# Total Maximum Daily Load

# for

# Fork Creek

**(Hydrologic Unit Code:** 03040202-060**)**

**Stations: PD-067, PD-068**

**Fecal Coliform**

**June 2005**

**SCDHEC Technical Report Number: 022-05**

In compliance with the provisions of the Federal Clean Water Act, 33 U.S.C §1251 et.seq., as amended by the Water Quality Act of 1987, P.L. 400-4, the U.S Environmental Protection Agency is hereby establishing a Total Maximum Daily Load (TMDL) for Fecal Coliform for Fork Creek in the Pee Dee River Basin. Subsequent actions must be consistent with this TMDL.

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# 1 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) requires 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).

The South Carolina Department of Health and Environmental Control (DHEC) has identified Fork Creek upstream of water quality monitoring station PD-068 located on an Unnumbered Road 1.5 Miles Southwest of the Town of Jefferson (UTM coordinates 554548.20 meters, 3832187.04 meters) as being impacted by fecal coliform bacteria. This station was first placed on the South Carolina's 303(d) list of impaired waters in 2002, and continues to be impaired. The fecal coliform bacteria impairment is also shown at the water quality monitoring station PD-067 located on Route 151 south of the Town of Jefferson. This station is located about 1.2 miles upstream of PD-068 station, and has been on South Carolina's 303(d) list since 1998. Both PD-067 and PD-068 are upstream of the confluence of Fork Creek with Little Fork Creek.

Two additional water quality monitoring stations are also located in the Fork Creek Watershed (03040202-060). They are considered outside of the project area because they are not showing a fecal coliform bacteria impairment. These ambient water quality monitoring stations (PD-647 and PD-215) are located on Little Fork Creek, and as a consequence, this Fork Creek tributary was not included in the Load Reduction Management Plan Supporting Fecal Coliform Bacteria TMDL Development.

It is assumed that water bodies possessing high concentrations of fecal coliform bacteria my also be contaminated by pathogens, or disease producing bacteria or viruses, which may exist in fecal material. Some waterborne diseases associated with fecal material include typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. The presence of fecal contamination is, therefore, an indicator that a potential health risk exists for individuals exposed to this water. The objective of this study is, therefore, to develop a Load Reduction Management Plan supporting future TMDL development efforts that will result in a reduction of fecal coliform bacteria concentrations to levels that do not present a health risk, and that are below the state standard.

## 1.2 Watershed Description

The Fork Creek Watershed (03040202-060) is located in the Sand Hills region of South Carolina and represents two separate systems that join together prior to discharging into the Lynches River. Both these Fork Creek and Little Fork Creek systems flow predominately north to south before Little Fork Creek flows into Fork Creek south of the Town of Jefferson. Additional Fork Creek tributaries include Canal Branch, Gum Branch, Mill Branch, Meeting House Branch, and Joes Branch.

Four water quality monitoring stations are found in the Fork Creek watershed (03040202-060). The two showing fecal coliform bacteria impairment (PD-068 and PD-067) are sited on Fork Creek upstream of the location where Little Fork Creek converges with Fork Creek. The watershed area above Unnumbered Road 1.5 Miles Southwest of the Town of Jefferson (Water Quality Monitoring Station PD-068), just upstream of the Little Fork Creek discharge point, is therefore, considered the Fork Creek project area for this Load Reduction Management Plan supporting future TMDL development efforts. As depicted in Figure 1-1, the Fork Creek project area is divided into the following eight subbasins:

- Upper Fork Creek (3.7 square miles);
- Upper Tributaries (3.2 square miles);
- Canal Branch (2.4 square miles);
- Western Tributaries (3.1 square miles);
- Gum Branch (6.0 square miles);
- Mill Branch (2.8 square miles);
- Jefferson Tributaries (2.7 square miles); and
- Meeting House and Joes Branches (2.0 square miles).

The predominant soil types consist of an association of the Blaney-Candor-Vaucluse-Gilead series. The erodability of the soil (k) averages 0.12; and the slope of the terrain averages 7 % with a range of 1-15 %. The predominant land uses (NLCD) in the Fork Creek watershed project area are cropland/pasture (59 % above monitoring station PD-067 and 58 % above monitoring station PD-068) and forest (37 % above PD-067 and 38 % above PD-068). The remaining land use in the watershed is developed land (4 % above PD-067 and 5 % above PD-068) (See Table 3-1 and Figure 3-1).

One point source is located in the project area (Cleveland Caroknit Plant - SC0002500). It is located downstream of the fecal coliform bacteria impairment shown at the Route 151 ambient water quality monitoring station (PD-067); and as a consequence, it is not considered a large contributor to the fecal coliform bacteria concentrations in the project area. In addition, it is estimated that approximately 300 septic systems are currently in use in the project area and are considered potential sources of fecal coliform bacteria loading.

Both agricultural and urban land uses are considered nonpoint sources of fecal coliform bacteria loading. Although the eastern portion of the Town of Jefferson drains into the Fork Creek project area, agriculture is the largest contributor of fecal coliform bacteria. Figure 1-1 delineates the location of approximately 500 farm fields in the 26 square mile Fork Creek project area. According to the Natural Resource Conservation Service (NRCS) District Conservationist for Chesterfield County (Charles Babb, November 15, 2004), the predominate agricultural land uses leading to fecal coliform bacteria loading are beef cattle direct deposition into the stream, and runoff from cattle manure and poultry litter. He estimates that approximately 4,000 cattle reside in the Fork Creek watershed (03040202-060) and that there are 120,000 turkeys and 150,000 chickens in the watershed at any one time. It was also mentioned by the Pee Dee Resource Conservation & Development Council (RC&D) Coordinator (David Arthur, October 26, 2004) and the regional South Carolina Department of Natural Resources officer (John Alford, October 26, 2004) that as a result of economics and other factors, the quantity of turkeys in the Fork Creek project area have been reduced substantially because the turkey integrators have contracted with growers located in other watersheds. As a result, it was noted on the October 26, 2004 field trip that many of the viable turkey operations were lacking birds.

### 1.3 Water Quality Standard

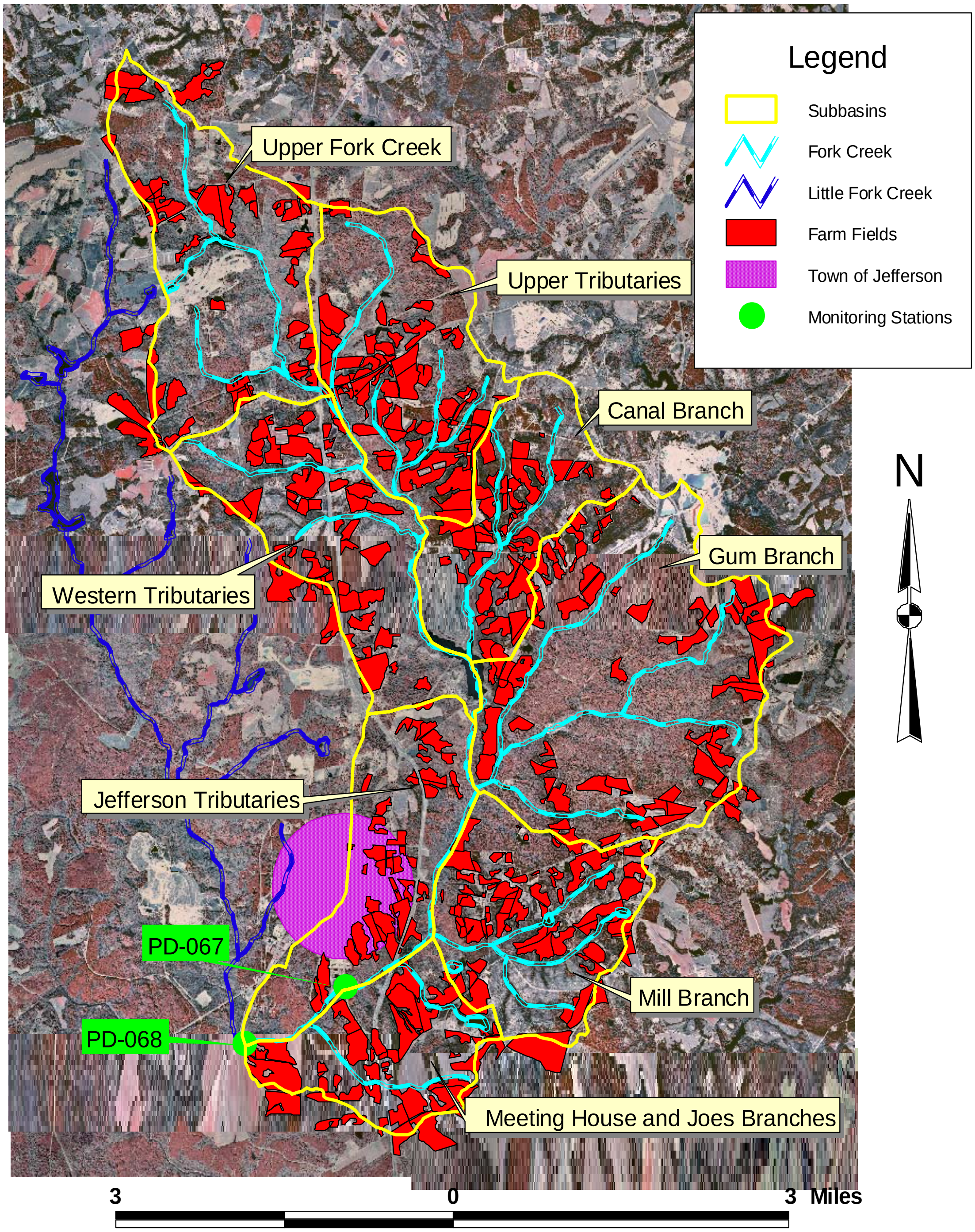
The impaired stream, Fork Creek above PD-068, is designated as Class Freshwater. Waters of this class are described as follows:

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

The South Carolina standard for fecal coliform bacteria 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 percent of the total samples during any 30-day period exceed 400/100 ml. (R.61-68).

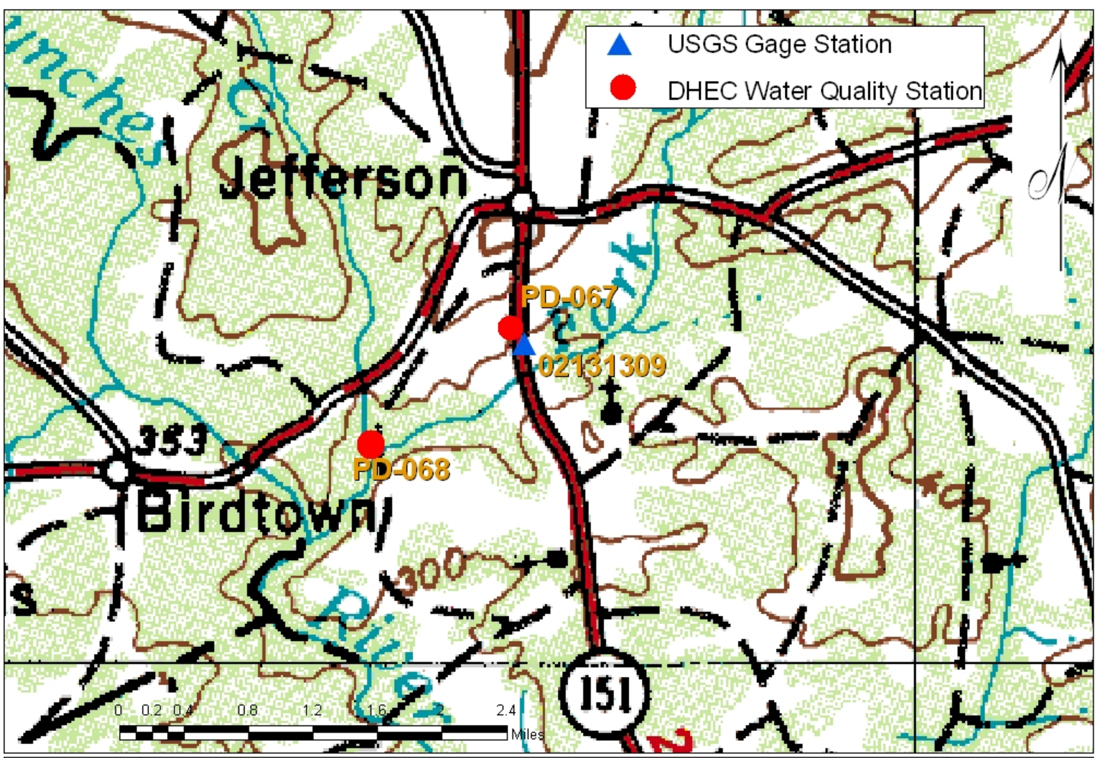
# Figure 1-1
# Fork Creek Project Area



# 2 WATER QUALITY ASSESSMENT

The spatial, seasonal and hydrologic variability of fecal coliform data collected from 1976-2003 at ambient water quality monitoring stations PD-067 and PD-068 were examined. This examination can provide insights into the contributing factors of high fecal coliform loading to the stream prior to conducting a detailed source assessment and TMDL analysis. For example, high concentrations during low flow conditions would be consistent with in-stream sources, whereas high concentrations only during storm events would indicate land-based sources.

Fecal coliform data collected by DHEC at monitoring stations PD-067 and PD-068 were collected predominately during warm weather months (May-October), and results from these stations were the primary basis for the 303(d) listing of the stream for bacteria impairment. Fork Creek fecal coliform data from DHEC monitoring stations PD-067 and PD-068 are provided in Appendix A. Figure 2-1 shows locations of monitoring stations PD-067 and PD-068.




MALCOLM PIRNIE | Pee Dee RC & D
Fork Creek Watershed Project
Water Quality and Stream Gage Station Locations | FIGURE 2-1
March 2005

## 2.1 Spatial Variability

Water quality monitoring stations PD-067 and PD-068 are relatively close to each other, separated by approximately one river mile. Therefore, it is not surprising that fecal coliform bacteria concentrations were of similar magnitude at the two monitoring stations during many sampling events (Figure 2-2).

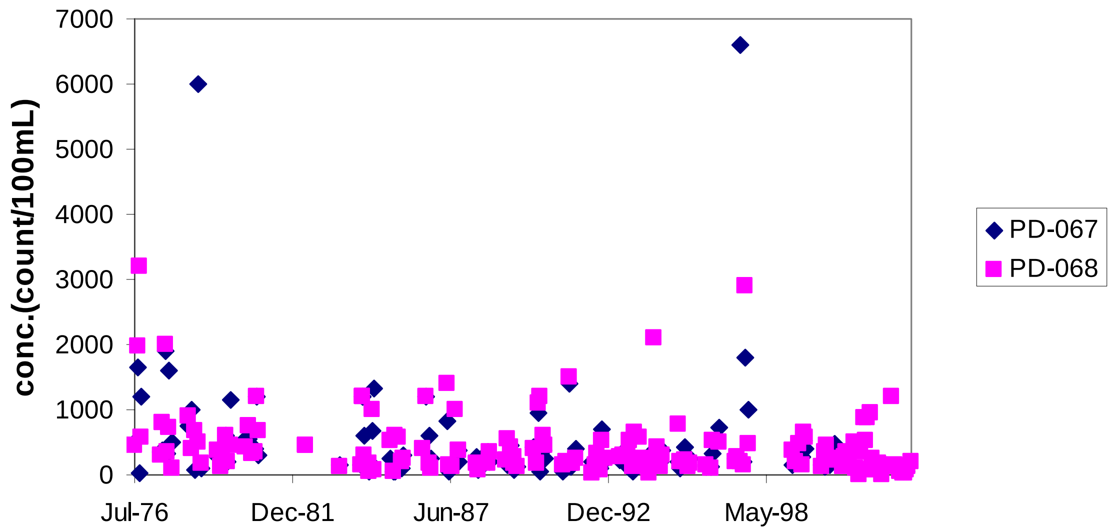



**Figure 2-2**: Fecal coliform concentration vs. time at monitoring stations PD-067 and PD-068.

There are a few markedly higher concentrations measured at station PD-067 than station PD-068, and a few concentrations that were higher at station PD-068 than PD-067. However, none of the stations have a consistently higher or lower concentration than the other. It is, therefore, likely that this consistency in fecal coliform bacteria concentrations prevails throughout the watershed, and as a result, the sources of fecal coliform bacteria loading are also equally distributed throughout the project watershed area.

Contributions from the Town of Jefferson enter Fork Creek downstream of station PD-067 but upstream of PD-068. The fact that concentrations do not significantly change between these two locations indicates that the town does not contribute an inordinately higher fecal coliform bacteria load than other nonpoint sources of bacteria in the Fork Creek project area.

### 2.2 Seasonal Variability

As shown in Figure 2-3, the mean fecal coliform bacteria concentrations were highest in July and September, a warm period of the year. The late winter and spring months, between February and June, had lower mean fecal coliform bacteria concentrations. And the mean fecal coliform concentrations during the fall months, from October through January, were found to be intermediate.

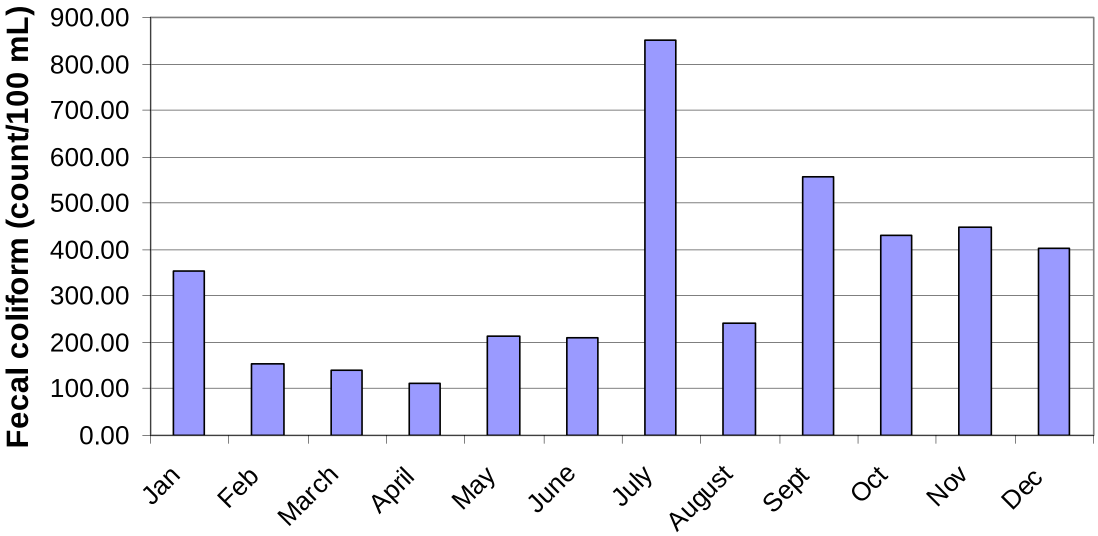



**Figure 2-3**: Mean fecal coliform concentration vs. month in Fork Creek. Mean values were calculated using 1990-2003 data from DHEC stations PD-067 and PD-068.

This general temperature-dependent pattern is due to: (1) higher fecal coliform bacteria die-off rates occurring in colder temperatures and leading to lower concentrations in the water column during colder periods of the year; (2) livestock spending more time in the stream during hot weather than during cold weather leading to higher direct fecal deposits from in-stream cattle during warmer periods of the year; (3) poultry litter application occurs in spring, summer, and early fall; (4) the gathering of stocker cattle during the fall and early winter seasons; and (5) higher flows that are generally experienced during winter and spring months can dilute fecal coliform concentrations while lower flows that are generally experienced during late summer and fall months can concentrate fecal coliform in the water column.

## 2.3 Hydrologic Variability

To assess the hydrologic variability of fecal coliform bacteria concentrations, stream flow data were obtained from the USGS gauging station 02131309, located at the same site as the DHEC water quality monitoring station PD-067. To estimate the flow from monitoring station PD-068, located downstream from PD-067, the flow at PD-067 was adjusted by simply multiplying the flow at PD-067 by the ratio of the drainage area above PD-068 to the drainage area above PD-067 (Paired Watershed Approach).

The plot of fecal coliform concentration vs. flow demonstrates that higher fecal coliform bacteria concentrations tend to occur during low flow conditions (Figure 2-4). However, the water quality criterion was exceeded under the full range of observed flow conditions. This indicates that there are both dry-weather and wet-weather sources of fecal coliform bacteria. Thus, under dry weather conditions, sources such as livestock in streams, failing septic systems and straight pipe discharge may provide fecal coliform bacteria loads to the stream. While under wet weather conditions, run-off related sources, such as livestock manure deposited on pastureland, wildlife, and poultry litter application may provide fecal coliform bacteria to the stream.

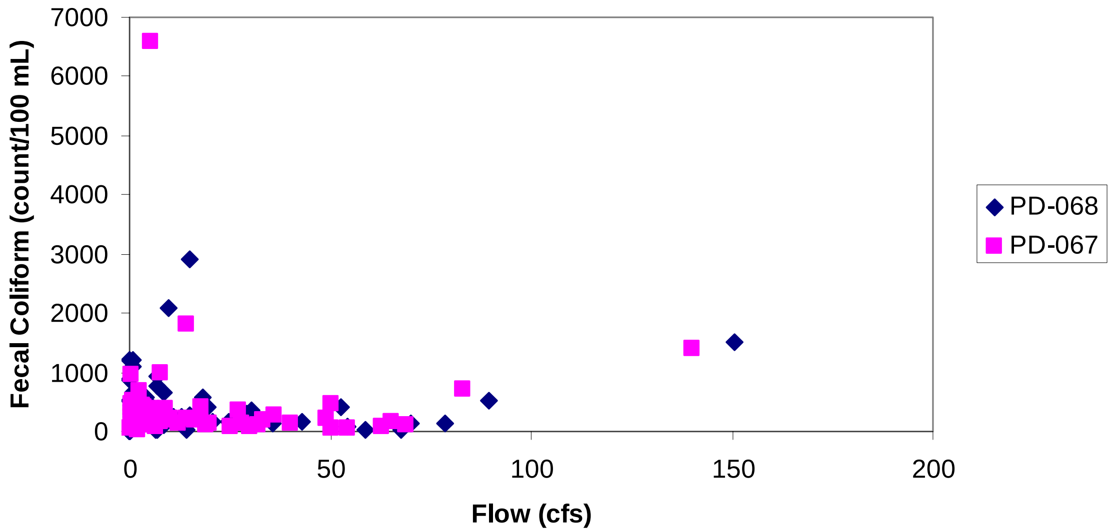



**Figure 2-4**: Fecal coliform concentration vs. streamflow in Fork Creek at stations PD-067 and PD-068, 1990-2003.

# 3 SOURCE ASSESSMENT

Figure 3-1 and Table 3-1 show the distribution of land use categories in the Fork Creek project area, obtained from the Multi Resolution Land Characteristics (MRLC) consortium's National Land Cover Data (NLCD).

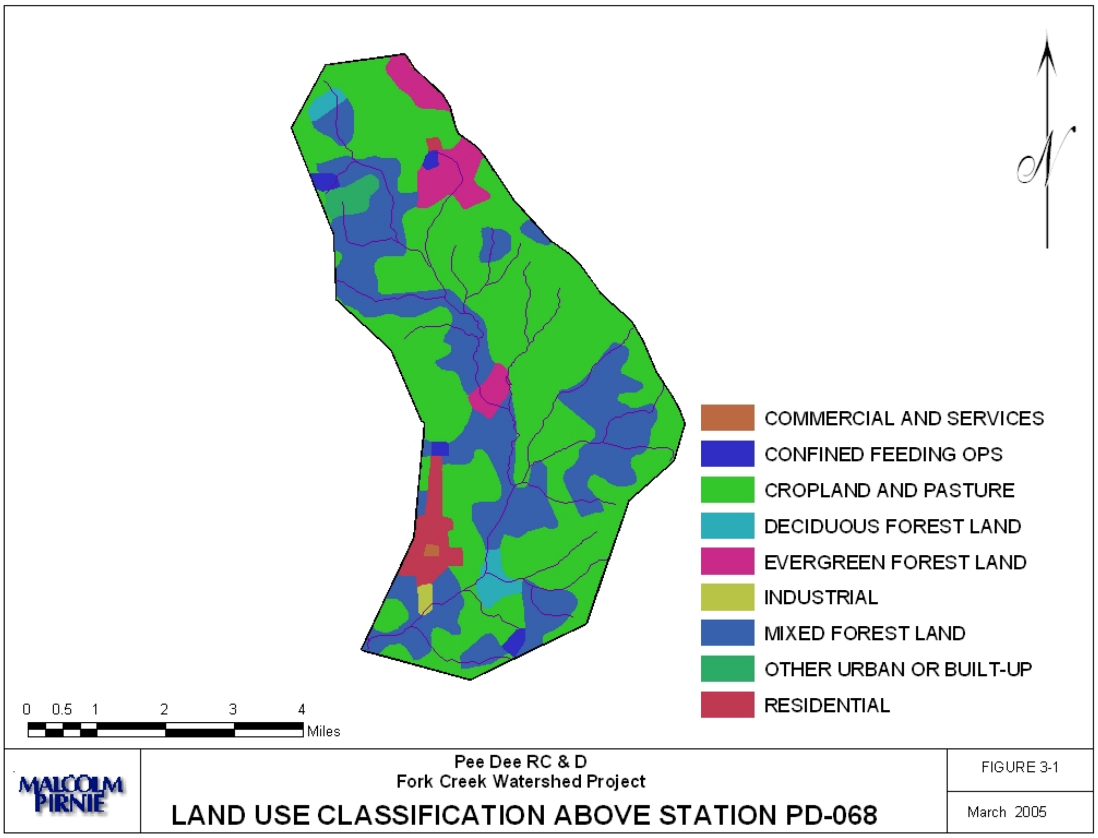


**TABLE 3-1**
**Land Use Classification in the Fork Creek Watershed above Water quality Monitoring Stations PD-067 and PD-068**

| Land Use Class | Land use | Area above PD-067 (acres) | Area above PD-067 (%) | Area above PD-068 (acres) | Area above PD-068 (%) |
|---|---|---|---|---|---|
| **Forest** | Mixed Forest | 4,780 | 29.7 | 5,365 | 31.1 |
| | Deciduous Forest | 299 | 1.9 | 299 | 1.7 |
| | Evergreen Forest | 817 | 5.1 | 840 | 4.9 |
| | Subtotal | **5,896** | **36.6** | **6,504** | **37.6** |
| **Pasture** | | **5,338** | **33.2** | **5,611** | **32.4** |
| **Cropland** | | **4,194** | **26.1** | **4,409** | **25.5** |
| **Developed** | Industrial | 14 | 0.1 | 56 | 0.3 |
| | Commercial and services | 23 | 0.1 | 24 | 0.1 |
| | Residential | 423 | 2.6 | 499 | 2.9 |
| | Other Built-up | 207 | 1.3 | 207 | 1.2 |
| | Subtotal | **666** | **4.1** | **785** | **4.5** |
| ***Total*** | | ***16,095*** | ***100.0*** | ***17,309*** | ***100.0*** |

The source assessment phase of this study involved the identification and quantification of fecal coliform bacteria loads as applied to the land surface in the Fork Creek project area, or directly to the stream, as in the case of failing septic systems. The Bacterial Indicator Tool (BIT) developed by USEPA as part of its BASINS family of software was used to quantify the fecal coliform bacteria loading rates from various non-point sources (USEPA, 2000a). The BIT is a spreadsheet that calculates loading factors for various animal sources including wildlife, unconfined livestock, and manure application as fertilizer. The spreadsheet requires the user to define the number of animals present in the watershed, as well as area in acres for the forest, pastureland, cropland and built-up land components of the watershed. The overall estimated in-stream deposition of fecal coliform bacteria resulting from livestock was used to account for loads from all livestock sources, including grazing and in-stream livestock. Estimated loading rates were used in a mass balance calculation (as described in section 4) to determine amounts of fecal coliform contributed to the stream by various sources.

The accuracy and precision of estimated loading rates are reduced by many sources of uncertainty and environmental variability. However, both local knowledge and a large body of previous studies and tools provide a basis for assessing the potential order-of-magnitude of various bacterial sources.

## 3.1 Point Sources

There is one permitted discharge facility in the Fork Creek project area: Cleveland Caroknit Plant (SC0002500), which is located upstream of water quality monitoring station PD-068 and downstream of monitoring station PD-067. The permitted flow of discharge of the point source is 0.72 MGD and is mostly composed of industrial waste. This facility has permit limits for total residual chlorine (TRC), ammonia nitrogen ($NH_3N$) and biological oxygen demand ($BOD_5$). Although this facility is not expected to be a major source of fecal coliform bacteria, it was included in the TMDL calculations.

## 3.2 Non-Point Sources

Non-point sources of fecal coliform bacteria loading that were explicitly considered included wildlife, cattle, poultry litter application, and failing septic systems/straight pipe discharges. Estimates of the number of fecal coliform counts per animal per day were based on literature-derived values of the BIT and are summarized in Table 3-2. Other sources are expected to be relatively minor by comparison, and are implicitly included by inclusion in other sources. For example, the small number of horses, sheep and goats in the project watershed can be conceptually lumped into the cattle source.

**TABLE 3-2**
**Fecal Coliform Unit Loading Rates**

| Source | Fecal Coliform Loading Rate | Units | BIT Reference |
|---|---|---|---|
| Deer | $5.0 \times 10^8$ | counts/animal/day | Best Professional Judgment |
| Raccoon | $1.2 \times 10^8$ | counts/animal/day | Best Professional Judgment |
| Cattle | $1.0 \times 10^{11}$ | counts/animal/day | ASAE, 1998 |
| Poultry litter | $1.3 \times 10^6$ | counts/gram litter | LIRPB,1978 |
| Septage | $1.0 \times 10^4$ | counts/100 mL | Horsley and Witten, 1996 |
| Developed Land | $1.1 \times 10^7$ | counts/acre/day | Horner, 1992 |

### *3.2.1 Wildlife*

A value of 35 deer per square mile was assumed for forest, pasture and cropland, based on estimates provided for the Town of Jefferson section of Chesterfield County by the South Carolina Department of Natural Resources (personal conversation, Charles Ruth, Deer Project Supervisor, SCDNR, November 15, 2004). A value of 32 raccoons per square mile was assumed for these same land uses, based on the upper end of the raccoon density range given in the South Carolina Piedmont according to the SCDNR Wildlife Management Guide for Raccoon (1997). Although the actual raccoon density might be as much as 10 times lower, the upper end of the range was used to implicitly account for other wildlife such as birds, rodents, etc.

### *3.2.2 Cattle*

According to the NRCS District Conservationist for Chesterfield County (Charles Babb, November 15, 2004), there are approximately 4,000 cattle in the Fork Creek watershed at any one time. Mr. Babb also indicated that the number of animals present in the watershed can vary throughout a year, depending on the time of the year that stockers gather their animals. Stockers normally gather their animals during the winter season, and so the number of animals can increase during the winter time. There are no dairy or feedlot operations in the Fork Creek watershed (personal conversation, Charles Babb, November 15, 2004). Cattle manure is not collected or applied as fertilizer to cropland (personal conversation, Charles Babb, November 15, 2004).

There are places where cattle can directly access Fork Creek or its tributaries, but the direct deposit of fecal coliform bacteria from in-stream cattle was not explicitly differentiated from deposition on land. Instead, run-off resulting from manure deposits on pastures was used to estimate loads from all livestock sources (grazing and in-stream).

### *3.2.3 Poultry Litter Application*

An estimation of the magnitude of poultry litter application was based largely on the local knowledge and professional judgment of the District Conservationist, Charles Babb. Poultry litter was assumed to be applied to both Cropland and pastureland at a rate of 2.75 tons/acre. In any given year, 90% of cropland and 90% of pastureland was assumed to receive an application. A higher percentage of the litter application occurs during spring and fall seasons.

### *3.2.4 Failing Septic Systems*

The Town of Jefferson is served by the town's wastewater treatment plant. The remainder of the Fork Creek project area is sparsely populated. The total number of septic systems within the project watershed of Fork Creek was estimated to be 300 (approximately 12 per square mile) based on the average septic system density in Chesterfield County, according to 1990 census data.

The failure rate of septic systems was assumed to be 1 % (personal conversation, Kalvin Hancock, Chesterfield County Health Department representative, November 12, 2004). Implicitly included with failing septic systems are "straight pipe" discharges of wastewater directly to the stream. Default values of the BIT that were used for this project include 2.55 persons served per septic system, a volume of 70 gallons wastewater generated per person per day, and a fecal coliform count of 10,000 counts/100 mL in wastewater reaching the stream (Horsley and Witten, 1996).

### *3.2.5 Urban/Suburban Runoff*

Runoff from developed land contributes fecal coliform loads mostly from domestic animals, and to a lesser extent, wildlife. Instead of explicitly calculating the number of domestic animals (e.g. cats, dogs, etc.) in the watershed, the BIT uses literature-based rates of fecal coliform accumulation on different types of built-up land. For the Fork Creek project area, an average value of 1.13 × 107 counts/acre/day was used based on the work of Horner (1992).

# 4 LOAD-DURATION METHOD

The load duration curve method was used to calculate the existing and the TMDL load for Fork Creek at DHEC water quality monitoring stations PD-067 (located on Route 151) and PD-068 (located on an unnumbered road). The load-duration method develops TMDLs based on a frequency analysis of the historic hydrologic record, resulting in a cumulative frequency of daily flows, and pollutant concentration data. A water quality standard load or “allowable load” is calculated by multiplying the numeric water quality criteria by the flows from the frequency analysis. Multiplying the water quality data by the daily flow calculates actual pollutant loads. The critical flow and allocation are determined by a comparison of the pollutant loads with the allowable loads.

The load-duration method was selected for this project because it is a relatively simple method that provides adequate estimate of fecal coliform bacteria loading over a range of streamflow conditions. In addition, the load-duration method has a successful track record of DHEC approval for similar fecal coliform bacteria TMDL applications across the state of South Carolina. Primary disadvantages of the load-duration method are its limited predictive capability and its limited capability to link load reduction estimates, hydrologic conditions and contributing areas. In this project, the load duration curve analysis was supplemented by mass balance calculations to estimate the loads contributed by various non-point sources (as discussed on section 4.2). Estimates of the necessary load reduction were determined using a combination of results obtained from the mass balance approach and the calculated loads from the load-duration curve method. The load-duration curve method includes all flow conditions ensuring that critical conditions are protected.

## 4.1 Development of the Load-Duration Curve

Because the load-duration curve methodology is based on frequency analysis of streamflow, the first step in the analysis involved collecting or estimating historical record of flow in Fork Creek at both DHEC water quality monitoring stations PD-067 and PD-068. Fork Creek at water quality monitoring station PD-067 has a USGS gauge (USGS 02131309) that has a record of flow data from August 27, 1976 to September 30, 1997. It was desired to get a longer period of flow data as this increases the confidence of the results obtained from the load-duration method. Therefore, a paired watershed approach, where the flow data obtained from a gauged stream with a long period of flow record having a similar sized drainage area, land use and topography, was used to estimate flow for Fork Creek at water quality monitoring station PD-067 from October 1, 1997 to September 30, 2003.

Hanging Rock Creek (USGS station 02131472), located approximately 60 miles southwest of Fork Creek in Lancaster County has similar watershed characteristics (size, land use and topography) as Fork Creek. Compared to another gauged stream (Lynches River at Effingham), also with a similar watershed characteristics (though different size), flow data at Hanging Rock gave a better linear regression fit ($R^2$ = 0.73 versus $R^2$ = 0.59) with flow data at Fork Creek during the periods of time that flow data was available from all three stations. As a result, data from the gauge on Hanging Rock Creek was used to estimate flow for Fork Creek at water quality monitoring station PD-067. A linear trend line gave the best fit to the flow data between the two streams ($R^2 = 0.73$), and the equation of the line was used to estimate daily flow at PD-067 on Fork Creek for dates ranging from October 1, 1997 to September 30, 2003. This estimated flow record was appended to the flow record from the USGS gauge station on Fork Creek, and there data were used to generate the flow-duration curve.

In order to obtain an estimated streamflow record at water quality monitoring station PD-068, flow data obtained or estimated for Fork Creek at water quality monitoring station PD-067 from August 27, 1976 to September 30, 2003 was adjusted by simply multiplying the daily flow rates at PD-067 by the ratio of the drainage area above PD-068 to the drainage area above PD-067 (1.08). This adjusted flow data was then used to generate the flow-duration curve at water quality monitoring station at PD-068.

In evaluating the cumulative distribution of the stream flow, flow data at both water quality monitoring stations for the time period of August 27, 1976 to September 30, 2003 were ranked from low to high and the values that exceeded certain selected percentiles determined. The fecal coliform bacteria loads at the two water quality monitoring stations were calculated by multiplying the fecal coliform bacteria concentration data by the flow rate that corresponded to the date of coliform sampling. To generate the load-duration curves, the loads were plotted against the appropriate flow recurrence interval (Figures 4-1 & 4-2). The water quality standard load or “allowable load” (target line on Figures 4-1 & 4-2) was calculated by multiplying the appropriate fecal coliform bacteria standard concentration by the flows from the frequency analysis. At a given streamflow, fecal coliform bacteria loads above the target line are in violation of the standard, while loads below the line are in compliance.

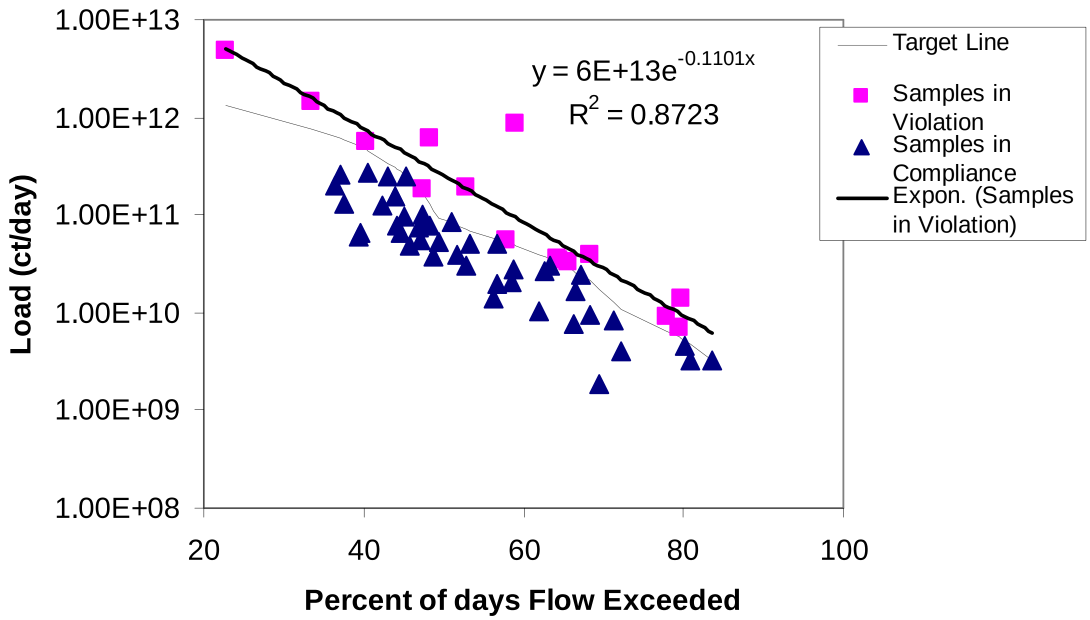



**Figure 4-1**: Load duration curve for Fork Creek at Monitoring Station PD-067

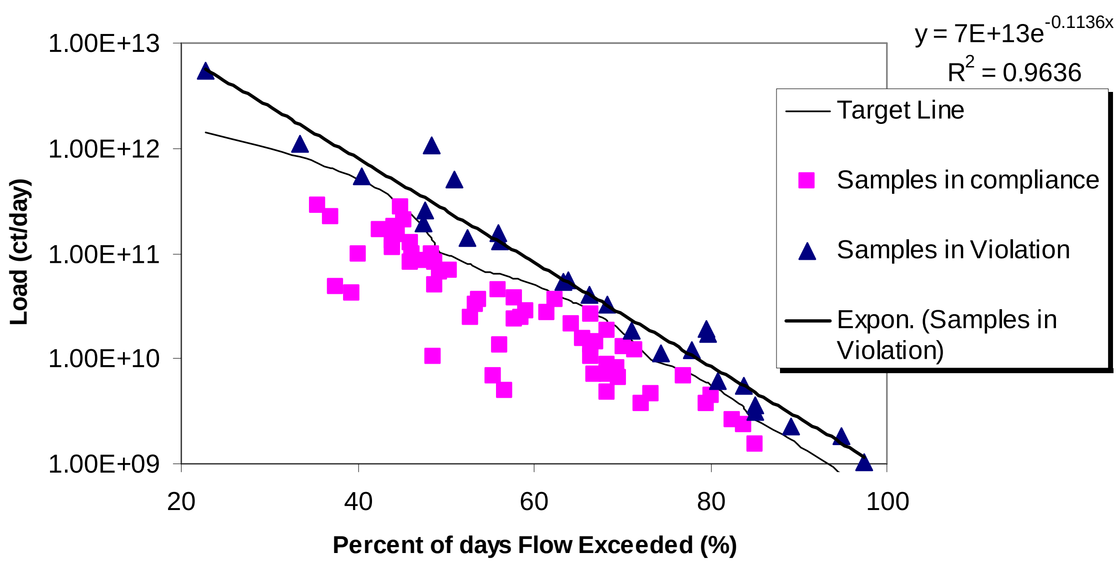



**Figure 4-2**: Load duration curve for Fork Creek at monitoring station PD-068

The total existing loads of fecal coliform bacteria at the two water quality monitoring stations in the Fork Creek project area were determined from the samples that violated the water quality standard. That is, a best fit trend line was determined for fecal load data in violation of the standard and the equation of the trend line used to estimate loads for the range of the flow recurrence intervals that had a majority of the loads in violation of the standard. The existing loads were then calculated by taking the average of the loads estimated within those flow duration intervals. The best fit trend lines at both water quality monitoring stations PD-067 and PD-068 were exponential curves with regression coefficients values of $R^2 = 0.87$ at PD-067 and $R^2 = 0.96$ at PD-068. The majority of the violating loads were between 22% and 80% streamflow duration intervals at PD-067, and between 22% and 95% duration intervals at PD-068. Therefore, the average existing loads were determined within these flow duration intervals at 2% intervals. A table showing equations of the trend lines developed for the loads in violation at the two water quality monitoring stations and evaluated values of the exiting loads is provided in Appendix B. Similarly, the allowable loads at the two monitoring stations on Fork Creek were calculated by determining trend line for the target loads at each station and calculating the average loads estimated within the appropriate flow duration intervals (i.e, 22% - 80% at PD-067 and 22% - 95% at PD-068 at 2% intervals). Calculations for both existing and allowable loads are provided in Appendix B.

### 4.2 Mass Balance Calculations

A mass balance approach was used to estimate amounts of loads contributed by various non-point sources including grazing livestock and livestock defecating directly into streams; wildlife; urban run off and failing septic systems. In quantifying the fecal coliform bacteria load contributed by the various sources, the BIT described in section 3.0 was used to estimate coliform loads to the land surface and stream (USEPA, 2000a).

The BIT spreadsheet was used to estimate loads to the land surface from wildlife, urban sources, livestock, poultry litter application, and failing septic systems. To determine the loads actually reaching the stream from these sources, land surface accumulated loads resulting from these sources were multiplied by an attenuation factor that was evaluated by a trial and error method as explained below. An attenuation factor is a fraction amount by which the total land surface accumulated load is reduced before it is directly deposited into the stream.

In determining the attenuation factor used, individual in-stream fecal coliform bacteria loads resulting from urban run-off, wildlife, livestock and poultry litter application were summed, and the resulting total load equated to the total existing load estimated from the load-duration curve method. The attenuation factor that allowed the summed total of the individual loads to equal the existing load estimated from the load-duration curve method was used in the mass balance calculation. Attenuation factors evaluated at water quality monitoring stations were 0.018% at PD-067 and 0.015% at PD-068. Percentages of the fecal coliform bacteria load contributed by each source were then evaluated, allowing for the determination of the dominant fecal coliform sources to the stream. It is important to note that the evaluated run-off fecal coliform bacteria load resulting from livestock is used to account for loads from all livestock sources, including grazing and in-stream livestock.

# 5 LOAD ASSESSMENT RESULTS

This section summarizes results of the total existing and recommended loads estimated by the load-duration curve analysis, and the breakdown by source of those determined from the mass balance calculations.

## 5.1 Existing Conditions

Total loads under observed conditions at water quality monitoring stations PD-067 and PD-068 were calculated from the trend line of the observed values that violated the water quality standard. Observed values exceeded the water quality standards within flow recurrence intervals of 22% to 80% at PD-067 and within flow recurrence intervals of 22% to 95% at PD-068. The total average existing load at PD-067 is $8.97 \times 10^{11}$ counts/day and at PD-068 is $7.65 \times 10^{11}$ counts/day.

A mass balance approach was used (as discussed in section 4) to estimate the fecal coliform bacteria loads contributed by different sources to Fork Creek at water quality monitoring stations PD-067 and PD-068 (Tables 5-1 and 5-2). At both water quality monitoring stations, livestock is estimated to be the single largest contributing source on an annual animal basis, followed by poultry litter application, and then by wildlife. Urban runoff and failing septic systems were estimated to be the least contributing sources, both showing a negligible component of the total load; which is not surprising given the small proportion of developed land and low density of the population in the watershed. It is important to note that percentages of the total load contributed by each source are estimates, but these estimated percentages indicate the relative importance of each source.

**TABLE 5-1**
**Fecal Coliform Bacteria Load to Fork Creek at Water quality Monitoring Station PD-067**

| Source | Land Accumulated Load (counts/day) | In-Stream Fecal Load (counts/day) | Percent of Total Load (%) |
|---|---|---|---|
| Wildlife | 4.04E+12 | 7.13E+08 | 0.08 |
| Livestock | 4.99E+15 | 8.81E+11 | 98.24 |
| Poultry Litter application | 8.40E+13 | 1.48E+10 | 1.65 |
| Urban Runoff | 5.74E+09 | 1.01E+06 | 0.00011 |
| Failing Septic systems | 0 | 2.03E+08 | 0.02 |
| **ALL** | | 8.97E+11 | 100.00 |

**TABLE 5-2**
**Fecal Coliform Bacteria Load to Fork Creek at Water quality Monitoring Station PD-068**

| Source | Land Accumulated Load (counts/day) | In-Stream Fecal Load (counts/day) | Percent of Total Load (%) |
|---|---|---|---|
| Wildlife | 4.26E+12 | 6.40E+08 | 0.08 |
| Livestock | 4.99E+15 | 7.51E+11 | 98.15 |
| Poultry Litter application | 8.83E+13 | 1.33E+10 | 1.74 |
| Urban Runoff | 6.76E+09 | 1.02E+05 | 0.000133 |
| Failing Septic systems | 0 | 2.03E+08 | 0.03 |
| **ALL** | | 7.65E+11 | 100.00 |

## 5.2 Total Maximum Daily Load

The Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant loading a water body can receive and still maintain water quality standards. In this case, the pollutant of concern is fecal coliform bacteria, and the load is expresses as counts/day (number of coliform bacteria counts/day). Conceptually, the TMDL load is calculated using the following equation:

TMDL = Sum of WLA + Sum of LA + MOS

Where:

WLA (Waste load allocation) is the pollutant load allocated to existing and future point sources.

LA (Load allocation) is the pollutant load allocated to non-point sources and natural occurrences.

MOS (margin of safety) is used to account for uncertainty in determining pollutant loads allowing for the unknown.

Table 5-3 shows TMDL components for Fork Creek at water quality monitoring stations PD-067 and PD-068.

The South Carolina DHEC has previously used a margin of safety at 5 % of the fecal coliform bacteria standard or a fecal concentration of 20 counts/ 100 ml. For Fork Creek at water quality monitoring station PD-067, this equates to MOS fecal load of $2.50 \times 10^{10}$ counts/day, and at monitoring station PD-068, it equates to $2.33 \times 10^{10}$ counts/day.

The waste load allocation for the Cleveland Caroknit Plant was calculated by using the water quality standard of 400 counts/ 100 ml for fecal coliform bacteria, as has previously been done by South Carolina DHEC. The WLA for the Cleveland Caroknit Plant is $1.09 \times 10^{10}$ counts/day. This WLA is only applied to the TMDL calculations at monitoring station PD-068 because the permitted discharge facility (Cleveland Caroknit Plant) is located upstream of monitoring station PD-068, but downstream of monitoring station PD-067, and thus, does not contribute fecal coliform bacteria to the stream above monitoring station PD-067.

The LA was determined from the target line of the load-duration curve within the range of flow recurrence intervals for which the water quality standard was violated (22% to 80% at PD-067 and 22% to 95% at PD-068), which was developed by setting the fecal coliform bacteria concentration of 380 counts/day that is equivalent to the standard concentration less the MOS. The LA for Fork creek at PD-067 is $5.0 \times 10^{11}$ counts/day and at PD-068 is $4.65 \times 10^{11}$ counts/day.

**TABLE 5-3**
**TMDL Components for Fork Creek at Monitoring Stations PD-067 and PD-068**

| Impaired Station | Sum of WLA (counts/day) | Sum of LA (counts/day) | MOS (counts/day) | TMDL (counts/day) |
|---|---|---|---|---|
| PD-067 | NA | $4.65 \times 10^{11}$ | $2.50 \times 10^{10}$ | $5.25 \times 10^{11}$ |
| PD-068 | $1.09\times 10^{10}$ | $4.65 \times 10^{11}$ | $2.33 \times 10^{10}$ | $4.99 \times 10^{11}$ |

### 5.3 Critical Conditions

Both monitoring and load-duration curve results demonstrate that the fecal coliform bacteria standard at monitoring stations PD-067 and PD-068 on Fork Creek can be exceeded under low flow and high flow conditions. Load-duration curves show that at both monitoring stations, PD-067 and PD-068, most of the standard violations occurred during medium flows; however, standard violations occurred over much of the total range of flows. Monitoring results also indicate that the critical seasonal condition for Fork Creek is the warm weather period (July and September) when in-stream livestock depositions are active. Because the load duration method makes of use of data from the full range of flow and seasonal conditions, the resulting TMDL inherently addresses the critical conditions.

## 6 POTENTIAL ALLOCATIONS

The WLA of the Cleveland Caroknit Plant, which discharges on Fork Creek upstream PD-068 and downstream PD-067 is equal to 1.09 × $10^{10}$ counts/day. This WLA value is almost an insignificant component of the TMDL at water quality monitoring station PD-068. The stream segment of interest above station PD-067 has no current or planned point source discharges; therefore, the recommended load allocation at this water quality station included no waste loads.

The required total load reduction is the difference between the existing load and the target load expressed as a percentage. The target load to the stream is the TMDL minus MOS, and for Fork Creek at monitoring station PD-067, it is equivalent to the load allocation (LA). The target loading for Fork Creek at PD-067 requires a total reduction of 44.3 % from the current load of 8.97 × $10^{11}$ counts/day. At PD-068, Fork Creek requires a total reduction of 37.7 % from the current load of 7.65 × $10^{11}$ counts/day (Table 6-1). Because livestock sources are the single major contributing sources of fecal coliform bacteria to Fork Creek at both monitoring stations (accounting for 98% of the total coliform load at both stations), it is recommended that allocations include the highest percentage of reduction from livestock sources at both monitoring stations. Recommended allocations at monitoring station PD-067 includes a 45% reduction in loads from livestock sources and a 20% reduction in loads from poultry litter. At monitoring station PD-068, recommended allocations include a 38% reduction in loads from livestock sources and a 20% reduction in loads from poultry litter. The recommended load allocations are based on good engineering and agricultural practices. Although much smaller percent reductions in loads from poultry litter than 20% are needed to meet the water quality criteria, the recommended 20% is believed to improve maintenance of soil nutrient levels. Also, because poultry and turkey productions fluctuate quite frequently, it would be necessary to include the recommended percent reduction in loads from poultry litter in order to cut down high loads that may result from poultry litter at times when poultry and turkey productions increase. Additionally, recommended poultry litter load reductions adhere to the state standard buffer zones of 100 ft from streams and wetlands and 50 ft from ditches, within which poultry litter can not be applied. Other non-point sources (wildlife, urban runoff and failing septic systems) contribute negligible components of the total load and thus do not necessarily require load reductions for the stream to meet the fecal coliform standard.

**TABLE 6-1**
**Recommended Load Reduction for Fork Creek at Monitoring Stations PD-067 and PD-068**

| Impaired Station | Existing Load (counts/day) | Target Load (counts/day) | Required Reduction (%) |
|---|---|---|---|
| PD-067 | 8.97 × $10^{11}$ | 5.0 × $10^{11}$ | 44.3 |
| PD-068 | 7.65 × $10^{11}$ | 4.76 × $10^{11}$ | 37.7 |

# 7 AGRICULTURAL LAND USE CHARACTERIZATION

A Geographic Information System (GIS) database will be used during TMDL implementation planning to identify viable pasture, poultry litter application and other types of farm field sites for agricultural BMP and conservation practice implementation.

## 7.1 GIS Datalayer Development of Agricultural Land Uses

Numerous South Carolina agricultural agencies are charged with the responsibility of satisfying the provisions described in this fecal coliform bacteria Load Reduction Management Plan, and any future requirements resulting from state TMDL development endeavors. GIS datalayers have been developed to assist these agencies meet the following future tasks associated with the implementation of agricultural BMP and conservation practices in the Fork Creek project area:

- Assess potential sources of fecal coliform bacteria loading from specific pasture, hayfield and cropland land use areas;
- Effectively and efficiently consolidate and monitor corrective actions (i.e., Best Management Practices (BMPs) and conservation practices) associated with meeting the goals of the Load Reduction Management Plan;
- Facilitate consensus building among the various agencies and landowners during implementation decision making.

The datalayer development effort included the following steps:

1. Approximately 500 pastures, croplands, hayfields, idle farms, and farm fields converted to forestry practices located in the Fork Creek project area were digitized using available 1999 color Digital Ortho Quarter Quadrangle (DOQQ) photos. Farm field boundaries were obtained by referencing hand-marked Farm Service Agency (FSA) hardcopy aerial photographs located in the Chesterfield County Agriculture Service Center in Chesterfield, South Carolina. Additional farm fields were also digitized when they were noted on DOQQ aerial photographs but lacked an FSA designated boundary because the grower was not enrolled in an FSA program.

2. Farm field administrative attribute information was also obtained from the hand-marked FSA hardcopy aerial photographs. This included respective farm tract and field (common land use) numbers, and farm field acreages. A project-specific administrative numbering scheme was also applied to those farm fields noted on the DOQQ but not enrolled in an FSA program.

3. Additional fecal coliform bacteria loading attribute information applicable to specific farm field boundary areas were acquired from two sources:

- Interviews conducted with agricultural agency field experts in Chesterfield County;
- Field surveys of the Fork Creek project area conducted on October 26, 2004 by the Pee Dee RC&D Council and MSD Associates.

Known or field verified attribute information acquired during the field visit included agricultural land use cover types (i.e., pasture, cropland, hayfield); presence of animals; and poultry houses. No poultry litter piles or hog operations and associated sprayfields were noted in the watershed.

### 7.2 Agricultural Land Use Characterization Results

The results of the agricultural land use characterization are detailed below for each of the eight Fork Creek project area subbasins. The Meeting House and Joes Tributary subbasins were consolidated and reviewed as a single subbasin area. Table 7-1 depicts an assortment of farm field information categorized by subbasin that is pertinent to fecal coliform bacteria loading. The information was acquired during this agricultural land use characterization.

**Table 7-1**
**Farm Field Characteristics**

| Subbasin | Total Farm Fields | Pastures | Cropland | Hayfields | Poultry Operations | Converted to Forestry | Idle Farms |
|---|---|---|---|---|---|---|---|
| Upper Fork Creek | 54 | 6 | 2 | 8 | 1 | 24 | 10 |
| Upper Tributaries | 62 | 15 | 3 | 6 | 4 | 24 | 3 |
| Canal Branch | 41 | 0 | 4 | 0 | 0 | 11 | 3 |
| Western Tributaries | 52 | 13 | 6 | 10 | 1 | 13 | 3 |
| Gum Branch | 77 | 7 | 13 | 9 | 1 | 11 | 13 |
| Mill Branch | 75 | 6 | 6 | 10 | 1 | 13 | 10 |
| Jefferson Tributaries | 45 | 3 | 3 | 5 | 0 | 6 | 16 |
| Meeting House and Joes Tributaries | 42 | 5 | 3 | 12 | 1 | 6 | 4 |
| *Total* | *448* | *55* | *40* | *60* | *9* | *108* | *62* |

Agricultural land use activity in the Fork Creek project area is decreasing over the short-term, as demonstrated by the large number of idle farms (62), and over the long-term, as demonstrated by the large number of farms converted to pine plantation and forestry (108). In addition, local agricultural experts have mentioned that a large integrated company is in the process of contracting with growers outside of the Fork Creek project area; thereby resulting in sharp decrease in turkey production (David Arthur and John Alford, October 26, 2004). It is, therefore, expected that:

- An overall reduction in fecal coliform bacteria will occur in the Fork Creek project area; and

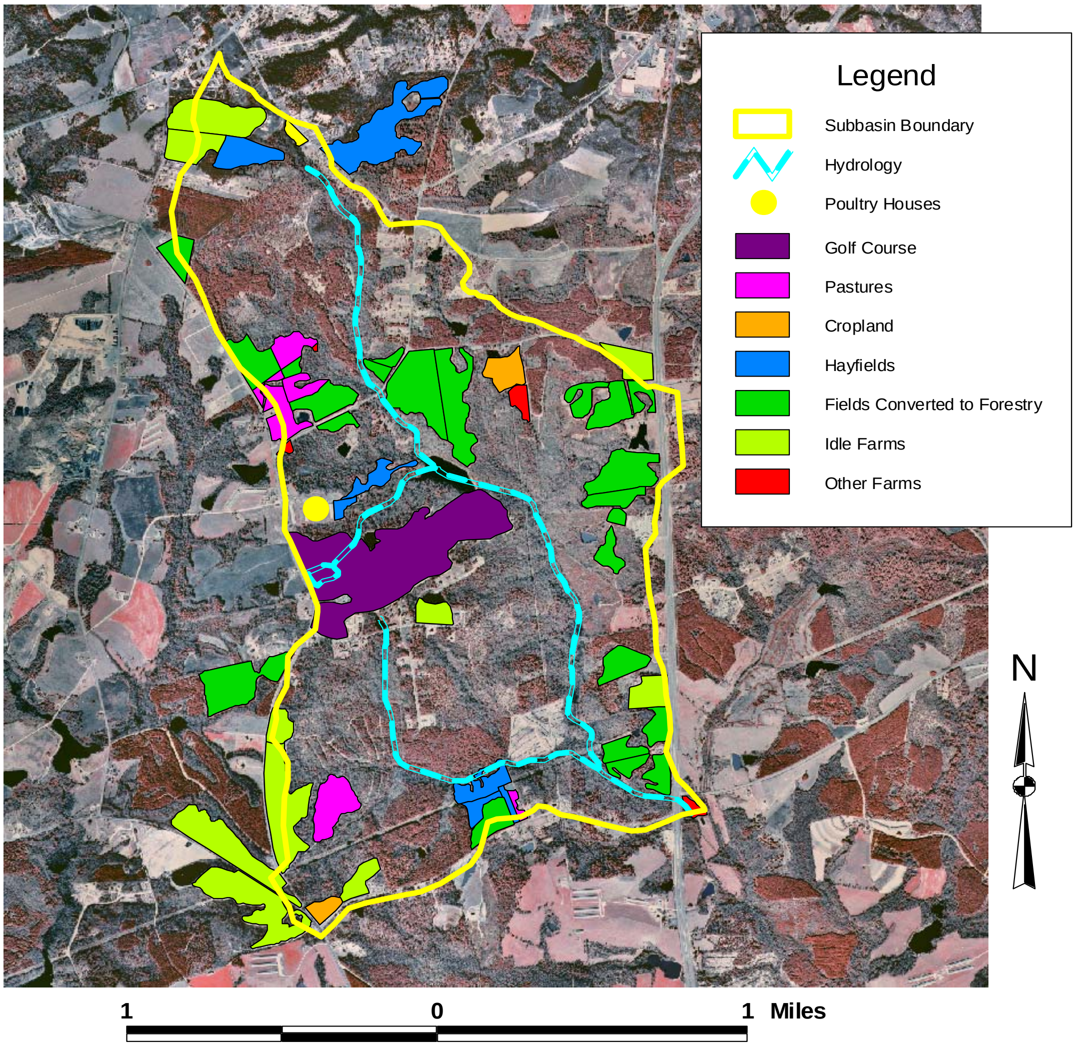
- Agricultural agency field personnel will be able to conduct a more refined search of those farm fields that are potentially the greatest sources of fecal coliform bacteria loading; particularly pasture areas.

This land use information will be consolidated with the water quality modeling results and stakeholder recruitment efforts to initiate the development of an effective TMDL implementation effort. The following Fork Creek Subbasin descriptions and figures provide a detailed accounting of agricultural practices in the Fork Creek project area. The figure scales are approximate.

***Upper Fork Creek Subbasin***

This subbasin represents the extreme headwaters of the Fork Creek project area. Several tributaries combine to form the Fork Creek mainstem. As shown in Figure 7-1, the farm fields in this subbasin are more greatly scattered than in the majority of the other subbasins. Moreover, most of the farm fields have either been converted to forestry or have gone idle. A poultry house, a few pastures, and a golf course are potentially the greatest sources of fecal coliform bacteria in the Upper Fork Creek subbasin.

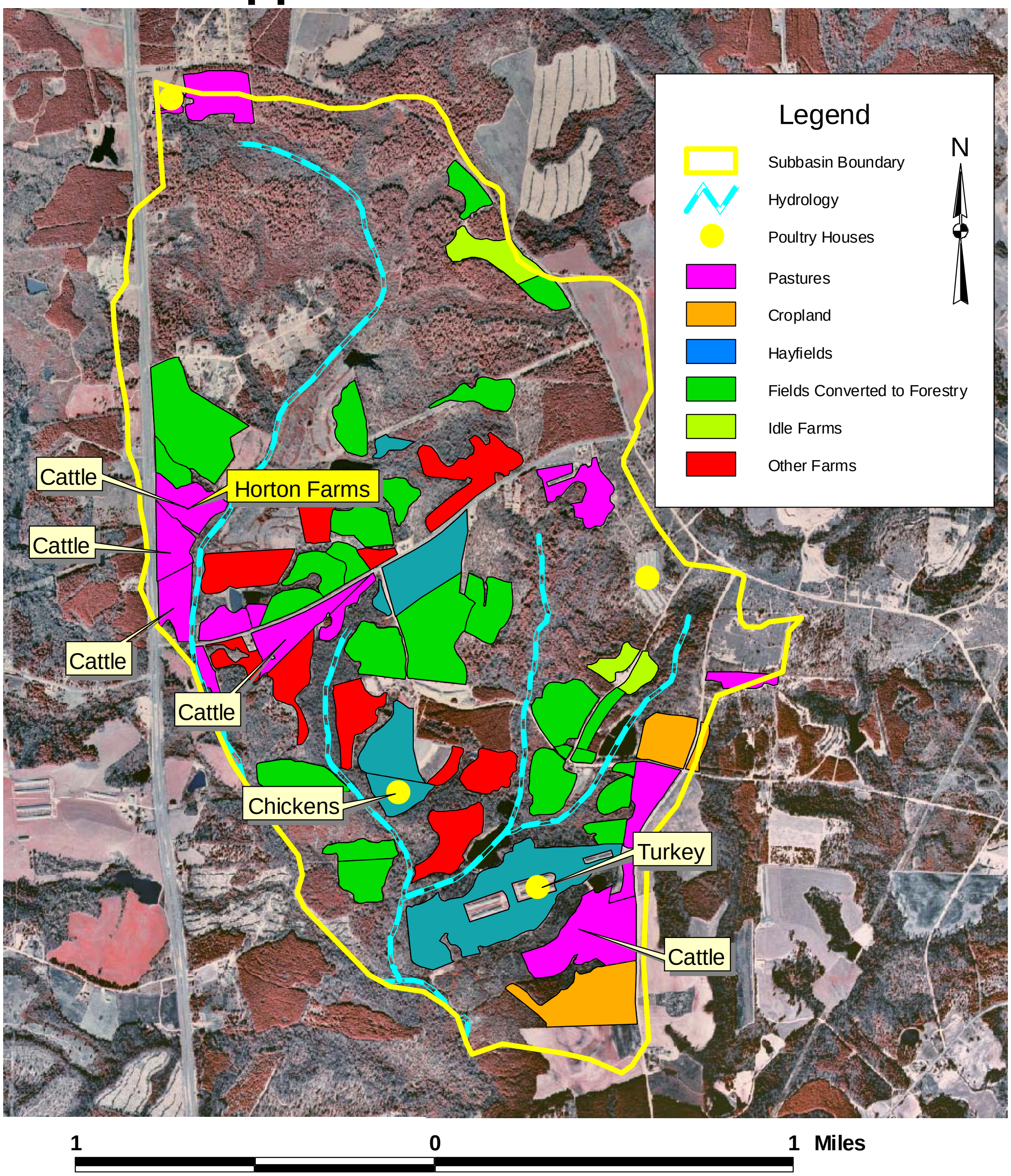
# Figure 7-1
# Upper Fork Creek Subbasin




***Upper Tributaries Subbasin***

This Subbasin includes eastern drainage from two large unnamed tributaries to Fork Creek just south of the Upper Fork Creek Subbasin. As depicted in Figure 7-2, there are numerous potential sources of fecal coliform bacteria in this Subbasin. Pastures were noted to have cattle neighboring both tributary streams on the October 26, 2004 field survey, and four poultry houses could be a source of litter for adjacent pastures, hayfields, and cropland. This Subbasin should be prioritized by the agricultural agency TMDL implementation team.

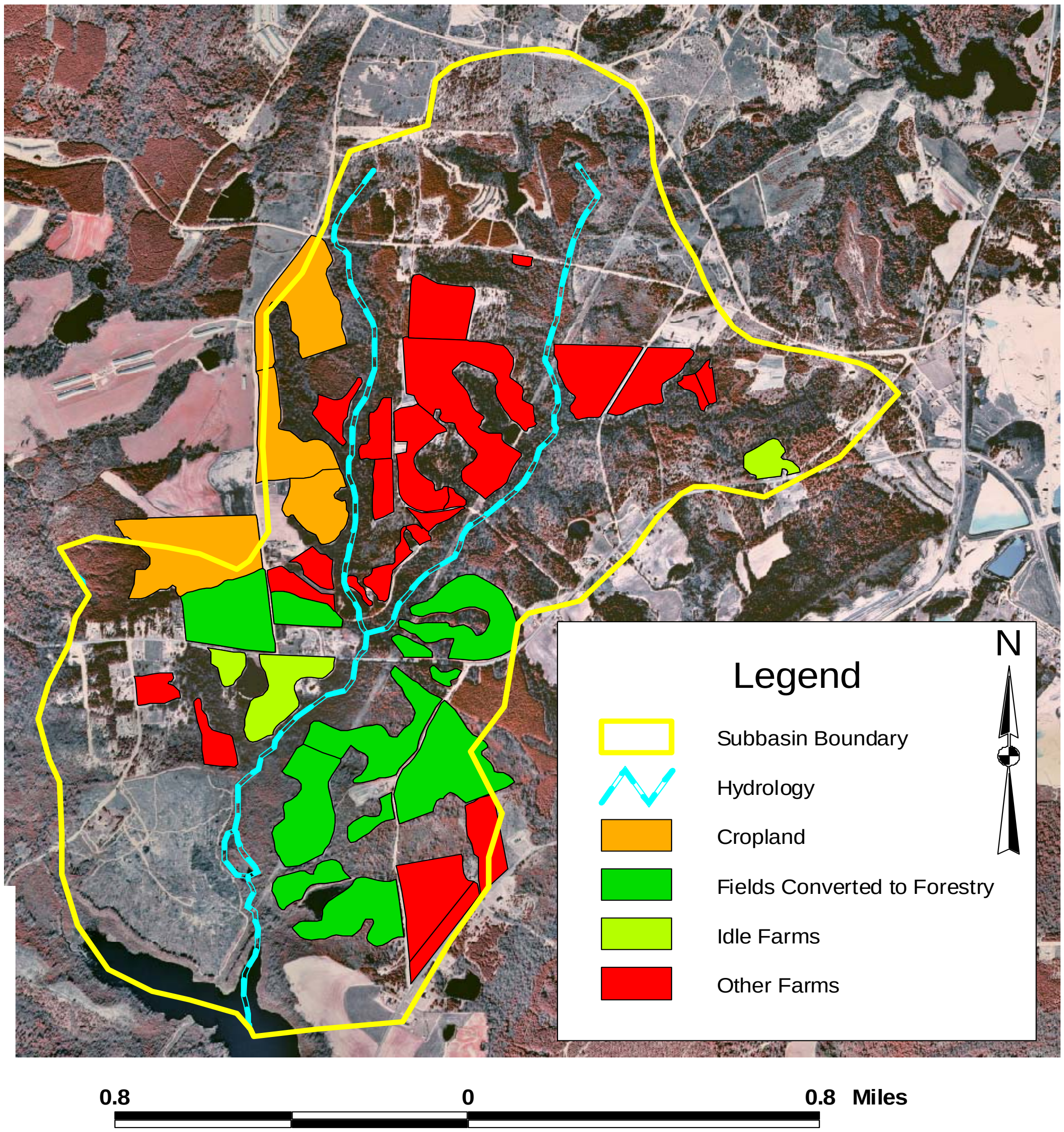
**Figure 7-2**
**Upper Tributaries Subbasin**



***Canal Branch Subbasin***

Canal Branch is a small Subbasin that drains into Fork Creek from the northeast. It is located south of the Upper Tributaries Subbasin. The farm fields in the Subbasin's lower regions have been converted to forestry or gone idle. To the west, several croplands were noted to be located in close proximity to poultry houses found just outside of this Subbasin. Many farm fields found adjacent to and between the two headwater tributaries of Canal Branch could not be characterized during the October 26, 2004 field survey. It appears from the aerial photographs that these farm fields marked as 'Other Farms' on Figure 7-3 are primarily cropland. To determine their potential for fecal coliform bacteria loading, it is recommended that the Chesterfield County NRCS District Conservationist make an effort to meet the landowner(s) of these farm fields.

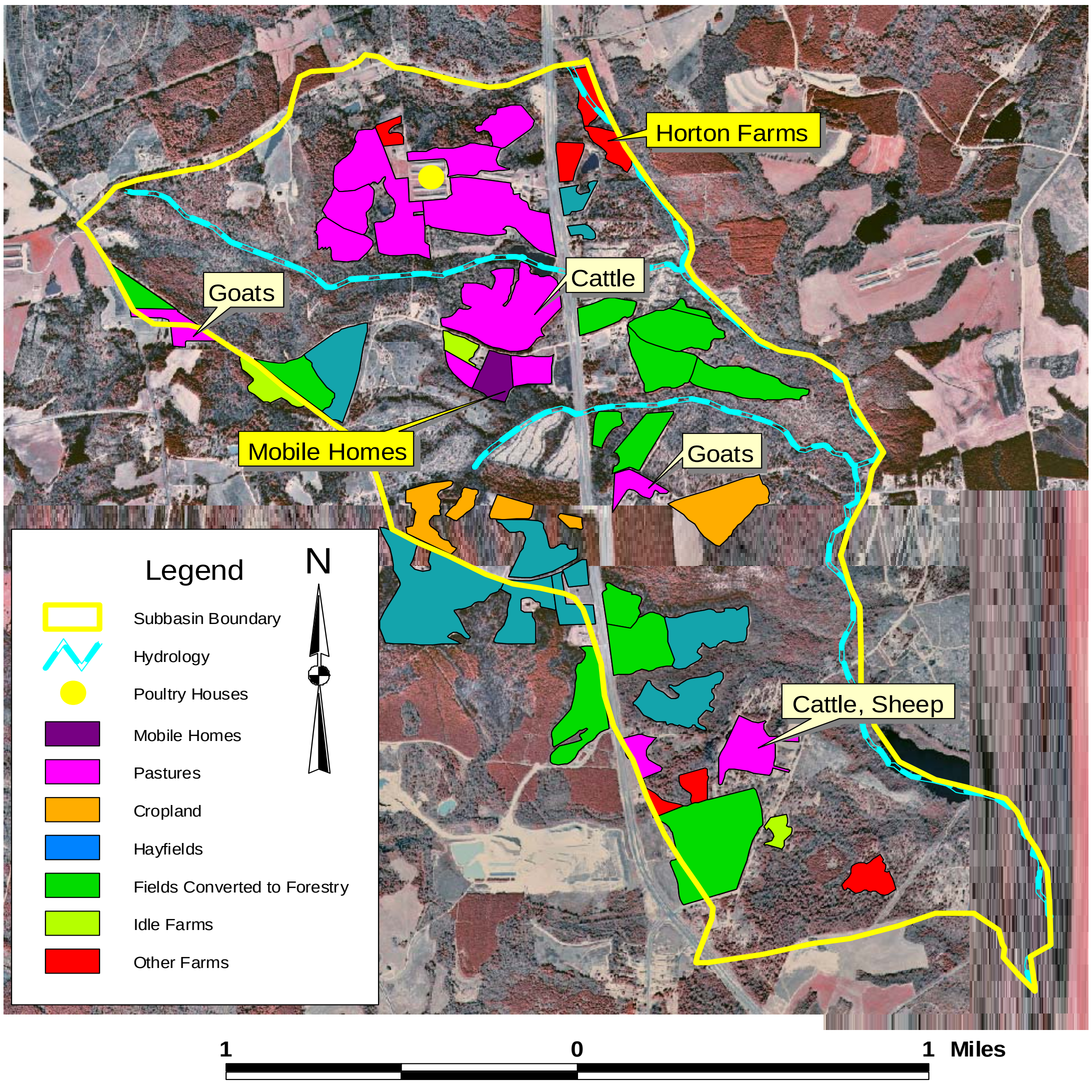
# Figure 7-3
# Canal Branch Subbasin




***Western Tributaries Subbasin***

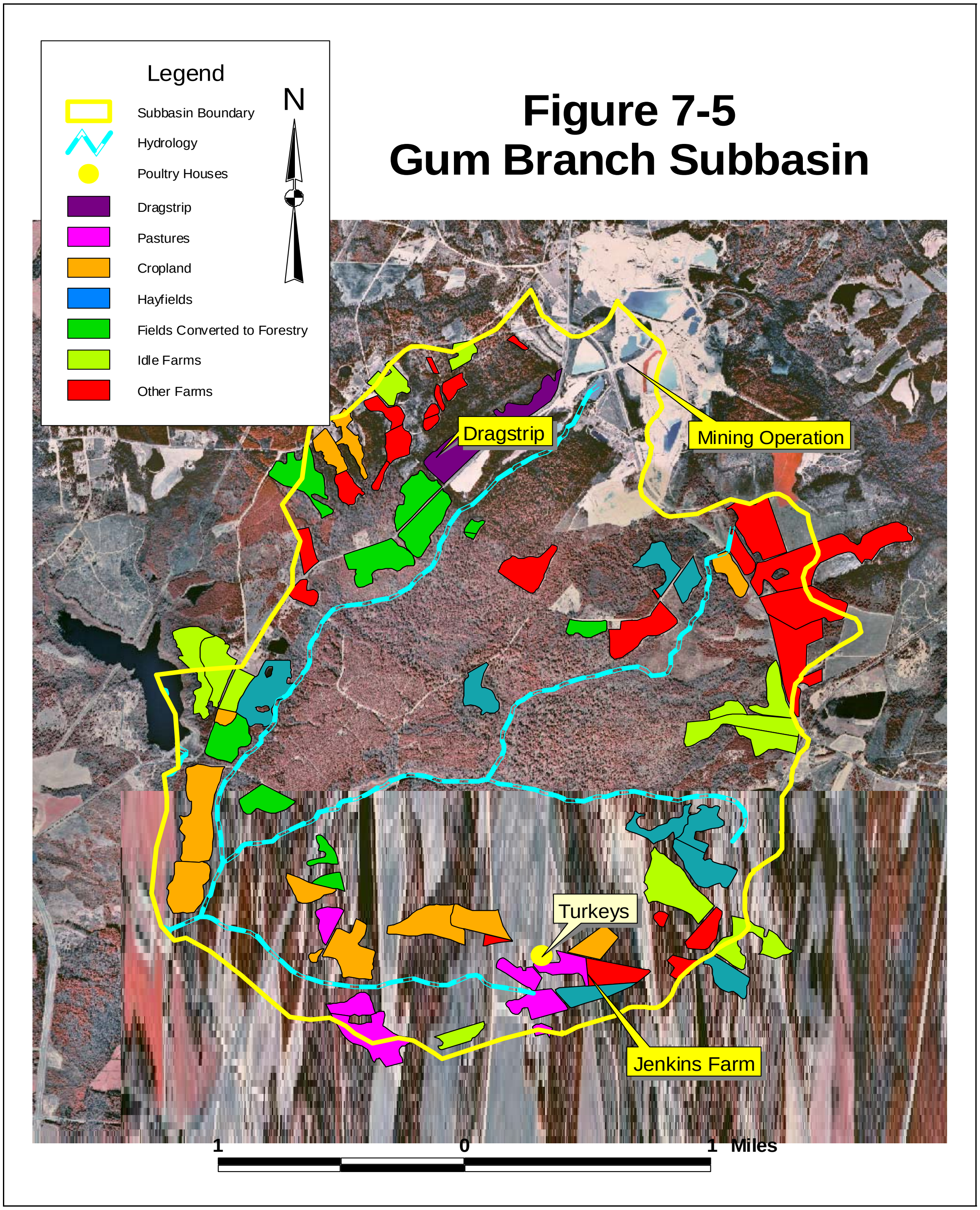
This Subbasin, characterized in Figure 7-4, possesses two tributaries draining into Fork Creek from a western direction. It is located just south of the Upper Fork Creek Subbasin and on the opposite side of Fork Creek from the Upper Tributaries Subbasin. Several farm fields located in this Subbasin were noted to possess grazing animals during the October 26, 2004 field survey. In addition, a poultry house was located in the midst of several pastures suggesting that poultry litter could potentially be applied to these farm fields. Mobile homes were also found in the vicinity of one of the tributaries discharging directly into Fork Creek. The project implementation team should consider reviewing these homes for fecal coliform bacteria loading from septic tanks or straight pipes.

# Figure 7-4
# Western Tributaries Subbasin



***Gum Branch Subbasin***

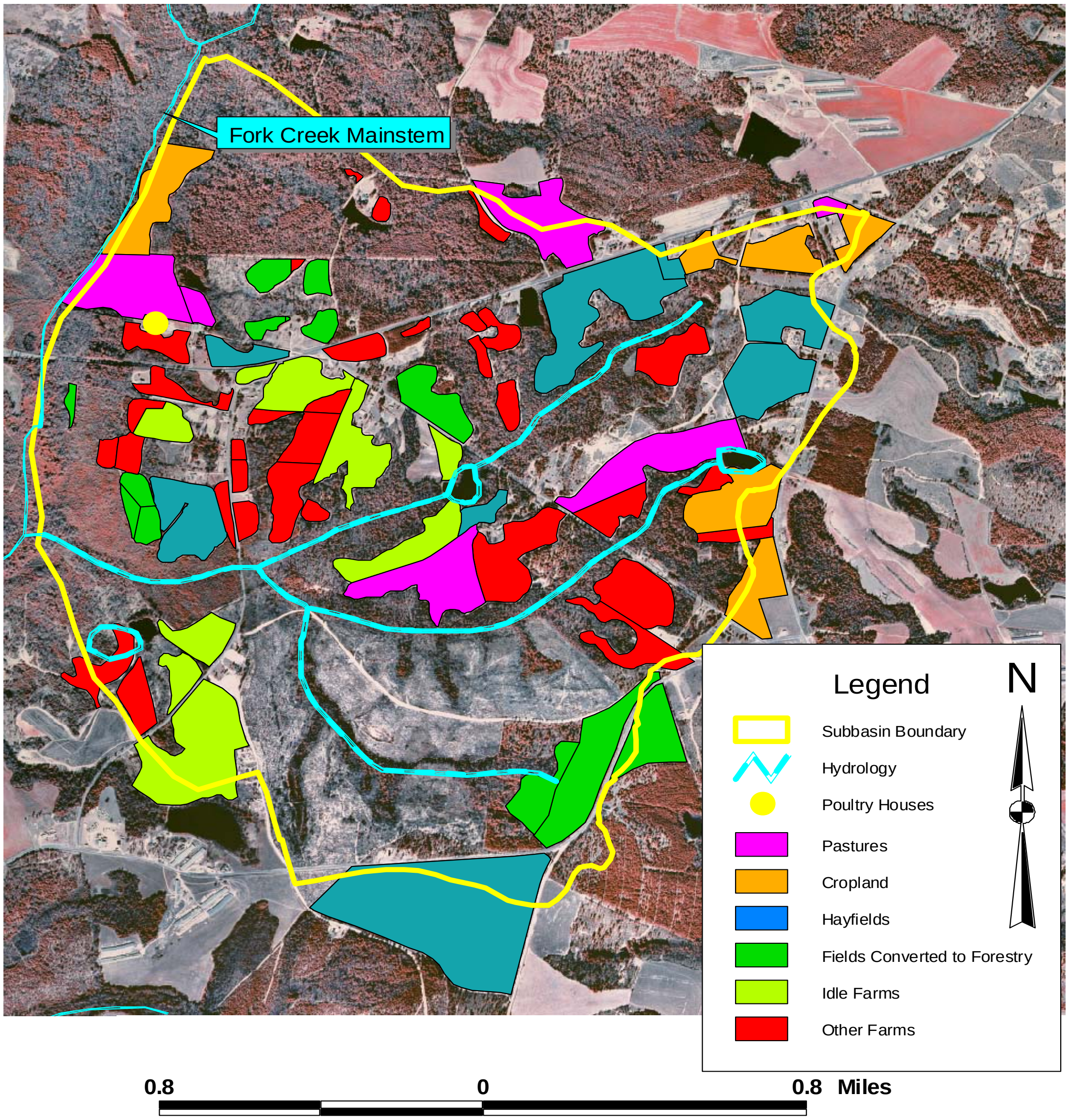
This Subbasin, depicted in Figure 7-5, is located south of Canal Branch where three tributaries join to form Gum Branch just prior to discharging into Fork Creek. It possesses the smallest concentration of farm fields due to the dominance of existing forestry land uses, recently converted farm fields to forestry, and many idle farms. The Jefferson-Pageland Dragstrip, a motorsport complex, is located adjacent to the northern Gum Branch tributary. A large mining operation is also located in the headwaters of this tributary. Potential sources of fecal coliform bacteria loading are located along the southern Gum Branch tributary where a poultry house is located adjacent to cropland and several pastures.




***Mill Branch Subbasin***

As depicted in Figure 7-6, this Subbasin is comprised of three tributaries that flow together prior to discharging into Fork Creek. Although the Subbasin was once highly concentrated with farm fields, many have been converted to forestry practices or have gone idle. Cropland and hayfields remain in the headwater regions and two large pastures are positioned between two tributaries where the potential for animal access is high. In addition, a pasture and a cropland located in the vicinity of a poultry house in the northeastern section of the Subbasin lie directly adjacent to the Fork Creek mainstem; and as a consequence, should be reviewed by the project implementation team.

# Figure 7-6
# Mill Branch Subbasin

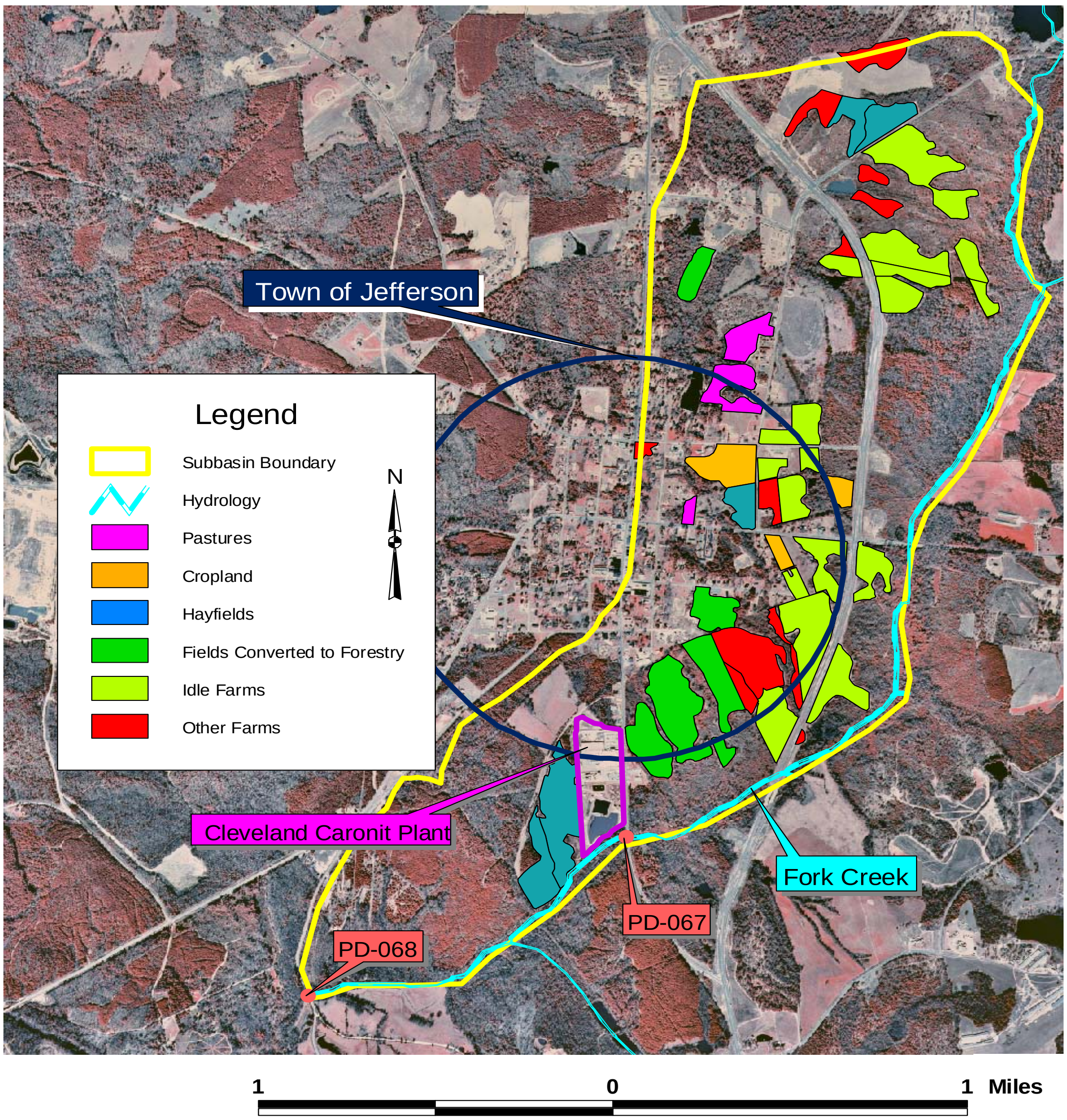



***Jefferson Tributaries Subbasin***

As shown in Figure 7-7, this Subbasin includes urban runoff from the Town of Jefferson and Cleveland Caronit Plant point source discharges. Although a few pastures, cropland, and hayfields are found in this Subbasin, they tend to be located away from the Fork Creek Mainstem. In fact, those farm fields that are located in the vicinity of Fork Creek have either been converted to forestry or have gone idle. As a consequence, they buffer Fork Creek from urban nonpoint source pollutant loading. No direct urban pollutant discharges (i.e., straight pipes) were noted during the field survey. The Cleveland

Caronit point source discharge is downstream of the fecal coliform bacteria impaired PD-067 ambient water quality monitoring station, and as a result, it is not expected to be the primary source of fecal coliform bacteria loading.

**Figure 7-7**
**Jefferson Tributaries Subbasin**

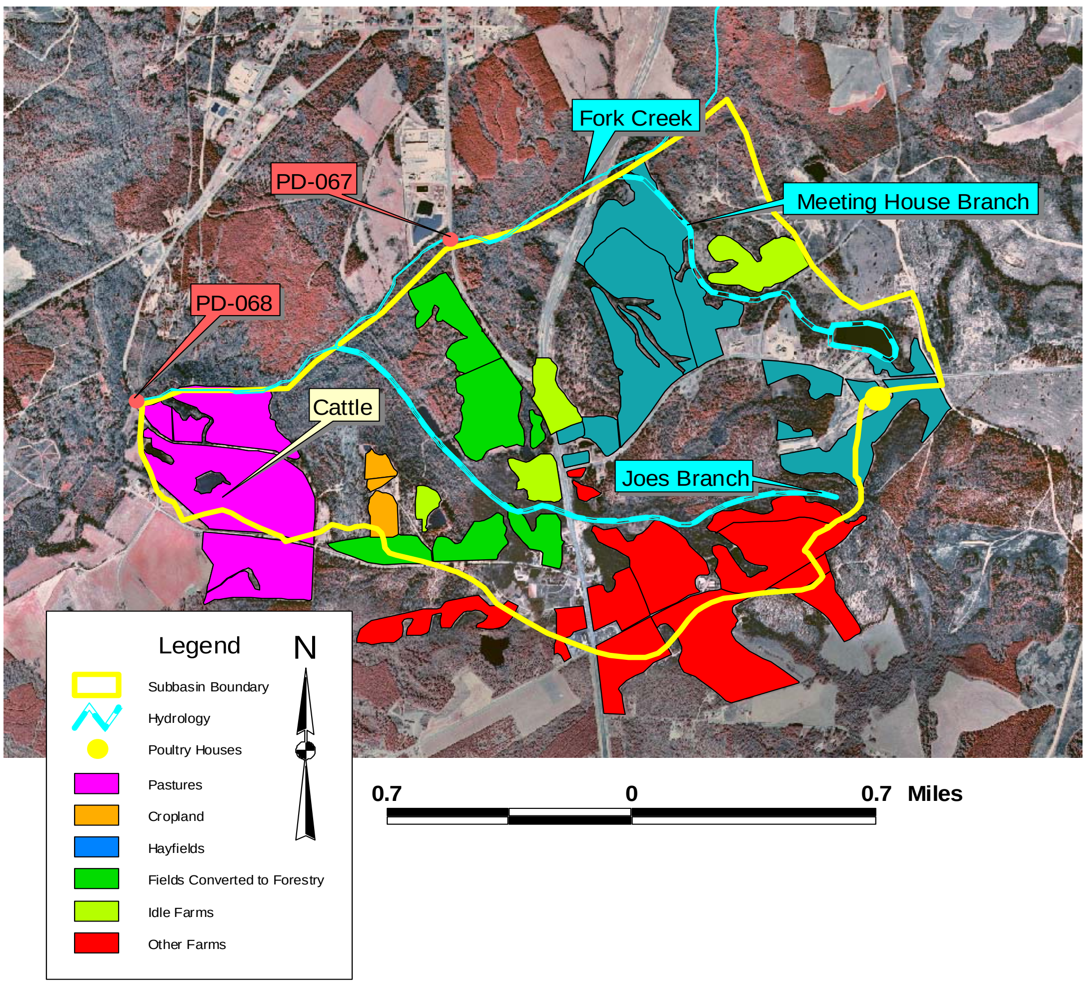



***Meeting House and Joes Branches Subbasin***

This Subbasin is comprised of two Fork Creek tributaries. As shown in Figure 7-8, Meeting House Branch discharges into Fork Creek above the PD-067 ambient monitoring station, while Joes Branch flows into Fork Creek between the PD-067 and PD-068 stations. The project implementation team should focus initial efforts on Meeting House Creek. Achieving fecal coliform bacteria concentrations below the state standard at PD-

067 might increase the downstream assimilative capacity of Fork Creek to a point where PD-068 is also compliant. The large quantity of hayfields along Meeting House Branch should be reviewed to determine if they are acquiring an overabundance of litter from the neighboring poultry houses. The cattle sited in the pasture along Fork Creek in the vicinity of PD-068 should also be investigated.

**Figure 7-8**
**Meeting House and Joes Branches Subbasin**



# 8 IMPLEMENTATION PLANNING RECOMMENDATIONS

The Load Reduction Plan was developed using the best data available to identify a **load reduction allocation scenario** that, when implemented, will meet the state water quality goals for fecal coliform bacteria in the Fork Creek project area. Additional watershed planning efforts included in this Load Reduction Plan consist of a **detailed characterization and accounting of agricultural land uses** and the formation of a **stakeholder group and an informed citizenry**. These three Load Reduction Plan components will facilitate and provide a structure for the development and application of an effective TMDL implementation plan. Four implementation planning strategies are recommended:

- Watershed Management and Planning Administration;
- Selection and Implementation of Corrective Actions;
- Citizen Awareness and Education; and
- Continued Water Quality Sampling.

***Watershed Management and Planning***

To reduce the quantities of fecal coliform bacteria from the potential loading sources within the Fork Creek project area, a decision-making framework and management process is required. This framework will be developed to:

- Foster cooperation between federal, state and local agencies and partners; and
- Advance a coordinated approach to acquiring landowner support for the implementation of corrective actions that meet the goals of the load reduction allocation scenario.

The recommended framework will contain provisions that address the monitoring of implementation tasks (and their measured success) in the Fork Creek project area, the application of a citizen awareness and education program, and the administration of multiple and concurrent grant and other cost-share programs.

***Selection and Implementation of Corrective Actions***

The administration of the load reduction allocation scenario suggests the need for a multi-phased approach to TMDL implementation to meet the applicable water quality standards and support the recreation use classification. The load reduction allocation scenario identifies a primary need for corrective actions that address fecal coliform bacteria loading reductions from direct livestock deposition into the stream and failing septic systems; and secondary corrective actions that address loading from two agricultural land use sources of runoff: pastures harboring grazing livestock and farm fields receiving poultry litter. A DHEC sampling program has shown that the concentrations of fecal coliform bacteria are frequently in violation of the state standard at two ambient water quality monitoring stations in the Fork Creek project area (PD-068 and PD-067). The agricultural land use characterization has identified over one hundred farm field cover type practices that are potential sources of fecal coliform bacteria loading.

*Prioritization of Land Use Activity.* As a result of these quantities and widespread locations of potential fecal coliform bacteria loading sources, the targeting and ranking of farm fields for implementation measures is a necessary component to implementation planning. It not only ensures the optimal utilization of implementation revenues, but also facilitates a multi-phased implementation approach where stakeholders can identify and prioritize sets of farm fields for corrective action based on their probability of success and the availability of implementation funds. The recommended prioritization approach to agricultural and residential land use implementation considers two factors: The effectiveness of corrective action implementation on fecal coliform bacteria loading, and the geographic location of the land use activity. The effectiveness factor would phase implementation activities based on the results of the load reduction allocation scenario recommendations. The following effectiveness factor is proposed for agricultural and residential land uses:

- **Stage 1:** Reduce direct inputs to stream from livestock (and other farm animals), and eliminate input from septic systems in the near-stream areas.

- **Stage 2:** Eliminate input from upland sources (such as loafing and feed lots, and manure and litter storage areas) as well as inappropriate manure or litter application and failing septic systems in the upland areas.

The following geographic factor is proposed for agricultural land uses only:

- **Tier 1 Subbasins**: **Critical to Achieving Water Quality Goals**.

  Upper Tributaries - Largest quantity of animal sitings and poultry houses;
  Western Tributaries - Large quantity of animal sitings and a poultry house; and
  Mill Branch - Potential pasture access to stream (including the Fork Creek mainstem) and a poultry house.

- **Tier 2 Subbasins: Important to Achieving Water Quality Goals.**

  Meeting House and Joes Branches - Pastures and Hayfields in vicinity of ambient water quality monitoring stations.
  Gum Branch - the lower tributary contains pastures and cropland neighboring a poultry house.
  Canal Branch - Cropland neighboring out of Subbasin poultry house and stream.

- **Tier 3 Subbasins: Noncritical to Achieving Water Quality Goals.**

  Jefferson Tributaries - Considerable buffering in vicinity of Fork Creek.
  Upper Fork Creek - A poultry house and a small number of pastures only.

No geographic factor is to be applied to residential land uses. It is recommended that any failing septic systems or straight pipes are to be addressed immediately regardless of their Subbasin location within the Fork Creek project area.

It is recommended that the Stage 1 corrective actions be administered sequentially to the Tiered Subbasins prior to implementing the Stage 2 corrective actions; which would then be administered according to the same sequential Tiered Subbasins application.

*Corrective Action Implementation.* Once farm fields have been prioritized based on their potential for causing unacceptable loads of fecal coliform bacteria, fundable and site-specific corrective actions will be selected. The South Carolina Department of Natural Resources and the NRCS have jointly developed a handbook of conservation practices applicable to South Carolina farming concerns entitled ***Farming for Clean Water in South Carolina*** (July, 1997). The Handbook provides descriptions of several corrective actions that address various sources of fecal coliform bacteria loading, and the relative costs for the implementation of these respective corrective actions. Corrective actions that are applicable to the direct deposition of farm animal waste into streams include:

- ‘Stream protection’ that promotes the fencing off buffer zones and managing livestock access to streams;

- ‘Stream crossings’ which allows livestock to drink and cross streams a designated points; and

- ‘Water tanks’ and ‘Farm Ponds’ that provide livestock with alternative sites for drinking water.

To limit fecal coliform bacteria loading from pasture runoff, ‘pasture management’ and ‘runoff management’ are recommended by the Handbook where rotational grazing, proper pasture stocking rates, paddock planning based on cutting intervals for forage, methods of keeping feedlots and loafing areas dry, and other grazing techniques that improve water quality are promoted.

To address the over-application and non-uniform application of poultry litter on farm fields in the project watershed area, the Chesterfield County NRCS District Conservationist has suggested the adoption of an education program. This program could be designed to promote the following activities specified in the ‘Nutrient Management’ and ‘Manure Testing’ sections of the Manual:

- Testing litter at the poultry houses for fertilizer value;

- Testing farm field soils to determine if and how much litter should be applied to meet crop yield goals;

- Calibrating litter spreading by trucks to apply proper rates; and

- Applying litter at proper times and frequencies.

In addition, it was noted by the Chesterfield County NRCS District Conservationist that many of the farm fields accepting poultry litter are lacking buffers. Numerous USDA conservation programs (i.e., Conservation Reserve Program, the Environmental Quality Incentives Program) provide funding for streamside buffers.

Although no stockpiles of litter were noted during the October 26, 2004 field survey, it is probable that this practice occurs throughout the Fork Creek project area due to the presence of a large quantity of poultry houses. The leaching and runoff of litter from the open stockpiles could result in marked fecal coliform bacteria loading. Corrective actions could include the short-term application of plastic sheeting or long-term use of covered facilities with impervious ground liners.

Site-specific corrective actions for the sources of fecal coliform bacteria outlined in the load reduction allocation scenario will be made by technical experts following on-site farm field investigations.

***Citizen Awareness and Education***

The success of this multi-phased approach to implementation also requires support and acceptance from the landowners, growers, and operators farming in the project watershed area. A citizen awareness and education program is, therefore, suggested to make the local citizenry aware of:

- The human health risks of fecal coliform bacteria impaired water bodies;
- The different sources of fecal coliform bacteria;
- How these sources are contributing to the specific water quality impairment in the project watershed area; and
- The available, voluntary, and often cost-shared corrective actions utilized to minimize fecal coliform bacteria loading into Fork Creek project area.

Outreach plan components may include field days where successful and demonstration corrective actions are endorsed; workshops presenting water quality issues and the benefits of corrective actions; use of agricultural operators willing to share management solutions; partner building with commodity groups to promote conservation; the use of local school districts to take part in water quality sampling or corrective action implementation and construction; and the development of brochures specific to fecal coliform bacteria impairment in the Fork Creek project area. The brochures could be used to facilitate the advancement of project goals at large forums or at one-on-one meetings with landowners, growers, and operators.

A foundation of support for implementation endeavors has been established during the development of this Load Reduction Plan. Local, state, and federal agricultural and environmental agencies have dedicated an interest in the project; and municipal officials, including the Town of Jefferson Mayor, landowners, growers, operators and farming organizations located in the Fork Creek project area will be introduced to the project when the findings are presented at a meeting scheduled for February 2005.

***Continued Water Quality Sampling***

It is recommended that DHEC continue their sampling at the PD-068 and PD-067 ambient water quality monitoring sites in the Fork Creek project area throughout the implementation stage of the project to:

- Measure progress towards meeting the goals of the load reduction allocation scenario;

- Determine the effectiveness of the load reduction allocation scenario; and

- Allow for implementation flexibility by providing justification for making mid-course changes to the load reduction allocation scenario.

An evaluation of additional sampling site locations should also be investigated during initial implementation planning. Decisions to add site locations would be based partially on the findings from the detailed agricultural land use characterization. The additional sampling would help those responsible for implementation to further prioritize Subbasins and farm fields.

Potential action item tasks associated with the four recommended implementation planning strategies are depicted in Table 8-1. Suggested lead organizations and funding sources for each action item task are also listed.

**TABLE 8-1 RECOMMENDED IMPLEMENTATION ACTION ITEMS**

| Action Item | Lead Organization | Funding Source |
|---|---|---|
| **WATERSHED MANAGEMENT PLANNING AND ADMINISTRATION** | | |
| Development of Decision Making Stakeholder Group for Implementation Planning. | Pee Dee RC&D Council | EPA Section 319 Program. |
| Project Management and Coordination of Tasks and Agencies/Organizations in South Carolina. | Pee Dee RC&D Council. | EPA Section 319 Program. |
| Identification of Funding Sources, Proposal Development, and Grant Administration. | Pee Dee RC&D Council. | EPA Section 319 Program. |
| Continuous Measurement of Project Success and Administration of Mid-Course Changes to Meet Project Goals. | Pee Dee RC&D Council. | EPA Section 319 Program. |

| | | |
|---|---|---|
| **SELECTION AND IMPLEMENTATION OF CORRECTIVE ACTIONS** | | |
| Targeting and Prioritizing Farm Fields for Implementation Using GIS Database of Farm Field Information (Criteria for Selection may Include Vicinity to Stream, Soil Types, Slopes, Land Use Practices, etc.). | Chesterfield SWCD with Support from NRCS District Conservationists. | EPA Section 319 Program. |
| Selection and Implementation of Farm Field Specific Corrective Actions. | Chesterfield SWCD with Support from NRCS District Conservationists and SC Department of Natural Resources (DNR). | EPA Section 319 Program, USDA Conservation Reserve Program (CRP), USDA Environmental Quality Incentives Program (EQIP), USDA Wildlife Habitat Incentives Program (WRP), USDA Wetland Reserve Program (WRP). |
| | | |
| **CITIZEN AWARENESS AND EDUCATION** | | |
| Development and Implementation of an Outreach Plan (and Outreach Materials; including Home*A*Syst and Farm*A*Syst Information) that Builds Support for Implementing Corrective Actions. | Pee Dee RC&D Council / SC Department of Natural Resources / SC DHEC /Town of Jefferson. | EPA Environmental Education and/or Environmental Justice Grant Programs. |
| Promotion of Various Voluntary BMP / Conservation Practices to Landowners of Prioritized Farm Fields at One-on-One Meetings. | Chesterfield SWCD with Support from NRCS District Conservationists and SC DNR. | EPA Section 319 Program, USDA Conservation Reserve Program (CRP), USDA Environmental Quality Incentives Program (EQIP), USDA Wildlife Habitat Incentives Program (WRP), USDA Wetland Reserve Program (WRP). |
| Poultry Litter Application Training. | Chesterfield SWCD with Support from NRCS District Conservationists and SC DNR. | EPA Section 319 Program. EPA Section 319 Program, USDA Conservation Reserve Program (CRP), USDA Environmental Quality Incentives Program (EQIP), USDA Wildlife |

| | | |
|---|---|---|
| | | Habitat Incentives Program (WRP), USDA Wetland Reserve Program (WRP). |
| | | |
| **CONTINUED WATER QUALITY SAMPLING** | | |
| Evaluation of Sampling Site Locations. | Chesterfield SWCD with Support from NRCS District Conservationists and SC DNR. | EPA Section 319 Program. |
| Collect and Analyze Water Quality Samples for Fecal Coliform Bacteria Concentrations Under all Flow Conditions. | Chesterfield SWCD with Support from NRCS District Conservationists and SC DNR. | EPA Section 319 Program. |
| Document Water Quality Improvements from Farm Field Specific Corrective Actions at the Respective Water Quality Sampling Sites. | Pee Dee RC&D. | EPA Section 319 Program. |
| | | |

## 9 REFERENCES

American Society of Agricultural Engineers (ASAE). 1998. *ASAE Standards, 45th edition: Standards, Engineering Practices, Data*. St. Joseph, MI.

Horner, R.R. 1992. Water quality criteria/pollutant loading estimation/treatment effectiveness estimation. In R.W. Beck and Associates. *Covington Master Drainage Plan*. King County Surface Water Management Division. Seattle, WA.

Horsley and Whitten. 1996. *Identification and Evaluation of Nutrient and Bacteriological Loadings to Maquoit Bay, Burnswick, and Freeport, Maine. Final Report*. Casco Bay Estuary Project, Portland, ME.

Long Island Regional Planning Board. 1978. *Long Island Comprehensive Waste Treatment Management Plan. Volume II: Summary Documentation*. Nassau-Suffolk Regional Planning Board. Hauppauge, NY.

South Carolina Department of Health and Environmental Control (SCDHEC), 2004, *Total Maximum Daily Load Development for Big Wateree Creek: Station CW-072 Fecal Coliform Bacteria*.

South Carolina Department of Health and Environmental Control (SCDHEC), 2004, *Total Maximum Daily Load Development for Allison Creek: Station CW-171 Fecal Coliform Bacteria.* Technical Report No. 011-03.

South Carolina Department of Natural Resources and United States Department of Agriculture, Natural Resources Conservation Service, 1997, *Farming For Clean Water in South Carolina: A Handbook of Conservation Practices.*

South Carolina Department of Natural Resources, 1997, *Wildlife management Guide: Raccoon*. SCDNR Publication 97WL1798. 4p.

United States Environmental Protection Agency (USEPA), 2000a, Bacterial Indicator Tool User's Guide. EPA-823-B-01-003. 17p.

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

Virginia Department of Conservation and Recreation and Virginia Department of Environmental Quality, 2003, *Guidance Manual for Total Maximum Daily Load Implementation Plans.*

# APPENDICES

# APPENDIX A

## FECAL COLIFORM CONCENTRATION DATA FROM DHEC MONITORING STATIONS

| DHEC station | Date | Fecal Coli counts/100 mL |
|---|---|---|
| PD-067 | 5/1/1990 | 420.00 |
| | 6/13/1990 | 280.00 |
| | 7/9/1990 | 960.00 |
| | 8/2/1990 | 50.00 |
| | 9/10/1990 | 380.00 |
| | 10/4/1990 | 250.00 |
| | 5/21/1991 | 60.00 |
| | 6/11/1991 | 90.00 |
| | 7/29/1991 | 1400.00 |
| | 8/19/1991 | 120.00 |
| | 9/3/1991 | 280.00 |
| | 10/21/1991 | 390.00 |
| | 5/21/1992 | 200.00 |
| | 6/18/1992 | 190.00 |
| | 7/16/1992 | 240.00 |
| | 8/26/1992 | 90.00 |
| | 9/16/1992 | 700.00 |
| | 10/29/1992 | 220.00 |
| | 5/12/1993 | 230.00 |
| | 6/17/1993 | 340.00 |
| | 7/14/1993 | 330.00 |
| | 8/17/1993 | 170.00 |
| | 9/9/1993 | 110.00 |
| | 10/21/1993 | 40.00 |
| | 5/3/1994 | 130.00 |
| | 6/23/1994 | 100.00 |
| | 7/12/1994 | 380.00 |
| | 8/18/1994 | 230.00 |
| | 9/29/1994 | 190.00 |
| | 10/20/1994 | 370.00 |
| | 5/10/1995 | 210.00 |
| | 6/8/1995 | 100.00 |
| | 7/27/1995 | 420.00 |
| | 8/10/1995 | 430.00 |
| | 9/13/1995 | 160.00 |
| | 10/3/1995 | 240.00 |
| | 5/7/1996 | 130.00 |
| | 6/26/1996 | 130.00 |
| | 7/25/1996 | 330.00 |

| | |
|---|---|
| 10/9/1996 | 720.00 |
| 5/7/1997 | 260.00 |
| 6/5/1997 | 200.00 |
| 7/16/1997 | 6600.00 |
| 8/20/1997 | 190.00 |
| 9/11/1997 | 1800.00 |
| 10/15/1997 | 1000.00 |
| 5/5/1999 | 140.00 |
| 6/16/1999 | 380.00 |
| 7/19/1999 | 460.00 |
| 8/23/1999 | 270.00 |
| 9/16/1999 | 530.00 |
| 10/7/1999 | 390.00 |
| 5/11/2000 | 140.00 |
| 6/6/2000 | 120.00 |
| 7/5/2000 | 150.00 |
| 8/9/2000 | 150.00 |
| 9/25/2000 | 230.00 |
| 10/17/2000 | 480.00 |
| 1/28/2003 | 80.00 |
| 2/19/2003 | 45.00 |
| 3/26/2003 | 84.00 |
| 4/2/2003 | 53.00 |
| 5/7/2003 | 160.00 |

| DHEC Station | Date | Fecal Coli count/100ml |
|---|---|---|
| PD-068 | 5/1/1990 | 410.00 |
| | 6/13/1990 | 180.00 |
| | 7/9/1990 | 1100.00 |
| | 8/2/1990 | 1200.00 |
| | 9/10/1990 | 590.00 |
| | 10/4/1990 | 440.00 |
| | 5/21/1991 | 150.00 |
| | 6/11/1991 | 190.00 |
| | 7/29/1991 | 1500.00 |
| | 8/19/1991 | 170.00 |
| | 9/3/1991 | 170.00 |
| | 10/21/1991 | 250.00 |
| | 5/21/1992 | 30.00 |
| | 6/18/1992 | 150.00 |
| | 7/16/1992 | 330.00 |
| | 8/26/1992 | 80.00 |
| | 9/16/1992 | 530.00 |
| | 10/29/1992 | 250.00 |
| | 5/12/1993 | 270.00 |
| | 6/17/1993 | 290.00 |
| | 7/14/1993 | 300.00 |
| | 8/17/1993 | 310.00 |
| | 9/9/1993 | 530.00 |
| | 10/21/1993 | 130.00 |
| | 11/9/1993 | 660.00 |
| | 12/14/1993 | 260.00 |
| | 1/11/1994 | 580.00 |
| | 2/3/1994 | 160.00 |
| | 3/8/1994 | 160.00 |
| | 4/5/1994 | 130.00 |
| | 5/3/1994 | 31.00 |
| | 6/23/1994 | 240.00 |
| | 7/12/1994 | 2100.00 |
| | 8/18/1994 | 420.00 |
| | 9/29/1994 | 130.00 |
| | 10/20/1994 | 290.00 |
| | 5/10/1995 | 780.00 |
| | 6/8/1995 | 210.00 |
| | 7/27/1995 | 230.00 |
| | 8/10/1995 | 190.00 |
| | 9/13/1995 | 120.00 |
| | 10/3/1995 | 180.00 |
| | 5/7/1996 | 160.00 |
| | 6/26/1996 | 100.00 |
| | 7/25/1996 | 530.00 |
| | 10/9/1996 | 510.00 |

| | |
|---|---|
| 5/7/1997 | 200.00 |
| 6/5/1997 | 270.00 |
| 7/16/1997 | 200.00 |
| 8/20/1997 | 160.00 |
| 9/11/1997 | 2900.00 |
| 10/15/1997 | 470.00 |
| 5/5/1999 | 370.00 |
| 6/16/1999 | 210.00 |
| 7/19/1999 | 480.00 |
| 8/23/1999 | 140.00 |
| 9/16/1999 | 660.00 |
| 10/7/1999 | 570.00 |
| 5/11/2000 | 120.00 |
| 6/6/2000 | 350.00 |
| 7/5/2000 | 450.00 |
| 8/9/2000 | 220.00 |
| 9/25/2000 | 230.00 |
| 10/17/2000 | 240.00 |
| 1/17/2001 | 120.00 |
| 2/21/2001 | 280.00 |
| 3/12/2001 | 340.00 |
| 4/18/2001 | 140.00 |
| 6/26/2001 | 510.00 |
| 7/17/2001 | 100.00 |
| 8/13/2001 | 0.00 |
| 9/20/2001 | 350.00 |
| 10/23/2001 | 880.00 |
| 11/19/2001 | 520.00 |
| 12/5/2001 | 880.00 |
| 12/6/2001 | 71.00 |
| 1/7/2002 | 940.00 |
| 2/4/2002 | 260.00 |
| 3/19/2002 | 80.00 |
| 4/16/2002 | 170.00 |
| 5/7/2002 | 150.00 |
| 6/3/2002 | 0.00 |
| 7/15/2002 | 120.00 |
| 10/14/2002 | 1200.00 |
| 11/25/2002 | 160.00 |
| 1/28/2003 | 40.00 |
| 2/19/2003 | 29.00 |
| 3/26/2003 | 29.00 |
| 4/2/2003 | 75.00 |
| 5/7/2003 | 130.00 |
| 6/12/2003 | 190.00 |

# APPENDIX B

# CALCULATIONS OF EXISTING AND ALLOWABLE LOADS

## Calculation of Existing Load from Trend Line at PD-067

Equation of Trend line: $y = 6E{+}13\ e^{-0.1101\ x}$

| Exceedence **%** | Existing Load **(ct/day)** |
|---|---|
| 22 | 5.32E+12 |
| 24 | 4.27E+12 |
| 26 | 3.43E+12 |
| 28 | 2.75E+12 |
| 30 | 2.21E+12 |
| 32 | 1.77E+12 |
| 34 | 1.42E+12 |
| 36 | 1.14E+12 |
| 38 | 9.14E+11 |
| 40 | 7.34E+11 |
| 42 | 5.89E+11 |
| 44 | 4.72E+11 |
| 46 | 3.79E+11 |
| 48 | 3.04E+11 |
| 50 | 2.44E+11 |
| 52 | 1.96E+11 |
| 54 | 1.57E+11 |
| 56 | 1.26E+11 |
| 58 | 1.01E+11 |
| 60 | 8.11E+10 |
| 62 | 6.51E+10 |
| 64 | 5.22E+10 |
| 66 | 4.19E+10 |
| 68 | 3.36E+10 |
| 70 | 2.70E+10 |
| 72 | 2.16E+10 |
| 74 | 1.74E+10 |
| 76 | 1.39E+10 |
| 78 | 1.12E+10 |
| 80 | 8.97E+09 |
| | |
| **Mean =** | **8.97E+11** |

**Existing Load = 8.97 E+11 counts/day**

## Calculation of Allowable Load from Trend Line at PD-067

Equation of Trend Line: $y = 3E{+}13\ e^{-0.1065\ x}$

| Exceedence % | Targ.Load (ct/day) |
|---|---|
| 22 | 2.88E+12 |
| 24 | 2.33E+12 |
| 26 | 1.88E+12 |
| 28 | 1.52E+12 |
| 30 | 1.23E+12 |
| 32 | 9.93E+11 |
| 34 | 8.03E+11 |
| 36 | 6.49E+11 |
| 38 | 5.24E+11 |
| 40 | 4.24E+11 |
| 42 | 3.42E+11 |
| 44 | 2.77E+11 |
| 46 | 2.24E+11 |
| 48 | 1.81E+11 |
| 50 | 1.46E+11 |
| 52 | 1.18E+11 |
| 54 | 9.54E+10 |
| 56 | 7.71E+10 |
| 58 | 6.23E+10 |
| 60 | 5.03E+10 |
| 62 | 4.07E+10 |
| 64 | 3.29E+10 |
| 66 | 2.66E+10 |
| 68 | 2.15E+10 |
| 70 | 1.74E+10 |
| 72 | 1.4E+10 |
| 74 | 1.13E+10 |
| 76 | 9.16E+09 |
| 78 | 7.4E+09 |
| 80 | 5.98E+09 |
| | |
| **Mean =** | **5E+11** |

**Allowable Load = 5.00E+11 counts/day**

**Calculation of Existing Load from Trend Line at PD-068**
Equation of Trend line: $y = 7E+13\ e^{-0.1136\ x}$

| Exceedance (%) | Existing Load (ct/day) |
|---|---|
| 22 | 5.75E+12 |
| 24 | 4.58E+12 |
| 26 | 3.65E+12 |
| 28 | 2.91E+12 |
| 30 | 2.32E+12 |
| 32 | 1.85E+12 |
| 34 | 1.47E+12 |
| 36 | 1.17E+12 |
| 38 | 9.34E+11 |
| 40 | 7.44E+11 |
| 42 | 5.93E+11 |
| 44 | 4.72E+11 |
| 46 | 3.76E+11 |
| 48 | 3.00E+11 |
| 50 | 2.39E+11 |
| 52 | 1.90E+11 |
| 54 | 1.52E+11 |
| 56 | 1.21E+11 |
| 58 | 9.63E+10 |
| 60 | 7.67E+10 |
| 62 | 6.11E+10 |
| 64 | 4.87E+10 |
| 66 | 3.88E+10 |
| 68 | 3.09E+10 |
| 70 | 2.46E+10 |
| 72 | 1.96E+10 |
| 74 | 1.56E+10 |
| 76 | 1.25E+10 |
| 78 | 9.93E+09 |
| 80 | 7.91E+09 |
| 82 | 6.30E+09 |
| 84 | 5.02E+09 |
| 86 | 4.00E+09 |
| 88 | 3.19E+09 |
| 90 | 2.54E+09 |
| 92 | 2.02E+09 |
| 94 | 1.61E+09 |
| **Mean =** | **7.65E+11** |

**Existing Load = 7.65E+11 counts/day**

**Calculation of Allowable Load from Trend Line at PD-068**
Equation of Trend Line: $y = 4E+13\ e^{-0.1115\ x}$

| Exceedance (%) | Target Load (ct/day) |
|---|---|
| 22 | 3.44E+12 |
| 24 | 2.75E+12 |
| 26 | 2.20E+12 |
| 28 | 1.76E+12 |
| 30 | 1.41E+12 |
| 32 | 1.13E+12 |
| 34 | 9.03E+11 |
| 36 | 7.22E+11 |
| 38 | 5.78E+11 |
| 40 | 4.62E+11 |
| 42 | 3.70E+11 |
| 44 | 2.96E+11 |
| 46 | 2.37E+11 |
| 48 | 1.90E+11 |
| 50 | 1.52E+11 |
| 52 | 1.21E+11 |
| 54 | 9.71E+10 |
| 56 | 7.77E+10 |
| 58 | 6.22E+10 |
| 60 | 4.97E+10 |
| 62 | 3.98E+10 |
| 64 | 3.18E+10 |
| 66 | 2.55E+10 |
| 68 | 2.04E+10 |
| 70 | 1.63E+10 |
| 72 | 1.30E+10 |
| 74 | 1.04E+10 |
| 76 | 8.35E+09 |
| 78 | 6.68E+09 |
| 80 | 5.35E+09 |
| 82 | 4.28E+09 |
| 84 | 3.42E+09 |
| 86 | 2.74E+09 |
| 88 | 2.19E+09 |
| 90 | 1.75E+09 |
| 92 | 1.40E+09 |
| 94 | 1.12E+09 |
| **Mean =** | **4.65E+11** |

**Allowable Load = 4.65E+11 counts/day**