Total Maximum Daily Loads for Fecal Coliform Bacteria and for Copper to Pigeon House Branch, North Carolina

Final Version Approved by EPA

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Neuse River Basin

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Final version submitted to EPA

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SUMMARY SHEET
Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

State: North Carolina
County: Wake

Major River Basin: Neuse River Basin
Watershed: Pigeon House Branch - in Upper Neuse Watershed HUC 03020201

Impaired Waterbody (2000 303(d) List):

Stream Index #	Segment Name	Designated Use	
		Partial Support [mi.]	Not Support [mi.]
27-33-18	Pigeon House Branch – source to Crabtree Creek	---	2.9

Constituent(s) of Concern: Fecal Coliform Bacteria, Copper

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

Applicable Water Quality Standards for Class C Waters:

Fecal coliforms shall not exceed a geometric mean of 200/100ml (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.

Copper: 7 ug/l.

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 95th and 10th percent flow exceeded (excludes extreme drought (>95th percentile) and floods (<10th percentile). Percent reductions expressed as the average value between existing loads (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 for in the load curve analysis by determining the average difference between the existing load violation trend line and the allowable load line. This approach was chosen because existing load violations occur at all flow levels.

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:

Pollutant	LA	WLA [1]	MOS [2]	TMDL	Percent Reduction[3]
Fecal Coliform	2.04×10^{8} counts/day	7.63×10^{9} counts/day	Explicit	7.83×10^{9} counts/day	78%
Copper	3.35×10^{5} ug/day	1.26×10^{7} ug/day	Explicit	1.29×10^{7} ug/day	66%

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 14 percent for copper.
3. Average reduction required over the range of flows between the 95th and 10th percent flow exceeded, as estimated in Pigeon House Branch using the continuous streamflow gage from nearby Rocky Branch.

4. Public Notice Date: April 15, 2003

5. Submittal Date:

6. Establishment Date:

7. Endangered Species (yes or blank):

8. EPA Lead on TMDL (EPA or blank):

9. TMDL Considers Point Source, Nonpoint Source, or both: both

For Fecal Coliform Bacteria and Copper

To Pigeon House Branch

1.0 Introduction

On the draft 2002 North Carolina Integrated Report, the North Carolina Division of Water Quality (DWQ) identified a 2.9-mile segment (27-33-18) of Pigeon House Branch in the Neuse Basin as impaired by fecal coliform bacteria and copper. The impaired segment extends from the stream's source to its confluence with Crabtree Creek. This section of the stream is located in subbasin 03-04-02. Pigeon House Branch is designated as a class C water. Class C waters are freshwaters that are protected for secondary recreation, fishing, and propagation and survival of aquatic life.

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or which have impaired uses. This list, contained within Categories 4 through 7 of the Integrated Report, is submitted biennially to the U.S. Environmental Protection Agency (EPA) 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 Integrated Report. A TMDL is the maximum amount of a pollutant (e.g., fecal coliform or copper) that a waterbody can receive and still meet water quality standards, and an allocation of that load among point and nonpoint sources. The objective of a TMDL is to estimate allowable pollutant loads and allocate 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 EPA (1991, 2000a) and the Federal Advisory Committee are as follows:

Target identification or selection of pollutant(s) and endpoint(s) for consideration. An endpoint is an instream numeric target. The pollutant and endpoint are generally associated with measurable water quality related characteristics that indicate compliance with water quality standards. North Carolina indicates known problem pollutants on the 303(d) list.

Source assessment. Sources that contribute to the impairment should be identified and loads quantified, to the extent that that is possible.

Reduction target. Estimation of level of pollutant reduction needed to achieve water quality goal. The level of pollution should be characterized for the waterbody, highlighting how current conditions deviate from the target endpoint. Generally, this component is identified through water quality modeling.

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 (portion of TMDL) or implicitly through conservative assumptions. The margin of safety should be included in the reduction target.

Allocation of pollutant loads. Allocating available pollutant load (TMDL), and hence pollutant control responsibility, to the sources of impairment. The wasteload allocation portion of the TMDL accounts for the loads associated with existing and future point sources. The load allocation portion of the TMDL accounts for the loads associated with existing and future nonpoint sources. Any future nonpoint source loading should remain within the TMDL that is calculated in this assessment; in other words, this TMDL does not leave allocation for future sources.

Seasonal variation. The TMDL should consider seasonal variation in the pollutant loads and endpoint. Variability can arise due to streamflows, temperatures, and exceptional events (e.g., droughts and hurricanes).

Critical conditions. Critical conditions occur when fecal coliform levels exceed the standard by the largest amount. If the modeled load reduction is able to meet the standard during critical conditions, then it should meet the standard at all, or nearly all, times.

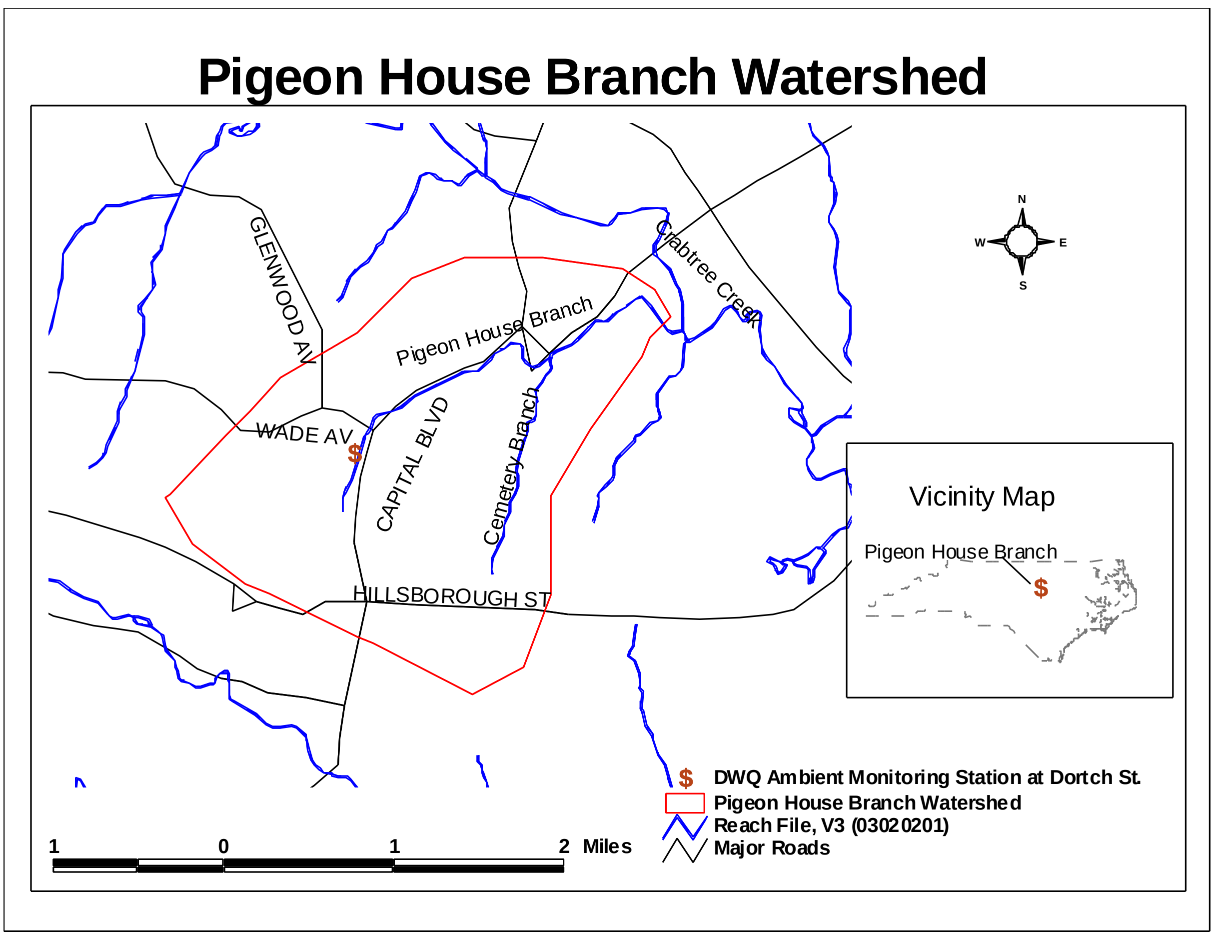
Section 303(d) of the CWA and the Water Quality Planning and Management regulation (USEPA, 2000a) require EPA to review all TMDLs for approval or disapproval. Once EPA approves a TMDL, then the waterbody may be moved to Category 4a of the 2002 Integrated Report. Waterbodies remain on Category 4a until compliance with water quality standards is achieved. Where conditions are not appropriate for the development of a TMDL, management strategies may still result in the restoration of water quality.

The goal of the TMDL program is to restore designated uses to water bodies. Thus, the implementation of bacteria and copper controls will be necessary to restore designated uses in Pigeon House Branch. Although an implementation plan is not included as part of this TMDL, reduction strategies are needed. The involvement of local governments and agencies will be critical to developing an implementation plan and reduction strategy.

1.1 Watershed Description

Pigeon House Branch, located in the upper Neuse basin, drains into Crabtree Creek within the City of Raleigh (see Figure 1). The creek's watershed lies entirely within Wake County and is about 4 square miles in area. DWQ has an ambient water quality monitoring site (Storet number J3300000) at Dortch St., about 2.5 miles from the confluence with the Crabtree Cr. The watershed at this point is 1.15 square miles. <u>This will be the evaluation point for the TMDL since fecal coliform and copper data have been and will continue to be collected here</u>.

Figure 1.



Note: watershed delineation in Fig. 1 is inexact, and has been used for display purposes only.

The land use/land cover characteristics of the watershed were determined using 1996 land cover data that were developed from 1993-94 LANDSAT satellite imagery. The North Carolina Center for Geographic Information and Analysis, in cooperation with the NC Department of Transportation and the United States Environmental Protection Agency Region IV Wetlands Division, contracted Earth Satellite Corporation of Rockville, Maryland to generate comprehensive land cover data for the entire state of North Carolina. Tabulated land cover/land use data for the Pigeon House Branch Watershed are shown in Table 1. During the formation of this geographic dataset, developed land was identified using the proportion of synthetic cover present; low density developed was 50-80% synthetic cover, and high density developed was 80-100% synthetic cover. Assuming that synthetic cover is impervious, and that all non-developed land cover classes have 1% impervious cover, the Pigeon House Branch watershed is estimated to have 57-78% impervious surface.

That the impervious cover estimate is so high is not surprising considering the watershed is entirely within the City of Raleigh. For management purposes, DWQ will consider that there is only one land class in Pigeon House Branch watershed – urban land. This land, however, may be drained by a variety of means. These include storm pipes and sewers that are under the separate jurisdiction of the City of Raleigh, Department of Transportation, federal government (railroad tracks), and Wake County, as well as overland runoff and interflow from urban land into the stream network.

Table 1. Land use/land cover in Pigeon House Branch watershed

Land Use/Land Cover	**Pigeon House Branch Watershed Acres**
High Density Developed	1314 (49.1%)
Low Density Developed	946 (35.4%)
Cultivated	0 (0.0%)
Managed Herbaceous	127 (4.7%)
Forest	289 (10.8%)
Total	2674

The USGS 14-digit hydrologic unit code (HUC) for Pigeon House Branch is 03020201090020.

1.2 Water Quality Monitoring Program

There are two sources of fecal coliform and copper data for Pigeon House Branch: 1) data from the North Carolina Division of Water Quality's ambient monitoring program; 2) special study data collected by the City of Raleigh. More information is provided below, and both of these datasets are included in Appendix I.

Pigeon House Branch was listed as impaired based on data from the DWQ ambient monitoring station, which is located at Dortch St. or approximately 2.5 miles from the stream's confluence with Crabtree Creek. Water samples collected at this site on a monthly basis are analyzed for fecal coliform, copper and other water quality parameters.

DWQ used the ambient data as the basis for the TMDL calculation because those data have been collected on a consistent basis, and will be used to assess compliance in the future. Furthermore, DWQ conducts ambient monitoring using QAQC (quality assurance and quality control) protocols established for sample collection and analysis. Raleigh undertook monitoring, as described below, for their own source identification purposes; consequently, Raleigh did not follow formal QAQC protocols for sample collection and transport. As a result, Raleigh data will be used in this TMDL for source assessment and implementation strategy development purposes.

The City of Raleigh conducted synoptic sampling at 12 locations in the Pigeon House Branch watershed. Raleigh sampled these sites on 8 days (approximately weekly) in June and July 2001. The samples were analyzed for a number of water quality parameters, including fecal coliform and copper. These data show extremely high fecal coliform levels, with noticeably higher counts at the entrance to Equipment Service Depot off of West St., at the culvert between West St. and Peace St., and at Automotive Way past Crabtree Boulevard. More attention to these data may help to identify specific sources of fecal coliform, possibly including leaky sewer lines and illicit discharges.
The copper data from Raleigh do not show the same level of impairment as DWQ's copper data; however, there are some sites, particularly the entrance to the Equipment Service Depot off of West St. and the culvert between West St. and Peace St., which indicate copper impairment.

1.3 Water Quality Targets

The North Carolina fresh water quality standard for **fecal coliform** in Class C waters (T15A: 02B.0211) states:

> Organisms of the coliform group: fecal coliforms shall not exceed a geometric mean of 200/100ml (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; 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.

The instream numeric target, or endpoint, is the restoration objective expected to be reached by implementing the specified load reductions in the TMDL. The target allows for the evaluation of progress towards the goal of reaching water quality standards for the impaired stream by comparing the instream data to the target. For this TMDL the water quality target is the instantaneous concentration of 400cfu/100ml. Cfu stands for colony-forming units; it may also be referred to as simply ‘counts’ in this assessment. The geometric mean will not be considered because the method used to develop the TMDL analysis method is incompatible with the available data; the method relies on observed data, and, as previously mentioned, those are limited to a monthly frequency. Typically in North Carolina, compliance with the instantaneous part of the fecal coliform criterion has also meant compliance with the geometric mean part of the criterion.

For **copper**, the North Carolina freshwater **action level for toxic substances** in Class C waters (T15A: 02B.0211) states:

If the Action Levels for any of the substances listed in this Subparagraph (which are generally not bioaccumulative and have variable toxicity to aquatic life because of chemical form, solubility, stream characteristics or associated waste characteristics) are determined by the waste load allocation to be exceeded by a receiving water by a discharge under the specified low flow criterion for toxic substances (Rule .0206 in this Section), the discharger shall monitor the chemical or biological effects of the discharge; efforts shall be made by all dischargers to reduce or eliminate these substances from their effluents. Those substances for which Action Levels are listed in this Subparagraph shall be limited as appropriate in the NPDES permit based on the Action Levels listed in this Subparagraph if sufficient information (to be determined for metals by measurements of that portion of the dissolved instream concentration of the Action Level parameter attributable to a specific NPDES permitted discharge) exists to indicate that any of those substances may be a causative factor resulting in toxicity of the effluent. NPDES permit limits may be based on

translation of the toxic form to total recoverable metals. Studies used to determine the toxic form or translators must be designed according to "Water Quality Standards Handbook Second Edition" published by the Environmental Protection Agency (EPA 823-B-96-007) which are hereby incorporated by reference including any subsequent amendments. The Director shall consider conformance to EPA guidance as well as the presence of environmental conditions that limit the applicability of translators in approving the use of metal translators.
(a) Copper: 7 ug/l

For purposes other than consideration of NPDES permitting of point source dischargers as described in this Subparagraph, the Action Levels in this Rule, as measured by an appropriate analytical technique, per 15A NCAC 2B .0103(a), shall be considered as the numerical ambient water quality standard(s). (emphasis added for this TMDL document)

In essence, the North Carolina TMDL criterion for copper is 7 ug/l. The term 'action level' refers to a water quality standard for a parameter that is not highly bioaccumulative, and that has variable toxicity to aquatic life due to chemical and environmental variables such as chemical form, solubility, stream pH, and stream hardness. Instream toxicity testing and biological sampling may be used to determine compliance with an action level parameter such as copper.

2.0 Source Assessment

A source assessment is used to identify and characterize the known and suspected sources of fecal coliform bacteria and copper in the watershed. It is a qualitative assessment due to the requirements of the simpler analysis method of this TMDL. Further source characterization may be done before and/or during TMDL implementation.

2.1 Point Source Assessment

General sources of fecal coliform and copper are divided between point and nonpoint sources. Currently, there are no facilities in the watershed that discharge **wastewater** through the National Pollutant Discharge Elimination System (NPDES).

A recent EPA mandate (Wayland, 2002) requires NPDES permitted **stormwater** to be placed in the wasteload allocation (WLA), which had previously been reserved for continuous point source wastewater loads. The two entities that are permitted through Phase I of the NPDES stormwater program to discharge in the Pigeon House Branch watershed are the City of Raleigh (NC0029033) and the North Carolina Department of Transportation (NCS000250). As part of Phase II of the NPDES stormwater program, Wake County, which has jurisdiction over some land and storm pipes in the Pigeon House Branch watershed, will be added.

2.2 Nonpoint Source Assessment

Nonpoint sources of fecal coliform bacteria include those sources that can **not** be identified as entering the waterbody at a specific location (e.g., an NPDES permitted pipe). In theory, nonpoint source pollution includes urban, agricultural and background (e.g., forest, wildlife) sources. Fecal coliform bacteria may originate from human and non-human sources. Table 2 lists the potential human and animal nonpoint sources of fecal coliform bacteria (Center for Watershed Protection, 1999). The nonpoint sources of fecal coliform bacteria in Pigeon House Branch include runoff from urban development (non-NPDES regulated stormwater), sewer line systems (leaky sewer lines and sewer system overflows), wildlife, and probably illicit connections in unknown locations.

Nonpoint sources of **copper** in Pigeon House Branch watershed generally include urban stormwater, and potentially sewer line systems (leaky sewer lines and sewer system overflows).

A more specific discussion of the nonpoint sources of fecal coliform and copper in the Pigeon House Branch watershed is provided below.

2.2.1 Livestock

There is no known livestock in the Pigeon House Branch watershed.

Table 2. Potential sources of fecal coliform bacteria in urban watersheds (Center for Watershed Protection, 1999).

Source Type		Source
Human Sources	Sewered watershed	Combined sewer overflows
		Sanitary sewer overflows
		Illegal sanitary connections to storm drains
		Illegal disposal to storm drains
Non-human Sources	Domestic animals and urban wildlife	Dogs, cats
		Rats, raccoons, opossum, squirrels
		Pigeons, gulls, ducks, geese

2.2.2 Failed Septic Systems

There are no septic systems in the Pigeon House Branch watershed.

2.2.3 Urban Development

Fecal coliform bacteria can originate from various urban sources. These sources include pet and wildlife waste, illicit discharges/connections of sanitary waste, and leaky sewer systems. Additionally, in the Pigeon House Branch watershed there may be a homeless human population, which could account for additional fecal coliform loading.

Copper originates from various urban sources as well. The primary source of copper in urban stormwater is deposition of abraded automobile brake linings (brake emissions) on roads (Davis et al., 2001; Malmqvist, 1983; Hewitt and Rashed, 1990). Davis et al. (2001) estimated that copper from brake wear composed at least 50% of copper in stormwater; this was from an analysis of a low density residential area that assumed residents account for all vehicle traffic, or where all travel outside the area is matched by non-resident travel inside. The proportion of copper from vehicle brakes is likely to be significantly greater than 50% in the Pigeon House Branch watershed, where major traffic thoroughfares with non-resident traffic are likely to increase vehicle copper loadings. Secondary sources include building siding (possibly from wood preservative) and roofs (especially commercial buildings), and wet and dry atmospheric deposition (Davis et al., 2001). Additional sources may include leaky sewer systems and sanitary sewer overflows.

2.2.4 Sanitary Sewer Overflows

The city of Raleigh owns and operates a wastewater treatment plant and sewage collection system. From 1997 through 2002, Raleigh reported five sanitary sewer overflows (SSOs) of greater than 1,000 gallons, including one SSO of greater than 50,000 gallons in the Pigeon House watershed. There were also six SSOs of less than 1,000 gallons during that time. None of the SSOs appeared in the monitoring data, as samples where not taken within 10 days of a spill, or in one case the spill occurred outside of the monitoring station’s watershed. DWQ did not explicitly account for SSOs in the modeling. They are merely mentioned as a source of fecal coliform, and potentially copper, that should receive further attention during development of an implementation strategy.

2.2.5 Wildlife

Wildlife is a source of fecal coliform bacteria throughout the watershed. Wildlife deposit feces containing fecal coliform bacteria on the land surface; later, the bacteria may be transported to the drainage network via runoff or shallow groundwater following a rain event. Direct deposition of fecal coliform bacteria from wildlife into the stream is another avenue for loading. Wildlife in Pigeon House Branch watershed is expected to include raccoons, opossum, squirrels, and birds (pigeons in particular).

2.3 Source Assessment Conclusion

The source assessment for this TMDL is offered as a qualitative assessment of the potential sources of fecal coliform and copper. For copper, it is highly likely that automobile brake deposits are the leading source, followed by buildings and atmospheric deposition. Fecal coliform sources are less certain. The primary sources are likely to be leaky sewer systems, and urban runoff containing fecal coliform from pet waste, wildlife waste and potentially human waste. Other sources may include sanitary sewer overflows, and illicit discharges/connections of sanitary waste. The specific entry points to Pigeon House Branch from all of these sources are not currently known, though the City of Raleigh has conducted some spatially intensive monitoring which may shed light on this (see page 9 and Appendix I).

Additionally, Raleigh and DWQ are collaborating on a bacterial source tracking project that will seek to identify general fecal coliform sources (i.e., human, pets, or wildlife).

3.0 Analytical Approach

Since the allocation of the Pigeon House Branch TMDLs is essentially limited to one source, urban stormwater (that regulated by NPDES, the City of Raleigh and the Department of Transportation as of January 2003; and that which is not regulated by NPDES, State Government Complex and Wake County land as of January 2003), a model to establish pollutant contribution by various sources is not required. Consequently, the primary analysis need is determining the TMDL, or amount of load reduction. Rather than use a complex, mechanistic model such as HSPF, DWQ will employ a load duration approach to determine these TMDLs. Using this approach provides a simplified and direct manner to establish the relationship between water quality and streamflow. Load duration curves are based entirely on observed data, and they employ a cumulative frequency distribution of streamflow. The methodology used will be described further below and is based on work by Stiles in Kansas (2002), Cleland (2002), and Sheely in Mississippi (2002).

3.1 Flow Duration Curves

In order to develop a load duration curve for TMDL development, the first step is to create a flow duration curve, which displays the cumulative frequency distribution of daily flow data over the period of record. The duration curve relates flow values measured at a monitoring station to the percent of time the flow values were equaled or exceeded. Flows are ranked from lowest, which are exceeded nearly 100 percent of the time, to highest, which are exceeded less than 1 percent of the time.

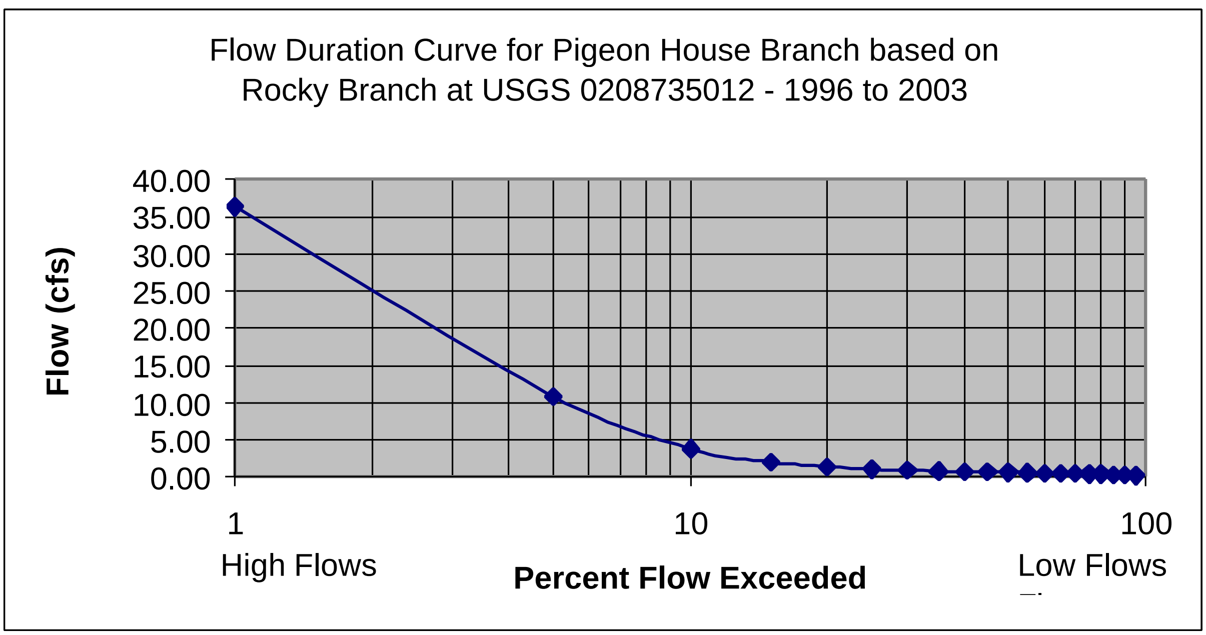
Flow duration curves are limited to the period of record available at a monitoring station. The confidence in the duration curve approach in predicting a realistic percent load reduction increases when longer periods of record are used to generate the graphs. One of the shortcomings of using this method to develop TMDLs is that many ambient monitoring locations, including that at Pigeon House Branch, do not have a USGS gage. However, a nearby gage in a watershed of similar size and land use as the ungaged watershed can be used to estimate flows. Flows at the ungaged location can be estimated using a drainage area ratio, as explained below.

DWQ developed a flow duration curve using daily streamflow data collected at a continuous gage on Rocky Branch (USGS 0208735012) between October 1996 and March 2003. There were other alternatives that were not quite as useful as the Rocky Branch gage. Pigeon House Branch has a gage (USGS 0208732534), but that drains only 0.27 square miles of the watershed and often reports zero flow; at the ambient monitoring station, the watershed drains 1.15 square miles. Another option was the USGS gage (0208732885) at Marsh Creek. The record for this extends as far back as 1984, but it drains 6.84 square miles. The flow per drainage area ratios for Marsh Creek and Rocky

Branch are similar, though Rocky Branch's ratio is slightly higher. After comparing the flow duration curves using the various gages, DWQ chose the Rocky Branch gage because it is nearby, and drains a nearly identical amount of land (1.17 square miles) as Pigeon House Branch at Dortch St. The Rocky Branch watershed is slightly less urban than that of Pigeon House Branch, though it still has a significant amount of impervious area.

To estimate Pigeon House Branch flows from Rocky Branch flows, DWQ completed the following steps: 1) list the observed Rocky Branch flows chronologically during the entire period of record; 2) calculate the daily flow per square mile by dividing the observed flows by the watershed area; 3) order the results from 2) and rank them according to percentile; and finally, 4) multiply the result from 3) by the area of the Pigeon House Branch watershed. The result may be seen in Figure 2 below.

Figure 2.



3.2 Load Duration Curves

Flow duration curves are transformed into load duration curves by multiplying the flow values along the flow duration curve by the pollutant concentrations and the appropriate conversion factors. On the load duration curve, allowable and existing loads are plotted against the flow recurrence interval. The allowable load is based on the water quality numerical criteria for fecal coliform and copper, less the margin of safety, and on flow values from the flow duration curve. The line drawn through the allowable load data points is called the target line.

The existing load is simply based on measured fecal coliform and copper concentrations and an estimate of flow in the stream during sampling days, plus conversion factors. An example of this calculation is provided:

1.28 cfs * 590 counts/100 ml * 1000 ml/l * 7.462 gallons/cfs * 3.785 l/gallon * 86400 sec./day = 1.84 * 10^10 counts/day

In this TMDL, the estimate of flow comes from the USGS report of mean daily flow at Rocky Branch (USGS 0208735012, see previous section). There is an exception to this statement, however; between 1994 and 1996, DWQ used Marsh Cr. mean daily flow to calculate load on Pigeon House Branch, as flow data did not become available until 1996 on Rocky Branch. The positioning of the existing load on the plot is based on the recurrence interval (percent flow exceeded) of the estimated flow. Existing loads that plot above the target line indicate a violation of the water quality criterion, while loads plotting below the line represent compliance. The load duration plots for Pigeon House Branch are shown in Figures 3 and 4.

Figure 3.

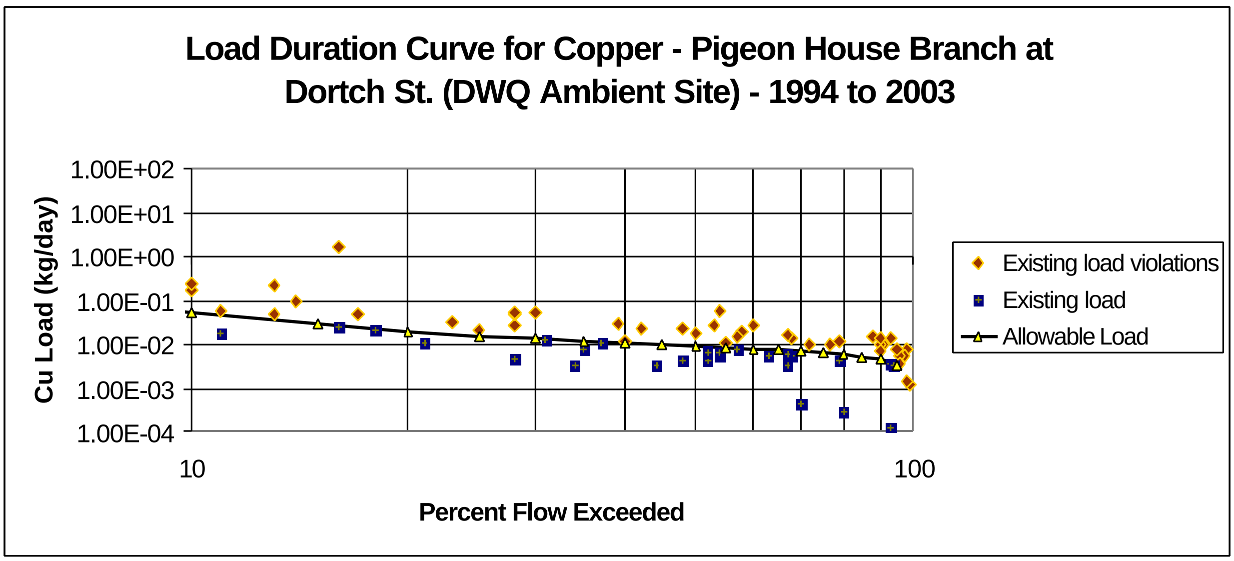
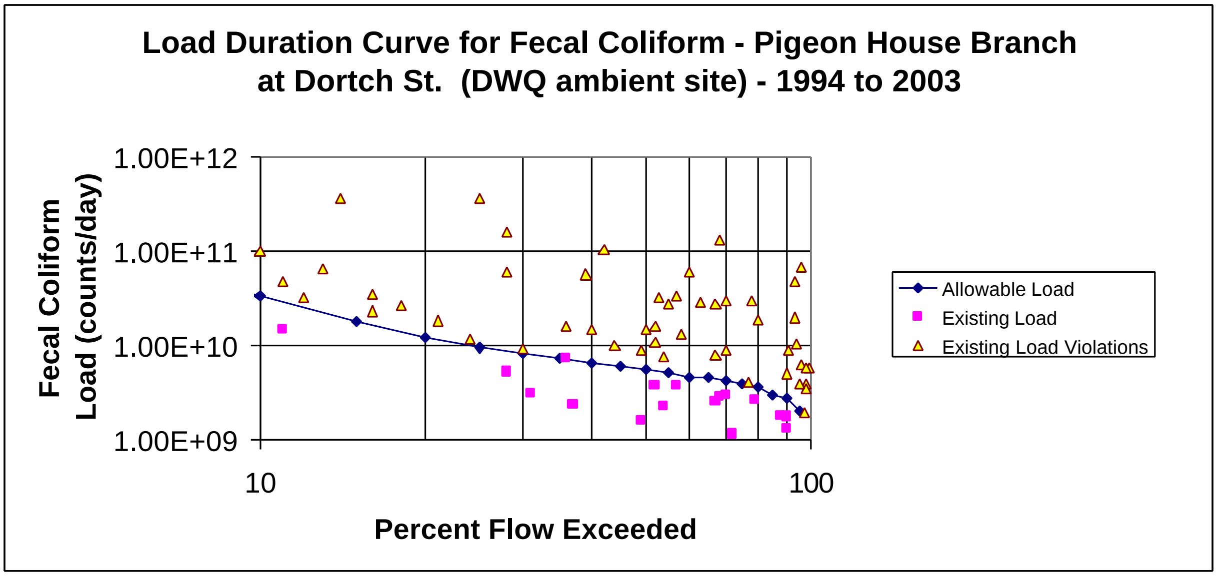


Figure 4.



Further explanation on how load duration curves are used to calculate the TMDLs is provided below.

4.0 Total Maximum Daily Load

A Total Maximum Daily Load is the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount among point and nonpoint sources. A TMDL comprises the sum of wasteload allocations (WLA) for point sources, load allocations (LA) for nonpoint sources, and a margin of safety. This definition is expressed by the equation:

$$\text{TMDL} = \text{S WLA} + \text{S LA} + \text{MOS}$$

The objectives of the TMDL are to estimate allowable pollutant loads, and to allocate to the general pollutant sources in the watershed. Providing recommendations for regulatory or other actions to be taken to achieve compliance with applicable water quality criteria based on the relationship between pollution sources and in-stream water quality conditions is more the focus of an implementation strategy, which will be done separately following this assessment.

40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measures. The fecal coliform TMDL will be expressed in terms of counts per day, and represents the maximum one-day load the stream can assimilate and maintain the water quality criterion. For copper, the TMDL is expressed as micrograms per day, and represents the maximum one-day load the stream can assimilate and maintain the water quality criterion.

The two main components of a TMDL, the reduction target, including a margin of safety, and the allocation strategy, will be presented in the following sections.

4.1 Reduction Target

To determine the amount of fecal coliform and copper load reduction necessary to comply with the water quality criteria, the period of critical conditions and the existing loading must be established.

4.1.1 Existing Conditions

The load duration curves for the impaired streams in the watershed are presented in Figure 5 and 6 on following pages. The criteria violations occur at both high and low flows, which indicate that impairment occurs during wet and dry weather. This also means that the sources of fecal coliform and copper are both near the stream channel, as evidenced by high concentrations during dry weather/low flow, and distant from the stream channel, as evidenced by high concentrations during high flows. The wet weather fecal coliform impairment appears to be more intractable as, at higher flows, the proportion of samples in violation of the allowable load to samples below the allowable load is greatest.

Superimposed on the graphs is a trend through the data points violating the water quality criterion. A power curve provided the best fit, as determined by the correlation coefficient, R^2 (see Figures 5 and 6 below). The trend equations appear above the curves in each of the figures. Due to the scatter in the fecal coliform violations, the best R^2, 0.58, remained somewhat low (see Figure 6).

To represent the TMDLs as a single value, the existing load was calculated from the trend as the average of the load violations occurring when the flow (or load) was exceeded at a frequency greater than 10 percent and less than 95 percent. Additionally, the average load is calculated by using percent flow exceeded in multiples of 5 percent. Consideration of violations of the one-day maximum fecal coliform criterion for Pigeon House Branch when the flow frequency is between 10 and 95 percent, yields loads ranging between 9.49×10^{9} and 1.63×10^{11} counts/day. The average of these values, 3.61×10^{10} counts/day, represents the total existing load in the stream. For copper, the range of one-day violations of the criterion includes loads of between 7.20×10^{6} and 2.08×10^{9} kg/day, and an average of 3.81×10^{7} ug/day. See Appendix II for a further breakdown of the existing load calculations.

4.1.2 Reduction Target Calculation

The next step is to determine the percent reductions needed to comply with the water quality criteria. For both copper and fecal coliform in Pigeon House Branch, the allowable load was exceeded during all – low, average and high - streamflows. To calculate the necessary reduction in load, DWQ considered all violations through the use of the trend curve.

DWQ calculated the percent reduction as the difference between the average of the trend 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 multiples of 5) the equation of the trend curve is used to estimate the existing load; the allowable load is calculated in a similar fashion by substituting the allowable load curve. Next, DWQ took the average of these estimates and calculated the percent difference between the averages. For fecal coliform, the averages were 3.16×10^{10} and 7.83×10^{9} counts/day for the existing and target loads, respectively. This equates to a 78% reduction required. For copper, the averages were 3.81×10^{7} and 1.29×10^{7} ug/day for the existing and target loads, respectively. This equates to a 66% reduction in load. Detailed calculations for estimating the percent reduction for each stream are provided in Appendix II.

Figure 5.

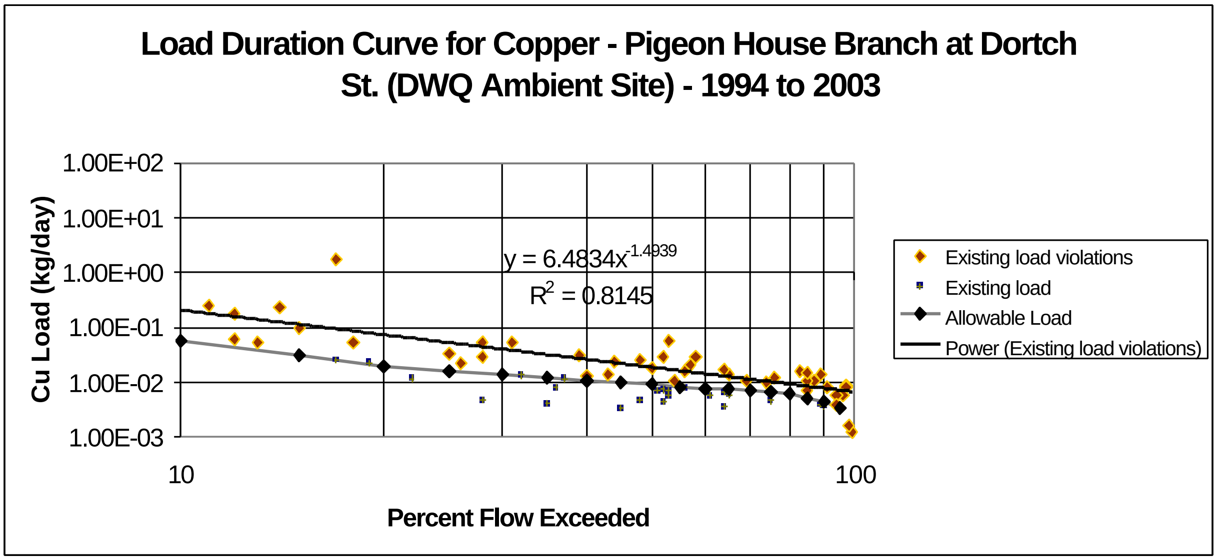
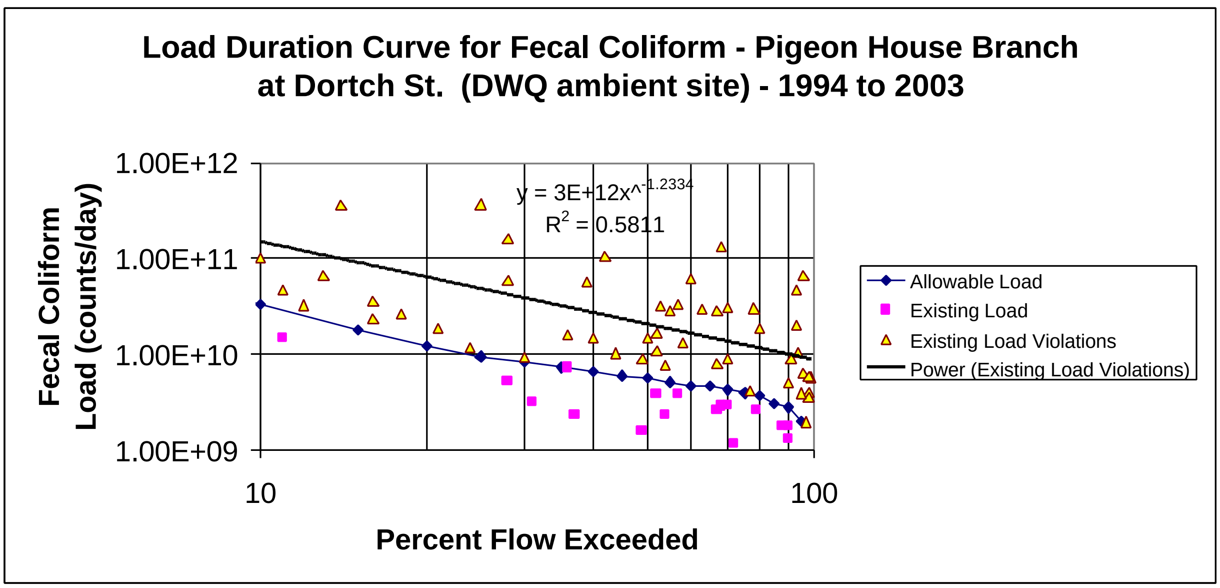


Figure 6.



4.1.3 Critical Conditions

Critical conditions are accounted for in the load curve analysis by using an extended period of streamflow and water quality data, and by examining at what flows (percent flow exceeded) the existing load violations occur. In theory, the flow range (percent flow exceeded) with the greatest difference between the existing load violations trend line and the allowable load line may be the critical condition. However, in Pigeon House Branch, the existing load violations occur at all flows, so DWQ elected to use the average difference between the exiting load violation trend line and the allowable load line.

4.2 Margin of Safety

There are two methods for incorporating an MOS in a TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In these TMDLs, an explicit MOS was used.

To provide an explicit margin of safety, the allowable load curves above (Figures 5 and 6) use adjusted standards of 6 ug/L copper (versus the actual standard of 7 ug/L for copper) and 360 counts/100mL for fecal coliform (versus the actual instantaneous standard of 400 counts/100mL). This provides a 14% margin of safety for copper and a 10% margin of safety for fecal coliform.

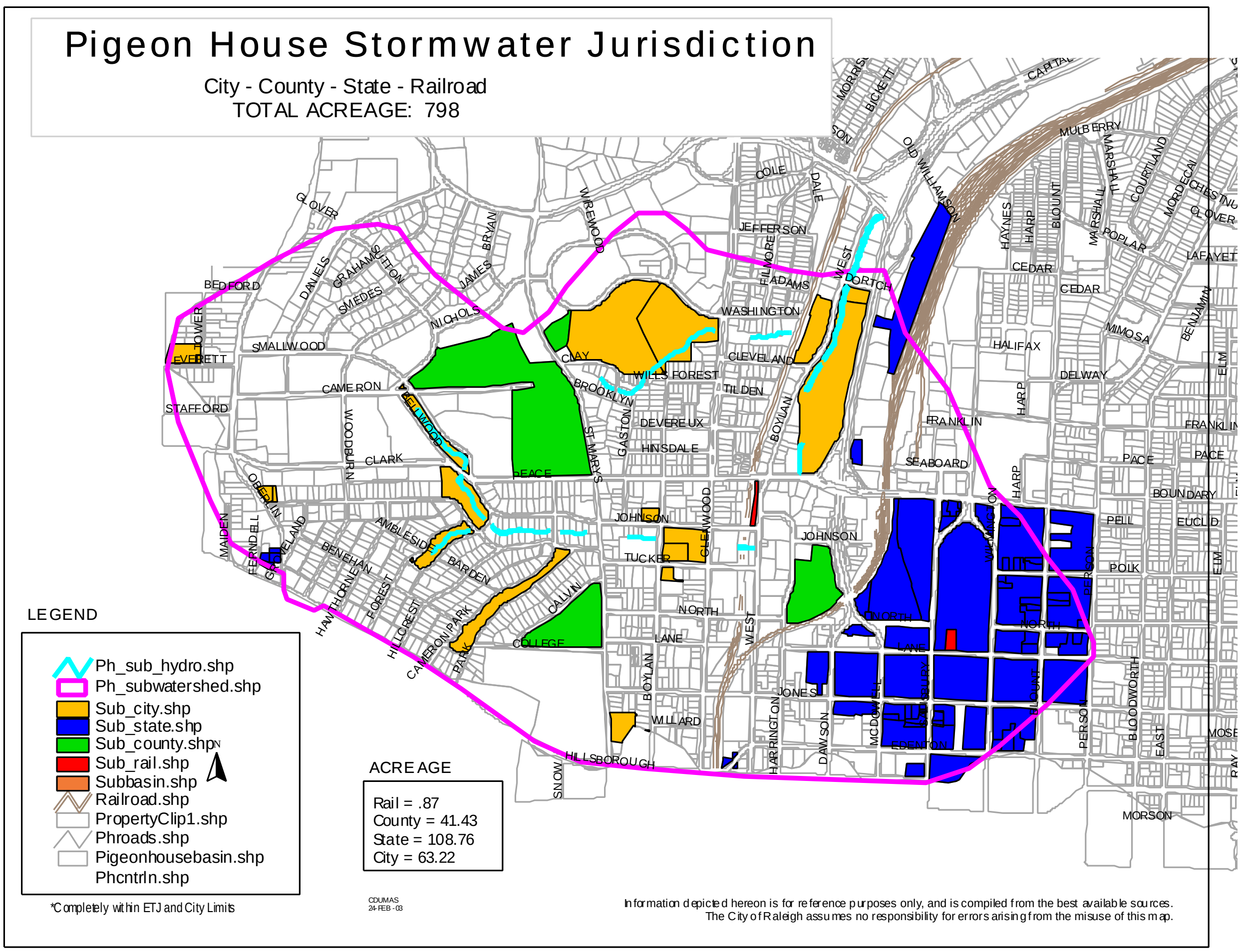
4.3 TMDL Allocation

The TMDLs determined above for fecal coliform and copper must be allocated to a wasteload allocation (WLA) and a load allocation (LA).

The Pigeon House Branch watershed is, for the most part, an urban landscape that is drained by a network of stormwater pipes and sewers. Additionally, most of this stormwater network is included in NPDES stormwater permits for Municipal Separate Storm Sewer System (MS4s). Specifically, the City of Raleigh and the North Carolina Department of Transportation have Phase I MS4 permits for NPDES stormwater discharge. Wake County, which has jurisdiction over some of the stormwater network, is expected to be added to this regulatory framework in Phase II. The State of North Carolina Government Complex and some federal land has stormwater infrastructure within the Pigeon House Branch watershed that is currently not scheduled to be permitted through NPDES. This may change, however. Also, fecal coliform and copper reductions will be sought from these lands.

The assumption in this TMDL is that all fecal coliform and copper enters the drainage network through the storm sewer system, or via leaks in the sanitary sewer system, **except** that which travels overland in sheet flow. The latter is assumed to occur within 50 feet of open channels of the Pigeon House drainage network. Based on mapping done for the City of Raleigh by contractors, DWQ defines the open channel network in Figure 7. The rationale for this assumption is that property adjacent to streams is not likely to be piped; it is more likely that stormwater will travel overland or in shallow groundwater to the stream channel.

Figure 7.



Notes on Figure 7: 1 " = 1300 ft., watershed area is outlined
The area noted for the 'rail' category in Figure 7 is low because the area of all the railroad tracks and rights of way do not show as parcels under the county's property database. The true area for the 'rail' category is probably closer to 20 to 30 acres.

Considering that the lion's share of the watershed is drained by current or near future NPDES stormwater permit holders, the lion's share of the TMDL will be put in the WLA, per EPA guidance (personal communication, EPA Region IV). In accordance with 40 CFR §130.2 (i), it is reasonable to express allocations for NPDES-regulated stormwater discharges from multiple point sources as a single waste load allocation (WLA), rather than assigning individual WLAs to each stormwater outfall within the MS4 area. Additionally, DWQ will not attempt to separate NPDES regulated stormwater from non-NPDES regulated stormwater; they will be lumped together in the WLA because there is insufficient technical basis to separately quantify the NPDES and non-NPDES stormwater loading.

4.3.1 Load Allocations

To calculate a load allocation, DWQ assumed that the 50 feet on either side of an open drainage channel (see Figure 7 for display of open drainage channels) would drain directly to the stream network (<u>not</u> via the storm sewer network) and hence should be included in the LA. The open channel mapping comes from the City of Raleigh. Based on this, DWQ calculated that 0.03 square miles (8600 feet in length times 50 feet on either side of drainage) drain by means other than stormwater piping to open channels. 0.03 square miles is 0.026 **percent** of the 1.15 square miles in the Pigeon House subwatershed (up to the monitoring station at Dortch St.), so the LA portion of the TMDL, using the listed assumptions, is diminutive.

The LAs are 0.026 percent of the TMDLs, which equals 5.16 X 10^4 ug/day for copper, and 3.13 X 10^7 counts/day for fecal coliform.

4.3.2 Wasteload Allocations

For the Pigeon House Branch TMDL, the WLA consists of copper and fecal coliform loading from the stormwater system, regardless of what entity has jurisdiction over the outfall. There are no continuous NPDES discharges in the watershed. The WLA component was calculated as the difference between the TMDL and the LA components. See Table 8 for the full TMDL allocation.

Any future NDPES facility (in this case, continuous discharge) permitted to discharge fecal coliform bacteria or copper in the watershed will be required to meet permit limits. Future facilities discharging at concentrations less than the water quality standard should not cause or contribute fecal coliform bacteria or copper impairment in the watershed.

Table 8. Pigeon House Branch Fecal Coliform and Copper TMDL Components

Pollutant	WLA [1]	LA [2]	MOS [3]	TMDL	Percent Reduction[4]
Fecal Coliform	7.63E+09 counts/day	2.04E+08 counts/day	Explicit	7.83E+09 counts/day	78%
Copper	1.26E+07 ug/day	3.35E+05 ug/day	Explicit	1.29E+07 ug/day	66%

Notes:

1. All future permitted discharges shall not exceed the water quality criteria for fecal coliform bacteria maximum one-day concentration of 400 counts/100mL or a monthly average of 200 counts/100mL. WLA=TMDL – LA (see note 2).
2. LA = TMDL multiplied by area drained by unpiped flow (see 4.3.1), where TMDL is the average allowable load between the 95th and 10th percent flow exceeded.
3. Margin of safety (MOS) equivalent to 10 percent of the target concentration for fecal coliform and 14 percent for copper (see 4.2).
4. Average reduction required between the 95th and 10th percent flow exceeded estimated in the stream. Used only DWQ ambient data in calculations (see Section 1.2).

4.4 Seasonal Variation

Seasonal variation was incorporated in the load curves by using the entire period of record of flow recorded at the gages. Seasonality was also addressed by using water quality data that was collected during multiple seasons.

5.0 Implementation Plan

The TMDL analysis was performed using the best data available to specify the percent reductions necessary to achieve water quality criteria. The intent of meeting the criteria is to support the designated use classifications in the watershed. As a class C water, the designated uses that apply to Pigeon House Branch are aquatic life propagation and maintenance of biological integrity, and secondary recreation.

Achieving reductions in copper loading may be particularly challenging as changes to the sources (brake linings, building siding and atmospheric loading) are not feasible in the near term. They would require, for instance, changes to how automobile brakes are constructed. To reduce copper loading a more likely, though still quite challenging, scenario is to treat stormwater before it enters the stream network. Stormwater from roadways, in particular, will need to be treated to maintain water quality standards. The good news in this case is that the copper impairment is not very severe. According the synoptic surveys by the City of Raleigh (see Water Quality Monitoring section on p. 9, and Appendix I) several hot spots exist, including the entrance to the Equipment Service Depot off of West St. and the culvert between West St. and Peace Street. Best management practice (BMP) installation directed at reducing copper loading, and fecal coliform as well, should probably focus on these areas.

An important component of the fecal coliform TMDL implementation plan will be the bacterial source tracking project that DWQ and the City of Raleigh are scheduled to begin this year as part of a larger EPA 319 project. Using antibiotic resistance techniques, the agencies and their contractor will categorize the sources of the bacteria found in the stream. The source categories are expected to be humans, pets and wildlife. This, along with Raleigh's source assessment efforts (see Appendix I), will provide better criteria for formulating a management strategy, and subsequently for installing BMPs, to reduce fecal coliform loading. Of course, the overall goal is to meet the designated use of allowing secondary recreation, and should the management strategy and initial BMPs fail to do that, additional BMPs will be required.

5.1 Urban Sources of Pollutant Loading

The City of Raleigh and the NC Department of Transportation were issued a NPDES Municipal Separate Storm Sewer System (MS4) permits under the Phase 1 storm water regulations. Each permittee is required to develop a Storm Water Management Program (SWMP). The SWMP covers the duration of the permit (5-year renewable) and comprises a comprehensive planning process which involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, public education, and other appropriate methods and provisions. With respect to fecal coliform and copper pollution reduction, additional activities and programs conducted by city, county, and state agencies are recommended to support the SWMP:

- Field screening and monitoring programs to identify the types and extent of fecal coliform and copper water quality problems, relative degradation or improvement over time, areas of concern, and source identification.

- Requirements that all new and replacement sanitary sewage systems are designed to minimize discharges from the system into the storm sewer system.

- Mechanisms for reporting and correcting illicit connections, breaks, surcharges, and general sanitary sewer system problems with potential to release to the municipal separate storm sewer system.

6.0 Stream Monitoring

In order to evaluate the fecal coliform model, monitor water quality conditions and assess progress of the TMDL, an evaluation location was established for the Pigeon House Branch watershed. The evaluation location of this watershed is Pigeon House Branch at Dortch St., which is the DWQ ambient monitoring station. DWQ should consider moving the ambient monitoring station closer to Pigeon House Branch's confluence with Crabtree Creek, which defines the extent of the fecal coliform and copper impairments. Additionally, for this reason, **reductions in copper and fecal coliform loading should be sought from the entire Pigeon House Branch watershed to its confluence with Crabtree Creek.** Fixes (e.g. BMP installation) should be applied where sources have been identified, and in subwatersheds where there are high levels of fecal coliform or copper.

Continued monitoring of the fecal coliform concentration at multiple water quality sampling points in the watershed is critical in characterizing sources of fecal coliform contamination and documenting future reduction of loading. Monitoring should be expanded to provide water quality information to characterize seasonal trends and refined source identification and delineation. In addition, monitoring efforts should be refined and enhanced in order to characterize dry and wet season base flow conditions (concentrations) and promote selective storm response (hydrograph) characterization. The Storm Water Management Program (see previous page) is a good means for achieving the continued and increased monitoring.

7.0 Future Efforts

This TMDL represents an early phase of a long-term restoration project to reduce fecal coliform and copper loading to acceptable levels (meeting water quality standards) in the Pigeon House Branch watershed. DWQ and the City of Raleigh should evaluate the progress of implementation strategies, and refine the TMDL as necessary, in the next phase (five-year cycle). This will include recommending specific implementation plans for identified problem areas. 319 nonpoint source grants may be a good source of funding for BMP implementation.

8.0 Public Participation

DWQ will publish a notice in the Raleigh newspaper, The News & Observer, outlining information on the development of this draft TMDL and will allow the public 30 days to comment on the draft. Additionally, during this public notice period, DWQ will present the TMDL to the public on May 6, 2003 and offer opportunity for questions and comments.

9.0 Further Information

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/

Technical questions regarding this TMDL should be directed to the following members of the DWQ Modeling/TMDL Unit:

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APPENDIX I. DWQ Ambient data for fecal coliform and copper

date	fecal coliform (cfu/100 ml)	data qualifier	copper (ug/L)	data qualifier
9/28/94	1200		26	
10/26/94	1200		14	
11/29/94	400		10	
12/27/94	70		6	
1/23/95	260		3	
2/24/95	280		6	
3/21/95	530		39	
4/12/95	870		13	
5/9/95	1700		6	
6/8/95	10	K	380	
7/26/95	7200		22	
8/8/95	1200		28	
9/12/95	430		13	
10/26/95	420		12	
12/21/95	36		4	
1/26/96	9		4	
2/6/96	10		12	
4/24/96	400		24	
5/1/96	1000		8	
6/10/96	6900		19	
7/1/96	230		21	
8/8/96	1000		16	
9/25/96	100		9	
10/2/96	2500		12	
11/5/96	240		5	
12/4/96	1100	K	5	
1/16/97	7300		32	
2/11/97	810		7	
3/5/97	690		6	
4/8/97	160		5	
5/8/97	100		3	
6/11/97	1300		12	
7/22/97	620		28	
8/27/97	3000		12	
9/25/97	6800		22	
10/14/97	230		14	
11/12/97	510		5.7	
12/5/97	560		16	
1/9/98	960		12	
2/9/98	120		6.1	
3/5/98	140		6.1	

Final version submitted to EPA

date	fecal coliform (cfu/100 ml)	data qualifier	copper (ug/L)	data qualifier
4/8/98	2300		4.6	
5/11/98	6000	L	21	
6/1/98	2200		20	
7/7/98	6000	L	13	
8/18/98	3100		17	
9/8/98	13000	L	22	
10/5/98	14000	L	8.1	
11/10/98	2000		7.8	
12/1/98	260		4.6	
1/12/99	2300		5.4	
2/8/99	650		3	
3/3/99	580		7.5	
4/16/99	6000	L	2	K
5/13/99	660		13	
6/2/99	11000	L	12	
8/11/99	210		14	
9/8/99	2500		23	
10/4/99	14000	L	8.4	
11/10/99	590		3.8	
12/6/99	600	L	29	
1/20/00	1100		28	
2/7/00	220		2	K
3/13/00	540		41	
4/12/00	600	L	2	
5/9/00	2700		7.4	
6/19/00	4700		22	
7/18/00	170		20	
8/17/00	710		15	
9/2/00	4100		10	
10/23/00	3200		4.7	
11/28/00	760		9.5	
12/7/00	250			
1/23/01	2600			
2/28/01	710			
5/8/01	660	B4,Q		
6/21/01	200	Q		
7/23/01	1900	B1,Q		
9/24/01	2800	Q		
10/11/01	810	Q,B4		
11/29/01	370			

Notes: Data qualifiers are: K - Actual value is known to be less than value given. L - Actual value is known to be greater than value given. B4 – Filters have counts of both > 60 or 80 and <2. Data qualifier continued Reported value is a total of the counts from all countable filters reported per 100 ml. Q – Holding time exceeded.

APPENDIX I. City of Raleigh - Refined Sampling Program Data

DATE	LOCATION	LAND USE	Cu (mg/L)	F. C.(CFU/100mL)
6/6/01	1. W Johnson St.	comm/res.	3	2800
6/6/01	2. West St.	comm/res.	2	1900
6/6/01	3. culvert - West St. to Peace St.	comm/res.	6	14000
6/6/01	4. entrance to ESD off West St.	multi	2	11000
6/6/01	5. West St. (Thomas Concrete)	multi	3	3100
6/6/01	6. connector - Wade Ave. to Glenwood Ave.	res.	1	1600
6/6/01	7. Harris Wholesale off Capital Blvd.	multi	1	1200
6/6/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	3	2200
6/6/01	9. Crabtree Blvd.	multi	2	2100
6/6/01	10. Automotive Way	res.	1	5700
6/6/01	11. Frank St.	res.	1	2100
6/6/01	12. N Boundary St.	res.	5	950
6/13/01	1. W Johnson St.	comm/res.	2	9200
6/13/01	2. West St.	comm/res.	2	2900
6/13/01	3. culvert - West St. to Peace St.	comm/res.	5	39000
6/13/01	4. entrance to ESD off West St.	multi	1	3800
6/13/01	5. West St. (Thomas Concrete)	multi	4	1900
6/13/01	6. connector - Wade Ave. to Glenwood Ave.	res.	2	1800
6/13/01	7. Harris Wholesale off Capital Blvd.	multi	2	11000
6/13/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	2	1000
6/13/01	9. Crabtree Blvd.	multi	2	920
6/13/01	10. Automotive Way	res.	1	1900
6/13/01	11. Frank St.	res.	1	3800
6/13/01	12. N Boundary St.	res.	63	3200
6/21/01	1. W Johnson St.	comm/res.	2	7500
6/21/01	2. West St.	comm/res.	2	860
6/21/01	3. culvert - West St. to Peace St.	comm/res.	10	1500
6/21/01	4. entrance to ESD off West St.	multi	3	56000
6/21/01	5. West St. (Thomas Concrete)	multi	5	1900
6/21/01	6. connector - Wade Ave. to Glenwood Ave.	res.	2	1700
6/21/01	7. Harris Wholesale off Capital Blvd.	multi	2	29000
6/21/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	3	1100
6/21/01	9. Crabtree Blvd.	multi	2	1100
6/21/01	10. Automotive Way	res.	2	1400
6/21/01	11. Frank St.	res.	2	2200
6/21/01	12. N Boundary St.	res.	2	3800
6/27/01	1. W Johnson St.	comm/res.	2	2200
6/27/01	2. West St.	comm/res.	2	1600

6/27/01	3. culvert - West St. to Peace St.	comm/res.	4	1600
6/27/01	4. entrance to ESD off West St.	multi	4	32000
6/27/01	5. West St. (Thomas Concrete)	multi	6	5000
6/27/01	6. connector - Wade Ave. to Glenwood Ave.	res.	1	600
6/27/01	7. Harris Wholesale off Capital Blvd.	multi	1	9600
6/27/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	4	2200
6/27/01	9. Crabtree Blvd.	multi	3	8000
6/27/01	10. Automotive Way	res.	2	2800
6/27/01	11. Frank St.	res.	4	9800
6/27/01	12. N Boundary St.	res.	2	6000
7/5/01	1. W Johnson St.	comm/res.	4	5800
7/5/01	2. West St.	comm/res.	4	4300
7/5/01	3. culvert - West St. to Peace St.	comm/res.	7	21000
7/5/01	4. entrance to ESD off West St.	multi	10	4100000
7/5/01	5. West St. (Thomas Concrete)	multi	7	18000
7/5/01	6. connector - Wade Ave. to Glenwood Ave.	res.	4	6200
7/5/01	7. Harris Wholesale off Capital Blvd.	multi	2	6800
7/5/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	5	4800
7/5/01	9. Crabtree Blvd.	multi	5	5800
7/5/01	10. Automotive Way	res.	3	8800
7/5/01	11. Frank St.	res.	2	12000
7/5/01	12. N Boundary St.	res.	2	4700
7/12/01	1. W Johnson St.	comm/res.	2	1500
7/12/01	2. West St.	comm/res.	2	3500
7/12/01	3. culvert - West St. to Peace St.	comm/res.	3	2000
7/12/01	4. entrance to ESD off West St.	multi	3	58000
7/12/01	5. West St. (Thomas Concrete)	multi	5	8000
7/12/01	6. connector - Wade Ave. to Glenwood Ave.	res.	1	2000
7/12/01	7. Harris Wholesale off Capital Blvd.	multi	2	500
7/12/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	2	1
7/12/01	9. Crabtree Blvd.	multi	2	5500
7/12/01	10. Automotive Way	res.	5	3500
7/12/01	11. Frank St.	res.	2	3500
7/12/01	12. N Boundary St.	res.	2	2000
7/18/01	1. W Johnson St.	comm/res.	1	700
7/18/01	2. West St.	comm/res.	2	2200
7/18/01	3. culvert - West St. to Peace St.	comm/res.	3	700
7/18/01	4. entrance to ESD off West St.	multi	26	31500
7/18/01	5. West St. (Thomas Concrete)	multi	5	800
7/18/01	6. connector - Wade Ave. to Glenwood Ave.	res.	2	200
7/18/01	7. Harris Wholesale off Capital Blvd.	multi	10	5600
7/18/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	2	700
7/18/01	9. Crabtree Blvd.	multi	2	500
7/18/01	10. Automotive Way	res.	2	600
7/18/01	11. Frank St.	res.	1	200

7/18/01	12. N Boundary St.	res.	2	600
7/25/01	1. W Johnson St.	comm/res.	3	17000
7/25/01	2. West St.	comm/res.	5	17000
7/25/01	3. culvert - West St. to Peace St.	comm/res.	12	27000
7/25/01	4. entrance to ESD off West St.	multi	7	270000
7/25/01	5. West St. (Thomas Concrete)	multi	18	110000
7/25/01	6. connector - Wade Ave. to Glenwood Ave.	res.	5	12000
7/25/01	7. Harris Wholesale off Capital Blvd.	multi	2	33000
7/25/01	8. Gravel Service Rd. parallel to Capital Blvd.	multi	8	15000
7/25/01	9. Crabtree Blvd.	multi	6	27000
7/25/01	10. Automotive Way	res.	2	18000
7/25/01	11. Frank St.	res.	2	20000
7/25/01	12. N Boundary St.	res.	2	10000

Pigeon House Branch Locations Index (provided by the City of Raleigh)

Location 1: *Stream at West Johnson St.* This location is at Edna Metz Wells Park at the intersection of W. Johnson St and Peace St. This is a small park in an older residential neighborhood near Cameron Village. Samples were taken in the stream just upstream of the culvert under E Forest Rd. Grass, trees and other vegetation surround the creek, as well as numerous trash barrels. No sources of pollution or contamination are visible, although higher fecal coliform levels may be a result of neighborhood residents walking their dogs near the stream, as has been witnessed on numerous occasions. Much, but not all, of the stream is shaded by trees during the day.

Location 2: *Stream at West St.* Samples were taken in the creek before it enters the culvert crossing under West St; the culvert begins just north of the intersection of West St with Tucker St. This location is in a commercial area with the creek paralleling a small parking lot on the southern side of the creek. Throughout the day, trees shade the vast majority of the creek. No sources of pollution are visible, however, evidence of homeless activity is clearly visible through old shirts and jackets present, some hanging in trees, others lying in the water. Human contamination may be a partial explanation for higher fecal coliform levels.

Location 3: *Pipe discharging to culvert between West St. and Peace St.* Samples were taken from a 60-in concrete pipe approximately 450-ft into the box culvert (when measuring from the south to the north end of the culvert) that collects stormwater from the State Government Complex. Flow from this pipe is always steady and constant. No apparent pollution or contamination is visible, but homeless activity is a possibility inside the culvert.

Location 4: *Pipe discharging just upstream of entrance to ESD off West St.* The creek parallels West St and flows under the entrance to the Equipment Service Depot south of Dortch St. The sample is taken immediately from a 54-in concrete pipe running perpendicular to Capital Blvd. Shade and other factors surrounding the stream are not an influence on this sample because the sample is taken as the water leaves the pipe. It has been suggested that there may be a sanitary sewer line running parallel to Capital Blvd (this has not been confirmed), and possible sanitary sewer leaks would account for higher fecal coliform levels.

Location 5: *Stream at West St. (Thomas Concrete).* This site is located directly across the street from Thomas Concrete on West St. The creek is shaded by trees and much other vegetation for the majority of the day, if not all of the day. Thomas Concrete has an NPDES permitted storm drain that outlets directly into the creek; residue and chunks of concrete are clearly visible and in the morning hours, it is quite evident that this has an impact on the conditions immediately surrounding the outfall. Due to this clear contamination, samples are taken immediately upstream of the Thomas Concrete storm drainage site so the Thomas Concrete water may not contaminate the sample. NOTE: The pH of water draining from Thomas Concrete is always at least above 10.0, usually around 11.5 and reaching up to 12.2 on some days.

Location 6: *Stream at connector ramp from Wade Ave to Glenwood Ave.* This sample is taken from the tributary flowing from the direction of Williamson Dr, just downstream from the Glenwood Ave culvert—not from the direction of Cowper Dr (the tributaries are separate and then join together at this site). This site is not shaded, as there are no large trees to offer shade nearby. This site is at an island connector between two busy streets, which should limit the amount of human and animal activity at the site. No evidence of human activity or domestic animals is visible.

Location 7: *Pipe at Harris Wholesale off Capital Blvd.* Harris Wholesale is located off northbound Capital Blvd between Fairview Rd and Wake Forest Rd. Samples are taken from the 96-in concrete pipe that runs perpendicular to Capital Blvd underneath Harris Wholesale; the samples are taken directly from the pipe. No apparent causes of pollution or contamination are visible other than wildlife present in the stream. Flow is not steady; it varies between a higher, steady flow and a low flow, sometimes even a trickle.

Location 8: *Stream at gravel service road parallel to Capital Blvd.* As Atlantic Ave passes underneath Capital Blvd, there is a gravel service road running under the overpass between the northbound and southbound lanes of Capital Blvd above. At this point, the creek is surrounded by dense vegetation with nearby trees shading the stream in various sections. No obvious sources of pollution or contamination are visible.

Location 9: *Stream at Crabtree Blvd.* Samples are taken from the creek as it passes under Crabtree Blvd near its intersection with Capitol Blvd., just downstream from the Gateway Plaza Shopping Center. There are many trees and other vegetation that shade the sections of the stream. Large boulders, rocks, and other riprap are on the slope leading from the parking lot on the east bank of the stream. Many broken beer and liquor bottles can be seen along the rocks indicating possible human contamination.

Location 10: *Stream at Automotive Way.* The sample site is in front of a car wash located on Automotive Way as it merges into Capital Blvd. The stream flows from the direction of Plainview Ave. and then into a culvert that passes under Capital Blvd for a short time. The samples are taken from the stream before it enters the culvert. There are no trees at the site nor other vegetation offering shade to the stream. Besides the hand car wash and a nearby house, there are no visible pollution or contamination sources.

Location 11: *Stream at Frank St.* Samples are taken near the intersection of Frank St and Norris St, before the stream passes under Frank St. Nearby trees and vegetation do offer shade to some areas of the stream but not all. The site is in a neighborhood and alongside a large patch of grass where many people are likely to walk their dogs and other domestic pets.

Location 12: *Stream at North Boundary St.* This location is within Oakwood Cemetery. The creek passes through a culvert under Oakwood Ave and flows north through the cemetery. No shade is offered to the creek through the cemetery. The streambanks are covered by grass and more dense vegetation. No apparent pollution or contamination is visible.

Appendix II. TMDL Calculations

Copper load allocation at Pigeon House ambient site based on trendline equation and percent flow exceeded.

Power Eqn. Trendline: y = 6.4834x^-1.4939
where: x = percent flow exceeded

Percent Flow Exceeded	Existing Load (kg/day)	Target load (kg/day)	% Reduction
95	7.20E-03	3.28E-03	54.4%
90	7.80E-03	4.57E-03	41.5%
85	8.50E-03	4.99E-03	41.3%
80	9.31E-03	5.99E-03	35.6%
75	1.02E-02	6.46E-03	37.0%
70	1.14E-02	6.99E-03	38.5%
65	1.27E-02	7.56E-03	40.4%
60	1.43E-02	7.70E-03	46.1%
55	1.63E-02	8.42E-03	48.3%
50	1.88E-02	9.27E-03	50.6%
45	2.20E-02	9.84E-03	55.2%
40	2.62E-02	1.08E-02	58.6%
35	3.20E-02	1.20E-02	62.5%
30	4.03E-02	1.37E-02	66.0%
25	5.29E-02	1.57E-02	70.3%
20	7.38E-02	2.00E-02	72.9%
15	1.13E-01	3.00E-02	73.6%
10	2.08E-01	5.56E-02	73.2%
	average reduction		53.7%

Target load based on estimated flow and target conc of 6 ug/L
Existing load based on trendline equation - power equation
Only used DWQ ambient data for these calculations (see Section 1.2)

avg existing load (95 to 10 interval)	3.81E-02
avg target load (95 to 10 interval)	1.29E-02
avg reduction	66%

Appendix II. TMDL Calculations continued

F.C. load allocation at Pigeon House ambient site based on trendline equation and percent flow exceeded

Power Eqn. Trendline: 3E+12* x^-1.264
where: x = percent flow exceeded

Percent Flow Exceeded	Existing Load (cnts/day)	Target load (cnts/day)	% Reduction
95	9.49E+09	1.99E+09	79.1%
90	1.02E+10	2.76E+09	72.8%
85	1.09E+10	3.02E+09	72.3%
80	1.18E+10	3.63E+09	69.2%
75	1.28E+10	3.91E+09	69.5%
70	1.40E+10	4.23E+09	69.7%
65	1.53E+10	4.58E+09	70.1%
60	1.70E+10	4.66E+09	72.5%
55	1.89E+10	5.10E+09	73.1%
50	2.14E+10	5.61E+09	73.7%
45	2.44E+10	5.96E+09	75.6%
40	2.83E+10	6.56E+09	76.8%
35	3.35E+10	7.25E+09	78.4%
30	4.07E+10	8.29E+09	79.7%
25	5.13E+10	9.50E+09	81.5%
20	6.80E+10	1.21E+10	82.2%
15	9.78E+10	1.81E+10	81.5%
10	1.63E+11	3.37E+10	79.4%
		Average reduction	75.4%

Final version submitted to EPA
Target load based on estimated flow and target conc of 360 counts/100mL
Existing load based on trendline equation - power equation
Only used DWQ ambient data for these calculations (see Section 1.2)

avg existing load (95 to 10 interval)	3.61E+10
avg target load (95 to 10 interval)	7.83E+09
avg reduction	78%

Appendix III.

Responsiveness Summary for TMDLs for fecal coliform and copper to Pigeon House Branch - Raleigh, NC

NC Division of Water Quality
May, 2003

Comments from specified organizations are in italics as they appear in the delivered documents. DWQ's response follows in plain text.

The City of Raleigh would like to thank the State for the opportunity to comment on the draft Pigeon House Branch TMDL prepared by Division of Water Quality staff. We have the following comments:

1.The City of Raleigh takes exception to the placement of stormwater in the wasteload allocation (WLA) of the draft TMDL. There is, and has always been, a clear distinction between wastewater, which is a point source, and stormwater, which is a non-point source. Including stormwater in the WLA ignores this critical distinction. Placement of stormwater in the WLA contradicts the established understanding of the nature of non-point source pollution. In addition, including stormwater under the WLA may place limitations on issuance of new NPDES permits in this impaired (303(d) listed) water; may prohibit the State from issuing an NPDES Phase II Stormwater permit to Wake County; and could possibly be interpreted to require a moratorium on new development or expansions within the watershed. Such a moratorium would apply to city, state, and federally owned properties as well as private property.

DWQ agrees with the City of Raleigh that NPDES stormwater does not belong in the WLA. However, EPA has mandated that NPDES stormwater shall be put in the WLA. As far as what Raleigh has suggested for the effects of allocating the TMDL this way, DWQ will move forward by using appropriate alternatives for the management of stormwater runoff in accordance with these TMDLs. We anticipate that this will focus on the best management practices to meet these requirements, while still allowing additional activities to occur in these areas.

2.The City of Raleigh takes exception to both NPDES and non-NPDES permitted stormwater discharges being lumped together under the WLA primarily because this may become a significant issue during the implementation phase of the TMDL. The City of Raleigh would only support this arrangement if the City could be assured that those entities not identified as holding NPDES permits (such as the railroad and downtown NC Government complex) would be subject to the same restrictions and would be held accountable for reducing their pollutant loads similar to those entities that have NPDES permits.

Because there is insufficient technical basis to separately quantify the NPDES and non-NPDES stormwater loading, DWQ, with EPA's consent, decided to combine the two stormwater categories together. DWQ will seek pollutant load reductions from all sources within the watershed. Clearly, however, the regulatory agencies have more control over sources that require NPDES permits. The difference is that implementation of BMPs is mandatory for NPDES stormwater permit holders, while TMDL required load reductions are more or less voluntary for non-NPDES sources.

3. The City of Raleigh takes exception to the inference that the Department of Transportation (NCDOT) is the only State entity accountable under the State's NPDES stormwater permit. Since there are other portions of the Municipal Separate Storm Sewer System (MS4) outside of the jurisdiction of NCDOT that are owned and operated by the State, such as the downtown government complex, these areas should be included under the State's NPDES stormwater permit. In addition, it would appear that the State's NPDES stormwater permit would legally have to be issued for the State MS4 as a whole, under the signature of the State CEO, and that an individual department such as NCDOT would not qualify for separate permitting for just their portion of the MS4.

DWQ understands this concern and is continuing to investigate the issue. DWQ wants to assure that the best alternatives for addressing stormwater discharges from various activities in this area, from both a management and permitting perspective, are used.

4. The City of Raleigh would argue that under section 2.2.5, birds and other wildlife are a source of fecal coliform bacteria (FCB) throughout the watershed and not just in isolated urban areas as indicated.

This section has been changed to reflect Raleigh's comment.

5.The City of Raleigh takes exception to the statement in the 3rd paragraph of 4.3 that "Raleigh defines" the open channel network as illustrated. Raleigh has never "defined" the open channel system. There may be many more open channels within the watershed than those noted on the map. The system shown is simply based on maps prepared by contractors for the City of Raleigh.

Changed to 'Based on mapping done for the City of Raleigh by contractors, DWQ defines the open channel network in Figure 7'.

6.The City of Raleigh would take exception to the assumption in the 3rd paragraph of section 4.3 that "all fecal coliform and copper enters the drainage network through the storm sewer system". There is strong evidence from Charlotte studies that some FCB is transported directly to streams through underground flows from leaking sewers and failing septic systems. The magnitude of the contribution from these sources is unknown at this time.

This sentence has been changed as follows: the assumption in this TMDL is that all fecal coliform and copper enters the drainage network through the storm sewer system or via leaks in the sanitary sewer system **except** that which travels overland in sheet flow.

7.The City of Raleigh believes that the acreage noted under the "rail" category in Figure 7 is far greater than the .87 acres noted.

The area noted for the 'rail' category in Figure 7 is low because the area of all the railroad tracks and rights of way do not show as parcels under the county's property database. The true area for the 'rail' category is probably closer to 20 to 30 acres. This will be noted below Figure 7.

8.The City of Raleigh believes that the 0.03 acres assigned to the Load Allocation in section 4.3.1 is incorrect due to a math error.

Raleigh is correct; this is a mistake in the draft TMDL. It should read 0.03 square miles, not acres. Corrections have been made in the final TMDL.

9.The City of Raleigh believes that the phrase "and the problem pollutants" in the last sentence of the 1st paragraph of section 5.0 should be removed since this would indicate that uses apply to pollutants as opposed to streams.

The phrase "and other problem pollutants" has been removed.

END OF RESPONSIVENESS SUMMARY

END OF TMDL DOCUMENT