Total Maximum Daily Load for Fecal Coliform for the Roaring River in North Carolina

[Waterbody ID 12-46]

Final Report
May 2011

Yadkin-Pee Dee River Basin

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TMDL Summary Sheet

303(d) List Information

State: North Carolina
Counties: Wilkes
Basin: Yadkin- Pee Dee River Basin

Waterbody Name	Description	Assessment Unit (AU):	Class	12digit HU	Impairment	Miles
Roaring River	From source to Yadkin River	12-46	B	03040101	Fecal Coliform	5.9

Constituents of Concern: Fecal Coliform Bacteria
Reason for Listing: Standard Violations

Applicable Water Quality Standard for Class B Waters:

- Fecal coliform shall not exceed a geometric mean of 200/100 ml (membrane filter count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100 ml in more than 20 percent of the samples examined during such period.

TMDL Development

Analysis/Modeling:
Load duration curves are based on cumulative frequency distribution of flow conditions in the watershed. Allowable loads are average loads over the recurrence interval between the 95^{th} and 10^{th} percent flow exceeded (excludes extreme drought (>95^{th} percentile) and floods (<10^{th} percentile). Percent reductions are expressed as the average value between existing loads (typically calculated using an equation to fit a curve through actual water quality violations) and the allowable load at each percent flow exceeded.

Critical Conditions:
Critical conditions are accounted in the load curve analysis by using an extended period of stream flow and water quality data, and by examining at what flow (percent flow exceeded) the existing load violations occur.

Seasonal Variation:
Seasonal variation in hydrology, climatic conditions, and watershed activities are represented through the use of a continuous flow gage and the use of all readily available water quality data collected in the watershed.

TMDL Allocation Summary

Pollutants/Watershed	Existing Load	WLA	LA	MOS	TMDL
Fecal Coliform (colony forming units (cfu)/day)					
Roaring River	3.11E+12	1.058E+10	1.0252E+12	10%	1.0358E+12

Notes:
WLA = Wasteload Allocation, LA = Load Allocation, MOS = Margin of Safety.

1. LA = TMDL – WLA – MOS.
2. TMDL represents the average allowable load between the 95th and 10th percent recurrence interval.
3. Explicit (10%) margin of safety is considered.
4. Overall reduction is based on the instantaneous standard of 400 cfu/100ml and is assumed to be more stringent than the geometric mean standard.

Contributing Municipalities: NONE

Contributing NPDES Facilities TMDL Allocation Summary:

NPDES Permittee	Existing Permitted Load (cfu/day)	WLA (cfu/day)	Percent Reduction Required
North Wilkes High School	1.591E+08	1.591E+08	0%
Traphill Elementary School	6.059E+07	6.059E+07	0%
NC DOT	N/A	1.036E+10	0%

Estimated reduction by source for fecal coliform (shown in cfu/day) for the Roaring River:

	WLA	LA
Existing Load (cfu/day)	1.058E+10	3.103E+12
Allocation (cfu/day)	1.058E+10	1.0252E+12
Percent Reduction Needed	0%	67.1%

Public Notice Date: 3/12/11
Submittal Date: 4/19/2011
EPA Approval Date: 5/11/2011

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1.0 Introduction

1.1 TMDL Definition

This report presents the development of a Fecal Coliform Total Maximum Daily Load (TMDL) for the Roaring River in the Yadkin-Pee Dee River Basin (Figure 1.1) in North Carolina. As identified by the North Carolina Division of Water Quality (DWQ), the impaired segment of the waterbody is described in Table 1.1.

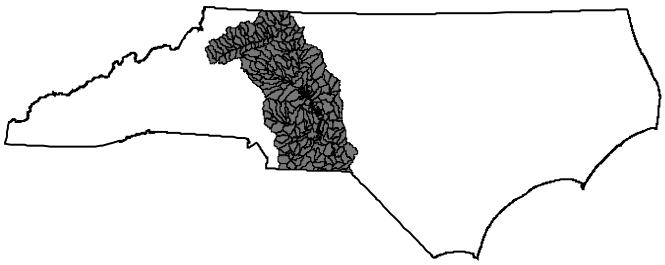


Figure 1.1 - Location of the Yadkin River Basin within North Carolina

Table 1.1 - Description of impaired segments for the Roaring River

Waterbody Name	Description	Assessment Unit (AU):	Class	Subbasin	Impairment	Miles
Roaring River	From source to Yadkin River	12-46	B	03040101	Fecal Coliform	5.9

Class B waters are freshwaters protected for primary recreation, which includes swimming on a frequent or organized basis and all Class C uses. Class C waters are protected for secondary recreation, fishing, aquatic life including propagation and survival, and wildlife.

Section 303(d) of the Clean Water Act (CWA) requires States to develop a list of water bodies that do not meet water quality standards or have impaired uses. The list, referred to as the 303(d) list, is submitted biennially to the U.S. Environment Protection Agency (USEPA) for review. The 303(d) process requires that a Total Maximum Daily Load (TMDL) be developed for each of the waters appearing on the 303(d) list.

1.2 TMDL Components

The objective of a TMDL is to allocate allowable pollutant loads to known sources so that actions may be taken to restore the water to its intended uses (USEPA, 1991). Generally, the primary components of a TMDL, as identified by USEPA (1991, 2000) and the Federal Advisory Committee (USEPA, 1998) are as follows:

Target identification or selection of pollutant(s) and end-point(s) for consideration. The pollutant and end-point are generally associated with measurable water quality related characteristics that indicate compliance with water quality standards.

Source assessment. All sources that contribute to the impairment should be identified and loads quantified, where sufficient data exist.

Assimilative Capacity. Estimation of level of pollutant reduction needed to achieve water quality goal. The level of pollution should be characterized for the water body, highlighting how current conditions deviate from the target end-point. Generally, this component is identified through water quality modeling.

Allocation of Pollutant Loads. Allocating pollutant control responsibility to the sources of impairment. The waste load allocation portion of the TMDL accounts for the loads associated with point sources. Similarly, the load allocation portion of the TMDL accounts for the loads associated with nonpoint sources, stormwater, and natural background.

Margin of Safety. The margin of safety addresses uncertainties associated with pollutant loads, modeling techniques, and data collection. Per EPA (2000a), the margin of safety may be expressed explicitly as unallocated assimilative capacity or implicitly due to conservative assumptions.

Seasonal Variation. The TMDL should consider seasonal variation in the pollutant loads and end-point. Variability can arise due to stream flows, temperatures, and exceptional events (e.g., droughts, hurricanes).

Critical Conditions. Critical conditions indicate the combination of environmental factors that result in just meeting the water quality criterion and have an acceptably low frequency of occurrence.

Section 303(d) of the CWA requires EPA to review all TMDLs for approval. Once EPA approves a TMDL, the water body may be moved off the 303(d) list. Water bodies remain impaired until compliance with water quality standards is achieved.

1.3 Water Quality Target: North Carolina Standards and Classifications

The North Carolina fresh water quality standard for Class B waters for fecal coliform (15A NCAC 02B. 0219) states:

> *The following water quality standards apply to surface waters that are for primary recreation, including frequent or organized swimming and are classified as Class B waters. Water quality standards applicable to Class C waters as described in Rule .0211 of this Section also apply to Class B waters.*

> *Organisms of coliform group: fecal coliforms not to exceed geometric mean of 200/100 ml (MF count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 ml in more than 20 percent of the samples examined during such period.*

The North Carolina fresh water quality standard for Class C waters for fecal Coliform (15a NCAC 02B .0211) states:

> *Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (MF count) based upon at least five consecutive samples examined during any 30 day period, nor exceed 400/100ml in more than 20 percent of the samples examined during such period; violations of the fecal coliform standard are expected during rainfall events and, in some cases, this violation is expected to be caused by uncontrollable nonpoint source pollution; all coliform concentrations are to be analyzed using the membrane filter technique unless high turbidity or other adverse conditions necessitate the tube dilution method; in case of controversy over results, the MPN 5-tube dilution technique shall be used as the reference method.*

1.4 Watershed Description

The Roaring River is located in the Yadkin-Pee Dee River Basin in northern Wilkes County (Figure 1.2). The watershed covers 139 square miles and is located along the Blue Ridge Escarpment with an elevation change of 2,992 feet from the headwaters to the confluence with the Yadkin River. The headwaters that form the Roaring River are located within Stone Mountain State Park, the Blue Ridge Parkway, and several other conservation areas. These areas are heavily forested. Agricultural land increases farther south and downstream towards the Yadkin River.

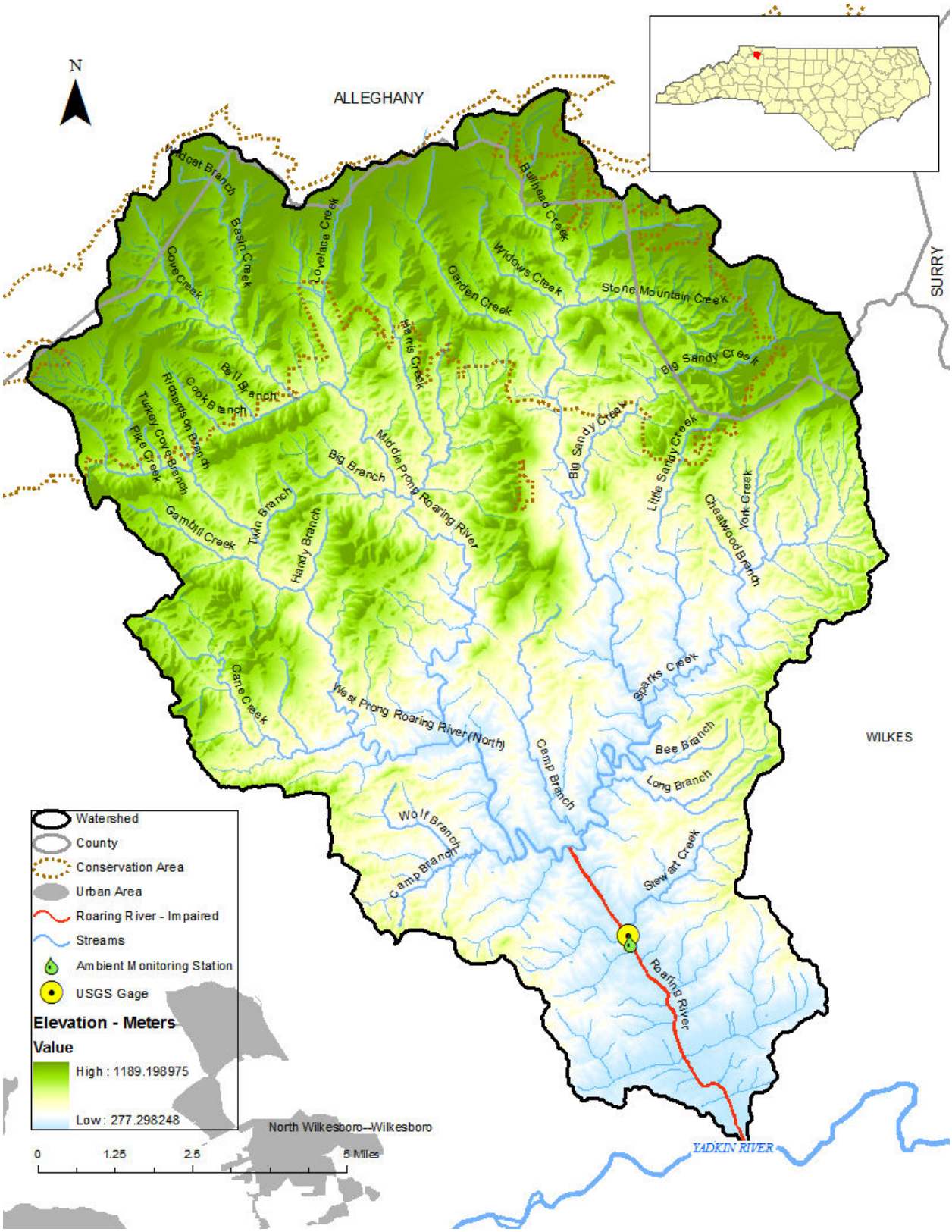


Figure 1.2 - Roaring River watershed and surrounding area.

The population density and growth rate are low in the Roaring River watershed compared to North Carolina as a whole (Table 1.2).

Table 1.2 - Population information

Area	Persons per square mile, 2010	2000 Census Population	2010 Census Population	Population, percent change 2000-2010
Watershed	48.7*	6,401	6,766*	5.7%*
Wilkes County	91.6	65,630	69,340	5.7%
North Carolina	195.8	8,046,406	9,535,483	18.5%

Source: http://2010.census.gov/2010census/data/
* Based on Wilkes County population percent change 2000-2010 (5.7%)

Land Cover

The land cover dataset used for this project was created by the NC Center for Geographic Information and Analysis (CGIA) for the upper portion of the Yadkin River Basin. Data are derived from Landsat 5 imagery from 2006 and 2007. The methodology used to create this dataset was based on that used to create the 2001 National Land Cover Database (NLCD). In addition, the NCDOT
integrated the road network right-of-way as an additional land class. Land cover classifications and 30 meter grid cells are also based on those from the NLCD. Table 1.3 shows the area in square miles for each of the land categories. The land cover is shown graphically in Figure 1.3.

Table 1.4 shows the land cover distribution adjacent to streams. These data were derived by using GIS to select only land cover grid cells that were intersected by a 1:24000 stream segment.

Table 1.3 - Land cover distribution in the Roaring River watershed

Land Cover Description	Area (square miles)	Area (percent)
Deciduous Forest	75.70	54.21%
Pasture/Hay	26.40	18.91%
Evergreen Forest	16.97	12.15%
Mixed Forest	6.79	4.87%
Developed, Low Intensity	6.21	4.44%
Developed, Open Space	4.71	3.37%

Scrub/Shrub	1.06	0.76%
Grassland/Herbaceous	0.65	0.47%
Barren Land	0.36	0.26%
Developed, Medium Intensity	0.29	0.21%
Cultivated Crops	0.27	0.20%
Woody Wetlands	0.13	0.09%
Open Water	0.06	0.04%
Developed, High Intensity	0.03	0.02%
Total	**139.63**	**100%**
NCDOT*	1.5*	1.0%

* The NCDOT land cover was obtained from a modified CGIA land cover file provided by the NCDOT and was calculated independently from the other land categories. NCDOT land is not shown in Figure 1.3, however it generally follows the road-like distribution of the developed land categories.

Table 1.4 - Land cover adjacent to streams in the Roaring River watershed

Description	Land Cover Distribution Adjacent to Streams
Deciduous Forest	33.4%
Evergreen Forest	19.9%
Pasture/Hay	16.3%
Mixed Forest	12.0%
Developed, Low Intensity	8.0%
Developed, Open Space	5.9%
Scrub/Shrub	2.1%
Woody Wetlands	0.7%
Cultivated Crops	0.7%
Open Water	0.5%
Grassland/Herbaceous	0.4%
Developed, Medium Intensity	0.1%
Barren Land	0.1%
Total	**100.0%**

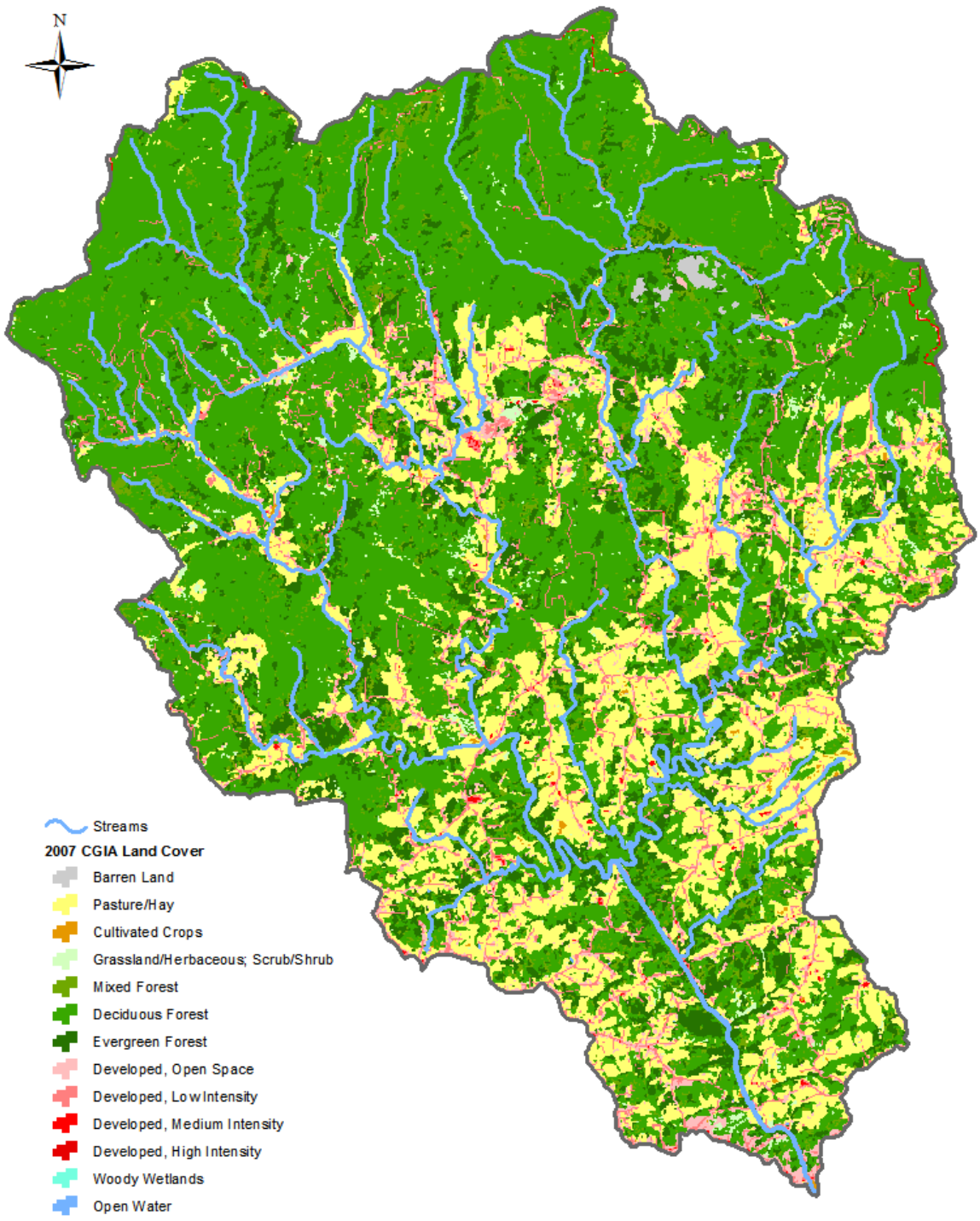


Figure 1.3 - Land Cover distribution in the Roaring River watershed

1.5 Water Quality Monitoring

The DWQ has one monitoring station on the Roaring River: Q0660000 at state road 1990, near the town of Roaring River. The location of this station is shown in Figure 1.4.

In addition to routine monthly samples, ten additional samples were taken at this station in June (5 samples) and August (5 samples) of 2004 as part of a "5-in-30" study to determine if fecal coliform concentrations exceeded the geometric mean portion of the standard (*fecal coliforms not to exceed geometric mean of 200cfu/100 ml based on at least five consecutive samples examined during any 30-day period*). These sampling dates are highlighted in Appendix Table A.1. A more detailed accounting of this sampling can be found in Table 1.5. Other locations in this watershed were also sampled during this study and their locations are shown on Figure 1.4. The 5-in-30 study report can be found in Appendix B.

Table 1.5 - Roaring River water quality sampling

Station	Sampling Period	Number of Samples Collected	Approximate Sampling Frequency	Number of Samples Exceeding Standard (400 colony forming units (cfu)/100 ml)	June 2004 5 in 30 Geomean[1]	August 2004 5 in 30 Geomean[1]
Q0660000	Jan. 2000 – Apr. 2010	148	monthly	17 (11%)	524 cfu/100 ml	264 cfu/100 ml

1. Geomean is calculated when there are five consecutive samples examined during any 30-day period.

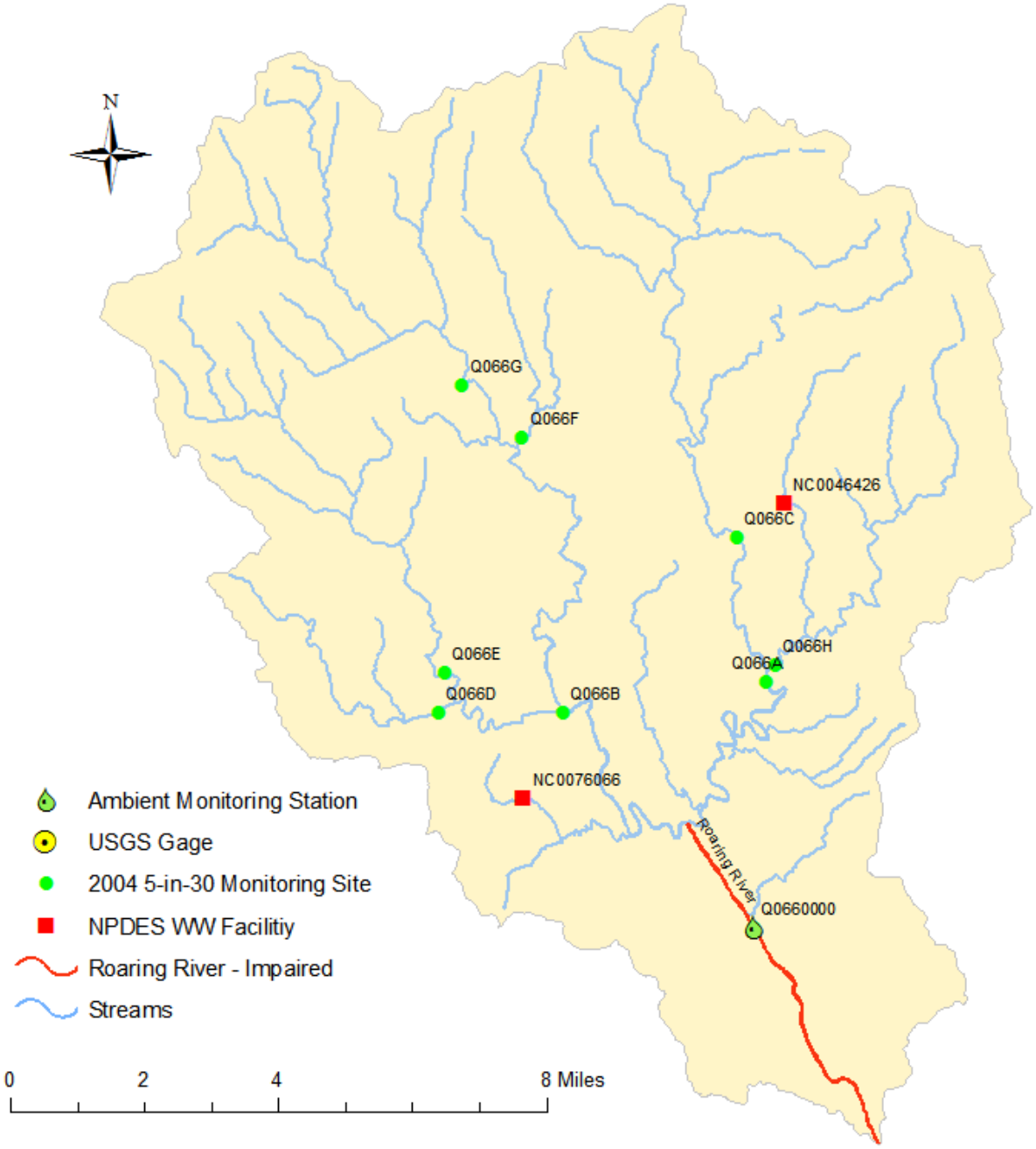


Figure 1.4 - Water quality monitoring in the Roaring River watershed

2.0 Source Assessment

2.1 Nonpoint Source Assessment

Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body at a single location. Nonpoint source loading typically occurs during rain events when surface runoff transports water carrying fecal coliform over the land surface and discharges it into the stream network. The transport of fecal coliform from the land to the stream is dictated by the hydrology, soil type, land use, and topography of the watershed.

There are many types of nonpoint sources in watersheds that contribute to stream impairments. Fecal coliform bacteria from non-human sources originate from excretions from warm-blooded wildlife, livestock and pets. Wildlife in the watershed are considered to make up background concentrations of fecal coliform. A more direct path to the stream occurs when wildlife defecate in, or even inhabit, the drainage network, including stream and wetland channels, and stormwater conveyance pipes.

Grazing animals contribute fecal coliform through either direct access to streams or runoff from deposition or manure spreading. Land cover data for the watershed indicates that pasture/hay land area (grazing land) represents 19 percent of the watershed. Some of this land is concentrated near the streams in the watershed (Figure 1.3) and runoff could be a contributing factor if manure is improperly applied, particularly if just before a storm event. The land cover shows that over 30 percent of the streams in the watershed have adjacent pasture/hay or developed land with only a thin buffer of trees or no tree buffer. According to the Wilkes County Soil and Water Conservation District (Wilkes Soil and Water) agriculture in this watershed is primarily made up of corn, tobacco, cattle, and chickens. Numerous chicken houses are visible in orthophotographs of the watershed. Wilkes Soil and Water suggests that stream buffer compromises, over application of manure or spreading manure too close to streams, and cattle overstocking may all be issues in this watershed. However, much of the watershed is held in private land, and stream observations are limited.

Nonpoint source contributions to the bacterial levels from human activities generally arise from malfunctioning or improperly-sited septic systems, or illicit straight pipes that bypass septic systems. The Wilkes County Health Department is not aware of problematic areas in this watershed regarding failing septic systems or straight pipe discharges.

2.2 Point Source Assessment

All wastewater discharges to surface water in the State of North Carolina must receive a permit to control water pollution. The Clean Water Act of 1972 initiated strict control of wastewater discharges with responsibility of enforcement given to the Environmental Protection Agency (EPA). The EPA then created the National Pollutant Discharge Elimination System (NPDES) to track and control point sources of pollution. The primary method of control is issuance of

permits to discharge with limitations on wastewater flow and constituents. The EPA delegated permitting authority to the State of North Carolina in 1975. Table 2.1 shows dischargers in the Roaring River watershed. Locations of dischargers are shown in Figure 1.4. Permit violations for fecal coliform are shown in Appendix C.

Table 2.1 - NPDES Waste Water Dischargers in the Roaring River Watershed

Facility	Permit	Type	Permitted Flow (MGD)	Monthly Average Limit	Daily Max Limit	Fecal Coliform Permit Violations 2000-Apr. 2010
North Wilkes High School	NC0076066	100% Domestic <1 MGD	0.0105	200#/ 100ml	400#/ 100ml	5
Traphill Elementary School	NC0046426	100% Domestic <1 MGD	0.004	200#/ 100ml	400#/ 100ml	1

In addition, human sewage can be discharged to surface waters during sanitary sewer overflow (SSO) events due to a failure at a pump station or stormwater infiltration. There are no sanitary sewers in this watershed.

2.3 NPDES Stormwater Permits

The only stormwater permit in the Roaring River watershed is held by the North Carolina Department of Transportation (NC DOT), whose NPDES Phase I permit applies statewide. The (NCDOT) has approximately 1.5 square miles of road and right-of-way in the 139 square-mile watershed, which are covered under their statewide Phase I NPDES stormwater permit (NCS000250). NPDES-permitted sources are to be included in the wasteload allocation (WLA) per EPA guidance (USEPA, 2002).

3.0 Total Maximum Daily Loads and Loads and Load Allocation

3.1 TMDL Objective

The TMDL objective is to meet North Carolina water quality standards for fecal coliform, which are not to exceed a geometric mean of 200/100 ml (MF count) based on at least five consecutive samples examined during any 30-day period and not to exceed 400/100 ml in more than 20 percent of the samples examined during such period.

3.2 Methodology

The load duration curve method is intended to be a simple method to calculate pollutant reductions. This method was chosen for the Roaring River because of the availability of long-term data and is an efficient method to calculate a percent load reduction from nonpoint sources. The methodology used to develop the load duration curve was based on Cleland (2002).The required load reduction was determined based on water quality monitoring and stream flow data from January 2000 through April 2010.

3.2.1 Flow Duration Curve

Development of a flow duration curve is the first step of the load duration approach. A flow duration curve employs a cumulative frequency distribution of measured daily stream flow over the period of record. The curve relates flow values measured at the monitoring station for the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which are exceeded nearly 100 percent of the time, to highest, which are exceeded less than 1 percent of the time. Reliability of the flow duration curve depends on the period of record available at monitoring stations. Accuracy of the curve increases when longer periods of record are used. The flow duration curve, shown in Figure 3.1, was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occurred.

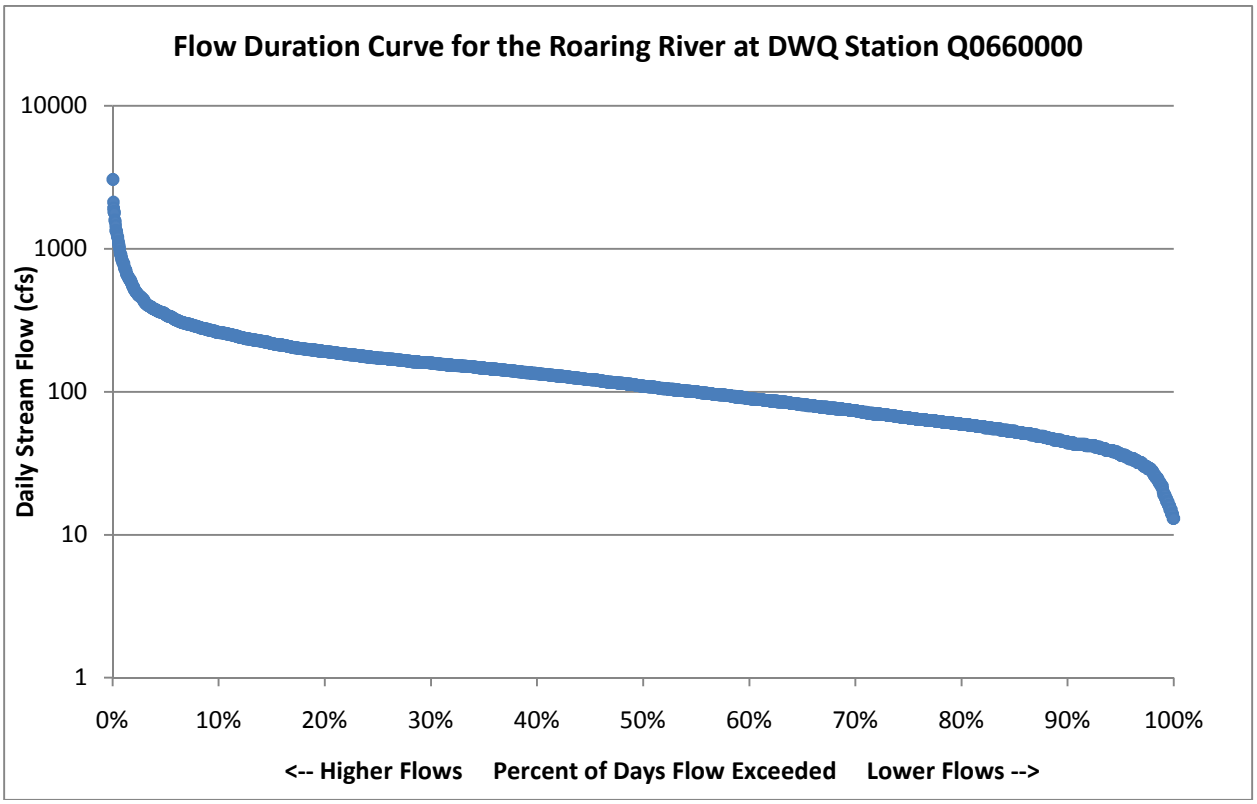


Figure 3.1 - Flow Duration Curve for the Roaring River at DWQ Station Q0660000

Daily flow data were used from USGS Roaring River gauging station 02112120, co-located with the DWQ station.

3.2.2 Load Duration Curve

A load duration curve is developed by multiplying the flow values along the flow duration curve by the pollutant concentration and the appropriate conversion factors. The allowable load assumes a fecal coliform concentration based on water quality numeric criteria and margin of safety. The target, or allowable load line, resembles the flow duration curve; hence it determines the assimilative capacity of a stream or river under different flow conditions. Values above the line are exceedances and values below the line are acceptable loads. Therefore, a load duration curve can help define the flow regime during which exceedances occur. Figure 3.2 shows existing loads plotted against the allowable load. For the Roaring River, the criteria violations occurred mostly during moist and high flow conditions. Few exceedances during dry conditions suggest that point sources in the watershed may not be a significant source of fecal coliform bacteria in this watershed.

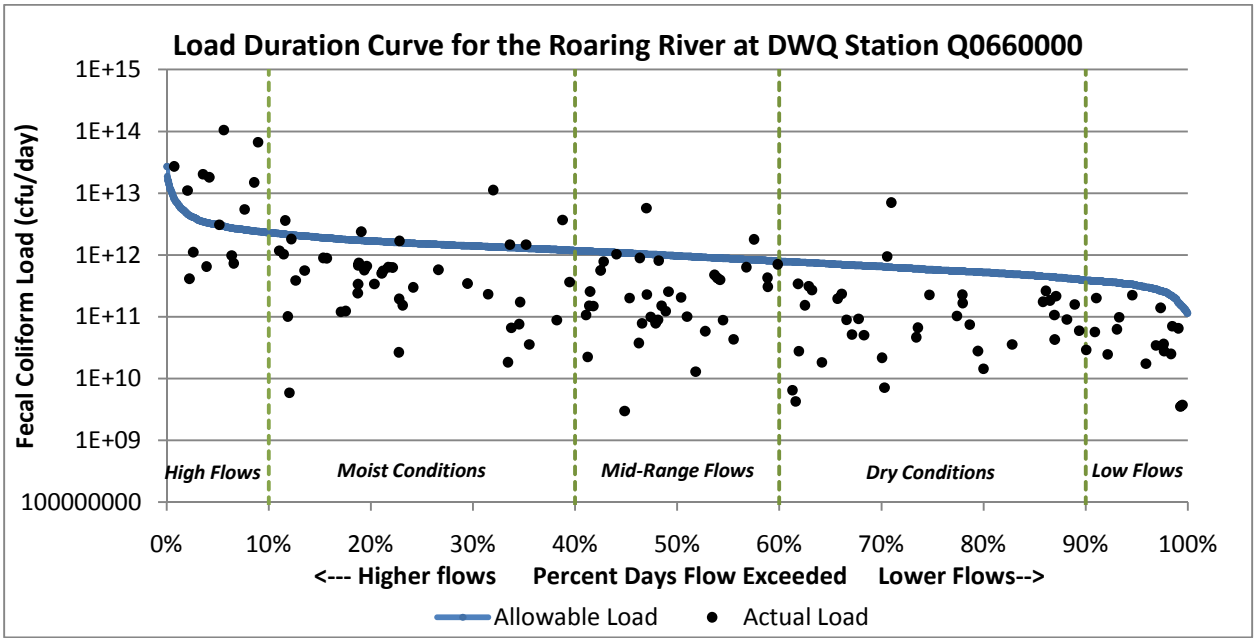


Figure 3.2 – Load Duration Curve for the Roaring River at DWQ Station Q0660000

3.3 Total Maximum Daily Load

Total Maximum Daily Load (TMDL) can be defined as the total amount of pollutant that can be assimilated by the receiving water body while achieving water quality standards. A TMDL can be expressed as the sum of all point source wasteload allocations (WLAs), nonpoint source load allocations (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluent limitations and water quality. This definition can be expressed by equation 3.1.

$$TMDL = \sum WLAs + \sum LAs + MOS \quad (3.1)$$

The purpose of the TMDL is to estimate allowable pollutant loads and to allocate those loads in order to implement control measures and to achieve water quality standards. The Code of Federal Regulations (40 CFR § 130.2 (1)) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For fecal coliform contamination, TMDLs are expressed as counts, or colony forming units (cfu), per 100 milliliters. TMDLs represent the maximum one-day load the river can assimilate and maintain the water quality criterion. A load duration curve approach was utilized to estimate the TMDL for fecal coliform.

3.4 Margin of Safety (MOS)

The MOS is included in the TMDL estimation to account for the uncertainty in the simulated relationship between the pollutants and the water quality standard. In this study, the MOS was explicitly included in following TMDL analysis by setting the TMDL target at 10 percent lower than the water quality target for fecal coliform. The water quality standard and the target can be seen in Table 3.1.

Table 3.1 - Water quality standards and margin of safety

Pollutant	Standard	Target w/ 10% MOS
Fecal Coliform (cfu/day)	400 cfu/100ml	360 cfu/100 ml

Target Reduction

The load reduction needed to meet the instantaneous fecal coliform standard was estimated with the observed data that exceeded the applicable water quality standard (360 cfu/100 ml) within the 10^{th} to 95^{th} percentile flow recurrence range. Typically the remaining flow recurrence range is not included in the TMDL calculation to allow cases of extreme drought or flood to be excluded.

A polynomial curve equation for the data points violating the water quality criterion was estimated. The equation is presented in Equation 3.2.

$$y = -9E+12x^2 + 8E+12x + 2E+12 \quad R^2 = 0.0116 \quad (3.2)$$

Where, Y = fecal coliform (cfu/100ml) and X = Percent Flow Exceeded.

To present the TMDLs as a single value, the existing load was calculated from the polynomial curve equation as the average of the load violations occurring when the flow exceeded at a frequency greater than 10 percent and less than 95 percent. Additionally, the average load was calculated by using percent flow exceedances in multiples of 5 percent. The allowable loadings

for each exceedance were calculated from the TMDL target value, which includes the 10 percent MOS. The target curve based on the allowable load and the polynomial curve based on the exceedances are shown in Figure 3.3.

The necessary percent reduction was calculated by taking the difference between the average of the polynomial curve load estimates and the average of the allowable load estimates. For example, at each recurrence interval between 10 and 95 (again using recurrence intervals in multiple of 5), the equation of the polynomial curve was used to estimate the existing load. The allowable load was then calculated in a similar fashion by substituting the allowable load curve. The estimated values are given in Appendix Table A.2.

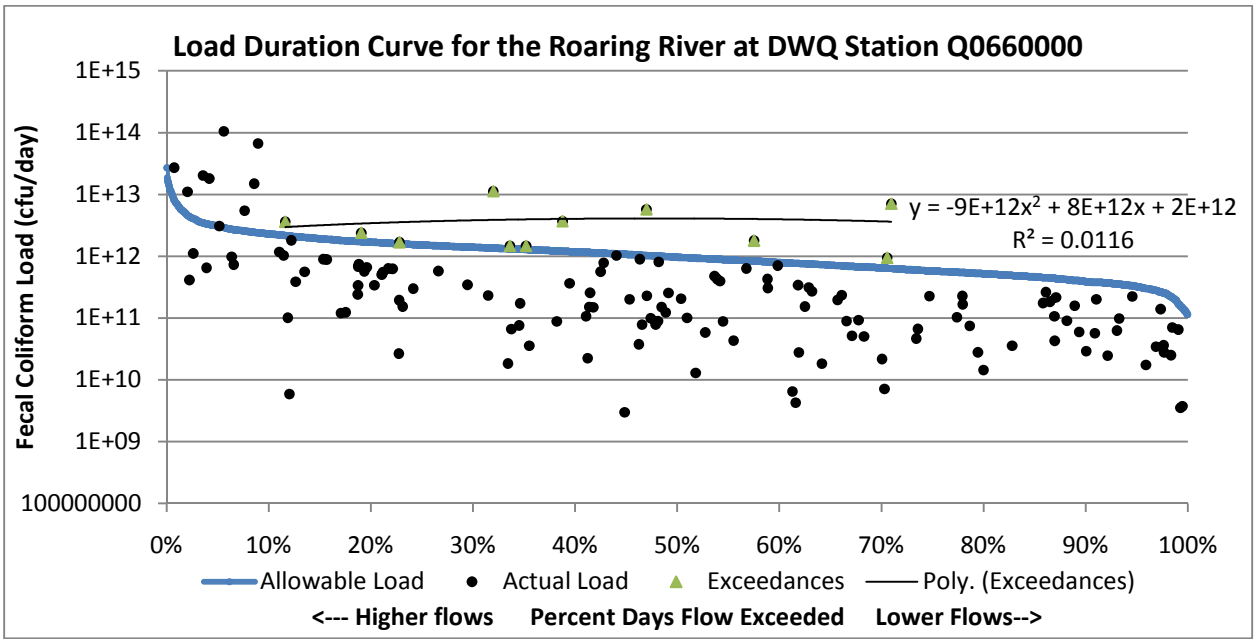


Figure 3.3 - Load duration curve with allowable and estimated exceeding loads of fecal coliform in the Roaring River at station Q0660000

3.5 TMDL Allocation

As identified by the above load duration curve method, a significant reduction of fecal coliform is needed in the Roaring River. A summary of the reductions needed is provided in Table 3.2 (also, see Appendix Table A.2).

Table 3.2 - Reduction required for fecal coliform

Pollutant	Target with MOS	Average Exceeding Load	Allowable Load (TMDL-MOS)	Average Reduction Required
Fecal Coliform (cfu/day)	<360 cfu/100ml	3.11E+12	1.04E+12	66.7%

The TMDL objectives require the instream fecal coliform concentrations to meet both the instantaneous standard of 400 cfu/100ml and the geometric mean standard of 200 cfu/100ml. This analysis used the instantaneous standard as the endpoint for the fecal coliform TMDL in the creek. To verify that the required reduction will also meet the geometric mean standard, the reduction was applied to those fecal coliform concentrations measured during the sampling to calculate the geometric mean (highlighted in Appendix Table A.1) and a new geometric mean was calculated. The results of this analysis are shown in Table 3.3 and indicate that the required reduction will meet the geometric mean portion of the fecal coliform standard.

Table 3.3 - Verification of geometric mean portion of fecal coliform standard

Sampling Period	Measured Geometric Mean	Geometric Mean with Reduction
June 2004	524	174
August 2004	264	88

3.5.1 Waste Load Allocation (WLA)

Two waste water treatment facilities (WWTF) plus the NC Department of Transportation hold NPDES permits in the Roaring River Watershed. The two WWTF load contributions are shown in Table 3.4

Table 3.4 – Existing NPDES Load Contributions

Facility Name	Permit Number	Flow (mgd)	Flow (cfs)	Permit Limit (Daily Max)	Load (cfu/day)	% of Average Ambient Station Load	Stream Miles to DWQ station
North Wilkes High School	NC0076066	0.0105	0.016	400#/100ml	159053352	0.007%	6.4
Traphill Elementary School	NC0046426	0.004	0.006	400#/100ml	60591753	0.003%	11

In order to estimate contributions from the WWTFs, it was assumed that all fecal coliform discharged reaches the ambient station with no attenuation. Based on facility limits of flow and the more stringent daily fecal coliform concentrations, the combined WWTF load contributes less than 1% of the average load at DWQ station Q0660000 based on data from years 2000 through 2010. Factoring actual distances from the Ambient Station, bacteria die-off, and the small loading percentage calculated above, it appears that these WWTFs do not present a significant load to the Roaring River. Therefore it was assumed that the WWTFs are adequately regulated under existing permits and the waste load allocations in this TMDL were calculated at

the existing permit limits. The waste load allocation for NPDES permittes in the Roaring River watershed are shown in Table 3.5.

Table 3.5 – NPDES waste load allocations and required reductions

NPDES Permittee	Permitted Load (cfu/day)	WLA (cfu/day)	Percent Reduction Required
North Wilkes High School	1.591E+08	1.591E+08	0%
Traphill Elementary School	6.059E+07	6.059E+07	0%
NC DOT - Stormwater	n/a	1.036E+10	0%
Total		**1.058E+10**	**0%**

Monitoring data is not available for stormwater draining from NCDOT areas in the watershed. Consequently, the NCDOT WLA was assigned as 1 percent of the load allocation, based on DOT land comprising 1 percent of the watershed from the land cover data in section 1.4. The NC DOT will continue to implement measures required by the NPDES stormwater permit (NCS000250), including illicit discharge detection and elimination, post-construction controls, management of hydraulic encroachments, sediment and erosion control, BMP retrofits, stormwater pollution prevention for industrial facilities, research, and education programs.

3.5.2 Load Allocation (LA)

All fecal coliform loadings from nonpoint sources such as non-MS4 urban land, agriculture land, and forestlands are reported as the LA. The estimated contributions of fecal coliform from the nonpoint sources are presented in Table 3.6. The estimated percent reduction needed from nonpoint sources is 67%, as shown in Table 3.7.

Table 3.6 – Estimated TMDL and load allocation for fecal coliform for the Roaring River

Pollutant	Average Exceeding Load	WLA	LA	Explicit MOS_1	TMDL
Fecal Coliform (cfu/day)	3.11E+12	1.058E+10	1.0252E+12	10 %	1.0358E+12

Note: The Margin of safety is included in the TMDL by lowering the Fecal Coliform standard from 400 to 360 cfu/100 ml.

Table 3.7 – Estimated reduction by source for fecal coliform (shown in cfu/day) for the Roaring River

	WLA	LA
Existing Load (cfu/day)	1.058E+10	3.103E+12
Allocation (cfu/day)	1.058E+10	1.0252E+12
Percent Reduction	0%	67%

3.5.3 Critical Condition and Seasonal Variation

Critical conditions are considered in the load duration curve analysis by using an extended period of stream flow and water quality data, and by examining the flows (percent flow exceeded) where the existing loads exceed the target line.

Seasonal variation is considered in the development of the TMDLs, because allocation applies to all seasons. According to the load duration curve (Figure 3.3), exceedances for fecal coliform occurred mostly during mid range to high flow conditions throughout the year; therefore, wet weather conditions are critical for fecal coliform loading to the Roaring River.

4.0 Summary and Future Consideration

This report presents the development of the Fecal Coliform Total Maximum Daily Load (TMDL) for the Roaring River in the Yadkin Pee-Dee River Basin.

Available water quality data were reviewed to determine the critical periods and the sources that lead to exceedances of the standard. The necessary percent reduction to meet the TMDL requirement was then calculated by taking a difference between the average of the polynomial curve load estimates and the average of the allowable load estimates. The summary of the results is as follows:

- A 67.1% percent reduction in nonpoint source contributions of fecal coliform is required in order to meet the water quality standard in the Roaring River. It appears that nonpoint sources are responsible for the exceedance of fecal coliform standards.

4.1 Future Efforts

Reduction of fecal coliform bacteria in this watershed will result from reduced overland and stormwater runoff, and improved land management. Landowners, stakeholder groups, local governments, and agencies are encouraged to utilize all available funding sources for water quality improvement projects within the watershed. The following programs provide technical and financial resources for reducing non-point source pollution:

- The North Carolina Soil and Water Conservation Service

- The Natural Resources Conservation Service
- Clean Water Act Section 319 Nonpoint source pollution control grant
- North Carolina Clean Water Management Trust Fund
- 205(j) Water Quality Management Planning Grant

5.0 Public Participation

TBD

6.0 References

Cleland, B.R. 2002. TMDL Development from the "Bottom Up" – Part II: Using load duration curves to connect the pieces. Proceedings from the WEF National TMDL Science and Policy 2002 Conference.

U.S. Environmental Protection Agency (USEPA). 1991. Guidance for Water Quality-Based Decisions: The TMDL Process. Assessment and Watershed Protection Division, Washington, DC.

U.S. Environmental Protection Agency (USEPA) 1998. Draft Final TMDL Federal Advisory Committee Report. U.S. Environmental Protection Agency, Federal Advisory Committee (FACA). Draft final TMDL Federal Advisory Committee Report. 4/28/98.

U.S. Environmental Protection Agency (USEPA) 2000. Revisions to the Water Quality Planning and Management Regulation and Revisions to the National Pollutant Discharge Elimination System Program in Support of Revisions to the Water Quality Planning and management Regulation; Final Rule. Fed. Reg. 65:43586-43670 (July 13, 2000).

U.S. Census Bureau:
Wilkes - http://quickfacts.census.gov/qfd/states/37/37193.html

Appendix A: TMDL Data

Table A.1. Water Quality and Flow Data for the Roaring River at DWQ Ambient Station Q0660000 (highlighted rows indicate data was collected for 5 in 30 testing).

Date	Result (cfu/100 mL)	Flow (cfs)
2/7/2000	18	98
3/23/2000	73	190
4/12/2000	45	112
5/9/2000	36	100
7/19/2000	150	50
8/15/2000	180	49
9/12/2000	140	51
10/10/2000	64	40
11/8/2000	27	44
12/27/2000	54	43
1/9/2001	100	40
2/8/2001	*Non-detect	57
4/23/2001	27	76
5/7/2001	19	60
6/12/2001	140	46
7/12/2001	190	43
8/14/2001	3000	153
9/6/2001	210	51
10/9/2001	21	34
11/7/2001	24	42
12/11/2001	10000	272
1/10/2002	10	59
2/20/2002	28	68
3/7/2002	4	73
7/9/2002	120	24
8/1/2002	51	29
9/9/2002	140	19
10/1/2002	150	85
11/14/2002	170	213
12/9/2002	32	114
1/15/2003	13	118
2/4/2003	340	124
3/12/2003	7	131

Date	Result (cfu/100 mL)	Flow (cfs)
4/24/2003	130	309
5/19/2003	155	196
6/4/2003	2000	370
7/9/2003	370	340
8/12/2003	770	289
9/4/2003	13000	331
10/13/2003	110	135
11/12/2003	48	147
12/1/2003	67	235
1/5/2004	110	187
3/15/2004	5	150
4/19/2004	35	179
5/13/2004	180	128
6/1/2004	290	114
6/8/2004	310	118
6/11/2004	1100	137
6/22/2004	2100	394
6/25/2004	190	252
7/26/2004	190	92
8/20/2004	136	92
8/26/2004	270	96
8/27/2004	320	90
9/3/2004	191	102
9/22/2004	310	239
9/24/2004	500	195
9/29/2004	870	517
10/27/2004	140	168
11/3/2004	88	160
12/13/2004	100	229
1/6/2005	140	183
2/3/2005	170	215
3/8/2005	120	187
4/7/2005	170	248

Geomean = 523.87

Geomean = 264.25

Date	Result (cfu/100 mL)	Flow (cfs)
5/19/2005	70	175
6/15/2005	410	146
7/14/2005	2200	277
8/25/2005	160	101
10/25/2005	100	80
11/15/2005	49	77
12/14/2005	68	121
1/31/2006	10	145
3/15/2006	2	87
4/6/2006	9	83
5/17/2006	27	78
6/15/2006	87	50
7/17/2006	140	66
8/10/2006	150	62
9/12/2006	770	95
10/25/2006	50	61
11/14/2006	77	109
12/5/2006	28	115
1/16/2007	140	193
2/19/2007	1	122
3/7/2007	6	181
4/26/2007	21	148
5/29/2007	46	79
6/19/2007	110	62
7/16/2007	35	50
8/20/2007	39	29
9/10/2007	190	30
10/10/2007	240	38
10/31/2007	130	85
11/27/2007	160	87
1/10/2008	73	86
2/19/2008	23	104
3/6/2008	47	131
4/14/2008	35	116
4/24/2008	38	108
5/12/2008	93	112
5/27/2008	40	68
6/9/2008	77	48
6/25/2008	44	32

Date	Result (cfu/100 mL)	Flow (cfs)
7/8/2008	4000	72
7/21/2008	41	25
8/6/2008	8	18
8/18/2008	9	17
9/9/2008	2000	117
9/22/2008	53	46
10/8/2008	67	63
10/20/2008	26	56
11/13/2008	400	150
11/20/2008	12	74
12/3/2008	13	87
12/17/2008	140	185
1/12/2009	25	202
1/27/2009	54	114
2/4/2009	5	106
2/17/2009	3	88
3/17/2009	44	181
3/25/2009	47	130
4/14/2009	120	194
4/30/2009	380	181
5/12/2009	50	197
5/27/2009	1200	923
6/9/2009	600	246
6/24/2009	70	197
7/14/2009	33	132
7/23/2009	80	131
8/4/2009	170	102
8/31/2009	120	80
9/9/2009	530	73
9/30/2009	80	117
10/15/2009	250	128
10/29/2009	61	155
11/4/2009	26	139
12/1/2009	27	118
12/14/2009	98	305
12/21/2009	140	197
1/7/2010	18	150
1/27/2010	34	497
2/9/2010	70	379

Date	Result (cfu/100 mL)	Flow (cfs)
2/17/2010	1	241
3/10/2010	24	205

Date	Result (cfu/100 mL)	Flow (cfs)
3/23/2010	98	463
4/7/2010	17	243

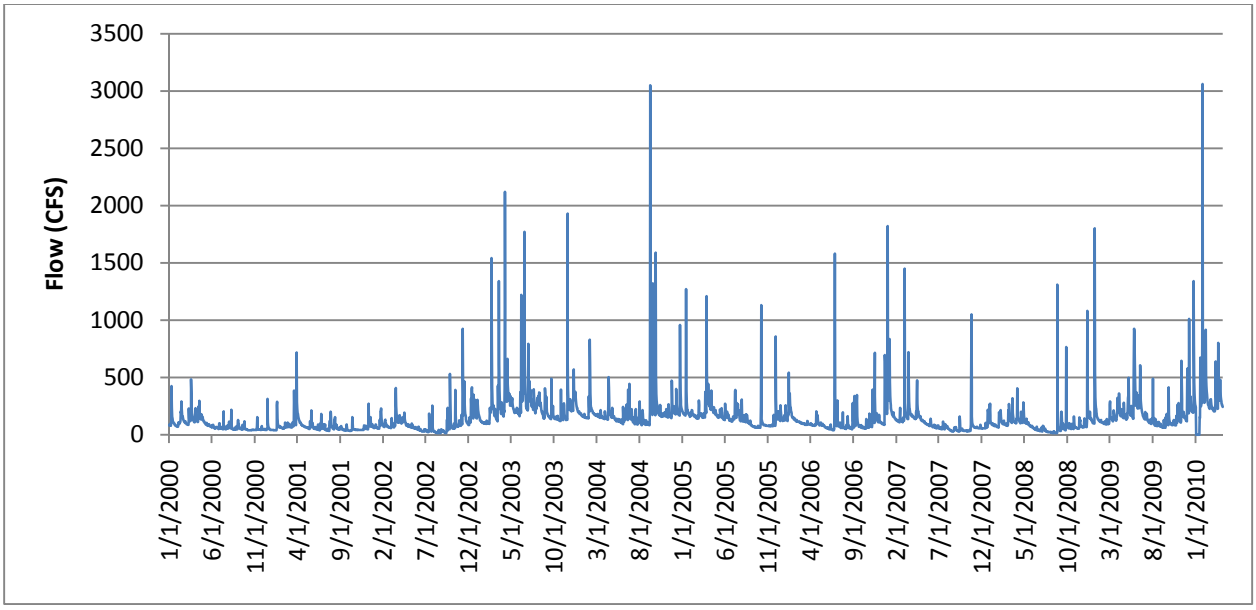


Figure A.1. Daily average flow (cfs) measured at USGS Gage 02112120.

Table A.2. Estimation of Load Reduction Required in Fecal Coliform for the Roaring River at Station Q0660000.

% Flow Exceeded	Flow (cfs)	Actual Load	Allowable Load	Reduction Needed
10%	260	2.71E+12	2.2909E+12	
15%	217	2.9975E+12	1.9121E+12	
20%	192	3.24E+12	1.6918E+12	
25%	172	3.4375E+12	1.5155E+12	
30%	159	3.59E+12	1.401E+12	
35%	147	3.6975E+12	1.2953E+12	
40%	134	3.76E+12	1.1807E+12	
45%	122	3.7775E+12	1.075E+12	
50%	110	3.75E+12	9.6925E+11	
55%	100	3.6775E+12	8.8113E+11	
60%	90	3.56E+12	7.9302E+11	
65%	81	3.3975E+12	7.1372E+11	
70%	74	3.19E+12	6.5204E+11	
75%	66	2.9375E+12	5.8155E+11	

% Flow Exceeded	Flow (cfs)	Actual Load	Allowable Load	Reduction Needed
80%	59	2.64E+12	5.1987E+11	
85%	53	2.2975E+12	4.67E+11	
90%	44	1.91E+12	3.877E+11	
95%	36	1.4775E+12	3.1721E+11	
	Average	**3.1138E+12**	**1.0358E+12**	**66.7%**

Appendix B. DWQ 5-in-30 Study

Michael F. Easley, Governor

William G. Ross Jr., Secretary
North Carolina Department of Environment and Natural Resources

Alan W. Klimek, P.E. Director
Division of Water Quality

2004 Roaring River Fecal Coliform investigation

The fecal coliform data collected during January through December 2003 for all Ambient Monitoring stations have been screened to identify waterbodies sampled that may be at risk for not fully supporting recreation uses, i.e. those with geometric means >200 colonies/100ml or >20% of samples exceeding 400 colonies/100ml.

One site on the "B" classified Roaring River was found to have elevated fecal coliform numbers in the calendar year of 2003. In June and August of 2004, investigative sampling (5 samples in 30 days) was initiated to determine if standard 2B.0219 (3b) was violated. In addition to the Ambient monitoring station Q0660000, Roaring River nr Roaring River, 2 more stations upstream were sampled in June and 7 more in August to aid in locating potential coliform sources. The results and comments follow.

Roaring River nr Roaring River (Ambient site Q0660000)

The Roaring River nr Roaring River **exceeded** one part of standard 2B.0219(3b) in the June and August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in August, but **exceeded** in June. **Refer to attached table and map.**

East Prong Roaring River @ SR1945 (study site Q066A)

The East Prong Roaring River **exceeded** one part of standard 2B.0219(3b) in the June and August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in August, but **exceeded** in June. **Refer to attached table and map.**

Roaring River@ SR1002 (Traphill Rd.) (study site Q066B)

The Roaring River nr Traphill **exceeded** one part of standard 2B.0219(3b) in the June and August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in June and August. **Refer to attached table and map.**

East Prong@ SR1002 (Traphill Rd.) (study site Q066C)

The East Prong @ SR1002 was not sampled in June but **exceeded** one part of standard 2B.0219(3b) in the August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in August. **Refer to attached table and map.**

Tributary @ SR1730 (study site Q066D)

The tributary @ SR1730 was not sampled in June but **exceeded** one part of standard 2B.0219(3b) in the August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in August. **Refer to attached table and map.**

Tributary @ SR 1730 (upstream) (study site Q066E)

The tributary @ SR 1730 upstream was not sampled in June but **exceeded** one part of standard 2B.0219(3b) in the August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in August. **Refer to attached table and map.**

Middle Prong @ SR 1736 (study site Q066F)

The Middle Prong @ SR 1736 was not sampled in June but **exceeded** the standard 2B.0219(3b) in the August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period, as well as **exceeding** the standard of 400/100 ml in more than 20 percent of the samples examined during such period. **Refer to attached table and map.**

Middle Prong @ SR1735 (study site Q066G)

The Middle Prong @ SR1735 was not sampled in June but **exceeded** the standard 2B.0219(3b) in the August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period, as well as **exceeding** the standard of 400/100 ml in more than 20 percent of the samples examined during such period. **Refer to attached table and map.**

Little Sandy @ SR 1944 (study site Q066H)

The Little Sandy @ SR 1944 was not sampled in June but **exceeded** one part of standard 2B.0219(3b) in the August sampling: fecal coliforms not to exceed a geometric mean of 200/100 ml based upon at least five consecutive samples examined during any 30-day period. It did however **meet** the portion of the standard not to exceed 400/100 ml in more than 20 percent of the samples examined during such period in August. **Refer to attached table and map.**

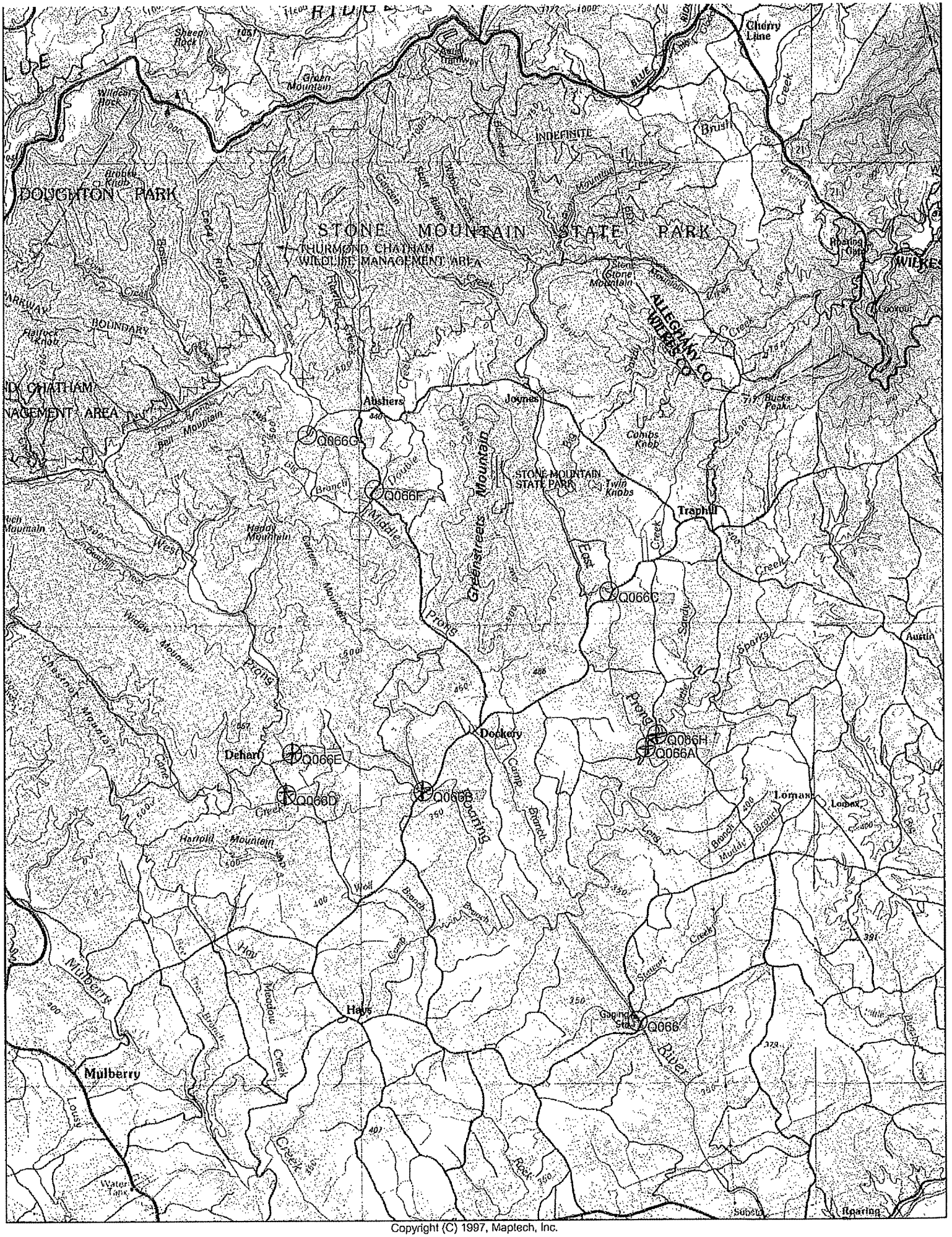
June 2004 Roaring River 5-in-30 Sampling

Roaring River Fecal Coliform Sample Locations	**6/1/04 Results: Col/100ml**	6/8/04 **Results: Col/100ml**	6/11/04 **Results: Col/100ml**	6/22/04 **Results: Col/100ml**	6/25/04 **Results: Col/100ml**	**Geo. Mean**
RR @ Roaring River	290	310	1100	2100	190	579
RR @ SR 1945	480	1200	100	900	280	388
RR @ Traphill Rd.	260	180	330	200	250	239

August, 2004 Roaring River 5-in-35* Sampling

Roaring River Fecal Coliform Sample Locations	**8/20/04** Results **Col/100ml**	**8/2704 Results: Col/100ml**	**9/3/04 Results: Col/100ml**	**9/22/04 Results: Col/100ml**	**9/24/04 Results: Col/100ml**	**Geo Mean**
RR @ Roaring River Q0660000	136	320	191	310	500	264
East Prong @ SR 1945 Q066A	350	230	490	180	350	301
RR @ Traphill Rd. Q066B	320	380	210	90	250	225
East Prong @SR 1002 Q066C	250	290	127	130	350	211
Trib @ SR 1730 Q066D	250	390	240	230	40	185
Trib @ SR 1730 upstream Q066E	150	240	170	110	500	202
Middle Prong @ 1736 Q066F	450	550	450	260	136	330
Middle Prong @ 1735 Q066G	500	1200	700	190	109	387
Little Sandy @ SR 1944 Q066H	300	180	520	260	300	294

*Due to adverse weather in August, the sampling period exceeded the 30 day protocal


STONE MOUNTAIN STATE PARK
THURMOND CHATHAM WILDLIFE MANAGEMENT AREA
DOUGHTON PARK
Cherry Line
Sheep Rock
Wildcat Rock
Green Mountain
Brushy Knob
Flattop Knob
Bell Mountain
Rich Mountain
Hardy Mountain
Carters Mountain
Window Mountain
Chestnut Mountain
Harnold Mountain
Stone Mountain
Twin Knobs
Camps Knob
Bucks Peak
Greenstreets Mountain
Alleghany Co.
Wilkes Co.
Alsiers
Joynes
Traphill
Austin
Dockery
Deharo
Lomax
Hays
Mulberry
Gaging Station
Roaring River
Q066G
Q066F
Q066C
Q066E
Q066D
Q066B
Q066H
Q066A
Q066
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Appendix C. NPDES Fecal Coliform Permit Violations

Table C.1. Permit violations for fecal coliform for the NPDES dischargers in the watershed as of March 2011. Rows highlighted in yellow show violations that occurred during the study period of this TMDL.

Permit #	Date	Description	Limit (cfu/100ml)	Calculated (cfu/100ml)
NC 0076066	10/1/2010	Daily max	400	440
NC 0076066	9/30/2010	Monthly avg.	200	290
NC 0076066	8/31/2010	Monthly avg.	200	258
NC 0076066	1/14/10	Daily max	400	480
NC 0076066	1/28/10	Daily max	400	510
NC 0076066	1/31/10	Monthly avg.	200	497
NC 0076066	6/30/09	Monthly avg.	200	226
NC 0076066	8/28/08	Daily max	400	520
NC 0046426	12/31/08	Monthly avg.	200	229

Appendix D: Public Notification of TMDL for Fecal Coliform for the Roaring River

The TMDL public comment period was announced on the NC Modeling and TMDL website on 3/14/11, on the WRRI listserv on 3/12/11.

- Notice on the Modeling and TMDL Website: http://portal.ncdenr.org/web/wq/ps/mtu

3/14/2011 Public Review Draft Roaring River TMDL is available for review and comment. The comment period extends through April 12, 2011. Comment submittal instructions are available with the above link.

- WRRI listserv email received regarding public comment period:

The WRRI Daily Digest
Volume 1 : Issue 732 : "text" Format

201103/6 : DRAFT Total Maximum Daily Load for the Roaring River, Yadkin - Pee Dee River Basin, North Carolina
"Painter, Andy" <andy.painter@ncdenr.gov>

Date: Fri, 11 Mar 2011 15:23:04 -0500
From: "Painter, Andy" <andy.painter@ncdenr.gov>
To: "wrri-news@lists.ncsu.edu" <wrri-news@lists.ncsu.edu>
Subject: DRAFT Total Maximum Daily Load for the Roaring River, Yadkin - Pee Dee River Basin, North Carolina
Message-ID:
<C30443CA151D664AB85C3515E5C5E9FE24CC2F7A7E@NCWITMXMBEV39.ad.ncmail>

Please post the following announcement on the WRRI listserv. Thanks!

Now Available for Public Comment

DRAFT Total Maximum Daily Load for Fecal Coliform for the Roaring River, Yadkin - Pee Dee River Basin, North Carolina

March 2011
North Carolina Department of Environment and Natural Resources Division of Water Quality

This draft TMDL report was prepared as a requirement of the Federal Water Pollution Control Act, Section 303(d). Interested parties are invited to comment on the draft TMDL report by April 12, 2011. Comments concerning the report should be directed to Andy Painter at andy.painter@ncdenr.gov<mailto:andy.painter@ncdenr.gov> or write to:

Andy Painter

NC Division of Water Quality
Planning Section
1617 Mail Service Center
Raleigh, NC 27699

The draft TMDL can be downloaded from the following link:
http://portal.ncdenr.org/c/document_library/get_file?uuid=507f9f1c-741f-4a9b-993d-ce85308db37c&groupId=38364

Appendix E: Public Comments

Public Comment Roaring River Fecal Coliform Bacteria TMDL Responsiveness Summary

April 2011

The public comment period extended from May 12, 2011 through April 12, 2011. Comments were received from the North Carolina Department of Transportation. These comments with the NC Division of Water Quality responses are provided in the Responsiveness Summary presented below.

1)

- The report describes a method for characterizing the *existing* instream fecal coliform load by calculating a polynomial curve equation fit to the approximate average of the load violations occurring within a flow range of the 10th percentile (high flows) and 95th percentile (low flows). An average existing load was calculated to be 3.11E+12 cfu/day and presented in Tables 3.2 and 3.6. NCDOT recommends that the term "existing load" be replaced with an alternative description of the 3.11E+12 cfu/day value, such as "average estimated exceeding load".

  In our opinion, most readers of TMDL reports would interpret a pollutant load value labeled as the "existing load" to be a measure of central tendency for the entire dataset under existing conditions – in this case, between the 10th and 95th percentile flow regime. For the Roaring River, the measured (monitored) load on average is only 18% of the "existing load" calculated from the polynomial curve. Hence, to avoid confusion, it may be more appropriate to characterize the load calculated from the polynomial curve as the estimated exceeding load.

Response: DWQ has renamed the column headings in tables 3.2 and 3.6 from "Existing Load" to "Average Exceeding Load."

2)

- As an extension of the above comment, NCDOT notes that the most recent five years' worth of fecal coliform data presented in the report suggests that the

Roaring River may be very close to attaining the Class B bacteriological water quality standard. A limited number of improved manure management and animal exclusion practices will likely result in the consistent attainment of standards, which would make for a nice TMDL success story. While no data is available to suggest that NCDOT is a significant contributor to the impairment, the Department will continue to implement practices required under Part II of our NPDES stormwater permit to ensure the protection of water quality.

Response: We appreciate NCDOTs efforts to improve water quality.