TOTAL MAXIMUM DAILY LOAD (TMDL)

for

E. Coli

in the

South Fork Holston River Watershed (HUC 06010102)

Carter, Greene, Hawkins, Johnson, Sullivan, and Washington Counties, Tennessee

FINAL

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LIST OF ABBREVIATIONS

ADB	Assessment Database
AFO	Animal Feeding Operation
BMP	Best Management Practices
BST	Bacteria Source Tracking
CAFO	Concentrated Animal Feeding Operation
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CFU	Colony Forming Units
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
E. coli	Escherichia coli
EPA	Environmental Protection Agency
GIS	Geographic Information System
HSPF	Hydrological Simulation Program - Fortran
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
MS4	Municipal Separate Storm Sewer System
MST	Microbial Source Tracking
NHD	National Hydrography Dataset
NMP	Nutrient Management Plan
NPS	Nonpoint Source
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCR	Polymerase Chain Reaction
PDFE	Percent of Days Flow Exceeded
PFGE	Pulsed Field Gel Electrophoresis
Rf3	Reach File v.3
RM	River Mile
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
SWMP	Storm Water Management Program
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment & Conservation
TDOT	Tennessee Department of Transportation
TMDL	Total Maximum Daily Load
TWRA	Tennessee Wildlife Resources Agency
USGS	United States Geological Survey
UCF	Unit Conversion Factor
WCS	Watershed Characterization System
WLA	Waste Load Allocation
WWTF	Wastewater Treatment Facility

SUMMARY SHEET

Total Maximum Daily Load for E. coli in South Fork Holston River Watershed (HUC 06010102)

Impaired Waterbody Information

State: Tennessee
Counties: Carter, Johnson and Sullivan
Watershed: South Fork Holston River (HUC 06010102)
Constituents of Concern: E. coli

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06010102006T – 0200	WAGNER CREEK	5.5
TN06010102006T – 0300	CANDY CREEK	3.2
TN06010102012 – 0100	UNNAMED TRIB TO SOUTH FORK HOLSTON RIVER	2.0
TN06010102012 – 0300	UNNAMED TRIB TO SOUTH FORK HOLSTON RIVER	3.89
TN06010102012 – 0400	MORRELL CREEK	4.89
TN06010102012 – 0700	DRY CREEK	1.0
TN06010102012 – 0810	BIG ARM BRANCH	5.77
TN06010102012 – 0820	WOODS BRANCH	5.0
TN06010102012 – 0900	WEAVER BRANCH	5.9
TN060101020250 – 0900	WATERS BRANCH	1.82
TN060101020250 – 2000	LAUREL CREEK	3.8
TN06010102042 – 0200	BACK CREEK	14.1
TN06010102042 – 0400[a]	LITTLE CREEK	0.3
TN06010102042 – 0500	CEDAR CREEK	11.8
TN06010102042 – 1000[b]	BEAVER CREEK	11.1
TN06010102042 – 2000[b]	BEAVER CREEK	10.5
TN060101020540 – 0800	PAINT SPRING BRANCH	1.0
TN06010102237 – 0100[c]	BOOHER CREEK	7.2

[a] Portions of this waterbody lie in another state. A TMDL has been developed by the State of Virginia for those portions of the waterbody lying within their jurisdiction. Monitoring data for the Tennessee portion of the waterbody was unavailable. Additional monitoring is recommended to allow for either development of a TMDL or delisting.
[b] Portions of this waterbody lie in another state. A TMDL has been developed by the State of Virginia for those portions of the waterbody lying within their jurisdiction.
[c] TMDL could not be developed for Booher Creek. No monitoring data was available. Additional monitoring is recommended to allow for either development of a TMDL or delisting.

Designated Uses:

The designated use classifications for waterbodies in the South Fork Holston River Watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January, 2004* for recreation use classification (most stringent):

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL. In addition, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli. TMDLs were developed for impaired waterbodies on a HUC-12 subwatershed or waterbody drainage area basis. Recently collecting water quality monitoring data were available for waterbodies that are not listed on the Final 2004 303(d) list as impaired due to E. coli.

A TMDL could not be developed for the Tennessee portion of Little Creek due to insufficient monitoring data. Additional monitoring is recommended to allow for either development of a TMDL or delisting. A TMDL could not be developed for Booher Creek (06010102237_0100). Monitoring data was available for another Booher Creek (part of 06010102012_0820). This monitoring data appeared to have been used in the assessment of Booher Creek (06010102237_0100). Additional monitoring is recommended to allow for either development of a TMDL or delisting for Booher Creek (06010102237_0100).

For Beaver Creek, the TMDL analysis was revised due to the availability of new data. This revised TMDL supersedes the Fecal Coliform TMDL approved by EPA in 2004.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the South Fork Holston River Watershed were developed using a load duration curve methodology to assure compliance with the E. Coli 126 CFU/100 mL geometric mean and the 487 CFU/100 mL maximum water quality criteria for Tier II waterbodies and 941 CFU/100 mL maximum water quality criteria for non-Tier II waterbodies. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the region of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet desired maximum concentrations for E. coli. When sufficient data were available, load reductions were also determined based on geometric mean criteria.

Critical Conditions:

Water quality data collected over a period of 10 years for load duration curve analysis were used to assess the water quality standards representing a range of hydrologic and meteorological conditions.

Seasonal Variation:

The 10-year period used for LSPC model simulation period for development of load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Explicit MOS = 10% of the E. coli water quality criteria for each impaired subwatershed or drainage area.

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs [d]
				WWTFs [a]		Leaking Collection Systems [b]	MS4s [c]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0104 (DA)	Waters Branch	TN060101020250 – 0900	>79.9	NA	NA	NA	>81.9	>81.9
0104 (DA)	Laurel Creek	TN060101020250 – 2000	>79.9	NA	NA	NA	>81.9	>81.9
0302 (DA)	Painter Springs Branch	TN060101020540 – 0800	>61.1	NA	NA	NA	>65.0	>65.0
0401	Unnamed Trib to South Fork Holston River	TN06010102012 – 0300	>61.1	NA	NA	NA	>65.0	>65.0
	Morrell Creek	TN06010102012 – 0400	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Unnamed Trib to South Fork Holston River	TN06010102012 – 0100	>45.2	NA	NA	NA	>50.6	>50.6
0402 (DA)	Big Arm Branch	TN06010102012 - 0810	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Dry Creek	TN06010102012 - 0700	>61.1	NA	NA	NA	>65.0	>65.0
0402 (DA)	Woods Branch	TN06010102012 - 0820	34.5	NA	NA	NA	41.1	41.1
0403	Candy Creek	TN06010102006T – 0300	>54.6	NA	NA	NA	>59.1	>59.1
	Wagner Creek	TN06010102006T – 0200	>61.1	$1.669x10^{8}$	$1.247x10^{9}$	NA	>65.0	>65.0
	Weaver Branch	TN06010102012 – 0900	>49.7	NA	NA	NA	>54.7	>54.7

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies (cont'd)

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs [d]
				WWTFs [a]		Leaking Collection Systems [b]	MS4s [c]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0502	Back Creek	TN06010102042 – 0200	>44.6	2.861×10^{7}	2.137×10^{8}	0	>50.1	>50.1
	Beaver Creek	TN06010102042 – 1000	>59.7	1.431×10^{7}	1.069×10^{8}	0	>63.7	>63.7
	Beaver Creek	TN06010102042 – 2000[e]	>61.1	NA	NA	0	>65.0	>65.0
	Cedar Creek	TN06010102042 – 0500	23.9	NA	NA	0	31.5	31.5

Notes: NA = Not Applicable.

a. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

b. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

c. Applies to any MS4 discharge loading in the subwatershed or drainage area.

d. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all "other direct sources" (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these unpermitted sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

e. Portions of these waterbodies lie in another state. A TMDL for Fecal Coliform has been developed by the State of Virginia for those portions of the waterbodies lying within their jurisdiction. The required load reduction is for the Tennessee portion of the waterbodies.

PROPOSED E. COLI TOTAL MAXIMUM DAILY LOAD (TMDL) SOUTH FORK HOLSTON RIVER WATERSHED (HUC 06010102)

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those waterbodies that are not attaining water quality standards. State water quality standards consist of designated uses for individual waterbodies, appropriate numeric and narrative water quality criteria protective of the designated uses, and an antidegradation statement. The TMDL process establishes the maximum allowable loadings of pollutants for a waterbody that will allow the waterbody to maintain water quality standards. The TMDL may then be used to develop controls for reducing pollution from both point and nonpoint sources in order to restore and maintain the quality of water resources (USEPA, 1991).

2.0 SCOPE OF DOCUMENT

This document presents details of TMDL development for waterbodies in the South Fork Holston River Watershed, identified on the Final 2004 303(d) list as not supporting designated uses due to E. coli. Portions of the South Fork Holston River Watershed lie in both Tennessee and Virginia. This document addresses only impaired waterbodies in Tennessee. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis. In some cases, where appropriate, TMDLs are developed for an impaired waterbody drainage area only.

A TMDL could not be developed for the Tennessee portion of Little Creek due to insufficient monitoring data. Additional monitoring is recommended to allow for either development of a TMDL or delisting. A TMDL could not be developed for Booher Creek (06010102237_0100). Monitoring data was available for another Booher Creek (part of 06010102012_0820). This monitoring data appeared to have been used in the assessment of Booher Creek (06010102237_0100). Additional monitoring is recommended to allow for either development of a TMDL or delisting for Booher Creek (06010102237_0100).

For Beaver Creek, the TMDL analysis was revised due to the availability of new data. This revised TMDL supersedes the Fecal Coliform TMDL approved by EPA in 2004.

3.0 WATERSHED DESCRIPTION

The South Fork Holston River Watershed (HUC 06010102) is located in Eastern Tennessee (Figure 1), primarily in Sullivan and Johnson Counties. The South Fork Holston River Watershed lies within two Level III ecoregion (Blue Ridge Mountains, Ridge and Valley) and contains eight Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **The Interior Plateau (66c)** is characterized by high, hilly plateau dotted with isolated monadnocks. The highest elevations of the region range from 2600-4500 feet. The Interior Plateau is underlain by Precambrian metamorphic rock, including quartzite, greywacke, and a conglomerate of the Lynchburg formation. Gneiss and schist are also found as outcrops. The region was once dominated by Appalachian Oak Forest and Oak-History-Pine Forest. Forested areas are broken by pasture and livestock farms.

- **Southern Igneous Ridges and Mountains (66d)** occur in Tennessee's northeastern Blue Ridge near the North Carolina border, primarily on the Precambrian-age igneaous and high-grade metamorphic rocks. The typical crystalline rock types include granite, gneiss, schist, and metavolcanics, covered by well-drained, acidic brown loamy soils. Elevations of this rough, dissected region range from 2000-6200 feet, with Roan Mountain reaching 6286 feet. Although there are a few small areas of pasture and apple orchards, the region is mostly forested; Appalachian oak and northern hardwood forests predominate.

- **The Southern Sedimentary Ridges (66e)** in Tennessee include some of the westernmost foothill areas of the Blue Ridges Mountains ecoregion, such as the Bean, Starr, Chilhowee, English, Stone, Bald, and Iron Mountain areas. Slopes are steep, and elevations are generally 1000-4500 feet. The rocks are primarily Cambrian-age sedimentary (shale, sandstone, siltstone, quartzite, conglomerate), although some lower stream reachs occur on limestone. Soils are predominantly friable loams and fine sandy loams with variable amounts of sandstone rock fragments, and support mostly mixed oak and oak-pine forests.

- **Limestone Valleys and Coves (66f)** are small but distinct lowland areas of the Blue Ridge, with elevations mostly between 1500 and 2500 feet. About 450 million years ago, older Blue Ridge rocks to the east were forced up and over younger rocks to the west. In places, the Precambrian rocks have eroded through to Cambrian or Ordovician-age limestones, as seen especially in isolated, deep cove areas that are surrounded by steep mountains. The main areas of limestone include the Mountain City lowland area and Shady Valley in the north; and Wear Cove, Tuckaleechee Cove, and Cades Cove of the Great Smoky Mountains in the south. Hay and pasture, with some tobacco patches on small farms, are typical land uses.

- **The Southern Limestone/Dolomite Valleys and Low Rolling Hills (67f)** form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly low rolling ridges and valleys, and the solids vary in their productivity. Landcover includes intensive agriculture, urban and industrial, or areas of thick forest. White oak forests, bottomland oak forests, and sycamore-ash-elm riparian forests are the common forest types, and grassland barrens intermixed with cedar-pine glades also occur here.

- **The Southern Shale Valleys (67g)** consist of lowlands, rolling valleys, and slopes and hilly areas that are dominated by shale materials. The northern areas are associated with Ordovician-age calcareous shale, and the well-drained soils are often slightly acid to neutral. In the south, the shale valleys are associated with Cambrian-age shales that contain some narrow bands of limestone, but the soils tend to be strongly acid. Small farms and rural residences subdivide the land. The steeper slopes are used for pasture or have reverted to brush and forested land, while small fields of hay, corn, tobacco, and garden crops are grown on the foot slopes and bottomland.

- **The Southern Sandstone Ridges (67h)** ecoregion encompasses the major sandstone ridges, but these ridges also have areas of shale and siltstone. The steep, forested chemistry of streams flowing down the ridges can vary greatly depending on the geologic material. The higher elevation ridges are in the north, including Wallen Ridge, Powell Mountain, Clinch Mountain, and Bays Mountain. White Oak Mountain in the south has some sandstone on the west side, but abundant shale and limestone as well. Grindstone Mountain, capped by the Gizzard Group sandstone, is the only remnant of Pennsylvanian-age strata in the Ridge and Valley of Tennessee.

- **The Southern Dissected Ridges and Knobs (67i)** contain more crenulated, broken, or hummocky ridges, compared to smoother, more sharply pointed sandstone ridges. Although shale is common, there is a mixture and interbedding of geologic materials. The ridges on the east side of Tennessee's Ridge and Valley tend to be associated with the Ordovician-age Sevier shale, Athens shale, and Holston and Lenoir limestones. These can include calcareous shale, limestone, siltstone, sandstone, and conglomerate. In the central and western part of the ecoregion, the shale ridges are associated with the Cambrian-age Rome Formation: shale and siltstone with beds of sandstone. Chestnut oak forests and pine forests are typical for the higher elevations of the ridges, with areas of white oak, mixed mesophytic forest, and tulip poplar on the lower slopes, knobs, and draws.

The South Fork Holston River Watershed, located in Carter, Greene, Hawkins, Johnson, Sullivan, and Washington Counties, Tennessee, has a drainage area of approximately 550 square miles (mi^2) in Tennessee. The entire watershed, including Tennessee and Virginia, drains approximately 1,170 square miles. Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the South Fork Holston River Watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the South Fork Holston River Watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Tennessee portion of the South Fork Holston River Watershed is forest (68%) followed by pasture (17%). Urban areas represent approximately 8% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the South Fork Holston River Watershed are presented in Appendix A.

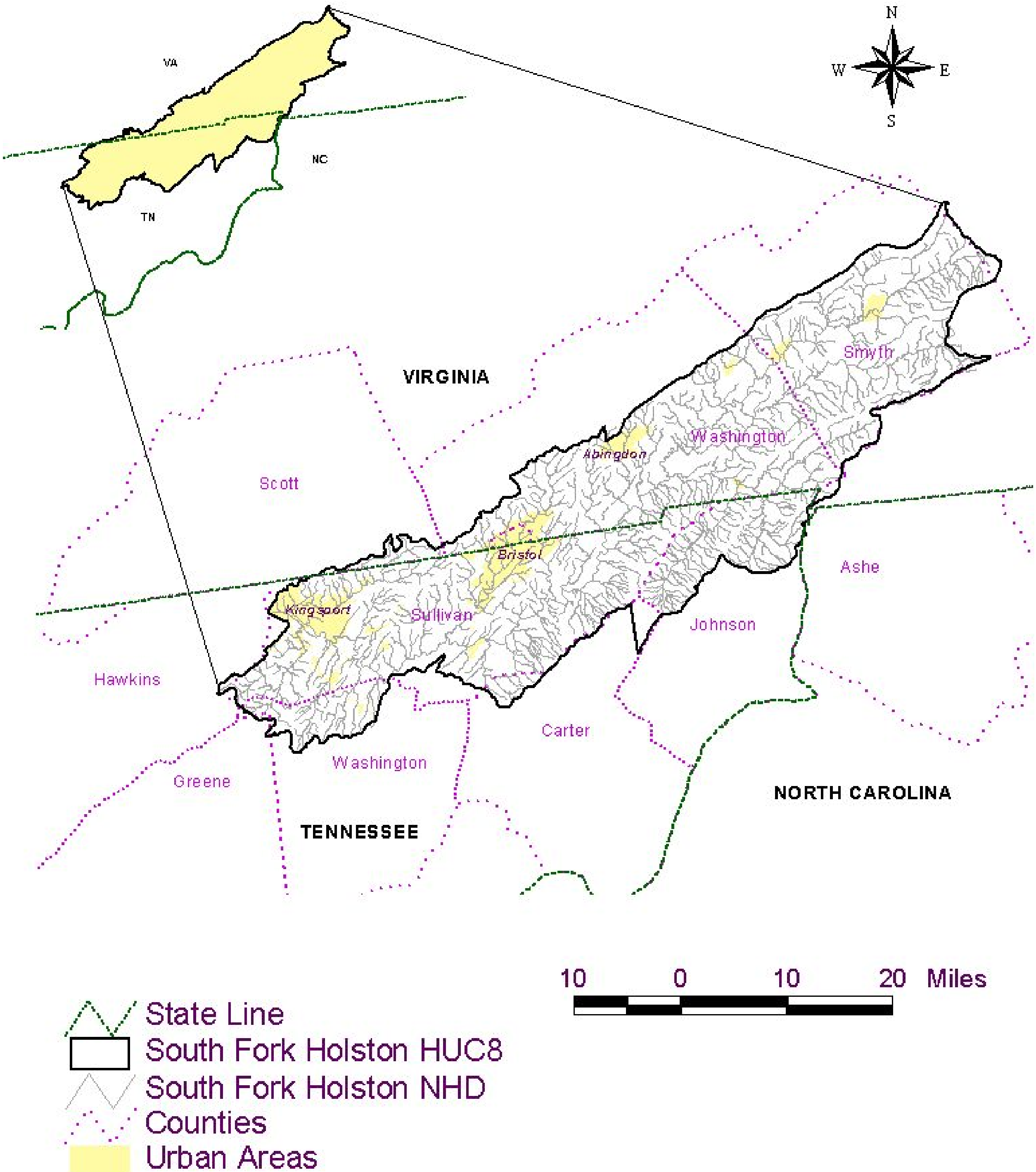

Figure 1. Location of the South Fork Holston River Watershed.

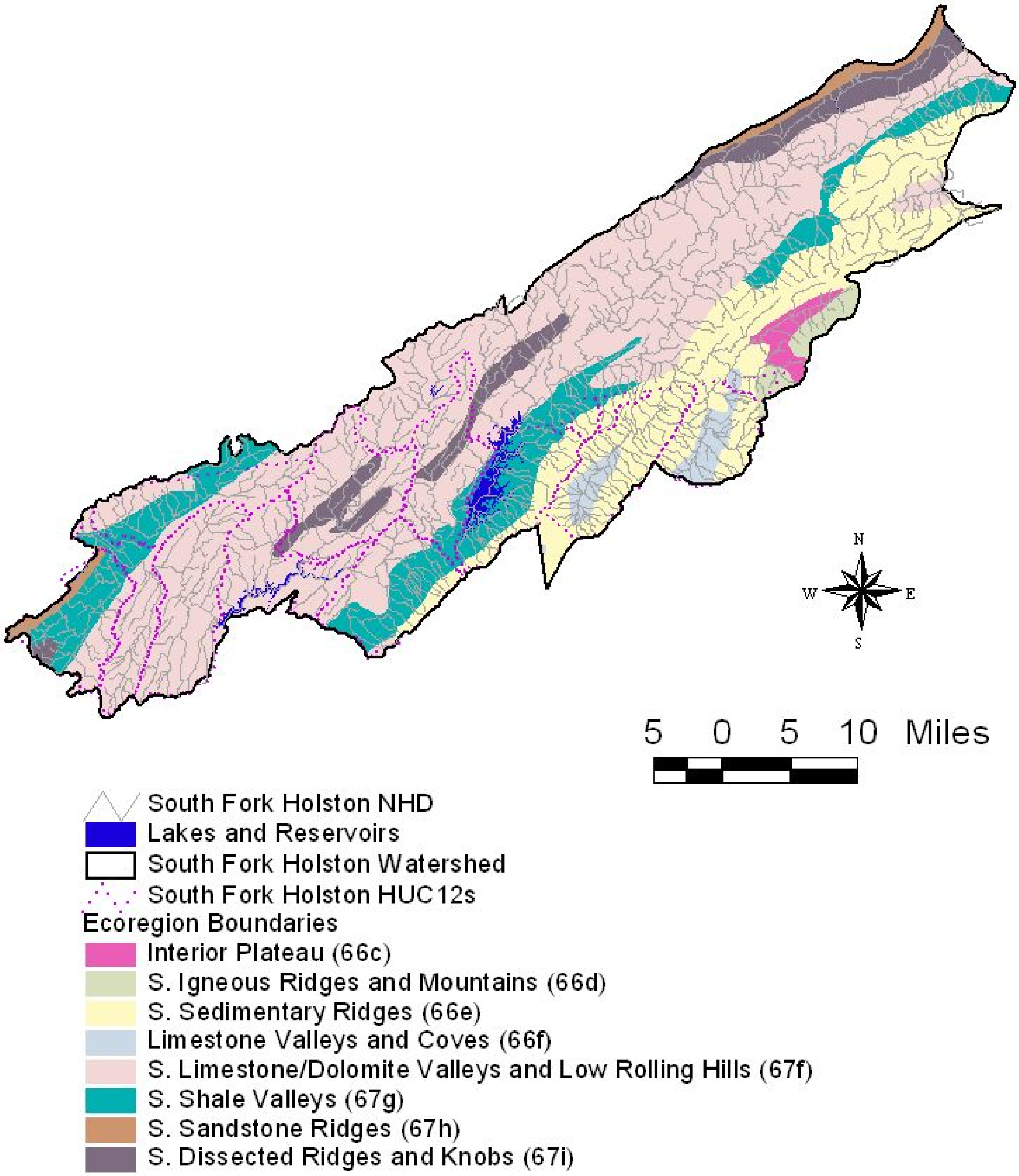

Figure 2. Level IV Ecoregions in the South Fork Holston River Watershed.

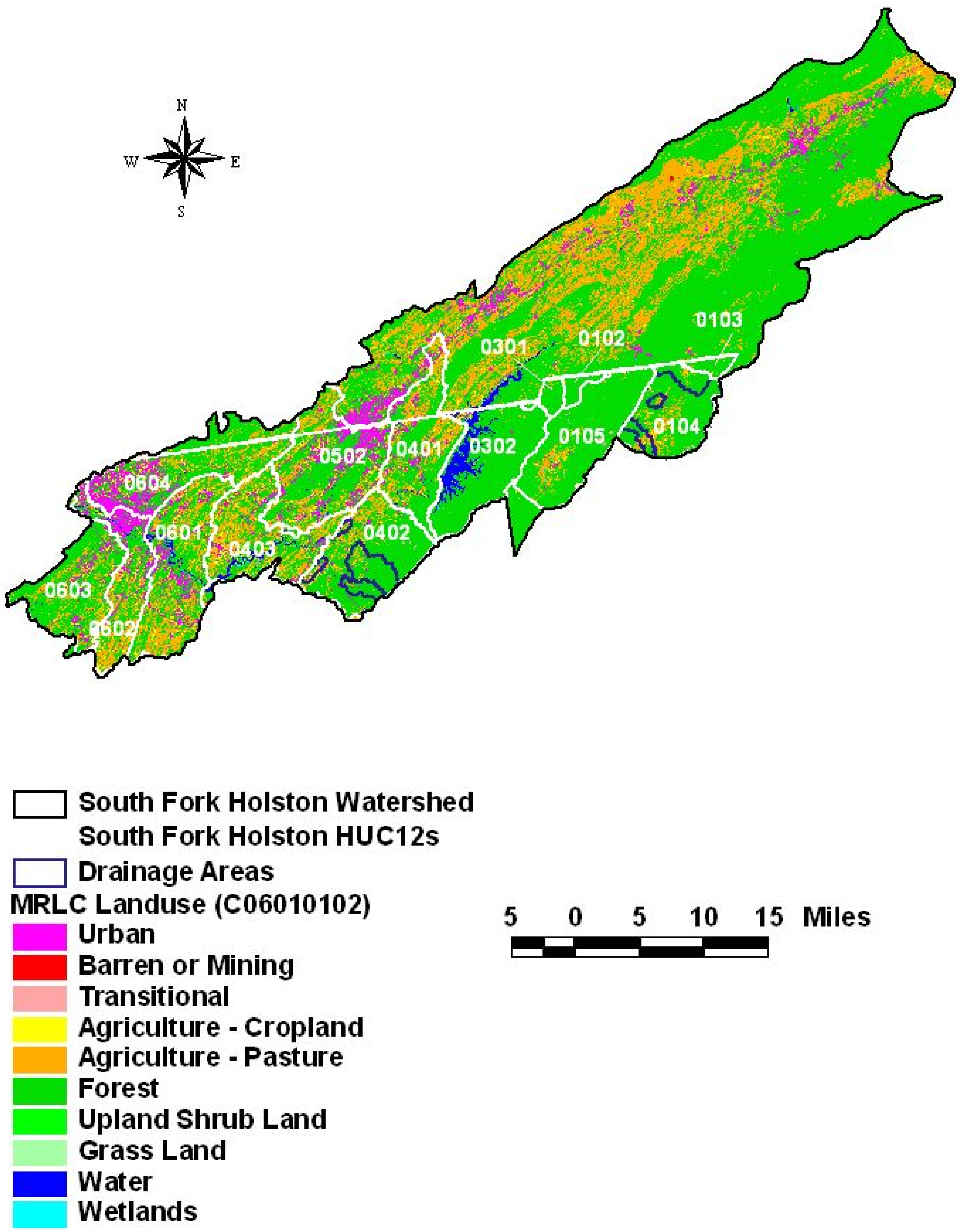

Figure 3. Land Use Characteristics of the South Fork Holston River Watershed.

Table 1. MRLC Land Use Distribution – South Fork Holston River Watershed

Land Use	Area – Entire HUC8		Area – Tennessee only	
	[acres]	%]	[acres]	[%]
Bare Rock/Sand/Clay	1,023	0.1	1,011	0.3
Deciduous Forest	328,286	43.9	132,541	37.9
Emergent Herbaceous Wetlands	356	0.0	211	0.1
Evergreen Forest	92,193	12.3	49,430	14.1
High Intensity Commercial/Industrial/ Transportation	12,717	1.7	7,531	2.2
High Intensity Residential	3,555	0.5	2,523	0.7
Low Intensity Residential	31,252	4.2	20,460	5.9
Mixed Forest	77,418	10.4	54,305	15.5
Open Water	9,388	1.3	7,744	2.2
Other Grasses (Urban/recreational)	6,579	0.9	5,980	1.7
Pasture/Hay	168,584	22.5	58,061	16.6
Quarries/Strip Mines/ Gravel Pits	188	0.0	23	0.0
Row Crops	14,393	1.9	8,625	2.5
Transitional	405	0.1	338	0.1
Woody Wetlands	1,277	0.2	901	0.3
Total	**747,614**	**100.0**	**349,685**	**100.0**

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2004 303(d) list (TDEC, 2005) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. This list identified portions of seventeen waterbodies in the South Fork Holston River Watershed as not supporting designated use classifications due, in part, to E. coli (see Table 2 & Figure 4). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

When used in the context of waterbody assessments, the term pathogens is defined as disease-causing organisms such as bacteria or viruses that can pose an immediate and serious health threat if ingested or introduced into the body. The primary sources for pathogens are untreated or inadequately treated human or animal fecal matter. The E. coli and fecal coliform groups are indicators of the presence of pathogens in a stream.

5.0 WATER QUALITY CRITERIA & TMDL TARGET

As previously stated, the designated use classifications for the South Fork Holston River waterbodies include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. Of the use classifications with numeric criteria for pathogens, the recreation use classification is the most stringent and will be used to establish target levels for TMDL development. The coliform water quality criteria, for protection of the recreation use classification, is established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January 2004* (TDEC, 2004a). Section 1200-4-3-.03 (4) (f) states:

> The concentration of the E. coli group shall not exceed 126 colony forming units per 100 mL, as a geometric mean based on a minimum of 5 samples collected from a given sampling site over a period of not more than 30 consecutive days with individual samples being collected at intervals of not less than 12 hours. For the purposes of determining the geometric mean, individual samples having an E. coli concentration of less than 1 per 100 mL shall be considered as having a concentration of 1 per 100 mL.
>
> Additionally, the concentration of the E. coli group in any individual sample taken from a lake, reservoir, State Scenic River, or Tier II or III stream (1200-4-3-.06) shall not exceed 487 colony forming units per 100 mL. The concentration of the E. coli group in any individual sample taken from any other waterbody shall not exceed 941 colony forming units per 100 mL.

Portions of Big Arm Branch, Laurel Creek, Little Creek, Morrell Creek, and Waters Branch within the Cherokee National Forest have been classified as Tier II streams. As of February 2, 2006, none of the other E. coli impaired waterbodies in the South Fork Holston River Watershed have been classified as either Tier II or Tier III streams.

The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 487 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for impaired waterbodies classified as Tier II streams. The geometric mean standard for the E. coli group of 126 colony forming units per 100 ml (CFU/100 ml) and the sample maximum of 941 CFU/100 ml have been selected as the appropriate numerical targets for TMDL development for the other impaired waterbodies.

Table 2 Final 2004 303(d) List for E. coli Impaired Waterbodies – South Fork Holston River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010102006T – 0200	WAGNER CREEK	5.5	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102006T – 0300	CANDY CREEK	3.2	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102012 – 0100	UNNAMED TRIB TO SOUTH FORK HOLSTON (at Silver Grove Rd.)	2.0	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102012 – 0300	UNNAMED TRIB TO SOUTH FORK HOLSTON	3.89	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102012 – 0400	MORRELL CREEK	4.89	Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102012 – 0700	DRY CREEK	1.0	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Animal Feeding Operations (NPS)
TN06010102012 – 0810	BIG ARM BRANCH	5.77	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	On-site Treatment Systems (Septic Systems and Similar)
TN06010102012 – 0820	WOODS BRANCH	5.0	Polycyclic Aromatic Hydrocarbons (PAHs) Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102012 – 0900	WEAVER BRANCH	5.9	Escherichia coli	Grazing in Riparian or Shoreline Zones

Table 2 (cont'd). Final 2004 303(d) List for E. coli Impaired Waterbodies – South Fork Holston River Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN060101020250 – 0900	WATERS BRANCH	1.82	Escherichia coli	Grazing in Riparian or Shoreline Zones
TN060101020250 – 2000	LAUREL CREEK	3.8	Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102042 – 0200	BACK CREEK (from Beaver Crk to headwaters; not incl. Unnamed trib)	14.1	Nitrates Loss of biological integrity due to siltation Physical Substrate Habitat Alterations Escherichia coli	Unrestricted Cattle Access Grazing in Riparian or Shoreline Zones
TN06010102042 – 0400	LITTLE CREEK	0.3	Escherichia coli	Discharges from MS4 area Sources Outside of State
TN06010102042 – 0500	CEDAR CREEK	11.8	Nitrates Loss of biological integrity due to saltation Other anthropogenic Habitat Alterations Escherichia coli	Discharges from MS4 area
TN06010102042 – 1000	BEAVER CREEK (from S. Fork Holston to Cedar Creek)	11.1	Escherichia coli	Discharges from MS4 area Grazing in Riparian or Shoreline Zones
TN06010102042 – 2000	BEAVER CREEK (from Cedar Creek to Virginia stateline)	10.5	Habitat loss due to alteration in stream-side or littoral vegetative cover Nitrates Loss of biological integrity due to siltation Escherichia coli	Discharges from MS4 area Grazing in Riparian or Shoreline Zones Sources Outside of State
TN060101020540 – 0800	PAINT SPRING BRANCH	1.0	Habitat loss due to alteration in stream-side or littoral vegetative cover Loss of biological integrity due to siltation Escherichia coli	Grazing in Riparian or Shoreline Zones
TN06010102237 – 0100	BOOHER CREEK	7.2	Escherichia coli	Grazing in Riparian or Shoreline Zones

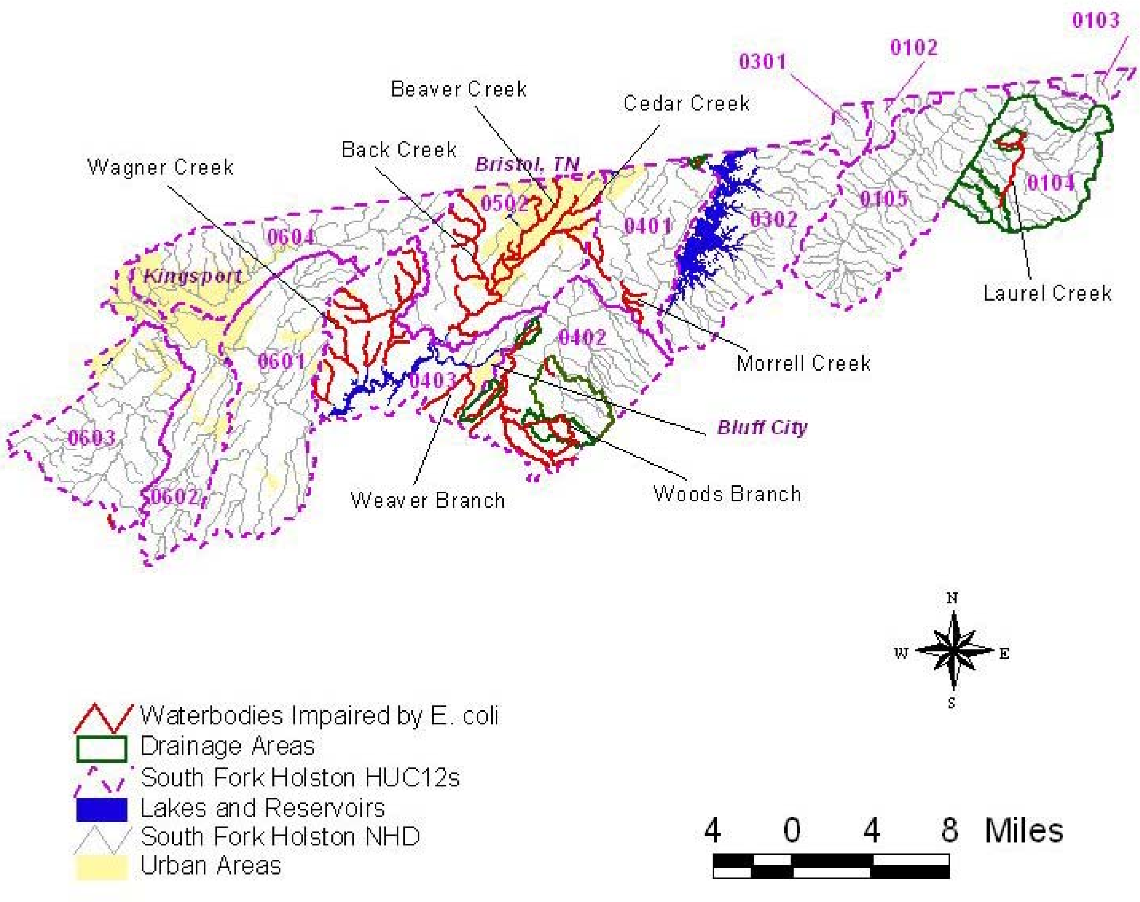

Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List). (Major impaired waterbodies have been labeled as a point of reference.)

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM TARGET

There are numerous water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the South Fork Holston River Watershed. Monitoring stations located on Tier II waterbodies have been italicized:

- HUC-12 06010102_0104:
  - *LAURE007.0JO – Laurel Creek, 0.1 mi south of Taylor Rd.*
  - *LAURE013.8JO – Laurel Creek, at Cold Springs Rd.*
  - *LAURE015.0JO – Laurel Creek, at Corum & Flatwood Br.*
  - *WATER000.1JO – Waters Branch, at Waters Rd.*
- HUC-12 06010102_0302:
  - PSPRI001.4SU – Paint Spring Branch, at 233 Painter Rd.
- HUC-12 06010102_0401:
  - *MORRE000.1SU – Morrell Creek, beside Central Church*
  - SFHOL3T0.7SU – Trib to South Fork Holston, at Bullock Hollow Rd., 0.2 mi south of Sugar Hollow Rd.
- HUC-12 06010102_0402:
  - *BARM000.1CT – Big Arm Branch, at Bunker Hill Rd.*
  - BOOHE000.3SU – Booher Creek, d/s of Plank farm & Plank Rd.
  - DRY000.2SU – Dry Creek, d/s of cattle farm
  - *DRY001.3SU – Dry Creek, off Holston Mtn Rd., u/s of cattle farm*
  - SFHOL2T0.6SU – Trib to South Fork Holston, Trib to South Fork Holston, at intersection of Wilver Gr & Riverside Rd.
  - WOODS000.5SU – Woods Branch, d/s of Lyons Rd, behind Lyons log cabin
- HUC-12 06010102_0403:
  - CANDY001.7SU – Candy Creek, off Hawley Rd.
  - WAGNE001.9SU – Wagner Creek, u/s of Holston Dr. bridge
  - WEAVE000.7SU – Weaver Branch, d/s of eads Rd. bridge
- HUC-12 06010102_0502:
  - BACK000.5SU – Back Creek, 100 yds u/s of Exide Rd.
  - BACK003.1SU – Back Creek, at driveway off Carden Highway Rd., 0.7 mi from SR75
  - BEAVE001.0SU – Beaver Creek, prior to embayment
  - BEAVE011.0SU – Beaver Creek, at Rooster Front park, d/s of Steele Creek
  - BEAVE015.3SU – Beaver Creek, at bridge on Anderson St., at TN/VA state line
  - CEDAR000.3SU – Cedar Creek, 200 yds u/s of Grovedale Rd.

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix C. Examination of the data shows exceedances of the 487 CFU/100 mL (Tier II) and 941 CFU/100 mL (non-Tier II) maximum E. coli standard at many monitoring stations. Water quality monitoring results for those stations with 10% or more of samples exceeding water quality maximum criteria are summarized in Table 3.

There were not enough data to calculate the geometric mean at each monitoring station. Whenever a minimum of 5 samples was collected at a given monitoring station over a period of not more than 30 consecutive days, the geometric mean was calculated.

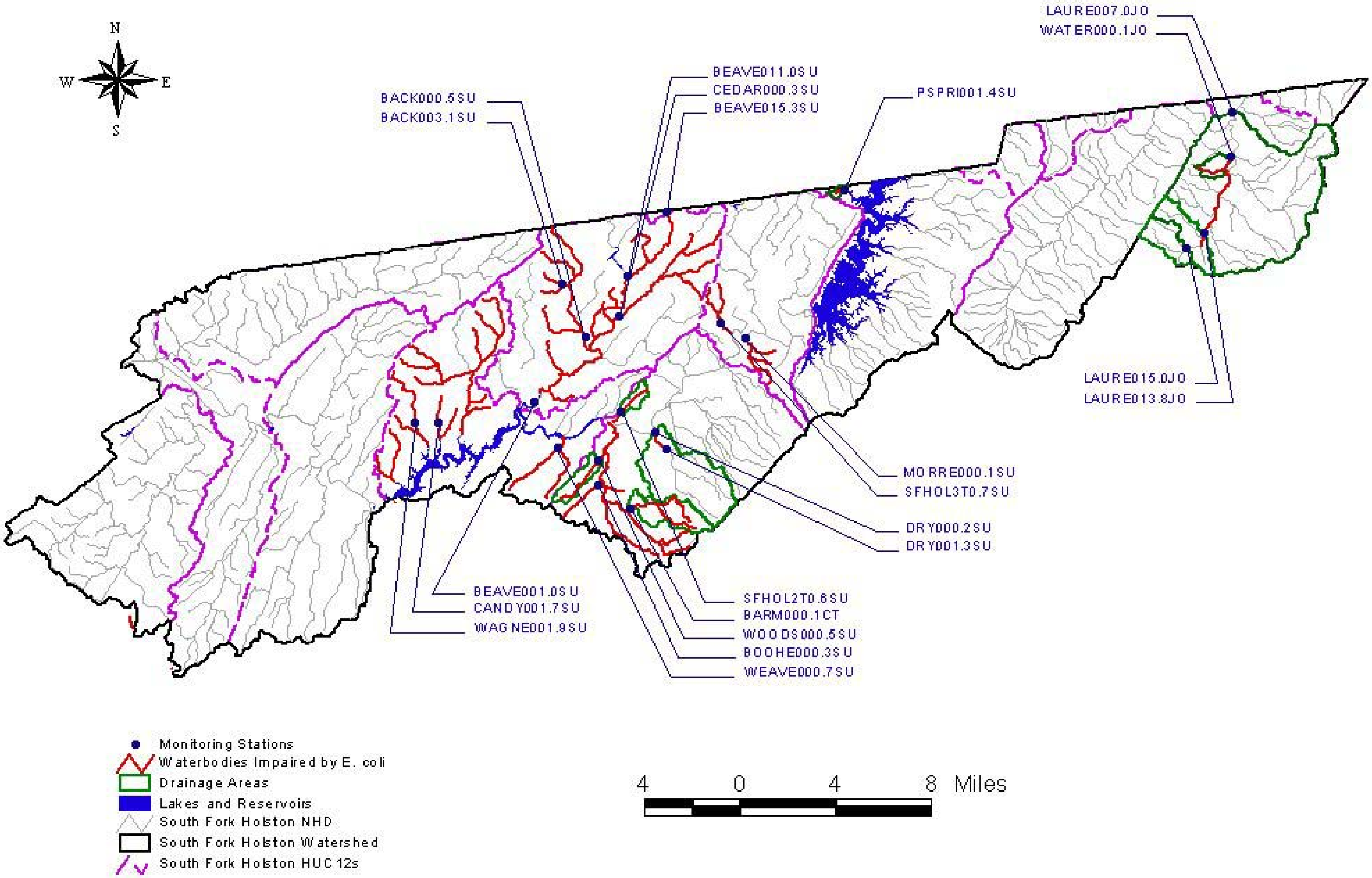

Figure 5. Water Quality Monitoring Stations in the South Fork Holston River Watershed

Table 3 Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Date Range	E. Coli (Max WQ Target = 941 Counts/100 mL)**				
		Data Pts.	Min. [CFU/100 ml]	Avg. [CFU/100 ml]	Max. [CFU/100 ml]	No. Exceed. WQ Max. Target
BACK000.5SU	1999 – 2003	13	29	>963	>2,419	4
BARM000.1CT	*2002 – 2003*	*9*	*40*	*>813*	*>2,420*	*4*
BEAVE001.0SU	1998 – 2004	33	5	>742	>2,419	9
BEAVE011.0SU	2002 – 2003	12	326	1,279	2,419	8
BEAVE015.3SU	1998 – 2004	33	144	>1,689	2,600	26
BOOHE000.3SU	2002 – 2003	9	99	>895	>2,420	4
CANDY001.7SU	2002 – 2003	9	64	>1,125	>2,420	4
CEDAR000.3SU	1999 – 2003	13	31	708	1,414	2
DRY000.2SU	2002 – 2003	9	>2,420	>2.420	>2,420	9
DRY001.3SU	*2003*	*5*	*52*	*>561*	*>2,420*	*1*
LAURE013.8JO	*2002 – 2003*	*11*	*21*	*588*	*1,733*	*5*
LAURE015.0JO	*2002 – 2003*	*10*	*1*	*>1,672*	*>2,420*	*8*
MORRE000.1SU	*2002 – 2003*	*10*	*86*	*>1,056*	*>2,420*	*7*
PSPRI001.4SU	2002 – 2003	10	167	>1,376	>2,420	5
SFHOL2T0.6SU	2002 – 2003	8	179	>883	>2,420	3
SFHOL3T0.7SU	2002 – 2003	10	65	>1,661	>2,420	7
WAGNE001.9SU	1999 – 2000	9	219	>1,352	>2,420	5
WATER000.1JO	*2002 – 2003*	*10*	*66*	*>1,210*	*>2,420*	*6*
WEAVE000.7SU	2002 – 2003	9	167	>854	>2,420	2
WOODS000.5SU	2002 – 2003	9	47	909	1,986	4

** Maximum water quality target is 487 CFU/100 mL for Tier II waterbodies and 941 CFU/100 mL for other waterbodies. Tier II waterbodies are italicized.

7.0 SOURCE ASSESSMENT

An important part of TMDL analysis is the identification of individual sources, or source categories of pollutants in the watershed that affect pathogen loading and the amount of loading contributed by each of these sources.

Under the Clean Water Act, sources are classified as either point or nonpoint sources. Under 40 CFR §122.2, a point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point sources can be described by three broad categories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTFs); 2) NPDES regulated industrial and municipal storm water discharges; and 3) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL must provide a Load Allocation (LA) for these sources.

7.1 Point Sources

7.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

Both treated and untreated sanitary wastewater contain coliform bacteria. There are 13 WWTFs in the South Fork Holston River Watershed that have NPDES permits authorizing the discharge of treated sanitary wastewater. Three of these facilities are located in impaired subwatersheds or drainage areas (see Table 4 & Figure 6). One additional facility is located in an impaired subwatershed or drainage area, but discharges to an unimpaired waterbody. The permit limits for discharges from these WWTFs are in accordance with the coliform criteria specified in Tennessee Water Quality Standards for the protection of the recreation use classification.

Non-permitted point sources of (potential) E. coli contamination of surface waters associated with STP collection systems include leaking collection systems and sanitary sewer overflows (SSOs).

> *Note: As stated in Section 5.0, the current coliform criteria are expressed in terms of E. coli concentration, whereas previous criteria were expressed in terms of fecal coliform and E. coli concentration. Due to differences in permit issuance dates, some permits still have fecal coliform limits instead of E. coli. As permits are reissued, limits for fecal coliform will be replaced by E. coli limits.*

A summary of effluent monitoring data, submitted on Discharge Monitoring Reports (DMRs) for the period from January 1998 to November 2005, for facilities that are located in HUC-12 subwatersheds or drainage areas containing waterbodies impaired for pathogens is presented in Table 5. Fecal coliform data are presented for informational purposes only. DMRs are not required for “package plants” such as those in operation at the Homeowners Association and Weaver and Akard Elementary Schools. Monthly Operation Reports (MORs) are submitted to the local Environmental Field Office.

Table 4 NPDES Permitted WWTFs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	Facility	Design Flow [MGD]	Receiving Stream
TN0025186	Weaver Elementary School	0.003 *	Unnamed tributary to Whitetop Creek at RM 3.8
TN0025178	Akard Elementary School	0.006	Unnamed tributary to Back Creek at RM 4.0
TN0056669	Misty Waters Homeowners Association	0.035	Unnamed tributary to Wagner Creek at RM 0.4
TN0023531	Bristol STP #2	15	S. Fork Holston River at RM 29.6 (Boone reservoir)

Table 5 Summary of DMRs for NPDES Permitted WWTFs in Impaired Subwatersheds or Drainage Areas

NPDES Permit No.	E. Coli (Permit Limit = 126 CFU/100 mL Avg.)					Fecal Coliform (Permit Limit = 200 CFU/100 mL Avg.)					Fecal Coliform (Permit Limit = 1000 CFU/100 mL Max.)					No. Bypass/ Overflow Events
	Data Pts.	Min. (CFU/100 mL)	Avg. (CFU/100 mL)	Max. (CFU/100 mL)	No. Exceed.	Data Pts.	Min. (CFU/100 mL)	Avg. (CFU/100 mL)	Max. (CFU/100 mL)	No. Exceed.	Data Pts.	Min. (CFU/100 mL)	Avg. (CFU/100 mL)	Max. (CFU/100 mL)	No. Exceed.	
TN0023531	548[a]	1	4	8	0	2,890[b]	2	28	219	1	2,890[b]	7	467	1780	23[c]	109

a. Period of record for E. coli data is June 2004 to November 2005
b. Period of record for Fecal coliform data is January 1998 to November 2005
c. All but one of the exceedances occurred prior to April 2003. According to information supplied by the consultant for the Cities of Bristol, TN, and Bristol, VA, the Bristol STP completed its surge basin installation in April 2003.

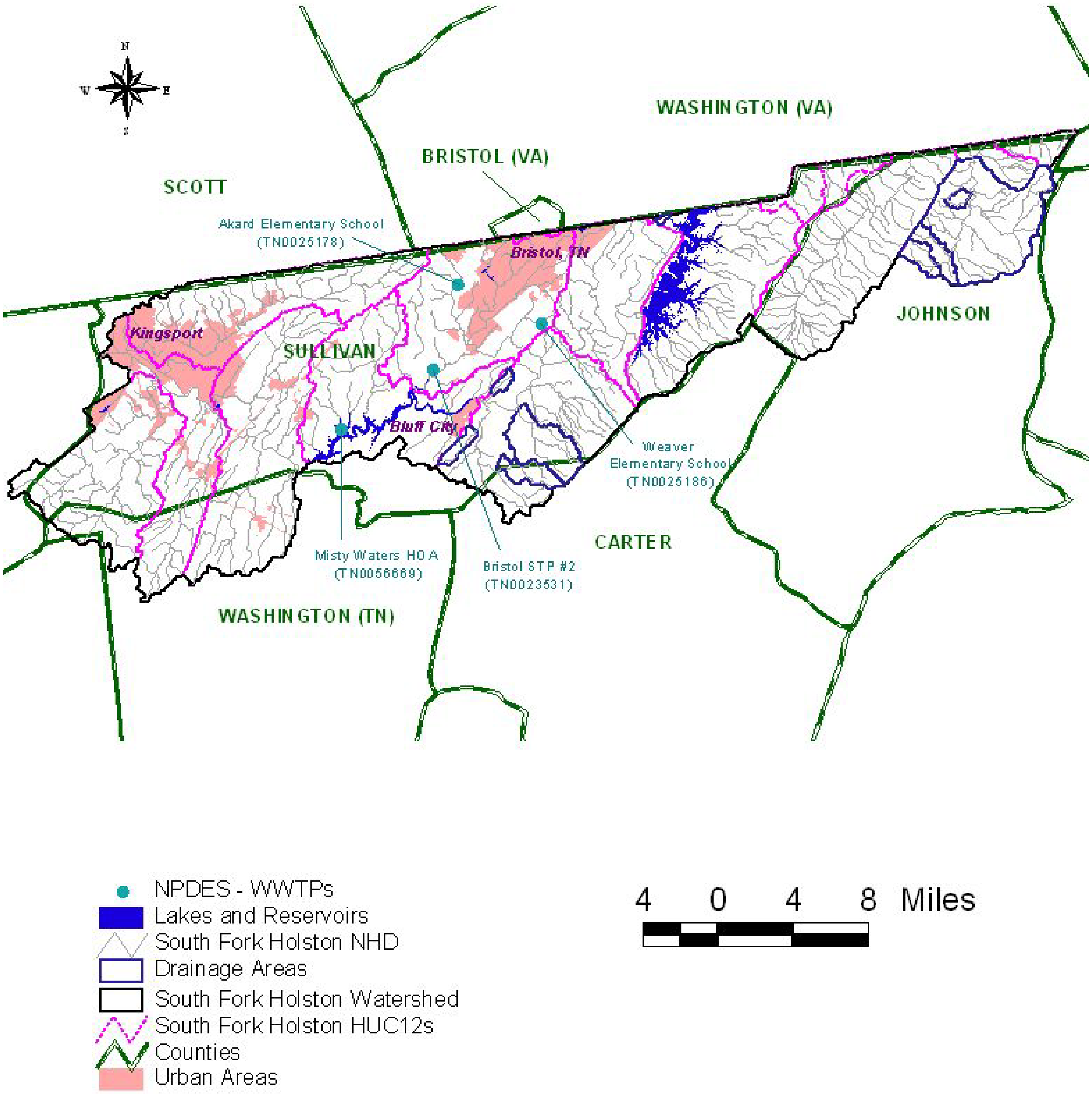

Figure 6. NPDES Regulated Point Sources in and near Impaired Subwatersheds and Drainage Areas of the South Fork Holston River Watershed.

The Bristol STP is located in the Tennessee portion of the South Fork Holston River watershed and serves both Bristol, Virginia, and Bristol, Tennessee, municipalities. However, the sanitary sewage collection system, with documented long-term wet-weather overflow problems, has historically been a significant source of coliform loading to the Beaver Creek subwatershed during these overflow events.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of E. coli. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Phase I of the EPA storm water program requires large and medium MS4s to obtain NPDES storm water permits. Large and medium MS4s are those located in incorporated places or counties serving populations greater than 100,000 people. At present, there are no MS4s of this size in the South Fork Holston River Watershed.

As of March 2003, regulated small MS4s in Tennessee must also obtain NPDES permits in accordance with the Phase II storm water program. A small MS4 is designated as regulated if: a) it is located within the boundaries of a defined urbanized area that has a residential population of at least 50,000 people and an overall population density of 1,000 people per square mile; b) it is located outside of an urbanized area but within a jurisdiction with a population of at least 10,000 people, a population density of 1,000 people per square mile, and has the potential to cause an adverse impact on water quality; or c) it is located outside of an urbanized area but contributes substantially to the pollutant loadings of a physically interconnected MS4 regulated by the NPDES storm water program. Most regulated small MS4s in Tennessee obtain coverage under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003). Bristol, TN, Kingsport, and Sullivan County are covered under Phase II of the NPDES Storm Water Program. Bluff City and Carter County have applications pending for coverage under Phase II of the NPDES Storm Water Program.

The Tennessee Department of Transportation (TDOT) has been issued an individual MS4 permit that authorizes discharges of storm water runoff from State roads and interstate highway right-of-ways that TDOT owns or maintains, discharges of storm water runoff from TDOT owned or operated facilities, and certain specified non-storm water discharges. This permit covers all eligible TDOT discharges statewide, including those located outside of urbanized areas.

Information regarding storm water permitting in Tennessee may be obtained from the Tennessee Department of Environment and Conservation (TDEC) website at:

http://www.state.tn.us/environment/wpc/stormh2o/.

7.1.3 NPDES Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations (AFOs) are agricultural enterprises where animals are kept and raised in confined situations. AFOs congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002a). Concentrated Animal Feeding Operations (CAFOs) are AFOs that meet certain criteria with respect to animal type, number of animals, and type of manure management system. CAFOs are considered to be potential point sources of pathogen loading and are required to obtain an NPDES permit. Most CAFOs in Tennessee obtain coverage under TNA000000, *Class II Concentrated Animal Feeding Operation General Permit*, while larger, Class I CAFOs are required to obtain an individual NPDES permit.

As of May 11, 2005, there are no Class II CAFOs in the South Fork Holston River watershed with coverage under the general NPDES permit. There are also no Class I CAFOs with individual permits located in the watershed.

7.2 Nonpoint Sources

Nonpoint sources of coliform bacteria are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. These sources generally, but not always, involve accumulation of coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of E. coli loading are primarily associated with agricultural and urban land uses. The majority of waterbodies identified on the Final 2004 303(d) list as impaired due to E. coli are attributed to nonpoint agricultural or urban sources.

7.2.1 Wildlife

Wildlife deposit coliform bacteria, with their feces, onto land surfaces where it can be transported during storm events to nearby streams. The overall deer density for Tennessee was estimated by the Tennessee Wildlife Resources Agency (TWRA) to be 23 animals per square mile.

7.2.2 Agricultural Animals

Agricultural activities can be a significant source of coliform bacteria loading to surface waters. The activities of greatest concern are typically those associated with livestock operations:

- Agricultural livestock grazing in pastures deposit manure containing coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.
- Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of coliform bacteria loading. Guidance for issues relating to manure application is available through the University of Tennessee Agricultural Extension Service and the Natural Resources Conservation Service (NRCS).
- Agricultural livestock and other unconfined animals often have direct access to waterbodies and can provide a concentrated source of coliform bacteria loading directly to a stream.

Data sources related to livestock operations include the 2002 Census of Agriculture. Another useful data source was the Integrated Pollutant Source Identification (IPSI) in the Beaver Creek watershed conducted by the Tennessee Valley Authority (TVA) (TVA, 2004). The IPSI provided information on livestock operations classified by relative size, accurate to the nearest 15 cows and 5 horses. Data from the IPSI, when available, are considered to be more accurate because they are based on actual location and size rather than an area ratio. Livestock data for counties containing E. coli-impaired watersheds are summarized in Table 6.

7.2.3 Failing Septic Systems

Some coliform loading in the South Fork Holston River Watershed can be attributed to failure of septic systems and illicit discharges of raw sewage. Estimates from 1997 county census data of people in the South Fork Holston River Watershed utilizing septic systems were compiled using the WCS and are summarized in Table 7. In middle and eastern Tennessee, it is estimated that there are approximately 2.37 people per household on septic systems, some of which can be reasonably assumed to be failing. As with livestock in streams, discharges of raw sewage provide a concentrated source of coliform bacteria directly to waterbodies.

7.2.4 Urban Development

Nonpoint source loading of coliform bacteria from urban land use areas is attributable to multiple sources. These include: stormwater runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, leaking septic systems, and domestic animals. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without interaction with soils and groundwater. Urban land use area in impaired subwatersheds in the South Fork Holston River Watershed ranges from 0.6% (Laurel Creek drainage area) to 19.0% (HUC-12 0502). Land use for the South Fork Holston River impaired drainage areas is summarized in Figures 7 thru 10 and tabulated in Appendix A.

Table 6 Livestock Distribution in the South Fork Holston River Watershed

County	Livestock Population (2002 Census of Agriculture)						
	Beef Cow	Milk Cow	Poultry		Hogs	Sheep	Horse
			Layers	Broilers			
Carter	3,559	548	49	10	34	25	1,087
Johnson	4,397	216	382	103	102	180	720
Sullivan	13,632	720	1,118	154	186	381	2,738
Washington	21,590	3,117	557	D	270	2,883	2,424

* In keeping with the provisions of Title 7 of the United States Code, no data are published in the 2002 Census of Agriculture that would disclose information about the operations of an individual farm or ranch. Any tabulated item that identifies data reported by a respondent or allows a respondent's data to be accurately estimated or derived is suppressed and coded with a 'D' (USDA, 2004).

Table 7 Population on Septic Systems in the South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Population on Septic Systems
Waters Branch DA	40
Laurel Creek DA	1,560
Paint Spring Branch DA	52
0401 (Morrell Creek)	8,184
Unnamed Trib #2 DA	183
Big Arm Branch DA	505
Dry Creek DA	1,913
Woods Branch DA	341
0403 (Wagner & Weaver Creeks)	11,947
0502 (Beaver Creek)	9,553

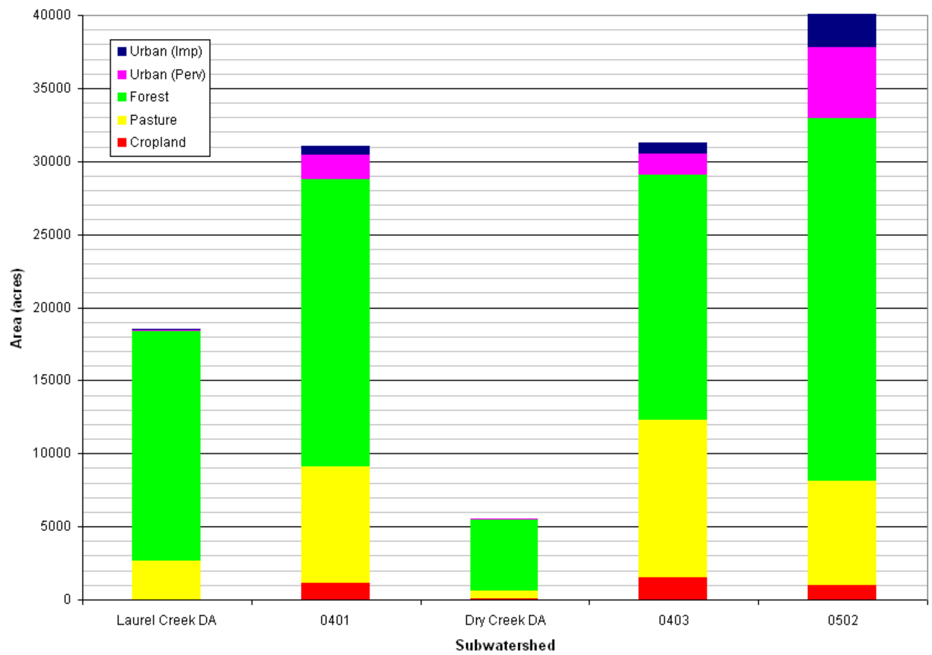

Figure 7. Land Use Area of South Fork Holston River Pathogen-Impaired Subwatersheds – Drainage Areas Greater Than 5,000 Acres.

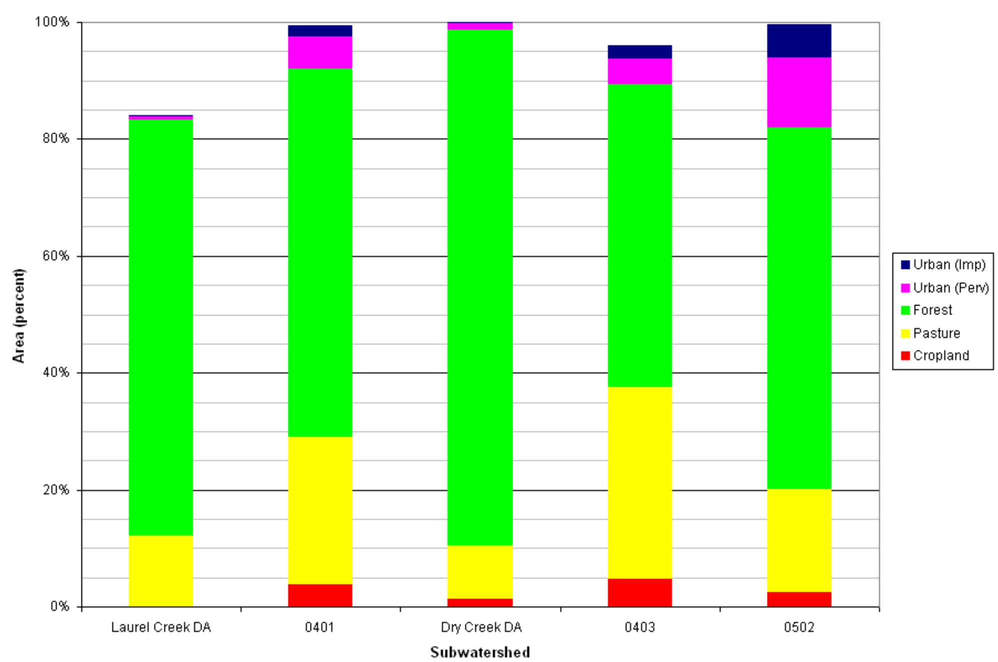

Figure 8. Land Use Percent of the South Fork Holston River Pathogen-Impaired Subwatersheds – Drainage Areas Greater Than 5,000 Acres.

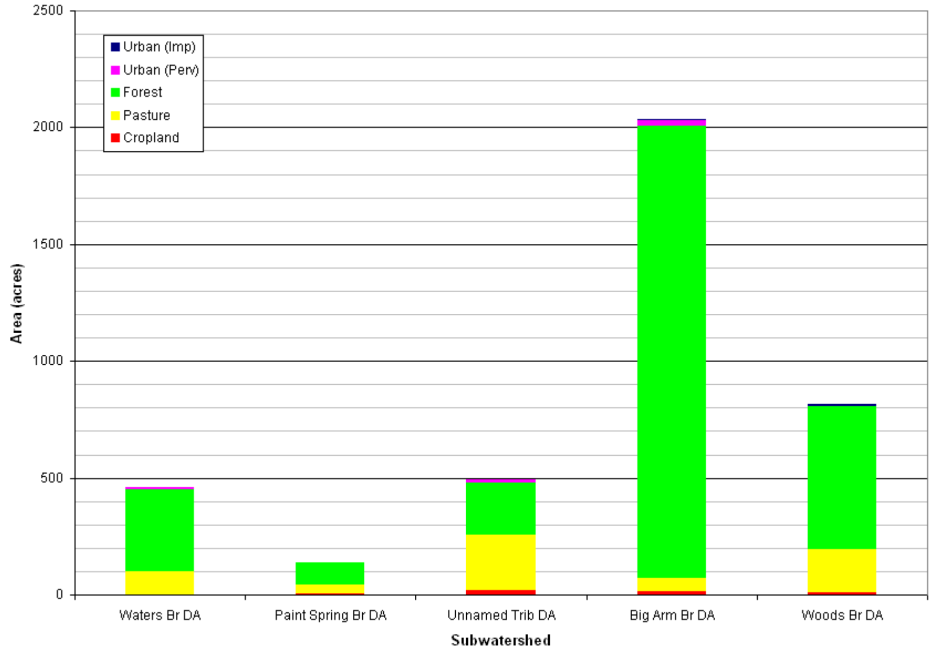

Figure 9. Land Use Area of South Fork Holston River Pathogen-Impaired Subwatersheds – Drainage Areas Less Than 5,000 Acres.

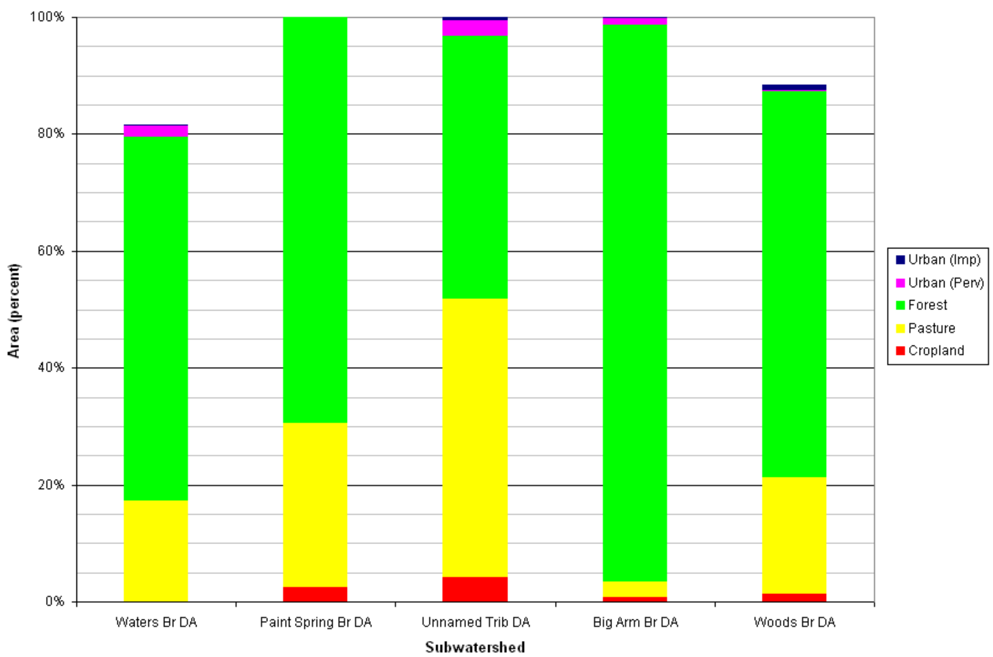

Figure 10. Land Use Percent of the South Fork Holston River Pathogen-Impaired Subwatersheds – Drainage Areas Less Than 5,000 Acres.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOADS

The Total Maximum Daily Load (TMDL) process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or <u>other appropriate measure</u>.

This document describes TMDL, Waste Load Allocation (WLA), and Load Allocation (LA) development for waterbodies identified as impaired due to E. coli on the Final 2004 303(d) list.

8.1 Expression of TMDLs, WLAs, & LAs

In this document, TMDLs are expressed as the percent reduction in instream loading required to decrease existing E. coli concentrations to desired target levels. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in E. coli loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as CFU/day.

8.2 Area Basis for TMDL Analysis

The primary area unit of analysis for TMDL development was the HUC-12 subwatershed containing one or more waterbodies assessed as impaired due to E. coli (as documented on the 2004 303(d) List). In some cases, however, TMDLs were developed for an impaired waterbody drainage area only. Determination of the appropriate area to use for analysis (see Table 8) was based on a careful consideration of a number of relevant factors, including: 1) location of impaired waterbodies in the HUC-12 subwatershed; 2) land use type and distribution; 3) water quality monitoring data; and 4) the assessment status of other waterbodies in the HUC-12 subwatershed.

8.3 TMDL Analysis Methodology

TMDLs for the South Fork Holston River Watershed were developed using load duration curves for analysis of impaired HUC-12 subwatersheds or specific waterbody drainage areas. A load duration curve (LDC) is a cumulative frequency graph that illustrates existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired

Table 8 Determination of Analysis Areas for TMDL Development

HUC-12 Subwatershed (06010102____)	Impaired Waterbody	Area
0104	Waters Branch	DA
	Laurel Creek	DA
0302	Paint Spring Branch	DA
0401	Unnamed Trib to South Fork Holston River Morrell Creek	HUC-12
0402	Unnamed Trib to South Fork Holston River	DA
	Big Arm Branch	DA
	Dry Creek	DA
	Woods Branch	DA
0403	Candy Creek Wagner Creek Weaver Branch	HUC-12
0502	Back Creek Beaver Creek (-1000 & -2000) Cedar Creek	HUC-12

Note: HUC-12 = HUC-12 Subwatershed
DA = Waterbody Drainage Area

targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves are considered to be well suited for analysis of periodic monitoring data collected by grab sample. LDCs were developed at monitoring site locations in impaired waterbodies and an overall load reduction calculated to meet E. coli targets according to the methods described in Appendix C.

8.4 Critical Conditions and Seasonal Variation

The critical condition for non-point source E. coli loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, E. coli bacteria builds up on the land surface, and is washed off by rainfall. The critical condition for point source loading occurs during periods of low streamflow when dilution is minimized. Both conditions are represented in the TMDL analysis.

The ten-year period from October 1, 1994 to September 30, 2004 was used to simulate flow. This 10-year period contained a range of hydrologic conditions that included both low and high streamflows. Critical conditions are accounted for in the load duration curve analysis by using the entire period of flow and water quality data available for the impaired waterbodies. In all subwatersheds, water quality data have been collected during most flow ranges. Based on the location of the water quality exceedances on the load duration curves, no one delivery mode for E. coli appears to be dominant (see Section 9.3 and Table 9).

Seasonal variation was incorporated in the load duration curves by using the entire simulation period and all water quality data collected at the monitoring stations. The water quality data were collected during all seasons.

8.5 Margin of Safety

There are two methods for incorporating MOS in TMDL analysis: a) implicitly incorporate the MOS using conservative model assumptions; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. For development of pathogen TMDLs in the South Fork Holston River Watershed, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of WLAs and LAs:

Instantaneous Maximum (Tier II):	MOS = 49 CFU/100 ml
Instantaneous Maximum (non-Tier II):	MOS = 94 CFU/100 ml
30-Day Geometric Mean:	MOS = 13 CFU/100 ml

8.6 Determination of TMDLs

E. coli load reductions were calculated for impaired segments in the South Fork Holston River Watershed using Load Duration Curves to evaluate compliance with the maximum target concentrations according to the procedure in Appendix C. When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentrations. Both instream load reductions (where applicable) for a particular waterbody were compared and the largest required load reduction was selected as the TMDL. These TMDL load reductions for impaired segments are shown in Table 9 and are applied according to the areas specified in Table 8. In cases where the geometric mean could not be developed, it is assumed that achieving the load reduction based on the maximum target concentrations should result in attainment of the geometric mean criteria.

8.7 Determination of WLAs & LAs

WLAs for MS4s and LAs for precipitation induced sources of E. coli loading were determined according to the procedures in Appendix C. These allocations represent the higher load reductions necessary to achieve instream targets <u>after application of the explicit MOS</u>. WLAs for existing WWTFs are equal to their existing NPDES permit limits. Since WWTF permit limits require that E. coli concentrations must comply with water quality criteria (TMDL targets) at the point of discharge and recognition that loading from these facilities are generally small in comparison to other loading sources, further reductions were not considered to be warranted. WLAs for CAFOs and LAs for "other direct sources" (non-precipitation induced) are equal to zero. WLAs, & LAs are summarized in Table 9.

Table 9 TMDLs, WLAs, & LAs for Impaired Subwatersheds and Drainage Areas in the South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs [d]
				WWTFs [a]		Leaking Collection Systems [b]	MS4s [c]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0104 (DA)	Waters Branch	TN060101020250 – 0900	>79.9	NA	NA	NA	>81.9	>81.9
0104 (DA)	Laurel Creek	TN060101020250 – 2000	>79.9	NA	NA	NA	>81.9	>81.9
0302 (DA)	Painter Springs Branch	TN060101020540 – 0800	>61.1	NA	NA	NA	>65.0	>65.0
0401	Unnamed Trib to South Fork Holston River	TN06010102012 – 0300	>61.1	NA	NA	NA	>65.0	>65.0
	Morrell Creek	TN06010102012 – 0400	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Unnamed Trib to South Fork Holston River	TN06010102012 – 0100	>45.2	NA	NA	NA	>50.6	>50.6
0402 (DA)	Big Arm Branch	TN06010102012 - 0810	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Dry Creek	TN06010102012 - 0700	>61.1	NA	NA	NA	>65.0	>65.0
0402 (DA)	Woods Branch	TN06010102012 - 0820	34.5	NA	NA	NA	41.1	41.1
0403	Candy Creek	TN06010102006T – 0300	>54.6	NA	NA	NA	>59.1	>59.1
	Wagner Creek	TN06010102006T – 0200	>61.1	$1.669x10^8$	$1.247x10^9$	NA	>65.0	>65.0
	Weaver Branch	TN06010102012 – 0900	>49.7	NA	NA	NA	>54.7	>54.7

Table 9 (cont'd) TMDLs, WLAs, & LAs for Impaired Subwatersheds and Drainage Areas in the South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs [d]
				WWTFs [a]		Leaking Collection Systems [b]	MS4s [c]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0502	Back Creek	TN06010102042 – 0200	>44.6	2.861×10^7	2.137×10^8	0	>50.1	>50.1
	Beaver Creek	TN06010102042 – 1000	>59.7	1.431×10^7	1.069×10^8	0	>63.7	>63.7
	Beaver Creek	TN06010102042 – 2000[e]	>61.1	NA	NA	0	>65.0	>65.0
	Cedar Creek	TN06010102042 – 0500	23.9	NA	NA	0	31.5	31.5

Notes: NA = Not Applicable.

a. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

b. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

c. Applies to any MS4 discharge loading in the subwatershed or drainage area.

d. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all "other direct sources" (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these unpermitted sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

e. Portions of these waterbodies lie in another state. A TMDL for Fecal Coliform has been developed by the State of Virginia for those portions of the waterbodies lying within their jurisdiction. The required load reduction is for the Tennessee portion of the waterbodies.

9.0 IMPLEMENTATION PLAN

The TMDLs, WLAs, and LAs developed in Section 8 are intended to be the first phase of a long-term effort to restore the water quality of impaired waterbodies in the South Fork Holston River Watershed through reduction of excessive pathogen loading. Adaptive management methods, within the context of the State's rotating watershed management approach, will be used to modify TMDLs, WLAs, and LAs as required to meet water quality goals.

9.1 Point Sources

9.1.1 NPDES Regulated Municipal and Industrial Wastewater Treatment Facilities

All present and future discharges from industrial and municipal wastewater treatment facilities are required to be in compliance with the conditions of their NPDES permits at all times, including elimination of bypasses and overflows. In Tennessee, permit limits for treated sanitary wastewater require compliance with coliform water quality standards (ref: Section 5.0) prior to discharge. No additional reduction is required. WLAs for WWTFs are derived from facility design flows and permitted E. coli limits and are expressed as average loads in CFU per day.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For existing and future regulated discharges from municipal separate storm sewer systems, WLAs will be implemented through Phase I & II MS4 permits. These permits will require the development and implementation of a Storm Water Management Program (SWMP) that will reduce the discharge of pollutants to the "maximum extent practicable" and not cause or contribute to violations of State water quality standards. The *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2003) and the TDOT individual MS4 permit (TNS077585) require SWMPs to include six minimum control measures:

- Public education and outreach on storm water impacts
- Public involvement/participation
- Illicit discharge detection and elimination
- Construction site storm water runoff control
- Post-construction storm water management in new development and re-development
- Pollution prevention/good housekeeping for municipal operations

The permits also contain requirements regarding control of discharges of pollutants of concern into impaired waterbodies, implementation of provisions of approved TMDLs, and descriptions of methods to evaluate whether storm water controls are adequate to meet the requirements of approved TMDLs.

In order to evaluate SWMP effectiveness and demonstrate compliance with specified WLAs, MS4s must develop and implement appropriate monitoring programs. An effective monitoring program could include:

- Effluent monitoring at selected outfalls that are representative of particular land uses or geographical areas that contribute to pollutant loading before and after implementation of pollutant control measures.
- Analytical monitoring of pollutants of concern in receiving waterbodies, both upstream and downstream of MS4 discharges, over an extended period of time.
- Instream biological monitoring at appropriate locations to demonstrate recovery of biological communities after implementation of storm water control measures.

The Division of Water Pollution Control Johnson City Field Office should be consulted for assistance in the determination of monitoring strategies, locations, frequency, and methods within 12 months after the approval date of this TMDL. Details of the monitoring plan and monitoring data should be included in the annual report required by the MS4 permit.

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

As of May 11, 2005, there are no Class I or Class II CAFOs in the South Fork Holston River watershed with coverage under the general NPDES permit. WLAs and implementation requirements are provided for any future facilities.

WLAs provided to CAFOs will be implemented through NPDES Permit No. TNA000000, General NPDES Permit for *Class II Concentrated Animal Feeding Operation* or the facility's individual permit. Among the provisions of the general permit are:

- Development and implementation of a site-specific Nutrient Management Plan (NMP) that:
    - Includes best management practices (BMPs) and procedures necessary to implement applicable limitations and standards;
    - Ensures adequate storage of manure, litter, and process wastewater including provisions to ensure proper operation and maintenance of the storage facilities.
    - Ensures proper management of mortalities (dead animals);
    - Ensures diversion of clean water, where appropriate, from production areas;
    - Identifies protocols for manure, litter, wastewater and soil testing;
    - Establishes protocols for land application of manure, litter, and wastewater;
    - Identifies required records and record maintenance procedures.

  The NMP must submitted to the State for approval and a copy kept on-site.

- Requirements regarding manure, litter, and wastewater land application BMPs.
- Requirements for the design, construction, operation, and maintenance of CAFO liquid waste management systems that are constructed, modified, repaired, or placed into operation after April 13, 2006. The final design plans and specifications for these systems must meet or exceed standards in the NRCS Field Office Technical Guide and other guidelines as accepted by the Departments of Environment and Conservation, or Agriculture.

Provisions of individual CAFO permits are similar. NPDES Permit No. TNA000000, *Class II Concentrated Animal Feeding Operation General Permit* is available on the TDEC website at http://www.state.tn.us/environment/wpc/programs/cafo/CAFO_GP_04.pdf

9.2 Nonpoint Sources

The Tennessee Department of Environment & Conservation (TDEC) has no direct regulatory authority over most nonpoint source discharges. Reductions of pathogen loading from nonpoint sources (NPS) will be achieved using a phased approach. Voluntary, incentive-based mechanisms will be used to implement NPS management measures in order to assure that measurable reductions in pollutant loadings can be achieved for the targeted impaired waters. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. There are links to a number of publications and information resources on EPA's Nonpoint Source Pollution web page (http://www.epa.gov/owow/nps/pubs.html) relating to the implementation and evaluation of nonpoint source pollution control measures.

TMDL implementation activities will be accomplished within the framework of Tennessee's Watershed Approach (ref: http://www.state.tn.us/environment/wpc/watershed/). The Watershed Approach is based on a five-year cycle and encompasses planning, monitoring, assessment, TMDLs, WLAs/LAs, and permit issuance. It relies on participation at the federal, state, local and nongovernmental levels to be successful.

The Holston River Watershed Alliance was formed in March 2000 by TVA and local stakeholders to define a vision for the watershed and to involve key partnerships in a sustainable coalition advancing that vision. Kingsport Tomorrow, a citizen-based action organization, TVA, business and government leaders from Kingsport, Sullivan and Hawkins Counties and the State of Tennessee are active participants in the effort. Recent focus has been on projects to remove impacted waters from the State's list.

BMPs have been utilized in the South Fork Holston River Watershed to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. These BMPs (e.g., animal waste management systems, waste utilization, stream stabilization, fencing, heavy use area treatment, livestock exclusion, etc.) may have contributed to reductions in in-stream concentrations of coliform bacteria in the South Fork Holston River Watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the South Fork Holston River Watershed are shown in Figure 11. It is recommended that additional information (e.g., livestock access to streams, manure application practices, etc.) be provided and evaluated to better identify and quantify agricultural sources of coliform bacteria loading in order to minimize uncertainty in future modeling efforts.

It is further recommended that BMPs be utilized to reduce the amount of coliform bacteria transported to surface waters from agricultural sources. Demonstration sites for various types of BMPs should be established, maintained, and evaluated (performance in source reduction) over a period of at least two years prior to recommendations for utilization for subsequent implementation. E. coli sampling and monitoring are recommended during low-flow (baseflow) and storm periods at sites with and without BMPs and/or before and after implementation of BMPs.

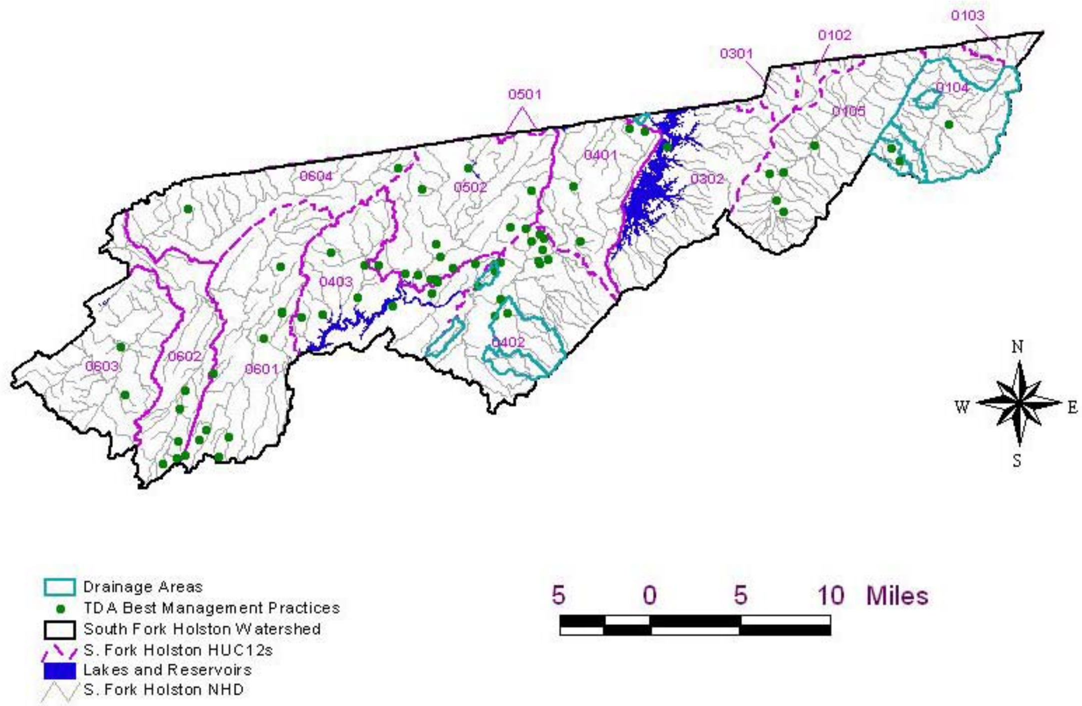

Figure 11. Tennessee Department of Agriculture Best Management Practices located in the South Fork Holston River Watershed.

9.3 Application of Load Duration Curves for Implementation Planning

The Load Duration Curve methodology (Appendix C) is a form of water quality analysis and presentation of data that aids in guiding implementation by targeting strategies to appropriate flow conditions. One of the strengths of this method is that it can be used to interpret possible delivery mechanisms of pathogens by differentiating between point and nonpoint problems. The E. coli load duration analysis was utilized for implementation planning. The E. coli load duration curve for each pathogen-impaired subwatershed (Figures C-2 through C-10) was analyzed to determine the frequency with which water quality monitoring data exceed the E. coli target maximum concentration of 941 CFU/100 mL under five flow conditions (low, dry, mid- range, moist, and high). The E. coli load duration curve for Beaver Creek at Mile 15.3 is presented in Figure 12 as an example.

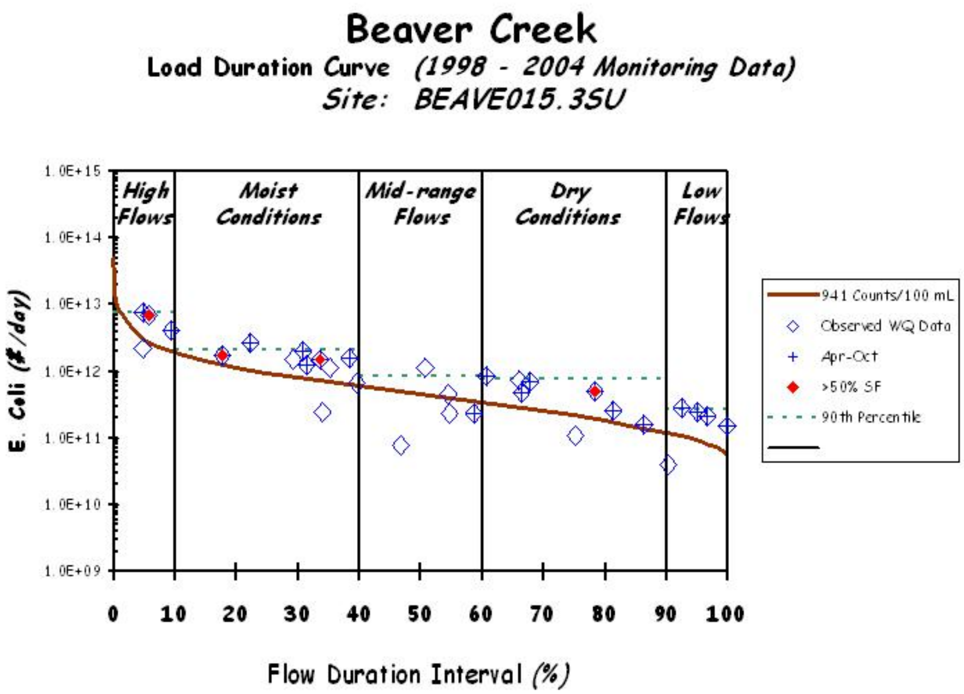

Figure 12. Sample E. Coli Load Duration Curve (Beaver Creek at Mile 15.3)

Table 10 presents an example of Load Duration analysis statistics for E. coli. Table 11 presents targeted implementation strategies for each source category covering the entire range of flow (Stiles, 2003). Each implementation strategy addresses a range of flow conditions and targets point sources, nonpoint sources, or a combination of each. Results indicate the implementation strategy for all subwatersheds will require BMPs targeting a variety of sources. The implementation strategies listed in Table 11 are a subset of the categories of BMPs and implementation strategies available for application to the pathogen-impaired South Fork Holston River Watersheds for reduction of pathogen loading and mitigation of water quality impairment.

See Appendix C for a detailed discussion of the Load Duration Curve Methodology applied to the South Fork Holston River Watershed.

Table 10 Sample Load Duration Curve Summary (Beaver Creek at Mile 15.3)

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Beaver Creek at Mile 15.3	% Samples > 941 CFU/100 mL	75.0	90.0	40.0	87.5	80.0
	Reduction	>61.1	>61.1	>49.7	>61.1	>61.1

Table 11 Example Implementation Strategies

Flow Condition	High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded	0-10	10-40	40-60	60-90	90-100
Municipal NPDES		**L**	**M**	**H**	**H**
Stormwater Management		**H**	**H**	**H**	
SSO Mitigation	**H**	**H**	**M**	**L**	
Collection System Repair		**L**	**M**	**H**	**H**
Septic System Repair		**L**	**M**	**H**	**M**
Livestock Exclusion[1]			**M**	**H**	**H**
Pasture Management/Land Application of Manure[1]	**H**	**H**	**M**	**L**	
Riparian Buffers[1]		**H**	**H**	**H**	
Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)					

[1] Example Best Management Practices (BMPs) for Agricultural Source reduction. Actual BMPs applied may vary.

9.4 Additional Monitoring

Documenting progress in reducing the quantity of pathogens entering the South Fork Holston River Watershed is an essential element of the TMDL Implementation Plan. Additional monitoring and assessment activities are recommended to determine whether implementation of TMDLs, WLAs, & LAs in tributaries and upstream reaches will result in achievement of instream water quality targets for E. coli. Future monitoring activities should be representative of all seasons and a full range of flow and meteorological conditions. Monitoring activities should also be adequate to assess water quality using the 30-day geometric mean standard. For individual monitoring locations, where historical E. coli data are greater than 1000 colonies/100 mL (e.g. DRY000.2SU in Table B-1) or future samples are anticipated to be, a 1:100 dilution should be performed as described in Protocol A of the *Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water* (TDEC, 2004b).

Tennessee's watershed management approach specifies a five-year cycle for planning and assessment. Each watershed will be examined (or re-examined) on a rotating basis. Generally, in years two and three of the five-year cycle, water quality data are collected in support of water quality assessment (including TMDL development) and planning activities. Therefore, a watershed TMDL is developed one to two years prior to commencement of the next cycle's monitoring period.

As mentioned in Section 2.0, monitoring data were not available for either the Tennessee portion of Little Creek or Booher Creek (06010102237_0100). Additional monitoring is recommended to allow for either development of a TMDL or delisting for both of these waterbodies.

For all other impaired waterbodies, additional monitoring and assessment activities are recommended only to verify reduction of pollutant loading as a result of implementation of appropriate BMPs within the subwatershed.

9.5 Source Identification

An important aspect of pathogen load reduction activities is the accurate identification of the actual sources of pollution. In cases where the sources of pathogen impairment are not readily apparent, Microbial Source Tracking (MST) is one approach to determining the sources of fecal pollution and pathogens affecting a waterbody. Those methods that use bacteria as target organisms are also known as Bacterial Source Tracking (BST) methods. This technology is recommended for source identification in pathogen impaired waterbodies.

Bacterial Source Tracking is a collective term used for various emerging biochemical, chemical, and molecular methods that have been developed to distinguish sources of human and non-human fecal pollution in environmental samples (Shah, 2004). In general, these methods rely on genotypic (also known as "genetic fingerprinting"), or phenotypic (relating to the physical characteristics of an organism) distinctions between the bacteria of different sources. Three primary genotypic techniques are available for BST: ribotyping, pulsed field gel electrophoresis (PFGE), and polymerase chain reaction (PCR). Phenotypic techniques generally involve an antibiotic resistance analysis (Hyer, 2004).

The USEPA has published a fact sheet that discusses BST methods and presents examples of BST application to TMDL development and implementation (USEPA, 2002b). Various BST projects and descriptions of the application of BST techniques used to guide implementation of effective BMPs to remove or reduce fecal contamination are presented. The fact sheet can be found on the following EPA website: http://www.epa.gov/owm/mtb/bacsortk.pdf.

A multi-disciplinary group of researchers is developing and testing a series of different microbial assay methods based on real-time PCR to detect fecal bacterial concentrations and host sources in water samples (McKay, 2005). The assays have been used in a study of fecal contamination and have proven useful in identification of areas where cattle represent a significant fecal input and in development of BMPs. It is expected that these types of assays could have broad applications in monitoring fecal impacts from Animal Feeding Operations, as well as from wildlife and human sources. Other BST projects have been conducted or are currently in progress throughout the state of Tennessee, as presented in sessions of the Thirteenth Tennessee Water Resources Symposium (Lawrence, 2003) and the Fifteenth Tennessee Water Resources Symposium (Bailey, 2005; Baldwin, 2005; Farmer, 2005).

9.6 Evaluation of TMDL Implementation Effectiveness

The effectiveness of the TMDL will be assessed within the context of the State's rotating watershed management approach. Watershed monitoring and assessment activities will provide information by which the effectiveness of pathogen loading reduction measures can be evaluated. Additional monitoring data, ground-truthing activities, and bacterial source identification actions are recommended to enable implementation of particular types of BMPs to be directed to specific areas in impaired subwatersheds. This will optimize utilization of resources to achieve maximum reductions in pathogen loading. These TMDLs will be re-evaluated during subsequent watershed cycles and revised as required to assure attainment of applicable water quality standards.

10.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed pathogen TMDLs for the South Fork Holston River Watershed was placed on Public Notice for a 35-day period and comments solicited. Steps that were taken in this regard include:

1) Notice of the proposed TMDLs was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDLs (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

3) Letters were sent to WWTFs located in E. coli-impaired subwatersheds or drainage areas in the South Fork Holston River Watershed, permitted to discharge treated effluent containing pathogens, advising them of the proposed TMDLs and their availability on the TDEC website. The letters also stated that a copy of the draft TMDL document would be provided on request. A letter was sent to the following facilities:

   Akard Elementary School (TN0025178)
   Misty Waters Homeowners Association (TN0056669)
   Weaver Elementary School (TN0025186)
   Bristol STP #2 (TN0023531)

4) A draft copy of the proposed TMDL was sent to those MS4s that are wholly or partially located in pathogen-impaired subwatersheds. A draft copy was sent to the following entities:

   City of Bluff City (TNS077780)
   City of Bristol, Tennessee (TNS075183)
   Carter County, Tennessee (TNS075124)
   City of Kingsport, Tennessee (TNS075388)
   Sullivan County, Tennessee (TNS075671)
   Tennessee Dept. of Transportation (TNS077585)

5) A letter was sent to water quality partners in the South Fork Holston River Watershed advising them of the proposed E. coli TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following partners:

Natural Resources Conservation Service
Tennessee Valley Authority
United States Forest Service
Tennessee Department of Agriculture
Tennessee Wildlife Resources Agency
Virginia Department of Environmental Quality
Friends of South Fork Holston River (Va.)
Kingsport Citizens for a Cleaner Environment
Tennessee Eastman Hiking & Canoeing Club
Holston River Watershed Alliance
Kingsport Tomorrow
Boone Watershed Partnership
Friends of Fort Patrick Henry
Johnson County Stream Watch
The Nature Conservancy

11.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

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REFERENCES

Bailey, F.C., Farmer, J.J., Ejiofor, A.O., and Johnson, T.L., 2005. *Use of Flow Duration Curves and Load Duration Curves to Enhance Fecal Bacterial Source Tracking in Stoners Creek, Davidson County, Tennessee*. In: Proceedings of The Fifteenth Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, Session 2B, Paper 4.

Baldwin, Trisha, Layton, Alice, McKay, Larry, Jones, Sid, Johnson, Greg, Fout, Shay, and Garret, Victoria, 2005. *Monitoring of Enterovirus and Hepatitis A Virus in Wells and Springs in East Tennessee*. In: Proceedings of The Fifteenth Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, Session 2B, Paper 6.

Farmer, J.J., Bailey, F.C., Ejiofor, A.O., and Johnson, T.L., 2005. *Comparison of Antibiotic Resistance Patterns, Carbon Utilization Profiles, and Pulsed-field Gel Electrophoresis of Eschericia Coli for Fecal Bacterial Source Tracking in the Duck River, Middle Tennessee*. In: Proceedings of The Fifteenth Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, Session 2B, Paper 5.

Hyer, Kenneth E., and Douglas L. Moyer, 2004. *Enhancing Fecal Coliform Total Maximum Daily Load Models Through Bacterial Source Tracking*. Journal of the American Water Resources Association (JAWRA) 40(6):1511-1526. Paper No. 03180.

Lawrence, Tom, 2003. *Getting to the Source, Microbial Source Tracking in an Urban Stream*. In: Proceedings of the Thirteenth Tennessee Water Resources Symposium, Montgomery Bell State Park, Tennessee, Session 2B, Paper 3.

Lumb, A.M., McCammon, R.B., and Kittle, J.L., Jr., 1994, Users Manual for an expert system, (HSPFEXP) for calibration of the Hydrologic Simulation Program –Fortran: U.S. Geological Survey Water-Resources Investigation Report 94-4168,102 p.

McKay, Larry, Layton, Alice, and Gentry, Randy, 2005. *Development and Testing of Real-Time PCR Assays for Determining Fecal Loading and Source Identification (Cattle, Human, etc.) in Streams and Groundwater.* This document is available on the UTK website: http://web.utk.edu/~hydro/Research/McKayAGU2004abstract.pdf .

NCSU. 1994. *Livestock Manure Production and Characterization in North Carolina*, North Carolina Cooperative Extension Service, North Carolina State University (NCSU) College of Agriculture and Life Sciences, Raleigh, January 1994.

Shah, Vikas G., Hugh Dunstan, and Phillip M. Geary, 2004. *Application of Emerging Bacterial Source Tracking (BST) Methods to Detect and Distinguish Sources of Fecal Pollution in Waters.* School of Environmental and Life Sciences, The University of Newcastle, Callaghan, NSW 2308 Australia. This document is available on the University of Newcastle website: http://www.newcastle.edu.au/discipline/geology/staff_pg/pgeary/BacterialSourceTracking.pdf.

Stiles, T., and B. Cleland, 2003, Using Duration Curves in TMDL Development & Implementation Planning. ASIWPCA "States Helping States" Conference Call, July 1, 2003. This document is available on the Indiana Office of Water Quality website: http://www.in.gov/idem/water/planbr/wqs/tmdl/durationcurveshscall.pdf .

TDEC. 1999. *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October 1999.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2003. *General Permit for Discharges from Small Municipal Separate Storm Sewer Systems.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control, February 2003. This document is available on the TDEC website: http://www.state.tn.us/environment/wpc/stormh2o/MS4II.htm.

TDEC. 2004a. *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, January 2004.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2004b. *Quality System Standard Operating Procedure for Chemical & Bacteriological Sampling of Surface Water.* State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control.

TDEC. 2005. *Final 2004 303(d) List*. State of Tennessee, Department of Environment and Conservation, Division of Water Pollution Control, August 2005.

TVA, 2004. IPSI. Tennessee Valley Authority. 2004.

USDA, 2004. *2002 Census of Agricultue, Tennessee State and County Data, Volume 1, Geographic Area Series, Part 42 (AC-02-A-42)*. USDA website URL: http://www.nass.usda.gov/census/census02/volume1/tn/index2.htm . June 2004.

USEPA. 1991. *Guidance for Water Quality –based Decisions: The TMDL Process.* U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-440/4-91-001, April 1991.

USEPA. 1997. *Ecoregions of Tennessee*. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon. EPA/600/R-97/022.

USEPA, 2002a. *Animal Feeding Operations Frequently Asked Questions*. USEPA website URL: http://cfpub.epa.gov/npdes/faqs.cfm?program_id=7 . September 12, 2002.

USEPA, 2002b. *Wastewater Technology Fact Sheet, Bacterial Source Tracking*. U.S. Environmental Protection Agency, Office of Water. Washington, D.C. EPA 832-F-02-010, May 2002. This document is available on the EPA website: http://www.epa.gov/owm/mtb/bacsortk.pdf.

APPENDIX A

Land Use Distribution in the South Fork Holston River Watershed

Table A-1. MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area					
	Waters Branch DA		Laurel Creek DA		Paint Springs Branch DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0.0	0.0	1.3	0.0	0.0	0.0
Deciduous Forest	0.7	0.1	30.0	0.1	57.5	41.5
Emergent Herbaceous Wetlands	0.0	0.0	1.1	0.0	0.0	0.0
Evergreen Forest	0.0	0.0	3.3	0.0	25.2	18.2
High Intensity Commercial/Industrial/Transp.	0.2	0.0	4.4	0.0	0.0	0.0
High Intensity Residential	0.0	0.0	0.0	0.0	0.0	0.0
Low Intensity Residential	12.2	2.2	140.6	0.6	0.0	0.0
Mixed Forest	168.1	29.7	10,477.1	47.6	13.6	9.8
Open Water	103.9	18.4	3,528.1	16.0	0.0	0.0
Other Grasses (Urban/recreation; e.g. parks)	171.0	30.2	4,458.1	20.2	0.0	0.0
Pasture/Hay	97.2	17.2	2,656.3	12.1	38.8	28.0
Quarries/Strip Mines/Gravel Pits	12.0	2.1	705.0	3.2	0.0	0.0
Row Crops	0.4	0.1	6.4	0.0	3.5	2.5
Transitional	0.0	0.0	3.3	0.0	0.0	0.0
Woody Wetlands	0.0	0.0	1.6	0.0	0.0	0.0
Total	565.8	100.0	22,016.7	100.0	138.7	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

Table A-1 (Cont.). MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area					
	0401		Big Arm Branch DA		Dry Creek DA	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	68.7	0.2	1.8	0.1	7.8	0.1
Deciduous Forest	11,507.2	36.8	1,343.5	66.0	2,735.9	49.3
Emergent Herbaceous Wetlands	12.9	0.0	0.0	0.0	0.0	0.0
Evergreen Forest	4,082.1	13.1	283.1	13.9	1,050.4	18.9
High Intensity Commercial/Industrial/Transp.	365.6	1.2	2.0	0.1	5.1	0.1
High Intensity Residential	86.3	0.3	0.0	0.0	1.3	0.0
Low Intensity Residential	1,818.1	5.8	26.0	1.3	68.3	1.2
Mixed Forest	3,649.1	11.7	303.8	14.9	1,092.6	19.7
Open Water	203.3	0.7	0.9	0.0	0.0	0.0
Other Grasses (Urban/recreation; e.g. parks)	274.2	0.9	4.7	0.2	3.6	0.1
Pasture/Hay	7,919.7	25.4	56.0	2.8	497.1	9.0
Quarries/Strip Mines/Gravel Pits	4.0	0.0	0.0	0.0	0.0	0.0
Row Crops	1,163.6	3.7	13.6	0.7	78.5	1.4
Transitional	0.9	0.0	0.0	0.0	0.0	0.0
Woody Wetlands	75.2	0.2	0.4	0.0	4.2	0.1
Total	31,230.8	100.0	2,035.8	100.0	5,544.8	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

Table A-1 (Cont.). MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area					
	Woods Branch DA		UT2 to SFHOL DA		0403	
	[acres]	[%]	[acres]	[%]	[acres]	[%]
Bare Rock/Sand/Clay	0.7	0.1	1.6	0.3	145.9	0.4
Deciduous Forest	70.7	7.7	70.1	14.1	8,285.6	25.4
Emergent Herbaceous Wetlands	10.7	1.2	0.0	0.0	49.4	0.2
Evergreen Forest	28.7	3.1	77.4	15.6	3,794.1	11.7
High Intensity Commercial/Industrial/Transp.	9.6	1.0	1.1	0.2	669.0	2.1
High Intensity Residential	0.0	0.0	0.0	0.0	57.6	0.2
Low Intensity Residential	0.0	0.0	14.9	3.0	1,459.4	4.5
Mixed Forest	291.6	31.6	59.6	12.0	3,530.5	10.8
Open Water	107.2	11.6	0.2	0.0	1,288.6	4.0
Other Grasses (Urban/recreation; e.g. parks)	111.4	12.1	13.3	2.7	847.1	2.6
Pasture/Hay	184.4	20.0	236.2	47.6	10,708.4	32.9
Quarries/Strip Mines/Gravel Pits	89.0	9.6	0.0	0.0	0.0	0.0
Row Crops	11.8	1.3	20.2	4.1	1,554.1	4.8
Transitional	6.0	0.7	0.0	0.0	0.0	0.0
Woody Wetlands	2.0	0.2	1.1	0.2	173.0	0.5
Total	923.6	100.0	495.7	100.0	32,562.5	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

Table A-1 (Cont.). MRLC Land Use Distribution of S. Fork Holston River Subwatersheds

Land Use	HUC-12 Subwatershed (06010102__) or Drainage Area	
	0502	
	[acres]	[%]
Bare Rock/Sand/Clay	111.0	0.3
Deciduous Forest	14,712.6	36.6
Emergent Herbaceous Wetlands	27.1	0.1
Evergreen Forest	4,283.6	10.7
High Intensity Commercial/Industrial/Transp.	1,475.8	3.7
High Intensity Residential	670.5	1.7
Low Intensity Residential	4,942.1	12.3
Mixed Forest	4,432.1	11.0
Open Water	137.7	0.3
Other Grasses (Urban/recreation; e.g. parks)	1,212.3	3.0
Pasture/Hay	7,080.2	17.6
Quarries/Strip Mines/Gravel Pits	0.2	0.0
Row Crops	1,009.0	2.5
Transitional	0.0	0.0
Woody Wetlands	105.4	0.3
Total	40,199.6	100.0

Note: Percent calculations were performed using a spreadsheet. Percentages and totals were rounded off and may differ slightly from values calculated by other means.

APPENDIX B

Water Quality Monitoring Data

There are a number of water quality monitoring stations that provide data for waterbodies identified as impaired for E. coli in the South Fork Holston River Watershed. The location of these monitoring stations is shown in Figure 5. Monitoring data recorded by TDEC at these stations are tabulated in Table B-1.

Table B-1. TDEC Water Quality Monitoring Data – South Fork Holston River Subwatersheds

Monitoring Station	Date	E. Coli
		[cts./100 mL]
BACK000.5SU	7/17/02	>2419
	8/20/02	1300
	9/11/02	727
	10/23/02	1733
	11/13/02	1553
	12/3/02	866
	9/9/99	866
	1/15/03	548
	2/18/03	326
	3/12/03	29
	4/15/03	411
	5/12/03	816
	6/25/03	921
BACK003.1SU	7/17/02	921
	8/20/02	770
	9/11/02	236
	10/23/02	249
	11/13/02	613
	12/3/02	144
	1/15/03	40
	2/18/03	291
	3/12/03	91
	4/15/03	488
	5/12/03	344
	6/25/03	727
BARM000.1CT	9/19/02	>2420
	10/17/02	>2420
	11/26/02	71
	12/17/02	99

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
BARM000.1CT (cont'd)	1/22/03	118
	3/5/03	201
	3/25/03	40
	4/30/03	1300
	6/17/03	649
BEAVE001.0SU	3/3/98	299
	6/25/98	>2419
	9/17/98	24
	12/15/98	1120
	3/2/99	179
	6/15/99	249
	9/7/99	11
	12/2/99	166
	2/17/00	89
	5/11/00	152
	8/10/00	2419
	11/28/00	517
	3/7/01	249
	6/26/01	144
	7/17/01	5
	10/9/01	285
	4/16/02	299
	7/17/02	727
	8/20/02	1553
	9/11/02	185
	10/23/02	461
	11/13/02	>2419
	12/3/02	649
	1/15/03	17
	2/18/03	687
	3/12/03	345
	4/15/03	770
	5/12/03	1203
	6/25/03	866

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
BEAVE001.0SU (cont'd)	8/12/03	>2419
	11/4/03	130
	8/4/04	1414
	11/4/04	2000
BEAVE009.7JO	7/10/02	102
BEAVE011.0SU	7/17/02	921
	8/20/02	980
	9/11/02	613
	10/23/02	326
	11/13/02	1986
	12/3/02	980
	1/15/03	1553
	2/18/03	1986
	3/12/03	2419
	4/15/03	1300
	5/12/03	866
	6/25/03	1414
BEAVE014.0JO	7/10/02	96
BEAVE015.3SU	3/3/98	548
	6/25/98	1553
	9/17/98	>2419
	12/15/98	1046
	3/2/99	326
	6/15/99	1046
	9/7/99	1414
	12/2/99	461
	2/17/00	1046
	5/11/00	1553
	8/10/00	1986
	11/28/00	308
	3/7/01	1553
	6/26/01	1300
	7/17/01	613
	10/9/01	>2419
	4/16/02	>2419
	7/17/02	>2419

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
BEAVE015.3SU (cont'd)	8/20/02	>2419
	9/11/02	>2419
	10/23/02	>2419
	11/13/02	2419
	12/3/02	>2419
	1/15/03	144
	2/18/03	649
	3/12/03	1733
	4/15/03	1986
	5/12/03	>2419
	6/25/03	>2419
	8/12/03	>2419
	11/4/03	2419
	8/4/04	>2419
	11/4/04	2600
BEAVE015.7JO	7/10/02	6
BEAVE016.7JO	7/10/02	1
BOOHE000.3SU	9/19/02	1986
	10/17/02	1414
	11/26/02	546
	12/17/02	272
	1/22/03	99
	3/5/03	108
	3/25/03	166
	4/30/03	>2420
	6/17/03	1046
CANDY001.7SU	9/19/02	>2420
	10/17/02	517
	11/26/02	816
	12/17/02	1986
	1/22/03	387
	3/5/03	64
	3/25/03	649
	5/1/03	1733
	6/17/03	1553

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
CEDAR000.3SU	9/9/99	980
	7/17/02	548
	8/20/02	770
	9/11/02	770
	10/23/02	1414
	11/13/02	921
	12/3/02	387
	1/15/03	770
	2/18/03	1300
	3/12/03	31
	4/15/03	313
	5/12/03	687
	6/25/03	308
DRY000.2SU	10/24/02	>2420
	11/25/02	>2420
	12/16/02	>2420
	1/21/03	>2420
	3/4/03	>2420
	3/27/03	>2420
	4/30/03	>2420
	5/20/03	>2420
	10/8/03	>2420
DRY001.3SU	3/4/03	148
	3/27/03	>2420
	4/30/03	102
	5/20/03	52
	10/8/03	84
LAURE0007.0JO	9/11/02	38
	10/23/02	<1
	10/24/02	45
	11/25/02	49
	12/16/02	161
	1/21/03	387
	3/4/03	29
	3/26/03	385

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
LAURE0007.0JO (cont'd)	4/29/03	5
	5/20/03	87
	10/1/03	105
LAURE013.8JO	9/11/02	308
	10/16/02	1733
	10/24/02	613
	11/25/02	184
	12/16/02	125
	1/21/03	613
	3/4/03	980
	3/26/03	1046
	4/29/03	21
	5/20/03	435
	10/1/03	411
LAURE015.0JO	9/11/02	DRY
	10/16/02	1986
	10/24/02	308
	11/25/02	1553
	12/16/02	770
	1/21/03	>2420
	3/4/03	>2420
	3/26/03	>2420
	4/29/03	<1
	5/20/03	2420
	10/1/03	>2420
MORRE000.1SU	9/19/02	225
	10/17/02	770
	11/26/02	548
	12/3/02	679
	12/17/02	>2420
	1/22/03	2420
	3/5/03	816
	3/25/03	86
	4/30/03	179
	6/17/03	2419

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
PSPRI001.4SU	9/11/02	>2420
	10/24/02	1986
	11/25/02	205
	12/16/02	416
	1/21/03	>2420
	3/4/03	387
	3/27/03	921
	4/30/03	>2420
	5/20/03	167
	10/8/03	>2420
SFHOL2T0.6SU	10/17/02	613
	11/26/02	308
	12/17/02	411
	1/22/03	517
	3/5/03	179
	3/25/03	1203
	4/30/03	>2420
	6/17/03	1414
SFHOL3T0.7SU	9/19/02	>2420
	10/17/02	2420
	11/26/02	>2420
	12/3/02	>2420
	12/17/02	2420
	1/22/03	770
	3/5/03	65
	3/25/03	488
	4/30/03	1986
	6/17/03	1203
WAGNE001.9SU	9/19/02	1203
	10/17/02	770
	11/26/02	727
	12/17/02	1300

Table B-1 (Cont.). TDEC Water Quality Monitoring Data – South Fork Holston Subwatersheds

Monitoring Station	Date	E. Coli [cts./100 mL]
WAGNE001.9SU (cont'd)	1/22/03	219
	3/5/03	687
	3/25/03	2420
	5/1/03	>2420
	6/17/03	>2420
WATER000.1JO	10/16/02	727
	10/24/02	308
	11/25/02	345
	12/16/02	2420
	1/21/03	>2420
	3/4/03	2420
	3/26/03	291
	4/29/03	687
	5/20/03	2420
	10/1/03	66
WEAVE000.7SU	9/19/02	>2420
	10/17/02	1733
	11/26/02	548
	12/17/02	387
	1/22/03	548
	3/5/03	649
	3/25/03	167
	4/30/03	548
	6/17/03	687
WOODS000.5SU	9/19/02	770
	10/17/02	649
	11/26/02	1300
	12/17/02	1046
	1/22/03	47
	3/5/03	411
	3/25/03	770
	4/30/03	1203
	6/17/03	1986

APPENDIX C

Development of TMDLs, WLAs, & LAs

The TMDL process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), nonpoint source loads (Load Allocations), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measure.

C.1 Development of TMDLs

E. coli TMDLs, WLAs, and LAs were developed for impaired subwatersheds and drainage areas in the South Fork Holston River Watershed using Load Duration Curves (LDCs) to determine the reduction in pollutant loading required to decrease existing, instream E. coli concentrations to target levels. TMDLs are expressed as required percent reductions in pollutant loading.

C.1.1 Development of Flow Duration Curves

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for impaired waterbodies in the South Fork Holston River Watershed were derived from LSPC hydrologic simulations based on parameters derived from calibrations at USGS Station No. 03479000, located on Watauga River near Sugar Grove, North Carolina, in the Watauga River watershed and USGS Station No. 03535000, located on Bullrun Creek near Halls Crossroads, Tennessee, in the Lower Clinch watershed (see Appendix D for details of calibration). For example, a flow-duration curve for Back Creek at RM 0.5 was constructed using simulated daily mean flow for the period from 10/1/94 through 9/31/04 (RM 0.5 corresponds to the location of monitoring station BACK000.5SU). This flow duration curve is shown in Figure C-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). Flow duration curves for other impaired waterbodies were derived using a similar procedure.

C.1.2 Development of Load Duration Curves and Determination of TMDLs

When a water quality target concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003). Data points representing greater than 50% stormflow (>50% SF) are highlighted to indicate the response to rainfall.

E. coli load duration curves for impaired waterbodies in the South Fork Holston River Watershed were developed from the flow duration curves developed in Section C.1.1, E. coli target concentrations, and available water quality monitoring data. Load duration curves and required load reductions were developed using the following procedure (Back Creek is shown as an example):

1. A target load-duration curve (LDC) was generated for Back Creek by applying the E. coli target concentration of 941 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results. The E. coli target maximum load corresponding to each ranked daily mean flow is:

   $(\text{Target Load})_{\text{Back Creek}} = (941\ \text{CFU}/100\ \text{mL}) \times (Q) \times (UCF)$

   where: Q = daily mean flow
   UCF = the required unit conversion factor

2. Daily loads were calculated for each of the water quality samples collected at monitoring station BACK000.5SU (ref.: Table B-1) by multiplying the sample concentration by the daily mean flow for the sampling date and the required unit conversion factor. BACK000.5SU was selected for LDC analysis because it was the monitoring station on Back Creek with the most exceedances of the target concentration.

   Note: In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.

   Example – 8/20/02 sampling event:
   Modelled Flow = 1.11 cfs
   Concentration = 1300 CFU/100 mL
   Daily Load = 3.53×10^{10} CFU/day

3. Using the flow duration curves developed in C.1.1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event. Each sample load was then plotted on the load duration curves developed in Step 1 according to the PDFE. The resulting E. coli load duration curve for is shown in Figure C-15.

4. For cases where the existing load exceeded the target maximum load at a particular PDFE, the reduction required to reduce the sample load to the target load was calculated.

   Example – 8/20/02 sampling event:
   Target Concentration = 941 CFU/100 mL
   Measured Concentration = 1300 CFU/100 mL
   Reduction to Target = 27.6%

5. The 90^{th} percentile value for all of the E. coli sampling data at BACK000.5SU monitoring site was determined. If the 90^{th} percentile value exceeded the target maximum E. coli concentration, the reduction required to reduce the 90^{th} percentile value to the target maximum concentration was calculated (Table C-14).

   Example: *Target Concentration = 941 CFU/100 mL*
   90^{th} Percentile Concentration = 1697 CFU/100 mL
   Reduction to Target = 44.6%

6. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the target geometric mean E. coli concentration of 126 CFU/100 mL. If the sample geometric mean exceeded the target geometric mean concentration, the reduction required to reduce the sample geometric mean value to the target geometric mean concentration was calculated.

   Example: *Insufficient monitoring data was available for any monitoring station in the South Fork Holston River watershed*

7. The load reductions required to meet the target maximum (Step 5) and target 30-day geometric mean concentrations (Step 6) of E. coli were compared and the load reduction of the greatest magnitude selected as the TMDL for Back Creek.

Load duration curves, required load reductions, and TMDLs of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-24 and Tables C-1 through C-17.

C.2 Development of WLAs & LAs

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$

Expanding the terms:

$$\text{TMDL} = [\Sigma\text{WLAs}]_{\text{WWTF}} + [\Sigma\text{WLAs}]_{\text{MS4}} + [\Sigma\text{WLAs}]_{\text{CAFO}} + [\Sigma\text{LAs}]_{\text{DS}} + [\Sigma\text{LAs}]_{\text{SW}} + \text{MOS}$$

For pathogen TMDLs in each impaired subwatershed or drainage area, WLA terms include:

- $[\sum WLAs]_{WWTF}$ is the allowable load associated with discharges of NPDES permitted WWTFs located in impaired subwatersheds or drainage areas. Since NPDES permits for these facilities specify that treated wastewater must meet instream water quality standards at the point of discharge, no additional load reduction is required. WLAs for WWTFs are calculated from the facility design flow and the Monthly Average permit limit.
- $[\sum WLAs]_{CAFO}$ is the allowable load for all CAFOs in an impaired subwatershed or drainage area. All wastewater discharges from a CAFO to waters of the state of Tennessee are prohibited, except when either chronic or catastrophic rainfall events cause an overflow of process wastewater from a facility properly designed, constructed, maintained, and operated to contain:
  - All process wastewater resulting from the operation of the CAFO (such as wash water, parlor water, watering system overflow, etc.); plus,
  - All runoff from a 25-year, 24-hour rainfall event for the existing CAFO or new dairy or cattle CAFOs; or all runoff from a 100-year, 24-hour rainfall event for a new swine or poultry CAFO.

  Therefore, a WLA of zero has been assigned to this class of facilities.
- $[\sum WLAs]_{MS4}$ is the required load reduction for discharges from MS4s. E. coli loading from MS4s is the result of buildup/wash-off processes associated with storm events.

LA terms include:

- $[\sum LAs]_{DS}$ is the allowable E. coli load from "other direct sources". These sources include leaking septic systems, illicit discharges, and animals access to streams. The LA specified for all sources of this type is zero CFU/day (or to the maximum extent practicable).
- $[\sum LAs]_{SW}$ represents the required reduction in E. coli loading from nonpoint sources indirectly going to surface waters from all land use areas (except areas covered by a MS4 permit) as a result of the buildup/wash-off processes associated with storm events.

Since WWTFs discharges must comply with instream water quality criteria (TMDL target) at the point of discharge, $[\sum WLAs]_{CAFO} = 0$, and $[\sum LAs]_{DS} = 0$, the expression relating TMDLs to precipitation-based point and nonpoint sources may be simplified to:

$$TMDL - MOS = [\sum WLAs]_{MS4} + [\sum LAs]_{SW}$$

WLAs for MS4s and LAs for precipitation-based nonpoint sources are equal and expressed as the percent reduction in loading required to decrease instream E. coli concentrations to TMDL target values minus MOS. As stated in Section 8.4, an explicit MOS, equal to 10% of the E. coli water quality targets (ref.: Section 5.0), was utilized for determination of the WLAs and LAs:

Instantaneous Maximum: Target – MOS = (941 CFU/100 ml) – 0.1(941 CFU/100 ml)

Target – MOS = 847 CFU/100 ml

30-Day Geometric Mean: Target – MOS = (126 CFU/100 ml) – 0.1(126 CFU/100 ml)

Target – MOS = 113 CFU/100 ml

C.2.1 Determination of WLAs for MS4s & LAs for Precipitation-Based Nonpoint Sources

WLAs for MS4s and LAs for precipitation-based nonpoint sources were developed using methods similar to those described in C.1.2 (again, using Back Creek as an example):

8. An allocation LDC was generated for Back Creek by applying the E. coli "target – MOS" concentration of 847 CFU/100 mL to each of the ranked flows used to generate the flow duration curve (ref.: Section D.1) and plotting the results on the target LDC developed in Step 1. The E. coli target maximum allocated load corresponding to each ranked daily mean flow is:

   $(\text{Target Load - MOS})_{\text{Back Creek}}$ = (847 CFU/100 mL) x (Q) x (UCF)

   where: Q = daily mean flow
   UCF = the required unit conversion factor

9. For cases where the existing load exceeded the "target maximum load – MOS" at a particular PDFE, the reduction required to reduce the sample load to the "target – MOS" load was calculated.

   Example – 8/20/02 sampling event:
   Target Concentration – MOS = 847 CFU/100 mL
   Measured Concentration = 1300 CFU/100 mL
   Reduction to Target – MOS = 34.8%

10. If the 90th percentile value for all of the E. coli sampling data at BACK000.5SU monitoring site (calculated in Step 5) exceeded the "target maximum – MOS" E. coli concentration, the reduction required to reduce the 90th percentile value to the "target maximum – MOS" concentration was calculated (Table C-14).

    Example: *Target Concentration – MOS = 847 CFU/100 mL*
    90th Percentile Concentration = 1697 CFU/100 mL
    Reduction to Target – MOS = 50.1%

11. For cases where five or more samples were collected over a period of not more than 30 consecutive days, the geometric mean E. coli concentration was determined and compared to the "target geometric mean E. coli concentration – MOS" of 113 CFU/100 mL. If the sample geometric mean exceeded the "target geometric mean – MOS" concentration, the reduction required to reduce the sample geometric mean value to the "target geometric mean – MOS" concentration was calculated.

Example: *Insufficient monitoring data was available for any monitoring station in the South Fork Holston River watershed*

12. The load reductions required to meet the "target maximum – MOS" (Step 10) and "target 30-day geometric mean – MOS" concentrations (Step 11) of E. coli were compared and the load reduction of the greatest magnitude selected as the WLA for MS4s and/or LA for precipitation-based nonpoint sources for Back Creek.

Load duration curves, required load reductions, WLAs for MS4s, and LAs for precipitation-based nonpoint sources of other impaired waterbodies were derived in a similar manner and are shown in Figures C-2 through C-18 and Tables C-1 through C-17. TMDLs, WLAs, & LAs for impaired subwatersheds and drainage areas in the South Fork Holston River Watershed are summarized in Table C-18.

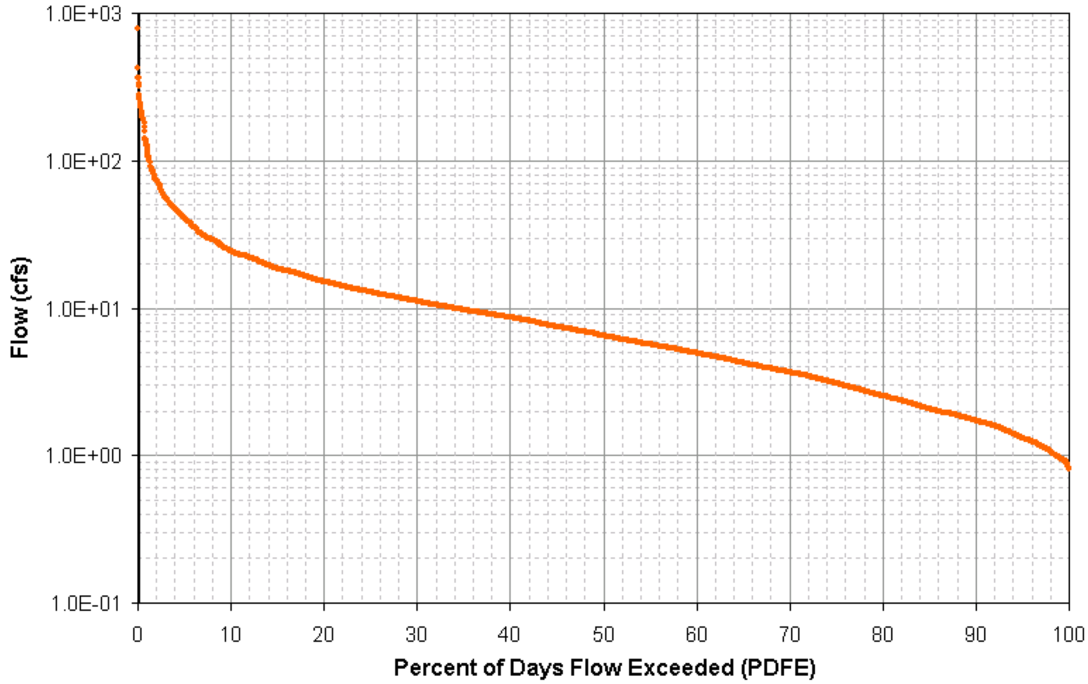

Figure C-1 Flow Duration Curve for Back Creek at BACK000.5SU

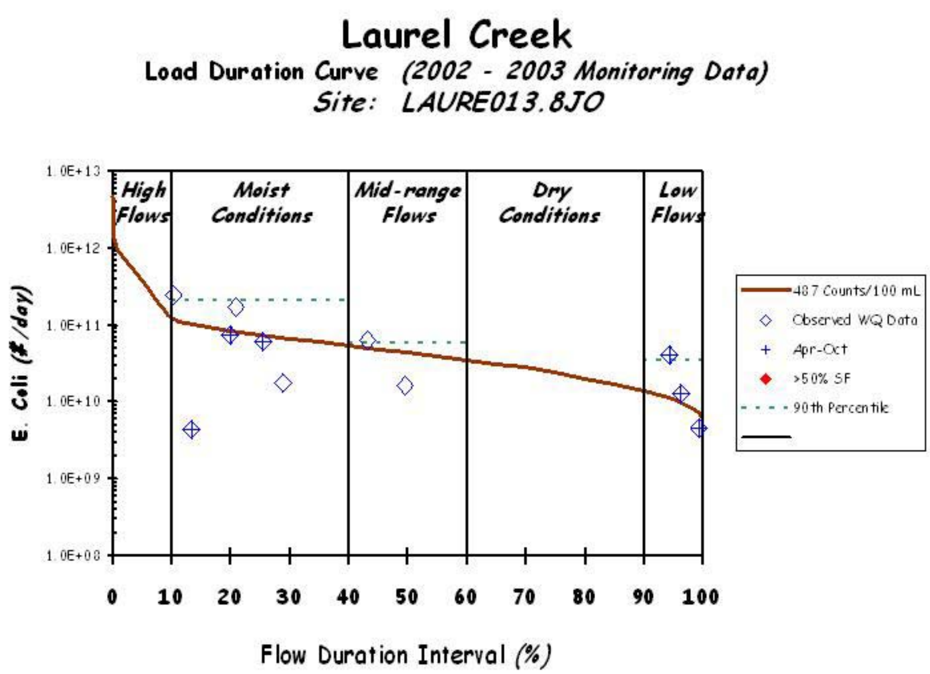

Figure C-2 E. Coli Load Duration Curve for Laurel Creek at LAURE013.8JO

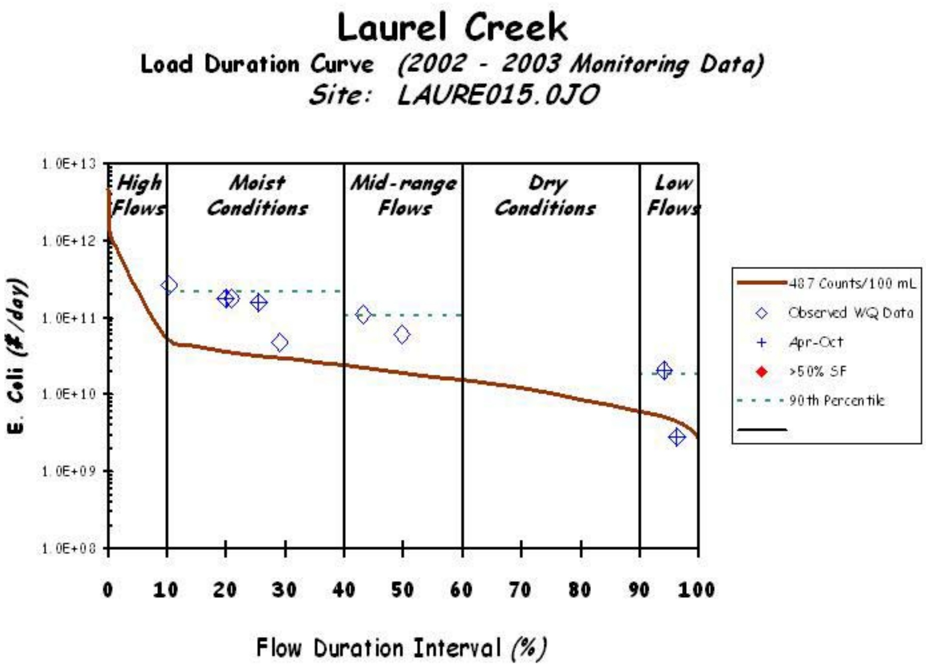

Figure C-3 E. Coli Load Duration Curve for Laurel Creek at LAURE015.0JO

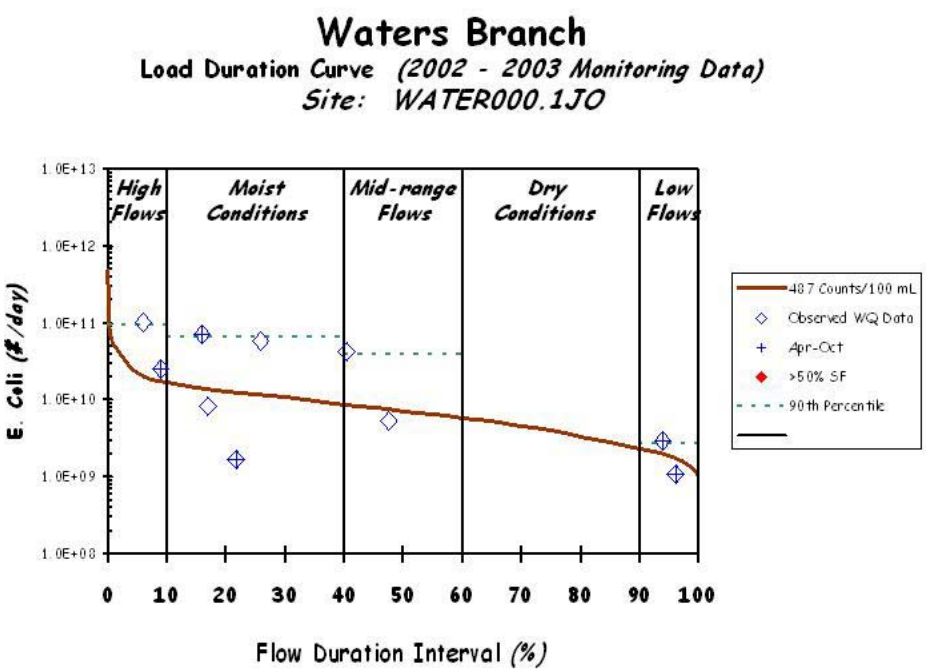

Figure C-4 E. Coli Load Duration Curve for Waters Branch

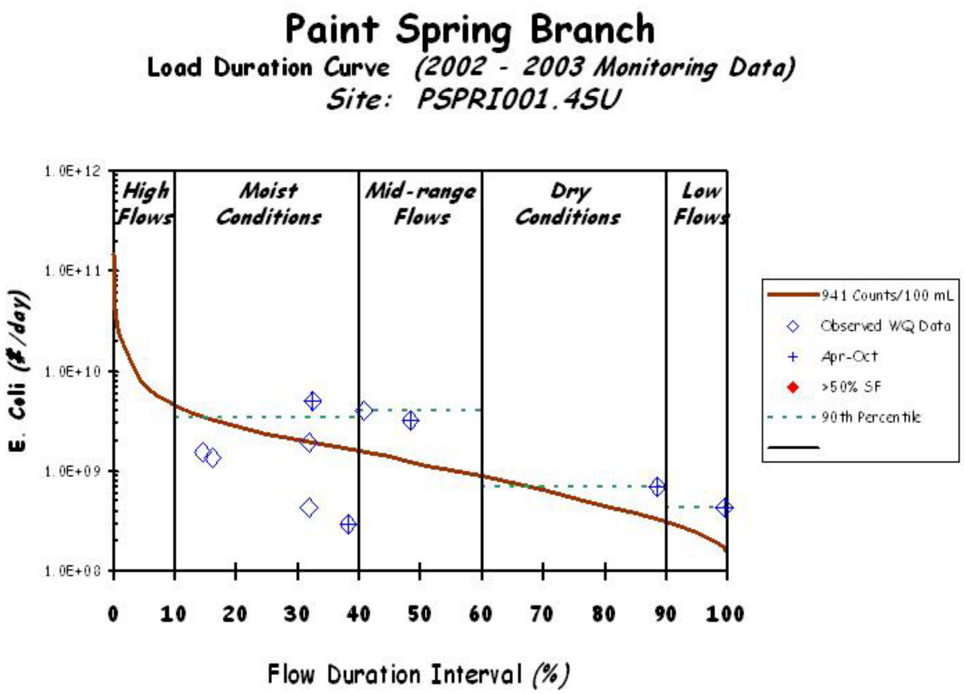

Figure C-5 E. Coli Load Duration Curve for Paint Spring Branch

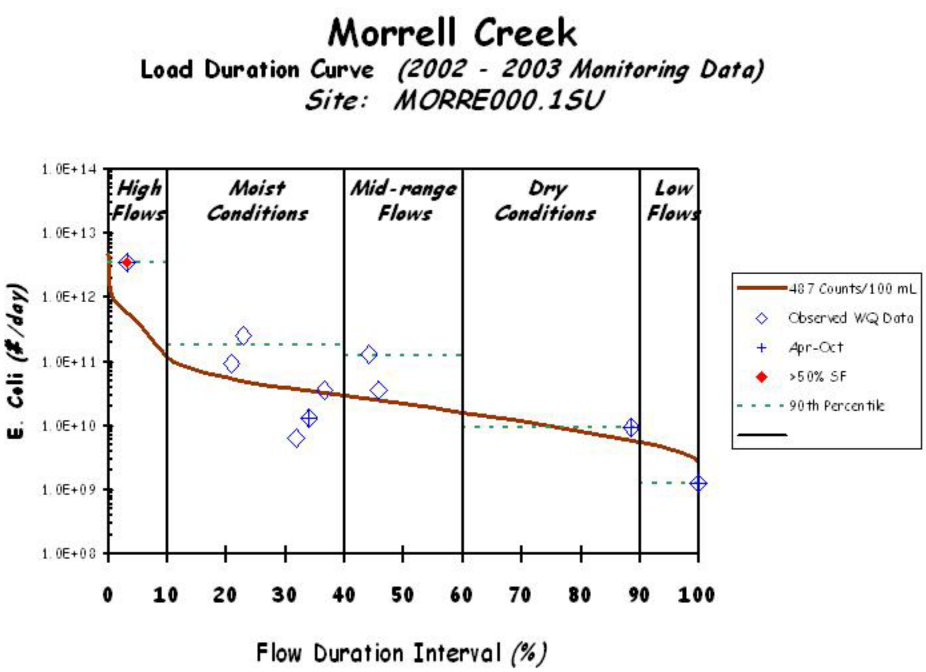

Figure C-6 E. Coli Load Duration Curve for Morrell Creek

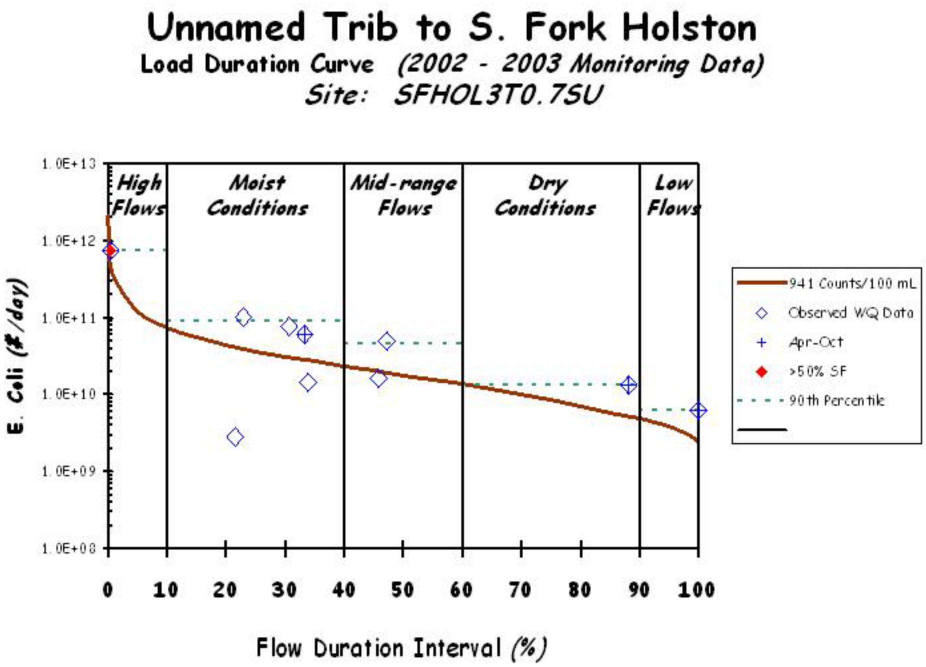

Figure C-7 E. Coli Load Duration Curve for Unnamed Trib to S. Fork Holston (SFHOL3T0.7SU)

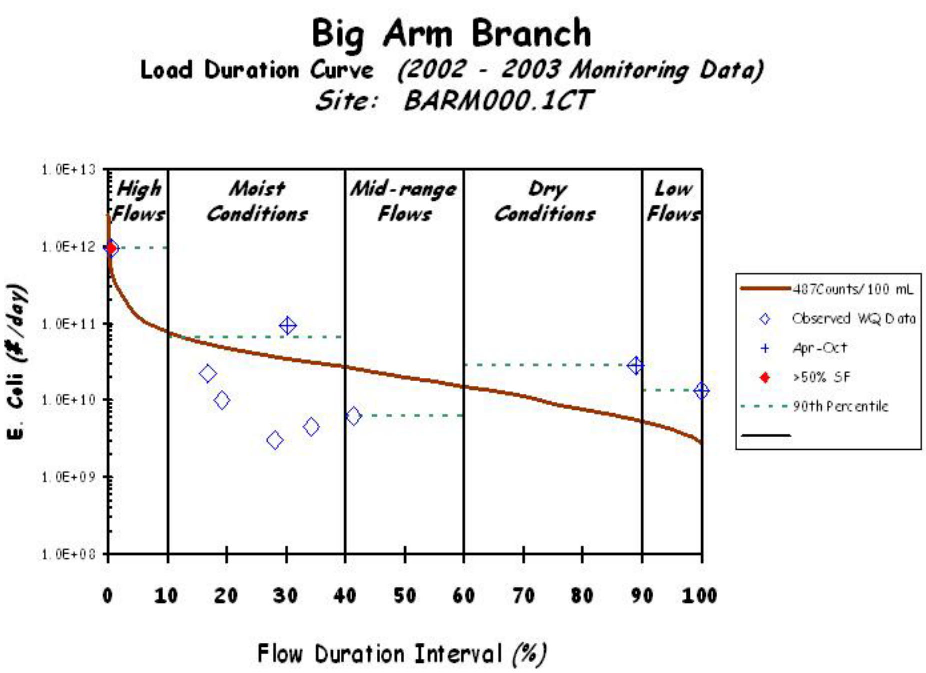

Figure C-8 E. Coli Load Duration Curve for Big Arm Branch

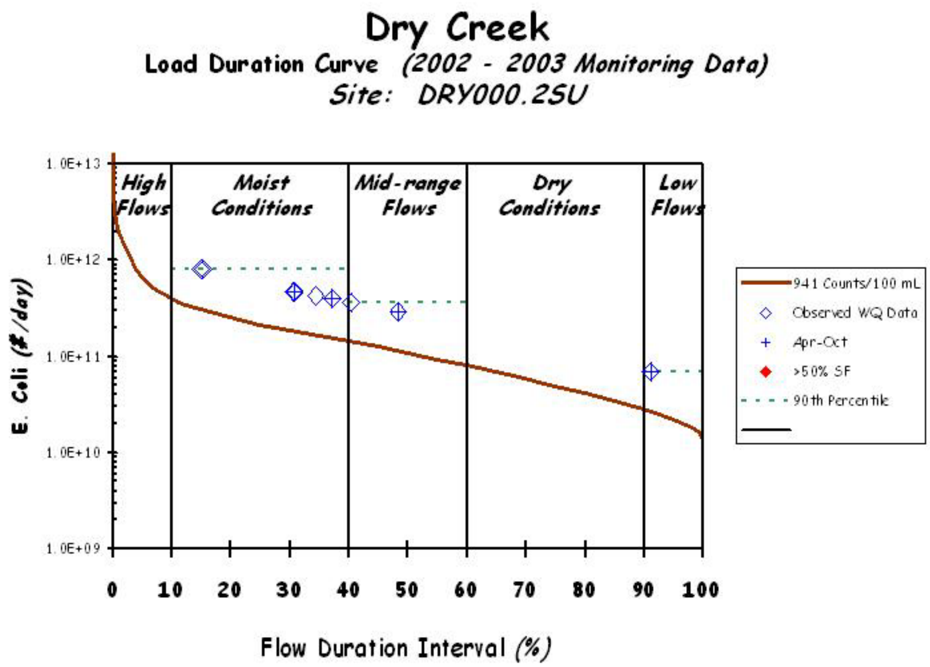

Figure C-9 E. Coli Load Duration Curve for Dry Creek at DRY000.2SU

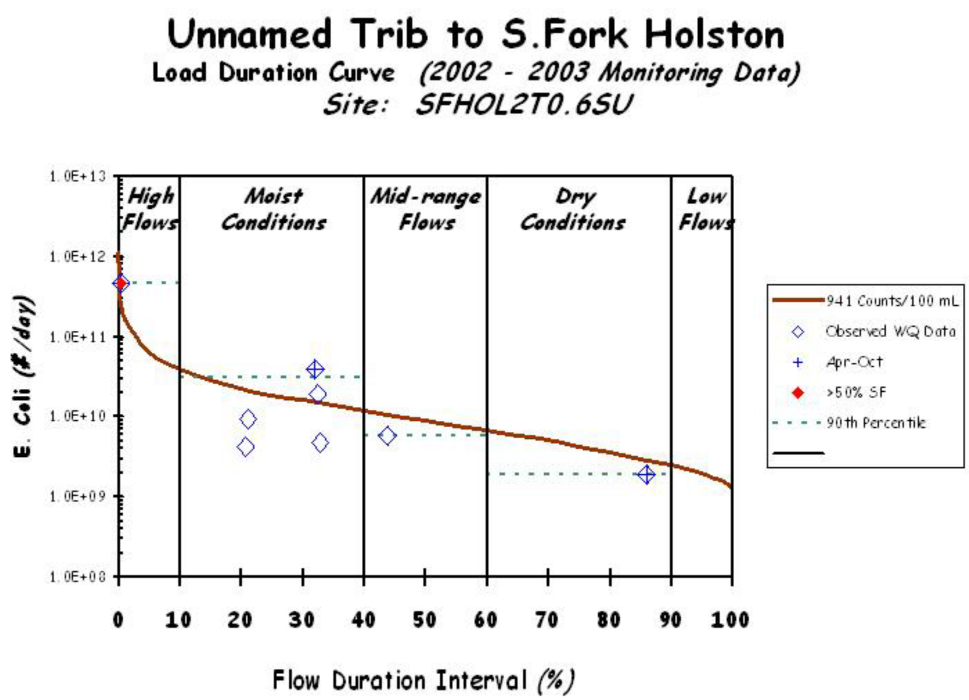

Figure C-10 E. Coli Load Duration Curve for Unnamed Trib to S. Fork Holston (SFHOL2T0.6SU)

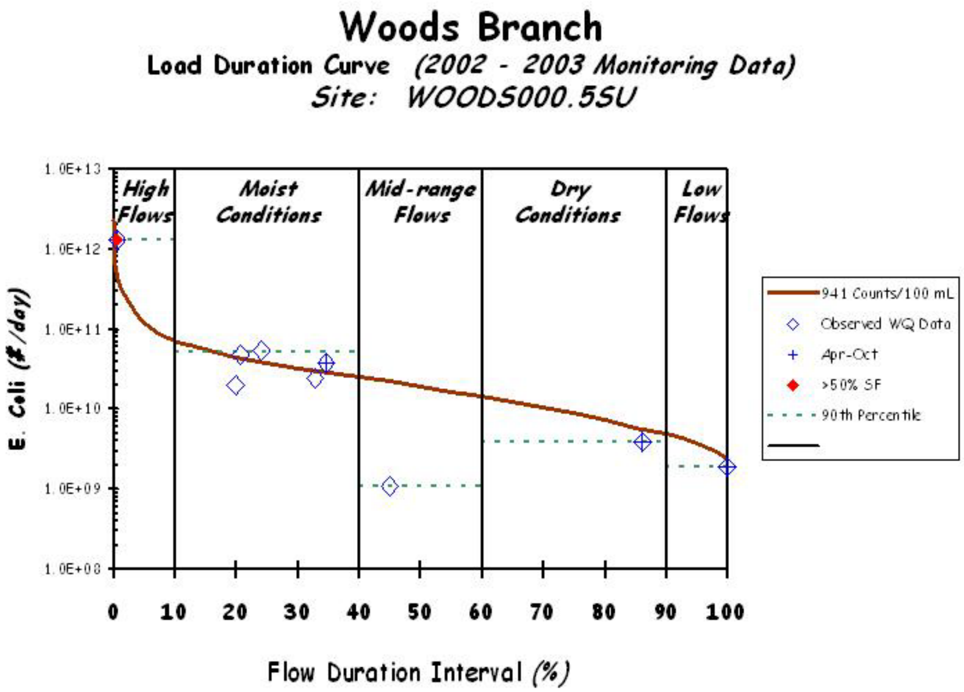

Figure C-11 E. Coli Load Duration Curve for Woods Branch

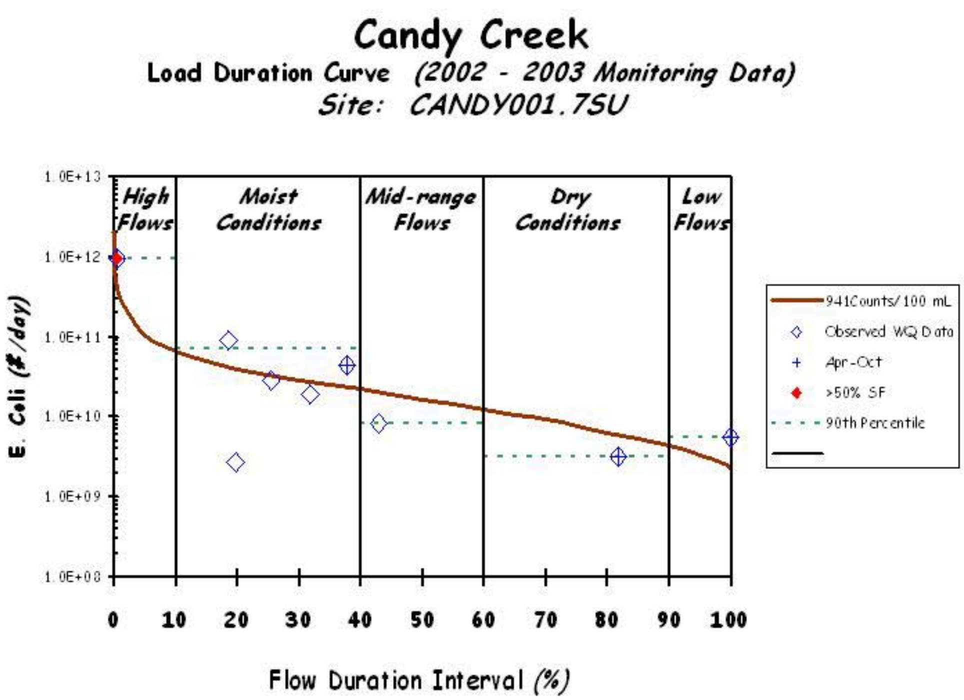

Figure C-12 E. Coli Load Duration Curve for Candy Creek

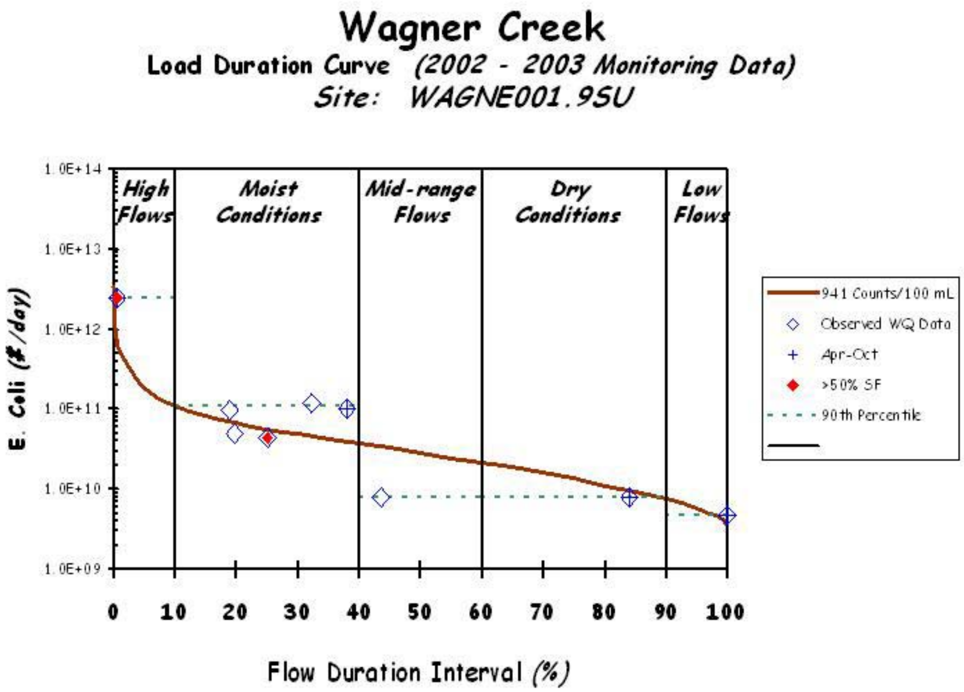

Figure C-13 E. Coli Load Duration Curve for Wagner Creek

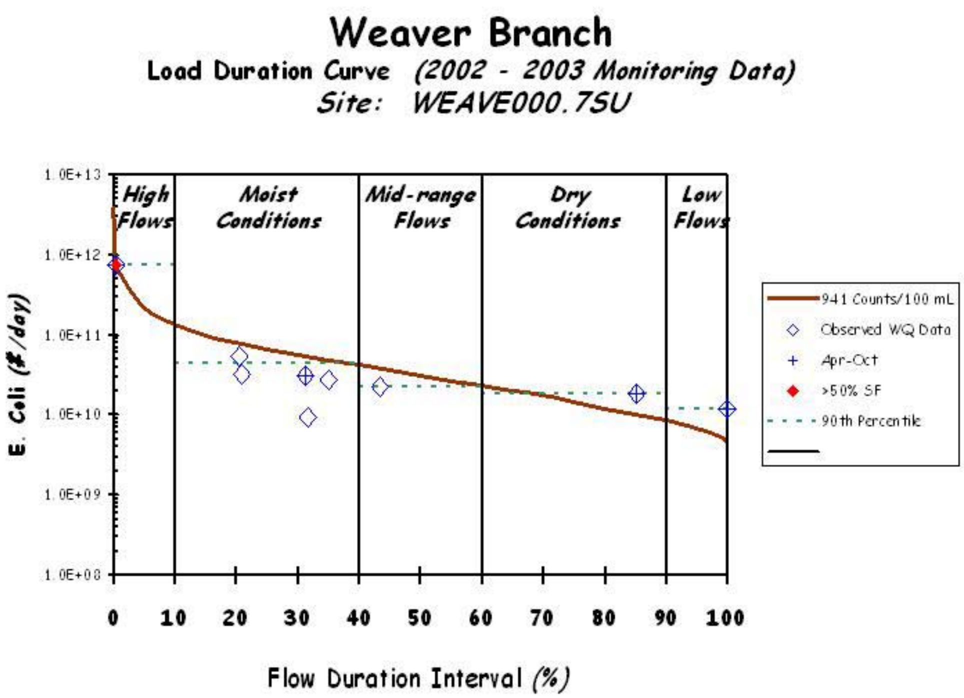

Figure C-14 E. Coli Load Duration Curve for Weaver Branch

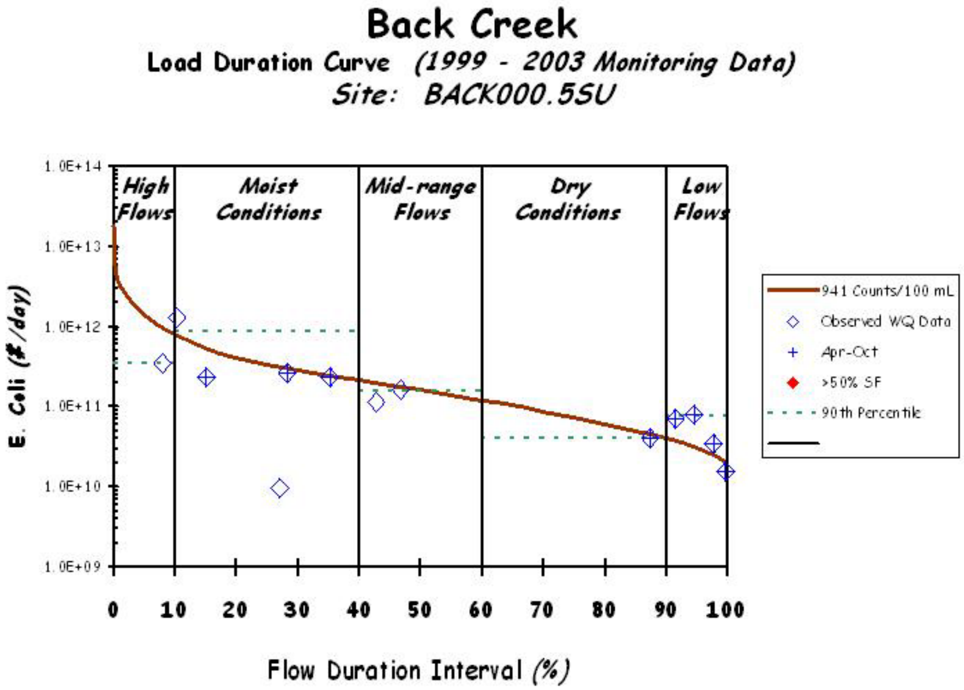

Figure C-15 E. Coli Load Duration Curve for Back Creek at BACK000.5SU

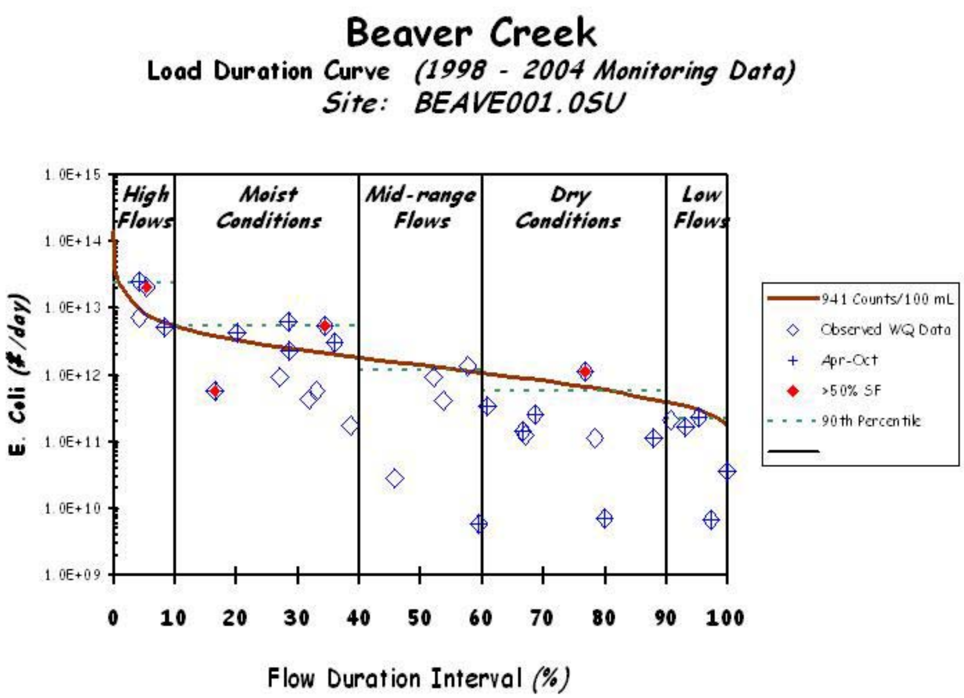

Figure C-16 E. Coli Load Duration Curve for Beaver Creek at BEAVE001.0SU

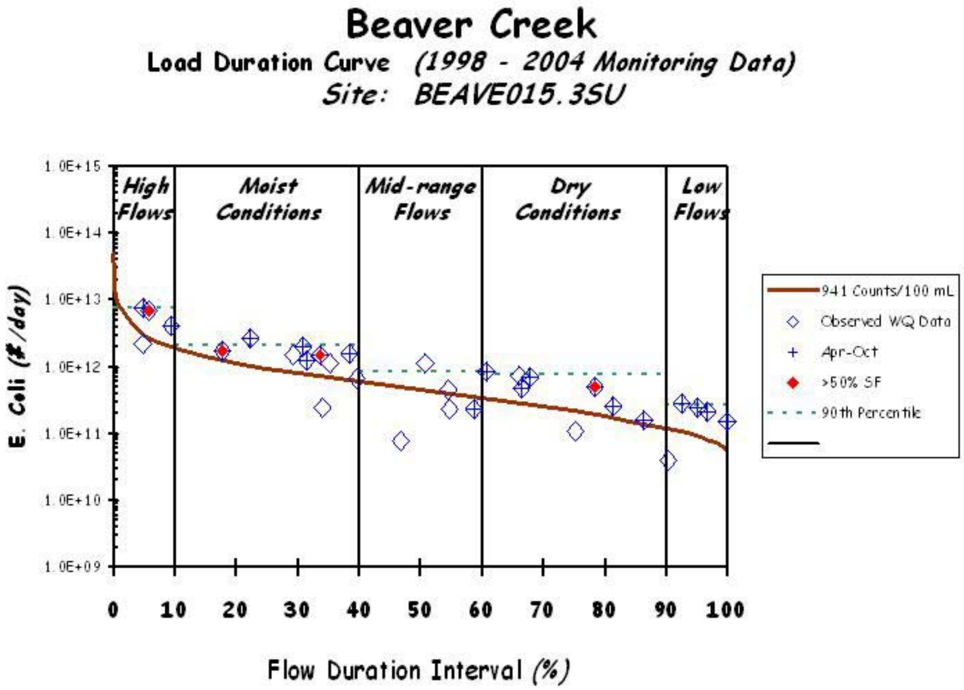

Figure C-17 E. Coli Load Duration Curve for Beaver Creek at BEAVE015.3SU

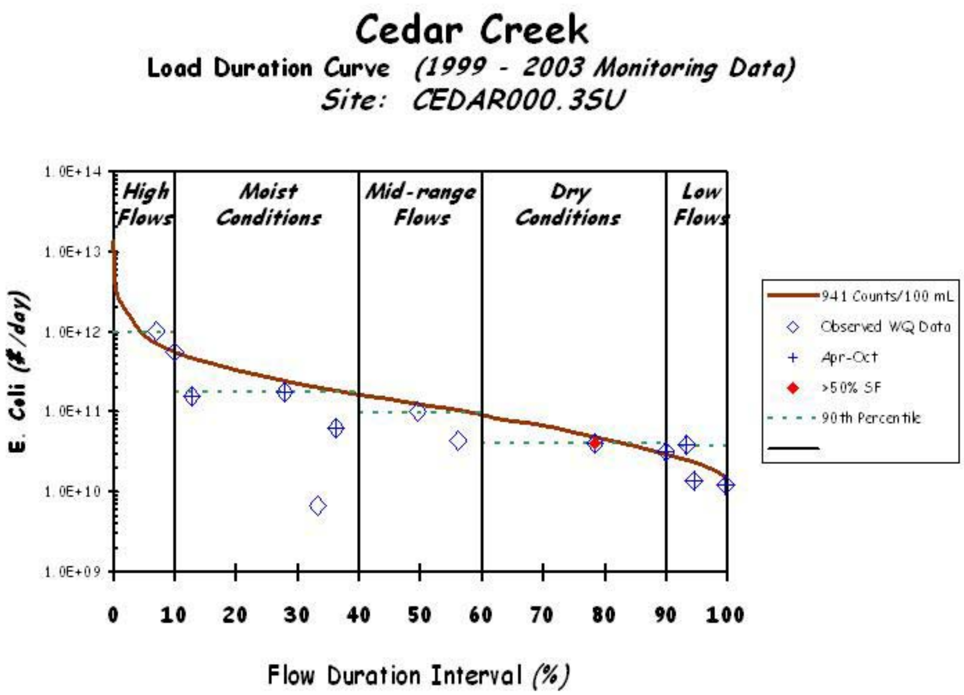

Figure C-18 E. Coli Load Duration Curve for Cedar Creek

Table C-1 Required Load Reduction for Laurel Creek at LAURE013.8JO

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/11/02	0.61	99.4	308	**NR**	**NR**
10/16/02	0.96	94.4	1733	**71.9**	**74.7**
10/24/02	0.85	96.5	613	**20.6**	**28.6**
11/25/02	3.68	49.7	184	**NR**	**NR**
12/16/02	5.77	28.8	125	**NR**	**NR**
1/21/03	4.26	43.2	613	**20.6**	**28.6**
3/4/03	10.12	10.3	980	**50.3**	55.3
3/26/03	6.80	20.9	1046	53.4	58.1
4/29/03	8.56	13.4	21	**NR**	**NR**
5/20/03	6.94	19.9	435	**NR**	**NR**
10/1/03	6.17	25.5	411	**NR**	**NR**
90th Percentile Concentration			**1046**	**53.4**	**58.1**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-2 Required Load Reduction for Laurel Creek at LAURE015.0JO

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/16/02	0.42	94.3	1986	75.5	78.0
10/24/02	0.37	96.5	308	**NR**	**NR**
11/25/02	1.61	49.9	1553	68.6	71.8
12/16/02	2.53	29.1	770	36.8	43.1
1/21/03	1.87	43.2	>2420	>79.9	>81.9
3/4/03	4.45	10.3	>2420	>79.9	>81.9
3/26/03	2.99	20.9	>2420	>79.9	>81.9
4/29/03	3.77	13.3	<1	**NR**	**NR**
5/20/03	3.05	20.0	2420	79.9	81.9
10/1/03	2.71	25.5	>2420	>79.9	>81.9
90th Percentile Concentration			**>2420**	**>79.9**	**>81.9**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-3 Required Load Reduction for Waters Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/16/02	0.17	94.0	727	**33.0**	**39.8**
10/24/02	0.15	96.3	308	**NR**	**NR**
11/25/02	0.63	47.6	345	**NR**	**NR**
12/16/02	0.99	25.8	2420	79.9	81.9
1/21/03	0.73	40.4	>2420	>79.9	>81.9
3/4/03	1.75	5.9	2420	79.9	81.9
3/26/03	1.18	17.0	291	**NR**	**NR**
4/29/03	1.48	8.9	687	**29.1**	**36.2**
5/20/03	1.20	15.9	2420	79.9	81.9
10/1/03	1.06	21.8	66	**NR**	**NR**
90th Percentile Concentration			**>2420**	**>79.9**	**>81.9**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-4 Required Load Reduction for Paint Spring Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/11/02	0.01	99.7	>2420	>61.1	>65.0
10/24/02	0.01	88.7	1986	52.6	57.4
11/25/02	0.09	31.8	205	**NR**	**NR**
12/16/02	0.15	14.5	416	**NR**	**NR**
1/21/03	0.07	40.8	>2420	>61.1	>65.0
3/4/03	0.15	16.1	387	**NR**	**NR**
3/27/03	0.09	31.8	921	**NR**	**8.0**
4/30/03	0.08	32.4	>2420	>61.1	>65.0
5/20/03	0.07	38.3	167	**NR**	**NR**
10/8/03	0.05	48.4	>2420	>61.1	>65.0
90th Percentile Concentration			**>2420**	**>61.1**	**>65.0**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-5 Required Load Reduction for Morrell Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.23	100.0	225	**NR**	**NR**
10/17/02	0.49	88.7	770	**36.8**	**43.1**
11/26/02	2.72	36.7	548	**11.1**	**20.1**
12/3/02	2.11	45.9	679	**28.3**	**35.5**
12/17/02	4.22	23.0	>2420	>79.9	>81.9
1/22/03	2.22	44.2	2420	79.9	81.9
3/5/03	4.57	21.0	816	**40.3**	**46.3**
3/25/03	3.11	31.9	86	**NR**	**NR**
4/30/03	2.94	34.0	179	**NR**	**NR**
6/17/03	59.68	3.1	2419	79.9	81.9
90th Percentile Concentration			**>2420**	**>79.9**	**>81.9**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-6 Required Load Reduction for Unnamed Trib to S. Fork Holston (SFHOL3T0.7SU)

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.11	100.0	>2420	>61.1	>65.0
10/17/02	0.23	88.2	>2420	>61.1	>65.0
11/26/02	1.33	30.7	>2420	>61.1	>65.0
12/3/02	0.83	47.3	>2420	>61.1	>65.0
12/17/02	1.72	23.0	2420	61.1	65.0
1/22/03	0.87	45.8	770	**NR**	**NR**
3/5/03	1.81	21.6	65	**NR**	**NR**
3/25/03	1.22	33.8	488	**NR**	**NR**
4/30/03	1.24	33.3	1986	52.6	57.4
6/17/03	25.05	0.4	1203	59.5	63.6
90th Percentile Concentration			**>2420**	**>61.1**	**>65.0**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-7 Required Load Reduction for Big Arm Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (487 CFU/100 ml)	Sample to Target - MOS (438 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.23	100.0	>2420	>79.9	>81.9
10/17/02	0.47	88.9	>2420	>79.9	>81.9
11/26/02	2.64	34.3	71	**NR**	**NR**
12/17/02	4.13	19.3	99	**NR**	**NR**
1/22/03	2.20	41.4	118	**NR**	**NR**
3/5/03	4.56	16.9	201	**NR**	**NR**
3/25/03	3.10	28.1	40	**NR**	**NR**
4/30/03	2.94	30.2	1300	62.5	66.3
6/17/03	59.43	0.5	649	**25.0**	**32.5**
90th Percentile Concentration			**>2420**	**>79.9**	**>81.9**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-8 Required Load Reduction for Dry Creek at DRY000.2SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941U/100 ml)	Sample to Target - MOS (847U/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/24/02	1.19	91.2	>2420	>61.1	>65.0
11/25/02	7.21	34.5	>2420	>61.1	>65.0
12/16/02	13.62	14.9	>2420	>61.1	>65.0
1/21/03	6.20	40.4	>2420	>61.1	>65.0
3/4/03	13.42	15.3	>2420	>61.1	>65.0
3/27/03	7.98	30.7	>2420	>61.1	>65.0
4/30/03	7.90	30.9	>2420	>61.1	>65.0
5/20/03	6.78	37.2	>2420	>61.1	>65.0
10/8/03	4.86	48.5	>2420	>61.1	>65.0
90th Percentile Concentration			**>2420**	**>61.1**	**>65.0**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-9 Required Load Reduction for Unnamed Trib to S. Fork Holston (SFHOL2T0.6SU)

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
10/17/02	0.13	86.0	613	**NR**	**NR**
11/26/02	0.64	32.8	308	**NR**	**NR**
12/17/02	0.94	21.2	411	**NR**	**NR**
1/22/03	0.47	43.8	517	**NR**	**NR**
3/5/03	0.95	20.8	179	**NR**	**NR**
3/25/03	0.65	32.4	1203	21.8	29.6
4/30/03	0.65	32.1	>2420	>61.1	>65.0
6/17/03	13.24	0.4	1414	33.5	40.1
90th Percentile Concentration			**>1716**	**>45.2**	**>50.6**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-10 Required Load Reduction for Woods Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.10	100.0	770	**NR**	**NR**
10/17/02	0.25	86.3	649	**NR**	**NR**
11/26/02	1.70	24.1	1300	27.6	34.9
12/17/02	1.89	20.7	1046	10.0	19.0
1/22/03	0.96	45.1	47	**NR**	**NR**
3/5/03	1.96	20.0	411	**NR**	**NR**
3/25/03	1.31	32.9	770	**NR**	**NR**
4/30/03	1.26	34.6	1203	21.8	29.6
6/17/03	26.98	0.5	1986	52.6	57.4
90th Percentile Concentration			**1437**	**34.5**	**41.1**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-11 Required Load Reduction for Candy Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.10	100.0	>2420	>61.1	>65.0
10/17/02	0.26	81.8	517	**NR**	**NR**
11/26/02	1.44	25.5	816	**NR**	**NR**
12/17/02	1.84	18.6	1986	52.6	57.4
1/22/03	0.90	42.9	387	**NR**	**NR**
3/5/03	1.77	19.8	64	**NR**	**NR**
3/25/03	1.20	31.8	649	**NR**	**NR**
5/1/03	1.03	37.8	1733	45.7	51.1
6/17/03	25.06	0.5	1553	39.4	45.5
90th Percentile Concentration			**>2073**	**>54.6**	**>59.1**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-12 Required Load Reduction for Wagner Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.16	100.0	1203	21.8	29.6
10/17/02	0.42	84.1	770	**NR**	**NR**
11/26/02	2.47	25.1	727	**NR**	**NR**
12/17/02	3.04	19.0	1300	27.6	34.8
1/22/03	1.49	43.7	219	**NR**	**NR**
3/5/03	2.97	19.7	687	**NR**	**NR**
3/25/03	2.00	32.3	2420	61.1	65.0
5/1/03	1.73	38.0	>2420	>61.1	>65.0
6/17/03	41.29	0.5	>2420	>61.1	>65.0
90th Percentile Concentration			**>2420**	**>61.1**	**>65.0**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-13 Required Load Reduction for Weaver Branch

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/19/02	0.20	100.0	>2420	>61.1	>65.0
10/17/02	0.44	85.3	1733	45.7	51.1
11/26/02	2.09	35.0	548	**NR**	**NR**
12/17/02	3.35	20.9	387	**NR**	**NR**
1/22/03	1.65	43.5	548	**NR**	**NR**
3/5/03	3.38	20.5	649	**NR**	**NR**
3/25/03	2.30	31.7	167	**NR**	**NR**
4/30/03	2.32	31.3	548	**NR**	**NR**
6/17/03	44.76	0.4	687	**NR**	**NR**
90th Percentile Concentration			**>1870**	**>49.7**	**>54.7**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-14 Required Load Reduction for Back Creek at BACK000.5SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/9/99	1.94	87.4	866	**NR**	**2.2**
7/17/02	1.36	94.7	>2419	>61.1	>65.0
8/20/02	1.11	97.8	1300	**27.6**	**34.8**
9/11/02	0.87	99.9	727	**NR**	**NR**
10/23/02	1.65	91.6	1733	45.7	51.1
11/13/02	33.79	10.4	1553	39.4	45.5
12/3/02	7.66	46.9	866	**NR**	**2.2**
1/15/03	8.68	42.8	548	**NR**	**NR**
2/18/03	43.16	8.0	326	**NR**	**NR**
3/12/03	13.40	27.1	29	**NR**	**NR**
4/15/03	23.02	15.2	411	**NR**	**NR**
5/12/03	13.02	28.2	816	**NR**	**NR**
6/25/03	10.52	35.3	921	**NR**	**8.0**
90th Percentile Concentration			**>1697**	**>44.6**	**>50.1**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-15 Required Load Reduction for Beaver Creek at BEAVE001.0SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
3/3/98	55.66	53.8	299	**NR**	**NR**
6/25/98	107.65	28.5	>2419	>61.1	>65.0
9/17/98	11.34	97.4	24	**NR**	**NR**
12/15/98	50.07	57.8	1120	16.0	24.4
3/2/99	96.94	31.9	179	**NR**	**NR**
6/15/99	18.67	88.0	249	**NR**	**NR**
9/7/99	26.03	80.1	11	**NR**	**NR**
12/2/99	27.80	78.4	166	**NR**	**NR**
2/17/00	81.30	38.7	89	**NR**	**NR**
5/11/00	39.25	66.8	152	**NR**	**NR**
8/10/00	91.06	34.5	2419	61.1	65.0
11/28/00	16.51	90.9	517	**NR**	**NR**
3/7/01	94.78	33.0	249	**NR**	**NR**
6/26/01	167.86	16.6	144	**NR**	**NR**
7/17/01	47.81	59.5	5	**NR**	**NR**
10/9/01	37.30	68.8	285	**NR**	**NR**
4/16/02	45.90	61.0	299	**NR**	**NR**
7/17/02	12.91	95.4	727	**NR**	**NR**
8/20/02	29.27	76.8	1553	39.4	45.5
9/11/02	7.88	100.0	185	**NR**	**NR**
10/23/02	14.64	93.3	461	**NR**	**NR**
11/13/02	357.66	5.3	>2419	>61.1	>65.0
12/3/02	58.29	52.1	649	**NR**	**NR**
1/15/03	68.11	45.9	17	**NR**	**NR**
2/18/03	427.02	4.1	687	**NR**	**NR**
3/12/03	112.14	27.1	345	**NR**	**NR**
4/15/03	275.17	8.4	770	**NR**	**NR**
5/12/03	144.20	20.2	1203	21.8	29.6
6/25/03	107.38	28.6	866	**NR**	**2.2R**
8/12/03	425.06	4.1	>2419	>61.1	>65.0
11/4/03	38.87	67.1	130	**NR**	**NR**
8/4/04	87.30	36.0	1414	33.5	40.1
11/4/04			2000	53.0	57.7
90th Percentile Concentration			**>2335**	**>59.7**	**>63.7**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-16 Required Load Reduction for Beaver Creek at BEAVE015.3SU

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
3/3/98	17.37	54.8	548	**NR**	**NR**
6/25/98	33.44	31.5	1553	39.4	45.5
9/17/98	3.65	96.9	>2419	>61.1	>65.0
12/15/98	17.45	54.6	1046	10.0	19.0
3/2/99	30.75	34.0	326	**NR**	**NR**
6/15/99	6.05	86.4	1046	10.0	19.0
9/7/99	7.37	81.5	1414	33.6	40.1
12/2/99	9.41	75.3	461	**NR**	**NR**
2/17/00	26.32	39.6	1046	10.0	19.0
5/11/00	12.41	66.5	1553	39.4	45.5
8/10/00	31.00	33.7	1986	52.6	57.4
11/28/00	5.15	90.4	308	**NR**	**NR**
3/7/01	29.93	35.2	1553	39.4	45.5
6/26/01	53.80	17.7	1300	27.6	34.8
7/17/01	15.44	58.7	613	**NR**	**NR**
10/9/01	11.92	68.0	>2419	>61.1	>65.0
4/16/02	14.55	60.8	>2419	>61.1	>65.0
7/17/02	4.05	95.3	>2419	>61.1	>65.0
8/20/02	8.40	78.5	>2419	>61.1	>65.0
9/11/02	2.56	100.0	>2419	>61.1	>65.0
10/23/02	4.75	92.6	>2419	>61.1	>65.0
11/13/02	119.04	5.7	2419	61.1	65.0
12/3/02	19.29	50.7	>2419	>61.1	>65.0
1/15/03	21.86	46.8	144	**NR**	**NR**
2/18/03	135.66	4.7	649	**NR**	**NR**
3/12/03	35.34	29.2	1733	45.7	51.1
4/15/03	85.71	9.3	1986	52.6	57.4
5/12/03	44.71	22.4	>2419	>61.1	>65.0
6/25/03	33.86	30.9	>2419	>61.1	>65.0
8/12/03	131.75	4.8	>2419	>61.1	>65.0
11/4/03	12.58	66.1	2419	61.1	65.0
8/4/04	27.17	38.5	>2419	>61.1	>65.0
11/4/04			2600	63.8	67.4
90th Percentile Concentration			**>2419**	**>61.1**	**>65.0**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-17 Required Load Reduction for Cedar Creek

Sample Date	Flow	PDFE	E. Coli Sample Concentration	Required Reduction	
				Sample to Target (941 CFU/100 ml)	Sample to Target - MOS (847 CFU/100 ml)
	[cfs]	[%]	[CFU/100 ml]	[%]	[%]
9/9/99	1.31	90.0	980	4.0	13.6
7/17/02	1.04	94.7	548	**NR**	**NR**
8/20/02	2.17	78.4	770	**NR**	**NR**
9/11/02	0.65	99.9	770	**NR**	**NR**
10/23/02	1.13	93.4	1414	33.6	40.1
11/13/02	25.38	9.9	921	**NR**	**8.0**
12/3/02	4.59	56.2	387	**NR**	**NR**
1/15/03	5.47	49.7	770	**NR**	**NR**
2/18/03	31.97	7.0	1300	27.6	34.8
3/12/03	8.91	33.2	31	**NR**	**NR**
4/15/03	20.83	12.8	313	**NR**	**NR**
5/12/03	10.71	27.8	687	**NR**	**NR**
6/25/03	8.25	36.2	308	**NR**	**NR**
90th Percentile Concentration			**1236**	**23.9**	**31.5**

Notes: 1. NR = No reduction required.
2. 30-day Geometric Mean could not be calculated due to insufficient data.
3. Reductions for individual samples (shaded area) is included for reference only.

Table C-18 TMDLs, WLAs, & LAs for South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs [d]
				WWTFs [a]		Leaking Collection Systems [b]	MS4s [c]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0104 (DA)	Waters Branch	TN060101020250 – 0900	>79.9	NA	NA	NA	>81.9	>81.9
0104 (DA)	Laurel Creek	TN060101020250 – 2000	>79.9	NA	NA	NA	>81.9	>81.9
0302 (DA)	Painter Springs Branch	TN060101020540 – 0800	>61.1	NA	NA	NA	>65.0	>65.0
0401	Unnamed Trib to South Fork Holston River	TN06010102012 – 0300	>61.1	NA	NA	NA	>65.0	>65.0
	Morrell Creek	TN06010102012 – 0400	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Unnamed Trib to South Fork Holston River	TN06010102012 – 0100	>45.2	NA	NA	NA	>50.6	>50.6
0402 (DA)	Big Arm Branch	TN06010102012 - 0810	>79.9	NA	NA	NA	>81.9	>81.9
0402 (DA)	Dry Creek	TN06010102012 - 0700	>61.1	NA	NA	NA	>65.0	>65.0
0402 (DA)	Woods Branch	TN06010102012 - 0820	34.5	NA	NA	NA	41.1	41.1
0403	Candy Creek	TN06010102006T – 0300	>54.6	NA	NA	NA	>59.1	>59.1
	Wagner Creek	TN06010102006T – 0200	>61.1	1.669×10^8	1.247×10^9	NA	>65.0	>65.0
	Weaver Branch	TN06010102012 – 0900	>49.7	NA	NA	NA	>54.7	>54.7

Table C-18(cont'd) TMDLs, WLAs, & LAs for South Fork Holston River Watershed

HUC-12 Subwatershed (06010102__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs [d]
				WWTFs [a]		Leaking Collection Systems [b]	MS4s [c]	
				Monthly Avg.	Daily Max.			
			[% Red.]	[CFU/day]	[CFU/day]	[CFU/day]	[% Red.]	[% Red.]
0502	Back Creek	TN06010102042 – 0200	>44.6	2.861×10^7	2.137×10^8	0	>50.1	>50.1
	Beaver Creek	TN06010102042 – 1000	>59.7	1.431×10^7	1.069×10^8	0	>63.7	>63.7
	Beaver Creek	TN06010102042 – 2000[e]	>61.1	NA	NA	0	>65.0	>65.0
	Cedar Creek	TN06010102042 – 0500	23.9	NA	NA	0	31.5	31.5

Notes: NA = Not Applicable.

a. Future WWTFs must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

b. Pathogen loading due to collection system failure is considered to be unpermitted point source loading from the municipal WWTF. With respect to pathogen loading from leaking collection systems, a WLA of zero is assigned. It is recognized, however, that a WLA of 0 CFU/day may not be practical. For these unpermitted sources, the WLA is interpreted to mean a reduction in pathogen loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

c. Applies to any MS4 discharge loading in the subwatershed or drainage area.

d. The load allocations (LAs) listed apply to precipitation induced nonpoint sources only. The objective for all "other direct sources" (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero. It is recognized, however, that for leaking septic systems a LA of 0 CFU/day may not be practical. For these unpermitted sources, the LA is interpreted to mean a reduction in E. coli loading to the maximum extent practicable, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

e. Portions of these waterbodies lie in another state. A TMDL for Fecal Coliform has been developed by the State of Virginia for those portions of the waterbodies lying within their jurisdiction. The required load reduction is for the Tennessee portion of the waterbodies.

APPENDIX D

Hydrodynamic Modeling Methodology

HYDRODYNAMIC MODELING METHOD

D.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for flow simulation of pathogen-impaired waters in the subwatersheds of the South Fork Holston River Watershed. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program - Fortran (HSPF)

D.2 Model Set Up

The South Fork Holston River Watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, 303(d)-listed waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for selected subwatersheds. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data files used in these simulations. Weather data from multiple meteorological stations were available for the time period from January 1970 through August 2004. Meteorological data for a selected 11-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 10-year period (10/1/94 – 9/30/04) used for TMDL analysis.

D.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U. S. Geological Survey (USGS) stream gaging stations for the same period of time. Two USGS continuous record stations located near the South Fork Holston River Watershed with a sufficiently long and recent historical record was selected as the basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for Watauga River near Sugar Grove, North Carolina, USGS Station 03479000, ecoregion 66, are shown in Table D-1 and Figures D-1 and D-2. The results of the hydrologic calibration for Bullrun Creek near Halls Crossroads, Tennessee, USGS Station 03535000, ecoregion 67, are shown in Table D-2 and Figure D-3 and D-4.

Table D-1. Hydrologic Calibration Summary: Watauga River (USGS 03479000)

		90.03685086	
Simulation Name:	USGS034679000	**Simulation Period:**	
		Watershed Area (ac):	57642.03
Period for Flow Analysis			
Begin Date:	**10/01/90**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/00**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**279.14**	Total Observed In-stream Flow:	**287.45**
Total of highest 10% flows:	**112.83**	Total of Observed highest 10% flows:	**119.65**
Total of lowest 50% flows:	**51.31**	Total of Observed Lowest 50% flows:	**52.05**
Simulated Summer Flow Volume (months 7-9):	**38.04**	Observed Summer Flow Volume (7-9):	**37.10**
Simulated Fall Flow Volume (months 10-12):	**57.06**	Observed Fall Flow Volume (10-12):	**54.65**
Simulated Winter Flow Volume (months 1-3):	**109.31**	Observed Winter Flow Volume (1-3):	**115.74**
Simulated Spring Flow Volume (months 4-6):	**74.73**	Observed Spring Flow Volume (4-6):	**79.96**
Total Simulated Storm Volume:	**240.50**	Total Observed Storm Volume:	**245.38**
Simulated Summer Storm Volume (7-9):	**28.28**	Observed Summer Storm Volume (7-9):	**26.59**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-2.89**	10	
Error in 50% lowest flows:	**-1.43**	10	
Error in 10% highest flows:	**-5.70**	15	
Seasonal volume error - Summer:	**2.54**	30	
Seasonal volume error - Fall:	**4.40**	30	
Seasonal volume error - Winter:	**-5.56**	30	
Seasonal volume error - Spring:	**-6.53**	30	
Error in storm volumes:	**-1.99**	20	
Error in summer storm volumes:	**6.38**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

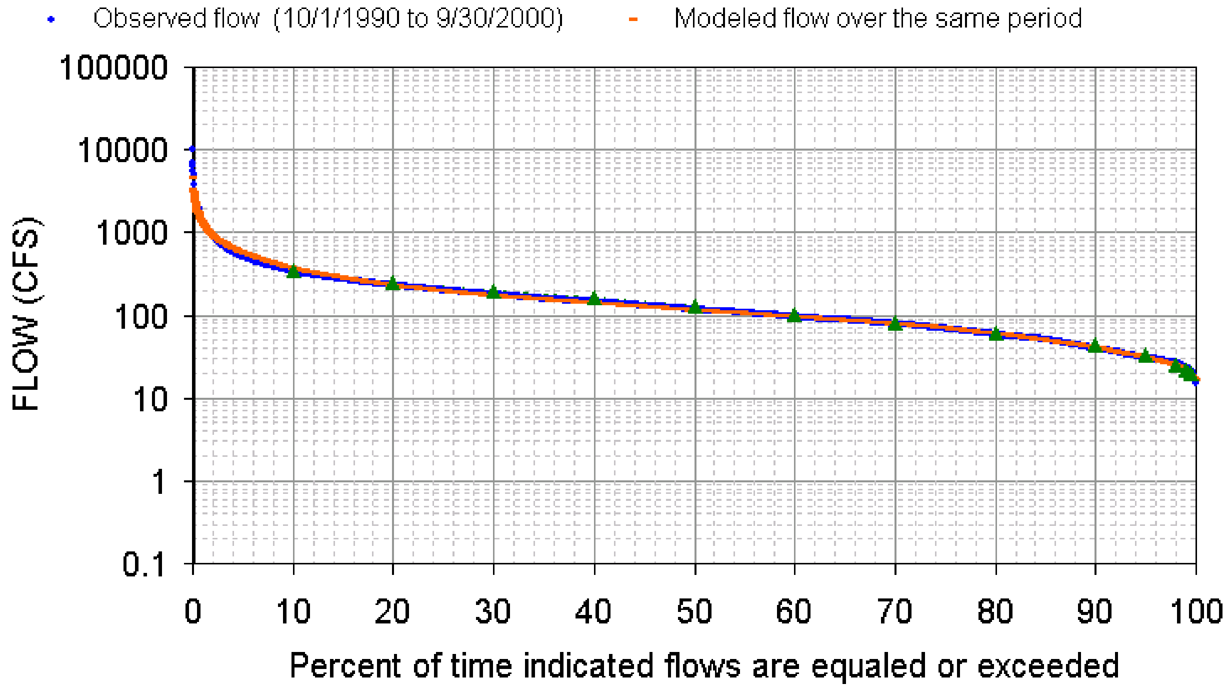

Figure D-1. Hydrologic Calibration: Watauga River, USGS 03479000)

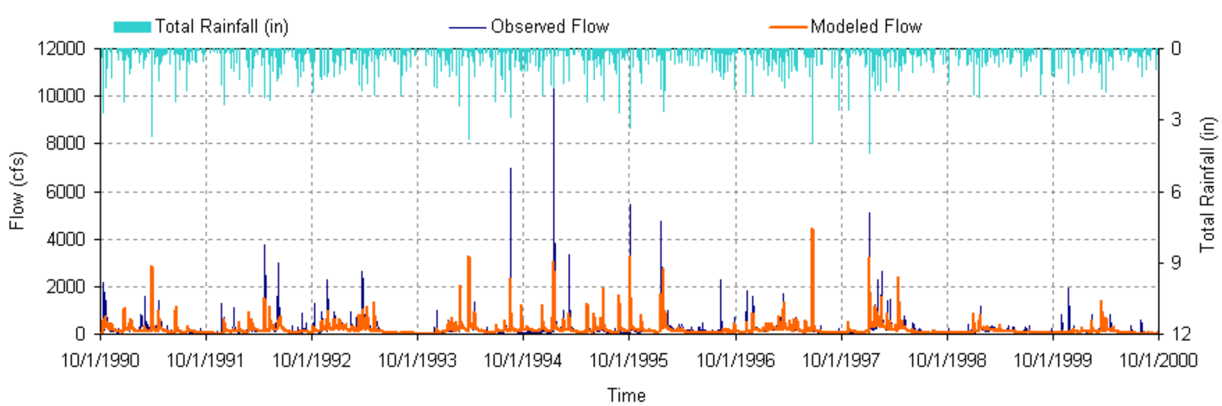

Figure D-2. 10-Year Hydrologic Comparison: Watauga River at Belleview, USGS 03479000

Table D-2. Hydrologic Calibration Summary: Bullrun Creek (USGS 03535000)

Simulation Name:	USGS03535000	**Simulation Period:**	
		Watershed Area (ac):	43607.17
Period for Flow Analysis			
Begin Date:	**10/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/86**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**82.36**	Total Observed In-stream Flow:	**91.27**
Total of highest 10% flows:	**42.83**	Total of Observed highest 10% flows:	**47.36**
Total of lowest 50% flows:	**9.68**	Total of Observed Lowest 50% flows:	**10.06**
Simulated Summer Flow Volume (months 7-9):	**9.30**	Observed Summer Flow Volume (7-9):	**7.91**
Simulated Fall Flow Volume (months 10-12):	**14.00**	Observed Fall Flow Volume (10-12):	**15.95**
Simulated Winter Flow Volume (months 1-3):	**31.45**	Observed Winter Flow Volume (1-3):	**35.49**
Simulated Spring Flow Volume (months 4-6):	**27.61**	Observed Spring Flow Volume (4-6):	**31.92**
Total Simulated Storm Volume:	**76.18**	Total Observed Storm Volume:	**83.16**
Simulated Summer Storm Volume (7-9):	**7.76**	Observed Summer Storm Volume (7-9):	**5.88**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-9.76**	10	
Error in 50% lowest flows:	**-3.75**	10	
Error in 10% highest flows:	**-9.57**	15	
Seasonal volume error - Summer:	**17.59**	30	
Seasonal volume error - Fall:	**-12.22**	30	
Seasonal volume error - Winter:	**-11.39**	30	
Seasonal volume error - Spring:	**-13.50**	30	
Error in storm volumes:	**-8.39**	20	
Error in summer storm volumes:	**31.99**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

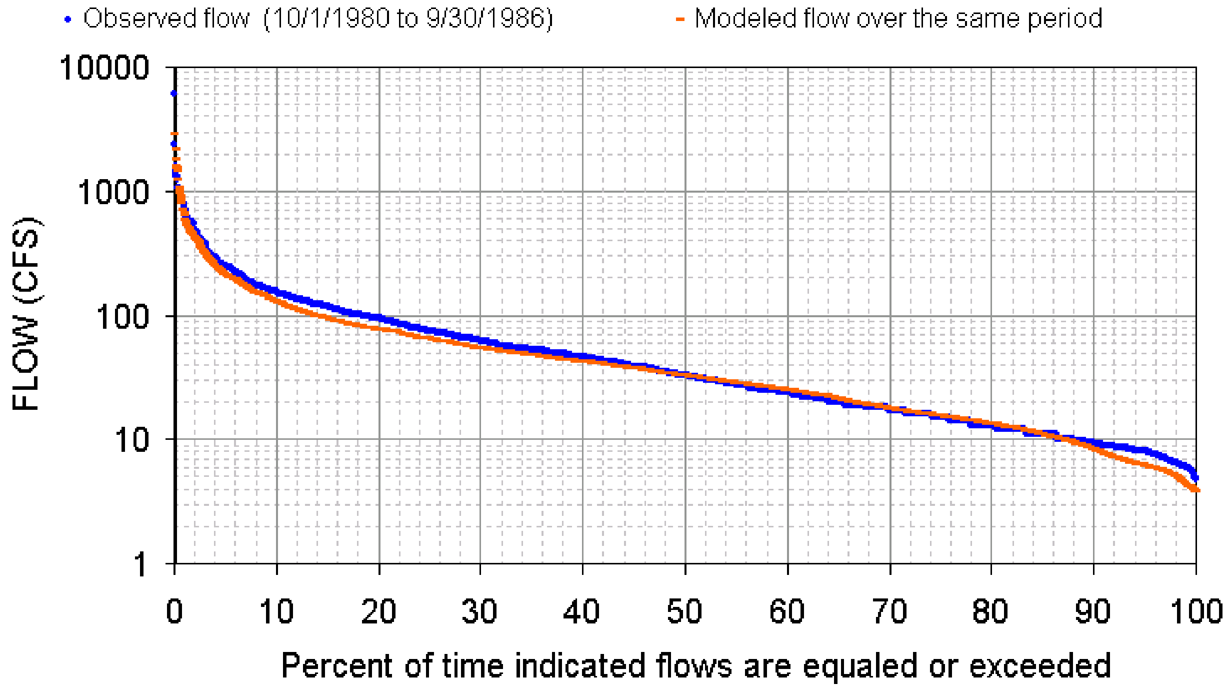

Figure D-3. Hydrologic Calibration: Bullrun Creek, USGS 03535000

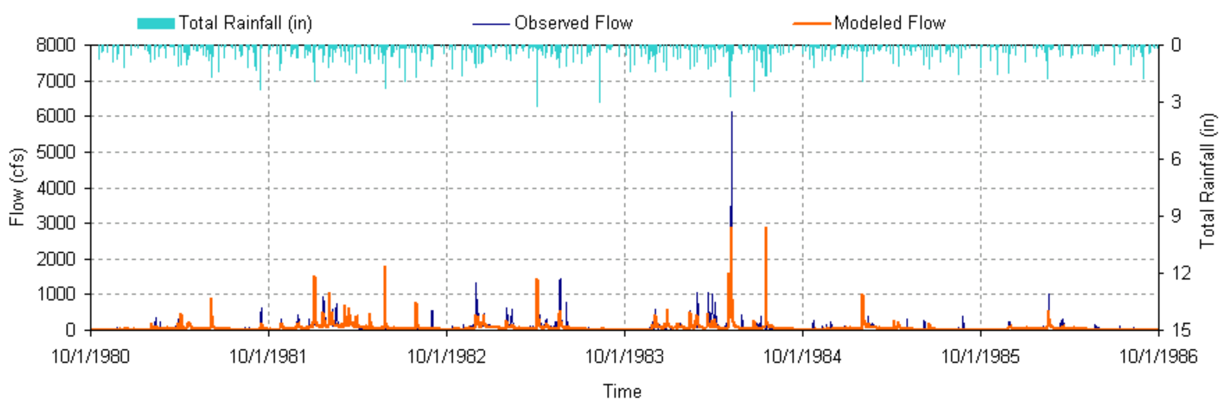

Figure D-4. 6-Year Hydrologic Comparison: Bullrun Creek, USGS 03535000

APPENDIX E

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR E. COLI IN SOUTH FORK HOLSTON RIVER WATERSHED (HUC 06010102), TENNESSEE

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for E. coli in the South Fork Holston River watershed, located in eastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

A number of waterbodies in the South Fork Holston River watershed are listed on Tennessee's Final 2004 303(d) list as not supporting designated use classifications due, in part, to discharge of pathogens from MS4 areas and pasture land. The TMDL utilizes Tennessee's general water quality criteria, continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of pathogens which will result in the reduced in-stream concentrations and attainment of water quality standards. The TMDL requires reductions of pathogen loading on the order of 24-80% in the listed waterbodies.

The proposed South Fork Holston River E. coli TMDL may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707
e-mail: Vicki.Steed@state.tn.us

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656
e-mail: Sherry.Wang@state.tn.us

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than September 11, 2006 to:

Division of Water Pollution Control
Watershed Management Section
6th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.

APPENDIX F

Public Notice Comments Received

ENSAFE
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220 Athens Way, Suite 410 | Nashville, Tennessee 37228 | Telephone 615-255-9300 | Facsimile 615-255-9345 | www.ensafe.com

September 8, 2006

Sherry H. Wang, Ph. D.
Division of Water Pollution Control
Watershed Management Section
6th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

**Re: Proposed Total Maximum Daily Load (TMDL)
For Pathogens
South Fork Holston River Watershed (HUC 06010102)**

Dear Ms. Wang:

We are writing this letter on behalf of the Cities of Bristol, Tennessee, and Bristol, Virginia, to present the Cities' comments relating to the above referenced TMDL. The comments are as follows:

1. Page ix: Only Johnson and Sullivan Counties are listed in this table. It appears from the text and associated graphics that Carter County also has impaired waterbodies.
2. Page 8 of 41, Section 5.0: The last sentence of the second paragraph relates to "the Watauga Watershed". It appears this should relate to the South Fork Holston River Watershed.
3. Page 12 of 41, Section 6.0: The listing of monitoring stations does not include BEAVE001.0SU.
4. Page 15 of 41, Section 6.0, Table 3: The table does not include monitoring stations LAURE007.0JO or BACK003.1SU.
5. Page 17 of 41, Table 5: Since the TMDL relates only to E. coli, the reference to permit information on fecal coliform should be omitted. However, if this information must remain in the report, please provide a footnote indicating that all but one of the fecal coliform permit limit exceedances occurred prior to April of 2003 when Bristol STP completed its surge basin installation following the 1999 disinfection system improvements. Also, data points for the daily maximum Fecal Coliform limit should list number of days (2,890), not 95 months (January 1999 through November 2005).

6. Page 19 of 41, Section 7.1.1: The first paragraph indicates that the collection system of Bristol, TN and Bristol, VA "has historically been a significant source to coliform loading to the Beaver Creek watershed." There appears to be no data to support that the sewer system overflows that periodically occur in the watershed are "significant" contributors to coliform impairment. Many of the overflows occur during wet weather events when the overflow is diluted and flows in Beaver Creek are already elevated. In fact, studies of Beaver Creek performed by the cities in the early 80's indicated that even combined system overflows (that are now eliminated) were difficult to isolate as significant coliform contributors. The word "significant" should be omitted from this sentence.

7. Page 20 of 41, Section 7.2.1 Wildlife: This section indicates that wildlife contributes coliform bacteria to the waterbodies in the basin. The Virginia Department of Environmental Quality in its approved TMDL for Beaver Creek indicates that bacterial source tracking data shows wildlife contributions ranging from under 10% to over 60% of the coliform bacterial sampled. However, the draft TMDL does not attempt to quantify or provide a waste load allocation for the wildlife contribution.

8. Page 27 of 41, Section 8.7: This section is listing a single load allocation (LAs) for all precipitation induced nonpoint sources in Table 9 in terms of % reduction. It states that "all 'other direct sources' (leaking septic systems, illicit discharges, and animals access to streams) is a LA of zero". Although confusing, this appears to mean all of these "other direct sources" are expected to be reduced by 100%. The contribution of wildlife does not appear to be considered in this allocation since it is implausible to expect wildlife contribution to be reduced to a load allocation of zero. The report should include a quantified estimate of these identified sources.

9. Page 34 of 41, Figure 12: There is no identification of the definition of the term in the legend ">50% SF". Please define.

10. In April 2004 the Virginia Department of Environmental Quality completed a TMDL for Beaver Creek which was subsequently approved by EPA. There is only one reference to this report in the draft TMDL in the footnotes of Table C-18 in Appendix C. Since the flow from Virginia is approximately one third of the total flow in Beaver Creek, more consideration should be given to the impacts of current and proposed E. coli concentrations in the Tennessee TMDL.

Sincerely,
EnSafe Inc.

By: R. Scott Heflinger, P.E.

pc: Mr. Bill Sorah
Mr. Matthew Dake
Mr. John Bowling

APPENDIX G

Response to Public Comments

Note: responses correspond to numbered comments (see Appendix F).

1. This oversight has been corrected. Big Arm Creek and its associated monitoring station are located in Carter County. All other waterbodies and monitoring stations are located in Johnson and Sullivan counties.

2. The reference to the Watauga Watershed has been removed.

3. BEAVE001.0SU has been added to the list of monitoring stations.

4. As stated on Page 13 of 41, Table 3 only includes monitoring stations with 10% or more of samples exceeding water quality maximum criteria. LAURE007.0JO and BACK003.1SU did not have any exceedances of their respective water quality maximum criteria.

5. Table 5 was constructed using a summary of DMR data. Daily maximum values are reported on a monthly basis in DMRs. Upon further investigation, MOR data was located. Daily maximum values are reported on a daily basis in MORs. Therefore, the number of data points has been revised from 95 monthly values to 2,890 daily values. TDEC has been unable to confirm the completion date for the surge basin. However, a footnote has been added as suggested.

6. Actually, the data support the presumption that overflows are significant contributors to loading and subsequent exceedances of maximum daily (instantaneous) in-stream pathogen standards during wet weather overflow events. As documented in the TMDL for Pathogens in the South Fork Holston River Watershed (approved by USEPA on September 23, 2004), a plot of fecal coliform vs. flow for the period July 1989 – July 2001 (see Figure G-1) indicates a direct relationship between flow and concentration: as flow increases, concentration increases. In addition, when hydrograph separation is conducted on Beaver Creek simulated flow data, analyses of samples indicates that most exceedances occur during stormflow events (see Figure G-2).

   In Figure G-3, a plot of E. coli vs. flow for the period March 1998 – August 2004 indicates a similar relationship between flow and concentration: as flow increases, concentration increases. In Figure G-4, analyses of samples indicates that most exceedances occur during storm events. The trends may not be as pronounced as the relationship between fecal coliform and flow due to the smaller body of historical monitoring data.

   The language remains unchanged.

7. The Virginia TMDL for Beaver Creek included bacterial source tracking data collected at the Virginia/Tennessee state line. Bacterial source tracking data was not available for the Tennessee portion of the Beaver Creek watershed. Therefore, the contribution from wildlife has not been quantified. The Division of Water Pollution Control encourages the Cities of Bristol, Tennessee and Bristol, Virginia to conduct BSP and/or other source identification activities to support appropriate BMP implementations to reduce E. coli loading in Beaver Creek.

8. The reference to "animals access to streams" is a reference to agricultural animals rather than to wildlife. Access to streams by grazing livestock is typically resolved by application of appropriate best management practices (BMPs). Therefore, the contribution from this source can be reduced to zero.

9. An explanation of the term ">50% SF" has been added to Section C.1.2.

10. In addition to the footnotes of Table C-18, there are references to the Virginia TMDL in the Summary section of the Draft TMDL (pages ix and xiii). The TMDL developed by the Virginia DEQ only applies to those portions of the waterbody lying within their jurisdiction. In the same way, the TMDL developed by TDEC only applies to those portions of the waterbody lying within the State of Tennessee. Evaluation of the geomean of all monitoring data at the stateline (GM=1359) and at mile 1.0 (GM=315) suggests that sources in Virginia are a major contributor to the impairment of Beaver Creek.

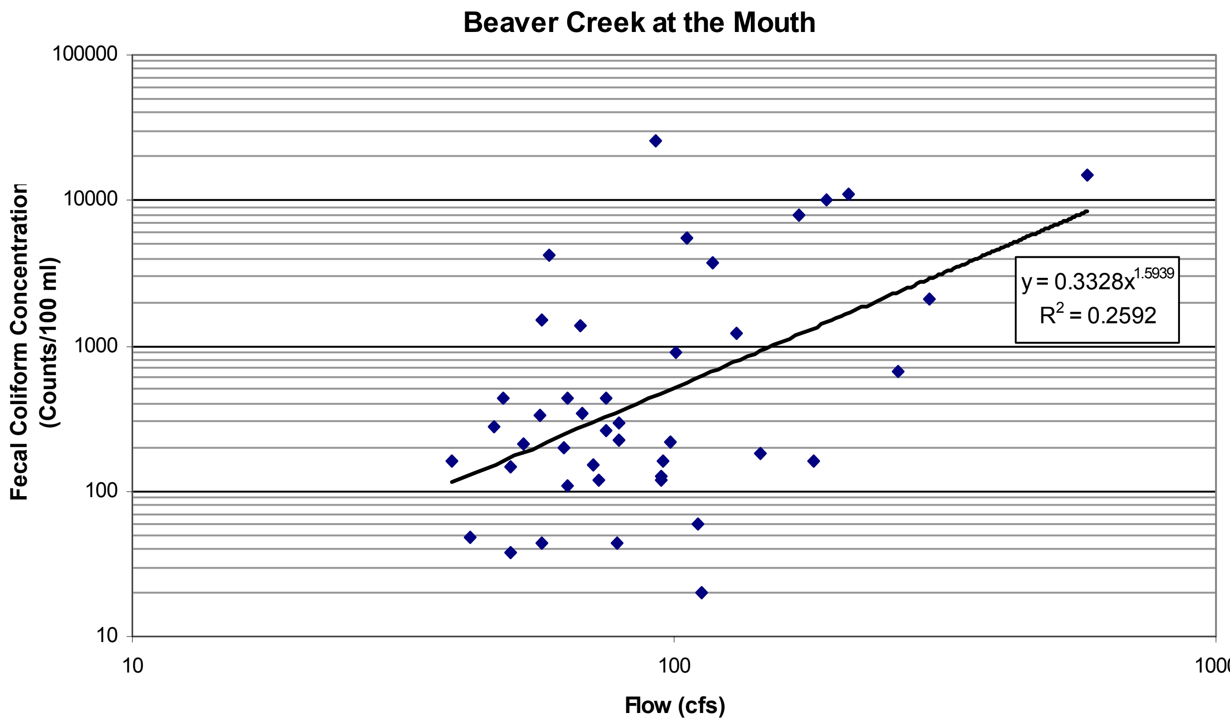

Figure G-1. Fecal coliform vs Flow – Beaver Creek at Mile 1.0

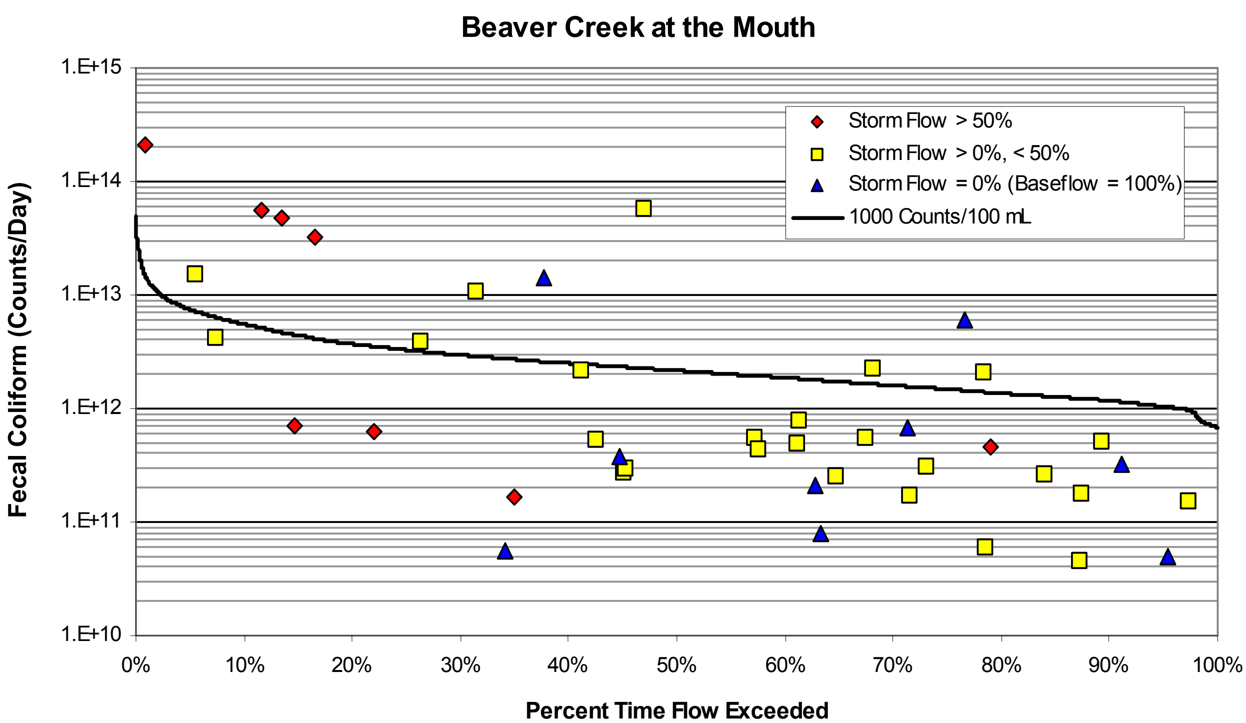

Figure G-2. Load Duration Curve – Fecal Coliform – Beaver Creek at Mile 1.0

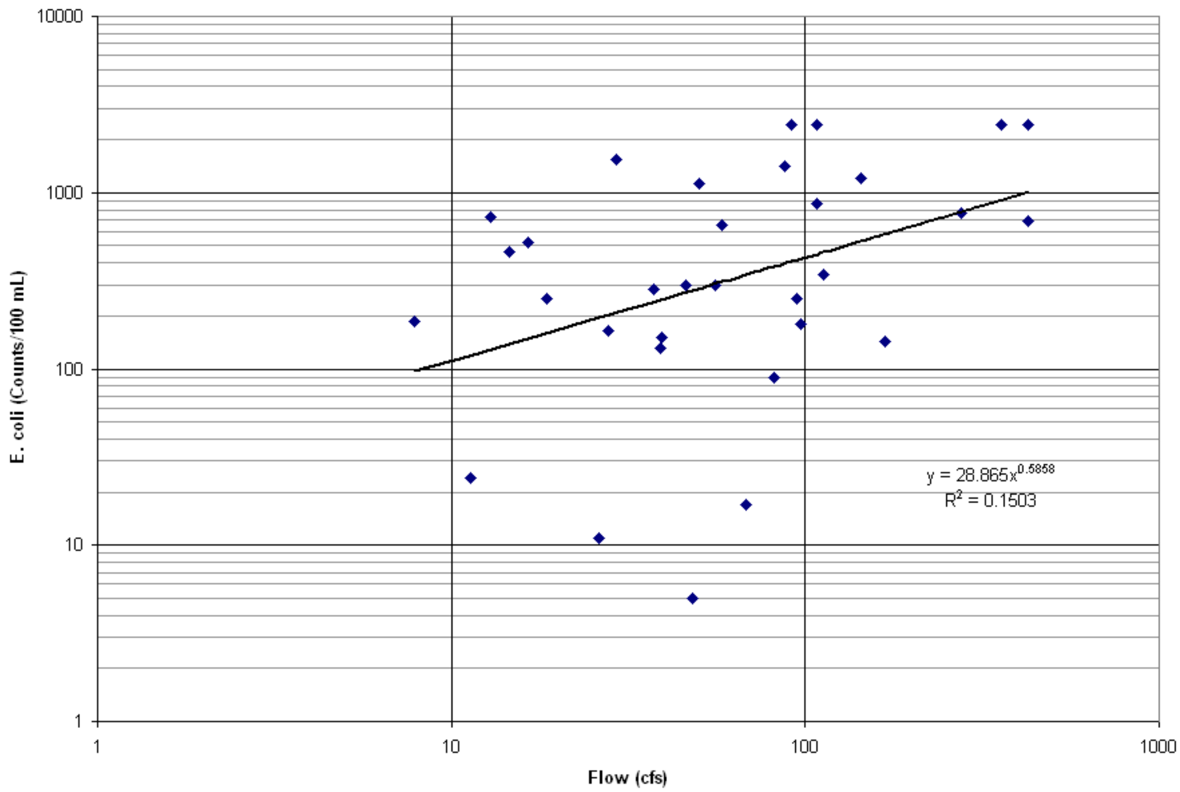

Figure G-3. E. coli vs Flow – Beaver Creek at Mile 1.0

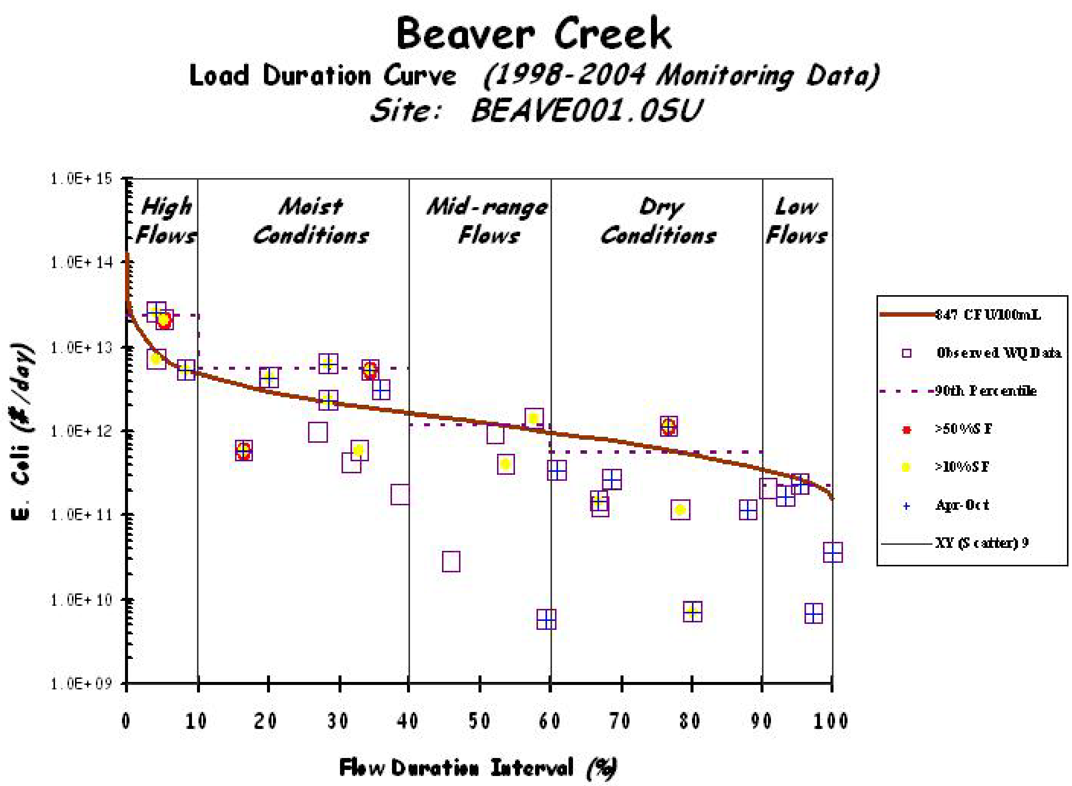

Figure G-4. Load Duration Curve -- E. coli – Beaver Creek at Mile 1.0