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

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Cape Fear River Basin and Roanoke River Basin

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SUMMARY SHEET

Total Maximum Daily Load (TMDL)

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1. 303(d) Listed Water Body Information

State: North Carolina

Counties: Alamance, Caswell, Durham, Forsyth, Guilford, Randolph, Rockingham, Stokes, and Surry
Major River Basins: Cape Fear River Basin (03030002 & 03030003) and Roanoke River Basin (03010103)
Watersheds: Haw River, Deep River, Third Fork Creek, and Dan River

Impaired Water Body (2002 303(d) List):

Water Body Name - (AU)	Water Quality Classification	Subbasin 6-digit Code	Impairment	Length (mi)
Haw River – 16-(1)d	C - Aquatic life and secondary contact recreation	03-06-02	Turbidity	13
Haw River – 16-(1)d	C - Aquatic life and secondary contact recreation	03-06-02	Fecal Coliform	13
Deep River - 17-(4)b	WS-IV – Potable water supply	03-06-08	Fecal Coliform	6.8
Third Fork Creek 16-41-1-12-(2)	WS-IV - Potable water supply	03-06-05	Turbidity	3.6
Dan River – 22-(31.5)	WS-IV - Potable water supply	03-02-03	Turbidity	14.2

Constituent(s) of Concern: Fecal Coliform Bacteria and Turbidity

Designated Uses: Biological integrity, water supply, propagation of aquatic life, and recreation.

Applicable Water Quality Standards for Class C and Class WS IV 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

Analysis/Modeling:

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 95^{th} and 10^{th} percent flow exceeded (excludes extreme drought (>95^{th} percentile) and floods (<10^{th} 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. Allocation Watershed/Stream Reach

Pollutants / Watersheds	Existing Load	WLA[1]	LA	MOS	TMDL	Percent Reduction
I. TSS (tons/day)						
Haw River	183.16	22.31	48.95	Explicit 10 %	71.26	61
Third Fork	1.58	0.36	0.39	Explicit 10 %	0.75	53
Dan River	248.20	1.21	100.53	Explicit 10 %	101.74	59
II. Fecal Coliform (#/day)						
Haw River	1.44E+13	1.79E+12	1.56E+12	Explicit 10 %	3.35E+12	77
Deep River	2.47E+12	5.87E+11	3.42E+10	Explicit 10 %	6.22E+11	75

Notes:

WLA = wasteload allocation, LA = load allocation, MOS = margin of safety.

1. WLA = TMDL – LA - MOS; where TMDL is the average allowable load between the 95th and 10th percent flow exceeded.

2. Margin of safety (MOS) equivalent to 10 percent of the target concentration for fecal coliform and turbidity.

3. 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).

4. Public Notice Date: September 16, 2004

5. Submittal Date: November 3, 2004

6. Establishment Date:

7. EPA Lead on TMDL (EPA or blank): No

8. TMDL Considers Point Source, Nonpoint Source, or both: Both

Table of Contents

1. Introduction

This report presents the development of Total Maximum Daily Loads (TMDLs) for four water bodies in North Carolina: Haw River, Deep River, Third Fork Creek, and Dan River. The first three water-bodies are located in the Cape Fear River Basin (CFRB) (Figure 1.1) while the Dan River is located in the Roanoke River Basin (RRB) (Figure 1.2). As identified by the North Carolina Division of Water Quality (DWQ), the impaired segments of the four water bodies are as follows (NCDENR 2003):

- The Haw River in the CFRB is impaired due to fecal coliform and turbidity. The impaired segment is located in sub-basin 30602 from NC 87 to NC 49. This section of the river runs approximately 13 miles and is designated as a class C water[1].

- The Deep River in the CFRB is impaired due to fecal coliform. The impaired segment is located in sub-basin 30608 from SR 1113 to SR 1921. This section of the stream runs approximately 7 miles and is designated as a class WS-IV water[2].

- The Third Fork Creek in the CFRB is impaired due to turbidity. The impaired segment is located in sub-basin 30605 from 2.0 miles upstream of NC Hwy 54 to New Hope Creek. This section of the stream runs approximately 4 miles and is designated as a class WS-IV water[2].

- The Dan River in the RRB is impaired due to turbidity. The impaired segment is located in sub-basin 30203 from a point 0.7 mile upstream of Jacobs Creek to a point of 0.8 mile down stream of Matrimony Creek. This section of the stream runs approximately 14 miles and is designated as a class WS-IV water[2].

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] 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] Class WS-IV waters are used as sources of potable water supply where WS-1, WS-II or WS-III classification is not feasible. WS-IV waters are generally in moderately to highly developed watersheds or Protected Areas, and involve no categorical restrictions on discharges.

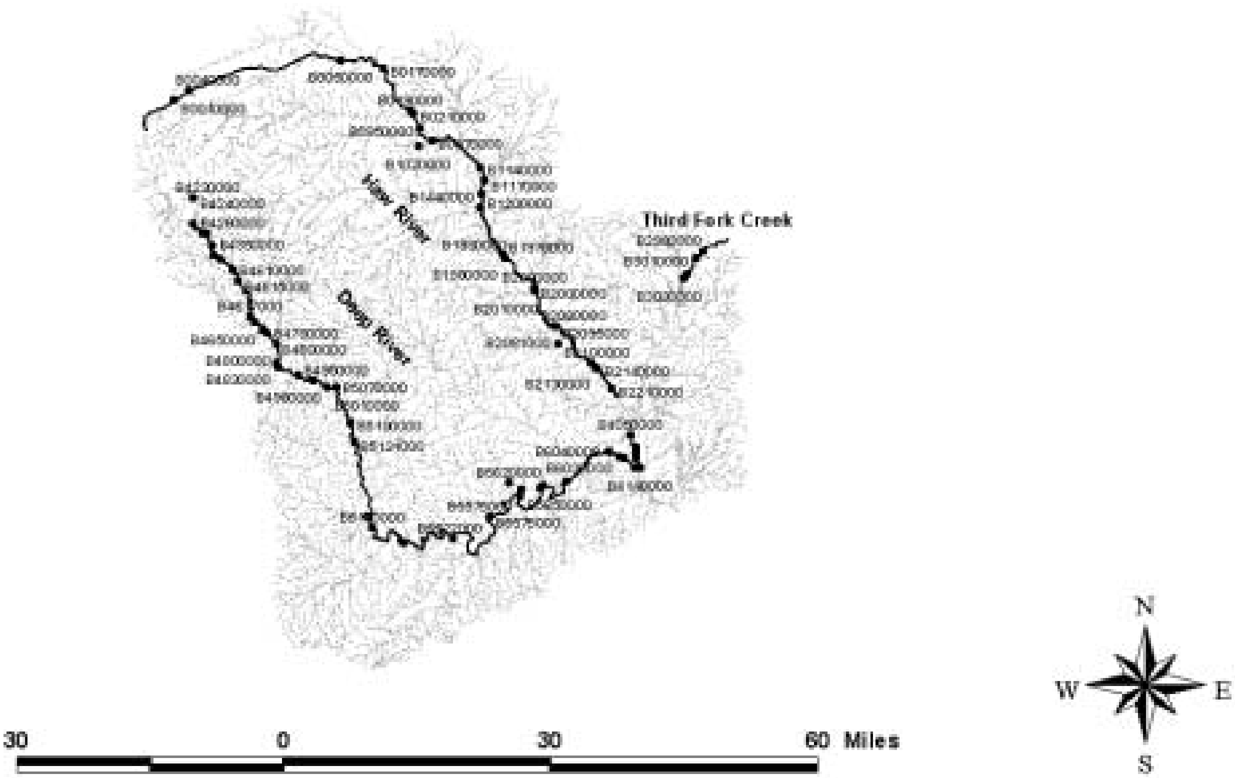

Figure 1.1. Upper Cape Fear River Basin showing Haw River, Deep River, and Third Fork Creek and water quality stations along the main water bodies.

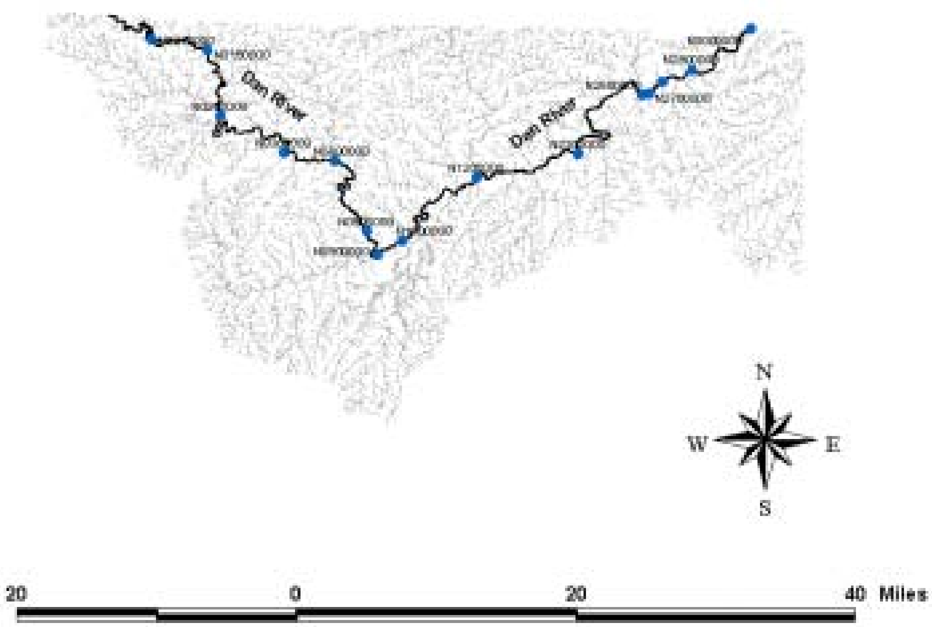

Figure 1.2. Roanoke River Basin showing the Dan River and water quality stations along the main water body.

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 non-point 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, then 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.

1.1. Watershed Description

Watershed areas that contributed turbidity and fecal coliform in the polluted section of the water bodies are manually delineated using the delineation tools provided in version 3.0 of the Better

Assessment Science Integrating Point and Non-point Sources (BASINS) system. The delineation of the watersheds was done to understand land use compositions in each watershed. The land use compositions were estimated using the BASINS default land use data, which was based on the USGS Geographic Information Retrieval and Analysis System (GIRAS). The GIRAS was developed on mid 70s; therefore, the land use compositions do not reveal the current land use status. However, it provides a comprehensible understanding of the distribution pattern of the land uses in the watersheds. The delineated watersheds and their land use distributions are shown in Figures 1.3 through 1.6. Statistics of the land use coverage are presented in Table 1.1.

Table 1.1. Land use acreages and their percent compositions in the four watersheds.

Land Use	Haw River		Deep River		Third Fork Creek		Dan River	
	Area (sq.mi)	Area (%)	Area (sq.mi)	Area (%)	Area (sq.mi)	Area (%)	Area (sq.mi)	Area (%)
Urban	112.00	18.49	36.93	29.54	9.75	59.16	33.97	2.98
Agriculture	280.40	46.27	33.68	26.94	X	X	327.64	28.74
Forest	200.10	33.02	51.31	41.05	6.25	37.93	769.39	67.49
Water/Wetland	12.18	2.01	1.93	1.54	0.03	0.21	7.30	0.64
Barren	1.15	0.19	1.18	0.94	0.44	2.69	1.60	0.14
Total	**606.00**	**100**	**125.01**	**100**	**16.48**	**100**	**1,139.89**	**100**

The Haw River, Deep River, and Third Fork Creek watersheds are spread the upper piedmont of North Carolina. The Dan River watershed is alternately flows between Virginia and North Carolina. The impaired segment of the river is located in North Carolina (Figure 1.6).

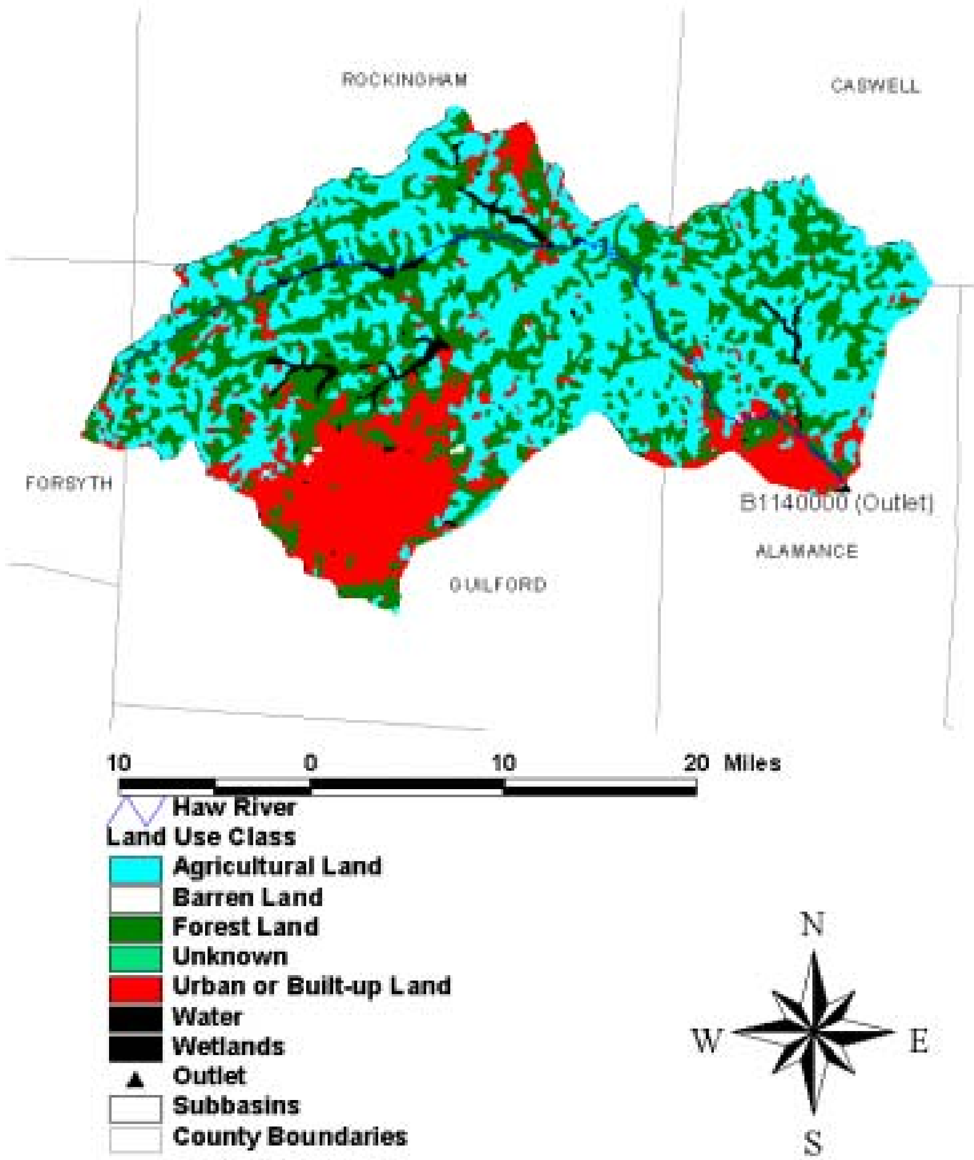

Figure 1.3. Mid 70's land use distribution in the Haw River watershed

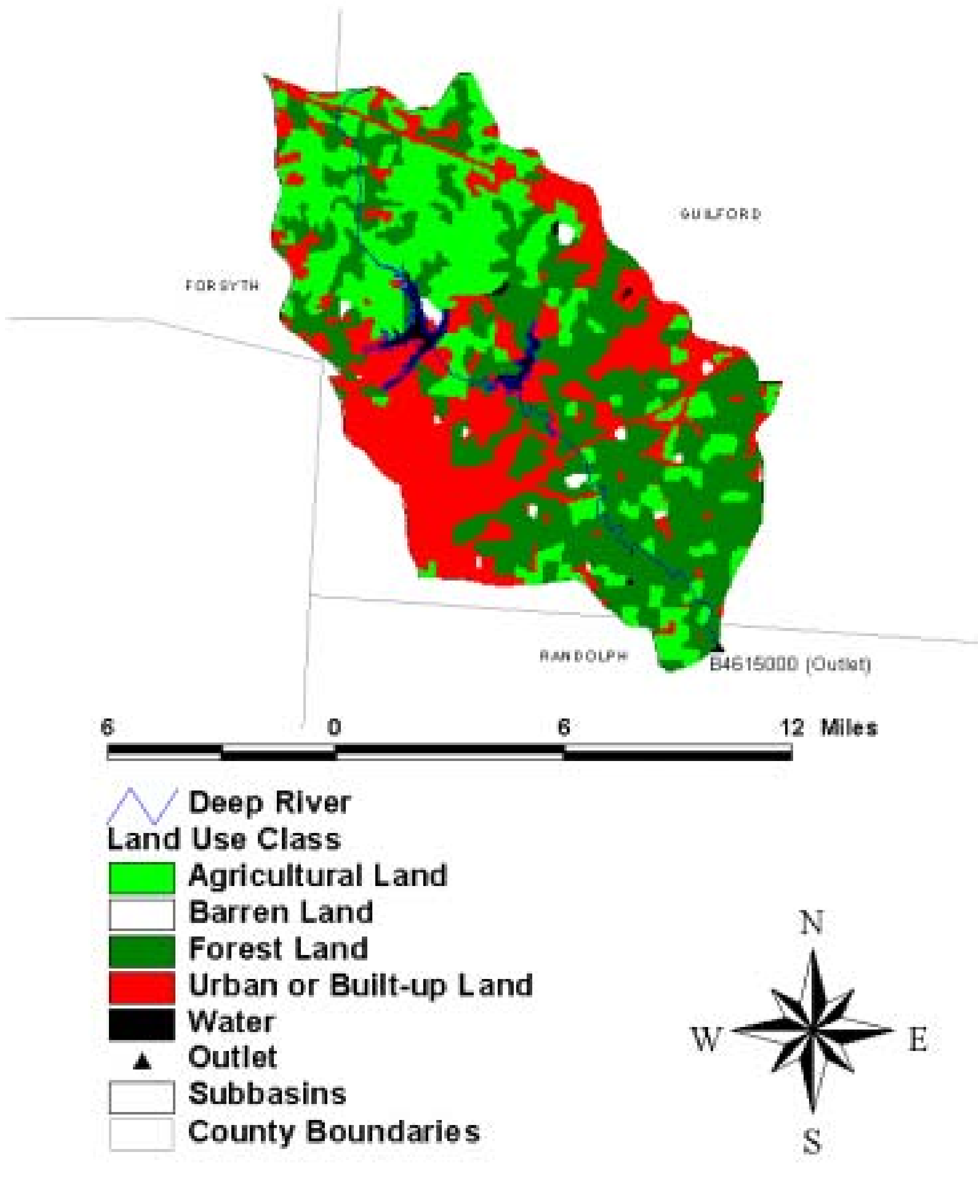

Figure 1.4. Mid 70's land use distribution in the Deep River watershed.

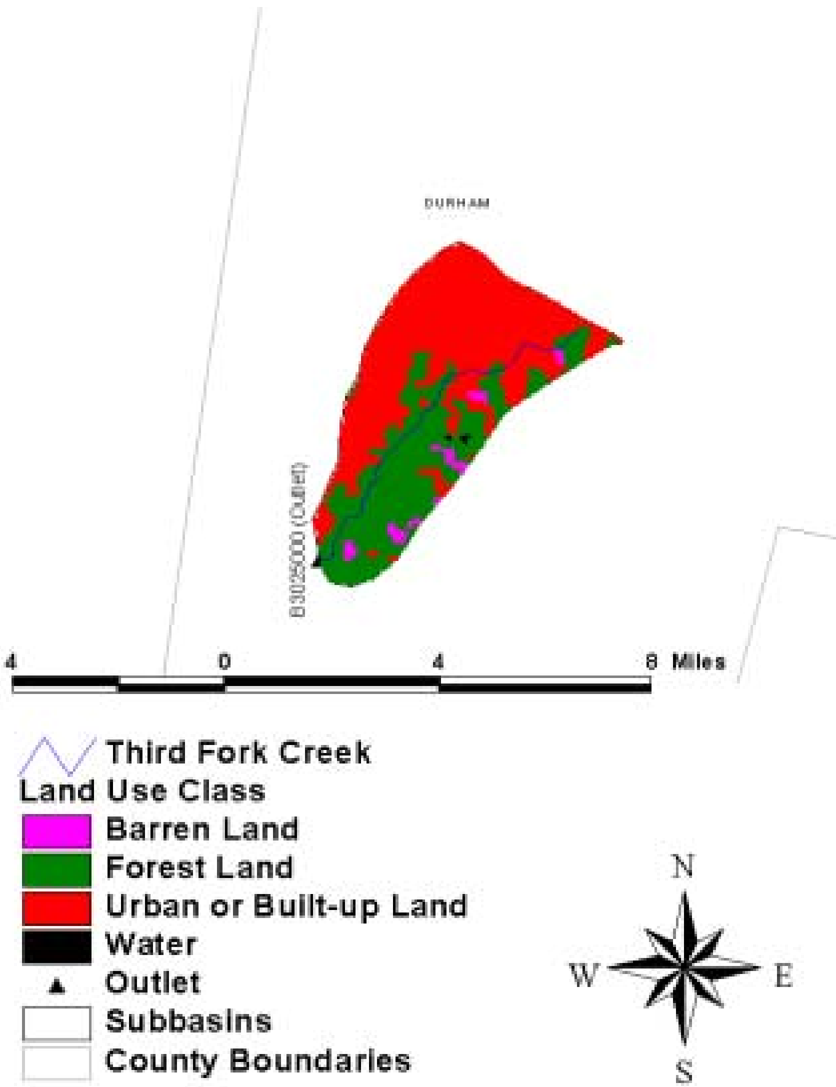

Figure 1.5. Mid 70's land use distribution in the Third Fork Creek watershed.

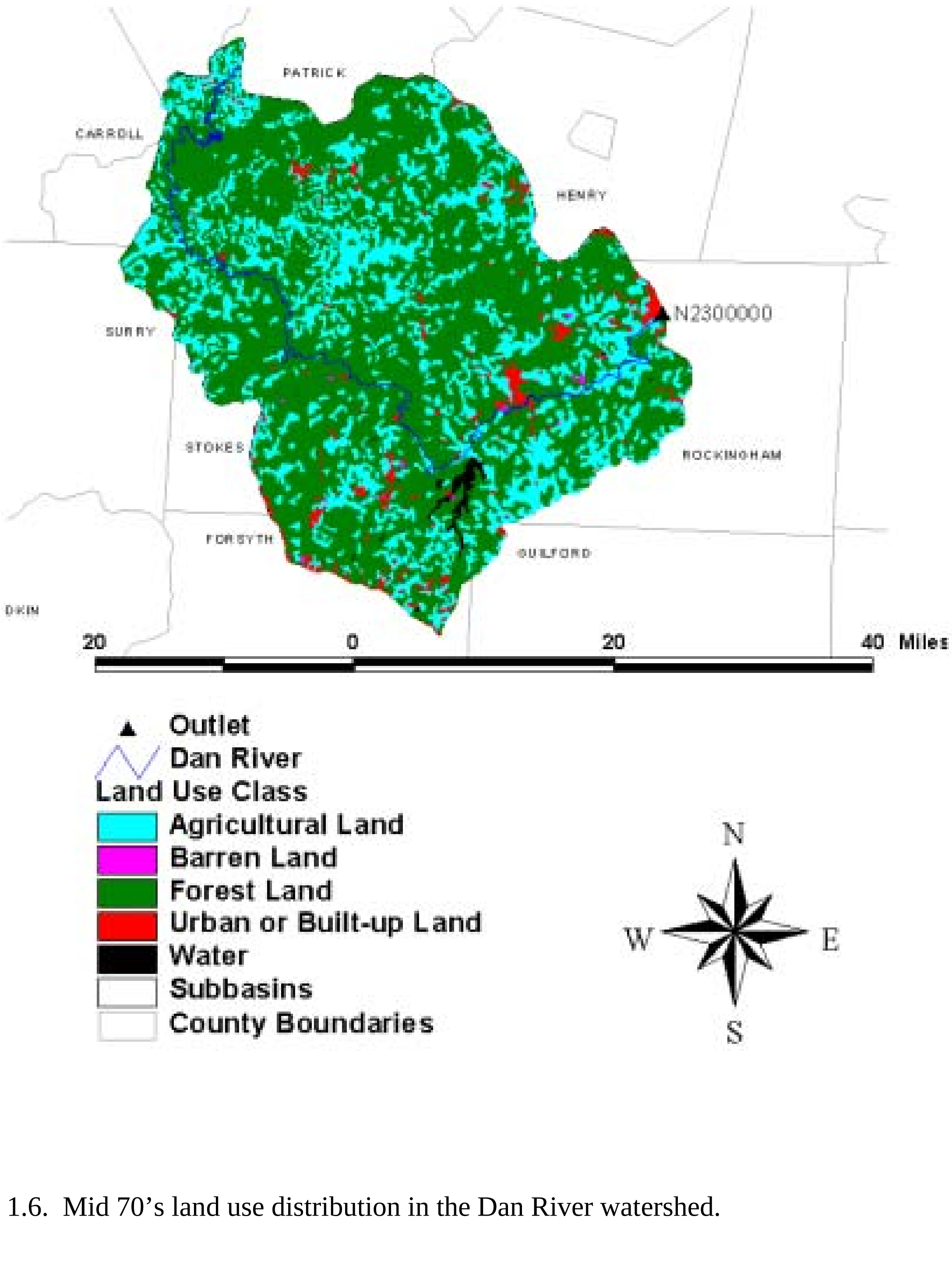

Figure 1.6. Mid 70's land use distribution in the Dan River watershed.

Dominating characteristics of land uses in the four watersheds vary. Agricultural and forested lands dominated the land uses in the Haw River watershed. Forested lands dominated the land uses in the Deep River and Dan River watersheds, whereas urban land dominated the land uses in Third Fork Creek watershed.

In recent years, significant developments have occurred and resulted in conversion of large rural parcels into residential and commercial areas in the watersheds. According to the U.S. Census, 1990 and 2000, population increased by 21 percent in Guildford and Alamance Counties. Likewise seven percent was encountered in Rockingham County. These three counties encompass the Haw River, Deep River, and Dan River watersheds. Similarly, population in Durham and Stokes Counties increased by 23 percent and 20 percent respectively. These two counties encompass the polluted section of the Third Fork Creek and Dan River watersheds respectively. The Dan River watershed also spreads through Patrick County and Henry County in Virginia. Population increments in the two counties were only 11 percent and 1 percent respectively, which is indeed comparatively insignificant.

Conversion of rural areas to urban land uses can significantly enhance soil erosion. Higher imperviousness of the new land use increases urban runoff volume and therefore, results in erosion of surface soils and stream channels. The DWQ conducted a special study in the Haw River watershed to understand the magnitude of sediment loading due to urbanization. The DWQ collected water samples at the ambient station, B1140000, in the watershed for a six-week period from 01/06/04 through 02/16/04. The station is located approximately 0.15 miles downstream from Hwy 49, at USGS station # 02096500, and receives runoff from both agricultural and urban lands. The major urban areas are Greensboro and Burlington.

Two major storm events occurred during the special study period (Figure 1.7). The first storm event occurred during the early morning of 2/3/04. The storm increased the flow from 381 cfs to 3170 cfs in the Haw River at B1140000. The storm event occurred very rapidly over a period of approximately six hours with a precipitation total of 0.61 inches. In addition, runoff in the drainage area was enhanced due to ground saturation from the previous week ice storm. The storm event carried substantial amount of sediment and solid materials from urban as well as agricultural lands, and the turbidity level increased from 7.6 NTU to 102 NTU (Figure 1.7).

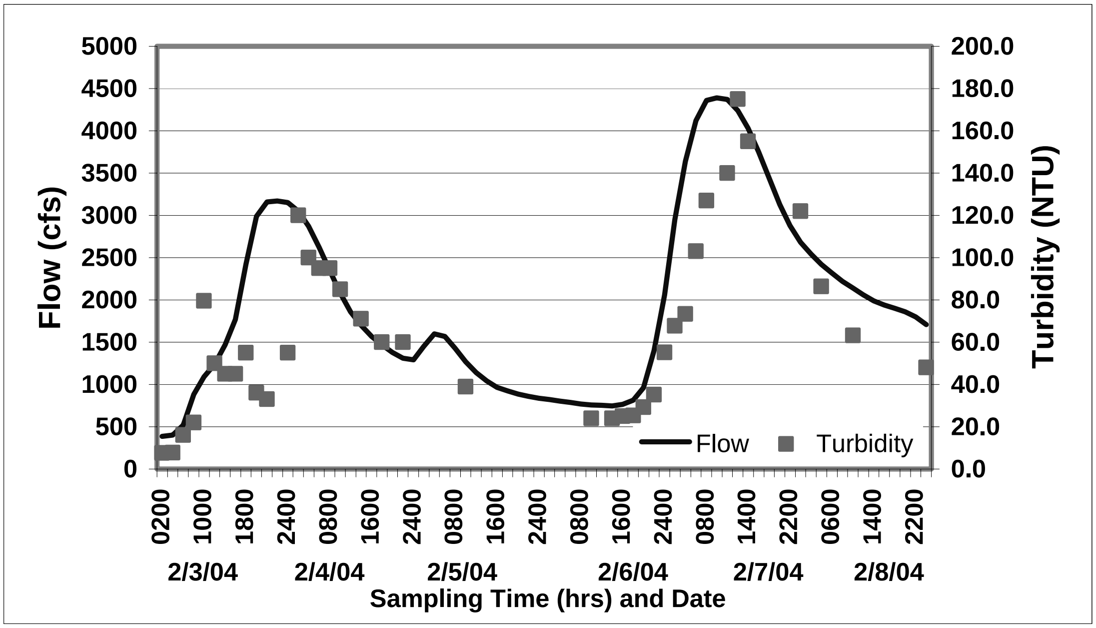

Figure 1.7. Association between turbidity and flow in the Haw River at ambient station B1140000.

The second storm event occurred on 02/06/04 and continued to 02/07/04 with 0.52 inches of precipitation. The saturated ground conditions from the previous storm events further enhanced the runoff throughout the watershed. Flow at the ambient station, B1140000, increased from 748 cfs to 4,390 cfs, and turbidity levels increased from 24 NTU to 175 NTU.

During the six weeks period, a significant relationship between turbidity and flow was observed in the Haw River, where urban lands are rapidly expanding. The relationship is given in Equation 1.1 below. In the Haw River, turbidity increased by 0.03 NTU for every flow increase and remained constant at 5.67 NTU on an average during no flow period.

Turbidity = 5.67 + 0.03 * Flow R-Square = 0.66 ----------------------------(1.1)

The conversion of rural land uses will shift the non-point source contribution of fecal coliform from agriculture activities such as cattle grazing and manure application to urban sources such as fecal waste from waste household pets, sanitary sewer overflows (SSOs) and leaking sewer lines.

Generally, fecal coliform contribution from SSOs and leaking sewer lines will be more obvious during typical and low periods. In a study conducted by the Piedmont Triad Council of Governments (PTCOG) in the East Fork Deep watershed (an upper part of the Deep River watershed), occasional exceedances of fecal coliform due to SSOs, leaking sewer lines, and direct pipelines are predicted (NCDENR, 2004).

1.2. Water Quality Target: North Carolina Water Quality Standard.

1.2.1. 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.*

1.2.2. 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.*

1.3. Water Quality Monitoring

The DWQ monitored water quality parameters which include fecal coliform, total suspended solids (TSS), and turbidity, in the three water bodies: Haw River, Deep River, and Dan River. The ambient stations – B1140000 near NC Hwy 49, B4615000 near Randleman, and N2300000 near Wentworth – were responsible for the 303(d) listing of a portion of the three water bodies respectively (Figures 1.1 and 1.2). The DWQ monitored the three ambient stations regularly from January 1997 through March 2004 (Appendix 11.1). The water samples were collected monthly for water quality assessment. A summary of the fecal coliform and turbidity data collected is presented in Table 1.2.

The Upper Cape Fear River Basin Association (UCFRBA) monitored the Third Fork Creek at the coalition station B3025000 at Hwy 54 (Figure 1.1). The association collected water samples monthly for the period from April 26, 2002 through September 25, 2003 to examine water quality parameters, which include fecal coliform, TSS, and turbidity. A summary of the fecal coliform and turbidity data collected in the coalition stations is also presented in Table 1.2.

Table 1.2: Summary of water quality monitoring for turbidity and fecal coliform impairment.

Water Bodies/ Parameters	Sampling periods	Number of samples collected	Number greater than standard	Exceeding percentage	Responsible organization
1. Haw River					
Fecal Coliform	1/97 – 9/03	80	21 [a]	26	DWQ
Fecal coliform	5/02 – 7/02	12	0 [b]	0	DWQ
Turbidity	1/97 – 9/03	73	8 [c]	11	DWQ
2. Deep River					
Fecal Coliform	1/97 – 9/03	72	17 [a]	24	DWQ
3. Third Fork Creek					
Turbidity	4/00 – 9/03	42	5	12	UCFRBA
4. Dan River					
Turbidiy	2/97 – 3/04	78	12	15	DWQ

[a] Instataneous fecal coliform measurement > 400 counts/100ml.
[b] 30-day Geometric mean of fecal coliform measurements > 200 counts/100ml.
[c] Turbidity measurements > 50 NTU.

1.3.1. Turbidity

The instantaneous data suggest that the turbidity level exceeded 50 NTU in more than 10% during the study period at the sites, B1140000, B3025000, and N2300000, in the Haw River, Third Fork Creek, and Dan River respectively (Table 1.2). It appears that there were occasional excursions of turbidity above the water quality standards.

1.3.2. Fecal Coliform

The DWQ launched an additional intensive fecal coliform monitoring program in the Haw River from May 21, 2002 through July 9, 2002 to assess the impairment status with regards to the standards specification requiring five samples per 30-day period. A total of 12 samples were collected during the period (Table 1.2). The data was utilized to estimate the 30-day geometric mean to examine whether fecal coliform exceeded the water quality standard, 200 counts /100 mL, at the ambient station, B1140000. None of the geometric means of fecal coliform exceeded the water quality standard (Figure 1.8).

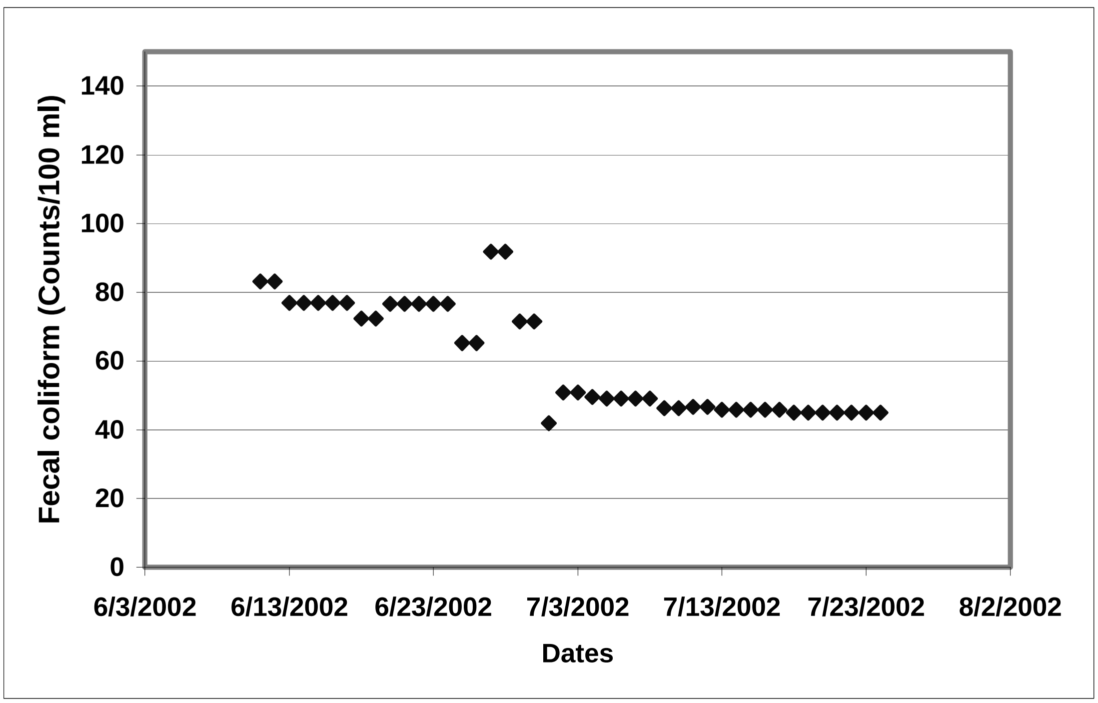

Figure 1.8. Rolling 30-day geometric mean of observed fecal coliform concentration in the Haw River at station B1140000.

Although the geometric mean of fecal coliform did not exceed 200 counts / 100ml at the ambient sites, B1140000, in the Haw River, the instantaneous data did, however, suggest that the fecal colifrom concentration exceeded 400 counts / 100ml in more than 20 % of the samples examined during January 1997 through September 2003 (Table 1.2).

Similar to the Haw River, the fecal coliform concentration also exceeded 400 counts / 100ml in more than 20 % of the samples examined at B4615000 in the Deep River. However, an additional intensive fecal coliform monitoring program with regards to the standards specification requiring five samples per 30-day period was not launched in the Deep River due to limitation in time. Therefore, evaluation of fecal coliform contamination in terms of geometric mean was not conducted for the Deep River.

2. General Source Assessment

Generally, sources of fecal coliform and turbidity may be point or non-point in nature. Point sources are typically those regulated under the National Pollution Discharge Elimination System (NPDES) program. Non-point sources are diffuse sources that typically cannot be identified as entering a water body at a single location. Following sections describe point and non-point sources of turbidity and fecal coliform.

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). The relationship between Turbidity and TSS is discussed below.

2.1.1. Non-point Sources of Turbidity

Potential sources of turbidity from non-point sources are forests, agricultural lands, construction sites, urban runoff, and stream channel erosion. Surface runoff is the main carrier of sediments from forests, agricultural land, and construction sites. Normally, runoff flowing through natural stands, where there are not any land disturbing operations being conducted, carries insignificant amount of sediments. However, when runoff passes through logging and harvesting sites, plantation sites, and site preparation sites, the runoff would carry significant amount of sediment, thereby increasing turbidity in a stream. Similarly, runoff flowing through agricultural land can carry substantial amount of sediments. The amount of sediment depends on erodability of soils, types of agricultural practices, crop type and density, rainfall intensity, and existence and type of agricultural BMPs.

Moreover, the amount of sediment load in runoff flowing through constructed site would be substantially higher than in runoff flowing through forests and agricultural land when erosion controls are not properly maintained or required. At a construction site, vegetation cover is lost and soil surface is often disturbed. As a result, the site becomes more exposed to rainfall, and thus increases the probability of rill and gully erosion to occur. The DWQ staff noticed several developing activities such as land clearing and site preparation for residential buildings, commercial areas, roads, and highways being conducted in the Haw River and Third Fork Creek watersheds.

Urbanization also increases the amount of sediment transported to receiving waters. Impervious urban landscapes like roads, bridges, parking lots, and buildings prevent rainwater to quickly percolate into ground. In the impervious lands, rainwater remains above the surface, gathers sediments and solid materials, and runs off in large amounts.

In addition, municipalities install storm sewer systems that quickly channel the urban runoff from roads and other impervious surfaces. Urban runoff increases its velocity once it enters the storm sewer system. When it leaves the system and empties into a stream, large volumes of quickly flowing runoff erode stream banks, damage streamside vegetation, and widen stream channels.

2.1.2. 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.

2.1.2.1. 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.

2.1.2.2. NPDES General Permits

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 permitee 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.

2.1.2.3. Municipal Separate Storm Sewer System (MS4)

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.

2.2. General Sources of Fecal Coliform

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

2.2.1. Non-point Sources of Fecal Coliform

Fecal coliform from non-point sources include those sources that cannot be identified as entering the water body at a specific location. Non-point source pollution can include both urban and agricultural sources, and human and non-human sources (Table 2.1). The non-point 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
		Hobby farms

2.2.1.1. Land Use Contribution

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 faces in runoff may be a frequent source of fecal coliform loading where forest dominates the streamside.

2.2.1.2. Urban Development/Sanitary Sewer Overflows/WWTP Residual Land Application

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).

2.2.2. Point Sources of Fecal Coliform

Point sources of fecal coliform 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.

2.2.2.1. 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 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.

2.2.2.2. NPDES General Permits

General permitted facilities are required to develop a pollution prevention plan to discharge domestic wastewaters from single family residences and other domestic discharges. The permitted flow of these facilities may not in any case exceed 1000 gallon per day. The facilities require to measure BOD5, 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.

3. Haw River Impairment

3.1. Source Assessment

3.1.1. NPDES Wastewater Permits

There were 24 facilities that discharged wastewater continuously to the polluted portion of the Haw River and tributaries under the NPDES program (Table 3.1). Nine out of 24 facilities discharged wastewaters directly to the Haw River (Appendix 11.2). In general, privately own facilities were permitted to discharge daily up to 45 mg/L of TSS and 400 counts/100mL of fecal coliform, whereas publicly own facilities were permitted to discharge weekly average up to 45 mg/L of TSS and 400 counts/100mL of fecal coliform to the Haw River.

Table 3.1. NPDES Wastewater Permits in the Haw River

Permit No.	Facility Name	Permitted Flow (MGD)	TSS (mg/L)	Fecal Coliform (#/100mL)
			Daily Permitted Limits	
NC0046809	Pentecostal Holiness Church	0.02	45	400
NC0066966	Quarterstone Farm WWTP	0.16	45	400
NC0001384	Williamsburg plant	0.025	45	400
NC0045144	Western Alamance High School	0.01	45	400
NC0031607	Western Alamance Middle School	0.015	45	400
NC0046043	Oak Ridge Military Academy	0.04	45	400
NC0045161	Altamahaw/Ossipee Elementary School	0.012	45	400
NC0046019	The Summit WWTP	0.015	45	400
NC0066010	Williamsburg Elementary School	0.004	45	400
NC0003913	Altamahaw Division plant	0.15	108 lb	400
NC0065412	Pleasant Ridge WWTP	0.0235	45	400
NC0060259	Willow Oak Mobile Home Park	0.0175	135	400
NC0084778	Harvin Reaction Technology	0.11	45	400
NC0029726	Guilford Correctional Center WWTP	0.025	45	400
NC0038156	Northeast Middle & Senior High WWTP	0.032	45	400
NC0022691	Autumn Forest Manuf. Home Community	0.082	45	400
NC0001210	Monarch Hosiery Mills Incorporated	0.05	81.5 lb	NA
NC0038172	McLeansville Middle School WWTP	0.0113	45	400
NC0055271	Shields Mobile Home Park	0.006	45	400
NC0073571	Countryside Manor WWTP	0.015	45	400
			Weekly Average Permitted Limit	
NC0023868	Eastside WWTP	12	45	400 GM
NC0024881	Reidsville WWTP	7.5	45	400 GM
NC0024325	North Buffalo Creek WWTP	16	45	400 GM
NC0047384	T.Z. Osborne WWTP	40	45	400 GM

GM = Geometric Mean

3.1.2. NPDES General Permits

All construction activities in the Haw River watershed that disturb one or more acres of land are subject to NC general permit NCG010000 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 that 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 (EPA TMDL and WLA Guidance Memo, 2002). Compliance with the turbidity standard in the Haw River is expected to be met when construction and other land management activities in the Haw River 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 Haw River watershed responsible in overseeing construction activities, as to the impaired status of the Haw River and the need for a high degree of review in the construction permit review process.

Similarly, all single family residences or domestic treatment facilities who discharge wastewaters not exceeding 1000 gallons per day in the Haw River 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 2.2.2.2.

3.1.3. NPDES Stormwater MS4s

Within the Haw River watershed, there is one community that obtained an NPDES stormwater permit under the first phase of federal stormwater regulations, the City of Greensboro. The permit number for the City of Greensboro is NCS000248.

The cities of Burlington, Elon College, Gibsonville, Graham, Greenville, and Haw River are identified under the second phase of federal stormwater regulations. The City of Reidsville is identified as a possible candidate for the second phase of federal stormwater regulations. The DWQ has not issued NPDES permit numbers to the cities (from personal communication with DWQ staff, Ms. Aisha Lau).

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The ArcView software was utilized to overlay the shape files of NC municipalities over the USGS land use coverage (discussed in Section 1.1) in order to estimate the land coverage of the cities under MS4 program. Approximately all urban lands in the Haw River watershed were occupied by the cities.

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 Haw River watershed.

The NCDA also ranks each county according to the number of animals in each particular category. Guildford County had the 7^{th} highest population of milk cows in 2003 and Alamance County had the 11^{th} highest population of chickens in North Carolina in 2002. With respect to other animals, none of these counties ranks in the top fifteen in terms of population.

Table 3.2. Estimated Livestock population in the Haw River watershed above NC 49 (NCDA).

Livestock	Counties				
	Alamance	Guilford	Forsyth	Rockingham	Caswell
Swine (2002)	1.2	8.6	<1	7.6	1.3
Cattle (2003)	19.2	16	7.2	10.9	11.1
Beef Cow (2003)	7.9	7.0	3.8	4.7	4.6
Milk Cow (2003)	1.7	2.0	<0.2	0.7	<0.2
Broiler (2002)	3,300	500	<500	<500	<500
Turkey (2002)	<500	<500	<500	<500	<500
Chickens (2002)	450	100	<50	<50	<50
(Source: http://www.ncagr.com/stats/cntysumm/) Year of the census is reported for each type of livestock. Counts are reported in thousands.					

3.1.5. Septic Tanks

The upper Haw River watershed is a rapidly urbanizing area. Thus, most households have connected to water and sewer services provided by municipalities. However, there are still households that do utilize septic systems, as shown in Table 3.3.

Table 3.3. Estimated housing units using septic systems in the Haw River watershed in 2002.

County	Number of Housing Units	Number of Septic Systems	Percentage of Housing Units with Septic Systems
Alamance	57,578	550	0.96
Guilford	189,272	687	0.36
Forsyth	138,573	436	0.31
Rockingham	41,129	540	1.31
Caswell	9,899	226	2.28
Source for housing unit: http://www.deh.enr.state.nc.us/oww/Program_improvement_team/Pit_Index.htm Source for septic system: http://quickfacts.census.gov/qfd/states/			

In the City of Greensboro, residents are required to switch from septic to sewer systems within 5 years of the sewer line extension. Recently, Greensboro sewer lines were extended throughout a large portion of the watershed area.

3.2. Technical Approach

Based on the above initial data analysis, it appears that both point sources and non-point sources contributed fecal coliform and turbidity in the Haw River. Because the magnitude of fecal coliform and turbidity in a water body associates with flow condition, a load duration approach is 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 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).

3.2.1. 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 solid (TSS) was selected as a surrogate measure for this study.

In order to observe relationship between TSS and turbidity in the Haw River, a regression equation between the two parameters was developed using the observed data collected from January 1997 through September 2003 in the ambient station, B1140000, near Haw River. The relationship is shown in Equation 3.1. The coefficient of determination (R-Square) between the two parameters was 0.57; therefore, a moderate relationship between the two parameters was experienced.

$$Y = 3.9327e^{0.0432 X} \quad \text{R-Square} = 0.57 \quad \text{----------------------(3.1)}$$

Where, Y = TSS in mg/l and X = turbidity in NTU.

Equation 3.1 suggests that the Haw River yielded approximately 3.93 mg/L of TSS during natural condition (NTU = 0). The river, however, increased exponentially TSS by 0.043 mg/L for each turbidity increase. Therefore, the corresponding TSS value at the turbidity standard of 50 NTU was 34 mg/L.

3.2.2. Endpoint for Fecal Coliform

The TMDL objectives require the instream fecal coliform concentrations to meet both the instantaneous standard of 400 counts /100mL and the geometric mean standard of 200 counts / 100mL. As discussed in Section 1.3.2, the Haw River does not seem to be contaminated due to fecal coliform when the river is evaluated with regards to the geometric mean standard. Therefore, only the instantaneous standard is considered to be the endpoints for the determination of the fecal colifrom TMDL for the river.

3.2.3. Flow Duration Curve

Development of flow duration curve is the first step of 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. For that reason, daily stream data collected from January 1928 through September 2003 at the USGS gage station, 02096500, near Haw River, was utilized to develop flow duration curves. The flow duration curve is shown in Figure 3.1. Flow statistics as generated by the curves are presented in Table 3.4.

Table 3.4: Flow Statistics for the four water bodies.

High Flow (< 10^{th} percentile)	Transitional Flow (Between 10^{th} and 30^{th} percentile)	Typical Flow (Between 30^{th} and 90^{th} percentile)	Low Flow (> 90^{th} percentile)
1270 – 42000 cfs	179 – 1270 cfs	100 – 179 cfs	5 – 100 cfs

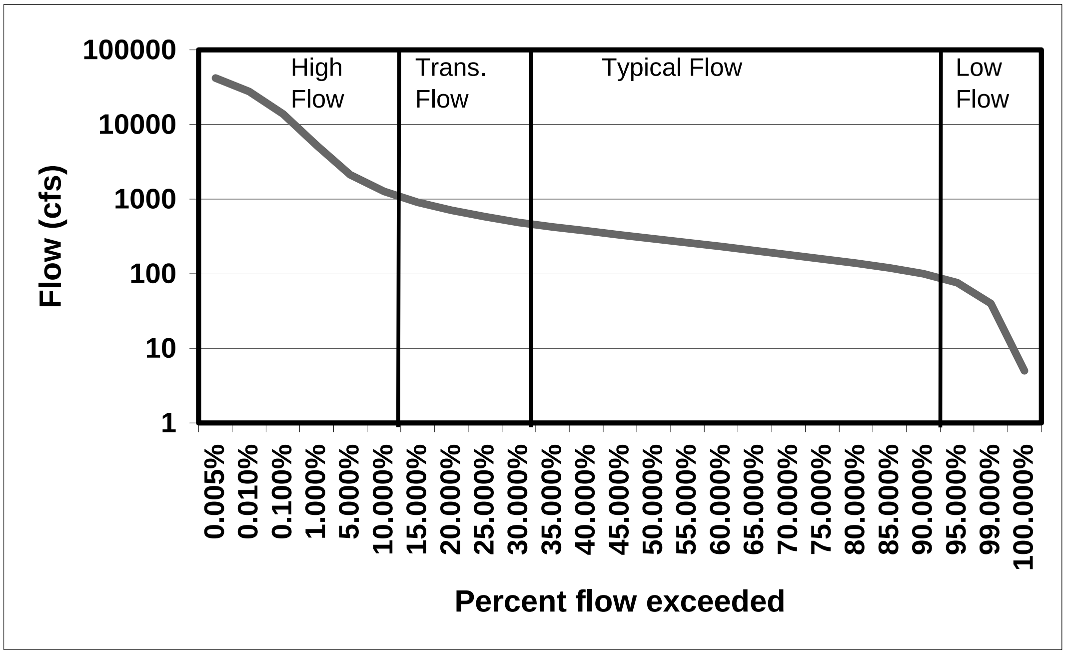


Figure 3.1. Flow Duration Curve for the Haw River at USGS 02096500.

The above flow duration curve 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 the Haw River are discussed in the following paragraphs.

3.2.4. 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 3.2, 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 mixture of point and non-point sources may cause exceedances during normal flows.

Following paragraphs discuss procedures to estimate endpoints for turbidity and fecal coliform in the Haw River in order to identify assimilative capacity of the river in each flow condition and to identify the flow regime during which exceedances occur.

3.2.4.1. Turbidity Assimilative Capacity

Existing TSS loads to the Haw River 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 50 NTU by the full range of measured flow values. Figures 3.2 presents the calculated load (scatter plot), power line (dotted line), and TMDL target loading (solid line) for the river.

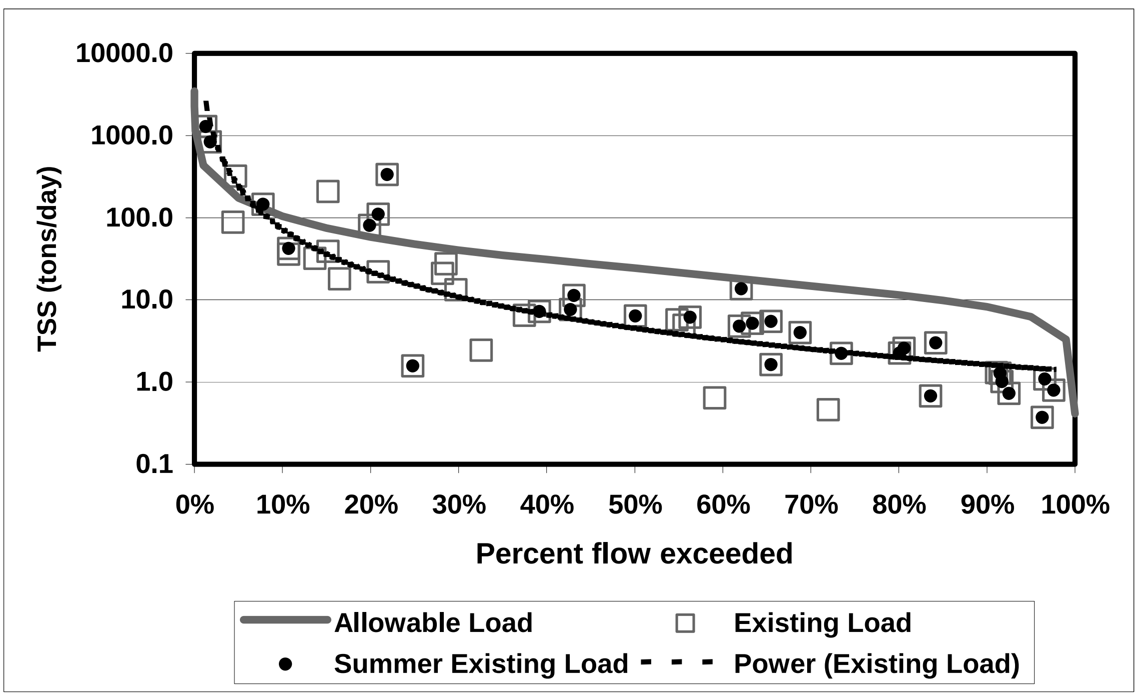


Figure 3.2. TSS Load duration curve for the Haw River at the ambient station, B1140000, from January 1997 through September 2003.

The assimilative capacity exceeded primarily during high-flows (< 10% of flow exceedance) and transitional-flows (10% –30% flow exceedance) in the Haw River. There was no TSS exceedance during typical-flows (30% - 90% flow exceedance) and low-flows (>90% flow exceedance). As evidenced by high loads during high and transitional flows suggest that the sources of turbidity could be from storm runoff and/or bank erosion. During the flow periods, runoff would carry a substantial amount of sediments and solid materials from impermeable as well as permeable land surfaces. The runoff can even transport the materials even from a far way lands.

Bank erosion may be another result of high and transitional flows. When high volume and velocity runoff exceeds the resistance of the lateral (side) soil material, bank erosion occurs. Because soils in the Haw River watershed are sandy clay loam and clay loam, which contain considerable proportion of clay and silt (Soil Survey of Guildford County, NC, 1977), bank erosion often causes high flocculation of clay and silt, thereby creating high turbidity in the river.

Furthermore, TSS load under natural background condition stayed under the turbidity standard of 50 NTU (34 mg/L) in the Haw River. The result was clearly explicated when a power line that represented average TSS loads under different flow conditions was drawn (Figure 3.2). The power line passed underneath the targeted line except during high flow period (<10% flow exceeded). The loads during high flow period is however unmanageable and hence is excluded in the TMDL estimation in this study.

3.2.4.2. Fecal Coliform Assimilative Capacity

The fecal coliform assessment also used the load duration curve approach to determine existing load and assimilative capacity. As stated in Section 3.2.2, analysis was performed for the instantaneous standard of 400 counts / 100mL to determine the most conservative measure of impairment. Figures 3.3 present the calculated loads and the TMDL target loadings for the fecal coliform.

In the Haw River, the criteria violations seem to have occurred at both high and low flows, suggesting that contamination due to fecal coliform occurred during both wet and dry weather conditions (Figure 3.3). As evidenced by high fecal coliform concentrations during dry weather/low flow, it seems that the sources of fecal coliform were near the Haw River itself. Furthermore, as evidenced by high concentrations during high flows, it seems that the sources were also far away from the river. Therefore, the results indicate that the combination of sewer pipe leakage, failing septic system, and direct pipeline had elevated the fecal coliform during dry weather/low flow in the river. Correspondingly, non-point sources and sporadic sources such as sanitary sewer overflows had elevated the fecal coliform during high flows.

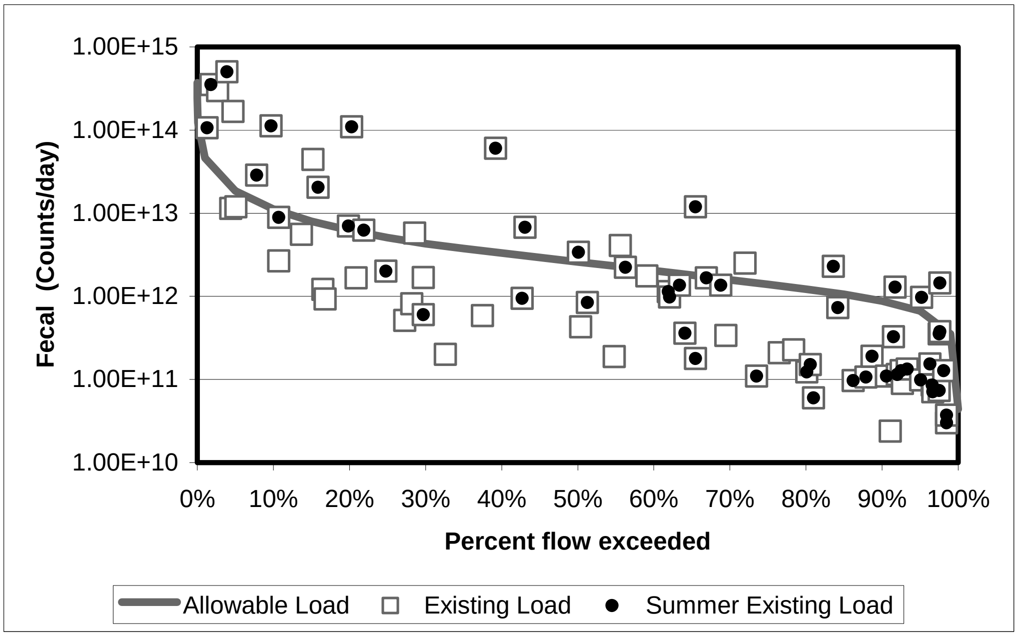


Figure 3.3. Fecal coliform load duration curve for the Haw River at the ambient station, B1140000, from January 1997 through September 2003.

3.3. Total Maximum Daily Loads (TMDL)

Sections 3.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for each pollutant in the Haw River watershed. These efforts formed the basis for the TMDL process. 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), non-point 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 3.2:

$$TMDL = \sum WLAs + \sum LAs + MOS \text{ ---------------(3.2)}$$

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 TSS (surrogate measure for turbidity) and fecal coliform contamination, TMDLs are expressed as tons per day and counts per 100 milliliter respectively. The TMDLs represent the maximum one-day load the stream can assimilate and maintain the water quality criterion.

Load duration curve approach was utilized to estimate the TMDL for TSS and fecal coliform. The systematic procedures adopted to estimate TMDLs are described below.

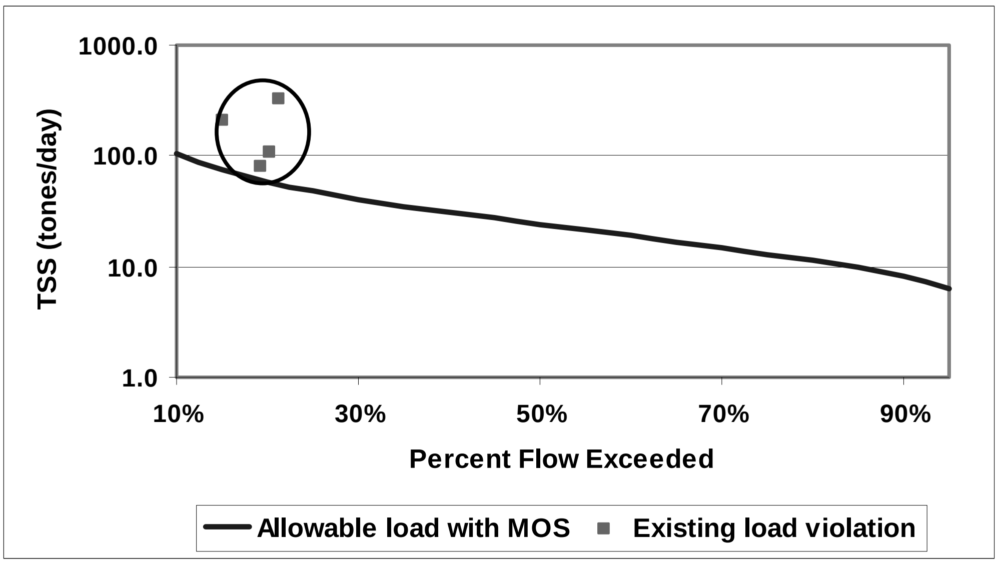
3.3.1. Margin of Safety (MOS)

Conceptually, 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 turbidity and fecal coliform.

3.3.2. Target Reduction

3.3.2.1. Turbidity

To determine the amount of turbidity reduction necessary to comply with the water quality criteria, exceedances of the estimated standard (34 mg TSS/L) were identified within the 10^{th} to 95^{th} percentile flow recurrence range. Because the assimilative capacity of the Haw River exceeded primarily during transitional-flow periods (between 10^{th} and 30^{th} percentile) (Figure 3.4), a valid power curve for existing violated loads could not be estimated from the observed data. Therefore, a simple arithmetic mean of the exceedances was used as an estimate of the existing violated load. The allowable loads for each exceedance were calculated based on the TMDL target value, which include the 10 percent MOS. The target curve based on the allowable loads and the exceedances used for the existing load are shown in Figure 3.4. The estimates of load reduction are presented in Appendix 11.3. A 61 percent reduction in TSS load is required in order to meet the water quality standard, which in tern accounts for the 10 percent margin of



safety.

Figure 3.4. Load duration curve allowable TSS load and existing total TSS load violation in the Haw River.

3.3.2.2. Fecal Coliform

The reduction for the instantaneous fecal coliform standard was estimated with the observed data that exceeded the applicable water quality standard (400 counts / 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 count / 100 mL, was not observed (see §1.3.2).

Unlike in turbidity, the criteria violations seem to have occurred at both high and low flows in the Haw River. A power curve equation for the data point violating the water quality criterion was estimated. The equation is presented in Equation 3.3. The coefficient of determination, R-Square, for the equation is 0.60; thus suggesting a reasonable fit of the equation.

$$Y = (2E+12) * X^{(-1.6432)} \quad \text{R-Square} = 0.60 \text{ -------------------------------(3.3)}$$

Where, Y = fecal coliform (Counts/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 exceedance in multiple 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 3.5.

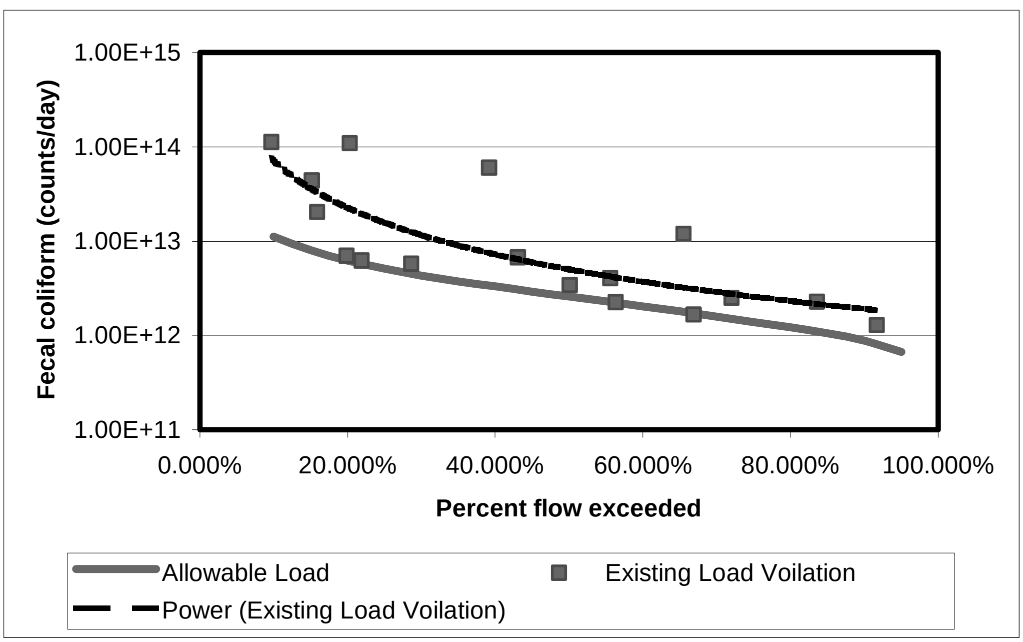


Figure 3.5. Load duration curve showing allowable and existing loads of fecal coliform in the Haw River.

The necessary percent reduction was calculated by taking a 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 11.3. The estimated average fecal coliform loads were 1.144E+13 counts per day and 3.35E+12 counts per day for the power curve and allowable load curve, respectively. This equates to an average 77 percent reduction in load.

3.3.3. TMDL Allocation

As identified by the above load duration curve method, significant amounts of TSS and fecal coliform are required to be reduced in the Haw River. A summary of reductions required is provided in Table 3.5.

Table 3.5. Reduction Required for TSS and Fecal Coliform

Pollutants	Target with MOS	Existing Load	Allowable Load	Reduction Required
I. TSS[1]	< 31 mg/L	183.16 tons/day	71.26 tons/day	61 %
II. Fecal Coliform[2]	< 360 #/100mL	1.44E+13 #/day	3.35E+12 #/day	77 %

[1] TSS is used as a surrogate variable for turbidity
[2] Instantaneous measurement of fecal coliform is used.

In order to meet the TMDL objectives, the reduction should be distributed over both point and non-point sources. A further analysis is, therefore, required to determine the breakdown between point source and non-point source loadings.

3.3.3.1. Waste Load Allocation (WLA)

All TSS and 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 TSS and 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 method that was used to estimate relative percent contribution of TSS and fecal coliform from the urban and rural sources for this study are presented in Appendix

11.4. The estimated relative percent contribution from the MS4 and rural areas (non-point sources including non-MS4 area) are presented in Table 3.6.

Table 3.6. Relative TSS and Fecal Coliform Contribution Rates for the Haw River.

Pollutants	Load from MS4 areas (%)	Load from other areas (%)
I. TSS	13	87
II. Fecal Coliform	19	81

The assimilative capacity determined in Section 3.2.4 was split based on the relative contributions presented in Table 3.6 to determine the allocation for the MS4 areas. The results of these calculations are summarized in Table 3.7.

The WLA associated with construction and other land management activities, as discussed in Section 3.1.2, 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 constriction permits rather than as numeric effluent limits.

3.3.3.2. Load Allocation (LA)

All TSS and fecal coliform loadings from non-point 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 11.4). The estimated relative percent contribution of TSS and fecal coliform from the non-point sources are presented in Table 3.7.

The assimilative capacity determined in Section 3.2.4 was split based on the relative contributions presented in Table 3.6 to determine the allocation for the non-point sources. The results of these calculations are summarized in Table 3.7.

Table 3.7. Estimated TMDL and Load Allocation for TSS and Fecal Coliform for the Haw River Watershed.

Pollutants	Existing Load	Construct-ion Activities	NPDES	MS4	WLA[1]	LA	MOS	TMDL
I. TSS (tons/day)	183.16	50 NTU	13.05	9.26	22.31	48.95	Explicit 10 %	71.26
II. Fecal Coliform (#/day)	1.44E+13	NA	1.15E+12	6.37E+11	1.79E+12	1.56E+12	Explicit 10 %	3.35E+12

[1]WLA = MS4 + NPDES (including construction activities)

3.3.3.3. Study Limitation

The available land cover for this study is outdated and fails to represent current land use condition. 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. In the load duration curves, the black mark inside a square box indicates pollutant transport during summer period.

According to the load duration curve (Figure 3.2), the greatest frequency of exceedances of turbidity occurred during high-flow periods throughout the season. The result shows that wet weather under high-flow period is the critical period for turbidity in the Haw River.

However, the existing load violation for fecal coliform occurred at all flow conditions throughout the season (Figure 3.3). Therefore, both dry and wet weathers are critical for fecal coliform.

4. Deep River Impairment

4.1. Source Assessment

4.1.1. NPDES Wastewater Permits

There were about 5 facilities that discharged wastewater continuously to the polluted portion of the Deep River and tributaries under the NPDES program (Table 4.1). The facilities were permitted to discharge up to 400 counts/100mL of fecal coliform daily. However, none of the facilities discharged wastewaters directly to the river (Appendix 11.2).

Table 4. 1. NPDES Wastewater Permits in the Deep River

Permit No.	Facility Name	Permitted Flow (MGD)	Daily Permitted Limits Fecal Coliform (#/100mL)
NC0038091	Southern Elementary School	0.0075	400
NC0038229	Southern Guilford High School	0.012	400
NC0055255	Crown Mobile Home Park	0.042	400
NC0041483	Plaza Mobile Home Park	0.003	400
			Weekly Average Permitted Limits
NC0024210	East Side WWTP	26	400 GM

GM = Geometric Mean

4.1.2. NPDES General Permits

All single family residences or domestic treatment facilities who discharge wastewaters not exceeding 1000 gallons per day in the Deep River 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 2.2.2.2.

4.1.3. NPDES Stormwater MS4s

Within the Deep River watershed, there is one community that obtained an NPDES stormwater permit under the first phase of federal stormwater regulations, the City of Greensboro. The cities of High Point and Archdale are identified under the second phase of federal stormwater regulations. The DWQ has not issued NPDES permit numbers to these cities except to the City of Greensboro. The permit number for the City of Greensboro is NCS000248.

The ArcView software was utilized to overlay the shape files of NC municipalities over the Deep River watershed (discussed in Section 1.1) in order to estimate the land coverage of the MS4 areas. All of the urban lands in river were identified for the MS4 programs.

4.1.4. 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 4.2 for the Deep River watershed.

Table 4.2. Estimated Livestock population in the Deep River watershed above Randleman (NCDA).

Livestock	Counties		
	Guilford	Forsyth	Randolph
Swine (2002)	8.6	<1	34
Cattle (2003)	16	7.2	39.1
Beef Cow (2003)	7.0	3.8	16.9
Milk Cow (2003)	2.0	<0.2	4.4
Broiler (2002)	500	<500	54,300
Turkey (2002)	<500	<500	<500
Chickens (2002)	100	<50	1,200
(Source: http://www.ncagr.com/stats/cntysumm/) Year of the census is reported for each type of livestock. Counts are reported in thousands.			

4.1.5. Septic Tanks

Some residences in the Deep River watersheds use septic tanks. A majority of the residents seem to be connected to sewer systems (Table 4.3).

Table 4.3. Estimated housing units using septic systems in the Deep River watershed in 2002.

County	Number of Housing Units	Number of Septic System	Percentage of Housing Units with Septic Systems
Guilford	189,272	687	0.36
Forsyth	138,573	436	0.31
Randolph	56,701	853	1.50
Source for housing unit: http://www.deh.enr.state.nc.us/oww/Program_improvement_team/Pit_Index.htm Source for septic system: http://quickfacts.census.gov/qfd/states/			

The Eastern portion of the Deep River, where the City of High Point is located, has the highest population density. The majority of the housing units were connected to the sewer system in 1990, and more households have probably converted from septic to sewer disposal over the last decade.

The Midwestern portion of the Deep River watershed includes recent expansion of High Point. Most of the housing units in this portion are in the process of converting form septic tank to sewer system.

4.2. Technical Approach

As discussed in Section 3.2, a load duration approach was used to identify source types, specify assimilative capacity of a stream, and to estimate magnitude of load reduction required to meet the water quality standard. Following paragraphs demonstrate systematic procedures to develop a load duration curve for the Deep River.

4.2.1. Endpoint for Fecal Coliform

The TMDL objectives require the instream fecal coliform concentrations to meet both the instantaneous standard of 400 counts /100mL and the geometric mean standard of 200 counts / 100mL. As discussed in Section 1.3.2, an additional intensive fecal coliform monitoring program with regards to the standards specification requiring five samples per 30-day period was not launched in the Deep River due to limitation in time. Therefore, evaluation of fecal coliform contamination in terms of geometric mean was not conducted for the river. Only instantaneous standard is considered to be the endpoints for the determination of the fecal colifrom TMDL for the river.

4.2.2. Flow Duration Curve

Daily stream data collected from January 1928 through September 2003 at the USGS gage station, 02099500, near Randleman, was used to develop flow duration curves. The flow duration curve is shown in Figure 4.1. Flow statistics as generated by the curves are presented in Table 4.4.

Table 4.4. Flow Statistics for the Deep River.

High Flow (< 10^{th} percentile)	Transitional Flow (Between 10^{th} and 30^{th} percentile)	Typical Flow (Between 30^{th} and 90^{th} percentile)	Low Flow (> 90^{th} percentile)
244 – 12000 cfs	29 – 244 cfs	17 – 29 cfs	1 – 17 cfs

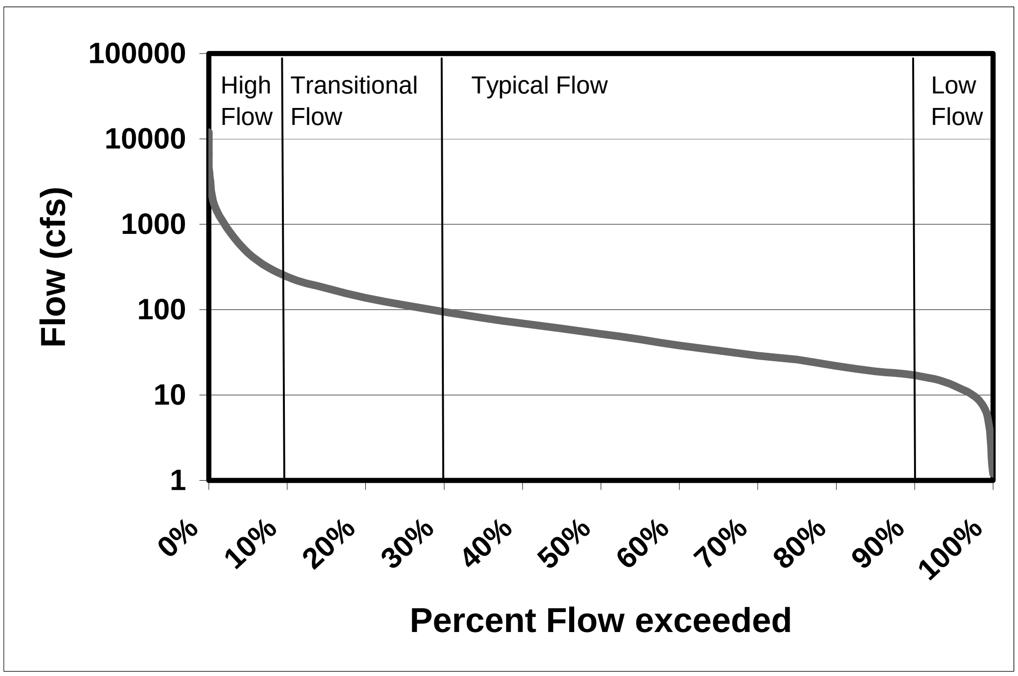


Figure 4.1. Flow Duration Curve for the Deep River at USGS 02099500.

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

4.2.3. Load Duration Curve

As discussed in Section 3.2.4, 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 4.2, 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.

4.2.4.2. Fecal Coliform Assimilative Capacity

The fecal coliform assessment used the load duration curve approach to determine existing load and assimilative capacity. As stated in Section 4.2.1, analysis was performed for the instantaneous standard of 400 counts / 100mL to determine the most conservative measure of impairment. Figures 4.2 present the calculated loads and the TMDL target loadings for the fecal coliform.

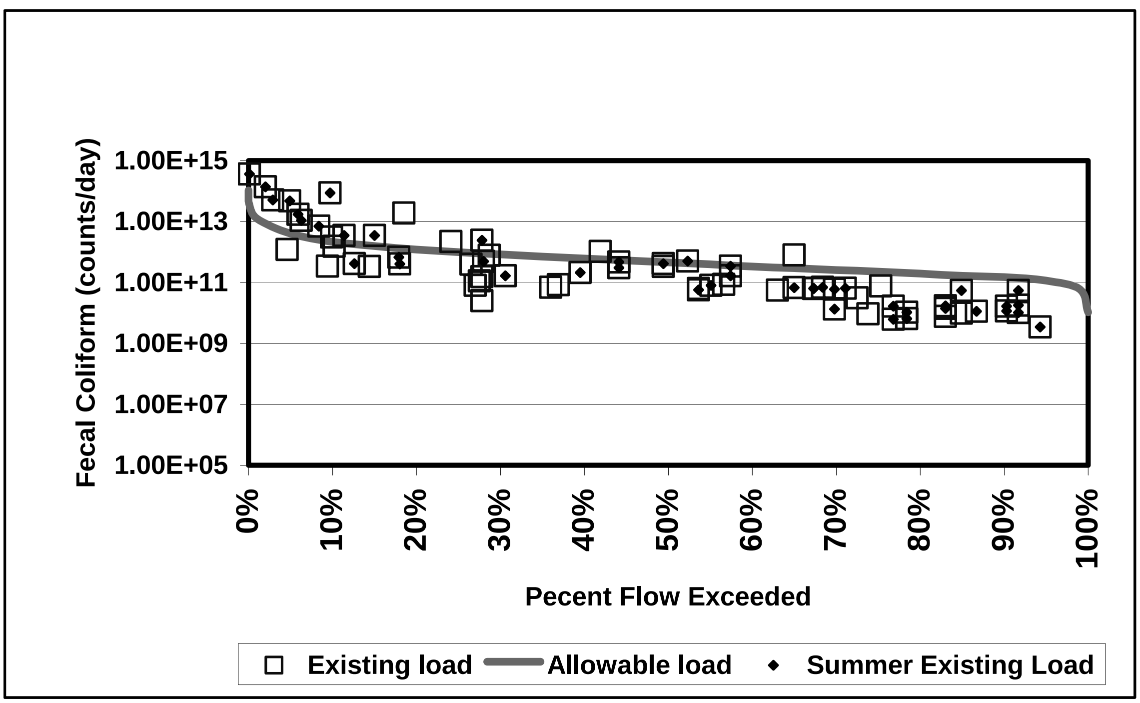


Figure 4.2. Fecal coliform load duration curve for the Deep River at the ambient station, B4615000, from January 1997 through September 2003.

There were no criteria violations during low flows in the Deep River (Figure 4.2). It seems that the sources like sewer pipe leakage, failing septic system, and direct pipeline are not the problems in the river. The criteria violations were seen to occur mostly during high and transitional flows, suggesting that the combination of non-point and sporadic sources would be the problem in the river.

4.3. Total Maximum Daily Loads (TMDL)

Sections 4.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for fecal coliform in the Deep River 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 is defined by the equation 4.1.

$$TMDL = \sum WLAs + \sum LAs + MOS \text{ ---------------(4.1)}$$

Where, WLA is waste load allocation (point source), LA is load allocation (non-point source), and MOS is marginal of safety. Detail explanation of the equation is given in Section 3.3.

4.3.1. Margin of Safety (MOS)

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.

4.3.2. Target Reduction

The reduction for the instantaneous fecal coliform standard was estimated with the observed data that exceeded the applicable water quality standard (400 counts / 100 mL) within the 10^{th} to 95^{th} percentile flow recurrence range. The criteria violations were occurring through out the flow regime except during low flow periods (Figure 4.3).

The existing loads at every 5^{th} percentile flow recurrence in the Deep River were calculated from the power curve equation (Equation 4.1). The allowable loadings were calculated from the TMDL target value, which included the 10 percent MOS. Within the 10^{th} to 95^{th} percentile flow recurrence range, the average of the two sets of loading estimates was calculated and the percent of the existing load that exceeded the target was determined. The estimated values are presented in Appendix 11.3. To meet the instantaneous limit and to account for the 10 percent MOS, about 75 percent reduction in fecal coliform is required. A summary of reductions required is provided in Table 4.5.

$$Y = (2E+11) * X^{(-1.9614)} \quad \text{R-Square} = 0.66 \text{ -------------------------------(4.2)}$$

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

Table 4.5. Reduction Required for Fecal Coliform

Pollutants	Target with MOS	Existing Load	Allowable Load	Reduction Required
Fecal Coliform[1]	< 360 #/100mL	2.47E+12 #/day	6.22E+11 #/day	75 %

[1] Instantaneous measurement of fecal coliform is used.

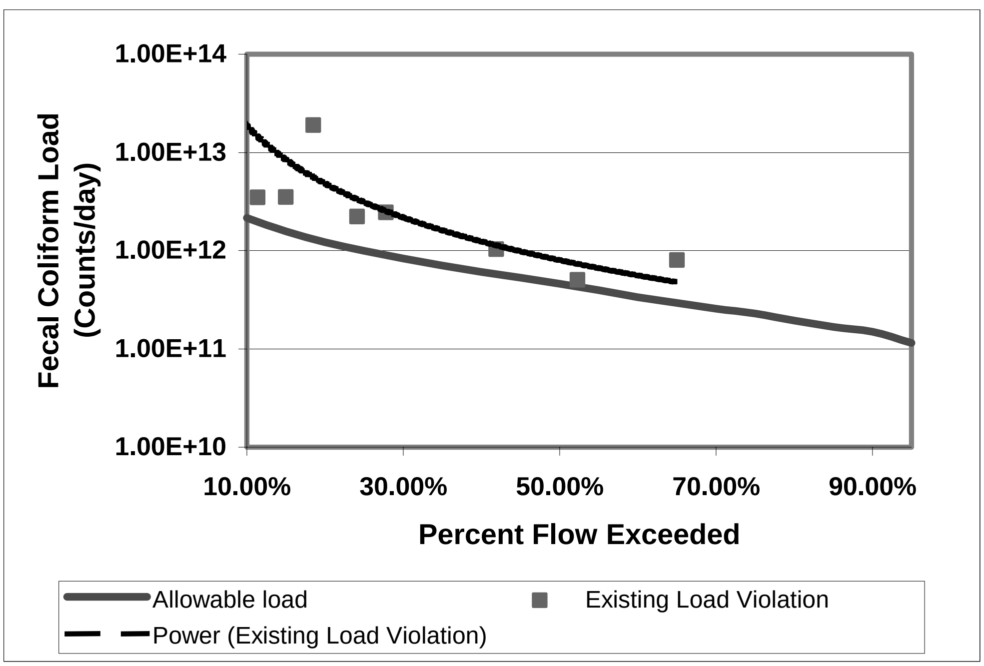


Figure 4.3. Load duration curve showing allowable and existing loads of fecal coliform in the Deep River

4.3.3. TMDL Allocation

As identified by the above load duration curve method, significant quantities of fecal coliform are required to be reduced in the Deep River. In order to meet the TMDL objectives, the reduction should be distributed over both point and non-point sources. A further analysis is, therefore, required to determine the breakdown between point source and non-point source loadings.

4.3.3.1. Waste Load Allocation (WLA)

All fecal coliform transported from the MS4 areas and wastewater facilities were assigned to the WLA components. The relative loading rates from the MS4 areas were determined as described in Section 3.3.3.1. The estimated relative percent contribution from the MS4 and rural areas (non-point sources including non-MS4 area) are presented in Table 4.6.

Table 4.6. Relative Fecal Coliform Contribution Rates for the Deep River.

Pollutants	Load from MS4 areas (%)	Load from other areas (%)
Fecal Coliform	31	69

The assimilative capacity determined in Section 4.2.2 was split based on the relative contributions presented in Table 4.6 to determine the allocation for the MS4 areas. The results of these calculations are summarized in Table 4.7.

4.3.3.2. Load Allocation (LA)

All fecal coliform loadings from non-point sources such as non-MS4 urban land, agriculture and forested lands were reported as LAs. The relative loading rates from these areas were determined using the similar procedures as described in Section 3.3.2.1 (See also Appendix 11.3). The estimated relative percent contributions of fecal coliform from the non-point sources are presented in Table 4.6.

The assimilative capacity determined in Section 4.2.3 was split based on the relative contributions presented in Table 4.6 to determine the allocation for the non-point sources. The results of these calculations are summarized in Table 4.7.

Table 4.7. Estimated TMDL and Load Allocation for Fecal Coliform for the Deep River Watershed.

Pollutants	Existing Load	NPDES	MS4	WLA[1]	LA	MOS	TMDL
Fecal Coliform (#/day)	2.47E+12	3.95E+11	1.92E+11	5.87E+11	3.42E+10	Explicit 10 %	6.22E+11

[1]WLA = MS4 + NPDES

4.3.3.3. Study Limitation

The available land cover for this study is outdated and fails to represent current land use condition. Therefore, 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).

4.3.4. Critical Condition and Seasonal Variation

According to the load duration curve (Figure 4.2), there were no violations due to fecal coliform during low–flow events in the Deep River. The violation seems to occur during high-flow events only. Therefore, wet weather is critical for fecal coliform in the Deep River.

5. Third Fork Creek Impairment

5.1. Source Assessment

The DWQ staff noticed several developing activities such as land clearing and site preparation for residential buildings, commercial areas, roads, and highways being conducted in the Third Fork Creek watershed. These activities are the main sources of turbidity. Surface runoff carries sediments and solids from these lands to the creek and increases turbidity level. In addition, point sources such as waste water treatment plants (WWTP) and MS4 areas are also responsible for TSS increment in a water body.

5.1.1. NPDES Wastewater Permits

There was only one facility, Brenntag Southeast, Inc., under the NPDES program that discharged wastewater to the Third Fork Creek (Table 5.1). The facility was permitted to discharge up to 30 mg/L of TSS daily.

Table 5.1. NPDES Wastewater Permits in the Third Fork Creek

Permit No.	Facility Name	Permitted Flow (MGD)	Daily Permitted Limits TSS (mg/L)
NC0086827	Brenntag Southeast, Inc.	0.0144	30

5.1.2. NPDES General Permits

All construction activities in the Third Fork Creek watershed that disturb one or more acres of land are subject to NC general permit NCG010000 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 briefly explained in Section 3.1.2.

5.1.3. NPDES Stormwater MS4s

The City of Durham in the Third Fork Creek watershed falls under the Phase I NPDES storm water program for MS4. All of the urban lands in the watershed were, therefore, occupied by the city.

5.2. Technical Approach

As discussed in Section 3.2, a load duration approach was adopted to determine impairment loads under different flow conditions to identify source types, specify assimilative capacity of a stream, and to estimate magnitude of load reduction required to meet the water quality standard. Following paragraphs explains its application for developing turbidity TMDL for the Third Fork Creek.

5.2.1. Endpoint for Turbidity

As discussed in Section 3.2.1, total suspended solid (TSS) was selected as a surrogate measure for the Third Fork Creek. In order to observe relationship between TSS and turbidity in the creek, a regression equation between the two parameters was developed using the observed data collected from April 2004 through September 2003 in the ambient station, B3025000. The equation is shown in Equation 5.1. The coefficient of determination between the two parameters was 0.73, suggesting a significant relationship.

$$Y = 0.0068\,X^{2} + 0.0827X + 7.7524 \quad \text{R-Square} = 0.73 \quad \text{----------------------(5.1)}$$

Where, Y = TSS in mg/l and X = turbidity in NTU.

Equation 5.2 suggests that the Third Fork Creek yielded approximately 7.75 mg/L of TSS during natural condition (NTU = 0). However, the creek showed a polynomial relationship between TSS and turbidity. Therefore, the corresponding TSS value at the turbidity standard of 50 NTU was 29 mg/L.

5.2.2. Flow Duration Curve

Daily stream data collected from January 1982 through September 2003 at the USGS gage station, 0209741955, at SR1100 near Glenlee, was used to develop flow duration curves. The gage station drains about 21 sq. miles of the Northeast Creek watershed. The watershed area is slightly bigger than the Third Fork Creek watershed (16.5 sq mi). The watershed is almost similar in characteristic and is adjacent to the Third Fork Creek at the Eastern side. Therefore, flows of the Third Fork Creek were estimated using “area ratio method.” In the method, the area ratio is first estimated by dividing the area of the Third Fork Creek watershed by the area of the Northeast Creek watershed. The flows of the Northeast Creek are then multiplied by the ratio to estimate the flows for the Third Fork Creek. The flow duration curve for the Third Fork Creek watershed is shown in Figure 5.1. Flow statistics as generated by the curves are presented in Table 5.2.

Table 5.2: Flow Statistics for the Third Fork Creek.

High Flow (< 10th percentile)	Transitional Flow (Between 10th and 30th percentile)	Typical Flow (Between 30th and 90th percentile)	Low Flow (> 90th percentile)
47 –2616 cfs	5 – 47 cfs	3 – 5 cfs	1 –3 cfs

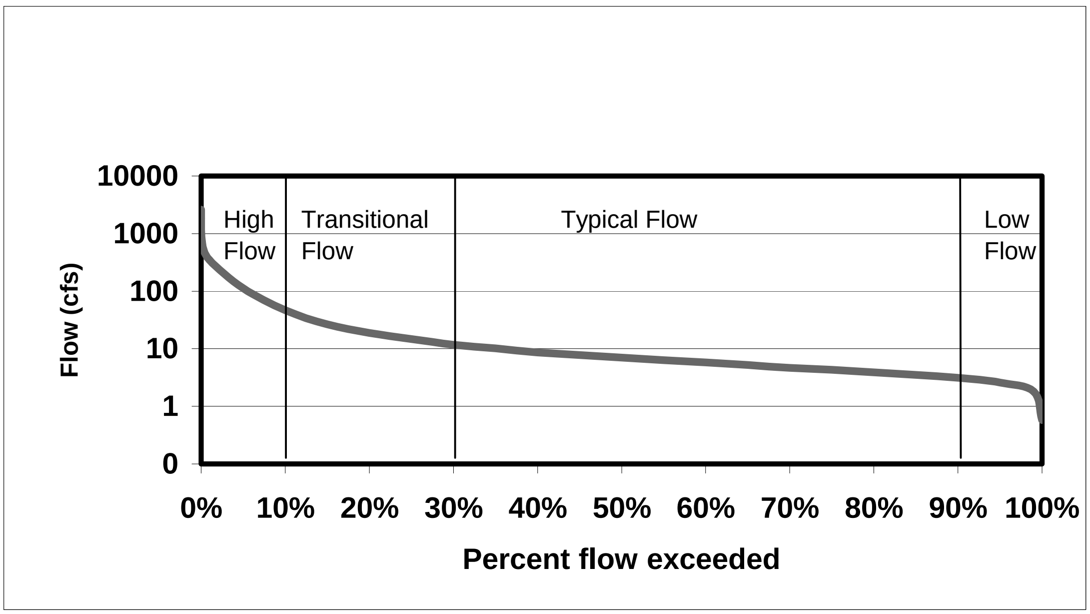


Figure 5.2. Flow Duration Curve for the Third Fork Creek. Flows from the Northeast Creek at USGS 0209741955 were used to estimate flows for the Third Fork Creek.

The flow duration curve 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.

5.2.3. Load Duration Curve

As discussed in Section 3.2.4, 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 5.2, 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.

Following paragraphs discusses procedures to estimate endpoints for turbidity in the Third Fork Creek in order to identify assimilative capacity of the creek in each flow conditions and to identify the flow regime during which exceedances occur.

5.2.4.1. Turbidity Assimilative Capacity

Existing TSS loads to the Third Fork Creek was 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 50 NTU by the full range of measured flow values. Figure 5.2 present the calculated load, (scatter plot) power line (dotted line), and the TMDL target loading (solid line) for the creek.

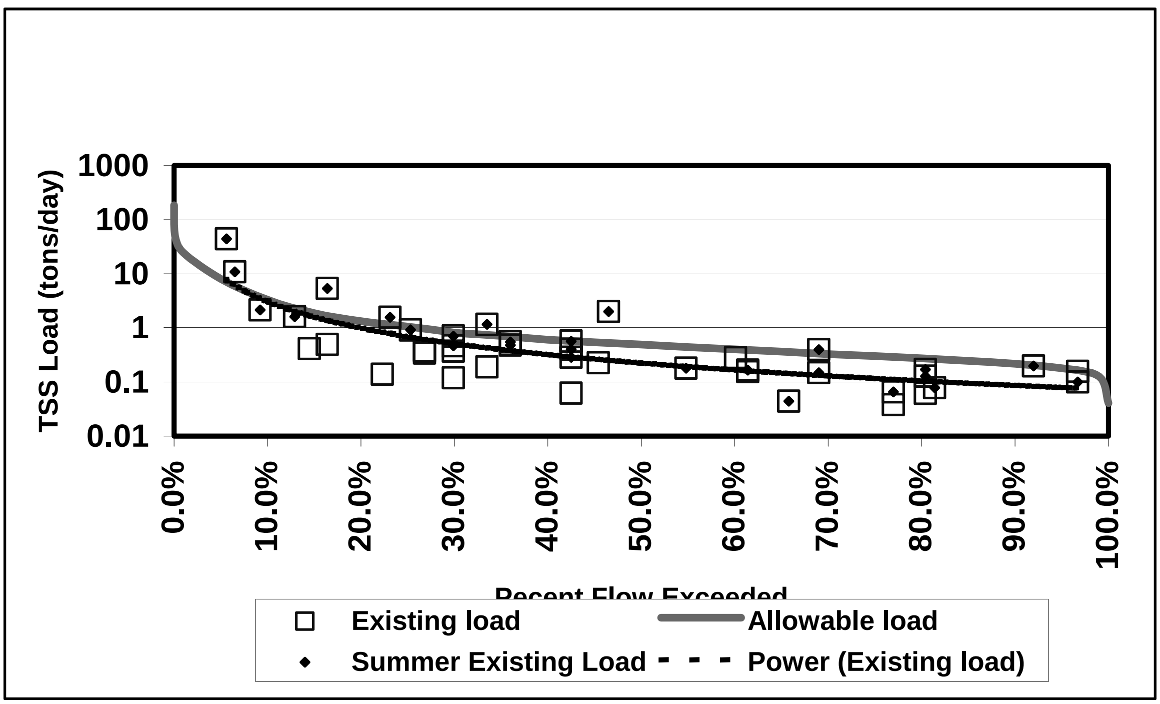


Figure 5.2. TSS Load duration curve for Third Fork Creek at the coalition station, B3025000, from April 2000 through September 2003.

Except during low flow periods, the assimilative capacity of the Third Fork Creek exceeded the targeted values (Figure 5.2). The result, therefore, suggests that non-point sources alone could have increased turbidity level in the creek.

Furthermore, the power line that represented average existing TSS loads clearly explicated that the TSS loads under natural background condition did not exceed the turbidity standard of 50 NTU (29 mg/L) in the Third Fork Creek (Figure 5.2). The power line passed underneath the targeted line except during high flow period (<10% flow exceeded), which is indeed unmanageable and hence is excluded in the TMDL estimation in this study.

5.3. Total Maximum Daily Loads (TMDL)

Sections 5.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for each pollutant in the Third Fork 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 is defined by the equation 5.2.

$$TMDL = \sum WLAs + \sum LAs + MOS \text{ ---------------(5.2)}$$

Where, WLA is waste load allocation (point source), LA is load allocation (non-point source), and MOS is marginal of safety. Detail explanation of the equation is given in Section 3.3.

Following sections describe the key components required by the TMDL guidelines to set the final TMDL allocation for the Watershed.

5.3.1. 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.

5.3.2. Target Reduction

To determine the amount of turbidity reduction necessary to comply with the water quality criteria, exceedances of the estimated standard (29 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 5.3). The power curve equation is presented in Equation 5.2. The correlation coefficient, R-Square, for the power curve is 0.71; thus suggesting a reasonable fit of the curve.

$Y = 0.3208 * X^{(-1.3974)}$ R-Square = 0.71 ---------------------------(5.2)
Where, Y = Turbidity (mg/L) and X = Percent Flow Exceeded.

The criteria violations occurred through out the typical flow regime (Figure 5.3). As described in Section 3.3, the loading estimates based on the power curve are presented in Appendix 4. Approximately 53 percent reduction in turbidity 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 5.3.

Table 5.3. Reduction Required for TSS in the Third Fork Creek

Pollutants	Target with MOS	Existing Load	Allowable Load	Reduction Required
TSS[1]	< 26 mg/L	1.58 tons/day	0.75 tons/day	53 %

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

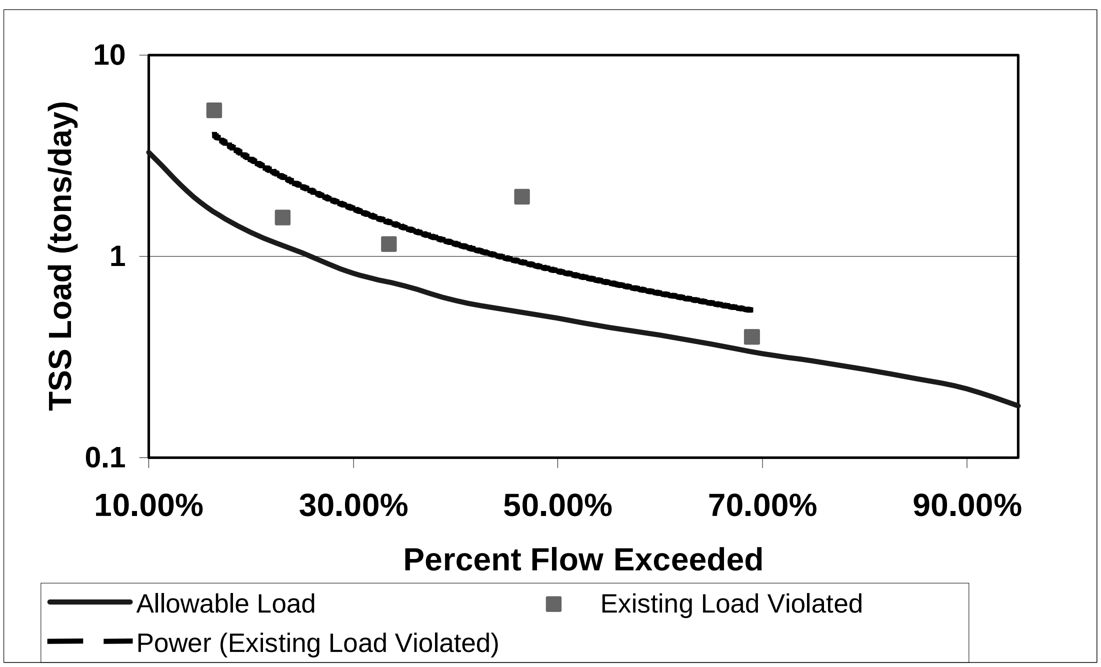


Figure 5.3. Load duration curve showing allowable and existing loads violation of the Third Fork Creek.

5.3.3. TMDL Allocation

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

5.3.3.1. Waste Load Allocation (WLA)

All TSS transported from the MS4 areas and waste load facility, Brenntag Southeast, were assigned to the WLA components. The relative loading rates from the MS4 areas are discussed in Section 3.3.3. A summary of the report and a description of method that was used to estimate relative percent contribution of TSS from the urban and rural sources are presented in Appendix 11.3. The estimated relative percent contribution from the MS4 and rural areas (non-point sources including non-MS4 area) are presented in Table 5.4.

Table 5.4. Relative TSS Contribution Rates for the Third Fork Creek.

Pollutants	Load from MS4 areas (%)	Load from other areas (%)
TSS	48	52

The assimilative capacity determined in Section 5.2.3 was split based on the relative contributions presented in Table 5.4 to determine the allocation for the MS4 areas. The results of these calculations are summarized in Table 5.5.

The WLA associated with construction and other land management activities, as discussed in Section 5.1.2, 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 constriction permits rather than as numeric effluent limits.

5.3.3.2. Load Allocation (LA)

All TSS loadings from non-point 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 11.3.) The estimated relative percent contribution of TSS from the non-point sources is presented in Table 5.5.

Table 5.5. Estimated TMDL and Load Allocation for TSS for the Third Fork Creek Watershed.

Pollutants	Existing Load	Construct-ion Activities	NPDES	MS4	WLA[1]	LA	MOS	TMDL
TSS (tons/day)	1.58	50 NTU	0.002	0.36	0.36	0.39	Explicit 10 %	0.75

[1]WLA = MS4 + NPDES (including construction activities)

5.3.3.3. Study Limitation

The available land cover for this study is outdated and fails to represent current land use condition. Therefore, the estimation of WLA in Table 5.5 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 § 2).

5.3.4. Critical Condition and Seasonal Variation

According to the load duration curve (Figure 5.2), the greatest frequency of exceedances of turbidity occurred during high-flow periods throughout the season. The result shows that wet weather under high-flow period is the critical period for turbidity in the Third Fork Creek.

6. Dan River Impairment

6.1. Source Assessment

As discussed in Section 1.1, population growth in Rockingham County and Stokes County are alarming. Several developing activities such as land clearing and site preparation for residential buildings, commercial areas, roads, and highways being conducted in the Dan River watershed. These activities are the main sources of turbidity. Surface runoff carries sediments and solids from these lands to the river and increases turbidity level. Transport of total suspended solids (TSS) from a developed land is discussed in Section 2.1.

In addition, point sources such as waste water treatment plants (WWTP) and MS4 areas are also responsible for TSS increment in a water body.

6.1.1. NPDES Wastewater Permits

There were about 26 facilities under the NPDES program that discharged wastewater to the Dan River and its tributaries (Table 6.1). Of the 26 facilities, four facilities - Kobewireland Copper Products, Madison WWTP, Danbury WWTP, and North Stokes High School - discharged wastewater directly to the Dan River (Appendix 11.2). Except JPS Elastomerics Corp-Caro Plt, the facilities were permitted to discharge up to 45 mg/L of TSS daily (Table 6.1). These facilities are located in North Carolina. Statistics of the facilities in Virginia are not documented in this study.

Table 6.1. NPDES Wastewater Permits in the Dan River

Permit No.	Facility Name	Permitted Flow (MGD)	Daily Permitted Limits TSS (mg/L)
NC0075027	Cains Way Mobile Home Park	0.0432	45
NC0078115	Greystone Subdivision WWTP	0.032	45
NC0083933	Rangecrest Road WWTP	0.06	45
NC0060461	Abington WWTP	0.385	45
NC0037311	Creekside Manor Rest Home	0.01	45
NC0028746	Briarwood Subdivision WWTP	0.05	45
NC0056791	Horizons Residential Care Ctr	0.015	45
NC0035173	Kobewireland Copper Products Incorporated	0.025	45
NC0044962	North Stokes High School	0.0115	45
NC0067091	Mikkola Downs WWTP	0.072	45
NC0029777	Stokes Correctional Center WWTP	0.0132	45
NC0059251	Quail Acres Mobile Home Park	0.018	45
NC0060542	Gold Hill Mobile Home Park	0.0176	45
NC0044750	Britthaven Of Madison	0.025	45
NC0037001	Bethany Elementary School	0.01	45
NC0003441	JPS Elastomerics Corp-Caro Plt	0.015	135
NC0044954	South Stokes High School	0.0173	45
NC0079049	R.H. Johnson Construction WWTP	0.06	45
NC0057720	Twin Lakes Mobile Home Park	0.04	45
NC0003492	R J Reynolds Tobacco Co - Brook Cove	0.02	45
			Weekly Average Permitted Limits
NC0021075	Madison WWTP	0.775	45
NC0082384	Danbury WWTP	0.1	45
NC0028011	Stoneville WWTP	0.25	45
NC0021873	Mayodan WWTP	4.5	45
NC0025526	Walnut Cove WWTP	0.5	45
NC0024406	Belews Creek Steam Station	0.01	45

6.1.2. NPDES General Permits

All construction activities in the Dan River watershed that disturb one or more acres of land are subject to NC general permit NCG010000 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 briefly explained in Section 3.1.2.

6.1.3. NPDES Stormwater MS4s

There was no municipality under the NPDES storm water program in the Dan River watershed.

6.2. Technical Approach

As discussed in Section 3.2, a load duration approach was adopted to identify source types, specify assimilative capacity of a stream, and to estimate magnitude of load reduction required to meet the water quality standard. In Section 3.2, essential components of developing a load duration curve are discussed in detail. Following paragraphs explains its application for developing turbidity TMDL for the Dan River.

6.2.1. Endpoint for Turbidity

As discussed in Section 3.2.1, total suspended solid (TSS) was selected as a surrogate measure for the Dan River. In order to observe relationship between TSS and turbidity in the River, a regression equation was developed using the observed data collected from February 1997 through March 2004 in the ambient station, N2300000. The equation is shown in Equation 6.1. The coefficient of determination between the two parameters was 0.92, thereby suggesting a significant relationship.

$$Y = 0.91\,X + 1.105 \quad \text{R-Square} = 0.92 \quad \text{----------------------(6.1)}$$

Where, Y = TSS in mg/l and X = turbidity in NTU.

Equation 6.1 suggests that the Dan River yielded approximately 1.105 mg/L of TSS under natural condition (NTU = 0). The river increased TSS on an average by 0.91 mg/L for each turbidity increase. Correspondingly, the river yielded 47 mg/L of TSS at the turbidity standard of 50 NTU.

6.2.2. Flow Duration Curve

Daily stream data collected from January 1939 through September 2003 at the USGS gage station, 02071000 near Wentworth was used to develop flow duration curves. The flow duration curve for the Dan River watershed is shown in Figure 6.1. Flow statistics as generated by the curves are presented in Table 6.2.

Table 6.2: Flow Statistics for the Dan River.

High Flow (< 10th percentile)	Transitional Flow (Between 10th and 30th percentile)	Typical Flow (Between 30th and 90th percentile)	Low Flow (> 90th percentile)
2020 – 47800 cfs	601 – 2020 cfs	396 – 601 cfs	61 – 396 cfs

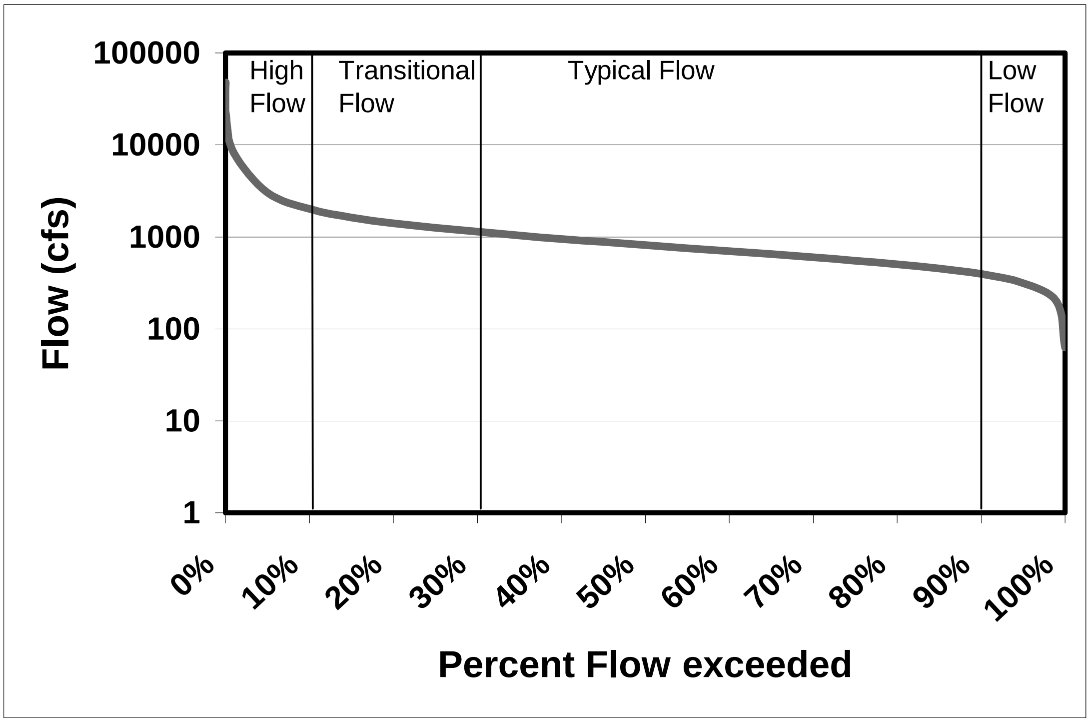


Figure 6.2. Flow Duration Curve for the Dan River at USGS 02071000 near Wentworth.

The flow duration curve was used to determine the seasonality and flow regimes during which the exceedances of the pollutants occur. It was also used to determine maximum daily pollutant load based on the flow duration and applicable standard.

6.2.3. Load Duration Curve

As discussed in Section 3.2.4, 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 6.2, 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.

Following paragraphs discusses procedures to estimate endpoints for turbidity in the Dan River in order to identify assimilative capacity of the River in each flow conditions and to identify the flow regime during which exceedances occur.

6.2.4.1. Turbidity Assimilative Capacity

Existing TSS loads to the Dan River was 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 50 NTU by the full range of measured flow values. Figure 6.2 present the calculated load (scatter plot), power line (dotted line), and the TMDL target loading (solid line) for the creek.

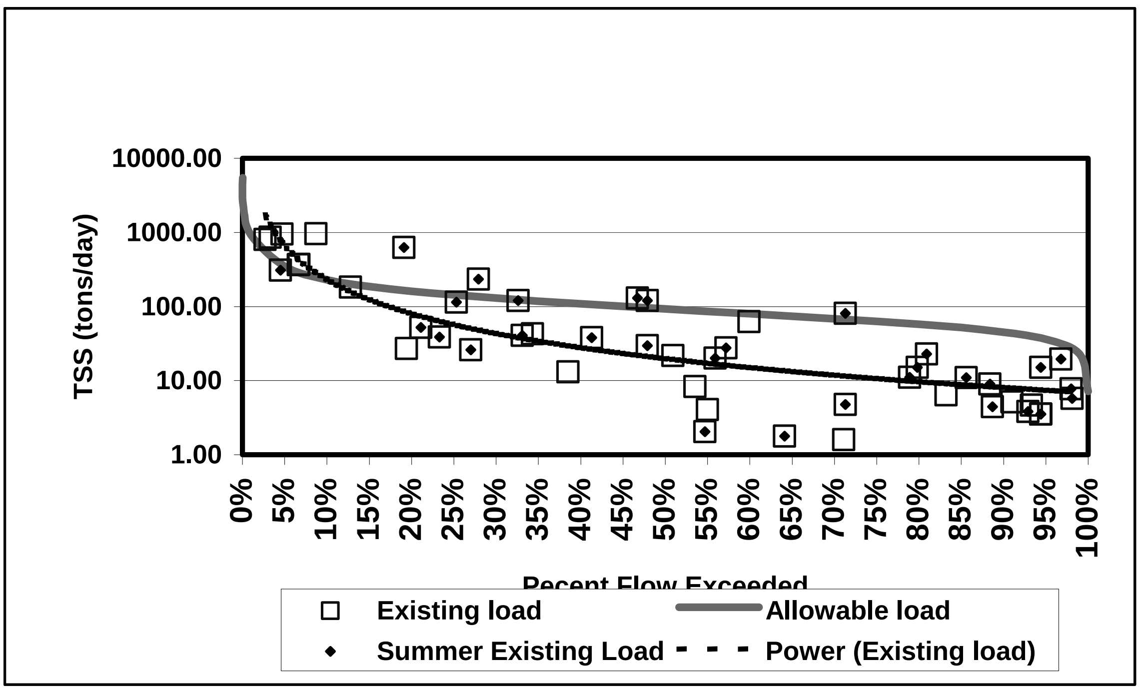


Figure 6.2. TSS Load duration curve for the Dan River at the ambient station, N2300000, from February 1997 through March 2004.

The assimilative capacity of the Dan River also exceeded the targeted values during all flow periods except during low flow period (6.2). The result suggests that non-point sources alone could have elevated turbidity level in the river.

Furthermore, the power line that represented average existing TSS loads clearly explicated that the TSS loads under natural background condition did not exceed the turbidity standard of 50 NTU (47 mg/L) in the Dan River (Figure 5.2). The power line passed underneath the targeted line except during high flow period (<10% flow exceeded), which is indeed unmanageable and hence is excluded in the TMDL estimation in this study.

6.3. Total Maximum Daily Loads (TMDL)

Sections 6.2 described the processes and rationale to identify the endpoints, assimilative capacity, potential sources, and target loadings for each pollutant in the Dan River 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 is defined by the equation 6.2.

$$TMDL = \sum WLAs + \sum LAs + MOS \text{ ---------------(6.2)}$$

Where, WLA is waste load allocation (point source), LA is load allocation (non-point source), and MOS is marginal of safety. Detail explanation of the equation is given in Section 3.3.

Following sections describe the key components required by the TMDL guidelines to set the final TMDL allocation for the Watershed.

6.3.1. 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.

6.3.2. Target Reduction

To determine the amount of turbidity reduction necessary to comply with the water quality criteria, exceedances of the estimated standard (47 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 6.3). The power curve equation is presented in Equation 6.2. The correlation coefficient, R-Square, for the power curve is 0.96; thus suggesting a reasonable fit of the curve.

$Y = 42.578 * X^{(-1.5074)}$ R-Square = 0.96 ---------------------------(6.2)

Where, Y = Turbidity (mg/L) and X = Percent Flow Exceeded.

The criteria violations occurred through out the typical flow regime (Figure 6.3). As described in Section 3.3.2, the loading estimates based on the power curve are presented in Appendix 11.3. Approximately 59 percent reduction in turbidity 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 6.3.

Table 6.3. Reduction Required for TSS in the Dan River

Pollutants	Target with MOS	Existing Load	Allowable Load	Reduction Required
TSS[1]	< 42 mg/L	248.20 tons/day	101.74 tons/day	59 %

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

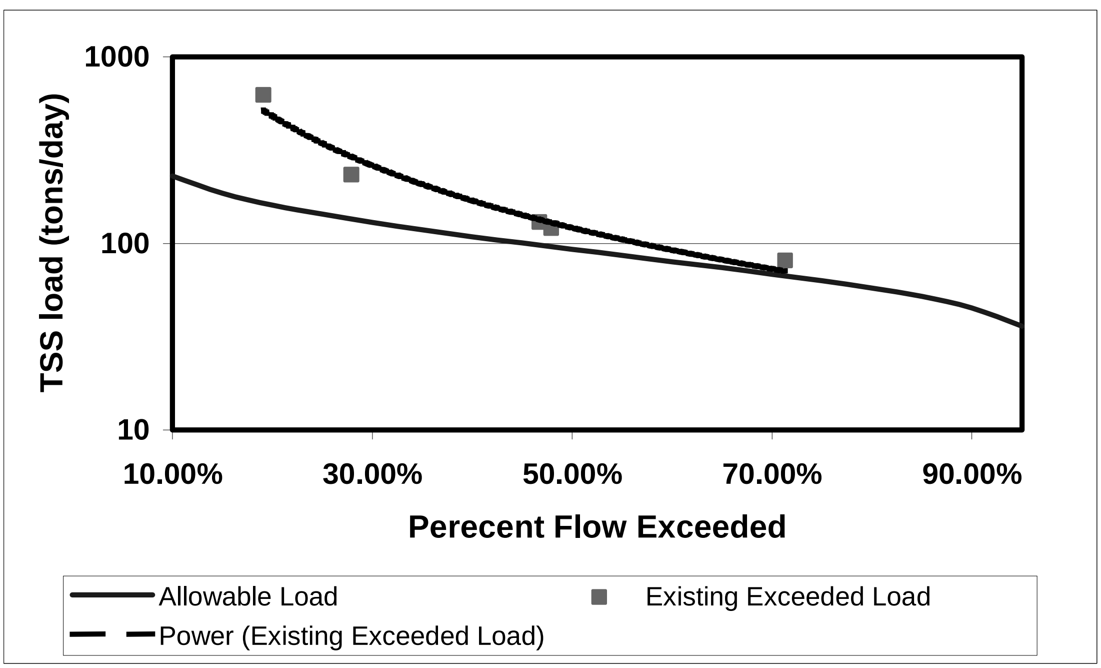


Figure 6.3. Load duration curve showing allowable and existing loads of turbidity in the Dan River.

6.3.3. TMDL Allocation

As identified by the above load duration curve method, significant amounts of TSS are required to be reduced in the Dan River. In order to meet the TMDL objectives, the reduction should be distributed over both point and non-point sources. A further analysis is, therefore, required to determine the breakdown between point source and non-point source loadings.

6.3.3.1. Waste Load Allocation (WLA)

All contributions of TSS from the 26 facilities listed in Table 6.1 were reported as the WLA components. The relative loading rates from the facilities are presented in Table 6.4.

The WLA associated with construction and other land management activities, as discussed in Section 6.1.2, 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 constriction permits rather than as numeric effluent limits.

6.3.3.2. Load Allocation (LA)

All TSS loadings from non-point sources such as urban, agriculture, and forested lands were reported as LAs. The estimated relative percent contribution of TSS from the non-point sources is presented in Table 6.4.

Table 6.4. Estimated TMDL and Load Allocation for TSS for the Dan River Watershed.

Pollutants	Existing Load	Construct-ion Activities	NPDES	MS4[1]	WLA[2]	LA	MOS	TMDL
TSS (tons/day)	248.20	50 NTU	1.21	0	1.21	100.53	Explicit 10 %	101.74

[1]There are no MS4 areas in the Dan River watershed.
[2]WLA = MS4 + NPDES (including construction activities).

6.3.3.3. Study Limitation

The available land cover for this study is outdated and fails to represent current land use condition. Therefore, the estimation of WLA in Table 6.4 is not authoritative. 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).

6.3.3.4. Critical Condition and Seasonal Variation

The greatest frequency of exceedances of turbidity in the Dan River occurred during high-flow periods throughout the season (Figure 6.2). The result shows that wet weather under high-flow period is the critical period for turbidity in the Dan River.

7. Summary and Future Consideration

This report presents the development of Total Maximum Daily Loads (TMDLs) for the four water bodies in North Carolina: Haw River, Deep River, Third Fork Creek, and Dan River. The Haw River is located in the Cape Fear River Basin (CFRB) and is impaired due to fecal coliform and turbidity. The Deep River and the Third Fork Creek are also located in the CFRB and are impaired due to fecal coliform and turbidity respectively. The Dan River is located in the Roanoke River Basin and is impaired due to turbidity.

Available water quality data were reviewed to determine the frequency of exceedances. A load duration curve method was applied to determine the critical periods and the sources that lead to exeedances 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 61 percent reduction in turbidity and 77 percent reduction in fecal coliform are required in order to meet the water quality standard in the Haw River. Storm runoff and bank erosion are seen to be responsible for the exceedance of turbidity, whereas both point and non-point sources are responsible for the exceedance of fecal coliform.

- About 75 percent reduction in fecal coliform is required in order to meet the water quality standard in the Deep River. The combination of non-point and sporadic sources are the major problem in the river.

- About 53 percent reduction in turbidity is required in order to meet the water quality standard in the Third Fork Creek. Non-point sources are the major problem in the creek.

- About 59 percent reduction in turbidity is required in order to meet the water quality standard in the Dan River. Non-point sources are the major problem in the River.

7.1 Stream Monitoring

Stream monitoring should continue on a monthly interval at the existing ambient monitoring stations. The continued monitoring of TSS and fecal coliform concentrations will allow for the evaluation of progress towards the goal of reaching water quality standards by comparing the instream data to the TMDL target.

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 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.

7.2 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 landuses during conversion from rural to urban uses. While stormwater controls are typically required during development activites, 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.

8. Public Participation

A draft of the TMDL was public noticed in local newspapers --The Herald Sun (Durham County), The Times-News (Alamance County), The Stokes News (Stokes County), The Reidsville Review (Rockingham County), and News and Record (Guilford County). The public notice was announced through the papers on different dates starting from September 17, 2004 through September 20, 2004 (Appendix 11.5). The TMDL was also public noticed through DWQ web site at http://h2o.enr.state.nc.us/tmdl/TMDL_list.htm#Draft_TMDLs.

A public comment period was through October 22, 2004. One written comment was received through email and is included in Appendix 11.6. The comment was carefully considered and the TMDL was revised accordingly.

9. Further Information

Technical questions regarding this TMDL should be directed to the following members of the DWQ Modeling/TMDL Unit:
Narayan Rajbhandari, Environmental Modeler, (narayan.rajbhandari@ncmail.net), and
Michelle Woolfolk, Supervisor (michelle.woolfolk@ncmail.net).

Further information concerning North Carolina’s TMDL program can be found on the Internet at the Division of Water Quality website: http://h2o.enr.state.nc.us/tmdl/General_TMDLs.htm.

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11. APPENDICES

Appendix 11.1. Water Quality Parameters Used for TMDL Development

Appendix Table 11.1A. DWQ monitoring data of turbidity and flow in the Haw River at the ambient station B1140000.

Sampling Date	Flow (cfs)	Turbidity (NTU	Sampling Date	Flow (cfs)	Turbidity (NTU	Sampling Date	Flow (cfs)	Turbidity (NTU
1/30/1997	680	31	2/22/2000	492	15	11/19/2002	2110	36
2/26/1997	453	12	3/21/2000	2210	35	12/12/2002	3200	70
3/26/1997	989	13	4/19/2000	1540	33	1/6/2003	835	21
4/28/1997	4790	65	5/31/2000	214	11	2/12/2003	535	14
5/27/1997	712	22	6/26/2000	384	6.2	3/11/2003	824	20
6/25/1997	185	12	7/25/2000	699	75	4/2/2003	1210	26
7/17/1997	202	8.8	8/24/2000	99	5.6	5/20/2003	862	45
8/26/1997	654	47	9/20/2000	1310	60	6/23/2003	492	13
9/16/1997	124	13	10/18/2000	126	4.4	7/21/2003	352	17
10/22/1997	222	29	11/30/2000	182	7.4	8/18/2003	2500	85
11/24/1997	511	60	12/14/2000	145	6.7	9/11/2003	287	8.8
12/18/1997	238	2.2	1/31/2001	399	7.6			
1/27/1998	2330	26	4/25/2001	295	3.7			
2/14/1998	900	100	5/10/2001	136	3.7			
3/24/1998	1210	39	6/19/2001	109	6.5			
4/29/1998	584	13	7/26/2001	680	40			
5/26/1998	349	18	8/30/2001	116	9.8			
6/25/1998	165	4.2	9/26/2001	195	37			
7/27/1998	137	3.5	10/23/2001	59	8.9			
8/24/1998	95	5.9	11/28/2001	89	17			
9/29/1998	94	2.4	12/19/2001	280	17			
10/28/1998	69	2.1	1/30/2002	264	20			
11/19/1998	97	2.2	2/6/2002	153	7.8			
12/29/1998	259	14	3/13/2002	293	19			
1/21/1999	520	45	4/3/2002	254	18			
4/22/1999	202	5.3	5/8/2002	106	11			
7/19/1999	139	6.9	6/5/2002	76	6.8			
8/16/1999	221	2.9	7/1/2002	67	6			
9/29/1999	3980	65	8/5/2002	54	10			
11/18/1999	171	2.9	9/5/2002	209	18			
12/22/1999	899	16	10/3/2002	90	5.4			

Appendix 11.1 continued.

Appendix Table 11.1B. DWQ monitoring data of total Suspended solids (TSS) and flow in the Haw River at the ambient station B1140000.

Sampling Date	Flow (cfs)	TSS mg/L	TSS Load (Tons/day)	Sampling Date	Flow (cfs)	TSS mg/L	TSS Load (Tons/day)
1/30/1997	680	12	21.95	1/21/1999	520	15	20.98
2/26/1997	453	2	2.44	4/22/1999	202	3	1.63
3/26/1997	989	12	31.92	7/19/1999	139	6	2.24
4/28/1997	4790	100	1288.51	8/16/1999	221	23	13.67
5/27/1997	712	42	80.44	9/29/1999	3980	78	835.08
6/25/1997	185	8	3.98	11/18/1999	171	1	0.46
7/17/1997	202	10	5.43	12/22/1999	899	16	38.69
8/26/1997	654	190	334.26	2/22/2000	492	10	13.23
9/16/1997	124	9	3.00	3/21/2000	2210	54	321.02
10/22/1997	222	8	4.78	4/19/2000	1540	35	144.99
11/24/1997	511	20	27.49	5/31/2000	214	9	5.18
12/18/1997	238	1	0.64	6/26/2000	384	7	7.23
1/27/1998	2330	14	87.75	10/18/2000	126	2	0.68
2/14/1998	900	86	208.21	1/31/2001	399	6	6.44
3/24/1998	1210	11	35.80	4/25/2001	295	8	6.35
4/29/1998	584	1	1.57	7/26/2001	680	60	109.75
5/26/1998	349	12	11.27	10/23/2001	59	5	0.79
6/25/1998	165	5	2.22	1/30/2002	264	8	5.68
7/27/1998	137	7	2.58	4/3/2002	254	9	6.15
8/24/1998	95	5	1.28	7/1/2002	67	6	1.08
9/29/1998	94	4	1.01	10/3/2002	90	3	0.73
10/28/1998	69	2	0.37	1/6/2003	835	8	17.97
11/19/1998	97	5	1.30	4/2/2003	1210	13	42.31
12/29/1998	259	7	4.88	7/21/2003	352	8	7.58

Appendix 11.1 continued.

Appendix Table 11.1C. DWQ monitoring data of fecal coliform and flow in the Haw River at the ambient station B1140000.

Sampling Date	Flow	Fecal Coliform (#/100mL)	Fecal Coliform (#/day)	Sampling Date	Flow	Fecal Coliform (#/100mL)	Fecal Coliform (#/day)	Sampling Date	Flow	Fecal Coliform (#/100mL)	Fecal Coliform (#/day)
1/30/1997	680	100	1.66E+12	2/22/2000	492	140	1.69E+12	6/18/2002	60	50	7.34E+10
2/26/1997	453	18	1.99E+11	3/21/2000	2210	3100	1.68E+14	6/25/2002	49	25	3.00E+10
3/26/1997	989	230	5.57E+12	4/19/2000	1540	760	2.86E+13	6/27/2002	59	1000	1.44E+12
4/28/1997	4790	910	1.07E+14	5/31/2000	214	260	1.36E+12	7/1/2002	67	1	1.64E+09
5/27/1997	712	400	6.97E+12	6/26/2000	384	6400	6.01E+13	7/2/2002	60	240	3.52E+11
6/25/1997	185	300	1.36E+12	7/25/2000	699	6400	1.09E+14	7/9/2002	49	31	3.72E+10
7/17/1997	202	2400	1.19E+13	8/24/2000	99	45	1.09E+11	8/5/2002	54	96	1.27E+11
8/26/1997	654	390	6.24E+12	9/20/2000	1310	3500	1.12E+14	9/5/2002	209	70	3.58E+11
9/16/1997	124	240	7.28E+11	10/18/2000	126	740	2.28E+12	10/3/2002	90	58	1.28E+11
10/22/1997	222	210	1.14E+12	11/30/2000	182	76	3.38E+11	11/19/2002	2110	230	1.19E+13
11/24/1997	511	460	5.75E+12	12/14/2000	145	64	2.27E+11	12/12/2002	3200	3800	2.98E+14
12/18/1997	238	300	1.75E+12	1/31/2001	399	60	5.86E+11	1/6/2003	835	59	1.21E+12
1/27/1998	2330	200	1.14E+13	4/25/2001	295	470	3.39E+12	2/12/2003	535	39	5.10E+11
2/14/1998	900	2000	4.40E+13	5/10/2001	136	18	5.99E+10	3/11/2003	824	46	9.27E+11
3/24/1998	1210	90	2.66E+12	6/19/2001	109	40	1.07E+11	4/2/2003	1210	300	8.88E+12
4/29/1998	584	140	2.00E+12	8/30/2001	116	34	9.65E+10	5/20/2003	862	970	2.05E+13
5/26/1998	349	790	6.75E+12	9/26/2001	195	350	1.67E+12	6/23/2003	492	50	6.02E+11
6/25/1998	165	27	1.09E+11	10/23/2001	59	260	3.75E+11	7/21/2003	352	110	9.47E+11
7/27/1998	137	45	1.51E+11	11/28/2001	89	41	8.93E+10	8/18/2003	2500	8200	5.02E+14
8/24/1998	95	140	3.25E+11	1/30/2002	264	29	1.87E+11	9/11/2003	287	120	8.43E+11
9/29/1998	94	560	1.29E+12	2/6/2002	153	56	2.10E+11				
10/28/1998	69	91	1.54E+11	3/13/2002	293	60	4.30E+11				
11/19/1998	97	10	2.37E+10	4/3/2002	254	360	2.24E+12				
12/29/1998	259	640	4.06E+12	5/8/2002	106	73	1.89E+11				
1/21/1999	520	64	8.14E+11	5/21/2002	92	51	1.15E+11				
4/22/1999	202	36	1.78E+11	5/30/2002	75	530	9.73E+11				
7/19/1999	139	36	1.22E+11	6/4/2002	86	63	1.33E+11				
8/16/1999	221	180	9.73E+11	6/5/2002	76	53	9.85E+10				
9/29/1999	3980	3600	3.51E+14	6/11/2002	66	44	7.10E+10				
11/18/1999	171	600	2.51E+12	6/13/2002	67	52	8.52E+10				

Appendix 11.1 continued.

Appendix Table 11.1D. DWQ monitoring data of fecal coliform and flow in the Deep River at the ambient station B4615000.

Sampling Date	Flow	Fecal Coliform (#/100mL)	Fecal Coliform (#/day)	Sampling Date	Flow	Fecal Coliform (#/100mL)	Fecal Coliform (#/day)
1/23/1997	103	45	1.13E+11	2/23/2000	99	320	7.75E+11
2/25/1997	102	10	2.50E+10	3/30/2000	66	640	1.03E+12
3/25/1997	102	62	1.55E+11	4/26/2000	71	120	2.08E+11
4/29/1997	4220	3500	3.61E+14	5/30/2000	30	81	5.95E+10
5/5/1997	222	640	3.48E+12	6/28/2000	93	73	1.66E+11
5/22/1997	45	72	7.93E+10	7/27/2000	53	320	4.15E+11
6/2/1997	62	200	3.03E+11	8/16/2000	29	91	6.46E+10
6/26/1997	25	27	1.65E+10	9/26/2000	392	1800	1.73E+13
7/28/1997	25	10	6.12E+09	10/30/2000	30	18	1.32E+10
8/28/1997	16	140	5.48E+10	11/29/2000	36	63	5.55E+10
9/29/1997	31	91	6.90E+10	12/21/2000	34	960	7.99E+11
11/19/1997	28	45	3.08E+10	1/16/2001	26	120	7.63E+10
12/17/1997	27	14	9.25E+09	4/3/2001	288	1000	7.05E+12
1/26/1998	186	73	3.32E+11	5/22/2001	42	160	1.64E+11
2/23/1998	494	100	1.21E+12	6/25/2001	47	50	5.75E+10
3/16/1998	79	36	6.96E+10	7/17/2001	24	11	6.46E+09
4/22/1998	206	82	4.13E+11	9/17/2001	21	33	1.70E+10
5/20/1998	152	110	4.09E+11	10/4/2001	17	28	1.16E+10
6/17/1998	62	310	4.70E+11	1/17/2002	21	15	7.71E+09
7/16/1998	21	27	1.39E+10	2/12/2002	47	55	6.32E+10
8/18/1998	49	420	5.04E+11	3/21/2002	105	31	7.96E+10
9/9/1998	102	980	2.45E+12	6/25/2002	16	26	1.02E+10
10/14/1998	20	110	5.38E+10	7/18/2002	17	40	1.66E+10
11/5/1998	20	20	9.79E+09	8/13/2002	14	10	3.43E+09
12/15/1998	53	260	3.37E+11	9/12/2002	16	46	1.80E+10
1/19/1999	260	54	3.44E+11	10/14/2002	722	2900	5.12E+13
3/17/1999	77	45	8.48E+10	11/20/2002	149	5200	1.90E+13
5/26/1999	24	18	1.06E+10	12/18/2002	107	150	3.93E+11
6/15/1999	19	24	1.12E+10	1/7/2003	117	770	2.20E+12
7/27/1999	32	82	6.42E+10	2/19/2003	248	510	3.09E+12
8/31/1999	42	330	3.39E+11	3/4/2003	241	260	1.53E+12
9/30/1999	939	6000	1.38E+14	4/1/2003	252	14000	8.63E+13
10/28/1999	32	80	6.26E+10	5/20/2003	153	180	6.74E+11
11/23/1999	34	81	6.74E+10	6/10/2003	374	1200	1.10E+13
12/28/1999	43	82	8.63E+10	7/15/2003	179	800	3.50E+12
				8/12/2003	475	4100	4.76E+13
				9/22/2003	101	200	4.94E+11

Appendix 11.1 continued.

Appendix Table 11.1E. UCFRBA monitoring data of TSS, turbidity, and flow in the Third Fork Creek at the ambient station B30325000.

Sampling Date	Flow (cfs) (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (ton/day)	Sampling Date	Flow (cfs) (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (ton/day)
4/26/2000	14.84	23.00	21.00	0.92	8/7/2003	7.81	13.60	29.00	0.29
5/4/2000	10.93	39.00	40.00	1.15	9/25/2003	54.67	14.40	20.00	2.12
6/5/2000	7.50	98.00	89.00	1.98					
7/6/2000	7.81	27.00	16.00	0.57					
8/2/2000	83.57	48.00	110.00	10.79					
9/6/2000	9.37	19.00	38.00	0.48					
10/10/2000	4.06	6.00	3.60	0.07					
11/20/2000	7.65	11.00	16.00	0.23					
12/5/2000	4.06	3.50	23.00	0.04					
1/17/2001	17.18	3.00	14.70	0.14					
2/15/2001	28.12	5.50	20.00	0.42					
3/14/2001	10.15	7.00	15.00	0.19					
4/5/2001	12.50	21.00	90.00	0.71					
5/10/2001	3.83	12.50	17.00	0.13					
6/14/2001	23.43	84.20	75.00	5.31					
7/2/2001	3.83	16.60	33.00	0.17					
8/1/2001	2.34	16.00	21.00	0.10					
9/3/2001	8.59	17.50	12.00	0.40					
10/2/2001	4.84	11.50	50.00	0.15					
11/1/2001	5.70	18.50	6.80	0.28					
12/13/2001	2.42	24.00	39.00	0.16					
1/2/2002	3.83	6.00	3.50	0.06					
2/5/2002	8.59	2.70	14.00	0.06					
3/5/2002	5.62	10.30	20.00	0.16					
4/2/2002	15.62	37.00	45.00	1.55					
5/2/2002	5.62	11.00	11.00	0.17					
6/3/2002	2.97	25.00	16.00	0.20					
7/1/2002	4.76	31.00	33.00	0.40					
8/2/2002	3.75	7.80	14.00	0.08					
9/2/2002	32.80	18.00	29.00	1.59					
10/2/2002	5.15	3.20	8.10	0.04					
11/5/2002	11.72	3.80	13.00	0.12					
12/10/2002	23.43	7.90	16.00	0.50					
1/6/2003	14.06	10.00	20.00	0.38					
2/6/2003	13.28	9.60	22.00	0.34					
3/10/2003	12.50	11.10	24.00	0.37					
4/7/2003	97.63	168.00	130.00	44.12					
5/7/2003	9.37	22.00	37.00	0.55					
6/3/2003	12.50	14.00	28.00	0.47					
7/9/2003	6.40	10.50	20.00	0.18					

Appendix 11.1 continued

Appendix Table 11.1F. DWQ monitoring data of TSS, turbidity, and flow in the Dan River at the ambient station N2300000.

Sampling Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (tons/day)	Sampling Date	Flow (cfs)	TSS (mg/L)	Turbidity (NTU)	TSS Load (tons/day)
2/20/1997	1440.00	7.00	11.00	27.12	1/25/1999	3210.00	110.00	120.00	949.84
3/20/1997	4640.00	64.00	70.00	798.82	4/20/1999	591.00	3.00	5.60	4.77
4/24/1997	3280.00	35.00	26.00	308.81	6/9/1999	418.00	8.00	5.60	9.00
5/28/1997	1210.00	8.00	7.90	26.04	7/28/1999	660.00	1.00	6.20	1.78
6/25/1997	939.00	15.00	10.00	37.89	8/25/1999	591.00	51.00	60.00	81.08
7/24/1997	1250.00	34.00	21.00	114.33	9/27/1999	279.00	26.00	28.00	19.51
8/21/1997	1090.00	43.50	26.00	127.55	10/21/1999	762.00	1.00	7.70	2.05
9/15/1997	846.00	53.00	26.00	120.61	11/8/1999	476.00	5.00	2.30	6.40
10/27/1997	736.00	14.00	11.00	27.72	2/29/2000	775.00	4.00	3.90	8.34
11/12/1997	595.00	1.00	2.60	1.60	3/22/2000	2610.00	52.00	50.00	365.09
1/6/1998	758.00	2.00	4.20	4.08	4/24/2000	845.00	13.00	9.30	29.55
1/22/1998	978.00	5.00	7.10	13.15	5/16/2000	516.00	8.00	4.40	11.10
2/19/1998	2580.00	53.00	50.00	367.83	6/15/2000	509.00	11.00	9.00	15.06
3/10/1998	4000.00	80.00	29.65	860.80	7/26/2000	354.00	4.00	5.60	3.81
4/28/1998	1310.00	11.00	9.30	38.76	8/29/2000	862.00	56.00	70.00	129.85
5/28/1998	1450.00	160.00	200.00	624.08	9/27/2000	1190.00	73.00	80.00	233.68
6/23/1998	750.00	10.00	9.10	20.18	12/11/2000	347.00	5.00	2.80	4.67
7/22/1998	500.00	17.00	14.00	22.87	6/21/2001	328.00	4.00	5.50	3.53
8/26/1998	451.00	9.00	13.00	10.92	9/13/2001	237.00	9.00	9.50	5.74
9/24/1998	414.00	4.00	5.30	4.45	12/18/2001	702	33.00	45.00	62.32
10/22/1998	329.00	4.00	4.50	3.54	3/4/2002	808	10.00	13.00	21.74
11/24/1998	383.00	5.00	4.30	5.15	6/4/2002	240	12.00	15.00	7.75
12/14/1998	2220.00	160.00	120.00	955.49	9/17/2002	328	17.00	37.00	15.00
					12/17/2002	1060	15.00	20.00	42.77
					3/26/2003	1780	38.00	55.00	181.95
					6/3/2003	1380	14.00	15.00	51.97
					9/30/2003	1080	14.00	15.00	40.67

Appendix 11.2. NPDES Permits

Watersheds	Permit No.	Facility Name	Facility Types	NC County	Receiving Water Body	Flow	Daily TSS	Daily Fecal Coliform
						(MGD)	(mg/L)	(#/100mL)
Haw River	NC0046809	Pentecostal Holiness Church	Discharging 100% Domestic < 1MGD	Guilford	Benaja Creek	0.02	45	400
Haw River	NC0066966	Quarterstone Farm WWTP	Discharging 100% Domestic < 1MGD	Guilford	Buffalo Creek	0.16	45	400
Haw River	NC0001384	Williamsburg plant	Industrial Process & Commercial Wastewater Discharge	Caswell	Buttermilk Creek	0.025	45	400
Haw River	NC0045144	Western Alamance High School	Discharging 100% Domestic < 1MGD	Alamance	HAW RIVER	0.01	45	400
Haw River	NC0031607	Western Alamance Middle School	Discharging 100% Domestic < 1MGD	Alamance	HAW RIVER	0.015	45	400
Haw River	NC0046043	Oak Ridge Military Academy	Discharging 100% Domestic < 1MGD	Guilford	HAW RIVER	0.04	45	400
Haw River	NC0045161	Altamahaw/Ossipee Elementary School	Discharging 100% Domestic < 1MGD	Alamance	HAW RIVER	0.012	45	400
Haw River	NC0046019	The Summit WWTP	Discharging 100% Domestic < 1MGD	Rockingham	HAW RIVER	0.015	45	400
Haw River	NC0066010	Williamsburg Elementary School	Discharging 100% Domestic < 1MGD	Rockingham	HAW RIVER	0.004	45	400
Haw River	NC0003913	Altamahaw Division plant	Industrial Process & Commercial Wastewater Discharge	Alamance	HAW RIVER	0.15	108	400
Haw River	NC0065412	Pleasant Ridge WWTP	Discharging 100% Domestic < 1MGD	Rockingham	Little Troublesome Creek	0.0235	45	400
Haw River	NC0060259	Willow Oak Mobile Home Park	Discharging 100% Domestic < 1MGD	Rockingham	Little Troublesome Creek	0.0175	135	400
Haw River	NC0084778	Harvin Reaction Technology	Groundwater Remediation Discharge	Guilford	North Buffalo Creek	0.11	45	400
Haw River	NC0029726	Guilford Correctional Center WWTP	Discharging 100% Domestic < 1MGD	Guilford	North Buffalo Creek	0.025	45	400
Haw River	NC0038156	Northeast Middle & Senior High WWTP	Discharging 100% Domestic < 1MGD	Guilford	Reedy Fork	0.032	45	400
Haw River	NC0022691	Autumn Forest Manuf. Home Community	Discharging 100% Domestic < 1MGD	Guilford	Reedy Fork	0.082	45	400
Haw River	NC0001210	Monarch Hosiery Mills Incorporated	Industrial Process & Commercial Wastewater Discharge	Alamance	Reedy Fork	0.05	81.5	NA
Haw River	NC0038172	McLeansville Middle School WWTP	Discharging 100% Domestic < 1MGD	Guilford	South Buffalo Creek	0.0113	45	400
Haw River	NC0055271	Shields Mobile Home Park	Discharging 100% Domestic < 1MGD	Alamance	Travis Creek	0.006	45	400
Haw River	NC0073571	Countryside Manor WWTP	Discharging 100% Domestic < 1MGD	Guilford	Troublesome Creek	0.015	45	400
Deep River	NC0038091	Southern Elementary School	Discharging 100% Domestic < 1MGD	Guilford	Hickory Creek	0.0075	45	400
Deep River	NC0038229	Southern Guilford High School	Discharging 100% Domestic < 1MGD	Guilford	Hickory Creek	0.012	45	400
Deep River	NC0055255	Crown Mobile Home Park	Discharging 100% Domestic < 1MGD	Guilford	Hickory Creek	0.042	45	400
Deep River	NC0041483	Plaza Mobile Home Park	Discharging 100% Domestic < 1MGD	Guilford	Hickory Creek	0.003	45	400
Third Fork Creek	NC0086827	Brenntag Southeast, Inc.	Groundwater Remediation Discharge	Durham	Third Fork Creek	0.0144	30	NA
Dan River	NC0075027	Cains Way Mobile Home Park	Discharging 100% Domestic < 1MGD	Forsyth	Ader Creek	0.0432	45	400
Dan River	NC0078115	Greystone Subdivision WWTP	Discharging 100% Domestic < 1MGD	Forsyth	Belews Creek	0.032	45	400
Dan River	NC0083933	Rangecrest Road WWTP	Discharging 100% Domestic < 1MGD	Forsyth	Belews Creek	0.06	45	400

Appendix 11.2 continued								
Dan River	NC0060461	Abington WWTP	Discharging 100% Domestic < 1MGD	Forsyth	Belews Creek	0.385	45	400
Dan River	NC0037311	Creekside Manor Rest Home	Discharging 100% Domestic < 1MGD	Forsyth	Belews Creek	0.01	45	400
Dan River	NC0028746	Briarwood Subdivision WWTP	Discharging 100% Domestic < 1MGD	Stokes	Brushy Fork Creek	0.05	45	400
Dan River	NC0056791	Horizons Residential Care Ctr	Discharging 100% Domestic < 1MGD	Forsyth	Buffalo Creek	0.015	45	400
Dan River	NC0035173	Kobewireland Copper Products Incorporated	Industrial Process & Commercial Wastewater Discharge	Stokes	DAN RIVER	0.025	45	400
Dan River	NC0044962	North Stokes High School	Discharging 100% Domestic < 1MGD	Stokes	DAN RIVER	0.0115	45	400
Dan River	NC0067091	Mikkola Downs WWTP	Discharging 100% Domestic < 1MGD	Forsyth	East Belews Creek	0.072	45	400
Dan River	NC0029777	Stokes Correctional Center WWTP	Discharging 100% Domestic < 1MGD	Stokes	Flat Shoals Creek	0.0132	45	400
Dan River	NC0059251	Quail Acres Mobile Home Park	Discharging 100% Domestic < 1MGD	Rockingham	Hogans Creek	0.018	45	400
Dan River	NC0060542	Gold Hill Mobile Home Park	Discharging 100% Domestic < 1MGD	Rockingham	Hogans Creek	0.0176	45	400
Dan River	NC0044750	Britthaven Of Madison	Industrial Process & Commercial Wastewater Discharge	Rockingham	Hogans Creek	0.025	45	400
Dan River	NC0037001	Bethany Elementary School	Discharging 100% Domestic < 1MGD	Rockingham	Huffines Mill Creek	0.01	45	400
Dan River	NC0003441	JPS Elastomerics Corp-Caro Plt	Industrial Process & Commercial Wastewater Discharge	Stokes	Little Dan River	0.015	135	NA
Dan River	NC0044954	South Stokes High School	Discharging 100% Domestic < 1MGD	Stokes	Little Neatman Creek	0.0173	45	400
Dan River	NC0079049	R.H. Johnson Construction WWTP	Discharging 100% Domestic < 1MGD	Forsyth	Rough Fork	0.06	45	400
Dan River	NC0057720	Twin Lakes Mobile Home Park	Discharging 100% Domestic < 1MGD	Stokes	Timmons Creek	0.04	45	400
Dan River	NC0003492	R J Reynolds Tobacco Co - Brook Cove	Industrial Process & Commercial Wastewater Discharge	Stokes	Voss Creek (Sandy Branch)	0.02	45	400
							Weekly Average Permitted Limits	
Haw River	NC0023868	Eastside WWTP	Municipal Wastewater Discharge, Large	Alamance	HAW RIVER	12	45	400 GM
Haw River	NC0024881	Reidsville WWTP	Municipal Wastewater Discharge, Large	Rockingham	HAW RIVER	7.5	45	400 GM
Haw River	NC0024325	North Buffalo Creek WWTP	Municipal Wastewater Discharge, Large	Guilford	North Buffalo Creek	16	45	400 GM
Haw River	NC0047384	T.Z. Osborne WWTP	Municipal Wastewater Discharge, Large	Guilford	South Buffalo Creek	40	45	400 GM
Deep River	NC0024210	East Side WWTP	Municipal Wastewater Discharge, Large	Guilford	Richland Creek	26	45	400 GM
Dan River	NC0021075	Madison WWTP	Municipal Wastewater Discharge, < 1MGD	Rockingham	DAN RIVER	0.775	45	400 GM
Dan River	NC0082384	Danbury WWTP	Municipal Wastewater Discharge, < 1MGD	Stokes	DAN RIVER	0.1	45	400 GM
Dan River	NC0028011	Stoneville WWTP	Municipal Wastewater Discharge, < 1MGD	Rockingham	Mayo River	0.25	45	400 GM
Dan River	NC0021873	Mayodan WWTP	Municipal Wastewater Discharge, Large	Rockingham	Mayo River	4.5	45	400 GM
Dan River	NC0025526	Walnut Cove WWTP	Municipal Wastewater Discharge, < 1MGD	Stokes	Town Fork Creek	0.5	45	400 GM
Dan River	NC0024406	Belews Creek Steam Station	Industrial Process & Commercial Wastewater Discharge	Stokes	West Belews Creek	0.01	45	400 GM

Appendix 11.3. Load Reduction Estimations

Appendix Table 11.3A. Estimation of Load Reduction Required in turbidity (tons TSS / day) for the Haw River.

Existing Load			**Allowable Load**	
Percent Flow Exceeded	**TSS Load**		**Percent Flow Exceeded**	**TSS Load**
15.00%	208.206		10.00%	104.5388
19.30%	80.44176		15.00%	74.90574
20.20%	109.752		20.00%	58.03137
21.20%	334.2594		25.00%	47.57749
Average	183.1648			71.26335
Load Reduction = 61%				

Note: Power curve estimation is not used for the data point violating the water quality criteria.

Appendix Table 11.3B. Estimation of Load Reduction Required in fecal coliform (# / day) for the Haw River.

%flow Exceeded	**Allaowable Load (# / day)**	**Est. Voilated Loads # / day)**
10.000%	1.11858E+13	8.79488E+13
15.000%	8.01502E+12	4.51728E+13
20.000%	6.20944E+12	2.81564E+13
25.000%	5.09086E+12	1.95135E+13
30.000%	4.29817E+12	1.44619E+13
35.000%	3.74328E+12	1.12258E+13
40.000%	3.3117E+12	9.01415E+12
45.000%	2.92416E+12	7.42799E+12
50.000%	2.59828E+12	6.24716E+12
55.000%	2.30762E+12	5.34153E+12
60.000%	2.03458E+12	4.6299E+12
65.000%	1.79677E+12	4.0593E+12
70.000%	1.57658E+12	3.59389E+12
75.000%	1.39162E+12	3.2087E+12
80.000%	1.22427E+12	2.88584E+12
85.000%	1.05693E+12	2.61221E+12
90.000%	8.80772E+11	2.37804E+12
95.000%	6.69387E+11	2.17588E+12
Average	3.35085E+12	1.44474E+13
Load Reduction = 77%		

Appendix 11.3 continued.

Appendix Table 11.3C. Estimation of Load Reduction Required in fecal coliform (# / day) for the Deep River.

% Flow Exceeded	Fecal Load (#/day)	Est. Exceeded Load (#/day)
10.00%	2.14908E+12	1.82991E+13
15.00%	1.56777E+12	8.26123E+12
20.00%	1.21547E+12	4.69883E+12
25.00%	9.95272E+11	3.03327E+12
30.00%	8.27926E+11	2.12131E+12
35.00%	7.04618E+11	1.56782E+12
40.00%	6.07733E+11	1.20656E+12
45.00%	5.28463E+11	9.57677E+11
50.00%	4.58001E+11	7.78879E+11
55.00%	3.96347E+11	6.46075E+11
60.00%	3.34693E+11	5.44708E+11
65.00%	2.92416E+11	4.65567E+11
70.00%	2.55424E+11	4.02582E+11
75.00%	2.29001E+11	3.51629E+11
80.00%	1.94E+11	3.0982E+11
85.00%	1.67E+11	2.75086E+11
90.00%	1.50E+11	2.45911E+11
95.000%	1.15E+11	2.21168E+11
Average	6.21531E+11	2.46596E+12
Load Reduction = 75%		

Appendix 11.3 continued.

Appendix Table 11.3D. Estimation of Load Reduction Required in Turbidity (# TSS / day) for the Third Fork Creek.

% Flow Exceeded	TSS Load (ton/day)	Est. Load Violated (ton/day)
10.00%	3.290173	8.010034
15.00%	1.864432	4.54532
20.00%	1.316069	3.04071
25.00%	1.041888	2.226143
30.00%	0.822543	1.725461
35.00%	0.712871	1.391085
40.00%	0.603198	1.154292
45.00%	0.542879	0.979118
50.00%	0.493526	0.845072
55.00%	0.444173	0.739693
60.00%	0.405788	0.655007
65.00%	0.367403	0.585692
70.00%	0.329017	0.528073
75.00%	0.301599	0.479539
80.00%	0.274181	0.438184
85.00%	0.246763	0.402591
90.00%	0.219345	0.371686
95.00%	0.18096	0.344638
Average	0.747601	1.581241
Load Reduction = 53%		

Appendix 11.3 continued.

Appendix Table 11.3E. Estimation of Load Reduction Required in Turbidity (# TSS / day) for the Dan River.

% Flow Exceeded	TSS Load (tons/day)	Est. Load Violated (ton/day)
10.00%	229.8497	1369.863
15.00%	185.4728	743.4249
20.00%	160.4397	481.8418
25.00%	143.3716	344.209
30.00%	129.7172	261.4956
35.00%	118.3385	207.2759
40.00%	108.439	169.4852
45.00%	100.7015	141.9138
50.00%	92.96398	121.0737
55.00%	86.13676	104.8707
60.00%	79.6509	91.97967
65.00%	74.18912	81.52512
70.00%	68.38599	72.90818
75.00%	63.038	65.70671
80.00%	57.57622	59.6155
85.00%	52.00066	54.40903
90.00%	45.05965	49.91739
95.00%	35.95669	46.01045
Average	101.7382	248.1959
Load Reduction = 59%		

Appendix 11.4. Estimates of Relative Loadings for Point and Non-point Sources

Appendix Table 11.4A. 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. mg/L
Mixed forest/pasture/low density residential	2400	15
Mixed forest/pasture/medium & low density residential	2100	20
Mixed forest/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 11.4B. Relative TSS Loading from Urban and Rural Areas.

Watershed	Land Use	Land %	Relative TSS Rate tons/sq mi/yr	Normalized TSS Load Rates tons/sq mi/yr	TSS Loading Ratio
Haw River	Rural	82.77	1688	1397.1576	88.33%
	MS4	17.23	1071	184.5333	11.67%
Deep River	Rural	73.41	1688	NA	NA
	MS4	26.59	1071	NA	NA
Third Fork Creek	Rural	40.84	1688	689.3792	52.11%
	MS4	59.16	1071	633.6036	47.89%
Dan River	Rural	100	1688	1688	100.00%
	MS4	0	0	0	0

Note: TSS data estimated in Appendix Table 4A 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 11.4 continued.

Appendix Table 11.4C. Relative Fecal Coliform Concentration from Urban and Rural areas

Watershed	Land Use	Land %	Relative Fecal Rate (mg/L)	Normalized Fecal Coliform Conc. Rates (mg/100mL)	Fecal Coliform Conc. Ratio
Haw River	Rural	82.77	20	16.554	82.06%
	MS4	17.23	21	3.6183	17.94%
Deep River	Rural	73.41	20	14.682	72.45%
	MS4	26.59	21	5.5839	27.55%
Third Fork Creek	Rural	40.84	20	NA	NA
	MS4	59.16	21	NA	NA
Dan River	Rural	100	20	NA	NA
	MS4	0	0	NA	NA

Note: Fecal coliform data estimated in Appendix Table 4A 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 11.5. Public Notice

The Herald Sun

Public Notice
State of North Carolina
Division of
Water Quality

AFFIDAVIT OF PUBLICATION

State of North Carolina
County of Durham

Donna B. Minor being duly sworn says that she is the Principal Clerk of The Durham Herald Co., Inc., publishers of The Herald-Sun a newspaper published in and of general circulation in said County, and that a notice of which the annexed is a true copy, was published in said newspaper one time on the 20th day of September, 2004.

Donna B. Minor

Principal Clerk

Sworn to and subscribed before me this 1st day of November, 2004.

Polly J. Mims

Notary Public

My commission expires December 16, 2006.

Durham County, North Carolina

POLLY J. MIMS
NOTARY PUBLIC
DURHAM COUNTY, NC

Appendix 11.5 continued.

The Times-News

RECEIVED
SEP 23 2004
DENR - WATER QUALITY
POINT SOURCE BRANCH

AFFIDAVIT OF INSERTION OF ADVERTISMENT
The Times-News Publishing Company

Burlington, NC
Alamance County

I, **LINDA GIBSON** Legal Advertising Manager of the **The Times-News Publishing Co.**, do certify that the advertisement of NCDENR/DWQ/NPDES

Entitled NOTICE
Public Notice
State of
North Carolina

Measuring 42 lines appeared in The Times-News, a newspaper published in Alamance County, Burlington, NC, in issues of September 17, 2004

Legal Advertising Manager

Sworn to and subscribed before me this 20 day of September, 2004

Notary Public

My commission expires May 4, 2008

Public Notice
State of North Carolina
Division of Water Quality

Availability of the Total Maximum Daily Load (TMDL) for Turbidity and Fecal Coliform for Haw River, Deep River, Third Fork Creek and Dan River in North Carolina

You are requested to review the TMDL and mail your comments to NC DWQ-Planning Branch Attn. Ms. Robin Markham 1617 Mail Service Center Raleigh, NC 27699-1617 Copies of the TMDL may be obtained by calling Ms. Robin Markham at 919-733-5083 ext 558 or on the Internet at http://h2o.enr.state.nc.us/tmdl. Written comments regarding the TMDL will be accepted until October 22, 2004.

September 17, 2004

Appendix 11.5 continued.

The Stokes News

NORTH CAROLINA
STOKES 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 Ferris W. Simpson who being first duly sworn, deposes and says: that he (she) is Business Manager (Publisher or other officer or employee authorized to make affidavit) of MOUNT AIRY NEWSPAPERS, INC., engaged in the publication of a newspaper known as THE STOKES NEWS, published, issued, and entered as periodicals class mail in the city of King in said County and State; that he (she) 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 STOKES NEWS on the following dates:

September 23, 2004

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 of 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 2 day of November, 2004

Ferris W. Simpson
Signature of person making affidavit

Sworn to and subscribed before me, this 2 day of November, 2004

Sandra V. Sutphin
Notary Public

My Commission expires: August 17, 2009

Official Seal
Sandra V. Sutphin
Notary Public - North Carolina
Surry County

CLIPPING OF LEGAL ADVERTISEMENT ATTACHED HERE

PUBLIC NOTICE

State of North Carolina
Division of Water Quality
Availability of the Total Maximum Daily Load (TMDL) for Turbidity and Fecal Coliform for Haw River, Deep River, Third Fork Creek and Dan River in North Carolina.

You are requested to review the TMDL and mail your comments to NC DWQ-Planning Branch, attn: Ms. Robin Markham, 1617 Mail Service Center, Raleigh, NC 27699-1617. Copies of the TMDL may be obtained by calling Ms. Robin Markham at (919) 733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl. Written comments regarding the TMDL will be accepted until October 22, 2004.

9/23

Appendix 11.5 continued.

The Reidsville Review

Ad # : 474271

Name (Primary) : NCDENR BUDGET OFFICE

Company (Primary) :

Street 1 (Primary) : WATER QUALITY SECTION

City (Primary) : RALEIGH

State (Primary) : NC

ZIP (Primary) : 27699-1617

Phone (Primary) : (919) 733-5083

Start Date : 09/19/2004

Stop Date : 09/19/2004

Publication : RDV - THE REIDSVILLE REVIEW

Class Code : 0111 - LEGAL NOTICES

Ad Sales Rep. : dpowell - DAISY POWELL-SWINTON

Total : $27.20

Depth : 23

PUBLIC NOTICE
STATE OF NORTH CAROLINA
DIVISION OF WATER QUALITY

Availability of the Total Maximum Daily Load (TMDL) for Turbidity and Fecal Coliform for Haw River, Deep River, Third Fork Creek and Dan River in North Carolina

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September 19, 2004

Appendix 11.5 continued.

News and Record

News & Record

Published by
News & Record, Inc.
Greensboro, North Carolina

North Carolina, Guilford County

Affidavit of Publication

9/17/2004

Before the undersigned, a Notary Public of said County and State, duly commissioned, qualified and authorized by law to administer oaths, personally appeared the Publisher's Representative who being first duly sworn, deposed and says:

1. That he/she is the Publisher's Representative of the Greensboro News & Record, Inc. a corporation, engaged in the publication of newspapers known as "News & Record", published, issued and entered as second class mail in the City of Greensboro in said County and State.

2. That he/she is authorized to make this affidavit and sworn statement; that the notice or other legal advertisement, a copy of which is attached hereto, was published in the News & Record on the dates listed below.

3. That the said newspaper (or newspapers) 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 of 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.

Publisher's Representative ______________________

Sworn to and subscribed before me, this 20th day of September, 2004.

____
Notary Public

My commission expires: August 23, 2005

VALERIE McNEIL
NOTARY PUBLIC
GUILFORD COUNTY, NC
Commission Expires 8-23-2005

Name	Ad #	Date	Edition	Class	PO	Ad Copy
NCDENR	6701322	09/18/04	News & Record	400	TMDL	Public NoticeState o

Public Notice
State of North Carolina
Division of Water Quality

Availability of the Total Maximum Daily Load (TMDL) for Turbidity and Fecal Coliform for Haw River, Deep River, Third Fork Creek and Dan River in North Carolina.

You are requested to review the TMDL and mail your comments to NC DWQ-Planning Branch, attn:, Ms. Robin Markham, 1617 Mail Service Center, Raleigh, NC 27699-1617. Copies of the TMDL may be obtained by calling Ms. Robin Markham at (919) 733-5083, ext. 558 or on the internet at http://h2o.enr.state.nc.us/tmdl/. Written comments regarding the TMDL will be accepted until October 22, 2004.

Appendix 11.6. Public Comments and DWQ Response

Followings are the comments received from Mr. Steve Shoaf, City of Burlington, NC and the DWQ' s responses to the comments. The comments are in plain text and the responses are in italics.

Comment 1. Page i: The stream segment identified for the Haw River (19.2 miles) is very discrete. How was this segment determined when it is possible that the contributing pollutants are coming from an upstream section?

The impaired segment in the Haw River from NC 87 to NC 40 was explicitly defined in the NC Water Quality Assessment and Impaired Waters List (2002 Integrated 305 (b) and 303(d) Report). The actual hydraulic length of the segment was approximately 13 miles. The 19.2 miles as estimated in the 303(d) list was incorrect. The actual distance is corrected in the final TMDL report.

Comment 2. Page 3: The first bullet item identifies the segment of the Haw River that is impaired, but states that the segment is 13 miles. Is the distance correct?

The distance is correct.

Comment 3. Page 6: The paragraph below the definitions states that "Once EPA approves a TMDL, then the water body may be moved to Category 4a… Water bodies remain on Category 4a of the list until compliance with water quality standards is achieved." After compliance is achieved, is the TMDL designation removed or does it continue indefinitely?

The TMDL designation can be removed for this pollutant after standard are achieved. The assessment unit may remain in category 4a if other TMDL apply.

Comment 4. Page 12: In the third paragraph the report states "The DWQ conducted a special study in the Haw River… for a six-week period from 01/06/04 to 01/16/04." I assume that the dates run into February.

Yes, the special study was conducted from 01/06/04 to 02/16/04. The study date is corrected in the final TMDL document.

Comment 5. Page 13: The turbidity equation relating turbidity to flow has an R-square value of 0.66. At what point does DWQ consider the R-square to be too weak to show a causal relationship? The graph presented on this page looks like the data fits better than suggested by the formula.

There is no fixed value that defines strength or weakness among variables. However, in theory, the correlation (relationship) between two variables is considered strong when their correlation (r) approaches to 1. In this study, the correlation between NTU and flow was 0.81 (r = Square Root of R-Square), which is high enough to justify a significant causal relationship between turbidity and flow for this study. The graph presented in Figure 1.7 shows the significant correlation.

Comment 6. Page 14: The water quality standard for turbidity states, "…if turbidity exceeds these levels due to natural background conditions, the existing turbidity level cannot be increased." This implies that turbidity can exceed 50 NTU and not violate the water quality standard. The regulation also states that implementation of BMP's will be considered as compliance with the water quality standard (page 25 of the report).

It is correct that turbidity could exceed 50 NTU under natural background conditions. In this study, however, the background turbidity level did not exceed 50 NTU. Largest part of TSS loads was below the targeted line during all flow conditions.

It is also correct that according to 15A NCAC 02B.0211 (3) (K) implementation of BMP's would be considered as compliance with the water quality standard.

Comment 7. Page 14: The water quality standard for fecal coliform states that violations of the standard are expected during rainfall events and "… this violation is expected to be caused by uncontrollable nonpoint source pollution…"

This study assumes that uncontrollable non-point source pollution would occur during heavy rainfall events. Therefore, the fecal coliform load during above 90th percentile flow event was not considered in the TMDL estimation.

Comment 8. Page 16: Based on the 2002 data, is it possible that there was one year or a series of rainfall events during the 1997 – 2003 period that is responsible for the bulk of the fecal coliform exceedances? The fecal coliform data for 2002 look very good.

This TMDL was developed based on the instantaneous monthly measurements. The measurement suggested that the fecal coliform exceeded 400 counts / 100 ml in more than 20% of the sample examined during the study period.

Comment 9. Page 24: The summary of the NPDES permit conditions is incorrect. The TSS (45 mg/L) and Fecal Coliform limits (400 cfu/100 mL **geometric mean**) in the permits are weekly averages. There are no daily maximums in the NPDES permits for these parameters.

There are daily maximums in the NPDES permits for these parameters. In general, privately own industries are permitted under daily maximum limit, whereas publicly own industries are permitted under weekly average limit. Daily Maximum limits are possible as the result of this TMDL. The summary tables of the NPDES permit in this study are revised accordingly.

Comment 10. Page 28: The formula for the relationship of TSS and turbidity has an R-square of 0.57. Again, this is not a very strong correlation.

The relationship is moderate, because correlation (r) is estimated at 0.75 (r = Square Root of R-Square value). Therefore, the relationship between TSS and NTU can be justified for this study.

Comment 11. Page 32: After converting turbidity NTU to TSS loading, there were no violations during typical and low flows. This suggests that some of the problem could be (is) related to natural, uncontrollable conditions during heavy rains.

In this study, turbidity measurement during above 90th percentile flow (high flow) period was not considered in order to exclude natural, uncontrollable conditions in the TMDL estimation.