Total Maximum Daily Load for Fecal Coliform for Salem Creek and Turbidity for Grants Creek in North Carolina

Final Report

EPA Approval Date: September 25, 2006

Yadkin-Pee Dee River Basin

Prepared by:
NC Department of Environmental and Natural Resources
Division of Water Quality
Water Quality Section – Planning Branch
1617 Mail Service Center
Raleigh, NC 27699-1617
(919) 733-5083

This page intentionally left blank.

TMDL Summary Sheet

1. 303(d) List Information

State: North Carolina
Counties: Rowan, Forsyth
Basin: Yadkin- Pee Dee River Basin
Hydrologic Unit Code (HUC): 03040101170 (Salem Creek)
03040103010 (Grants Creek)

Waterbody Name	Description	Assessment Unit (AU):	Class	Subbasin	Impairment	Miles
Salem Creek (Middle Fork Muddy Creek)	From Winston-Salem Water Supply Dam (Salem Lake) to Muddy Creek	12-94-12-(4)	C	03-07-04	Fecal Coliform	12.0
Grants Creek	From SR 1910 to Yadkin River	12-110b	C	03-07-04	Turbidity	**1.2** **

** The impairment length of Grants Creek is incorrectly listed on the 303(d) list as 1.2 miles. **The actual impairment length is 4.2 miles**. This will be corrected in the next version of the 303(d) list.

Constituents of Concern: Fecal Coliform Bacteria (Salem Creek) and Turbidity (Grants Creek)

Reason for Listing: Standard Violations

Applicable Water Quality Standards: For Class C waters:

- Turbidity: not to exceed 50 NTU
- 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.

2. TMDL Development

Development Tools: Load duration curves based on cumulative frequency distribution of flow conditions in the watershed. Allowable loads are average loads over the recurrence interval between the 95th and 10th percent flow record (excludes extreme drought (>95th percentile) and floods (<10th percentile). Percent reductions 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.

3. TMDL Allocation Summary

Pollutants/Watershed	Existing Exceeding Load	WLA	LA	MOS	TMDL	Percent Reduction[1]
I. TSS (tons/day)						
Grants Creek	8.03	0.683	4.17	0.68	5.54	31.0%
II. Fecal Coliform (colony forming units (cfu)/day)						
Salem Creek	5.74E12	7.49E11	7.37E10	9.14E10	9.14E11	84.1%

1. Percent reduction represents overall TMDL reduction - calculated as:
(Existing Load – TMDL)/Existing Load

Notes:

1. LA = TMDL – WLA – MOS.
2. TMDL represents the average allowable load between the 95th and 10th percent recurrence interval.
3. Explicit (10%) and implicit Margins of Safety are considered.
4. Turbidity is not a concentration and, as a measure, cannot be directly converted into loadings required for the TMDL. Total suspended solids (TSS) was therefore selected as the surrogate measure for turbidity and used to develop the TMDL target and limits (USEPA 1999).
5. Overall reduction is based on the instantaneous standard of 400 cfu/100ml and is assumed to be more stringent than the geometric mean standard.

4. Contributing Municipalities TMDL Allocation Summary

Watershed	Municipalities
Salem Creek	Winston-Salem
	Kernersville
	Walkertown
Grants Creek	Salisbury
	China Grove
	Landis

5. Contributing NPDES Facilities TMDL Allocation Summary

Watershed	**Permit Number**	**Owner**	**Facility Name**
Salem Creek	NC0037834	City of Winston Salem	Archie Elledge WWTP
Grants Creek	NC0034703	Rowan-Salisbury Schools	Knollwood Elementary School
	NC0037184	Lakeside Investment Properties	Oak Haven Mobile Home Park
	NC0042439	Westside Swim & Racquet Club	Westside Swim & Racquet Club

6. Public Notice Information

Summary:	A draft of the TMDL was publicly noticed through various means. The TMDL was public noticed in the relevant counties through two local newspapers (Salisbury Post on May 3, 2006 and Winston-Salem Journal on May 4, 2006, Appendix D). The TMDL was also public noticed on May 1, 2006 through the North Carolina Water Resources Research Institute email list-serve (Appendix D). Finally, the TMDL was available on DWQ's website http://h2o.enr.state.nc.us/tmdl/ during the comment period. The public comment period lasted until June 2, 2006. Two written comments were received, both from NC Department of Transportation. DWQ's responses to those comments are provided in Appendix E of the TMDL report.

Did notification contain specific mention of TMDL Proposal?	Yes
Were comments received from the public?	Yes
Was a responsiveness summary prepared?	Yes, see Appendix E of the TMDL report

7. **Public Notice Date:** May 1, 2006

8. **Submittal Date:** July 21, 2006

9. **Establishment Date:** September 25, 2006

10. **EPA Lead on TMDL (EPA or Blank):**

11. **DOT a Significant Contribution (Yes or Blank):**
    a. DOT a Significant Contribution in Grants Creek (Yes or Blank):
    b. DOT a Significant Contribution in Salem Creek (Yes or Blank):
12. **Endangered Species (Yes or Blank):**
    a. Endangered Species in Grants Creek (Yes or Blank):
    b. Endangered Species in Salem Creek (Yes or Blank):
13. **TMDL Considers Point Source, Nonpoint Source, or Both:** Both

Table of Contents

1.0 Introduction

1.1 TMDL Definition

This report presents the development of Total Maximum Daily Loads (TMDLs) for two waterbodies in North Carolina: Salem Creek and Grants Creek. Both waterbodies are located in the Yadkin-Pee Dee River Basin (Figure 1.1). As identified by the North Carolina Division of Water Quality (DWQ), the impaired segments of the two waterbodies are described in Table 1.1.

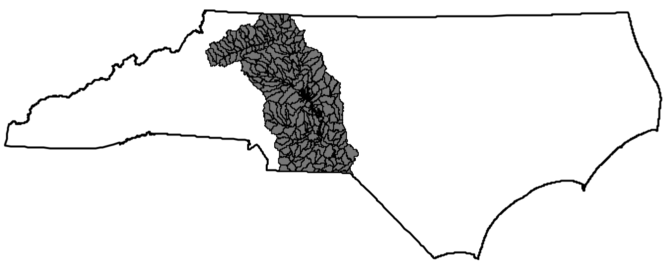

Figure 1.1. Location of Yadkin River Basin within North Carolina.

Table 1.1. Description of Impaired Segments for Grants Creek and Salem Creek.

Waterbody Name	Description	Assessment Unit (AU):	Class	Subbasin	Impairment	Miles
Salem Creek (Middle Fork Muddy Creek)	From Winston-Salem Water Supply Dam (Salem Lake) to Muddy Creek	12-94-12-(4)	C[1]	03-07-04	Fecal Coliform	12.0
Grants Creek	From SR 1910 to Yadkin River	12-110b	C	03-07-04	Turbidity	4.2[2]

[1] Class C waters are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture and other uses suitable for class C. There are no restrictions on watershed development or types of discharges.

[2] The impairment length of Grants Creek is incorrectly listed in the 303(d) list as 1.2 miles. The actual impairment length is 4.2 miles.

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 Category 5 of 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, 2000a) and the Federal Advisory Committee (FACA) (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. North Carolina indicates known pollutants on the 303(d) list.

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

Assimilative Capacity. Estimation or 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 existing and future point sources. Similarly, the load allocation portion of the TMDL accounts for the loads associated with existing and future nonpoint sources, storm water, 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).

Section 303(d) of the CWA and the Water Quality Planning and Management regulation (USEPA, 2000a) requires EPA to review all TMDLs for approval. Once EPA approves a TMDL, the water body may be moved to Category 4a of the 303(d) list. Water bodies remain on Category 4a of the list until compliance with water quality standards is achieved. Where conditions are not appropriate for the development of a TMDL, management strategies may be implemented in an effort to restore water quality.

1.3 Water Quality Target: North Carolina Standards

1.3.1 Water Quality Standard for Turbidity

The North Carolina fresh water quality standard for Class WS-IV and C waters for turbidity (T15A: 02B.0211) states:

> *The turbidity in the receiving water shall not exceed 50 Nephelometric Turbidity Units (NTU) in streams not designated as trout waters and 10 NTU in stream, lakes or reservoirs designated as trout water; for lakes and reservoirs not designated as trout waters, the turbidity shall not exceed 25 NTU; if turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased. Compliance with this turbidity standard can be met when land management activities employ Best Management Practices (BMPs) recommended by the Designated Nonpoint Source Agency. BMPs must be in full compliance with all specifications governing the proper design, installation, operation and maintenance of such BMPs.*

1.3.2 Water Quality Standard for Fecal Coliform

The North Carolina fresh water quality standard for Class WS-IV and C waters for fecal Coliform (T15A: 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 will be used as the reference method.*

1.4 Watershed Description

Watershed areas were delineated either by solely using the USGS 14-digit hydrologic units, or by a combination of the hydrologic units and the automatic delineation tools provided in version 3.0 of the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system.

Salem Creek is located in the Yadkin-Pee Dee River Basin. The Salem Creek watershed is located entirely within Forsyth County, and major parts of the watershed are located within the incorporated limits of the city of Winston-Salem, Figure 1.2. The watershed is located within hydrologic unit 03040101170060.

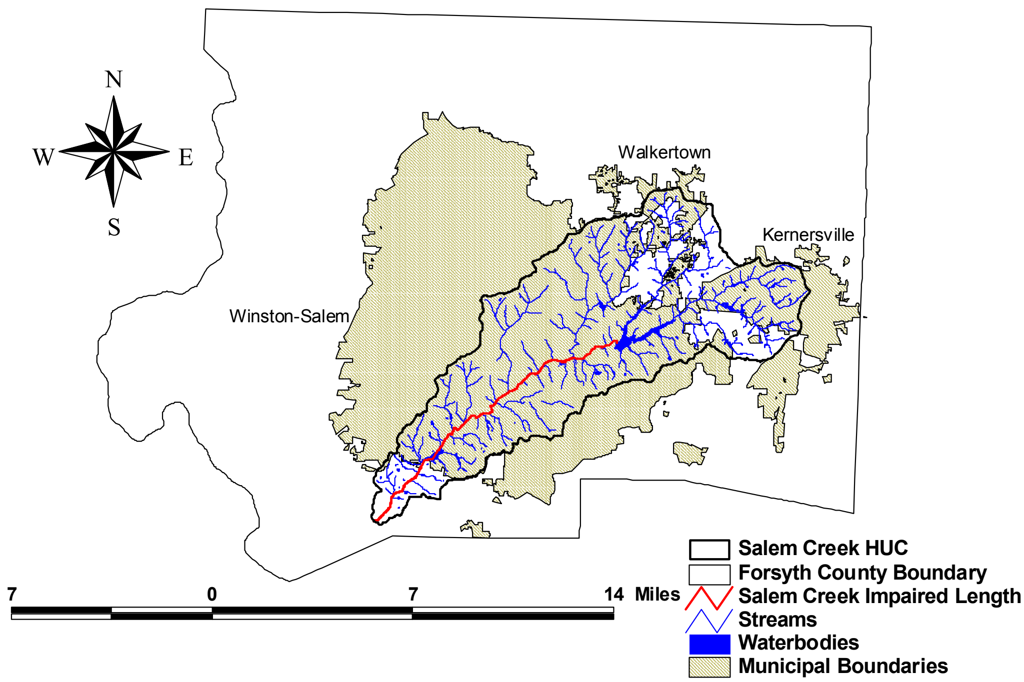

Figure 1.2. Salem Creek Watershed and Surrounding Area.

Grants Creek is located in the Yadkin-Pee Dee River Basin. The Grants Creek watershed is located entirely within Rowan County, and a part of the watershed is located within the incorporated limits of the city of Salisbury, Figure 1.3. The watershed is located within hydrologic unit 03040103010010.

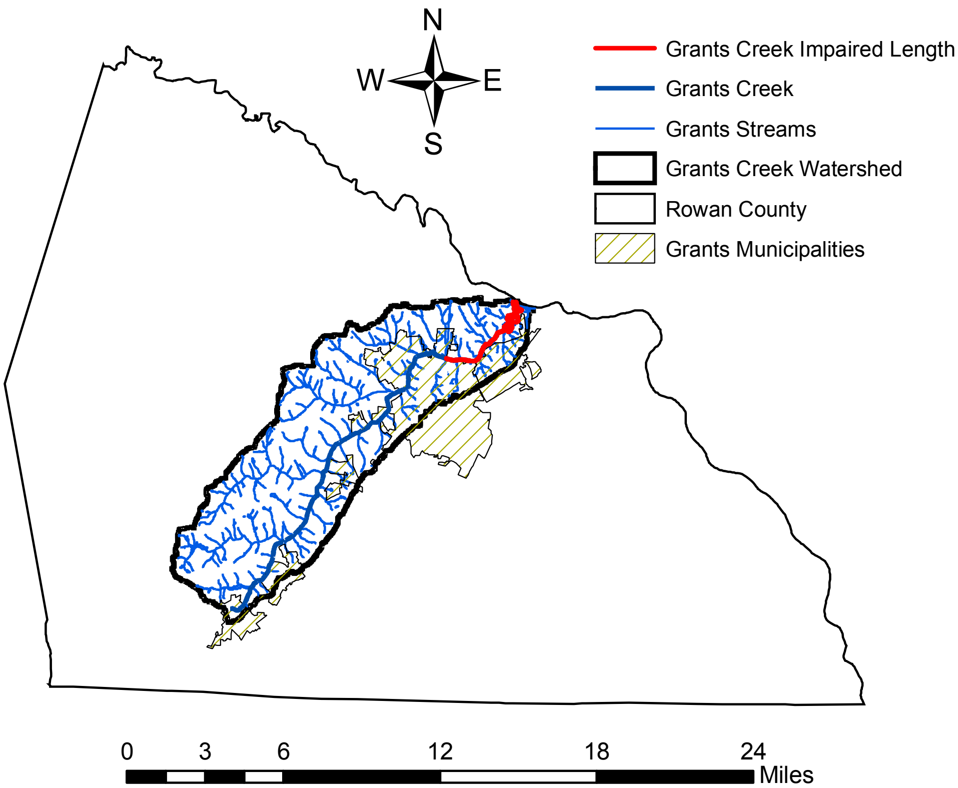

Figure 1.3. Grants Creek Watershed and Surrounding Area.

Population is measured in census blocks, which do not usually coincide with watershed boundaries. Therefore, population information is grouped by county, as seen in Table 1.2. The population totals in each county for 2000 and 2003 given, as well as percent change in these values. The percent change statistic gives an estimate on the rate of growth in each county.

Table 1.2. Population Information for Relevant Counties.

Population				
County	Population, Percent Change, 1990 to 2000	2000 Population	Population, percent change, April 1, 2000 to July 1, 2003	2003 Population
Rowan	17.8%	130,340	2.8%	133,931
Forsyth	15.1%	306,067	3.8%	317,810

http://quickfacts.census.gov/qfd/states/37/37025.html

Land Use/Land Cover

The land use/land cover characteristics of the two watersheds were determined using the 1996 land cover data developed from the 1993-1994 LANDSAT satellite imagery. The North Carolina Center for Geographic Information and Analysis (CGIA), in cooperation with the North Carolina Department of Transportation (NCDOT) and the Environmental Protection Agency

Region IV Wetland Division, contracted Earth Satellite Corporation of Rockville, Maryland to generate comprehensive land cover data for the entire state of North Carolina. The land use and land cover (LULC) data used contains more detailed information than is presented in this report. The original LULC data was grouped into five distinct groups: Forrest/Wetland, Cultivated Crop, Urban, Water, and Pasture/Herbaceous. This categorization is modeled after the North Carolina Basin Plans. Table 1.3 shows the area in acres for each of these categories in each watershed.

Table 1.3. Land Use Acreages and their Percent Compositions in the Two Watersheds.

	Grants Creek		Salem Creek	
Land Use	Area (acres)	Area (%)	Area (acres)	Area (%)
Forrest/Wetland	23,378	54	21,166	47
Cultivated Crop	2,688	6	58	0
Urban	2,298	5	11,352	25
Water	251	1	527	1
Pasture/Herbaceous	14,454	34	11,791	26
Total	43,069	100	44,894	100

Land use and land cover information is also provided graphically in the following figures. Salem Creek land use land cover information can be found in Figure 1.4. Grants Creek land use land cover information can be found in Figure 1.5.

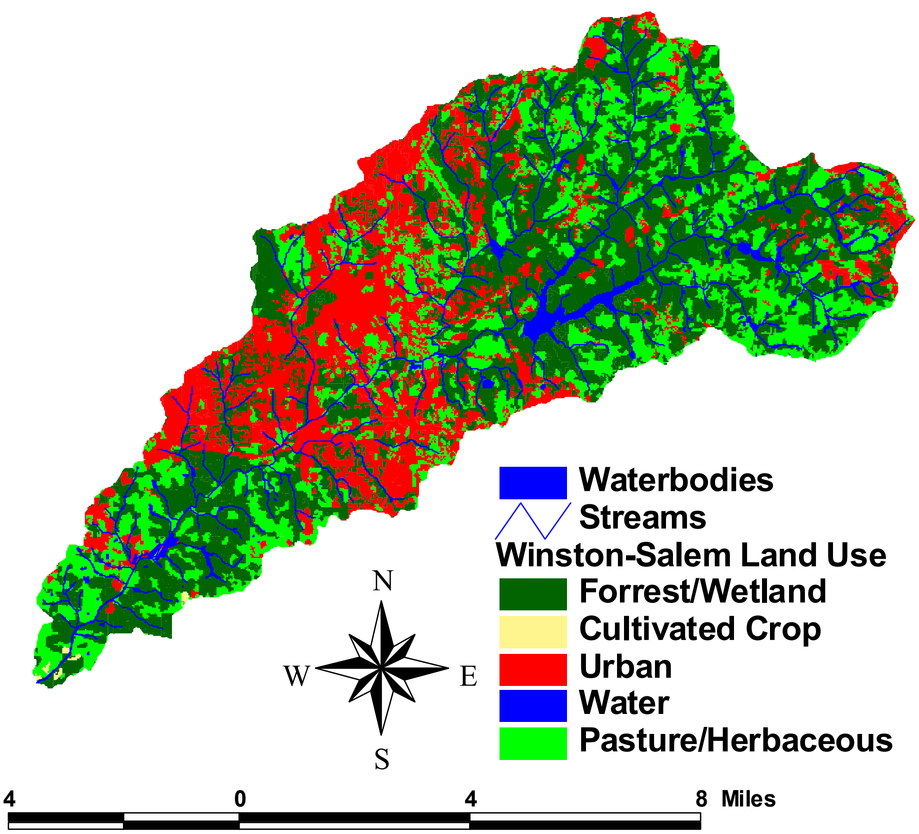

Figure 1.4. Land Use and Land Cover distribution in the Salem Creek Watershed.

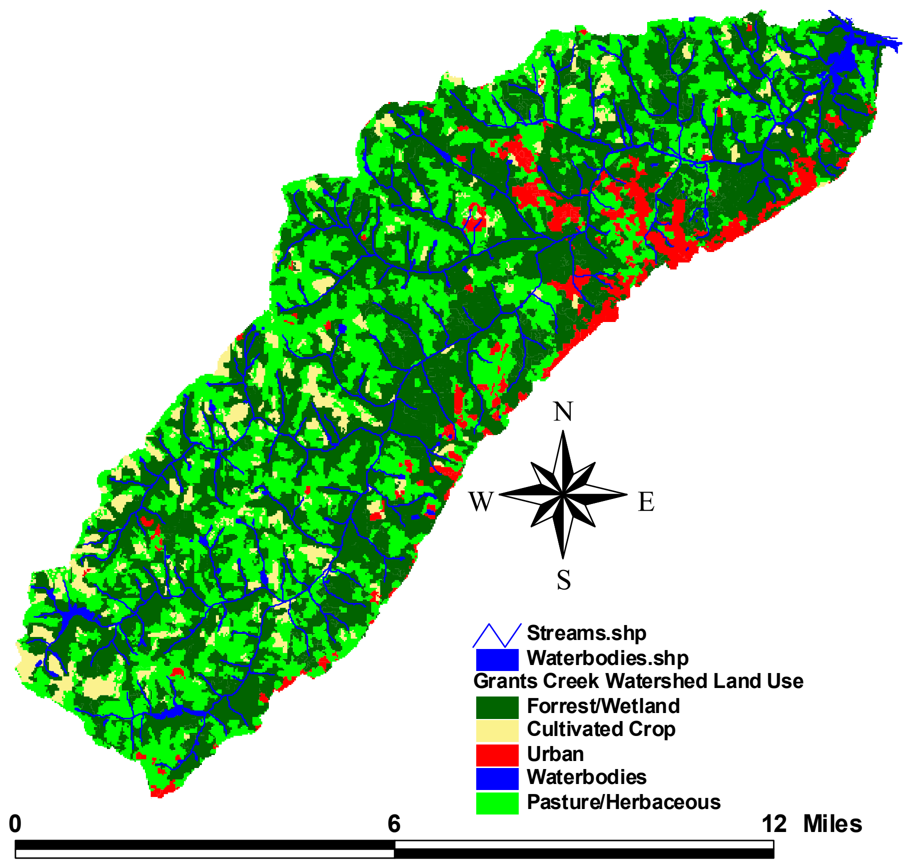

Figure 1.5. Land Use and Land Cover distribution in the Grants Creek Watershed.

1.5 Water Quality Monitoring

1.5.1 Fecal Coliform Monitoring in Salem Creek

The DWQ has one monitoring station on Salem Creek: Q2510000 at the Elledge water treatment plant. The Yadkin Pee-Dee River Basin Association (YPDRBA) maintains three sampling stations in Salem Creek: Q2540000 at West Clemmonsville Road, Q2570000 at Fraternity Church Road, and Q2479455 at SR 2740 Reynolds Park Road. The locations of these stations are shown in Figure 1.6. There are numerous qualifiers on the sampling data, which can be found in Appendix Table A.1. In addition to the normal monthly samples, nine additional samples were taken at two of the sites in the latter half of 2002 as a part of a special study. A more detailed accounting of sampling can be found in Table 1.4. The samples that were collected as part of the special study were further analyzed using Antibiotic Resistance Analysis (ARA). Further details of this analysis can be found in Maptech-HDR (2005).

Table 1.4. Salem Creek Sampling

Station	Sampling Period	Number of Samples Collected	Approximate Sampling Frequency	Number of Samples Exceeding Standard (400 colony forming units (cfu)/100 ml)
Q2479455	8/98-2/04	81	Monthly	22
Q2540000	8/98-2/04	67	Monthly	21
Q2570000	8/98-2/04	81	Monthly	29
Q2510000	8/98-3/04	61	Monthly	31

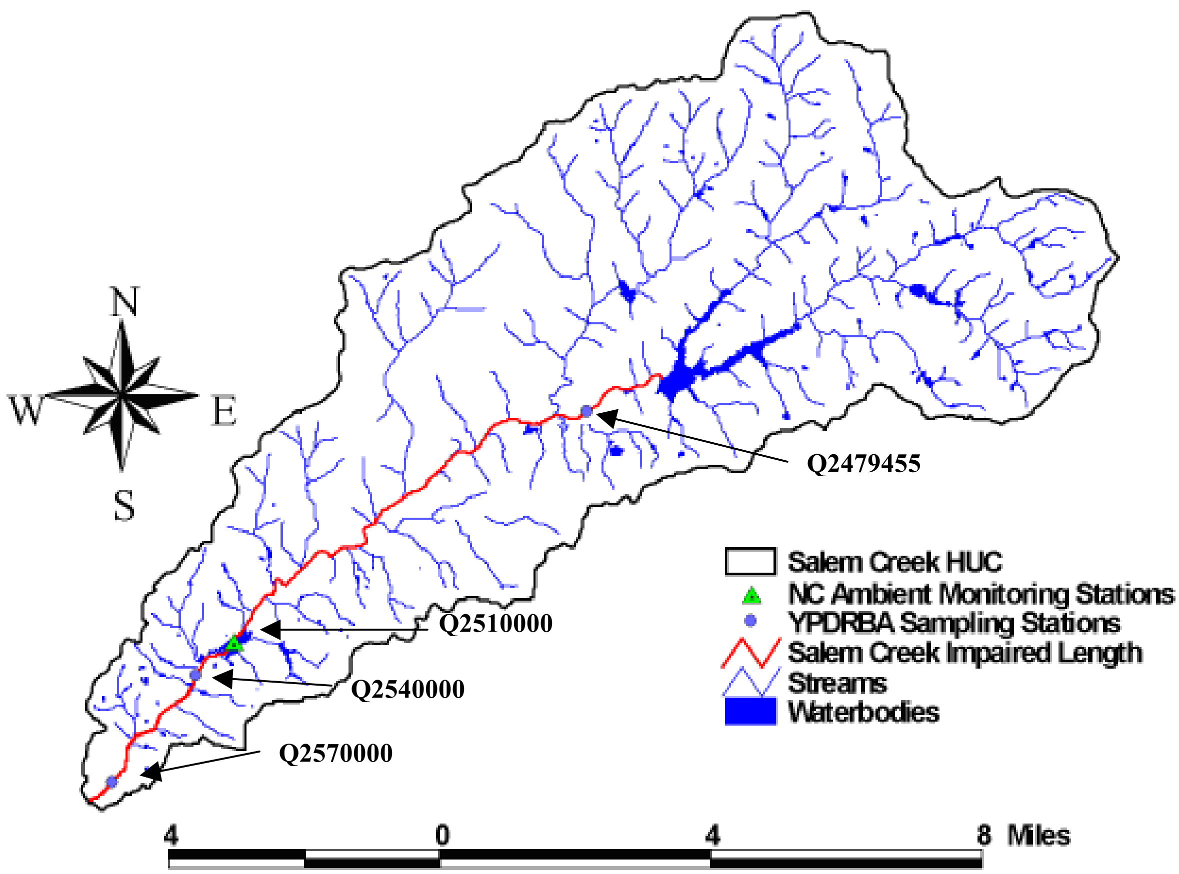

Figure 1.6. Water Quality Monitoring Stations in the Salem Creek Watershed.

1.5.2 Turbidity and TSS Monitoring in Grants Creek

There are two monitoring stations on Grants Creek: Q4540000 (maintained by YPDRBA at SR 1915 near Salisbury) and Q4600000 (maintained by the DWQ below Salisbury and Spencer wastewater treatment plant). Locations of the stations are shown in Figure 1.7. A more detailed accounting of sampling can be found in Table 1.5.

Table 1.5. Grants Creek Sampling.

Station	Turbidity Sampling Period	Turbidity Number of Samples Collected	TSS Sampling Period	TSS Number of Samples Collected	Approximate Sampling Frequency	Number of Samples Exceeding Standard (50 NTU)
Q4600000	1/97-12/04	91	1/97-7/04	57	Monthly/Every Two Months	10
Q4540000	6/98-2/04	69	No Samples	0	Monthly	6

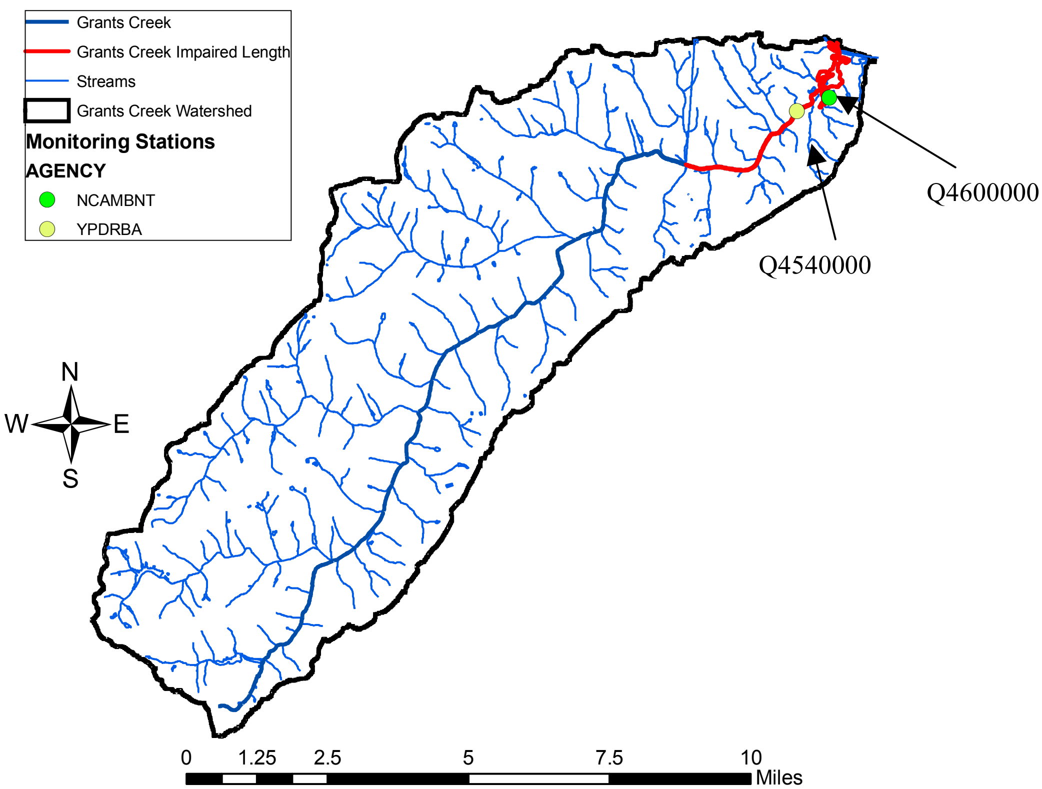

Figure 1.7. Water Quality Monitoring Stations in the Grants Creek Watershed.

2.0 Source Assessment

A source assessment is used to identify and characterize the known and suspected sources of turbidity and fecal coliforms in the two watersheds. This section outlines the assessment completed for the purpose of developing this TMDL. The NC Department of Environment and Natural Resources (DENR) Geographic Information System (GIS) was used extensively for these watershed characterizations.

2.1 General Sources of Turbidity

Turbidity is a measure of the cloudiness of water. In a water body, the cloudiness can be enhanced due to silt and clay from watershed and stream erosion, organic detritus from streams and wastewater, and phytoplankton growth. In this study, turbidity is measured in the Nephelometric Turbidity Unit (NTU) and is significantly correlated with total suspended solid (TSS).

2.1.1 Point Sources of Turbidity

Point sources are distinguished from nonpoint sources in that they discharge directly into streams at a discrete point. Point sources of turbidity consist primarily of large and small industries, wastewater-treatment plants, and Municipal Separate Storm Sewer System (MS4). As authorized by the Clean Water Act, the DWQ regulates the National Pollutant Discharge Elimination System (NPDES) permit program to control water pollution due to point sources. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

NPDES-Regulated Municipal and Industrial Wastewater Treatment Facilities Discharges from wastewater treatment facilities may contribute sediment to receiving waters as total suspended solids (TSS) and/or turbidity. Municipal treatment plants and industrial treatment plants are required to meet surface water quality criteria for turbidity in their effluent. When effluent turbidity concentrations exceed surface water quality criteria, and result in permit violations, action will be taken through the NPDES unit of North Carolina's Division of Water Quality.

NPDES general permitted facilities, while not subject to effluent TSS or turbidity limitations, are required to develop a storm water pollution prevention plan, and conduct qualitative and/or quantitative measurements at each storm water discharge outfall and vehicle maintenance area. Sampling methodology and constituents to be measured are characteristic of the volume and nature of the permitted discharge. For example, general permits for mining operations require the permittee to measure settleable solids, total suspended solids, turbidity, rainfall, event duration, and flow in storm water discharge areas. Measurements of pH, oil and grease, total suspended solids, rainfall, and flow are required in on-site vehicle maintenance areas. Similarly, monitoring is required in mine dewatering areas, wastewater associated with sand/gravel mining, and in overflow from other process recycle wastewater systems.

A recent EPA mandate (Wayland, 2002) requires NPDES permitted storm water to be placed in the waste load allocation (WLA), which was previously reserved for continuous point source waste loads. In 1990, EPA promulgated rules establishing Phase I of the NPDES storm water program. The Phase I program for Municipal Separate Storm Sewer System (MS4) requires operators of medium and large MS4s, which generally serve populations of 100,000 or greater, to implement a storm water management program as a means to control polluted discharges from these MS4s. The new Phase II program is applied to populations of between 10,000 and 100,000 people.

2.1.2 Nonpoint Sources of Turbidity

Nonpoint and stormwater sources include various erosional processes, including sheetwash, gully and rill erosion, wind, landslides, dry ravel, and human excavation that contribute sediment during storm or runoff events. Sediments are also often produced as a result of stream channel and bank erosion and channel disturbance (EPA, 1999). Nonpoint sources account for the vast majority of sediment loading to surface waters. A few of these sources include:

- Natural erosion occurring from the weathering of soils, rocks, and uncultivated land; geological abrasion; and other natural phenomena.
- Erosion from agricultural activities. This erosion can be due to the large land area involved and the land-disturbing effects of cultivation. Grazing livestock can leave areas of ground with little vegetative cover. Unconfined animals with direct access to streams can cause streambank damage and erosion.
- Erosion from unpaved roadways can be a significant source of sediment to rivers and streams. Exposed soils, high runoff velocities and volumes, and poor road compaction all increase the potential for erosion.
- Runoff from active or abandoned mines may be a significant source of solids loading. Mining activities typically involve removal of vegetation, displacement of soils, and other significant land disturbing activities.
- Soil erosion from forested land that occurs during timber harvesting and reforestation activities. Timber harvesting includes the layout of access roads, log decks, and skid trails; the construction and stabilization of these areas; and the cutting of trees. Established forest areas produce very little erosion.
- Streambank and streambed erosion processes often contribute a significant portion of the overall sediment budget. The consequence of increased streambank erosion is both water quality degradation as well as increased stream channel instability and accelerated sediment yields. Streambank erosion can be traced to two major factors: stream bank characteristics (erodibility potential) and hydraulic/gravitational forces (Rosgen, online). The predominant processes of stream bank erosion include: surface erosion, mass failure (planar and rotational), fluvial entrainment (particle detachment by flowing water, generally at the bank toe), freeze-thaw, dry ravel, ice scour, liquifaction/collapse, positive pore water pressure, both saturated and unsaturated failures, and soil piping.

2.2 General Sources of Fecal Coliform

Both point sources and nonpoint sources may contribute fecal coliform to the water bodies. Potential sources of fecal coliform loading are discussed below.

2.2.1 Point Sources of Fecal Coliform

Point sources of fecal coliform consist primarily of large and small industries, wastewater treatment plants, and MS4s. As authorized by the Clean Water Act, the DWQ regulates the NPDES permit program to control water pollution due to point sources. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

NPDES-Regulated Municipal and Industrial Wastewater Treatment Facilities Discharges from wastewater treatment facilities may contribute fecal coliform to receiving waters. Municipal treatment plants and industrial treatment plants are required to meet surface water quality criteria for fecal coliform in their effluent. When effluent coliform concentrations exceed surface water quality criteria, and result in permit violations, action will be taken through the NPDES unit of North Carolina's Division of Water Quality.

NPDES general permitted facilities are required to develop pollution prevention plans to discharge domestic wastewaters from single-family residences and other domestic discharges. The permitted flow of these facilities may not in any case exceed 1,000 gallons per day. The facilities are required to measure BOD_5, total suspended residue, fecal coliform, and total residual chlorine. The facilities must monitor the pollutants every year and document the following maintenance activities:

- Septic tanks shall be maintained at all times to prevent seepage of sewage to the ground.
- Septic tanks will be checked at least yearly to determine if solids must be removed or if other maintenance is necessary.
- Septic tanks shall be pumped out within three to five years of the issuance date on the Certificate of Coverage.
- Contents removed from septic tanks shall be disposed at a location and in a manner compliant with all local and state regulations.
- Surface sand filters, disinfection apparatus, and (if applicable) dechlorination apparatus shall be inspected weekly to confirm proper operation.

2.2.2 Nonpoint Sources of Fecal Coliform

Fecal coliform from nonpoint sources include those sources that cannot be identified as entering the water body at a specific location. Nonpoint source pollution can include both urban and agricultural sources and human and non-human sources (Table 2.1). The nonpoint sources of fecal coliform in the water bodies include wildlife, livestock (land application of agricultural manure and grazing), urban development (stormwater runoff, including sources from domestic animals), failing septic systems, and sewer line systems (illicit connections, leaky sewer lines and sewer system overflows).

Table 2.1. Potential Source of Fecal Coliform Bacteria in Urban and Rural Watersheds. (Source: Center for Watershed Protection, 1999)

Source Origin	Type	Source
Human Sources	Sewered watershed	Combined sewer overflows
		Sanitary sewer overflows
		Illegal sanitary connections to storm drains
		Illegal disposal to storm drains
	Non-sewered watershed	Failing septic systems
		Poorly operated package plant
		Landfills
		Marinas
Non-human Sources	Domestic animals and urban wildlife	Dogs, cats, rats, raccoons, pigeons, gulls, ducks, geese
	Livestock and rural wildlife	Cattle, horse, poultry, beaver, muskrats, deer, waterfowl
	Others	Hobby farms

Land use can contribute to fecal coliform runoff. Agricultural land alongside a stream would contribute fecal coliform from livestock and manure applications. In addition, when cattle have direct access to streams, feces may be deposited directly into a stream.

Runoff from urban surface is also a potentially significant source of fecal coliform loadings. Urban lands may contribute fecal coliform from pets such as dog and cats. In a study conducted by Hyer et al., 2001, the bacterial loads due to dog waste accounted for nearly 10 percent of the total bacterial load in three creeks of Virginia: Accotink Creek, Blacks Run, and Christians Creek. Furthermore, wildlife feces in runoff may be a frequent source of fecal coliform loading where forest dominates the streamside.

Fecal coliform can originate from various urban sources. These sources include pet waste, runoff through stormwater, sewers, illicit discharges/connections of sanitary waste, leaky sewer systems, and sewer system overflows.

Fecal coliform contamination can be profound when sewer pipes are clogged or flooded by stormwater. Infiltration of rainfall can enter the sewer system through cracks and leaks in pipes. This additional flow volume, in combination with the existing sewer flow, can exceed the capacity of the system resulting in a sanitary-sewer-overflow (SSO).

3.0 Salem Creek Impairment

3.1 Source Assessment

3.1.1 NPDES Wastewater Permits

There are four facilities that discharge wastewater to the polluted portion of Salem Creek and tributaries and are permitted individually under the NPDES program (Table 3.1). One of the four permitted facilities has a limit for fecal coliform discharge, as can be found in the BasinWide Information Management System (BIMS) database. Locations of the NPDES facilities are shown in Figure 3.1.

Table 3.1. Individual NPDES Permittees in the Salem Creek Watershed.

Permit	Owner	Facility	Permitted Flow (MGD)	Fecal Coliform (cfu/100ml)
NC0080853	Lucent Technologies, Inc.	Salem Business Park Remediation site	0.302	No Limit
NC0079821	City of Winston-Salem	R.A. Thomas WTP	No Limit	No Limit
NC0085871	Flakt Products Inc	Flakt Products Incorporated	No Limit	No Limit
NC0037834	City of Winston-Salem	Archie Elledge WWTP	30	Weekly average 400; monthly average 200

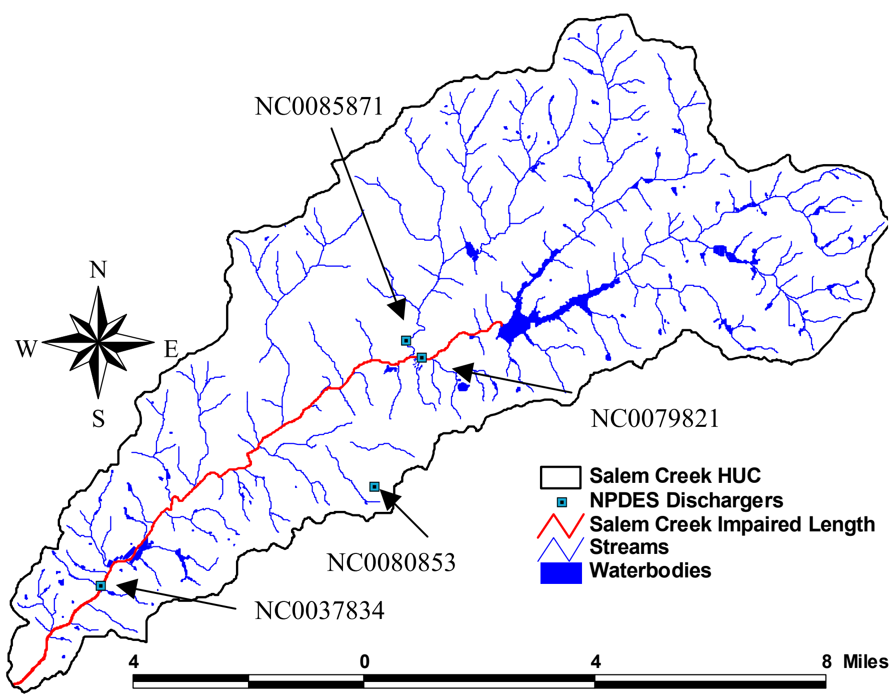

Figure 3.1. NPDES Facility Locations in the Salem Creek Watershed.

3.1.2 NPDES General Permits

All single family residences or domestic treatment facilities that discharge wastewaters not exceeding 1,000 gallons per day in the Salem Creek watershed are subject to NC general permit NCG550000 and as such are required to not cause or contribute to violations of water quality standards. Monitoring requirements for these facilities are outlined in Part I (page 2) of NCG550000 (http://h2o.enr.state.nc.us/NPDES/documents/NCG55_Permit_2002.pdf). A brief statement of maintenance activities is presented in Section 2.2.2.

3.1.3 NPDES Stormwater MS4s

Winston-Salem is under the Phase I MS4 stormwater permit. Walkertown and Kernersville are both identified under the second phase of the federal stormwater regulations. Therefore, all the nonpoint source loading from the watershed area that is inside the incorporated boundaries of the cities of Winston-Salem, Walkertown, and Kernersville, as well as all urban areas inside the zone of influence, are included in the WLA section of the TMDL.

3.1.4 Livestock Populations

The North Carolina Department of Agriculture (NCDA) regularly performs an agricultural census for each county of the state. This census includes estimated livestock populations in each county, as shown in Table 3.2 for the Salem Creek watershed.

Table 3.2. Estimated Livestock population in the Salem Creek watershed.

Livestock	Date data is valid from	Number
Hogs and Pigs	Dec. 1, 2003	No Data
Cattle	Jan 1, 2004	5,100
Beef Cows	Jan 1, 2004	2,800
Milk Cows	Jan 1, 2004	No Data
Broilers Produced	2003	No Data
Turkeys Raised	2003	No Data
All Chickens	Dec. 1, 2003	No Data
Source: http://www.ncagr.com/stats/cntysumm/forsyth.htm		

3.1.5 Septic Tanks

Septic tanks and cesspools can contribute to the nonpoint sources of fecal coliform found in Salem Creek. More information is provided in Table 3.3.

Table 3.3. Estimated Housing Units Using Septic Systems in the Salem Creek Watershed.

County	Number of Housing Units	Number of Septic Tank or Cesspool Systems	Percentage of Housing Units with Septic Tank or Cesspool Systems
Forsyth	138,573; 2002	37,913	27%

Source for Septic Tank and Cesspool System data:
http://factfinder.census.gov/servlet/QTTable?_bm=n&_lang=en&qr_name=DEC_1990_STF3_DP5&ds_name=DEC_1990_STF3_&geo_id=05000US37067
Source for Housing Unit data:
http://quickfacts.census.gov/qfd/states/37/37067.html

3.2 Technical Approach

Based on the above information, both point and nonpoint sources contribute fecal coliform to Salem Creek. Because of the size of Salem Creek, the amount of fecal coliform data, and the type of flow data available, a load duration approach has been adopted for this study. This approach determines impaired loads under different flow conditions – high flow, transition flow, typical flow, and low flow – to identify source types, specify assimilative capacity of a stream, and to estimate magnitude of load reduction required to meet the water quality standard. The methodology used to develop a load duration curve was based on Cleland (2002).

3.2.1 Endpoint for Fecal Coliform

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. Data is not collected in Salem Creek often enough for the geometric mean standard to apply, therefore only the instantaneous standard is used as the endpoint for the fecal coliform TMDL in the creek. It is assumed that if the instantaneous standard is met, it will follow that the geometric mean standard will also be met.

3.2.2 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 to the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which exceed nearly 100 percent of the time, to highest, which exceed less than 1 percent of the time.

Reliability of the flow duration curve depends on the period of record available at monitoring stations. Predictability of the curve increases when longer periods of record are used. Unfortunately, there is no currently operating flow gage in Salem Creek. Thus, daily flow data from USGS Gaging Station #02095000, on South Buffalo Creek near Greensboro, North Carolina, was used to establish the historic flow regimes and define ranges for the high, typical, and low flow conditions, from measured flow data from August 1998 to September 2004.

Flows at the downstream Salem Creek ambient station were estimated based on the drainage area ratio (2.085) between USGS station #02095000 and the watershed area upstream of the Salem Creek ambient station (i.e. Salem Creek drainage area is 2.085 times larger than South Buffalo Creek drainage area). Flows were also adjusted to account for point sources in each watershed by subtracting all reported NPDES point source flows discharging in the South Buffalo Creek watershed before calculating the estimated flow in Salem Creek. After the drainage area ratio for the flows was calculated, the NPDES point source flows in Salem Creek were added on.

The following method was used to estimate NPDES point source flows in Salem Creek. Because TMDL allocations are based on permitted flows, the permitted flow for Archie Elledge WWTP (30 million gallons per day (MGD)) was used as a constant flow for this facility. This is the only facility with a permitted flow limit in this watershed. The reported monthly average flows for the other three NPDES facilities were used to complete the total NPDES flow addition for Salem Creek.

Flow statistics as generated by the curves from the estimated flow data are presented in Table 3.4.

Table 3.4. Flow Statistics for estimated Salem Creek at ambient station Q2570000

High Flow (<10th Percentile)	Transitional Flow (Between 10th and 30th Percentile)	Typical Flow (Between 30th and 90th Percentile)	Low Flow (>90th Percentile)
278 – 4786 cfs	99 – 278 cfs	54 – 99 cfs	48 – 54 cfs

The flow duration curve, shown in Figure 3.2, was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occurred. It was also used to determine maximum daily pollutant load based on the flow duration and applicable standard. The applications of the flow duration curve for Salem Creek are discussed in the following paragraphs.

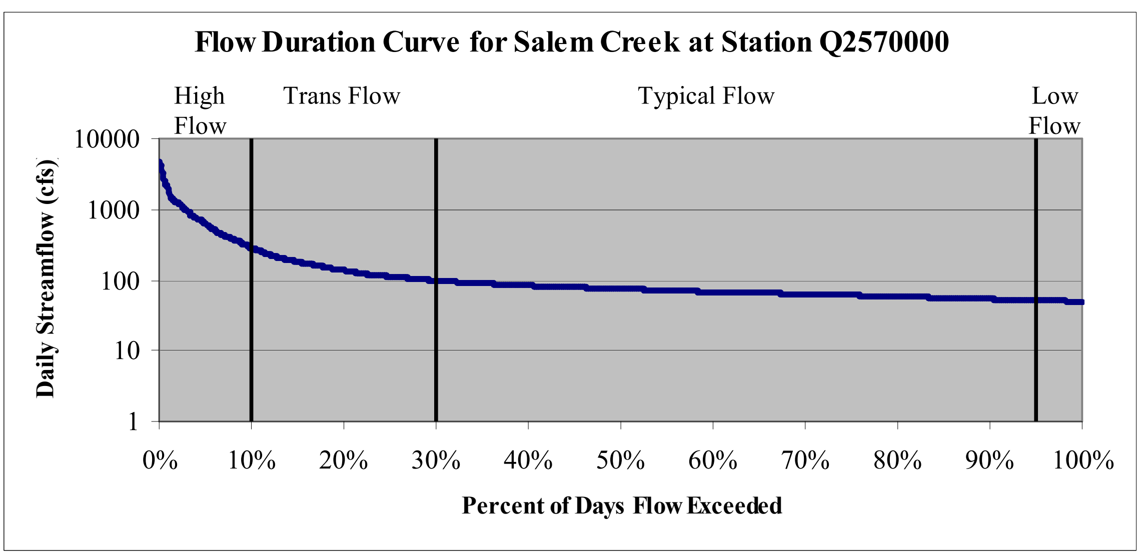

Figure 3.2. Flow Duration Curve for Salem Creek at Station Q2570000.

3.2.3 Load Duration Curve

A load duration curve is developed by multiplying the flow values along the flow duration curve by the pollutant concentrations and the appropriate conversion factors. As seen in Figure 3.3, allowable and existing loads are plotted against the flow recurrence interval. The allowable load is based on the water quality numerical criteria, margin of safety, and flow duration curve. The target line is represented by the line drawn through the allowable load data points and hence, it determines the assimilative capacity of a stream or river under different flow conditions. Any values above the line are exceeded loads and the values below the line are acceptable loads. Therefore, a load duration curve can help define the flow regime during which exceedances occur. Exceedances that occur during low-flow events are likely caused by continuous or point source discharges, which are generally diluted during storm events. Exceedances that occur during high-flow events are generally driven by storm-event runoff. A combination of point and nonpoint sources may cause exceedances during normal flows.

The following paragraphs discuss procedures to estimate endpoints for fecal coliform in Salem Creek in order to identify assimilative capacity of the river in each flow condition and to identify the flow regime during which exceedances occur.

The fecal coliform assessment also used the load duration curve approach to determine existing load and assimilative capacity. As stated in Section 3.2.1, analysis was performed for the instantaneous standard of 400 counts / 100ml to determine the most conservative measure of impairment. Figure 3.3 presents the calculated loads and the TMDL target loadings for fecal coliform.

In Salem Creek, the criteria violations seem to have occurred at all ranges of flows, suggesting that contamination due to fecal coliform occurred during both wet and dry weather conditions. The combined wet and dry contamination suggests sources from both point and nonpoint, as in sewer pipe leakage, failing septic systems, direct pipelines, and sanitary sewer overflows, for example. In the report, (Maptech-HDR 2005) analysis indicates that humans, pets, livestock, and wildlife all contribute fecal coliform to Salem Creek.

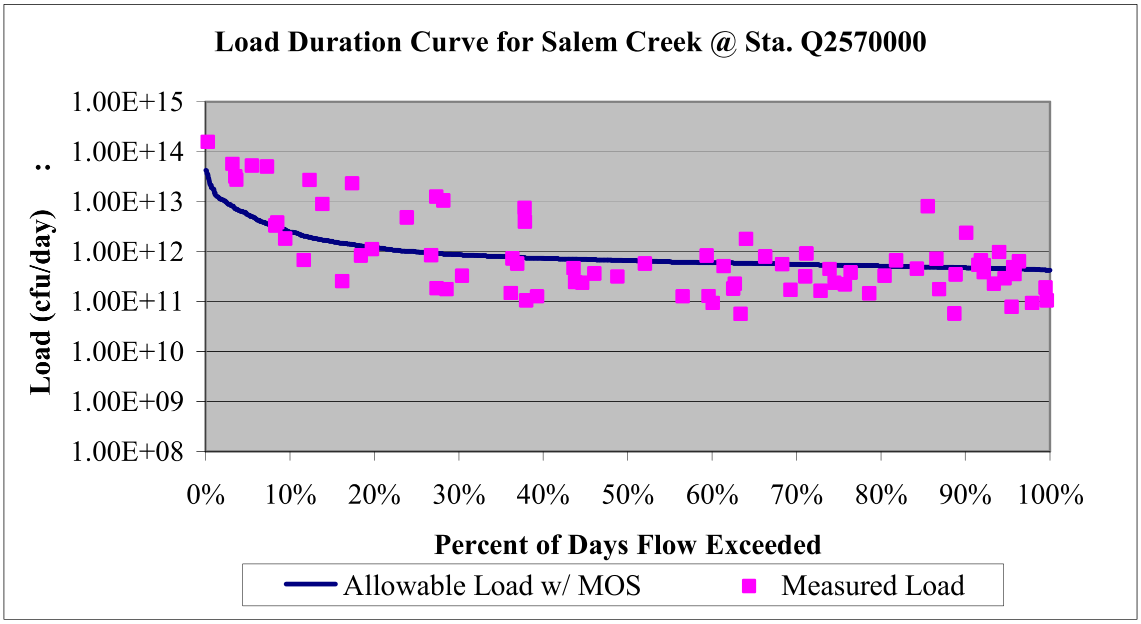

Figure 3.3. Fecal coliform load duration curve for Salem Creek at station Q2570000, from August 1998 through September 2004.

3.3 Total Maximum Daily Load (TMDL)

Section 3.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for each pollutant in the Salem Creek watershed. These efforts formed the basis for the TMDL process. The following sections describe the key components required by the TMDL guidelines to set the final TMDL allocation for the watershed.

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 loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS), which takes into account any uncertainty concerning the relationship between effluence limitations and water quality. This definition can be expressed by equation 3.1:

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

The objective of the TMDL is to estimate allowable pollutant loads and to allocate the known pollutant source in the watershed 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 stream can assimilate and maintain the water quality criterion. A load duration curve approach was utilized to estimate the TMDL for fecal coliform. The systematic procedures adopted to estimate TMDLs are described below.

3.3.1 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 explicit margin of safety can be seen in Table 3.5.

Table 3.5. Water Quality Standard and Explicit Margin of Safety.

Standard for Fecal Coliform	400 cfu/100 ml
Standard for Fecal Coliform with 10% MOS	360 cfu/100 ml

3.3.2 Target Reduction

The reduction for the instantaneous fecal coliform standard was estimated with the observed data that exceeded the applicable water quality standard (400 cfu/100 ml) within the 10^{th} to 95^{th} percentile flow recurrence range. The reduction for the geometric mean was not estimated, because fecal coliform violation at the water quality standard, 200 cfu/100 ml, was not observed (see §3.2.1).

A power curve equation for the data points violating the water quality criterion was estimated. The equation is presented in Equation 3.2. The coefficient of determination, R^2, for the equation is 0.72; thus suggesting a reasonable fit of the equation.

$$Y = 7.69E11 * X^{-1.66} \quad R^2 = 0.72 \qquad (3.2)$$

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 power curve equation as the average of the load violations occurring when the flow (or load) 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 power curve based on the exceedances are shown in Figure 3.4.

The necessary percent reduction was calculated by taking the difference between the average of the power 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 power 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.

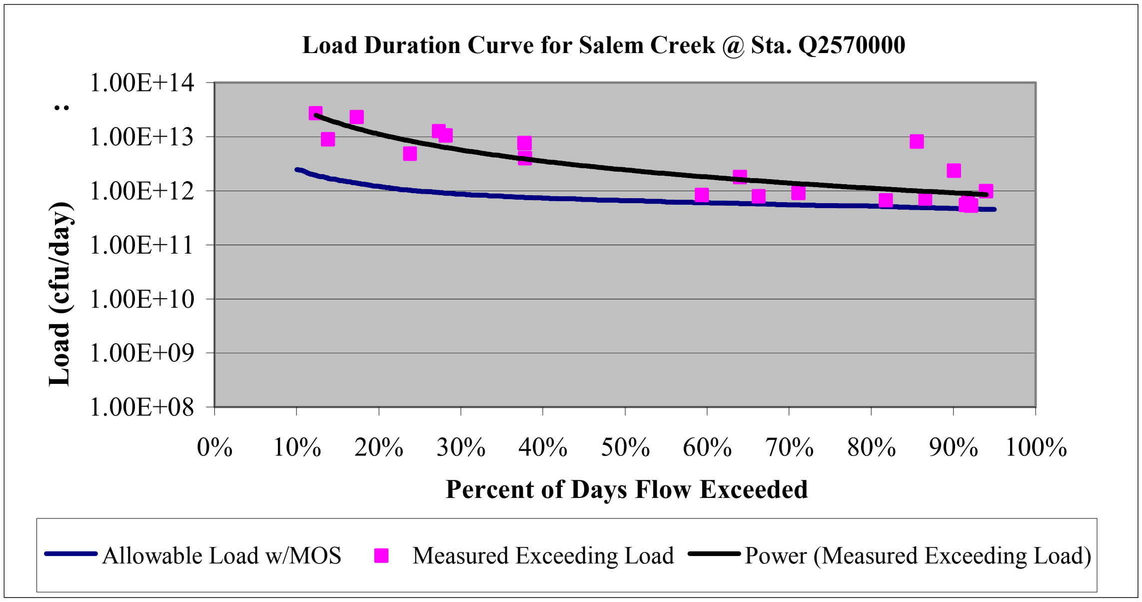

Figure 3.4. Load Duration Curve with Allowable and Estimated Exceeding Loads of Fecal Coliform in Salem Creek at station Q2570000.

3.3.3 TMDL Allocation

As identified by the above load duration curve method, a significant reduction of fecal coliform is required in Salem Creek. A summary of reductions required is provided in Table 3.6 (also, see Appendix Table A.2), where the # symbol represents colony forming units (cfu) or counts.

Table 3.6. Reduction required for Fecal Coliform.

Pollutant	Target with MOS	Estimated Exceeding Load	TMDL (Allowable Load + MOS)	Reduction Required
Fecal Coliform[1]	<360 cfu/100ml	5.74E12 #/day	9.14E11 #/day	84.1%

[1]Instantaneous measurement of fecal coliform is used.

In order to meet the TMDL objectives, the reduction should be distributed over both MS4 and nonpoint sources. Bacteria Source Tracking (BST) indicates a variety of sources are contributing fecal coliform to Salem Creek, including humans, pets, wildlife, and livestock (MapTech-HDR. 2005). However, BST provides information regarding sources and not the mode of delivery (i.e. point or nonpoint). A further analysis is therefore required to determine the breakdown between point and nonpoint source loadings. To accomplish this, data from the MapTech-HDR study was plotted with a load duration curve for station Q2510000, as shown in Figure 3.5. It is important to note that the TMDL is not established at this station, as this is not the most downstream station. Rather, this analysis is used for informational purposes only. The MapTech-HDR study did not sample at station Q2570000.

The MapTech-HDR study took place at DWQ station Q2510000 on Salem Creek (see Figure 1.6). Station Q2510000 is upstream of station Q2570000; therefore a new load duration curve was established for station Q2510000 using the same method described in Section 3.2.2. For this study, fecal coliform was analyzed to determine the relative contribution from four sources: livestock, wildlife, human, or pets. In Figure 3.5, each data point was then assigned to one of the four sources based on the source with the highest percentage contribution. So, those points shown as livestock in Figure 3.5 indicate that livestock was the primary contributor, not the sole contributor.

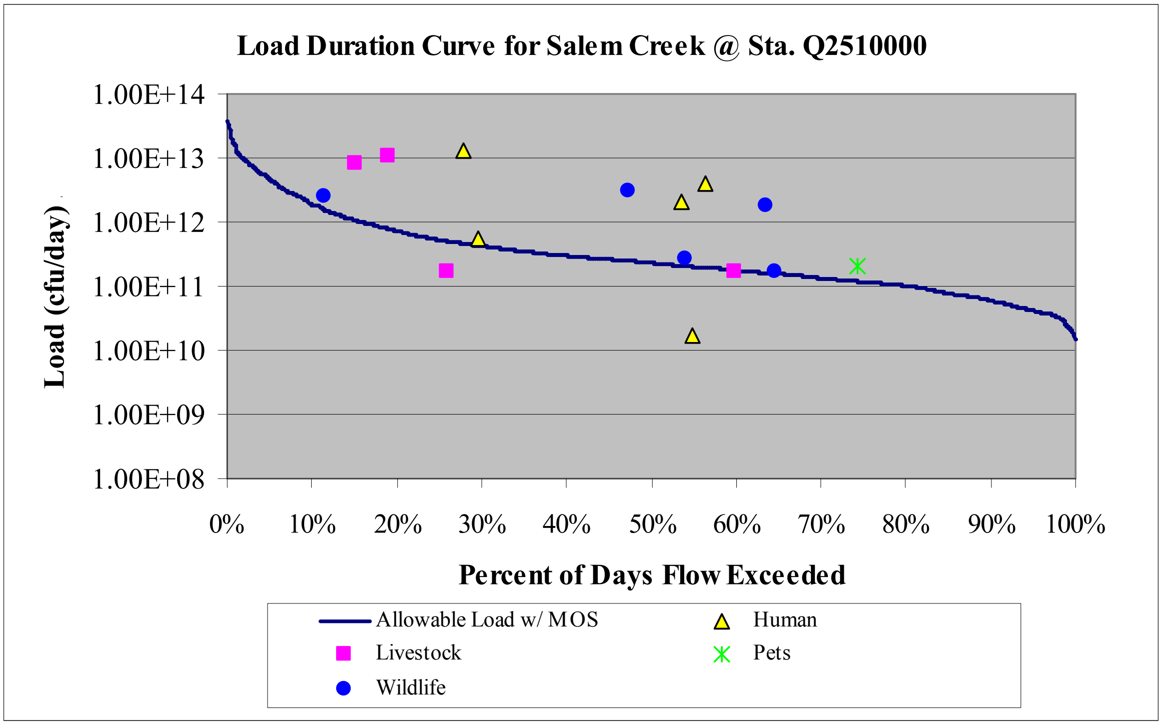

Figure 3.5. Load Duration Curve for data collected during MapTech-HDR study at station Q2510000.

The results of this analysis, as shown in Figure 3.5, indicate that pets are the least common source of fecal coliform in Salem Creek. Livestock tends to be the higher contributor during high flow events, while wildlife and humans are the dominant source during the typical flow period.

3.3.3.1. Waste Load Allocation (WLA)

All fecal coliform transported from the wastewater facilities and the MS4 areas were assigned to the WLA components. The relative loading rates from the facilities are listed in Table 3.1. The relative loading rates from the MS4 areas were determined based on the report by USGS, 1999. The report describes fecal coliform transports under different land use conditions in the City of Charlotte and Mecklenburg County, North Carolina. A summary of the report and a description of the method that was used to estimate relative percent contribution of fecal coliform from the urban and rural sources for this study are presented in Appendix C.1. The estimated relative percent contribution from the MS4 and other areas (nonpoint sources including non-MS4 area) are presented in Table 3.7.

Table 3.7. Relative Fecal Coliform Contribution Rates for Salem Creek Watershed.

Pollutant	Load from MS4 areas (%)	Load from other areas (%)
Fecal Coliform	80	20

The assimilative capacity determined in Section 3.3.2 was split based on the relative contributions presented in Table 3.7 to determine the allocation for the MS4 areas. The results of these calculations are summarized in Table 3.8. The resulting percent reduction in fecal coliform loading from MS4 areas is 93%, as shown in Table 3.9.

3.3.3.2. Load Allocation (LA)

All fecal coliform loadings from nonpoint sources such as non-MS4 urban land, agriculture land, and forestlands are reported as LAs. The relative loading rates from these areas were determined using the similar procedures as described in Section 3.3.3.1 (See also Appendix Table C.2). The estimated relative contributions of fecal coliform from the nonpoint sources are presented in Table 3.8. The estimated percent reduction from nonpoint sources is 93%, as shown in Table 3.9.

Table 3.8. Estimated TMDL and Load Allocation for Fecal Coliform for the Salem Creek Watershed.

Pollutant	Existing Load	WLA NPDES	WLA MS4	WLA[1]	LA	MOS	TMDL[2]
Fecal Coliform (cfu/day)	5.74E12	4.54E11	2.95E11	7.49E11	7.37E10	9.14E10	9.14E11

1. WLA = WLA NPDES + WLA MS4
2. TMDL = WLA + LA + MOS

Table 3.9. Estimated Percent Reduction by Source for Fecal Coliform (shown in cfu/day) for the Salem Creek Watershed.

	WLA NPDES	WLA MS4	LA	MOS	TOTAL
Existing Load (cfu/day)	4.54E11	4.22E12	1.07E12	x	5.74E12
Load Allocation (cfu/day)	4.54E11	2.95E11	7.37E10	9.14E10	9.14E11
Percent Reduction	0%	93.0%	93.1%	x	84.1%

3.3.3.3. Study Limitation

The available land use and land cover data for this study is outdated and does not accurately represent current land use conditions. Therefore, the estimation of WLA in Table 3.7 is not authoritative. The estimation helps to provide understanding of the relative loads and should be viewed in light of the limited data available to quantify the actual contributions from each individual source. The primary focus of efforts to minimize future impairment should focus on the percent reductions and control of sources identified in the Source Assessment (see §2).

3.3.4 Critical Condition and Seasonal Variation

Critical conditions are considered in the load 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), the existing load violation for fecal coliform occurred at all flow conditions throughout the year (Figure 3.4). Therefore, both dry and wet weathers are critical for fecal coliform.

4.0 Grants Creek Impairment

4.1 Source Assessment

A source assessment is used to identify and characterize the known and suspected sources of turbidity in the Grants Creek watershed. This section outlines the assessment completed for the purpose of developing this TMDL.

4.1.1 NPDES Wastewater Permits

Discharges from wastewater treatment facilities may contribute sediment to receiving waters as total suspended solids (TSS) and/or turbidity. Municipal treatment plants and industrial treatment plants are required to meet surface water quality criteria for turbidity in their effluent. Since these facilities are routinely achieving surface water quality criteria, this TMDL will not impose additional limits to current practices or existing effluent limits for publicly owned treatment plants (POTPs) and industrial treatment plants. When effluent turbidity concentrations exceed surface water quality criteria, and result in permit violations, action will be taken through the NPDES unit of North Carolina's Division of Water Quality.

Currently, there are five individual NPDES permitted facilities in the Grants Creek watershed. Information on each facility can be found in Table 4.1. Permit NC0004286 is inactive as of 6/30/2005. The permit was active for the time period used to estimate the flow duration curve, so flows from this facility are included in the flow estimation for Grants Creek. However, this facility will not receive a load allocation. Locations of the facilities can be seen in Figure 4.1.

Table 4.1. NPDES Wastewater Permits in the Grants Creek Watershed.

Permit	Owner	Facility	Permitted Flow (MGD)	TSS (mg/L) Daily Max	TSS (mg/L) Monthly Ave
NC0027502	Town of Landis	Landis WTP	No Limit	45	30
NC0034703	Rowan-Salisbury Schools	Knollwood Elementary School	0.011	45	30
NC0037184	Lakeside Investment Properties	Oak Haven Mobile Home Park	0.006	45	30
NC0042439	Westside Swim & Racquet Club	Westside Swim & Racquet Club	0.003	45	30
NC0049905	Inman Asphalt	Inman Asphalt-Salisbury	No Limit	67.5	45
NC0004286*	Fieldcrest Cannon, Inc.	Plant 16	0.05	135	39

* Permit NC0004286 is inactive as of 6/30/2005 and will not be included in final NPDES load allocations.

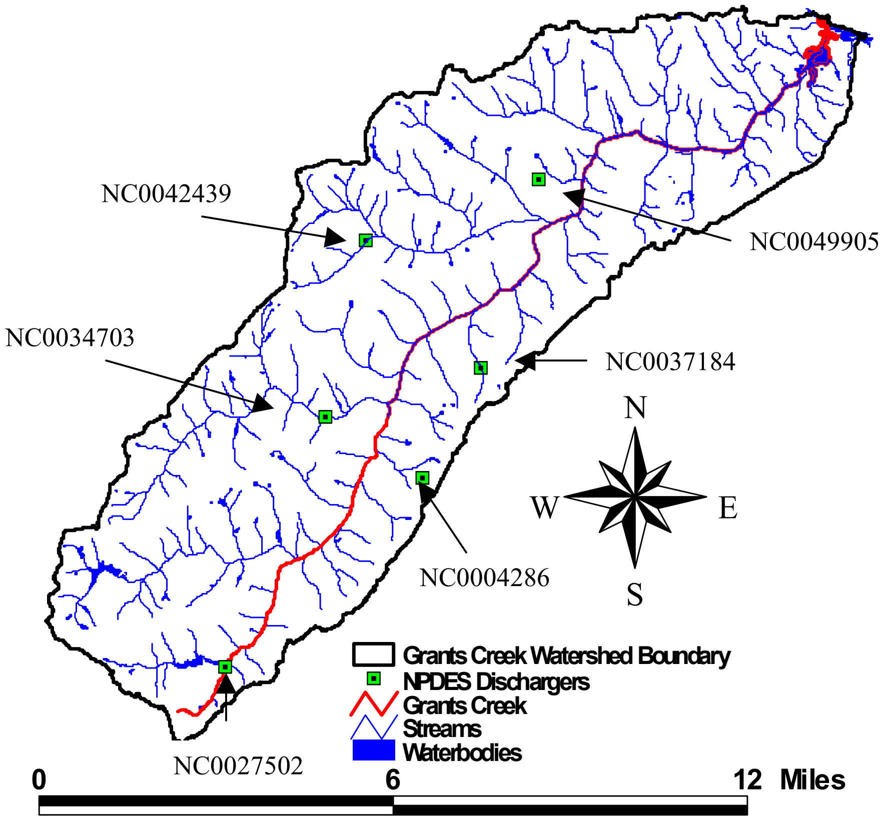

Figure 4.1. Locations NPDES Wastewater Permitted Facilities in the Grants Creek Watershed.

4.1.2 NPDES General Permits

All construction activities in the watershed that disturb one or more acres of land are subject to obtaining a North Carolina NPDES general permit, and as such are required to not cause or contribute to violations of water quality standards. As stated in Permit NCG010000, page 2, "The discharges allowed by this General Permit shall not cause or contribute to violations of Water Quality Standards. Discharges allowed by this permit must meet applicable wetland standards as outlined in 15A NCAC 2B .0230 and .0231 and water quality certification requirements as outlined in 15A NCAC 2H .0500". Monitoring requirements for these construction activities are outlined in Section B (page 5) of NCG010000. As stated, "All erosion and sedimentation control facilities shall be inspected by or under the direction of the permittee at least once every seven calendar days (at least twice every seven days for those facilities discharging to waters of the State listed on the latest EPA approved 303(d) list for construction related indicators of impairment such as turbidity or sedimentation) and within 24 hours after any storm event of greater than 0.5 inches of rain per 24 hour period." (NCG010000, Section B)

As per 40 CFR § 122.44(d)(1)(vii)(B), where a TMDL has been approved, NPDES permits must contain effluent limits and conditions consistent with the requirements and assumptions of the WLA in the TMDL. While effluent limitations are generally expressed numerically, EPA guidance on NPDES-regulated municipal and small construction storm water discharges is that these effluent limits be expressed as best management practices (BMPs) or other similar requirements, rather than numeric effluent limits (Wayland, 2002). Compliance with the turbidity standard in Grants Creek is expected to be met when construction and other land management activities in the Grants Creek watershed employ adequate BMPs. Upon approval of this TMDL, DWQ will notify the NC Division of Land Resources (DLR) and other relevant agencies, including county and local offices in the Grants Creek watershed (Rowan County) responsible for overseeing construction activities, as to the impaired status of Grants Creek and the need for a high degree of review in the construction permit review process.

4.1.3 NPDES Stormwater MS4s and other Nonpoint Sources

Nonpoint and stormwater sources include various erosional processes, including sheetwash, gully and rill erosion, wind, landslides, dry ravel, and human excavation that contribute sediment during storm or runoff events. Sediments are also often produced as a result of stream channel and bank erosion and channel disturbance (EPA, 1999). This is further discussed in Section 2.1.2.

Urban runoff can contribute significant amounts of turbidity, however, much of this runoff is designed to be regulated under the Storm Water Phase II Final Rule (EPA, 2000). Amendments were made to the Clean Water Act in 1990 and most recently in 1999 pertaining to permit requirements for stormwater dischargers associated with industrial activities and municipal separate storm sewer systems (MS4s). MS4s can discharge sediment to waterbodies in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. This rule applies to cities or counties that own or operate a municipal separate storm sewer system (MS4). As a result of the Phase II Rule, MS4 owners are required to obtain a National Point Source Discharge Elimination System (NPDES) permit for their stormwater discharges to surface waters.

The cities of Salisbury, China Grove, and Landis are considered to be under Phase II of the federal stormwater regulations. Therefore, all the nonpoint source loading from the watershed area that is inside the incorporated boundaries of these cities, as well as all urban areas not inside those city boundaries, but still inside the zone of influence are included in the WLA section of the TMDL.

4.2 Technical Approach

Based on the above information, it is most likely that both point sources and nonpoint sources contribute turbidity to Grants Creek. Because of the size of Grants Creek, the amount of turbidity and TSS data, and the type of flow data available, a load duration approach has been adopted for this study. This approach determines impairment loads under different flow conditions – high flow, transition flow, typical flow, and low flow – to identify source types, specify assimilative capacity of a stream, and to estimate the magnitude of load reduction required to meet the water quality standard. The methodology used to develop a load duration curve is based on Cleland (2002).

4.2.1 Endpoint for Turbidity

As discussed in Section 2.1, turbidity is a measure of cloudiness and is reported in Nephelometric Turbidity Units (NTU). Therefore, turbidity is not measured in terms of concentrations and cannot be directly converted into loadings required for developing a load duration curve. For this reason, total suspended solids (TSS) were selected as a surrogate measure for this study.

In order to observe the relationship between TSS and turbidity in Grants Creek, a regression equation between the two parameters was developed using the observed data collected from January 1997 through December 2004 at ambient stations Q4600000. The coefficient of determination (R-Square) between the two parameters was 0.8433; therefore, a significant relationship between the two parameters was experienced. The relationship is shown in Equation 4.1 and Figure 4.2.

$$\text{TSS (mg/L)} = 1.7666 * \text{Turbidity(NTU)} - 16.692 \quad R^2 = 0.9002 \qquad (4.1)$$

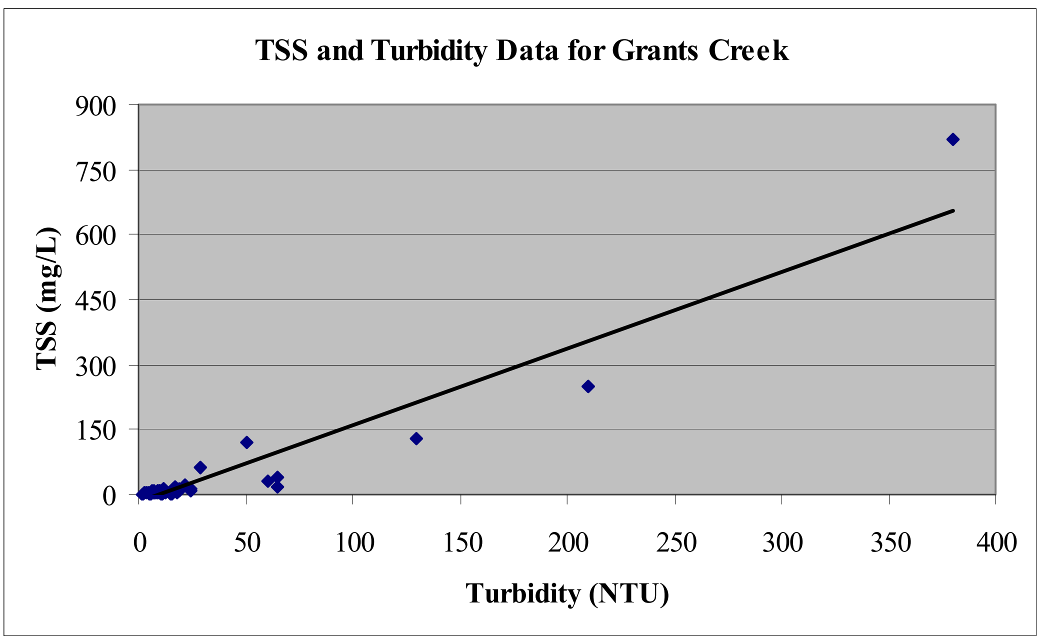

Figure 4.2. TSS-Turbidity Relationship for Grants Creek.

The standard for turbidity is 50 NTU, which using this equation translates to 71.64 mg/L of TSS. Using an explicit MOS of ten percent yields a TSS endpoint of 62.81 mg/L, as shown in Table 4.2.

Table 4.2. Endpoint for Turbidity Translated to TSS.

Standard for Turbidity	Standard for Turbidity with 10% MOS	Related Standard for TSS	Related Standard for TSS with 10% MOS
50 NTU	45 NTU	71.64 mg/L	62.81 mg/L

4.2.2 Flow Duration Curve

A flow duration curve was developed for Grants Creek using a similar procedure as described in section 3.2.2. Reliability of the flow duration curve depends on the period of record available at monitoring stations. Predictability of the curve increases when longer periods of record are used. Unfortunately, there is no currently operating flow gage in Grants Creek. Thus, daily flow data from USGS Gaging Station #02120780, on Second Creek near Barber, North Carolina, was used to establish the historic flow regimes and define ranges for the high, typical, and low flow conditions, from measured flow data from January 1997 to September 2004.

Flows at the downstream Grants Creek ambient station were estimated based on a drainage area ratio between USGS station #02120780 and the watershed area upstream of the Grants Creek ambient station. The drainage area ratio between Grants Creek and Second Creek is 0.57; meaning Grants Creek drainage area is 0.57 times the size of Second Creek. Flows were also adjusted to account for point sources in each watershed by subtracting all NPDES point source flows discharging in the Second Creek watershed before calculating the estimated flow in Grants Creek. After the drainage area ratio for the flows was calculated, the NPDES point sources flows in Grants Creek were added on using the same method as described in Section 3.2.2. In this case, permitted flows were used for all NPDES facilities except for NC0027502 because there is no permitted flow limit for this facility. Flow statistics as generated by the curves from the estimated flow data are presented in Table 4.3.

Table 4.3. Flow Statistics for estimated Grants Creek at ambient station Q4600000

High Flow (<10th Percentile)	Transitional Flow (Between 10th and 30th Percentile)	Typical Flow (Between 30th and 90th Percentile)	Low Flow (>90th Percentile)
88-2337 cfs	40 – 88 cfs	4 – 40 cfs	0.4 – 4 cfs

The flow duration curve, shown in Figure 4.3, was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occurred. It was also used to determine maximum daily pollutant load based on the flow duration and applicable standard. The applications of the flow duration curve for Grants Creek are discussed in the following paragraphs.

4.2.3 Load Duration Curve

As discussed in Section 3.2.3, a load duration curve is developed by multiplying the flow values along the flow duration curve by the pollutant concentrations and the appropriate conversion factors. As seen in Figure 4.4, allowable and existing loads are plotted against the flow recurrence interval. The allowable load is based on the water quality numerical criteria, margin of safety, and flow duration curve.

The following paragraphs discuss procedures to estimate endpoints for turbidity in Grants Creek in order to identify assimilative capacity of the creek in each flow condition and to identify the flow regime during which exceedances occur.

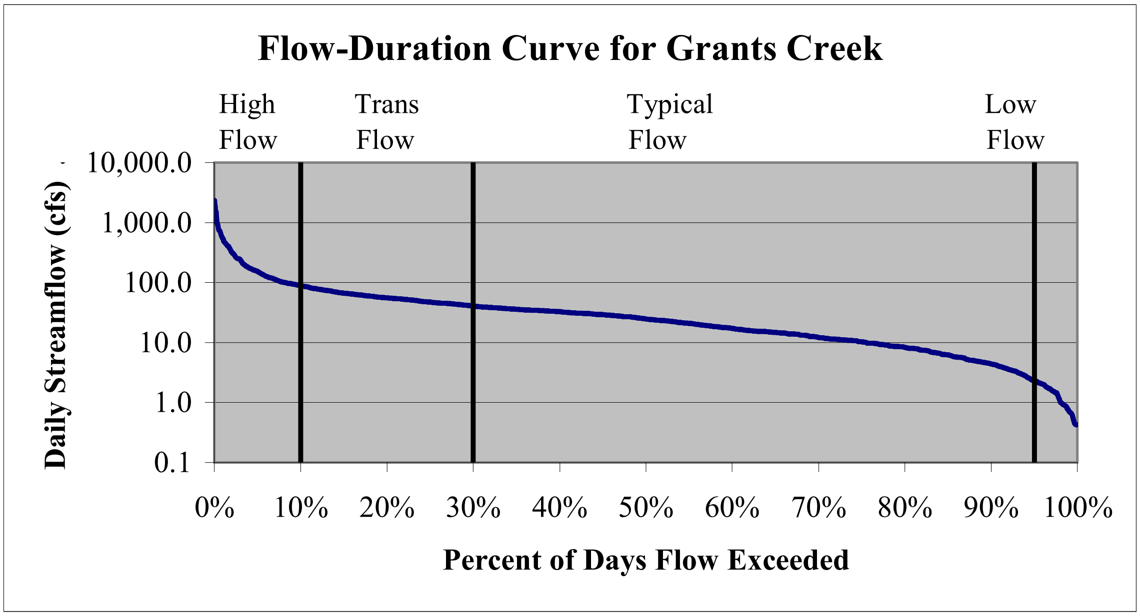

Figure 4.3. Flow Duration Curve for the Grants Creek Watershed. Flows from Second Creek at USGS Station #02120780 were used to estimate flows for Grants Creek.

Turbidity Assimilative Capacity

Existing TSS loads to Grants Creek were determined by multiplying the observed TSS concentration by the flow observed on the date of observation and converting the result to daily loading values. The assimilative capacities of the water bodies were determined by multiplying the TSS concentration that is equivalent to a turbidity value of 45 NTU by the full range of measured flow values. Figure 4.4 presents the TMDL target loading and observed TSS and turbidity for the creek.

Figure 4.5 shows the same information with the extreme high and low flow loads are cut out. The bottom five percent and the highest ten percent are cut from the load duration curve.

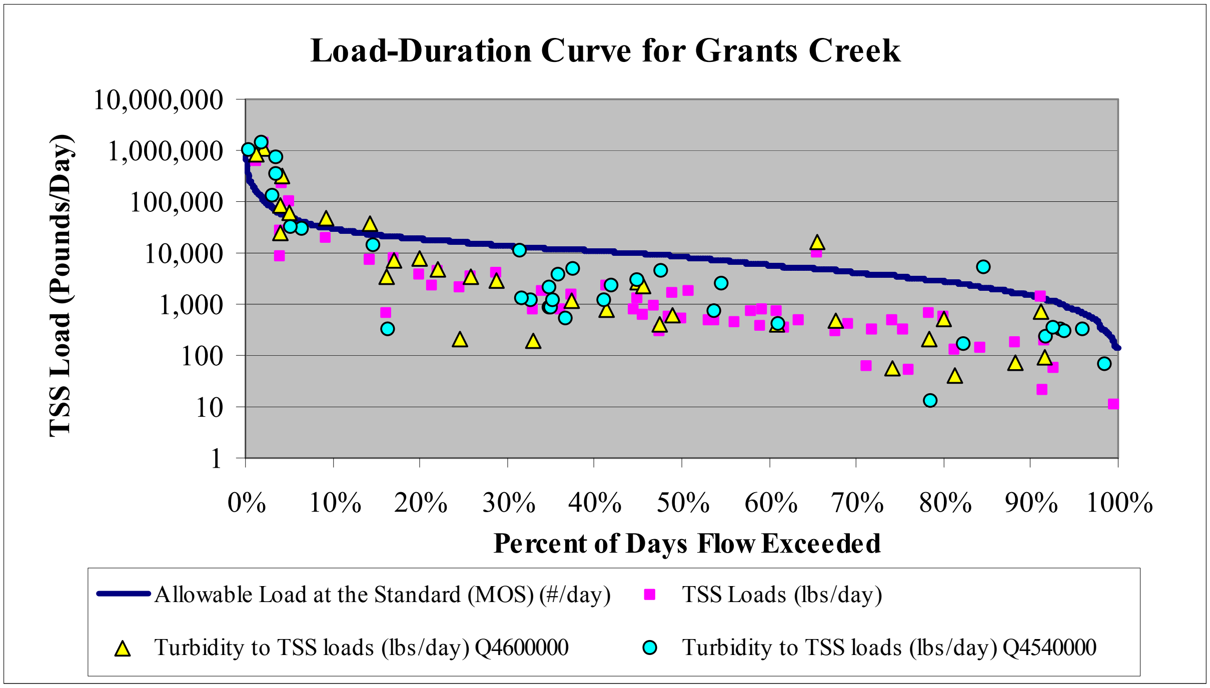

Figure 4.4. TSS Load duration curve for Grants Creek stations Q4600000 and Q4540000, from January 1997 through September 2004.

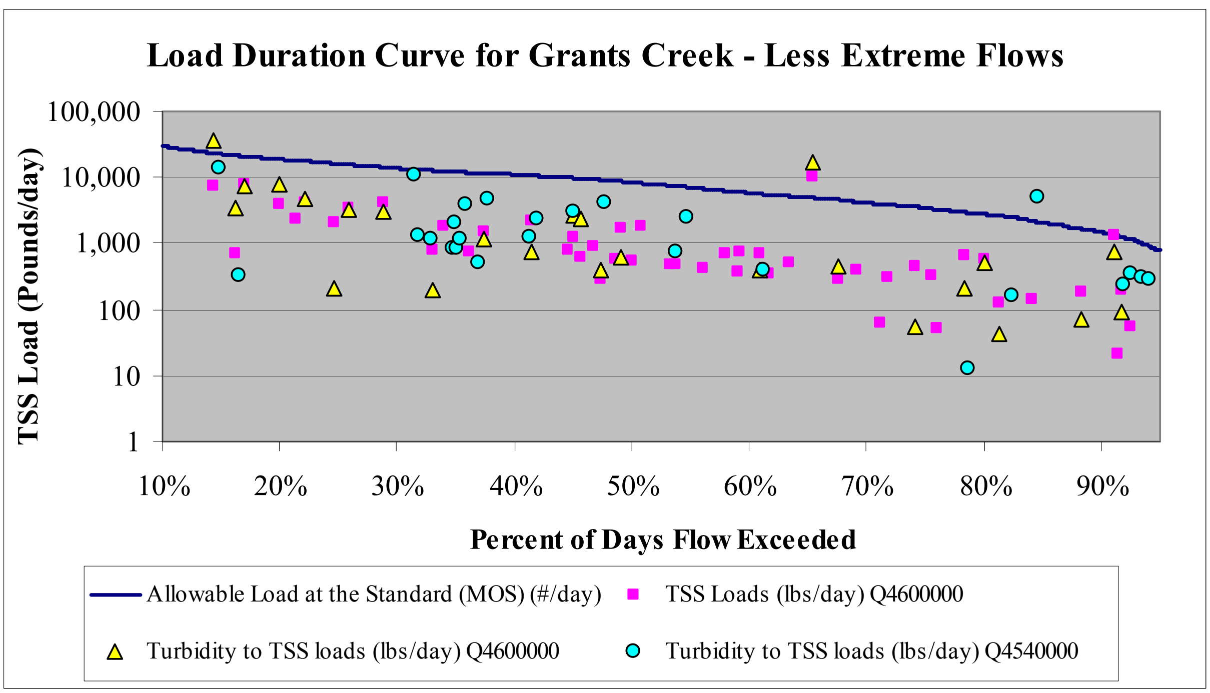

Figure 4.5. TSS Load duration curve for Grants Creek stations Q4600000 and Q4540000, from January 1997 through September 2004, less extreme flows.

Once the highest ten percent and the lowest five percent flows are removed from the calculation, there are only five instances of observed load exceeding the target value. The five instances are spread throughout the curve, in the higher flows, typical flows, and low flows.

4.3 Total Maximum Daily Load (TMDL)

Section 4.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for TSS and turbidity in the Grants Creek watershed. These efforts formed the basis for the TMDL process. The key components required by the TMDL guidelines to set the final TMDL allocation for the watershed are defined by the Equation 4.2.

$$TMDL = \sum WLAs + \sum LAs + MOS \qquad (4.2)$$

Where, WLA is waste load allocation (point source), LA is load allocation (nonpoint source), and MOS is margin of safety. A detailed explanation of the equation is given in Section 3.3. The following sections describe the key components required by the TMDL guidelines to set the final TMDL allocation for the Watershed.

4.3.1 Margin of Safety (MOS)

The Margin of Safety was explicitly included in following TMDL analysis by setting the TMDL target at 10 percent lower than the water quality target for turbidity. Details of the MOS can be found in Table 4.2.

4.3.2 Target Reduction

To determine the amount of turbidity reduction necessary to comply with the water quality criteria, exceedances of the estimated standard (71.64 mg TSS/L) were identified within the 10^{th} to 95^{th} percentile flow recurrence range. A power curve through the data point violating the water quality criterion was overlaid on the graph (Figure 4.6). The power curve equation is presented in Equation 4.3. The correlation coefficient, R-Square, for the power curve is 0.61; thus suggesting a reasonable fit of the curve.

$$Y = 3857 * X^{-1.28} \quad R^2 = 0.607 \qquad (4.3)$$

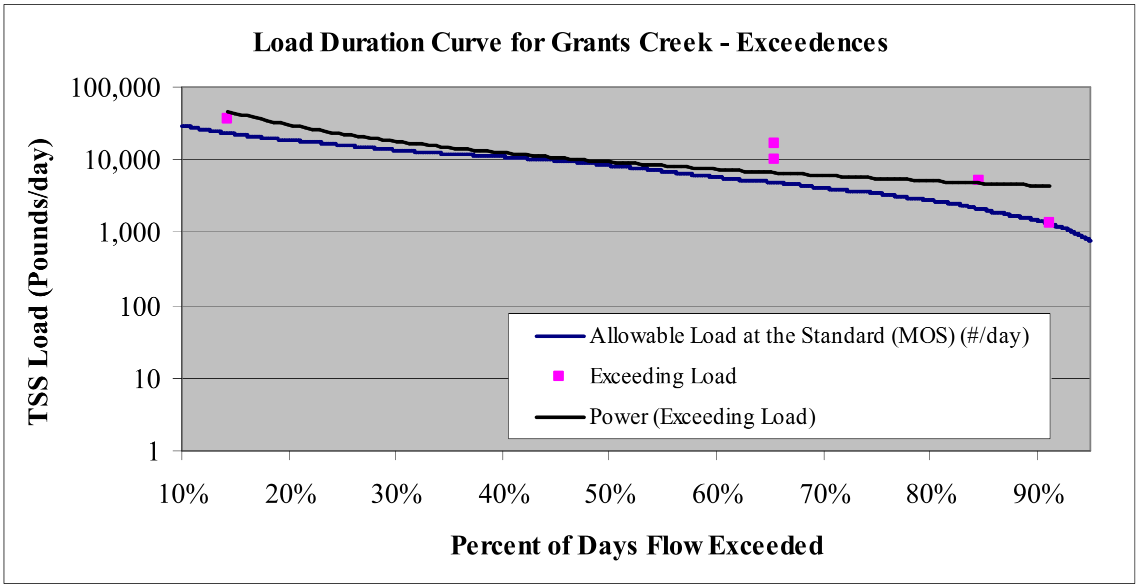

Figure 4.6. Load duration curve showing allowable, existing loads violation, and the power curve of exceeding loads in Grants Creek.

The criteria violations occurred throughout the typical flow regime (Figure 4.4). As described in Section 3.3, the loading estimates based on the power curve are presented in Appendix Table B.2. Approximately 31 percent reduction in TSS is required in order to meet the water quality standard and to account for the 10 percent of MOS. A summary of reductions required is provided in Table 4.4.

Table 4.4. Reduction Required for TSS in Grants Creek.

Pollutant	Target with MOS	Estimated Exceeding Load	TMDL (Allowable Load + MOS)	Reduction Required
TSS[1]	<71.64 mg/L	8.03 tons/day	5.54 tons/day	31.0%

[1]TSS is used as a surrogate variable for turbidity.

4.3.3 TMDL Allocation

As identified by the above load duration curve method, significant amounts of TSS are required to be reduced in Grants Creek. In order to meet the TMDL objectives, the reduction should be targeted towards nonpoint sources and MS4 areas.

4.3.3.1. Waste Load Allocation (WLA)

All TSS transported from the MS4 areas and NPDES permitted facilities were assigned to the WLA components. The loading rates from the NPDES facilities are listed in Table 4.1. The total allocation for NPDES permitted facilities is 0.0038 tons/day, as shown in Table 4.6. There are no load allocations for permits NC0049905 or NC0027502 because there is no permitted flow limit. There is also no load allocation for permit NC0004286 because this permit is no longer active (as of 6/30/2005).

The relative loading rates from the MS4 areas were determined based on the report by USGS, 1999. The report describes TSS and sediment transport under different land use conditions in the City of Charlotte and Mecklenburg County, North Carolina. A summary of the report and a description of the method used to estimate the relative percent contribution of TSS from the urban and rural sources for this study are presented in Appendix Table C.1. The estimated relative percent contribution from the MS4 and other areas (nonpoint sources including non-MS4 area) are presented in Table 4.5. Section 4.1.3 describes which areas of the Grants Creek watershed are considered MS4.

Table 4.5. Relative TSS contributions Rates for the Grants Creek watershed.

Pollutant	Load from MS4 areas (%)	Load from other areas (%)
TSS	14	86

The assimilative capacity determined in Section 4.2.3 was split based on the relative contributions presented in Table 4.5 to determine the allocation for the MS4 areas. The results of these calculations are summarized in Table 4.6. As shown in Table 4.7, the load allocation for MS4 areas represents a 39.5% reduction in TSS loading.

The WLA associated with construction and other land management activities, as discussed in Section 4.1.2, is equivalent to the surface water quality standard for turbidity in that any construction activity cannot cause or contribute to a violation of the water quality standard. As discussed, these WLAs are and will be expressed as BMPs in the general or individual construction permits rather than as numeric effluent limits.

4.3.3.2. Load Allocation (LA)

All TSS loadings from nonpoint sources such as non-MS4 urban land, agriculture land, and forested land were reported as LAs. The relative loading rates from these areas were determined using the similar procedures as described in Section 3.3.2. (See also Appendix Table C.3.) The estimated allocation of TSS from the nonpoint sources is presented in Table 4.6. As shown in Table 4.7, the allocation for nonpoint sources requires a 39.5% reduction in nonpoint source loading.

Table 4.6. Estimated TMDL and Load Allocation for TSS for the Grants Creek Watershed.

Pollutant	Existing Load	WLA NPDES	WLA MS4	WLA[1]	LA	MOS	TMDL[2]
TSS (tons/day)	8.03	0.0038	0.68	0.68	4.17	0.68	5.54

1. WLA = WLA NPDES + WLA MS4
2. TMDL = WLA + LA + MOS

Table 4.7. Estimated Percent Reduction by Source for TSS in the Grants Creek Watershed.

	WLA NPDES	WLA MS4	LA	MOS	TOTAL
Existing Load (tons/day)	0.0038	1.12	6.90	x	8.03
Load Allocation (tons/day)	0.0038	0.68	4.17	0.68	5.54
Percent Reduction	**0%**	**39.5%**	**39.5%**	**x**	**31.0%**

4.3.3.3. Study Limitation

The available land cover for this study is outdated and fails to represent current land use conditions. Therefore, the estimation of WLA in Table 4.7 is not authoritative. The primary focus of efforts to minimize future impairment should be on the percent reductions and control of sources identified in the Source Assessment (see § 4.1).

4.3.4 Critical Condition and Seasonal Variation

According to the load duration curve (Figure 4.4), the greatest frequency of exceedances of turbidity occurred during both high-flow and low-flow periods throughout the season. The results show that the few exceedances that did occur happened at both high and low flow, therefore the entire spectrum of flows are critical.

5.0 Summary and Future Consideration

This report presents the development of Total Maximum Daily Loads (TMDLs) for two waterbodies in North Carolina: Salem Creek and Grants Creek both of which are located in the Yadkin Pee-Dee River Basin. Salem Creek is impaired for fecal coliform and Grants Creek is impaired for turbidity.

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 power curve load estimates and the average of the allowable load estimates. The summary of the results is as follows:

- About 84 percent reduction in fecal coliform is required in order to meet the water quality standard in Salem Creek. Both point and nonpoint sources from a variety of origins are responsible for the exceedance of fecal coliform.

- About 31 percent reduction in TSS is required in order to meet the water quality standard for turbidity in Grants Creek. Both point and nonpoint sources are responsible for the exceedance of TSS.

5.1 Stream Monitoring

Stream monitoring should continue on a monthly interval at the existing ambient monitoring stations. The continued monitoring of TSS and fecal coliform will allow for the evaluation of progress towards the goal of reaching water quality standards by comparing the instream data to the TMDL target. In addition, every monitoring station should monitor both turbidity and TSS so a relationship between the two can be determined at every station.

Furthermore, to comply with EPA guidance, North Carolina may adopt new bacteria standards utilizing Escherichia coli (E. coli) or enterococci in the near future. Thus, in the future, monitoring efforts to measure compliance with this TMDL should include using E. coli or enterococci. Per EPA recommendations (EPA, 2000b), if future monitoring for E. coli/enterococci indicates the standard has not been exceeded, these monitoring data may be used to support delisting the water body from the 303(d) list. If a continuing problem is identified using E. coli/enterococci, the TMDL may be revised.

5.2 Implementation Plan

Reductions for fecal coliform should be sought through identification and repair of aging sewer infrastructure as well as targeting other storm-driven sources. Enforcement of stormwater BMP requirements for construction sites, additional education related to farming practices and other land disturbing activities, and additional urban stormwater controls for sediment are potential management options for improving turbidity levels.

For turbidity, much of the impairment is likely due to erosion from land uses during conversion from rural to urban uses. While stormwater controls are typically required during development activities, significant loadings can occur due to initial periods of land disturbance before controls are in place or during high rainfall periods during which the controls are inadequate. Additional turbidity impairment may be due to runoff from agricultural areas and from erosion of soils due to increased imperviousness in urbanizing areas.

The TMDL analysis was performed using the best data available to specify the fecal coliform and total suspended solids reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications in the watershed. A detailed implementation plan is not included in this TMDL. The involvement of local governments and agencies will be needed in order to develop an implementation plan.

6.0 Public Participation

A draft of the TMDL was publicly noticed through various means. The TMDL was public noticed in the relevant counties through two local newspapers (Salisbury Post on May 3, 2006 and Winston-Salem Journal on May 4, 2006, Appendix D). The TMDL was also public noticed on May 1, 2006 through the North Carolina Water Resources Research Institute email list-serve (Appendix D). Finally, the TMDL was available on DWQ's website http://h2o.enr.state.nc.us/tmdl/ during the comment period. The public comment period lasted until June 2, 2006. Two written comments were received, both from NC Department of Transportation. DWQ's responses to those comments are provided in Appendix E.

7.0 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.

Hyer, Kenneth, Doughlas Moyer, and Trisha Baldwin. 2001. Bacteria Source Tracking to Improve TMDL Development in Bacteria. U.S. Geological Survey, WRD, 1730 East Parham Rd., Richmond, VA 23228. In va.water.usgs.gov/GLOBAL/posters/BST.pdf.

Rosgen. D.L., A Practical Method of Computing Streambank Erosion Rate. Wildland Hydrology, Inc. Pagosa Springs, Colorado. Online at: http://www.wildlandhydrology.com/assets/Streambank_erosion_paper.pdf

MapTech-HDR. (2005). Pathogen Source Assessment for TMDL Development and Implementation in Salem and Muddy Creek Watersheds Winston-Salem, North Carolina. Prepared for North Carolina Division of Water Quality.

North Carolina Division of Water Quality. (2005). Total Maximum Daily Load for Turbidity and Fecal Coliform for Haw River, Deep River, Third Fork Creek, and Dan River in North Carolina. Final Report.

North Carolina Division of Water Quality. (2004). Total Maximum Daily Load for Turbidity for Fourth Creek (Subbasin 03-07-06) and Yadkin River Basin. Final Report.

North Carolina Division of Water Quality. 2004. Stormwater Permitting Unit. Online: http://h2o.enr.state.nc.us/su/PDF_Files/SW_General_Permits/NCG010000.pdf

North Carolina Division of Water Quality. 2004. Stormwater Permitting Unit. Online: (http://h2o.enr.state.nc.us/NPDES/documents/NCG55_Permit_2002.pdf).

North Carolina Department of Agriculture (NCDA): http://www.ncagr.com/stats/cntysumm/forsyth.htm

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) 1999. Protocol for Developing Sediment TMDLs. First Edition. EPA 841-B-99-044. U.S. EPA, Office of Water, Washington D.C.

U.S. Environmental Protection Agency (USEPA) 2000a. 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).

United States 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: http://quickfacts.census.gov/qfd/states/

U.S. Census Bureau:
http://factfinder.census.gov/servlet/QTTable?_bm=n&_lang=en&qr_name=DEC_1990_STF3_DP5&ds_name=DEC_1990_STF3_&geo_id=05000US37067

U.S. Census Bureau: http://quickfacts.census.gov/qfd/states/37/37067.html

U. S. Geological Survey (USGS). 1999. Relation of Land Use to Streamflow and Water Quality at Selected Sites in the City of Charlotte and Mecklenburg County, North Carolina, 1993-98. Water Resources Investigations Report 99-4180, Raleigh, NC.

Wayland, R. November 22, 2002. Memorandum from Rober Wayland of the U. S. Environmental Protection Agency to Water Division Directors. Subject: Establishing TMDL Waste Load Allocation for stormwater sources and NPDES permit requirements based on those allocations.

Appendix A: Salem Creek Data

Table A.1. Water Quality Data for Salem Creek at Station Q2570000.

Date	Fecal Coliform (cfu/100ml)	Fecal Coliform Remarks[1]
8/4/1998	420	B
9/2/1998	6000	L
10/21/1998	390	
11/12/1998	600	
12/4/1998	506	
1/7/1999	170	
2/10/1999	77	B
3/11/1999	35	B
4/8/1999	110	B
5/6/1999	500	B
6/9/1999	770	B
7/15/1999	300	
8/4/1999	160	
9/15/1999	2500	
10/14/1999	4200	
11/4/1999	600	
12/9/1999	160	
1/13/2000	320	
2/14/2000	3800	
3/20/2000	5000	
4/27/2000	320	
5/3/2000	240	
6/15/2000	6000	P
7/19/2000	330	
8/31/2000	5000	
9/12/2000	360	
10/23/2000	100	B
11/13/2000	110	
12/26/2000	150	B
1/22/2001	71	B
2/12/2001	72	B
3/21/2001	1400	B
4/9/2001	50	
5/14/2001	500	
6/6/2001	370	
7/17/2001	43	
8/7/2001	470	
9/11/2001	68	
10/9/2001	1800	
11/13/2001	130	B
12/4/2001	530	
1/15/2002	340	
2/12/2002	190	
3/5/2002	61	
4/9/2002	210	
5/7/2002	520	
6/11/2002	76	B
7/9/2002	63	
8/6/2002	88	B4
9/10/2002	180	
9/12/2002	230	B4
9/17/2002	1100	
9/19/2002	1700	B6
9/24/2002	300	B4
9/24/2002	410	
10/1/2002	260	B4
10/8/2002	280	B4
10/8/2002	390	
10/15/2002	330	B4
10/22/2002	4900	B3
11/5/2002	120	
12/3/2002	230	
1/7/2003	125	B4
1/16/2003	110	
1/28/2003	57	
1/30/2003	1600	
2/6/2003	3600	B3
2/11/2003	137	B4
2/12/2003	1900	
3/18/2003	440	
4/8/2003	240	
5/13/2003	260	
6/10/2003	230	
7/15/2003	62	
8/26/2003	310	
9/23/2003	1600	B1
10/28/2003	1900	B1
11/18/2003	74	
12/9/2003	140	B4
1/13/2004	123	B4
2/10/2004	270	

1. Fecal Coliform Remark Codes:
   - B Results based upon colony counts outside the acceptable range.
   - B1 Countable membranes with less than 20 colonies. Reported value is estimated or is a total of the counts on all filters reported per 100 ml.
   - B3 Countable membranes with more than 60 or 80 colonies. The value reported is calculated using the count from the smallest volume filtered and reported as a greater than ">" value.
   - B4 Filters have counts of both >60 or 80 and <20. Reported value is a total of the counts from all countable filters reported per 100 ml.
   - B6 Estimated Value. Blank contamination evident.
   - L Actual value is known to be greater than value given.
   - P Too numerous to count.

Table A.2. Estimation of Load Reduction Required in Fecal Coliform for Salem Creek at Station Q2570000

% Flow Exceeded	Flow (cfs)	Estimated Exceedance Load (cfu/day)	TMDL (cfu/day)
10%	278.39	3.54E+13	2.72E+12
15%	180.91	1.80E+13	1.77E+12
20%	136.81	1.12E+13	1.34E+12
25%	111.96	7.72E+12	1.1E+12
30%	99.24	5.70E+12	9.71E+11
35%	89.53	4.41E+12	8.76E+11
40%	83.20	3.53E+12	8.14E+11
45%	78.65	2.90E+12	7.7E+11
50%	74.61	2.44E+12	7.3E+11
55%	70.79	2.08E+12	6.93E+11
60%	67.82	1.80E+12	6.64E+11
65%	65.80	1.58E+12	6.44E+11
70%	62.67	1.39E+12	6.13E+11
75%	60.80	1.24E+12	5.95E+11
80%	58.83	1.12E+12	5.76E+11
85%	55.94	1.01E+12	5.47E+11
90%	53.71	9.17E+11	5.26E+11
95%	51.47	8.38E+11	5.04E+11
	Average	**5.74E+12**	**9.14E+11**
		Avg. Reduction Required	**84.1%**

Appendix B: Grants Creek Data

Table B.1. Water Quality Data for Grants Creek at Stations Q4600000 andQ4540000

	Station Q4600000	
Date	Residue total nonfilterable (mg/L)	Turbidity lab (NTU)
1/16/1997	250	210
2/19/1997	24	22
3/18/1997	18	17
4/14/1997		
5/21/1997	8	9.9
6/19/1997	2	15
7/28/1997	13	12
8/19/1997		8.9
9/17/1997	6	5.6
10/22/1997	7	9.1
11/17/1997	6	8.7
12/11/1997	4	10
1/13/1998	13	24
2/12/1998	9	24
3/10/1998	29	60
4/7/1998	8	8.7
5/6/1998	20	65
6/8/1998	9	7.6
7/9/1998	4	7.3
8/5/1998	6	5.6
9/17/1998	5	4.5
10/8/1998	8	6
11/2/1998	1	2.1
12/15/1998	8	12
1/7/1999	8	19
2/15/1999	2	11
3/11/1999	5	7.2
4/13/1999	4	5.5
5/10/1999	12	12
6/21/1999	4	13
8/2/1999	7	11
8/24/1999	3	10
9/27/1999	14	12
10/25/1999	4	4
11/15/1999	4	5.3
12/16/1999	4	18

	Station Q4540000
Date	Turbidity lab (NTU)
6/3/1998	21.00
7/16/1998	5.40
8/4/1998	3.40
9/2/1998	4.50
10/21/1998	6.70
11/12/1998	3.20
12/4/1998	4.60
1/7/1999	20.20
2/10/1999	13.50
3/11/1999	8.80
4/8/1999	6.20
5/6/1999	12.80
6/9/1999	11.70
7/15/1999	8.70
8/4/1999	8.30
9/15/1999	9.60
10/14/1999	17.30
11/4/1999	7.50
12/9/1999	8.20
1/13/2000	38.00
2/14/2000	407.00
3/20/2000	474.00
4/27/2000	15.50
5/4/2000	24.20
6/15/2000	94.50
7/19/2000	20.50
8/29/2000	20.30
9/12/2000	16.30
10/23/2000	4.21
11/13/2000	2.50
12/26/2000	8.50
1/22/2001	22.00
2/12/2001	12.00
3/21/2001	190.00
4/9/2001	12.00
5/14/2001	6.60

	Station Q4600000	
Date	Residue total nonfilterable (mg/L)	Turbidity lab (NTU)
2/15/2000	39	65
3/13/2000	4	7.8
4/17/2000	15	19
5/15/2000	6	7
6/7/2000	8	10
7/24/2000	130	130
8/15/2000	64	29
9/12/2000		6.6
10/5/2000	1	5
11/6/2000		4.3
12/11/2000		5.8
1/17/2001	1	5.8
2/12/2001		15
4/17/2001	14	
5/23/2001		110
6/25/2001		33
7/25/2001	10	12
8/13/2001		32
9/13/2001		6.3
10/9/2001	3	2.6
11/28/2001		8.3
12/27/2001		9.4
1/23/2002	820	380
2/27/2002		6.8
3/20/2002		28
4/24/2002	13	16
5/23/2002		10
6/17/2002		9
7/30/2002	4	6.5
8/26/2002		13
9/16/2002		22
10/23/2002	4	9
11/19/2002		24
12/16/2002		50
1/27/2003	4	7.5
2/20/2003		17
3/17/2003		75
4/7/2003	250	210
5/6/2003		110
6/19/2003		29
7/14/2003	14	17

	Station Q4540000
Date	Turbidity lab (NTU)
6/6/2001	6.10
7/17/2001	7.80
8/7/2001	6.50
9/11/2001	7.20
10/9/2001	20.00
11/13/2001	2.70
12/4/2001	3.50
1/15/2002	7.00
2/12/2002	13.00
3/5/2002	26.00
4/9/2002	7.00
5/7/2002	6.90
6/11/2002	26.00
7/9/2002	8.00
8/6/2002	17.00
9/24/2002	4.50
10/8/2002	5.40
11/5/2002	4.30
12/3/2002	6.10
1/7/2003	12.00
2/11/2003	6.10
3/18/2003	36.00
4/8/2003	70.00
5/13/2003	10.00
6/10/2003	32.00
7/15/2003	8.20
8/26/2003	11.00
9/23/2003	120.00
10/28/2003	13.00
11/18/2003	5.20
12/9/2003	6.60
1/13/2004	13.00
2/10/2004	31.00

	Station Q4600000	
Date	Residue total nonfilterable (mg/L)	Turbidity lab (NTU)
8/18/2003		19
9/23/2003		
10/7/2003	4	8.5
11/5/2003		6.2
12/2/2003		7.6
1/7/2004	8	13
2/5/2004		16
3/23/2004		9
4/14/2004	120	50
5/18/2004		22
6/30/2004		14
7/12/2004	4	7.6
8/9/2004		12
9/13/2004		12
11/2/2004		9.6
12/6/2004		7.1

Table B.2. Estimation of Load Reduction Required in TSS for Grants Creek.

% Flow Exceeded	Flow (cfs)	Estimated Exceedance Load (lb/day)	TMDL (lb/day) = allowable + MOS
10%	88.01	73,841.5	34,020.61
15%	66.67	43,908.8	25,774.33
20%	55.09	30,365.5	21,295.25
25%	47.37	22,810.8	18,312.63
30%	40.21	18,056.4	15,544.69
35%	35.65	14,818.5	13,779.49
40%	32.64	12,487.0	12,618.33
45%	28.99	10,737.0	11,205.50
50%	24.76	9,380.4	9,571.71
55%	20.70	8,301.5	8,003.35
60%	17.18	7,425.2	6,640.42
65%	14.78	6,701.1	5,715.31
70%	12.24	6,093.7	4,730.58
75%	10.36	5,577.9	4,003.25
80%	8.38	5,135.0	3,240.78
85%	6.22	4,751.0	2,404.51
90%	4.42	4,415.3	1,709.55
95%	2.36	4,119.6	912.08
	Average	**16,051.5**	**11,082.4**
		Avg. Reduction Required	**30.96%**

Appendix C: Estimates of Relative Loadings for Point and Nonpoint Sources

Appendix Table C.1. Estimates of TSS and Fecal Coliform Runoff Loading Rates for Urban and Rural Lands (USGS, 1999).

Land Use Type	TSS Conc. (tons/sq. mi)	FC Conc. (cfu/L)
Mixed forrest/pasture/low density residential	2400	15
Mixed forrest/pasture/medium & low density residential	2100	20
Mixed forrest/pasture/medium & low density residential	564	24.5
Rural Average	**1688**	**20**
Industrial	122	27.5
Industrial	300	14.6
Medium-density residential	225	29
Medium-density residential	77	26.5
High-density residential	1000	15
Developing	4700	13
Urban Average	**1071**	**21**

Appendix Table C.2. Relative Fecal Coliform Concentration from Urban and Rural areas for Salem Creek Watershed.

Land Use	Land %	Relative Fecal Rate (#/100ml)	Normalized Fecal Coliform Conc. Rates (#/100ml)	Fecal Coliform Conc. Ratio
Rural	21.02	20	4.20	20.23%
MS4	78.98	21	16.58	79.77%

Note: Fecal coliform data estimated in Appendix Table D.1 was utilized to estimate average fecal coliform concentrations in stormwater runoff. The relative percent contributions of fecal coliform were multiplied by the land use distribution and normalized to estimate the relative loading ratio for urban (MS4) and rural (non-MS4) areas.

Appendix Table C.3. Relative TSS Loading from Urban and Rural Areas.

Watershed	Land Use	Land %	Relative TSS Rate (tons sq mi/yr)	Normalized TSS Loading Rates (tons/sq mi/yr)	TSS Loading Ratio
Grants Creek	Rural	79.30%	1688	1338.52	85.79%
	MS4	20.70%	1071	221.74	14.21%

Note: TSS data estimated in Appendix Table C.3 was utilized to estimate average sediment loading in stormwater runoff. The relative percent contributions of TSS were multiplied by the land use distribution and normalized to estimate the relative loading percentage for urban (MS4) and rural (non-MS4) areas.

Appendix D. Public Notification of TMDLs for Fecal Coliform for Salem Creek and Turbidity for Grants Creek

-------- Original Message --------
Subject: [wrri-news] Comment on Draft TMDL to DWQ by June 2nd
Date: Mon, 01 May 2006 12:48:17 -0400
From: Kelly Porter <kaporter@gw.fis.ncsu.edu>
Reply-To: Kelly Porter <kaporter@gw.fis.ncsu.edu>
To: <wrri-news@lists.ncsu.edu>

TMDLs for Fecal Coliform for Salem Creek and Turbidity for Grants Creek
Yadkin-Pee Dee River Basin

Now Available Upon Request

Total Maximum Daily Load for Fecal Coliform for Salem Creek and Turbidity for Grants Creek in North Carolina is now available upon request from the North Carolina Division of Water Quality. This TMDL study was prepared as a requirement of the Federal Water Pollution Control Act, Section 303(d). The study identifies the sources of pollution, determines allowable loads to the surface waters and suggests allocation for turbidity for Grants Creek and fecal coliform for Salem Creek.

TO OBTAIN A FREE COPY OF THE TMDL REPORT:

Please contact Ms. Linda Chavis (919) 733-5083, extension 558 or write to:
Ms. Linda Chavis
Water Quality Planning Section
1617 Mail Service Center
Raleigh, NC 27699

Interested parties are invited to comment on the draft TMDL study by June 2, 2006. Comments concerning the report should be directed to Pam Behm at the above address. The draft TMDL is also located on the following website: http://h2o.enr.state.nc.us/tmdl

NORTH CAROLINA
FORSYTH COUNTY

AFFIDAVIT OF PUBLICATION

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified, and authorized by law to administer oaths, personally appeared D.H. Stanfield, who being duly sworn, deposes and says: that he is Controller of the Winston-Salem Journal, engaged in the publishing of a newspaper known as Winston-Salem Journal, published, issued and entered as second class mail in the City of Winston-Salem, in said County and State: that he is authorized to make this affidavit and sworn statement: that the notice or other legal advertisement, a true copy of which is attached hereto, was published in Winston-Salem Journal on the following dates:

May 4, 2006

and that the said newspaper in which such notice, paper document, or legal advertisement was published was, at the time of each and every such publication, a newspaper meeting all the requirements and qualifications of Section 1-597 of the General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina.

This 14th day of June, 2006 ______________________
(signature of person making affidavit)

Sworn to and subscribed before me, this 14th day of June, 2006

____
Notary Public

My Commission expires: September 28, 2010

OFFICIAL SEAL
Notary Public, North Carolina
COUNTY OF FORSYTH
KIMALEY JOHNSON
My Commission Expires 9-28-2010

PUBLIC NOTICE
State of North Carolina
Division of Water Quality
1617 MAIL SERVICE CENTER
RALEIGH, NC 27699-1617
Availability of the Total Maximum Daily Load (TMDL) for Fecal Coliform for Salem Creek and Turbidity for Grants Creek in North Carolina.
Copies of the TMDL are available may be obtained by calling Linda Chavis at 919-733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl. Written comments regarding this TMDL will be accepted until June 2, 2006. Please mail comments to NCDWQ Planning Section, Attn: Pam Behm, 1617 Mail Service Center, Raleigh, NC 27699.
WSJ: May 4, 2006

Salisbury Post

AFFIDAVIT OF PUBLICATION

NCDWQ PLANNING SECTION
ATTN: PAM BEHM
1617 MAIL SERVICE CENTER
RALEIGH NC 27699

NORTH CAROLINA
ROWAN COUNTY

Before the undersigned a Notary Public of said County and State, duly commisioned, qualified, and authorized by law to administer oaths, personally appeared WINFRED MENTION, who being first duly sworn, deposes and says that he is ASSISTANT ADVERTISING DIRECTOR of the SALISBURY POST, published, issued and entered as second class mail in the City of Salisbury, in said County and State, that he is authorized to make this affidavit and sworn statement,that the notice or other legal advertisement a true copy of which is attached hereto, was published in the SALISBURY POST , on the following dates:

05/03/2006

and that the said newspaper in which such notice, paper documnet or legal advertisement was published, at the time of each and every such publication, a newspaper meeting all the requirements and qualifications of Section 1-597 of the General Statutes of North Carolina and was a qualified newspaper within the meaning of Section 1-597 of the General Statutes of North Carolina.

NO. 53672 PUBLIC NOTICE S
$23.13

Winfred Mention
____

Sworn and subscribed before me

This 8th day of May, 2006

Shari T. Moore
NOTARY PUBLIC
My Commision Expires 2-28-09

No. 53672

PUBLIC NOTICE

State of North Carolina - Division of Water Quality

Availability of the Total Maximum Daily Load (TMDL) for Fecal Coliform for Salem Creek and Turbidity for Grants Creek in North Carolina.
Copies of the TMDL are available may be obtained by calling Linda Chavis at 919-733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl. Written comments regarding this TMDL will be accepted until June 2, 2006. Please mail comments to NCDWQ Planning Section, Attn: Pam Behm, 1617 Mail Service Center, Raleigh, NC 27699.

Appendix E. Responsiveness Summary for "Total Maximum Daily Load for Fecal Coliform for Salem Creek and Turbidity for Grants Creek in North Carolina"

DWQ received two written responses to the draft TMDL. Comments from specified organizations are in italics as they appear in the delivered documents. DWQ's response follows in plain text.

The following comments were submitted to DWQ from D.R. Henderson, P.E., NC Department of Transportation (NCDOT).

COMMENT: *In response to DWQ's public notice of the April 2006 draft turbidity TMDL for Grants Creek, the NCDOT would like to offer the following comments for your consideration:*

- *We support DWQ's decision not to identify the NCDOT as a significant contributor to the impairment of Grants Creek from turbidity. In addition to the information presented in the TMDL report, we believe DWQ's decision is further supported by the following facts:*

- *The NCDOT's road right-of-way occupies the smallest percentage (~3%) of any developed land cover category in the Grants Creek watershed. By way of comparison the percentage of the watershed within the corporate boundaries of other NPDES Phase II stormwater entities include Salisbury (~30%), Rowan County (100%), and Kannapolis (~6%).*

- *The NCDOT has very few unpaved secondary roads in the watershed which might be considered as a source of TSS. Over 98% of the state maintained roads in the watershed are paved, thereby minimizing sediment loads from the road surface.*

- *Finally, and most significantly, the NCDOT did not receive any notices of violation (NOVs) for failure to comply with applicable sediment and erosion control regulations within the watershed during the TMDL analysis period (1997 – 2004). This record of compliance also applies to the NCDOT's sediment and erosion control activities throughout Rowan County for the period.*

RESPONSE: DWQ did not expressly evaluate the NC DOT as a potential contributor. DWQ is currently working with the NCDOT to develop methodology to evaluate the role of NCDOT managed roads in contributing pollutants to impaired waterbodies.

COMMENT: *Per the guidance outlined in Section 11.4 TMDL Involvement of DWQ's Fact Sheet (dated November 2004) which accompanies the NCDOT's current NPDES permit (NCS000250), we respectfully request that the following statement be included in Section 5.2 Implementation Plan of the TMDL report:*

> *"Based on the TMDL analysis presented in this report for Grants Creek, the NCDOT was not identified as a significant contributor to the impairment. Compliance with those NPDES permit (NCS000250) requirements applicable within the TMDL area, excluding Part III – Section C, is expected to be sufficient to meet the NCDOT's WLA."*

RESPONSE: See response above. DWQ did not expressly evaluate the NC DOT as a contributor to the impairment of Grants Creek. As such, DWQ cannot add the requested text to the implementation plan of this TMDL document.

COMMENT: *Please provide clarification as to the geographic extent of the segment of Grants Creek impaired for turbidity. The description provided in Table 1.1 of the TMDL report, "From SR 1910 to Yadkin River", appears to be inconsistent with the stated length of the impaired segment (1.2 miles). Using the NCDOT's county road map for Rowan County we measured a distance of approximately 4 miles from where SR 1910 crosses Grants Creek downstream to the confluence with the Yadkin River. A similar distance measurement was obtained from the Salisbury USGS 7.5 minute topographic map. Additionally, Figures 1.3 and 1.7 in the TMDL report appear to be inconsistent with the information in Table 1.1, as these maps imply that the entire length (~18 miles) of the Grants Creek mainstem is impaired for turbidity.*

RESPONSE: The impairment length of Grants Creek is incorrectly listed on the 303(d) list as 1.2 miles. The correct impairment length of Grants Creek for turbidity is 4.2 miles. This will be corrected in the next 303(d) report. Additionally, Figures 1.3 and 1.7 were corrected accordingly.

The following comments were submitted to DWQ from A. McDaniel, NC Department of Transportation.

COMMENT: *In Table 1.3 the area units should be acres instead of square miles.*

RESPONSE: This has been corrected in the final TMDL document.

COMMENT: *On p. iv there is a short list of information items, one of which includes "DOT a Significant Contribution (Yes or Blank)". We believe this listing is a convenient quick reference and hope you all continue to include it in future TMDL reports. We would like to request however, that you include separate references to the DOT for each TMDL. In other words you might want to say "DOT a Significant Contribution in Grants Creek (Yes or Blank)" and on the next line include "DOT a Significant Contribution in Salem Creek (Yes or Blank)".*

RESPONSE: DWQ has added this distinction to the final TMDL document.

COMMENT: *Additionally, we respectfully request that if the modeler's decision regarding DOT as a significant contributor is something other than Yes (i.e. Blank), then the word "Blank" be typed in. By typing in the word "Blank" then the reader has positive confirmation that a decision was made as opposed to a situation where the modeler may have inadvertently omitted information.*

RESPONSE: DWQ follows EPA's recommended format in which the space is left blank and the word blank is not included. This format is geared towards expressly identifying when a situation occurs, not when it does not occur or was not evaluated. For both Salem and Grants Creek TMDLs, DWQ did not expressly evaluate the NCDOT as a potential contributor. DWQ is currently working with the NCDOT to develop methodology to evaluate the role of NCDOT managed roads in contributing pollutants to impaired waterbodies.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

SEP 2 5 2006

Mr. Alan W. Klimek, P.E., Director
Division of Water Quality
North Carolina Department of Environment and
Natural Resources
1617 Mail Service Center
512 N. Salisbury Street
Raleigh, NC 27699-1617

Dear Mr. Klimek:

The United States Environmental Protection Agency (EPA) has concluded a review of the "TMDL for Fecal Coliform for Salem Creek and Turbidity for Grants Creek in North Carolina" in Yadkin-Pee Dee River Basin, as submitted by letter on July 21, 2006, by the North Carolina Department of Environment and Natural Resources (NCDENR). Based upon our review, we have determined that the statutory requirements of the Clean Water Act (CWA), Section 303(d) have been met and hereby approve the fecal coliform and turbidity TMDLs for the impaired segments identified as Salem Creek and Grants Creek.

The enclosed Decision Document summarizes the elements of the review which were found to support EPA's approval of the TMDL. If you have any comments or questions relating to the approval of this TMDL or the enclosed Decision Document, please contact Bill Melville of my staff at (404) 562-9266.

Sincerely,

Gail Mitchell for

James D. Giattina, Director
Water management Division

Enclosure

cc: Michelle Woolfolk