# South Carolina
# Department of Health and Environmental Control

# Total Maximum Daily Load Development for
# Big Wateree Creek: Station CW-072
# Fecal Coliform Bacteria

**February 2, 2004**

**Bureau of Water**

D H E C

PROMOTE PROTECT PROSPER

South Carolina Department of Health
and Environmental Control

## Abstract

Big Wateree Creek, in Fairfield County, SC, meets the Catawba River and forms the Wateree River at head of Lake Wateree. The creek at water quality monitoring station CW-072 (Big Wateree Creek at US-21 south of Great Falls) has been placed on South Carolina's 303(d) list of impaired waters for violations of the fecal coliform standard. During the assessment period for the 2002 303(d) list (1996-2000), 29 % of samples violated the standard. The watershed of Big Wateree Creek has been mostly rural and agricultural. At the time the NLCD land use data was collected (early 1990's) the watershed was 77 % forest, 15 % transitional, 3.5 % pasture/hay, and 3.5 % cropland. There is one point source in the watershed, the White Oak Conference Center (SC0035980). The watershed is sparsely populated with only 352 people counted in the 2000 census. The probable sources of fecal coliform bacteria in the creek are runoff from agricultural activities, cattle-in-streams, and failing septic systems.

The load-duration curve methodology was used to calculate the existing load and the TMDL load for Big Wateree Creek at CW-072. The existing load was estimated to be 2.1E+12 cfu/day. The TMDL load was determined to be 4.37E+11 cfu/day, consisting of the Waste Load Allocation of 7.48E+08 and the Load Allocation of 4.14E+11 cfu/day and margin of safety of 2.2E+10 cfu/day. In order to reach the target load, a reduction in the existing load to the creek of 80 % will be necessary. Several TMDL implementation strategies to bring about these reductions are suggested.

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## Tables and Figures

# Big Wateree Creek (HUC 03050104-020-010)

## 1.0 INTRODUCTION:

### 1.1 Background

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

### 1.2 Watershed Description

The watershed of Big Wateree Creek is in Fairfield County, in the lower Piedmont region of South Carolina (Figure 1). Big Wateree Creek joins with the Catawba River to form the Wateree River. The junction of the two streams is at the upper end of Lake Wateree. The watershed is rural and has no cities or towns. Approximately 350 people lived in the watershed in 2000. Most of the 14-digit watershed is included in this TMDL. The area of the watershed is 151 $km^2$ (58 $mi^2$).

The predominant land uses (NLCD) in the part of this watershed is forest, accounting for 77 % of the land (Figure 2; Table 1). The next largest land use is classified as transitional (15%). Agricultural uses, cropland and pasture, account for the rest with each having about 3.5 % of the land. At the time the NLCD data were collected the developed land was under 1 %. This watershed is rather remote from population centers such as Columbia, so that it is not likely to grow fast.

### 1.3 Water Quality Standard

The impaired stream segment, Big Wateree Creek, is 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).

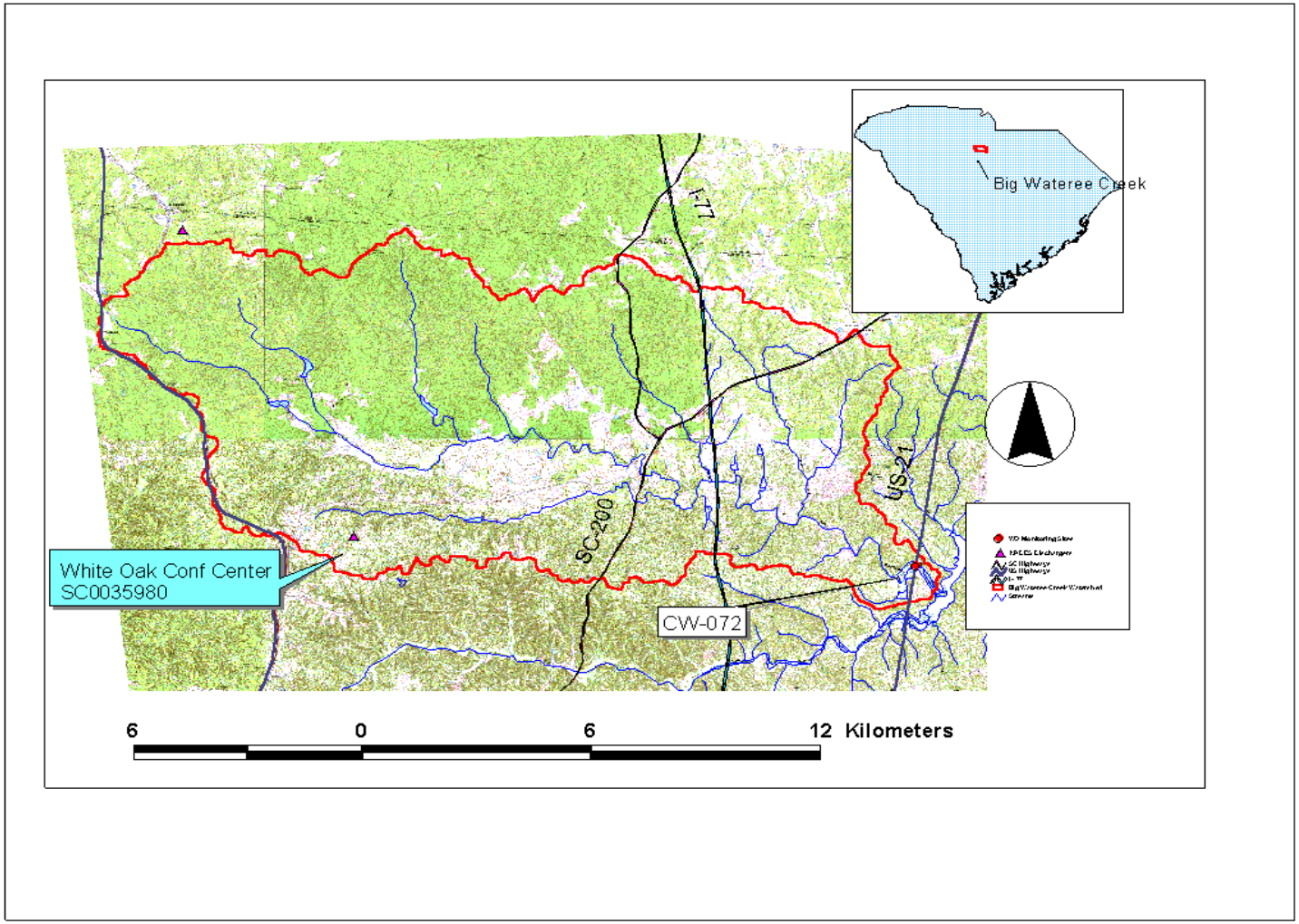


Figure 1. Map of the Big Wateree Creek watershed above CW-072.

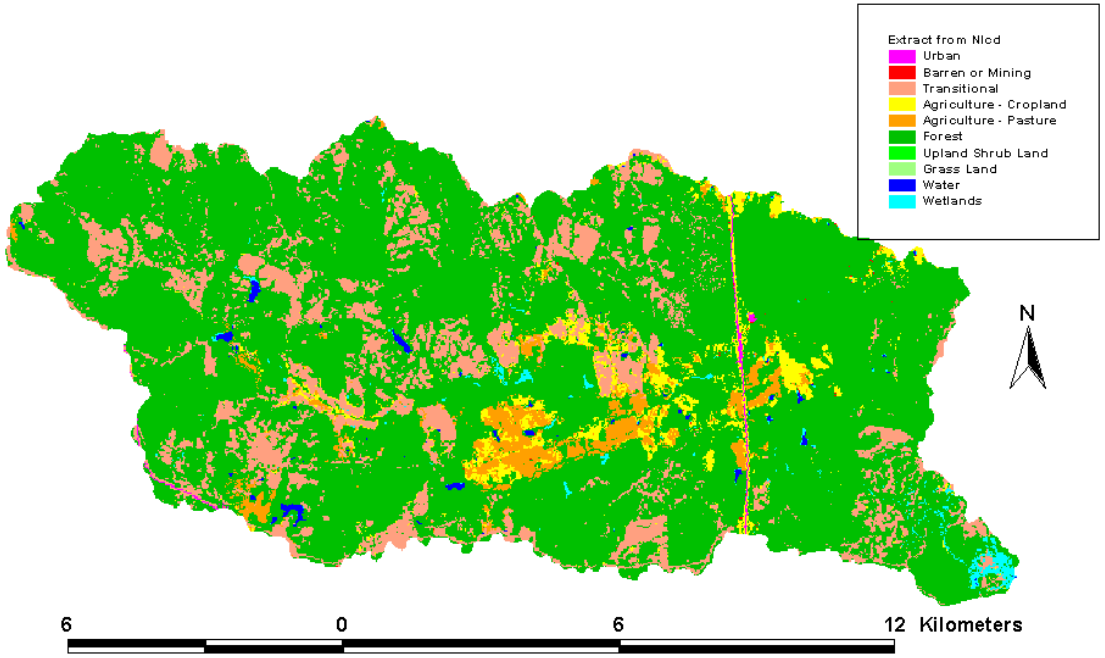


Figure 2. Map showing land uses in the Big Wateree Creek watershed.

Table 1. Land uses in the Big Wateree Creek watershed above CW-072.

| Land Use Class | Land Use | Area ($km^2$) | Percent | Area ($mi^2$) |
|---|---|---|---|---|
| | | | | |
| | Water | 0.6 | 0.4% | 0.2 |
| | | | | |
| | Residential Low Density | 0.0 | 0.0% | 0.0 |
| | Commercial, Industrial, & Transportation | 0.4 | 0.2% | 0.1 |
| **Developed** | | 0.4 | 0.2% | 0.1 |
| | | | | |
| | Barren | 0.1 | 0.0% | 0.0 |
| **Transitional** | **Transitional** | **22.6** | **14.9%** | **8.7** |
| | | | | |
| | Forest Deciduous | 34.6 | 22.9% | 13.4 |
| | Forest Evergreen | 62.1 | 41.0% | 24.0 |
| | Forest Mixed | 19.3 | 12.7% | 7.4 |
| **Forest** | | **116.0** | **76.6%** | **44.8** |
| | | | | |
| **Pasture** | Pasture | 5.2 | 3.5% | 2.0 |
| | | | | |
| **Cropland** | Cropland | 5.4 | 3.6% | 2.1 |
| | | | | |
| | Woody Wetlands | 1.1 | 0.7% | 0.4 |
| | Emergent Herbaceous Wetlands | 0.0 | 0.0% | 0.0 |
| **Wetlands** | | 1.2 | 0.8% | 0.4 |
| | | | | |
| **Total for Watershed** | | **151.5** | **100.0%** | **58.5** |

## 2.0 WATER QUALITY ASSESSMENT

Big Wateree Creek has one water quality monitoring station. Station CW-072 is located at the US-21 bridge near the lower end of the watershed. An assessment of water quality data collected in 1996 through 2000 at station CW-072 indicated that Big Wateree Creek at this location is impaired for recreational use. In addition to being listed on the 2002 303(d) list, Big Wateree Creek was also on the 1998 and 2000 lists. 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 and listed for fecal coliform bacteria on South Carolina's 303(d) list. During the assessment period (1996-2000), 29 % of the samples did not meet the fecal coliform criterion at CW-072. Stream fecal coliform data are provided in Appendix A.

There is little indication of any relationship between precipitation and fecal coliform concentrations in Big Wateree Creek (Figure 3). The number of samples (18) and the period of time represented are quite small, which may contribute to the lack of a clear pattern. The fecal coliform excursions in Big Wateree would appear to be caused primarily by continuous sources such as cattle-in-streams or failing septic systems. However some high rainfall events are associated with high fecal coliform concentrations.

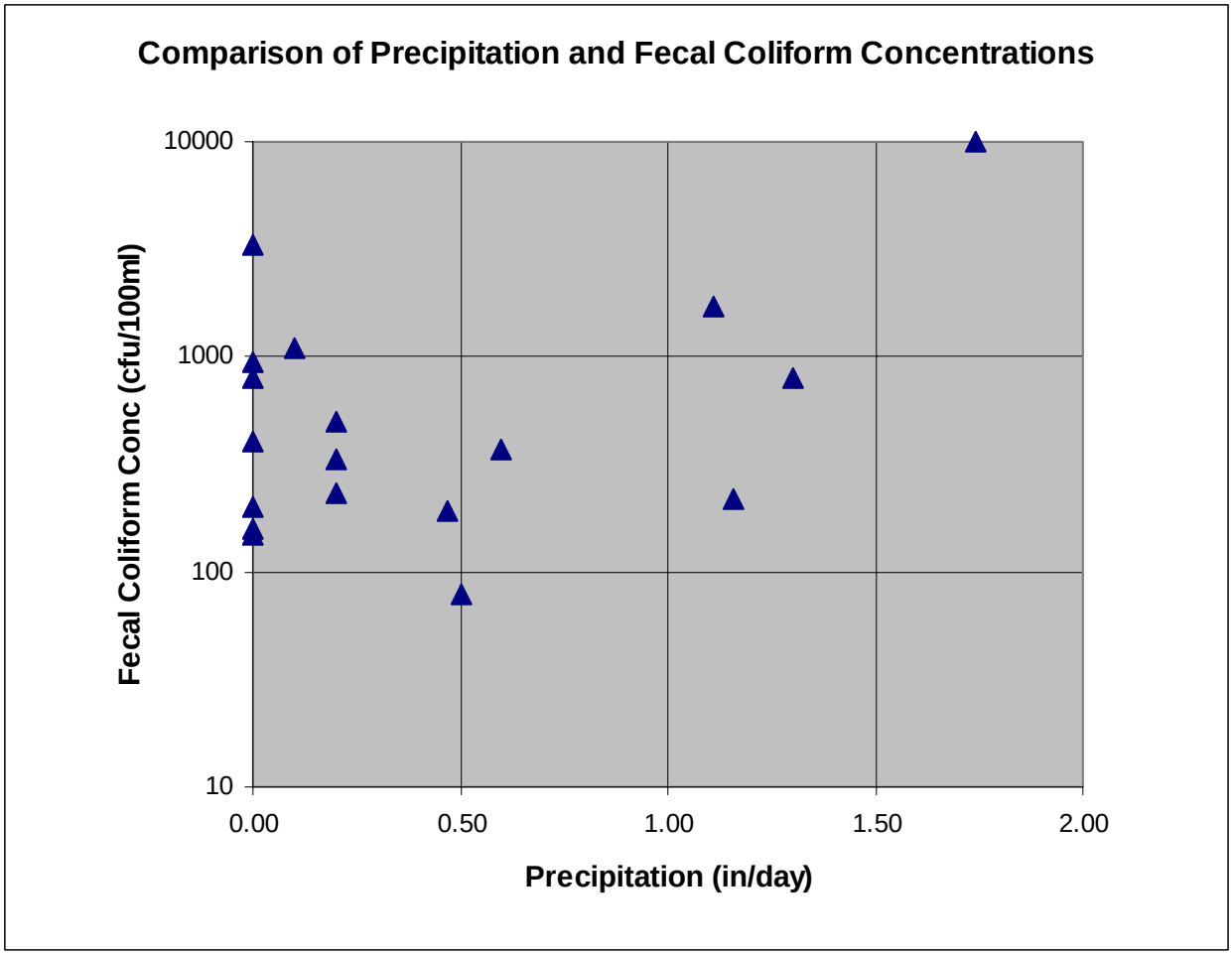


Figure 3. Comparison between precipitation and fecal coliform concentrations in Big Wateree Creek.

## 3.0 SOURCE ASSESSMENT

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 this 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 end of pipe.

### 3.1 Point Sources in the Big Wateree Creek Watershed

There is one NPDES facility in this watershed, White Oak Conference Center (SC0035980), which is located on a tributary of Big Wateree Creek. This point source is far upstream of the impaired sampling station. It has a permit to discharge 0.0495 mgd (187,000 l/day) of wastewater. This facility has consistently met its permit limits for fecal coliform bacteria. Monthly wastewater (DMR) data are provided in Appendix B.

### 3.2 Nonpoint Sources in Big Wateree Creek Watershed

#### 3.2.1 Wildlife

Wildlife (mammals and birds) contribute a low level of fecal coliform to surface waters. Wildlife wastes are carried into nearby streams by runoff following rainfall. Deer are the largest and probably most noticeable mammals in this area. The SC Department of Natural Resources (Charles Ruth, DNR Deer Project Supervisor, personal communication, 2000) has estimated a density of 45 deer/$mi^2$ for this area. Deer habitat includes forest, cropland, pastures, and some suburban areas. Wildlife are unlikely to be significant sources of fecal coliform bacteria in this watershed. Forest lands, which usually have only wildlife as sources of fecal coliform bacteria, usually have low loading rates for fecal coliform.

#### 3.2.2 Land Application of Manure

Turkey or chicken 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. The Big Wateree watershed has one operation (ND0075213) that has eight turkey houses with a maximum permitted limit of 24,000 brooder or growout turkeys. There are a large number of fields that have permits for land application of litter from this and another operation (ND0068331) located in a nearby watershed.

#### 3.2.3 Grazing Animals

Livestock such as cattle and horses spend most of their time grazing on pasture land. Runoff from rainfall washes some of the manure deposited in the pastures into nearby by streams. The 1997 Agricultural Atlas reported that Fairfield County had 6327 cattle and calves. Using the ratio of

pasture land in the watershed to that of the county, 994 cattle and calves were estimated to be in the Big Wateree watershed. However David Findley, NRCS Fairfield County Conservationist (personal communication, 2003), indicated that there are probably at least 2000 cattle in the watershed.

Grazing cattle and other livestock may contaminate streams with fecal coliform 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 Big Wateree Creek by this route is likely to be the major source of fecal coliform pollution in Allison Creek.

### 3.2.4 Failing Septic Systems

Septic systems that do not function properly may leak sewage onto the land surface where it can reach nearby streams. Failing septic systems may be of an improper design or construction or 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 a sewer line data layer theme and the boundaries of the Big Wateree Creek watershed. In 2000 there were only 352 people in 140 households in the Big Wateree watershed, none served by sewer. Assuming each household had its own system, there were 140 septic systems in the watershed. Using a failure rate of 20 % (Schueler, 1999) for the septic systems, that all wastewater reached the stream and the concentration of fecal coliform in that wastewater was $10^4$ cfu/100ml (Horsley and Witten, 1996), loading from septic systems is estimated to be 1.9E+09 cfu/day. This load is less than 1 % of the existing load calculated from the load duration curve. Therefore failing septic systems were estimated to be a minor source of fecal coliform loading to Big Wateree Creek.

## 4.0 LOAD-DURATION METHOD

A load-duration curve is 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.

In the ideal situation a long period of record for flow data would be available for the water body of interest. A longer period of record increases the confidence in the results of the load-duration method. Big Wateree Creek, like most small streams in South Carolina, is not gauged. Long Creek, in Gaston County, NC, is a comparable, gauged stream, with a similar sized drainage area, land uses, and is in the same ecoregion – the Piedmont. Data from the gauge (USGS 0214400) on Long Creek near Bessemer City, North Carolina for the period of record (Jan. 1, 1953 to Sept 30, 2001) was used to generate the flow-duration curve. The Long Creek watershed is smaller, 82.4 $km^2$ compared to 151.5 $km^2$ for Big Wateree Creek.

The flow for Big Wateree Creek was estimated by multiplying the daily flow rates from Long Creek by the ratio of the Big Wateree Creek drainage area to that of Long Creek (1.8394). 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 (Figure 4). The target line was created by calculating the allowable load from the flow and the appropriate fecal coliform standard concentration in the same manner. Sample loads above this line are violations of the standard, while loads below the line are in compliance.

The trend line was determined for loads that are above the target line. The trend line for Big Wateree Creek with the best fit was an exponential curve; the $r^2$ was 0.6506. The equation for the line and supporting data are provided in Appendix B. This trend line represents samples that violated the water quality standard. The existing load to Big Wateree Creek was calculated from

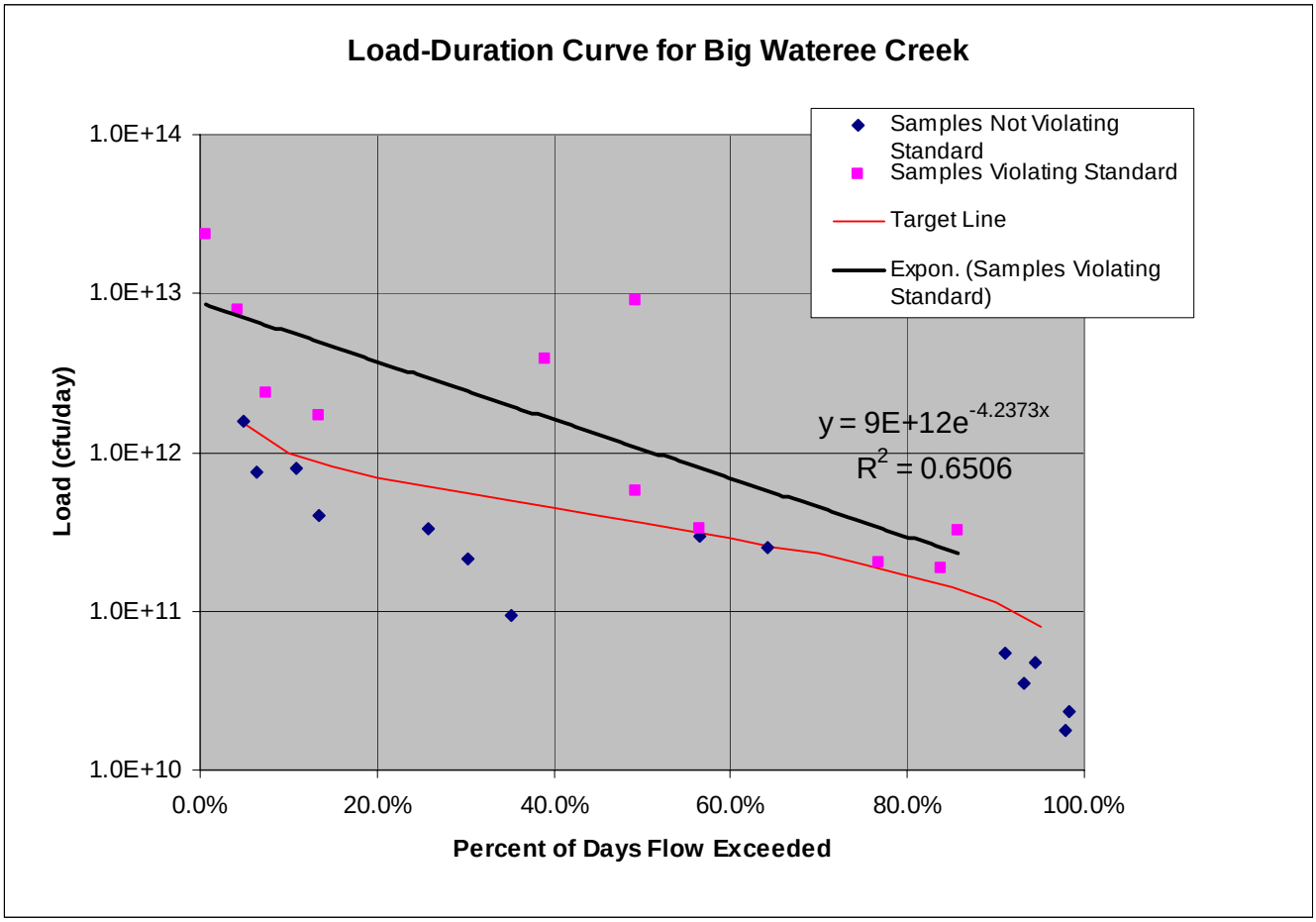


Figure 4. Load-Duration Curve for Big Wateree Creek at CW-072.

values along this trend line. Most of the violating loads were between the 10 % and 90 % flow recurrence intervals. The existing load is the average of loads from the 10 % to 90 % recurrence intervals at 5 % intervals, i.e. 0, 15, 20, 25 … 90.

The TMDL load is calculated from the target line in the same manner, that is the average of loads at 5 % intervals from 10 % to 85 %. The Load Allocation (LA) values are 95 % of the loads from the target line, that is the TMDL load minus the Margin of Safety. Calculations for both existing and TMDL loads are provided in Appendix B.

## 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:

$$\mathbf{TMDL = 3\ WLAs + 3\ LAs + MOS}$$

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 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

Critical conditions for Big Wateree Creek occur when a long period of low flow is followed by rainfall event that produces runoff. At low flow rates the continual sources like poorly functioning wastewater treatment plants, cattle in the streams, and failing septic systems cause the concentration of the fecal coliform in the creek to rise as dilution decreases. During the long dry period, fecal coliform bacteria build up on the land surface. Rainfall flushes much of this accumulation into the creek with runoff, which causes the already high concentrations to increase further.

Though most of the standard violations occurred during medium flows, standard violations occurred over much of the total range of flows. The inclusion of all flow conditions in the load-duration curve analysis insures that the critical conditions are protected. Existing and TMDL loads were calculated from the 10 – 85 % flow exceedence intervals.

## 5.2 Existing Load

The existing load was calculated from the trend line of observed values that exceeded the water quality standard and were between and including 10 and 90 % reoccurrence limits. Loadings from all sources are included in this figure: failing septic systems, cattle-in-streams, and loading from runoff. The total existing load for CW-072 is 2.1 E+12 cfu/day.

## 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 400 cfu/ 100 ml or 20 counts/ 100ml. For CW-072 this is equivalent to 2.2E+10 cfu/day**.** Through the use of conservative assumptions in the model the margin of safety also has an implicit component.

## 5.4 Total Maximum Daily Load

The Total Maximum Daily Load (TMDL) represents the maximum load the stream may carry and meet the water quality standard for the pollutant of interest. For this TMDL the load will be expressed as cfu/day (colony forming units/day).

The Waste Load Allocation (WLA) for the White Oak Conference Center is 7.48E+08 cfu/day. The WLA is an almost insignificant part of this TMDL.

The Load Allocation (LA) was determined from the target line of load-duration curve less the MOS. The LA of 4.14E+11 cfu/day accounts for most of the TMDL.

Table 2. TMDL components for Big Wateree Creek.

| Impaired Station | WLA cfu/day | LA cfu/day | MOS cfu/day | TMDL cfu/day | Target cfu/day |
|---|---|---|---|---|---|
| CW-072 | 7.48E+08 | 4.14E+11 | 2.2E+10 | 4.37E+11 | 4.15E+11 |

The target loading value is the load to the creek that it can receive and meet the water quality standard. It is simply the TMDL minus the MOS. The target loading for Big Wateree Creek requires a reduction of 80 % from the current load of 2.1E+12 cfu/day for CW-072.

# 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 Big Wateree Creek watershed. Local sources of nonpoint source education and assistance include Clemson Extension Service, the Natural Resource Conservation Service (NRCS), the Fairfield 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 Big Wateree 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 Big Wateree 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 who can assist with distribution of these tools as well as provide additional BMP information.

Using existing authorities and mechanisms, these measures will be implemented in the Big Wateree Creek Watershed in order to bring about an 80 % reduction in fecal coliform bacteria loading to Big Wateree Creek. 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


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## APPENDIX A Fecal Coliform Data

**Fecal Coliform Bacteria Data for Big Wateree Creek at US 21, Fairfield County**

| Station | Date | Time | FC (cfu/100ml) |
|---|---|---|---|
| | | | |
| CW-072 | 11/18/92 | 1100 | 160 |
| CW-072 | 12/17/92 | 830 | 330 |
| CW-072 | 1/15/93 | 1130 | 800 |
| CW-072 | 2/26/93 | 1230 | 230 |
| CW-072 | 3/12/93 | 1050 | 800 |
| CW-072 | 4/6/93 | 1300 | 1700 |
| CW-072 | 5/26/93 | 1430 | 3300 |
| CW-072 | 6/10/93 | 1130 | 400 |
| CW-072 | 7/1/93 | 1020 | 500 |
| CW-072 | 8/5/93 | 1310 | 78 |
| CW-072 | 9/24/93 | 850 | 950 |
| CW-072 | 3/9/98 | 1200 | 1100 |
| CW-072 | 4/15/98 | 1205 | 220 |
| CW-072 | 5/7/98 | 1350 | 190 |
| CW-072 | 6/10/98 | 1240 | 370 |
| CW-072 | 8/6/98 | 1325 | 150 |
| CW-072 | 9/14/98 | 1310 | 200 |
| CW-072 | 10/8/98 | 1145 | 10000 |
| CW-072 | 1/23/01 | | 640 |
| CW-072 | 2/22/01 | | 410 |
| CW-072 | 3/20/01 | | 400 |
| CW-072 | 4/10/01 | | 410 |
| CW-072 | 5/14/01 | | 230 |
| CW-072 | 6/19/01 | | 210 |
| CW-072 | 7/31/01 | | 140 |

## APPENDIX B White Oak Conference Center DMR Data

### Mean Daily Load (1/1991 - 5/2003): 1.99E+07 cfu/day

| SC0035980 | | | | Permit Limit: | | 0.0495 | mgd | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | 74055 | | | | 50050 | | | |
| Date | | Fecal Coliform (cfu/100ml) | | | | Flow (mgd) | | | Load (cfu/day) |
| | | Mean | | Max | | Mean | Max | | |
| 1/31/91 | < | 1 | | < 1 | | | 0.0218 | | 8.25E+05 |
| 11/30/91 | | 43 | | 43 | | | 0.0055 | | 8.95E+06 |
| 12/31/91 | < | 1 | | < 1 | | | 0.0053 | | 2.01E+05 |
| 7/31/92 | | 88 | | 88 | | | 0.02 | | 6.66E+07 |
| 8/31/92 | | 1 | | 1 | | | 0.0112 | | 4.24E+05 |
| 9/30/92 | | 126 | | 506 | | | 0.0153 | | 7.30E+07 |
| 10/31/92 | | 1 | | 1 | | | 0.0175 | | 6.62E+05 |
| 11/30/92 | < | 1 | | 294 | | | 0.01834 | | 6.94E+05 |
| 12/31/92 | | 1 | | 1 | | | 0.0092 | | 3.48E+05 |
| 1/31/93 | | 1 | | 1 | | | 0.0126 | | 4.77E+05 |
| 2/28/93 | | 1 | | 1 | | | 0.0126 | | 4.77E+05 |
| 3/31/93 | | 1 | | 1 | | | 0.0098 | | 3.71E+05 |
| 4/30/93 | | 1 | | 1 | | | 0.0063 | | 2.38E+05 |
| 5/31/93 | | 1 | | 1 | | | 0.0091 | | 3.44E+05 |
| 6/30/93 | | 91 | | 91 | | | 0.0386 | | 1.33E+08 |
| 7/31/93 | | 157 | | 157 | | | 0.0478 | | 2.84E+08 |
| 8/31/93 | | 100 | | 100 | | | 0.0123 | | 4.66E+07 |
| 9/30/93 | | 1 | | 1 | | | 0.0075 | | 2.84E+05 |
| 10/31/93 | | 188 | | 188 | | | 0.0038 | | 2.70E+07 |
| 11/30/93 | | 6 | | 6 | | | 0.0034 | | 7.72E+05 |
| 1/31/94 | | 1 | | 1 | | | 0.0106 | | 4.01E+05 |
| 2/28/94 | | 1 | | 1 | | | 0.0124 | | 4.69E+05 |
| 3/31/94 | | 1 | | 1 | | | 0.0212 | | 8.03E+05 |
| 4/30/94 | | 1 | | 1 | | | 0.0258 | | 9.77E+05 |
| 5/31/94 | | 1 | | 1 | | | 0.0259 | | 9.80E+05 |
| 6/30/94 | | 20 | | 20 | | | 0.0212 | | 1.61E+07 |
| 7/31/94 | | | | | | | 0.0186 | | 0.00E+00 |
| 8/31/94 | | 1 | | 1 | | | 0.0059 | | 2.23E+05 |
| 9/30/94 | | 100 | | 100 | | | 0.0105 | | 3.97E+07 |
| 10/31/94 | | 100 | | 100 | | | 0.0039 | | 1.48E+07 |
| 11/30/94 | | 1 | | 1 | | | 0.0059 | | 2.23E+05 |
| 12/31/94 | | 1 | | 1 | | | 0.0096 | | 3.63E+05 |
| 1/31/95 | | 1 | | 1 | | 0.0177 | 0.0177 | | 6.70E+05 |
| 2/28/95 | | 55 | | 55 | | | 0.0105 | | 2.19E+07 |
| 3/31/95 | | | | | | | 0.0039 | | 0.00E+00 |
| 4/30/95 | | 1 | | 1 | | | 0.0114 | | 4.32E+05 |

| Date | | Fecal Coliform (cfu/100ml) | | | | Flow (mgd) | | | Load (cfu/day) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | | Max | | Mean | Max | | |
| 7/31/95 | | 1 | | 1 | | | 0.0158 | | 5.98E+05 |
| 8/31/95 | | 1 | | 1 | | 0.0041 | 0.0096 | | 1.55E+05 |
| 9/30/95 | | 97 | | 1123 | | 0.0054 | 0.0101 | | 1.98E+07 |
| 10/31/95 | | 1 | | 1 | | 0.0055 | 0.008 | | 2.08E+05 |
| 11/30/95 | | 1 | | 1 | | 0.0045 | 0.0064 | | 1.70E+05 |
| 12/31/95 | | 1 | | 1 | | 0.002 | 0.0031 | | 7.57E+04 |
| 1/31/96 | | 1 | | 1 | | 0.0042 | 0.0059 | | 1.59E+05 |
| 2/29/96 | | 1 | | 1 | | 0.0075 | 0.0154 | | 2.84E+05 |
| 3/31/96 | | 99 | | 9500 | | 0.0096 | 0.0123 | | 3.60E+07 |
| 4/30/96 | | 18 | | 18 | | 0.0152 | 0.0176 | | 1.04E+07 |
| 5/31/96 | | 1 | | 1 | | 0.0132 | 0.0157 | | 5.00E+05 |
| 6/30/96 | | 8 | | 8 | | 0.0266 | 0.032 | | 8.06E+06 |
| 7/31/96 | | 85 | | 85 | | 0.0248 | 0.0268 | | 7.98E+07 |
| 8/31/96 | | 158 | | 158 | | 0.0204 | 0.0278 | | 1.22E+08 |
| 9/30/96 | | 68 | | 68 | | 0.0159 | 0.0205 | | 4.09E+07 |
| 10/31/96 | | 2 | | 2 | | 0.0133 | 0.0145 | | 1.01E+06 |
| 11/30/96 | | 2 | | 2 | | 0.0157 | 0.0136 | | 1.19E+06 |
| 12/31/96 | < | 2 | | < 2 | | 0.0092 | 0.0118 | | 6.97E+05 |
| 1/31/97 | < | 2 | | < 2 | | 0.0162 | 0.0207 | | 1.23E+06 |
| 2/28/97 | | 2 | | 2 | | 0.0179 | 0.0228 | | 1.36E+06 |
| 3/31/97 | | 2 | | 2 | | 0.0127 | 0.0159 | | 9.61E+05 |
| 4/30/97 | | 2 | | 2 | | 0.0155 | 0.0223 | | 1.17E+06 |
| 5/31/97 | | 2 | | 2 | | 0.0158 | 0.0174 | | 1.20E+06 |
| 6/30/97 | | 25 | | 25 | | 0.026 | 0.0316 | | 2.46E+07 |
| 7/31/97 | | 390 | | 1600 | | 0.025 | 0.0271 | | 3.69E+08 |
| 8/31/97 | | | | | | 0.0167 | 0.022817 | | 0.00E+00 |
| 9/30/97 | | 118 | | 118 | | 0.0138 | 0.0229 | | 6.16E+07 |
| 10/31/97 | | 2 | | 2 | | 0.0108 | 0.0121 | | 8.18E+05 |
| 11/30/97 | < | 2 | | < 2 | | 0.0129 | 0.0167 | | 9.77E+05 |
| 12/31/97 | < | 2 | | < 2 | | 0.0115 | 0.0176 | | 8.71E+05 |
| 1/31/98 | < | 2 | | < 2 | | 0.0208 | 0.0238 | | 1.57E+06 |
| 2/28/98 | | 1 | | 2 | | 0.016 | 0.021 | | 6.06E+05 |
| 3/31/98 | < | 2 | | < 2 | | 0.01 | 0.024 | | 7.57E+05 |
| 4/30/98 | | 16 | | 610 | | 0.021 | 0.0249 | | 1.27E+07 |
| 5/31/98 | | 1 | | 1 | | 0.015 | 0.016 | | 5.68E+05 |
| 6/30/98 | | 14.6 | | 108 | | 0.023 | 0.029 | | 1.27E+07 |
| 7/31/98 | | 4 | | 10 | | 0.02 | 0.031 | | 3.03E+06 |
| 8/31/98 | | 8.6 | | 37 | | 0.022 | 0.041 | | 7.16E+06 |
| 9/30/98 | | 48 | | 51 | | 0.021 | 0.027 | | 3.82E+07 |
| 10/31/98 | | 23 | | 182 | | 0.012 | 0.018 | | 1.04E+07 |
| 11/30/98 | | 13 | | 95 | | 0.014 | 0.021 | | 6.89E+06 |
| 12/31/98 | | 6.3 | | 10 | | 0.006 | 0.007 | | 1.43E+06 |
| 1/31/99 | < | 2 | | < 2 | | 0.014 | 0.021 | | 1.06E+06 |

| Date | | Fecal Coliform (cfu/100ml) | | | | Flow (mgd) | | | Load (cfu/day) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | | Max | | Mean | Max | | |
| 2/28/99 | < | 2 | | < 2 | | 0.015 | 0.021 | | 1.14E+06 |
| 3/31/99 | | 2.8 | | 4 | | 0.014 | 0.016 | | 1.48E+06 |
| 4/30/99 | | 4 | | 5 | | 0.009 | 0.012 | | 1.36E+06 |
| 5/31/99 | | 28 | | 33 | | 0.016 | 0.021 | | 1.70E+07 |
| 6/30/99 | < | 9 | | 41 | | 0.025 | 0.034 | | 8.52E+06 |
| 7/31/99 | | 62 | | 1400 | | 0.024 | 0.026 | | 5.63E+07 |
| 8/31/99 | | 33 | | 35 | | 0.014 | 0.019 | | 1.75E+07 |
| 9/30/99 | | 149 | | 340 | | 0.01 | 0.014 | | 5.64E+07 |
| 10/31/99 | < | 2 | | < 2 | | 0.013 | 0.014 | | 9.84E+05 |
| 11/30/99 | < | 2 | | < 2 | | 0.011 | 0.014 | | 8.33E+05 |
| 12/31/99 | < | 4 | | 10 | | 0.014 | 0.017 | | 2.12E+06 |
| 1/31/00 | < | 2 | | < 2 | | 0.02 | 0.023 | | 1.51E+06 |
| 2/29/00 | < | 6 | | 20 | | 0.02 | 0.021 | | 4.54E+06 |
| 3/31/00 | < | 2 | | < 2 | | 0.018 | 0.02 | | 1.36E+06 |
| 4/30/00 | < | 2 | | 2 | | 0.014 | 0.02 | | 1.06E+06 |
| 5/31/00 | < | 2 | | < 2 | | 0.014 | 0.016 | | 1.06E+06 |
| 6/30/00 | | 133 | | 6000 | | 0.028 | 0.036 | | 1.41E+08 |
| 7/31/00 | | 144 | | 260 | | 0.026 | 0.021 | | 1.42E+08 |
| 8/31/00 | | 21 | | 120 | | 0.014 | 0.023 | | 1.11E+07 |
| 9/30/00 | | 26 | | 30 | | 0.018 | 0.018 | | 1.77E+07 |
| 10/31/00 | | 35 | | 41 | | 0.013 | 0.016 | | 1.72E+07 |
| 11/30/00 | | 1 | | 2 | | 0.015 | 0.02 | | 5.68E+05 |
| 12/31/00 | | 2 | | 2 | | 0.009 | 0.012 | | 6.81E+05 |
| 1/31/01 | | 1 | | 1 | | 0.012 | 0.012 | | 4.54E+05 |
| 2/28/01 | | 1 | | 1 | | 0.014 | 0.017 | | 5.30E+05 |
| 3/31/01 | < | 1 | | < 2 | | 0.02 | 0.026 | | 7.57E+05 |
| 4/30/01 | | 1 | | 1 | | 0.017 | 0.026 | | 6.44E+05 |
| 5/31/01 | | 1 | | 1 | | 0.015 | 0.019 | | 5.68E+05 |
| 6/30/01 | | 8 | | 15 | | 0.02 | 0.03 | | 6.06E+06 |
| 7/31/01 | | 61 | | 76 | | 0.03 | 0.036 | | 6.93E+07 |
| 8/31/01 | | 106 | | 145 | | 0.02 | 0.024 | | 8.03E+07 |
| 9/30/01 | | 1 | | 2 | | 0.018 | 0.023 | | 6.81E+05 |
| 10/31/01 | | 2 | | 4 | | 0.016 | 0.017 | | 1.21E+06 |
| 11/30/01 | | 10 | | 23 | | 0.016 | 0.023 | | 6.06E+06 |
| 12/31/01 | | 3.1 | | 10 | | 0.0122 | 0.0137 | | 1.43E+06 |
| 1/31/02 | | 1 | | 1 | | 0.0146 | 0.0165 | | 5.53E+05 |
| 2/28/02 | | 2.2 | | 5 | | 0.0163 | 0.0173 | | 1.36E+06 |
| 3/31/02 | | 1.4 | | 2 | | 0.0173 | 0.0197 | | 9.17E+05 |
| 4/30/02 | | 1 | | 1 | | 0.0194 | 0.0223 | | 7.34E+05 |
| 5/31/02 | | 1 | | 2 | | 0.016 | 0.0171 | | 6.06E+05 |
| 6/30/02 | | 41 | | 46 | | 0.034 | 0.0391 | | 5.28E+07 |
| 7/31/02 | | 38 | | 52 | | 0.026 | 0.0293 | | 3.74E+07 |
| 8/31/02 | | 1.7 | | 3 | | 0.0171 | 0.0207 | | 1.10E+06 |

| Date | Fecal Coliform (cfu/100ml) | | Flow (mgd) | | Load (cfu/day) |
|---|---|---|---|---|---|
| | Mean | Max | Mean | Max | |
| 10/31/02 | 277 | 1600 | 0.0162 | 0.0198 | 1.70E+08 |
| 11/30/02 | 2 | 4 | 0.0151 | 0.0166 | 1.14E+06 |
| 12/31/02 | 1 | 1 | 0.0121 | 0.0154 | 4.58E+05 |
| 1/31/03 | 0.5 | 1 | 0.0135 | 0.0159 | 2.56E+05 |
| 2/28/03 | 1 | 1 | 0.0119 | 0.0247 | 4.50E+05 |
| 3/31/03 | 2 | 6 | 0.0287 | 0.0329 | 2.17E+06 |
| 4/30/03 | 7 | 28 | 0.0283 | 0.0352 | 7.50E+06 |
| 5/31/03 | 1.4 | 2 | 0.0192 | 0.0233 | 1.02E+06 |

## APPENDIX C Calculation of Existing and TMDL Loads

**Calculation of Existing Load from trend Line** $y = 9E+12\ e^{-4.2373\ x}$

| Percentile | Load (cfu/day) |
|---|---|
| 0.1 | 5.89E+12 |
| 0.15 | 4.77E+12 |
| 0.1 | 5.89E+12 |
| 0.2 | 3.86E+12 |
| 0.25 | 3.12E+12 |
| 0.3 | 2.52E+12 |
| 0.35 | 2.04E+12 |
| 0.4 | 1.65E+12 |
| 0.45 | 1.34E+12 |
| 0.5 | 1.08E+12 |
| 0.55 | 8.75E+11 |
| 0.6 | 7.08E+11 |
| 0.65 | 5.73E+11 |
| 0.7 | 4.64E+11 |
| 0.75 | 3.75E+11 |
| 0.8 | 3.03E+11 |
| 0.85 | 2.45E+11 |

**Mean Load** **2.10E+12 cfu/day**

**Calculation of TMDL Load from target line**

| % Exceeded | Load (cfu/day) |
|---|---|
| 0.1 | 9.41E+11 |
| 0.15 | 7.70E+11 |
| 0.2 | 6.50E+11 |
| 0.25 | 5.81E+11 |
| 0.3 | 5.30E+11 |
| 0.35 | 4.79E+11 |
| 0.4 | 4.28E+11 |
| 0.45 | 3.76E+11 |
| 0.5 | 3.42E+11 |
| 0.55 | 3.08E+11 |
| 0.6 | 2.74E+11 |
| 0.65 | 2.39E+11 |
| 0.7 | 2.22E+11 |
| 0.75 | 1.88E+11 |
| 0.8 | 1.61E+11 |
| 0.85 | 1.35E+11 |
| **Mean Load** | **4.14E+11** |

## APPENDIX D  Public Notification