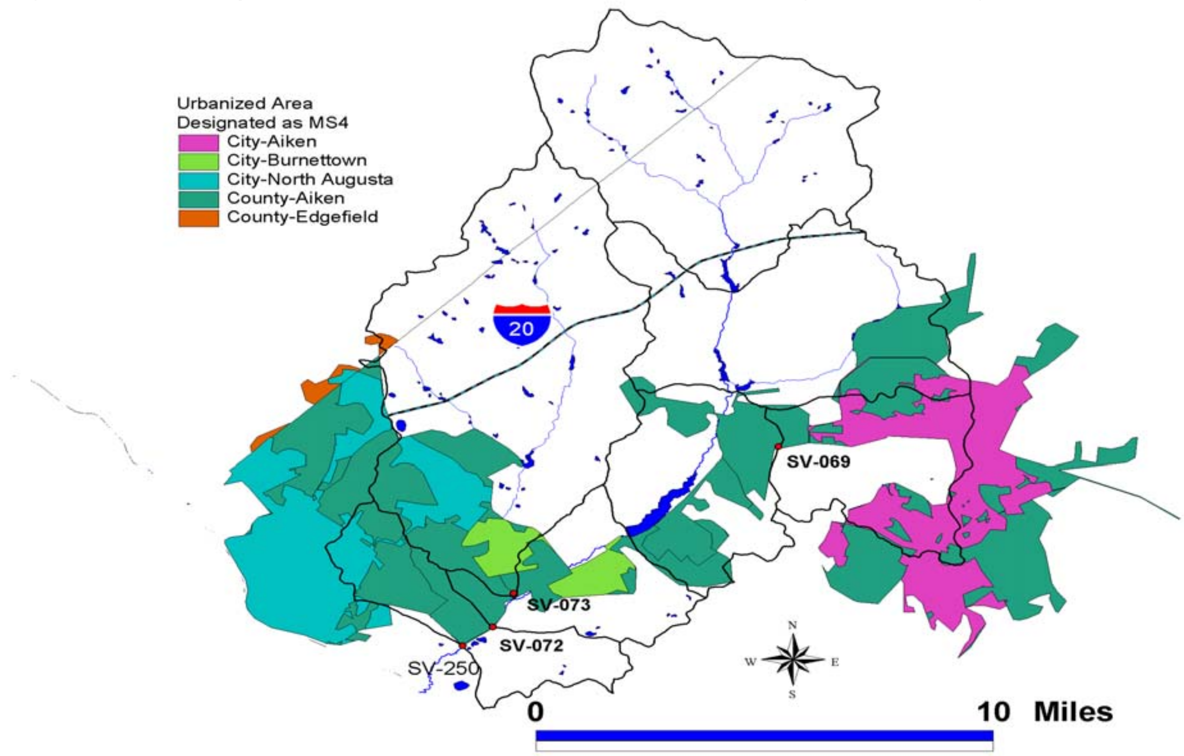
The City of North Augusta, Burnettown, the City of Aiken, Aiken County and Edgefield County have been designated as a Municipal Separate Storm Sewer System or MS4 under NPDES Phase II Stormwater rules. Parts of the MS4s are in the Horse Creek watershed (Figure 8). 99% of this urbanized land area under MS4 Phase II stormwater rules fall under jurisdiction of the Cities of North Augusta, Aiken, Burnettown, and Aiken County. These permitted sewer systems will be treated as point sources in the TMDL calculations below. Runoff from developed land that is collected by storm sewers and discharged untreated into streams is potentially a major source of fecal coliform bacteria to Horse Creek and tributaries.

3.2 Nonpoint Sources in the Horse Creek Watershed

3.2.1 Wildlife

In these rural and suburban watersheds wildlife (mammals and birds), which is a source of fecal coliform bacteria, is possibly a significant though not major contributor. Wildlife in this area includes deer and other mammals as well as a variety of birds. Wildlife wastes are carried into nearby streams by runoff following rainfall or deposited directly in streams. Waterfowl also may be significant contributors of fecal coliform bacteria, particularly in urban and suburban ponds, which often provide a desirable habitat for geese and ducks. Forest lands, which typically have only low concentrations of wildlife as sources of fecal coliform bacteria, usually have low loading rates for fecal coliform bacteria. A windshield survey of the watershed revealed numerous small ponds along the mainstem of Horse Creek. Waterfowl were observed in some of these ponds on the day of our visit.

Figure 8. Map of the Horse Creek watershed showing areas designated as an MS4.



3.2.2 Land Applied Manure

Livestock litter that is not properly stored or applied to land is a potential source of fecal coliform bacteria. Application of excessive amounts of litter, that is adding more nitrogen or phosphorus than the crop can use, and applying the litter too close to streams are the principal methods by which litter can pollute streams. There are currently no permitted Concentrated Animal Feeding Operations (CAFOs) in South Carolina. In addition, SCDHEC currently has no record of an active permitted livestock operations in the Horse Creek watershed. One swine permitted swine facility closed in January 1984.

3.2.3 Grazing Animals

Livestock, especially cattle, are frequently major contributors of fecal coliform bacteria to streams. Grazing cattle and other livestock may contaminate streams with bacteria in two ways. Runoff from pastures may carry the bacteria into streams following rain events. Cattle 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 of fecal coliform bacteria to both Sand River and Little Horse Creek by this route is likely to be a source of loading of fecal coliform bacteria. The 1997 Agricultural Atlas reported 12426 cattle and calves in Aiken County and 8255 cattle and calves in Edgefield County. It was assumed that the Aiken County estimate was representative of the watershed as a whole because only a very small portion of pastureland was found in Edgefield County (Figure 2). Using the ratio of pastureland in the each watershed to that of Aiken County, 92 cattle and calves were estimated to be in the SV-069 drainage area, 1420 in the SV-072 drainage area (includes both SV-069 and SV-073 drainage area), 395 in the SV-073 watershed, and 1605 in the SV-250 drainage area (includes all drainage area upstream). Cattle in the creek could be a major source of fecal coliform at SV-072, SV-073, and SV-250 where exceedences of the standard did not correlate well with turbidity. Also in the area, there are a number of thoroughbred stables, racetracks and horse-backing riding trails. Horses can also be a considerable source of fecal coliform bacteria, both from pasture runoff and manure deposited in stream. Note that many of the observed exceedences at these three sites occurred during ‘dry’ weather conditions. However, It should be considered that a significant proportion of transitional landuse in the entire watershed suggests less land will be available for grazing animals and, consequently, fewer grazing animals to contribute to future impairment.

3.2.4 Failing Septic Systems

Septic systems that do not function properly may leak sewage unto the land surface where it can reach nearby streams. Failing septic systems may be improperly designed or constructed or they maybe systems that no longer function. The number of households that have septic systems was estimated using a GIS. The 2000 census database layer was compared to the City boundaries of N. Augusta and Aiken and the boundaries of the Horse Creek watershed. In 2000 there were an estimated 14479 people in some 5658 households without sewer service in the Horse Creek watershed. The distribution of population among the four sampling stations is shown in Table 4. The number of rural households should correlate with the number of septic systems. Based on the evidence of continuous sources in the watershed, failing septic systems could be a major source of fecal coliform bacteria going into the stream. However, failing septic systems are likely to be a less important source of fecal coliform loading to Sand River (SV-069), where sanitary sewer service is available in most of the populated portion of the watershed. Observed ‘dry’ weather fecal coliform violations also support the potential for a continuous source such as septic tanks.

3.2.5 Urban Nonpoint Sources

As previously mentioned, the City of North Augusta, the City of Aiken, Burnettown, Aiken County and Edgefield Couty have been designated as a Municipal Separate Storm Sewer System or MS4 under NPDES Phase II Stormwater rules. The high percentage of impervious surfaces in built-up areas tends to increase runoff and reduce infiltration. The additional runoff compared to undeveloped land increases the amount of pollutants that are carried into streams. Dogs, cats, and other domesticated pets are the primary source of fecal coliform deposited on the urban landscape. There are also ‘urban’ wildlife, squirrels, raccoons, pigeons, and other birds, all of which contribute to the fecal coliform load.

Table 4. Populations in the Horse Creek watershed by water quality monitoring station (numbers are cumulative).

Station	Total Population	Rural Population	Rural Households
SV-069	13400	186	75
SV-073	11600	7635	2971
SV-072	46900	13865	5421
SV-250	54200	14479	5658

4.0 LOAD-DURATION CURVE METHOD

Load-duration curves were developed as a method of developing TMDLs that applies 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 TMDL loads for a water body. Development of the load-duration curve is described in this chapter.

The load-duration curve method requires an adequate period of record for flow data. Generally a longer record is better, though after a record of 20 to 30 years, additional data would affect mostly the extreme values, which are usually not included in the load-duration curve. Little Horse Creek had a gauge located near Graniteville, SC (USGS02196689; discontinued in April 2001). Data from gauge USGS 02196689 January 1, 1990 to April 9, 2001 was used to generate the flow-duration curve for stations SV-069 and SV-073 (Sand River is comparable in drainage area and landuse). Horse Creek, like many small streams in South Carolina is not gauged. Upper Three Runs, which is some 20 to 25 km Southeast of Horse Creek, is a comparable, gauged stream with similar land uses and topography. Data from gauge USGS 02197300 January 1, 1990 to November 30, 2002 was used to generate the flow-duration curve for stations SV-072 and SV-250 (stations comparable in drainage area and landuse).

The flows at different water quality monitoring sites were estimated by multiplying the measured daily flow rates from the appropriate USGS gauge by the ratio of the upstream drainage area to that of the ambient water quality monitoring site (USGS 02196689: SV-069=0.541, SV-073=1.733) (SV-072=1.685, SV-250=1.809). The flows were ranked from low to high and the values that exceed certain selected percentiles determined. The load-duration curve was generated by calculating the load from the observed fecal coliform concentrations, the flow rate that corresponds to the date of sampling, and a conversion factor. The load was plotted against the appropriate flow recurrence interval to generate the curve (Figures 9-12). A target line was created by calculating the allowable load from the flow and the appropriate fecal coliform standard concentration in the same manner (Table D-2). Sample loads above this line are violations of the standard, while loads below the line are in compliance.

The water quality target was set at 380 cfu/100ml for the instantaneous criterion, which is five percent lower than the water quality criteria of 400 cfu/100ml. A five percent explicit Margin of Safety (MOS) was reserved from the water quality criteria in developing the load-duration curves. The instantaneous criterion was targeted as a conservative approach and should be protective of both the instantaneous and 30-day geometric mean fecal coliform bacteria standards.

Trend lines were determined for sample loads for each station that exceeded the standard. Trend lines for all four locations were exponential functions (Figures 9-12). The r^2 (coefficient of determination or a measure of variance explained by the regression equation) for SV-069 is 0.36. The coefficient for the trend line for SV-073 was 0.46 and the r^2 for SV-072 and SV-250 were nearly 0.00, indicating a great deal of variability in the estimates. The existing loads to Horse Creek at the monitoring stations were calculated from the means of all loads that were roughly between the 10 % and 90 % flow recurrence intervals for each location (Table D-1). The exponential trend lines matched their respective target lines better than the alternatives.

The TMDL load is calculated from the target line. Load values at 5 % occurrence intervals along the target line from 10 to 90 % were averaged. The Load Allocation (LA) values are derived from the 380 cfu/100ml water quality target, which includes the explicit Margin of Safety. Calculations for both existing and TMDL loads are provided in Appendix D.

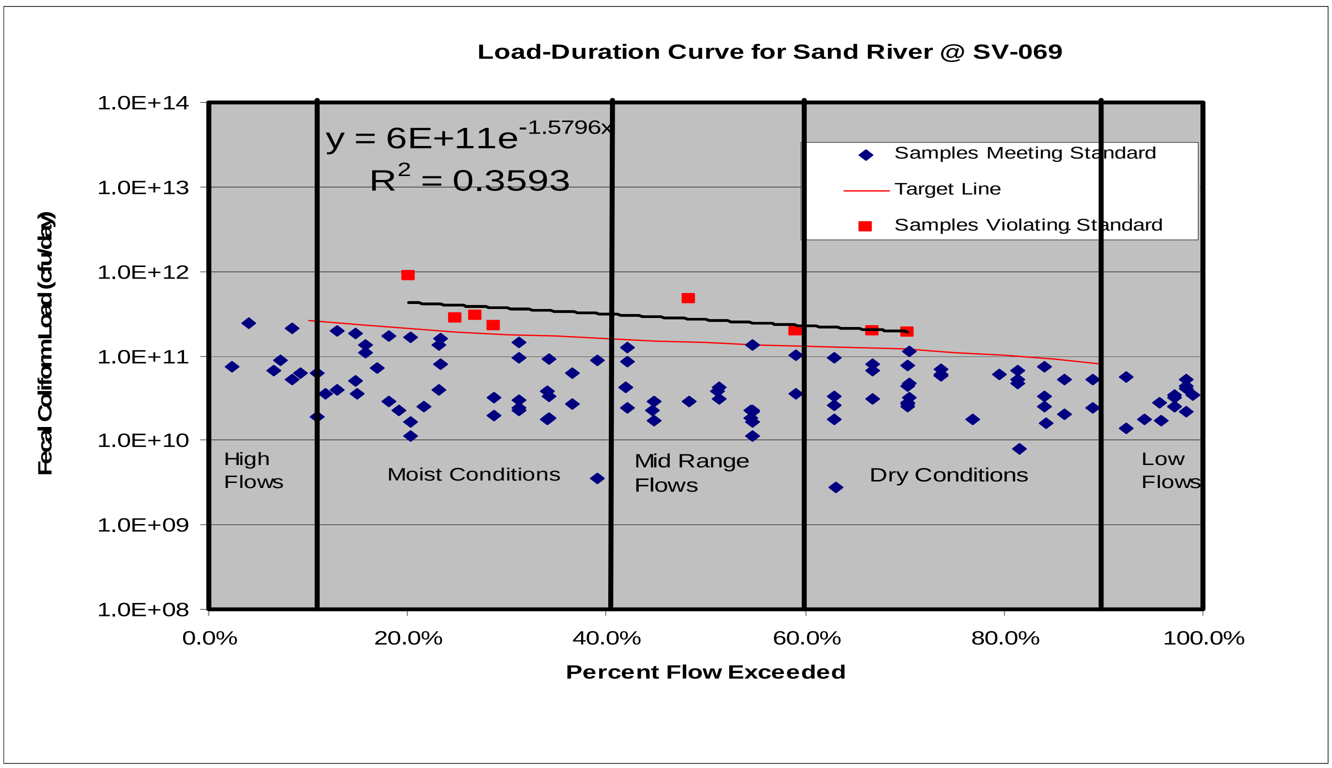


Figure 9. Load-Duration Curve for Sand River at SV-069

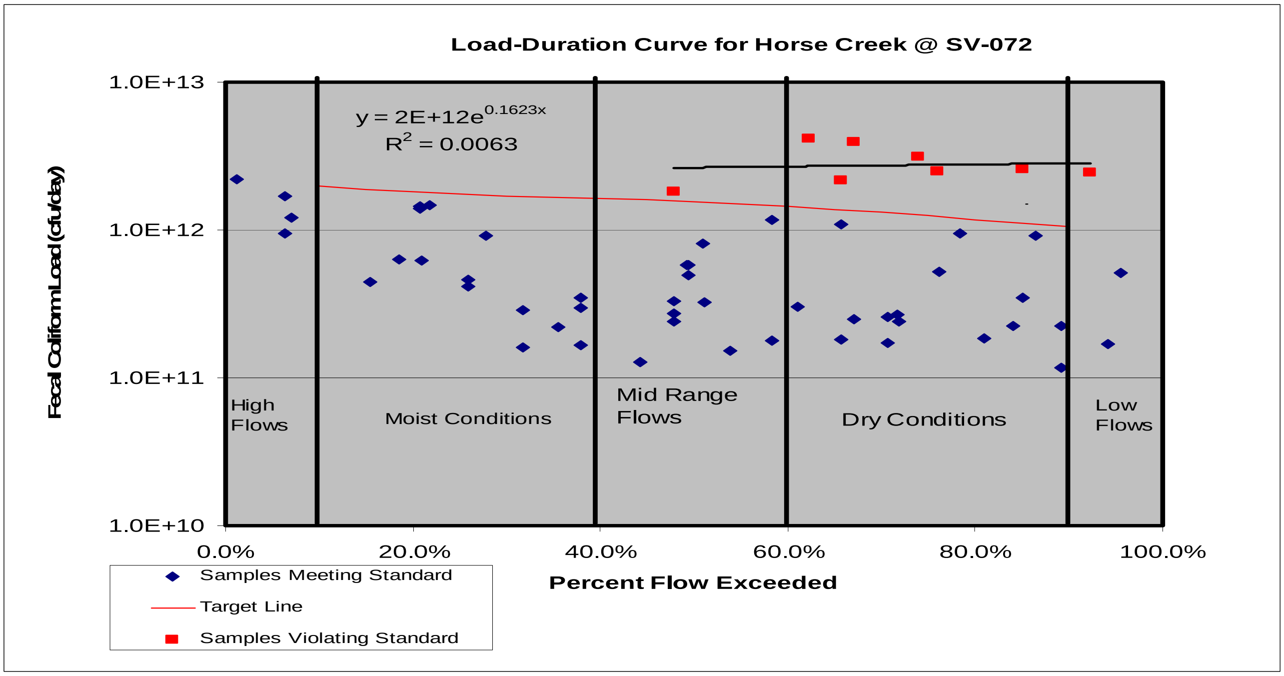


Figure 10. Load-Duration Curve for Horse Creek at SV-072

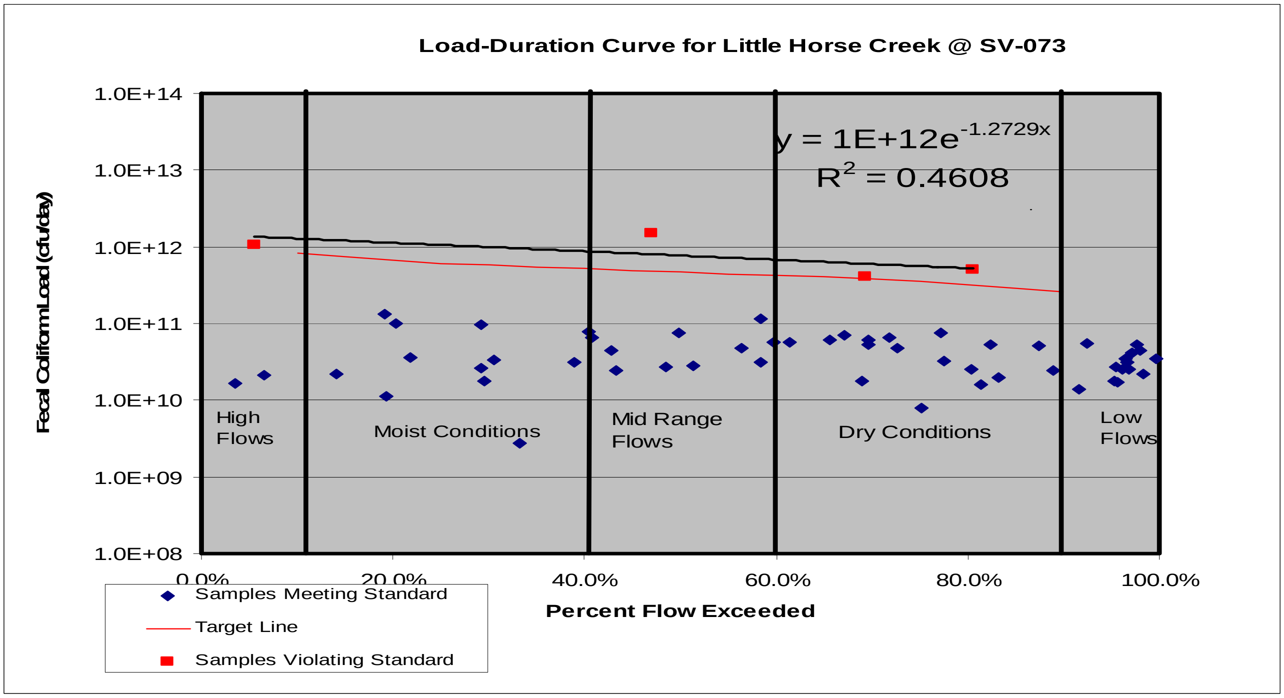


Figure 11. Load-Duration Curve for Little reek at SV-073

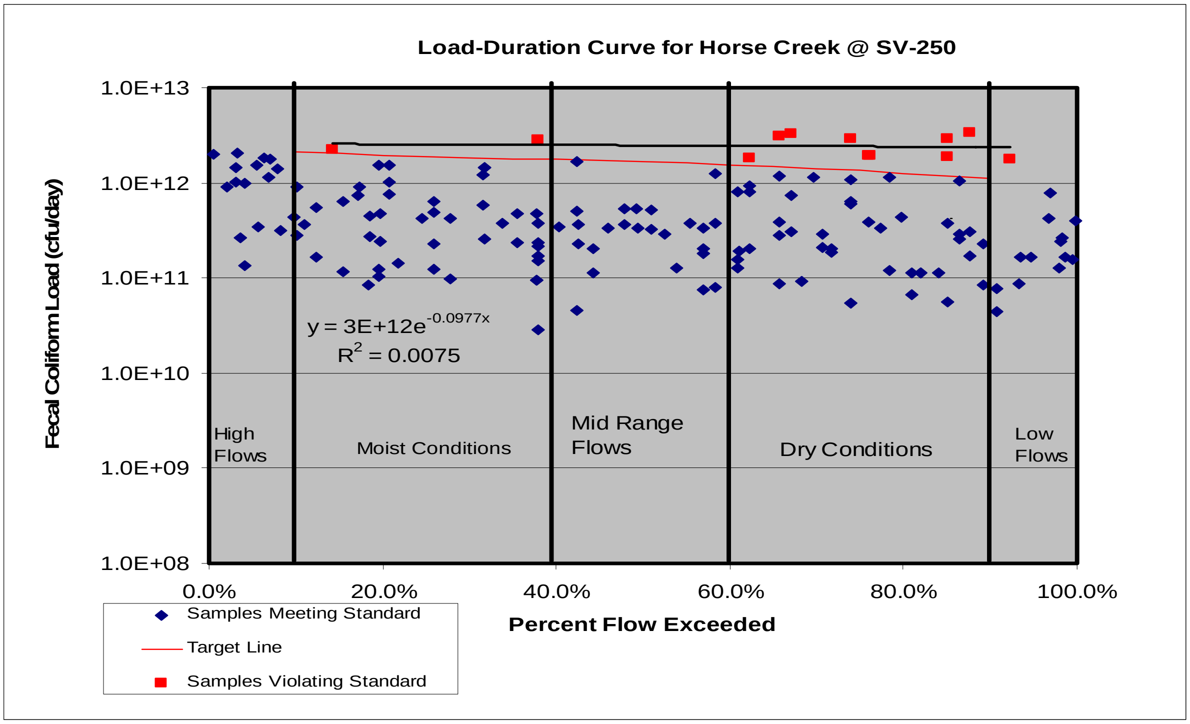


Figure 12. Load-Duration Curve for Horse Creek at SV-250

5.0 DEVELOPMENT OF 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:

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

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

5.1 Critical Conditions

These TMDLs are based on the flow recurrence interval between 10 % and 90 %. This encompasses 80 % of flows in Horse Creek. Only flows that are characterized as 'High' or 'Low' flows in Figures 9, 10, 11 and 12 are not included in the analysis. For these TMDLs critical conditions are this range of the flow recurrence interval.

5.2 Existing Load

The existing loads were calculated from the trend lines of observed values that exceeded the water quality standard and were roughly between the 10 and 90 % recurrence limits. Loadings from all sources are included in this value: urban runoff, cattle-in-streams, leaking sewers, and failing septic systems. Existing loads for all stations on Horse Creek are provided in Table 5.

5.3 Margin of Safety

The margin of safety (MOS) may be explicit and/or implicit. The explicit margin of safety is 5 % of the TMDL or 20 counts/ 100ml of the instantaneous criterion of 400 cfu/100 ml. Values of the MOS for each location are given in Table 5.

5.4 TMDL

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). The resulting TMDL should be protective of both the instantaneous, per day, and geometric mean, per 30-day, criteria.

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. Values for each component of the TMDLs for the three locations on Horse Creek are provided in Table 5. The required reduction in load, expressed as a percentage is also provided in Table 5.

The City of North Augusta, the City of Aiken and adjacent urbanized areas are designated as MS4s. The reduction percentages in this TMDL apply also to the fecal coliform waste load attributable to those areas of the watershed which are covered or will be covered under NPDES MS4 (Municipal Separate Storm Sewer System) permits. Compliance by an entity with responsibility for the MS4, with the terms of its individual MS4 permit will fulfill any obligations it has towards implementing this TMDL.

Table 5. TMDL components for Horse Creek.
Where Percentage Reduction = (Existing Load-TMDL Load) / Existing Load

Station ID	Existing Waste Load Continuous (cfu/day)	TMDL WLA Continuous (cfu/day)	TMDL WLA MS4	Existing Load (cfu/day)	TMDL LA (cfu/day)	MOS (cfu/day)	TMDL (cfu/day)	Percent Reduction
SV-069	NA	NA	47%	2.88E+11	1.53E+11	8.06E+09	1.61E+11	47%
SV-073	NA	NA	11%	5.48E+11	4.90E+11	2.58E+10	5.16E+11	11%
SV-072	2.62E+08	2.62E+08	30%	2.16E+12	1.52E+12	8.01E+10	1.60E+12	30%
SV-250	NA	NA	43%	2.86E+12	1.63E+12	8.60E+10	1.72E+12	43%

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* (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 Horse Creek watershed. Local sources of nonpoint source education and assistance include the Cities of Aiken and North Augusta, Aiken County, the Natural Resource Conservation Service (NRCS), the Aiken and Edgefield 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 Horse Creek. TMDL implementation projects are given highest priority for 319 funding.

The iterative BMP approach as defined in the general storm water NPDES MS4 permit is expected to provide significant implementation of this TMDL. Discovery and removal of illicit storm drain cross connection is one important element of the storm water NPDES permit. Public nonpoint source pollution education is another.

In addition to the resources cited above for the implementation of this TMDL in the Horse Creek watershed, Clemson Extension has developed a Home-A-Syst handbook that can help 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 and Watershed Manager 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 these watersheds in order to bring about the required reductions in fecal coliform bacteria loading to Horse Creek and tributaries. 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 AND BIBLIOGRAPHY

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APPENDIX A Fecal Coliform Data

Table A-1 Fecal coliform data for Horse Creek and Tributaries (1990-2002).

DATE	SV-069	SV-072	SV-073	SV-250
01/03/90	50			
01/23/90				110
02/07/90	64			97
03/07/90				36
03/08/90	82			
04/18/90				94
04/23/90	100			
05/10/90				200
05/30/90	109	75	77	
06/11/90	200	120	84	120
07/02/90				300
07/12/90	150	200	45	
08/01/90				75
08/02/90	260	80		
08/30/90				
09/04/90	160			
09/05/90		42	34	28
10/02/90	100	64	52	
10/04/90				58
01/03/91	40			24
01/06/91	8			50
02/06/91	8			50
03/14/91				84
04/02/91	65			88
05/06/91		300		150
05/07/91	300		180	
06/10/91	100	50	53	
06/13/91				57
07/02/91	90	78	58	
07/11/91				38
08/05/91	300			
08/07/91		200	82	
08/13/91				150
09/04/91				73
09/05/91	560	80	52	
10/03/91				75
10/10/91	30	200	150	
11/21/91	98			50
12/03/91	62			46
01/06/92	72			100
02/04/92	200			
02/11/92				25
03/05/92	30			
03/24/92				86
04/07/92	60			10
05/12/92	84			31
06/02/92				47
06/10/92	150			
07/06/92	360			
07/07/92				49
08/03/92	1200			
08/06/92				300
09/01/92	220			
09/03/92				100
10/01/92	240			43
11/04/92	600			300
12/03/92	40			
12/10/92				420
01/11/93	72			150
02/01/93	54			47
03/02/93				24
03/03/93	58			
04/12/93	72			
04/13/93				28
05/05/93	180			
05/10/93		36	78	53
06/01/93	200	90	110	120
07/01/93	100	64	40	
07/20/93				55
08/19/93	160	38	30	
08/24/93				66
09/01/93	200	300	300	
09/02/93				300
10/05/93	150	80	300	120
11/08/93	70			
11/09/93				600
12/09/93				20
12/14/93	600			
01/03/94	60			

DATE	SV-069	SV-072	SV-073	SV-250
01/06/94				20
02/03/94	46			6
03/09/94	92			
03/24/94				32
04/07/94				50
04/12/94	72			
05/03/94	88			
05/05/94		140	200	75
06/02/94	280	90	60	130
07/12/94	130	140	80	
07/13/94				110
08/01/94	600	310	326	
08/02/94				190
09/01/94	240	440	400	
09/21/94				80
10/03/94	1200	760	1200	
10/04/94				300
11/01/94	1600			
11/03/94				250
12/05/94	220			
12/06/94				52
01/05/95	20			
01/09/95				56
02/02/95	28			
02/08/95				16
03/08/95	300			
03/09/95				21
04/10/95	42			
04/13/95				160
05/08/95	52	68	44	
05/09/95				50
06/07/95	300	290	300	
06/12/95				66
07/26/95		220	120	300
07/27/95	460			
08/07/95	550			
08/08/95		600	300	
08/09/95				250
09/11/95	360			
09/12/95		170	330	
09/20/95				100
10/02/95	200			
10/18/95		130	90	200
11/02/95				30
11/07/95	120			
12/07/95	300			
12/12/95				50
01/02/96	75			
01/03/96				40
02/07/96	40			22
03/07/96	600			
03/12/96				170
04/02/96				76
04/03/96	50			
05/02/96	200	100	180	
05/08/96				100
06/03/96	230	58	10	82
07/10/96	280			
07/15/96		130	230	
07/17/96				78
08/19/96	180	290	600	300
09/03/96		120	130	120
09/04/96	200			
10/09/96	140			
10/21/96		30	85	25
11/12/96	95			120
12/03/96	60			
12/04/96				92
01/02/97	84			
01/22/97				18
02/04/97				19
02/05/97	58			
03/04/97	58			
03/05/97				75
04/03/97				22
04/15/97	78			
05/01/97	56	46	50	90
06/02/97	190	74	48	78
07/21/97	220			

DATE	SV-069	SV-072	SV-073	SV-250
07/22/97		60	38	34
08/05/97	230		100	300
08/07/97		160		
09/03/97		70	74	
09/09/97	300			20
10/01/97	250	70	42	
10/02/97				55
11/04/97	45			
11/05/97				80
12/01/97	60			
12/09/97				85
01/07/98				300
01/08/98	300			
02/03/98	280			
02/04/98				200
03/04/98				20
03/05/98	80			
04/02/98	120			140
05/04/98			530	210
05/05/98	88			
05/19/98		50		
06/01/98	300	65	50	120
07/07/98	190			
07/22/98		80	55	200
08/05/98		50	40	72
08/19/98	600			
09/08/98			65	300
10/05/98		80	120	80
10/21/98	140			
11/12/98				45
11/19/98	60			
12/02/98	75			
12/09/98				100
01/06/99	30			36
02/03/99				240
02/22/99	48			
03/10/99				20
03/16/99	82			
04/05/99	38			
04/14/99				30
05/06/99	110	38	300	46
06/15/99	300			
06/16/99		300	430	300
07/08/99		300	120	300
07/14/99	250			
08/04/99	360		65	
08/26/99		600		800
09/13/99	280		75	
09/16/99		1100		460
10/11/99	220	940	120	820
11/17/99	50			560
12/08/99	300			170
01/20/00	1200			360
02/17/00	240			230
03/20/00	1200			120
04/11/00	100			180
05/01/00		300	18	340
05/04/00	100			
06/05/00		320	24	340
06/22/00	280			
07/05/00		900	70	600
07/11/00	600			
08/01/00		1100	85	860
08/07/00	200			
09/07/00		760	190	550
09/13/00	160			
10/03/00	95	880	50	920
11/02/00	70			1100
12/04/00	30			130
01/02/01				35
02/13/01				35
03/22/01				80
04/05/01				15
06/11/01				30
07/26/01				600
08/22/01				60
09/13/01				100
10/30/01				56
11/27/01				82

DATE	SV-069	SV-072	SV-073	SV-250
12/11/01				190
01/23/02				18
02/20/02				15
03/14/02				35
04/18/02				26
05/16/02				110
06/19/02				70
07/10/02				70
08/12/02				190
09/05/02				52
10/08/02				100
11/07/02				160
12/03/02				5

Table A-2 Statistics for fecal coliform data 1990-2002 in Horse Creek and Tribs.

SV-069		SV-072	
Statistic	**Value**	**Statistic**	**Value**
Minimum	8	Minimum	30
Geometric Mean	216	Geometric Mean	246
Median	130	Median	120
Maximum	1600	Maximum	1100
% Violations	11%	% Violations	17%
SV-073		**SV-250**	
Statistic	**Value**	**Statistic**	**Value**
Minimum	120	Minimum	35
Geometric Mean	155	Geometric Mean	151
Median	720	Median	300
Maximum	22000	Maximum	4100
% Violations	73%	% Violations	24%

Appendix B

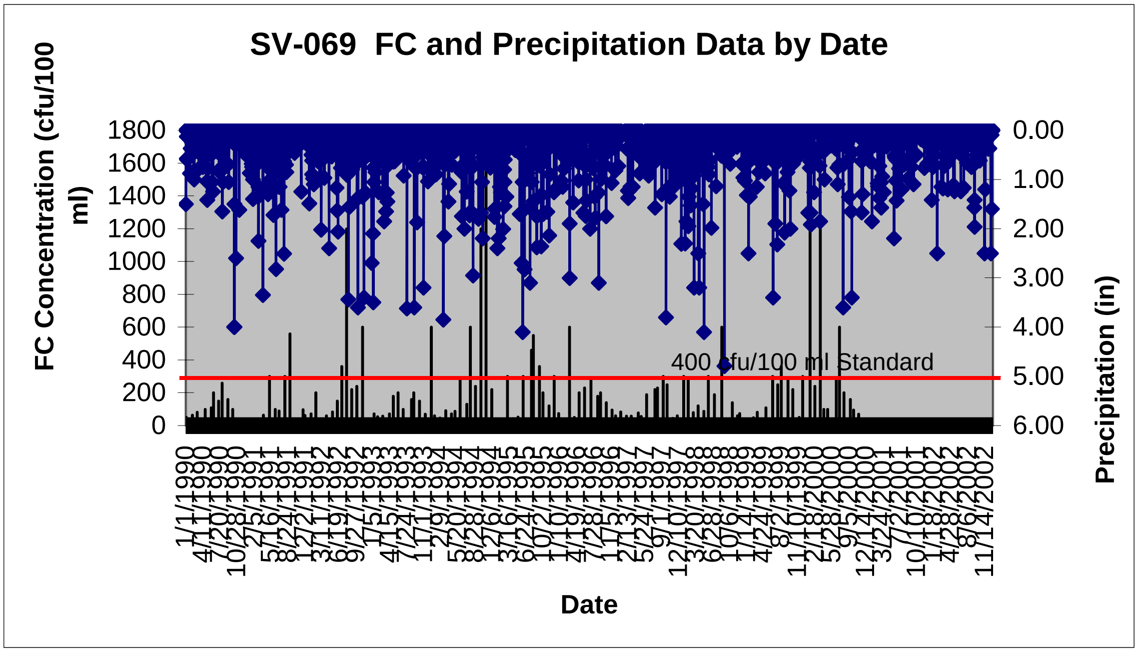

Figure B-1: Fecal Coliform Bacteria and Precipitation in Sand River

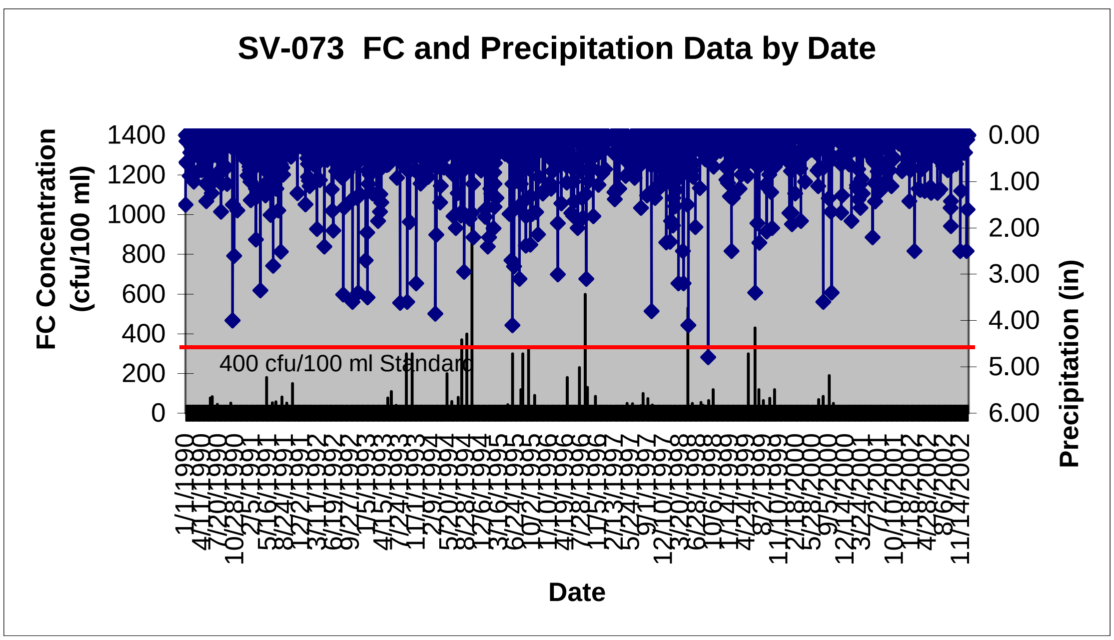

Figure B-2: Fecal Coliform Bacteria and Precipitation in Little Horse Creek

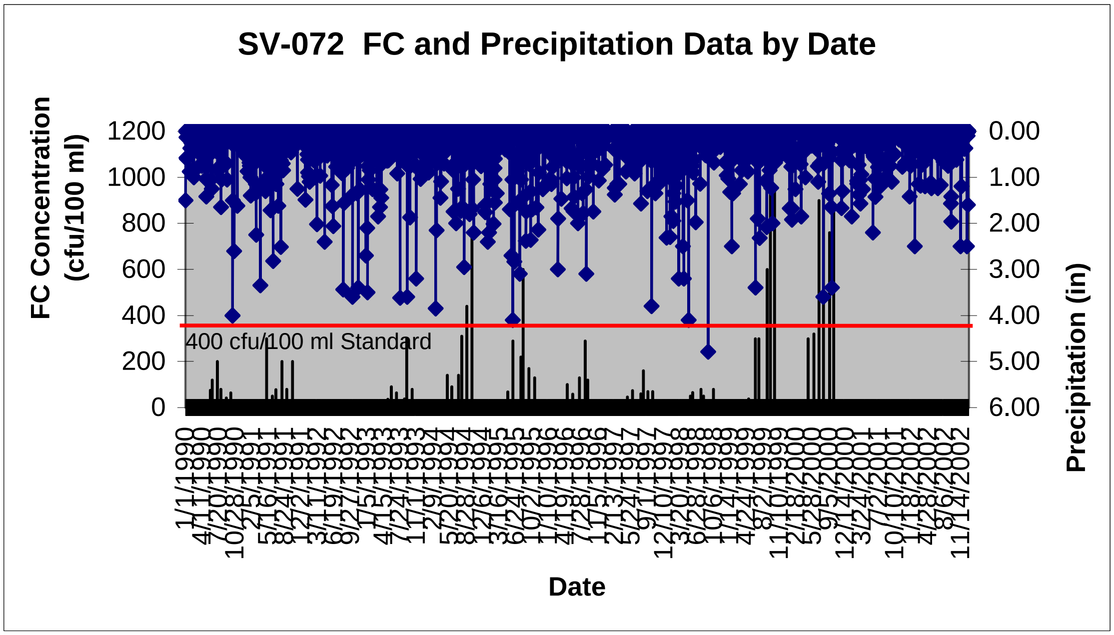

Figure B-3: Fecal Coliform Bacteria and Precipitation in Horse Creek

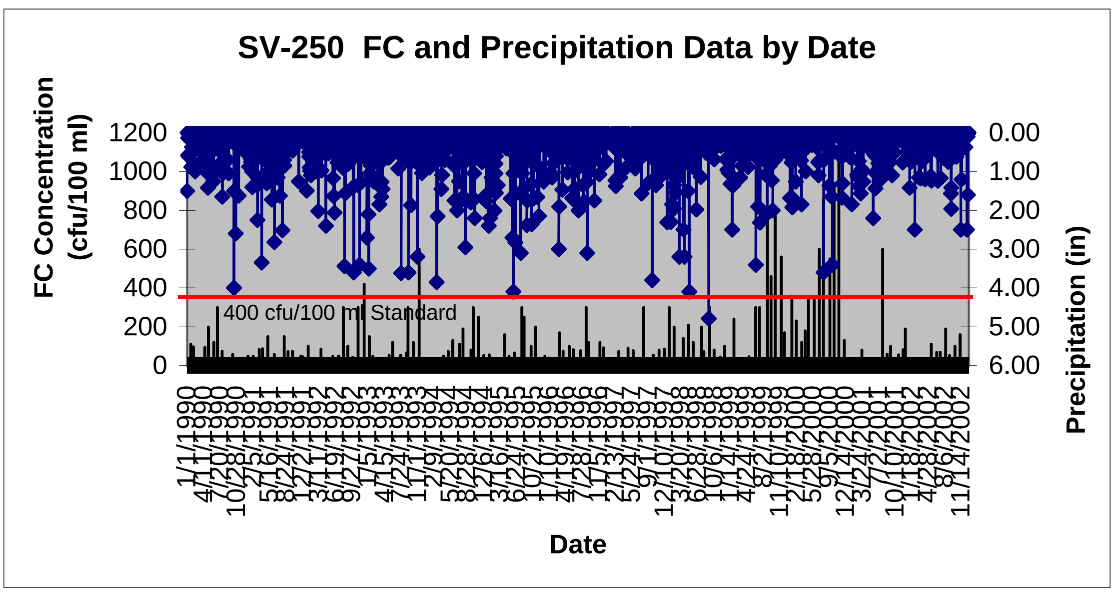

Figure B-4: Fecal Coliform Bacteria and Precipitation in Horse Creek

APPENDIX C DMR Data

Table C-1. DMR Data for Castlewood Mobile Home Estates (SC0032638)

DATE	FCAV	FCMX	MQAV (MGD)	MQMX (MGD)
11/30/91	2	2		0.015
12/31/91	515			0.02
1/31/93	1600	1600		0.017
3/31/93	740	740		0.017
4/30/93	105			0.014
5/31/93	170	170		0.0102
6/30/93	64	64		0.0141
7/31/93	2000	2000		0.0134
8/31/93	2	2		0.015
9/30/93	54	54		0.014
1/31/94	350	350	0.0161	0.0161
2/28/94	311	311	0.0148	0.02
3/31/94	440	440	0.014	0.015
4/30/94	2870	2870	0.012	0.015
5/31/94	325	325	0.008	0.012
6/30/94	10	10	0.008	0.01
7/31/94	9000	9000	0.016	0.016
8/31/94	170	170	0.014	0.019
9/30/94	130	130	0.0118	0.015
10/31/94	23	23	0.014	0.015
11/30/94	9000	9000	0.0079	0.0151
2/28/95	2	2	0.0141	0.0141
3/31/95	< 2	< 2	0.0125	0.0125
4/30/95	< 2	< 2	0.0146	0.0146
5/31/95	< 2	< 2	0.014	0.014
6/30/95	< 2	< 2	0.015	0.015
7/31/95	< 2	< 2	0.0137	0.0137
8/31/95	< 2	< 2	0.014	0.014
9/30/95	< 2	< 2	0.0139	0.0139
10/31/95	< 2	< 2	0.012	0.012
11/30/95	< 2	< 2	0.013	0.013
12/31/95	< 2	< 2	0.013	0.013
1/31/96	< 2	< 2	0.014	0.014
2/29/96	< 2	< 2	0.014	0.016
3/31/96	< 2	< 2	0.0135	0.0135
4/30/96	< 2	< 2	0.0145	0.0145
5/31/96	< 2	< 2	0.0143	0.0143
6/30/96	< 2	< 2	0.015	0.015
7/31/96	< 2	< 2	0.0135	0.0135

8/31/96	< 2	< 2	0.013	0.013
10/31/96	< 2	< 2	0.0125	0.0125
11/30/96	< 2	< 2	0.013	0.013
12/31/96	< 2	< 2	0.013	0.013
1/31/97	< 2	< 2	0.014	0.014
2/28/97	< 2	< 2	0.016	0.016
3/31/97	< 2	< 2	0.015	0.015
4/30/97	<2	<2	0.014	0.014
5/31/97	< 2	< 2	0.014	0.014
6/30/97	< 2	< 2	0.014	0.014
7/31/97	< 2	< 2	0.014	0.014
8/31/97	<2	<2	0.015	0.015
9/30/97	< 2	< 2	0.014	0.014
10/31/97	< 2	< 2	0.002	0.002
11/30/97	< 2	< 2	0.016	0.016
12/31/97	< 2	< 2	0.015	0.015
1/31/98	< 2	< 2	0.014	0.014
2/28/98	< 2	< 2	0.014	0.014
3/31/98	< 2	< 2	0.014	0.014
4/30/98	< 2	< 2	0.014	0.014
5/31/98	< 2	< 2	0.014	0.014
6/30/98	< 2	< 2	0.015	0.015
7/31/98	< 2	< 2	0.015	0.015
8/31/98	< 2	< 2	0.014	0.014
10/31/98	< 2	< 2	0.015	0.015
11/30/98	< 2	< 2	0.0155	0.0155
7/31/00	< 2	< 2	0.0173	0.0173
9/30/00	< 2	< 2	0.0173	0.0173
1/31/01	24	300	0.0014	0.0041
2/28/01	70	70	0.0029	0.0052
3/31/01	2	2	0.0049	0.0061
4/30/01	2	2	0.0105	0.019
5/31/01	2	2	0.0054	0.0061
6/30/01	2	2	0.0058	0.0076
7/31/01	2	2	0.005	0.008
8/31/01	500	500	0.005	0.008
9/30/01	26	26	0.002	0.003
10/31/01	220	220	0.004	0.005
11/30/01	4	4	0.005	0.008
12/31/01	16	16	0.09	0.016
1/31/02	2	2	0.006	0.013
2/28/02	2	2	0.004	0.008
3/31/02	< 2	< 2	0.003	0.004
4/30/02	2	2	0.004	0.006
5/31/02	2	2	0.003	0.004

6/30/02	2	2	0.003	0.004
7/31/02	2	2	0.002	0.003
8/31/02	2	2	0.0018	0.0021
9/30/02	2	2	0.004	0.008
10/31/02	2	2	0.0014	0.0018
11/30/02	2	2	0.0022	0.0031
12/31/02	2	2	0.005	0.007

APPENDIX D Calculation of Existing and TMDL Loads

Table D-1 Calculation of existing loads.

Using Equation, Calculation of Existing Load for SV-069:		Using Equation, Calculation of Existing Load for SV-073:	
Equation: y = 6E+11e ^ -1.5796		Equation: y = 1E+12e ^ -1.2729x	
Existing Load		**Existing Load**	
15%	4.73E+11	15%	8.26E+11
20%	4.37E+11	20%	7.75E+11
25%	4.04E+11	25%	7.27E+11
30%	3.74E+11	30%	6.83E+11
35%	3.45E+11	35%	6.40E+11
40%	3.19E+11	40%	6.01E+11
45%	2.95E+11	45%	5.64E+11
50%	2.72E+11	50%	5.29E+11
55%	2.52E+11	55%	4.97E+11
60%	2.33E+11	60%	4.66E+11
65%	2.15E+11	65%	4.37E+11
70%	1.99E+11	70%	4.10E+11
75%	1.84E+11	75%	3.85E+11
80%	1.70E+11	80%	3.61E+11
90%	1.45E+11	90%	3.18E+11
	2.88E+11		5.48E+11
Using Equation, Calculation of Existing Load for SV-072:		Using Equation, Calculation of Existing Load for SV-250:	
Equation: y = 2E+12e ^ 0.1623x		Equation: y = 3E+12e ^ -0.0977x	
%Exceede	**Load**	**%Exceede**	**Load**
10%	2.03E+12	10%	2.97E+12
15%	2.05E+12	15%	2.96E+12
20%	2.07E+12	20%	2.94E+12
25%	2.08E+12	25%	2.93E+12
30%	2.10E+12	30%	2.91E+12
35%	2.12E+12	35%	2.90E+12
40%	2.13E+12	40%	2.89E+12
45%	2.15E+12	45%	2.87E+12
50%	2.17E+12	50%	2.86E+12
55%	2.19E+12	55%	2.84E+12
60%	2.20E+12	60%	2.83E+12
65%	2.22E+12	65%	2.82E+12
70%	2.24E+12	70%	2.80E+12
75%	2.26E+12	75%	2.79E+12
80%	2.28E+12	80%	2.77E+12
90%	2.31E+12	90%	2.75E+12
	2.16E+12		2.86E+12

Table D-2. Calculations of TMDL loads.

SV-069	Load Allocation			SV-073	Load Allocation	
Target FC Conc:		380		Target FC Conc:		380
% Exceeded	Flow (cfs)			% Exceed	Flow (cfs)	
10%	28.15038	2.62E+11		10%	90.1203	8.38E+11
15%	24.90226	2.32E+11		15%	79.7218	7.41E+11
20%	22.73684	2.11E+11		20%	72.78947	6.77E+11
25%	20.57143	1.91E+11		25%	65.85714	6.12E+11
30%	19.48872	1.81E+11		30%	62.39098	5.8E+11
35%	18.40602	1.71E+11		35%	58.92481	5.48E+11
40%	17.32331	1.61E+11		40%	55.45865	5.16E+11
45%	16.2406	1.51E+11		45%	51.99248	4.83E+11
50%	15.69925	1.46E+11		50%	50.2594	4.67E+11
55%	14.61654	1.36E+11		55%	46.79323	4.35E+11
60%	14.07519	1.31E+11		60%	45.06015	4.19E+11
65%	13.53383	1.26E+11		65%	43.32707	4.03E+11
70%	12.99248	1.21E+11		70%	41.59398	3.87E+11
75%	11.90977	1.11E+11		75%	38.12782	3.54E+11
80%	10.82707	1.01E+11		80%	34.66165	3.22E+11
85%	9.744361	9.06E+10		85%	31.19549	2.9E+11
90%	8.661654	8.05E+10		90%	27.72932	2.58E+11
	Average	1.53E+11			Average	4.90E+11
SV-072	Load Allocation			SV-250	Load Allocation	
Target FC Conc:		380		Target FC Conc:		380
% Exceeded	Flow (cfs)			% Exceed	Flow (cfs)	
10%	214.0023	1.99E+12		10%	229.7678	2.14E+12
15%	203.892	1.9E+12		15%	218.9126	2.04E+12
20%	195.4667	1.82E+12		20%	209.8667	1.95E+12
25%	188.7264	1.75E+12		25%	202.6299	1.88E+12
30%	183.6713	1.71E+12		30%	197.2023	1.83E+12
35%	180.3011	1.68E+12		35%	193.5839	1.8E+12
40%	176.931	1.64E+12		40%	189.9655	1.77E+12
45%	171.8759	1.6E+12		45%	184.5379	1.72E+12
50%	166.8207	1.55E+12		50%	179.1103	1.67E+12
55%	161.7655	1.5E+12		55%	173.6828	1.61E+12
60%	155.0253	1.44E+12		60%	166.446	1.55E+12
65%	148.2851	1.38E+12		65%	159.2092	1.48E+12
70%	141.5448	1.32E+12		70%	151.9724	1.41E+12
75%	134.8046	1.25E+12		75%	144.7356	1.35E+12
80%	126.3793	1.17E+12		80%	135.6897	1.26E+12
85%	119.6391	1.11E+12		85%	128.4529	1.19E+12
90%	112.8989	1.05E+12		90%	121.2161	1.13E+12
	Average	1.52E+12			Average	1.63E+12