

TOTAL MAXIMUM DAILY LOAD (TMDL)
for
Pathogens
in the
Watts Bar Watershed (HUC 06010201)
Bledsoe, Cumberland, Loudon, McMinn, Meigs, Monroe,
Rhea, and Roane 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
DEM	Digital Elevation Model
DMR	Discharge Monitoring Report
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
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 Pathogens in Watts Bar Watershed (HUC 06010201)

Impaired Waterbody Information

State: Tennessee

Counties: Bledsoe, Cumberland, Loudon, McMinn, Meigs, Monroe, Rhea, and Roane

Watershed: Watts Bar (HUC 06010201)

Constituents of Concern: Pathogens

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06010201011 – 1000	PAINT ROCK CREEK	12.2
TN06010201013 – 0100	MUD CREEK	7.2
TN06010201013 – 0200	GREASY BRANCH	7.3
TN06010201013 – 1000 & 2000	POND CREEK	20.2
TN06010201015 – 0100	BACON CREEK	10.2
TN06010201015 – 1000	SWEETWATER CREEK	29.3
TN06010201040 – 0600	BLACK CREEK	16.7
TN06010201065 – 1000	STEEKEE CREEK	11.0
TN06010201087 – 1000	HINES CREEK	20.3
TN060102011149 – 1000	POLECAT CREEK	13.1
TN060102011621 – 1000	CANEY CREEK	13.2

Designated Uses:

The designated use classifications for waterbodies in the Watts Bar watershed include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Portions of Sweetwater Creek are also designated for domestic and/or industrial water supply.

Water Quality Goal:

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.

Additionally, consistent with current TMDL methodology, standards from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* for recreation use classification:

The concentration of a fecal coliform group shall not exceed 200 per 100 mL nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 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 a fecal coliform group or *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 fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

TMDL Scope:

Waterbodies identified on the Final 2004 303(d) list as impaired due to *E. coli*. TMDLs are generally developed for impaired waterbodies on a HUC-12 basis.

Analysis/Methodology:

The TMDLs for impaired waterbodies in the Watts Bar watershed were developed using the load duration curve methodology to assure compliance with the E. Coli 126 counts/100 mL geometric mean and 941 counts/100 mL maximum standards while also incorporating the fecal coliform 200 counts/100 mL geometric mean and 1,000 counts/100 mL maximum concentration as surrogates. 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 portion of the waterbody flow regime represented by these existing loads. Load duration curves were used to determine the load reductions required to meet the target maximum concentrations for E. coli and fecal coliform (standard - MOS). 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 and for load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Explicit – 10% of the water quality standard for each impaired subwatershed.

Summary of TMDLs, WLAs, & LAs for Impaired Waterbodies

HUC-12 Subwatershed (06010201___) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	TMDL	WLAs				LAs	
				WWTFs ^a (Monthly Avg.)	Leaking Collection Systems ^b	CAFOs	MS4s ^c	Precipitation Induced Nonpoint Sources	Other Direct Sources ^d
				E. Coli					
			[% Red.]	[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0306	PAINT ROCK CREEK	TN06010201011 – 1000	89.0	NA*	NA	NA	89.0	89.0	0
0305	MUD CREEK	TN06010201013 – 0100	99.1	NA*	NA	0	99.1	99.1	0
	GREASY BRANCH	TN06010201013 – 0200							
	POND CREEK	TN06010201013 – 1000 & 2000							
0304	BACON CREEK	TN06010201015 – 0100	89.1	7.154 x 10 ⁹	0	0	89.1	89.1	0
	SWEETWATER CREEK	TN06010201015 – 1000							
0503	BLACK CREEK	TN06010201040 – 0600	40.1	7.869 x 10 ⁹	0	NA	NA	40.1	0
0302	STEEKEE CREEK	TN06010201065 – 1000	91.0	NA*	NA	NA	91.0	91.0	0
0303	HINES CREEK	TN06010201087 – 1000	92.3	NA*	NA	NA	92.3	92.3	0
	POLECAT CREEK	TN060102011149 – 1000							
0402	CANEY CREEK	TN060102011621 – 1000	>65.0	NA*	NA	NA	NA	>65.0	0

Note: NA = Not Applicable.

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

a. WLAs for WWTFs expressed as E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform 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.

d. The objective for all “other direct sources” is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

PATHOGEN TOTAL MAXIMUM DAILY LOAD (TMDL) WATTS BAR WATERSHED (HUC 06010201)

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 Watts Bar watershed, identified on the Final 2004 303(d) list as not supporting designated uses due to *E. coli*. 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.

3.0 WATERSHED DESCRIPTION

The Watts Bar watershed (HUC 06010201) is located in East Tennessee (Figure 1), primarily in Loudon, Rhea, and Roane Counties. The Watts Bar watershed lies within two Level III ecoregions (Ridge and Valley, Southwestern Appalachians) and contains five Level IV ecoregions as shown in Figure 2 (USEPA, 1997):

- **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 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.
- **Cumberland Plateau (68a)** tablelands and open low mountains are about 1000 feet higher than the Eastern Highland Rim (71g) to the west, and receive slightly more precipitation with cooler annual temperatures than the surrounding lower-elevation ecoregions. The plateau surface is less dissected with lower relief compared to the Cumberland Mountains (69d) or the Plateau Escarpment (68c). Elevations are generally 1200-2000 feet, with the Crab Orchard Mountains reaching over 3000 feet. Pennsylvanian-age conglomerate, sandstone, siltstone, and shale is covered by well-drained, acid soils of low fertility. Bituminous coal that has been extensively surface and underground mined underlies the region. Acidification of first and second order streams is common. Stream siltation and mine spoil bedload deposits continue as long-term problems in these headwater systems. Pockets of severe acid mine drainage persist.
- **Plateau Escarpment (68c)** is characterized by steep, forested slopes and high velocity, high gradient streams. Local relief is often 1000 feet or more. The geologic strata include Mississippian-age limestone, sandstone, shale, and siltstone, and Pennsylvanian-age shale, siltstone, sandstone, and conglomerate. Streams have cut down into the limestone, but the gorge talus slopes are composed of colluvium with huge angular, slabby blocks of sandstone. Vegetation community types in the ravines and gorges include mixed oak and chestnut oak on the upper slopes, mesic forests on the middle and lower slopes (beech-tulip poplar, sugar maple-basswood-ash-buckeye), with hemlock along rocky streamsides and river birch along floodplain terraces.

The Watts Bar watershed, located in Bledsoe, Cumberland, Loudon, McMinn, Meigs, Monroe, Rhea, and Roane Counties, Tennessee, has a drainage area of approximately 684 square miles (mi²). 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 Watts Bar watershed have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Watts Bar watershed is summarized in Table 1 and shown in Figure 3. Predominant land use in the Watts Bar watershed is forest (70.4%) followed by agriculture (18.7%). Urban areas represent approximately 1.9% of the total drainage area of the watershed. Details of land use distribution of impaired subwatersheds in the Watts Bar watershed are presented in Appendix A.

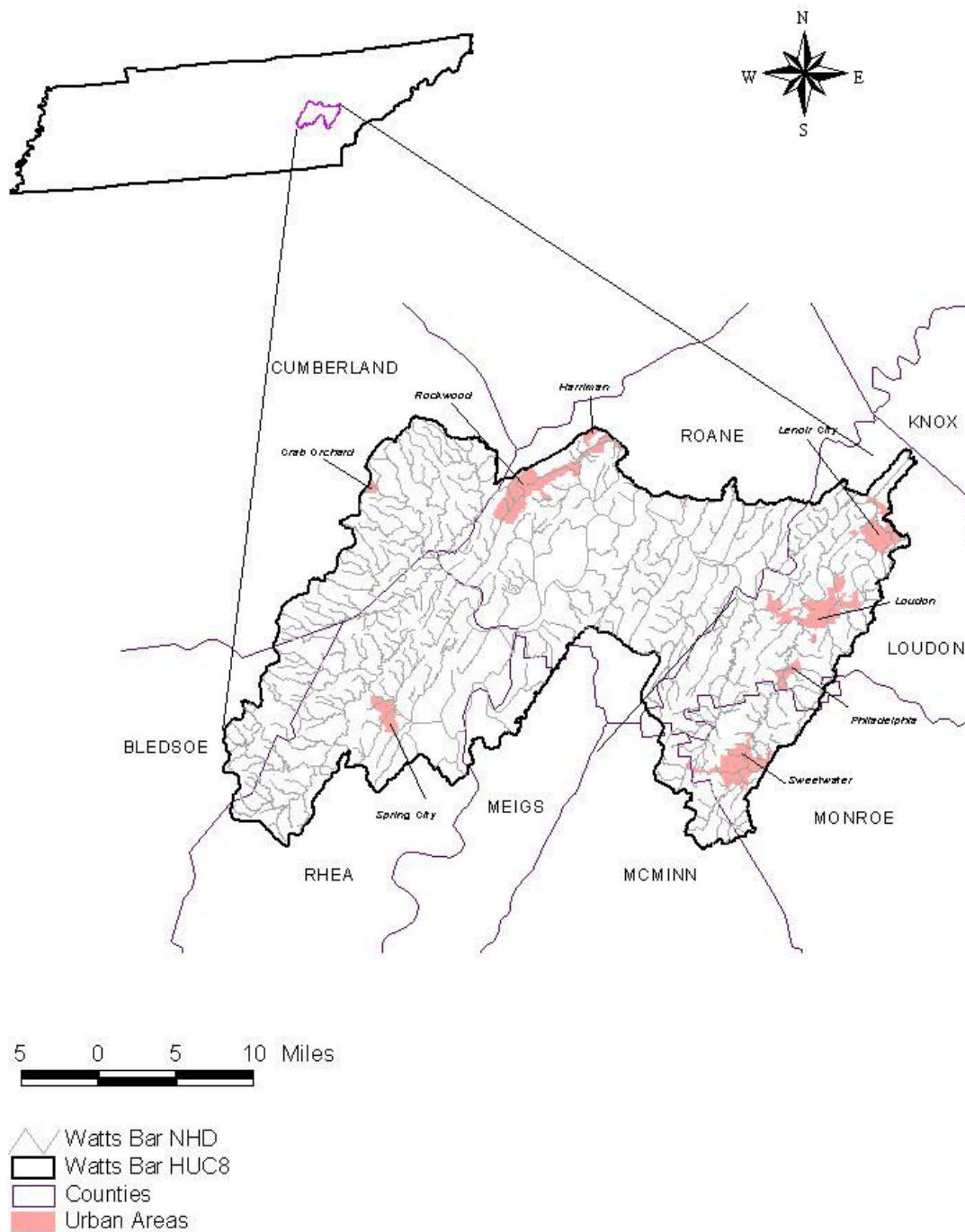


Figure 1. Location of the Watts Bar Watershed.

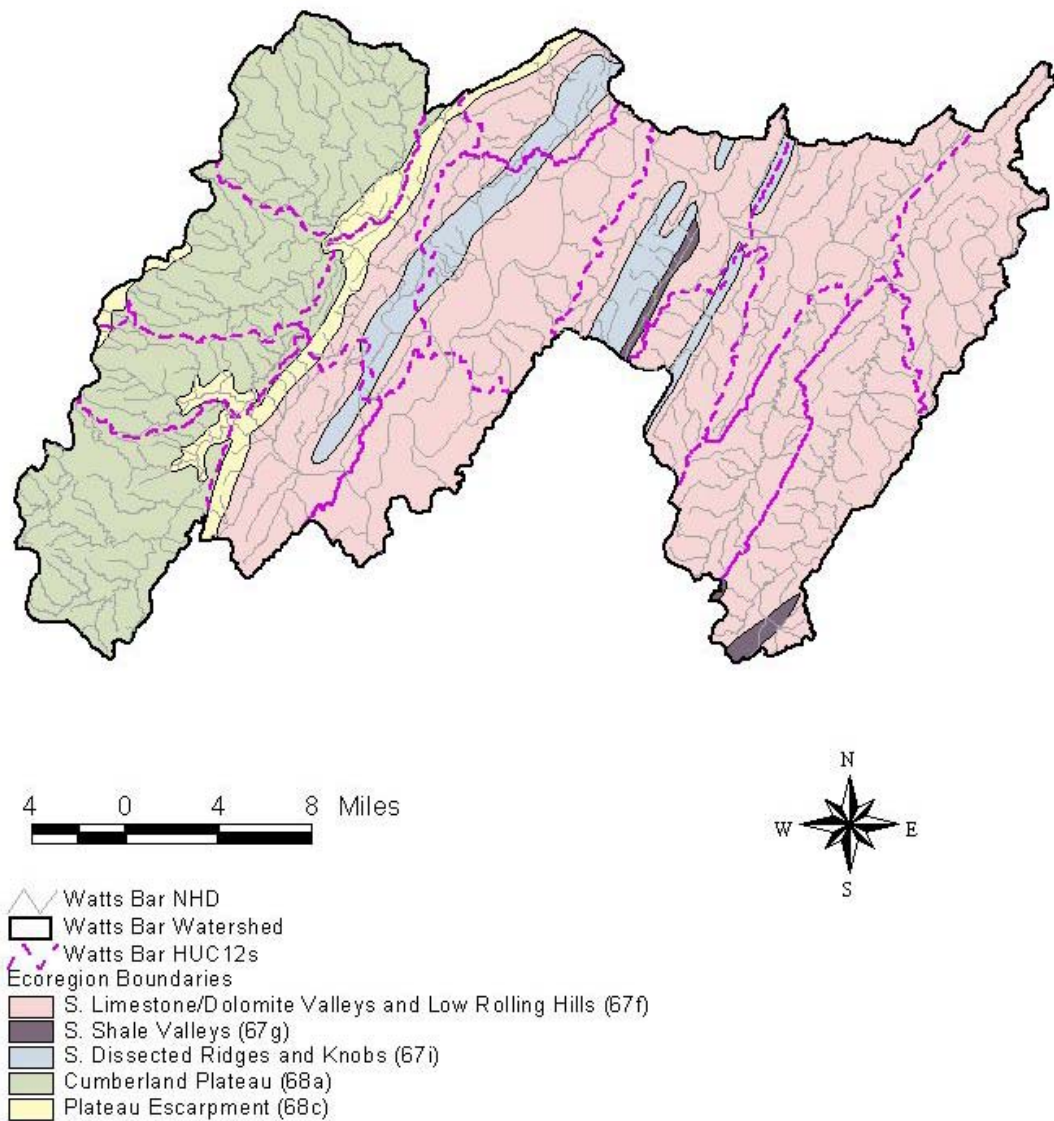


Figure 2. Level IV Ecoregions in the Watts Bar Watershed.

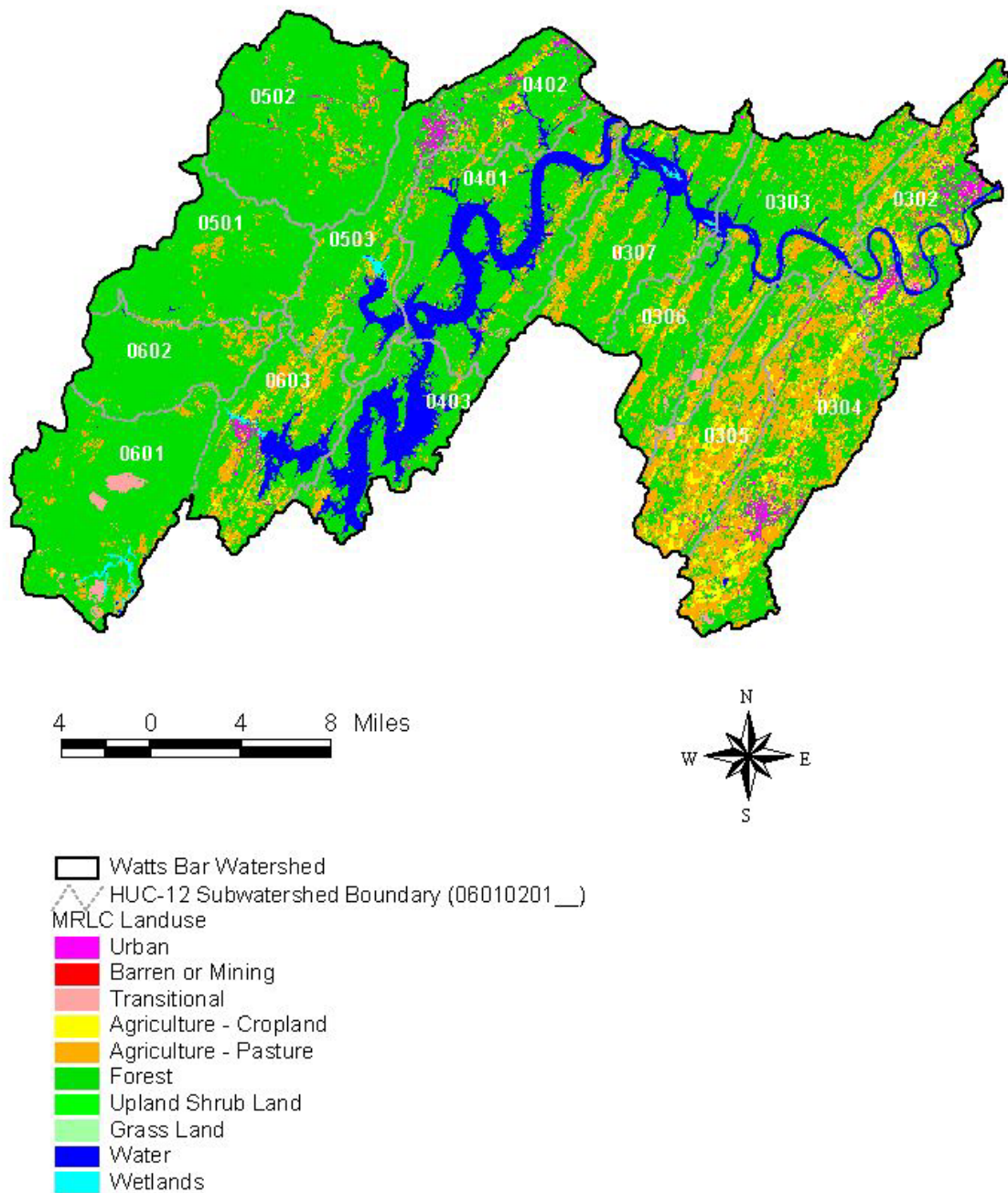


Figure 3. Land Use Characteristics of the Watts Bar Watershed.

Table 1. MRLC Land Use Distribution – Watts Bar Watershed

Land Use	Area	
	[acres]	[%]
Bare Rock/Sand/Clay	0	0.0
Deciduous Forest	159,474	37.3
Emergent Herbaceous Wetlands	253	0.1
Evergreen Forest	61,745	14.4
High Intensity Commercial/Industrial/Transportation	3,144	0.7
High Intensity Residential	603	0.1
Low Intensity Residential	4,917	1.1
Mixed Forest	79,790	18.7
Open Water	31,050	7.3
Other Grasses (Urban/recreational)	2,930	0.7
Pasture/Hay	65,254	15.3
Quarries/Strip Mines/Gravel Pits	44	0.0
Row Crops	14,490	3.4
Transitional	2,835	0.7
Woody Wetlands	1,031	0.2
Total	427,560	100.0

4.0 PROBLEM DEFINITION

The State of Tennessee's final 2004 303(d) list (TDEC, 2004a) was approved by the U.S. Environmental Protection Agency (EPA), Region IV in August of 2005. This list identified eleven waterbodies in the Watts Bar watershed as not supporting designated use classifications due, in part, to E. coli (see Table 2). The designated use classifications for these waterbodies include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation. Portions of Sweetwater Creek are also designated for domestic and/or industrial water supply.

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 fecal coliform and E. coli groups are indicators of the presence of pathogens in a stream.

The waterbody segments listed in Table 2 were assessed as impaired based on sampling data and/or biological surveys. The results of these assessment surveys are summarized in Table 3 and shown in Figure 4. The assessment information presented is excerpted from the EPA/TDEC Assessment Database (ADB) and is referenced to the waterbody ID in Table 2. ADB information may be accessed at:

http://gwidc.memphis.edu/website/wpc_arcmap

5.0 WATER QUALITY GOAL

As previously stated, the designated use classifications for the Watts Bar waterbodies include fish & aquatic life, recreation, irrigation, and livestock watering & wildlife. Portions of Sweetwater Creek are also designated for domestic and/or industrial water supply. 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, 2004b). 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.

None of the impaired waterbodies in the Watts Bar watershed have been classified as either Tier II or Tier III streams.

Prior to January 2004, the coliform water quality criteria, for protection of the recreation use classification, established by *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, October 1999* (TDEC, 1999), Section 1200-4-3-.03 (4) (f) states:

The concentration of a fecal coliform group shall not exceed 200 per 100 mL, nor shall the concentration of the *E. coli* group exceed 126 per 100 mL, as a geometric mean based on a minimum of 10 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 a fecal coliform group or *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 fecal coliform group in any individual sample shall not exceed 1,000 per 100 mL.

In addition to utilizing the *E. coli* water quality standards (with MOS) as the target, this TMDL utilizes a fecal coliform target as a surrogate for determining the attainment of the *E. coli* standard because of the demonstrated high correlation between *E. coli* and fecal coliform in this watershed. In the state of Tennessee, *E. coli* and fecal coliform are well correlated ($R = 0.902$) when evaluating all available ecoregion data (623 observations).

Therefore, this TMDL employs both the *E. coli* water quality standard and the surrogate fecal coliform criteria by determining the amount of load reduction required to comply with each of four criteria: 1) the geometric mean standard for *E. coli* of 126 counts/100mL, 2) the *E. coli* sample maximum of 941 counts/100 mL, 3) the geometric mean for fecal coliform of 200 counts/100 mL, and 4) the fecal coliform sample maximum of 1,000 counts/100 mL. The fecal coliform surrogate is most frequently used when insufficient monitoring data is available for *E. coli* or when analysis of *E. coli* monitoring data suggests that a listed segment is not impaired. The most protective (or highest percent of load reduction) of the four criteria will determine the percent reduction(s) required for impaired waterbodies. The analysis of fecal coliform data is only part of the methodology and is not included to comply with current water quality standards.

Note: In this document, the water quality standards are the instream goals. The term “target concentration” reflects the application of an explicit Margin of Safety (MOS) to the water quality standard. See Section 8.4 for an explanation of MOS.

Table 2. Final 2004 303(d) List for E. coli Impaired Waterbodies – Watts Bar Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010201011-1000	PAINT ROCK CREEK	12.2	Escherichia coli	Pasture Grazing
TN06010201013 – 0100	MUD CREEK	7.2	Escherichia coli	Pasture Grazing
TN06010201013 – 0200	GREASY BRANCH	7.3	Escherichia coli	Pasture Grazing
TN06010201013 – 1000 & 2000	POND CREEK	21.1	Nitrates Physical Substrate Habitat Alterations Escherichia coli	Pasture Grazing Livestock in Stream Animal Feeding Operations (NPS)
TN06010201015-0100	BACON CREEK	10.0	Nitrates Escherichia coli	Pasture Grazing Animal Feeding Operations (NPS)
TN06010201015-1000	SWEETWATER CREEK	29.3	Nitrates Siltation Escherichia coli	Municipal Point Source Discharge Channelization Pasture Grazing Land Development Animal Feeding Operations (NPS)
TN06010201040-0600	BLACK CREEK	16.7	Polycyclic Aromatic Hydrocarbons (PAHs) Organic Enrichment Physical Substrate Habitat Alterations Escherichia coli	Municipal Point Source Discharge Collection System Failures RCRA Hazardous Waste Channelization
TN06010201065-1000	STEEKEE CREEK	11.0	Physical Substrate Habitat Alterations Siltation Escherichia coli	Pasture Grazing

Table 2 (cont'd). Final 2004 303(d) List for E. coli Impaired Waterbodies – Watts Bar Watershed

Waterbody ID	Impacted Waterbody	Miles/Acres Impaired	Cause (Pollutant)	Pollutant Source
TN06010201087-1000	HINES CREEK	20.3	Escherichia coli	Pasture Grazing
TN060102011149-1000	POLECAT CREEK	13.1	Escherichia coli	Pasture Grazing
TN060102011621-1000	CANEY CREEK	13.2	Physical Substrate Habitat Alteration Siltation Escherichia coli	Pasture Grazing Collection System Failure

Table 3. Water Quality Assessment of Waterbodies Impaired Due to E. coli – Watts Bar Watershed

Waterbody ID	Segment Name	Comments
TN06010201011-1000	PAINT ROCK CREEK	2002 biorecon and bacteria station at RM3.1; 19 EPT, 12 intolerant, 54 total genera. BR score = 15. Habitat score = 134. G.M. all pathogen samples = 686. Non-rain event G.M. = 578.
TN06010201013 – 0100	MUD CREEK	Monitored by UT Students. 6 out of 7 E.coli observations over 1000.
TN06010201013 – 0200	GREASY BRANCH	Monitored by UT Students. 5 out of 6 E.coli observations over 1000.
TN06010201013 – 1000 & 2000	POND CREEK	2001 TDEC RBPIII station at RM2.3; 13 EPT, 33 total genera. Index score = 42. Habitat score = 173. Passed biocriteria, but this site may not be representative of the rest of the stream. 2001 TDEC RBPIII station at RM8.2; 5 EPT, 21 total genera. Index score = 20. Habitat score = 100. Failed biocriteria. Monitored by UTK in 2001; 24 out of 33 E.coli observations over 1000.
TN06010201015-0100	BACON CREEK	2002 TDEC RBPIII, chemical and bacteria station at RM0.1; 6 EPT, 31 total genera. Index score = 32. Habitat score = 115. Passed biocriteria. 7 out of 12 pathogen samples exceeded 1000.
TN06010201015-1000	SWEETWATER CREEK	2002 TDEC RBPIII, chemical, & bacteria station at RM3.2; 7 EPT, 16 total genera. Index score = 34. Habitat score = 133. Passed biocriteria. 3 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM9.3; 5 EPT, 17 total genera. Index score = 26. Habitat score = 92. Failed biocriteria. 7 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM17.3; 2 EPT, 21 total genera. Index score = 14. Habitat score = 123. Failed biocriteria. 9 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM19.4; 5 EPT, 26 total genera. Index score = 30. Habitat score = 98. Failed biocriteria. 5 out of 12 pathogen samples over 940. 2002 TDEC RBPIII, chemical, & bacteria station at RM23.3; 7 EPT, 25 total genera. Index score = 36. Habitat score = 90. Passed biocriteria. 2 out of 12 pathogen samples over 940.
TN06010201040-0600	BLACK CREEK	2002 TDEC RBPIII and bacteria station at RM3.2; 3 EPT, 18 total genera. Index score = 26. Habitat score = 131. Failed biocriteria. 3 out of 10 pathogen samples over 940. E.coli G.M. = 375.

Table 3 (cont'd). Water Quality Assessment of Waterbodies Impaired Due to E. coli – Watts Bar Watershed

Waterbody ID	Segment Name	Comments
TN06010201065-1000	STEEKEE CREEK	2002 TDEC RBPIII and bacteria station at mile 0.7; 6 EPT genera, 31 total genera. Index score = 24. Habitat score = 103. Failed biocriteria. 5 out of 10 pathogen samples over 940. E.coli G.M. = 637.
TN06010201087-1000	HINES CREEK	2002 TDEC biorecon and bacteria station at RM2.7; 11 EPT, 6 intolerant, 34 total genera. BR score = 11. Habitat score = 111. 2 out of 10 samples over 940. E.coli G.M. = 648.
TN060102011149-1000	POLECAT CREEK	2020 TDEC biorecon & bacteria station at Rm1.4; 14 EPT, 7 intolerant, 41 total genera. BR score = 11. Habitat score = 122. 6 out of 10 over 940. E.coli G.M. = 1108.
TN060102011621-1000	CANEY CREEK	2002 TDEC RBPIII biorecon & bacteria station at RM4.3; 4 EPT, 27 total genera. Index score = 24. Habitat score = 86. Failed biocriteria. 8 out of 10 pathogen samples over 940. E.coli G.M. = 1236.

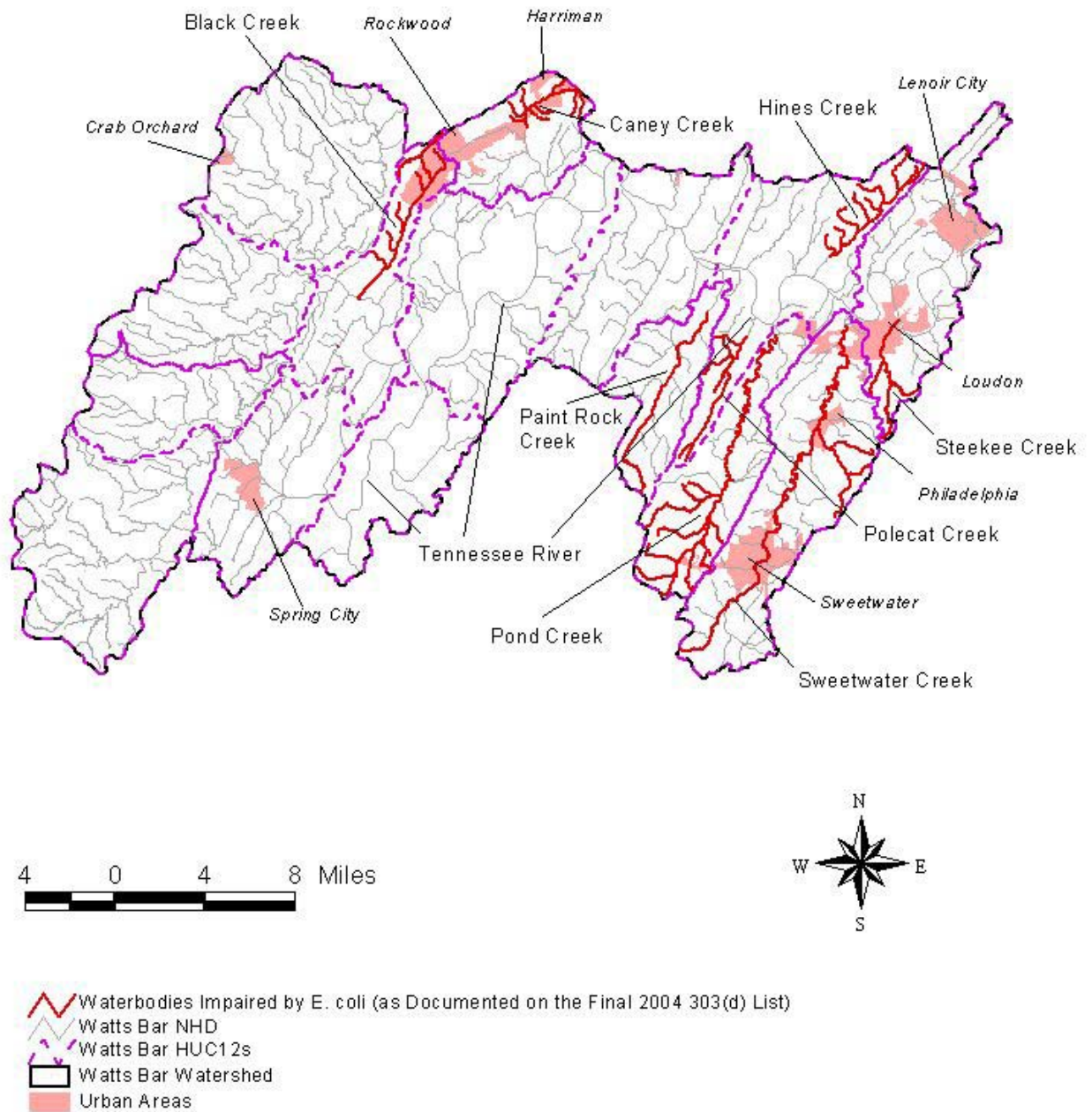


Figure 4. Waterbodies Impaired by E. Coli (as Documented on the Final 2004 303(d) List).

6.0 WATER QUALITY ASSESSMENT AND DEVIATION FROM GOAL

There are several water quality monitoring stations that provide data for waterbodies identified as impaired for pathogens in the Watts Bar watershed:

- Bacon Creek Subwatershed:
 - BACON000.1LO – Bacon Creek, downstream of Spring St. bridge
- Black Creek Subwatershed:
 - BLACK002.2RO – Black Creek, 2nd bridge from mouth on Whites Creek
 - BLACK003.3RO – Black Creek, at Black Creek Rd.
- Caney Creek Subwatershed:
 - CANEY004.3RO – Caney Creek, d/s of Hwy 27 bridge, near embayment
- Greasy Branch Subwatershed:
 - GREAS000.5MO – Greasy Branch, on Bright farm
- Hines Creek Subwatershed:
 - HINES002.7LO – Hines Creek, at Hall Rd. bridge
- Mud Creek Subwatershed:
 - MUD001.9MO – Mud Creek, d/s of confluence of east and west tribs of Mud Crk
- Paint Rock Creek Subwatershed:
 - PAINT003.1RO – Paint Rock Creek at Tennessee Chapel Rd. bridge
- Polecat Creek Subwatershed:
 - POLEC001.4LO – Polecat Creek, at private br between Hwy 72 and embayment
- Pond Creek Subwatershed:
 - POND002.3LO – Pond Creek, at Bradshaw Rd.; dirt rd ends at ford
 - POND005.7LO – Pond Creek, at bridge on Jim Dyke Rd.
 - POND008.2LO – Pond Creek, at Bright Rd., d/s of PC-3
 - POND008.3LO – Pond Creek, at Pond Creek Rd. bridge; at junction with Bright Rd. & Barr farm
 - POND011.0LO – Pond Creek, along New Hope Church Rd.; A.J. Smith property
 - POND013.1MO – Pond Creek, New Hope Church Rd. bridge
 - POND013.9MO – Pond Creek, at private wooden bridge; Bright farm by spring
- Steekee Creek Subwatershed:
 - STEEK000.7LO – Steekee Creek, at Blairland Baptist
 - STEEK002.0LO – Steekee Creek, u/s site xing

- Sweetwater Creek Subwatershed:
 - SWEET001.4LO – Sweetwater Creek, at River Rd. bridge
 - SWEET003.1LO – Sweetwater Creek, in Loudon City Park, at Roberson Springs Rd. bridge
 - SWEET003.2LO – Sweetwater Creek, at Robertson Spring Rd.
 - SWEET009.3LO – Sweetwater Creek, at Pond Creek Rd. bridge; d/s town of Philadelphia
 - SWEET010.4LO – Sweetwater Creek, at Washington Pike bridge, u/s of Philadelphia
 - SWEET013.7MO – Sweetwater Creek, at Jones Rd. bridge
 - SWEET017.3MO – Sweetwater Creek, at Hwy 11 bridge; d/s of Sweetwater
 - SWEET019.3MO – Sweetwater Creek, u/s of Sweetwater STP discharge; d/w of new Hwy 322 bridge
 - SWEET023.3MO – Sweetwater Creek, at Head-of-Creek Rd. bridge; near Monroe-McMinn county line

Additional monitoring was conducted by UTK at several of the same locations as listed above:

- Greasy Branch Subwatershed:
 - GS – same as GREAS000.5MO
- Mud Creek Subwatershed:
 - MC – same as MUD001.9MO
- Pond Creek Subwatershed:
 - PC1 – same as POND002.3LO
 - PC2 – same as POND005.7LO
 - PC3 – same as POND008.3LO
 - PC4 – same as POND0011.0LO
 - PC5 – same as POND013.1MO
 - PC6 – same as POND013.9MO

The location of these monitoring stations is shown in Figure 5. Water quality monitoring results for these stations are tabulated in Appendix B. Examination of the data shows violations of the 941 counts/100 mL maximum E. coli standard and the 1,000 counts/100 mL maximum fecal coliform criterion at many monitoring stations. Water quality monitoring results for those stations with 10% of samples in violation of water quality standards are summarized in Tables 4 (TDEC) and 5 (UTK).

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. All calculated geometric means were in violation of the 200 counts/100 mL geometric mean for fecal coliform.

All waterbodies listed on the Final 2004 303(d) List are provided a TMDL for pathogen loading.

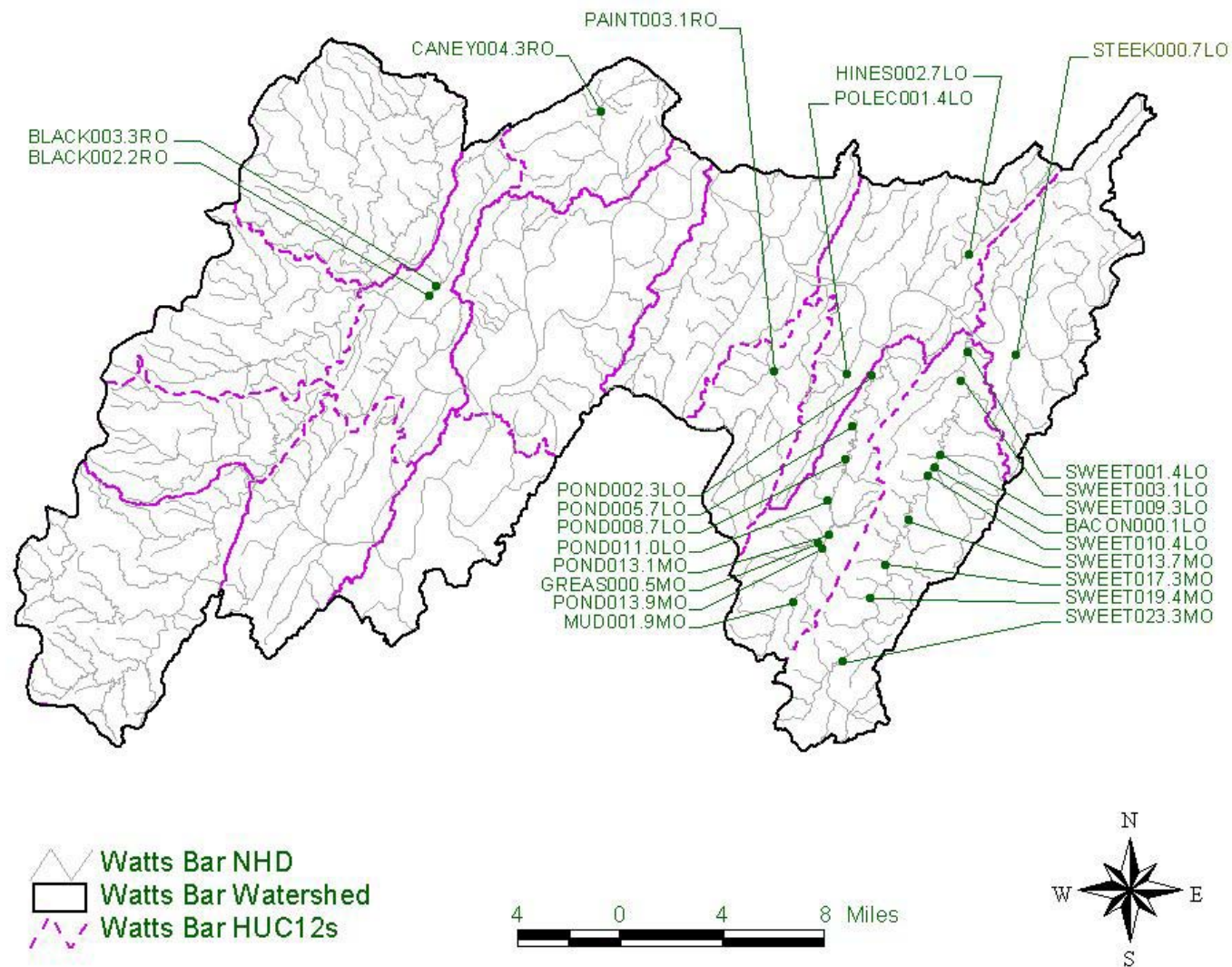


Figure 5. Water Quality Monitoring Stations in the Watts Bar Watershed

Table 4. Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Monitoring Dates	E. Coli						Fecal Coliform					
		Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.	Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.
			Min.	Avg.	Max.				Min.	Avg.	Max.		
BACON000.1LO	2003	8	84	1,341	3,590	6	75.0%	8	180	1,720	5,000	5	62.5%
BLACK003.3RO	2002	7	161	717	1,733	2	28.6%	0					
CANEY004.3RO	2002	7	1,120	>2,089	>2,419	7	100.0%	0					
GREAS000.5MO	2002	1	1,300	1,300	1,300	1	100.0%	1	1,900	1,900	1,900	1	100.0%
HINES002.7LO	2002	9	276	683	1,733	1	11.1%	0					
MUD001.9MO	2002	1	1,046	1,046	1,046	1	100.0%	1	1,100	1,100	1,100	1	100.0%
PAINT003.1RO	2002	9	228	1,001	>2,419	4	44.4%	0					
POLEC001.4LO	2002	9	378	>1,349	>2,419	6	66.7%	0					
POND002.3LO	2002	1	1,414	1,414	1,414	1	100.0%	1	1,900	1,900	1,900	1	100.0%
POND005.7LO	2002	1	3,310	3,310	3,310	1	100.0%	1	2,600	2,600	2,600	1	100.0%
POND008.3LO	2002	1	>2,419	>2,419	>2,419	1	100.0%	1	2,200	2,200	2,200	1	100.0%
POND011.0LO	2002	1	1,986	1,986	1,986	1	100.0%	1	1,000	1,000	1,000	0	0.0%
POND013.1	2002	1	3,180	3,180	3,180	1	100.0%	1	2,000	2,000	2,000	1	100.0%
POND013.9	2002	1	1,986	1,986	1,986	1	100.0%	1	1,100	1,100	1,100	1	100.0%
STEEK000.7LO	2000 – 2002	10	326	>1,373	>2,419	6	60.0%	1	1,060	1,060	1,060	1	100.0%
SWEET001.4LO	2003	9	83	1,466	8,840	2	22.2%	9	76	1,736	8,900	4	44.4%
SWEET003.1LO	2003	9	60	1,233	5,560	2	22.2%	9	104	1,384	6,200	4	44.4%
SWEET009.3LO	2003	9	397	1,701	4,430	5	55.5%	9	400	1,733	3,400	5	55.5%
SWEET010.4LO	2003	9	517	3,853	9,840	7	77.8%	9	220	2,979	7,300	6	66.7%

Table 4 (cont'd). Summary of TDEC Water Quality Monitoring Data

Monitoring Station	Monitoring Dates	E. Coli						Fecal Coliform					
		Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.	Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.
			Min.	Avg.	Max.				Min.	Avg.	Max.		
SWEET013.7MO	2003	9	517	1,070	3,230	2	22.2%	9	122	1,072	2,000	5	55.5%
SWEET017.3MO	2003	9	205	2,160	6,830	6	66.7%	9	168	2,131	4,800	6	66.7%
SWEET019.4MO	2003	9	260	>999	>2,419	3	33.3%	9	260	1,018	2,500	3	33.3%
SWEET023.3MO	2003	9	22	410	1,414	1	11.1%	9	92	566	2,300	2	22.2%

Table 5. Summary of UTK Water Quality Monitoring Data

Monitoring Station (UTK/TDEC)	Monitoring Dates	E. Coli						Fecal Coliform					
		Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.	Data Pts.	[Counts/100 mL]			No. Viol. WQ Crit.	Percent Viol. WQ Crit.
			Min.	Avg.	Max.				Min.	Avg.	Max.		
GS/GREAS000.5MO	2001 – 2002	11	300	32,888	241,920	9	81.8%	11	770	7,685	50,000	10	90.9%
MC/MUD001.9MO	2001 – 2002	12	<1	10,717	43,520	9	75.0%	12	<1	5,702	23,000	10	83.3%
PC-1/POND002.3LO	2001 – 2002	12	33.2	10,721	82,979	5	41.7%	12	600	3,182	13,000	8	66.7%
PC-2/POND005.7LO	2001 – 2002	12	410.6	6,839	32,550	10	83.3%	12	1,275	4,406	18,000	12	100.0%
PC-3/POND008.3LO	2001 – 2002	12	520	12,140	86,640	11	91.7%	12	1,200	6,550	33,000	12	100.0%
PC-4/POND011.0LO	2001 – 2002	12	517	30,625	173,290	10	83.3%	12	1,000	10,783	65,000	11	91.7%
PC-5/POND013.1MO	2001 – 2002	12	980	13,383	72,700	12	100.0%	12	1,700	6,996	22,000	12	100.0%
PC-6/POND013.9MO	2001 – 2002	11	160	6,868	41,060	8	72.7%	11	400	3,136	10,500	8	72.7%

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 9 NPDES permitted WWTFs that require monitoring of fecal coliform and/or *E. coli* within the Watts Bar watershed. The fecal coliform and *E. coli* permit limits for discharges from these WWTFs are in accordance with the criteria specified in the 1999 and 2004 State of Tennessee water quality standards (TDEC, 1999 and TDEC, 2004b, respectively) (ref.: Section 5.0).

Two of these facilities are located in impaired subwatersheds of the Watts Bar watershed. The Sweetwater Sewage Treatment Plant (STP) (TN0020052), with a design capacity of 1.5 MGD, discharges to Sweetwater Creek at mile 19.4. Seven of the nine permit violations recorded in 2003 were for overflows. A collection system rehab is in progress. The Rockwood STP (TN0026158), with a design capacity of 1.65 MGD, discharges to Black Creek at mile 5.3. A compliance evaluation inspection conducted in December 2004 reported numerous violations, including increased flow due to infiltration and inflow in collection systems and peak flows (greater than 5 MGD) in excess of the design capacity. Also, no bypasses or overflows were reported on Discharge Monitoring Reports (DMRs) between October 1, 2003 and September 30, 2004, although overflows had occurred. These problems can be a significant contributor to pathogen impairment in the watershed.

7.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

Municipal Separate Storm Sewer Systems (MS4s) are considered to be point sources of pathogens. Discharges from MS4s occur in response to storm events through road drainage systems, curb and gutter systems, ditches, and storm drains. Large and medium MS4s serving populations greater than 100,000 people are required to obtain NPDES storm water permits. At present, there are no MS4s of this size in the Watts Bar watershed. As of March 2003, small MS4s serving urbanized

areas, or having the potential to exceed instream water quality standards, are required to obtain a permit under the *NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems* (TDEC, 2002). An urbanized area is defined as an entity with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Under the General Permit, an annual report must be submitted to the Director of TDEC Water Pollution Control Division.

Two permittees are covered under Phase II of the NPDES Storm Water Program (Figure 6). The two permitted MS4s in the Watts Bar watershed are as follows:

NPDES Permit Number	Phase	Permittee Name	Issuance Date	Effective Date	Expiration Date
TNS077798	II	City of Lenoir City	3/8/04	9/22/03	2/26/08
TNS075591	II	Loudon County	3/8/04	10/15/03	2/26/08

The Tennessee Department of Transportation (TDOT) is also being issued MS4 permits for State roads in urban areas. Information regarding storm water permitting in Tennessee may be obtained from the 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 5, 2005, there are no Class I CAFOs with individual permits located in the watershed. There are four Class II CAFOs in the Watts Bar watershed with coverage under the general NPDES permit (see Figure 6). The four CAFOS in the Watts Bar watershed are as follows:

NPDES Permit Number	Permittee Name	Watershed	Issuance Date	Effective Date	Expiration Date
TNA000021	Watson Dairy	Pond	8/30/99	8/30/99	4/30/04
TNA000023	Holt Dairy Farm	Pond	8/30/99	8/30/99	4/30/04
TNA000025	Springbrook Farm	Pond	8/30/99	8/30/99	4/30/04
TNA000033	Sweetwater Valley Farms	Sweetwater	8/30/99	8/30/99	4/30/04

All of these CAFOs submitted incomplete applications and have been operating in violation of the Tennessee Water Quality Control Act. All previous permits have expired and new applications had not been received by March 1, 2005. All applicants were notified on February 11, 2005 of the need to submit applications within 30 days.

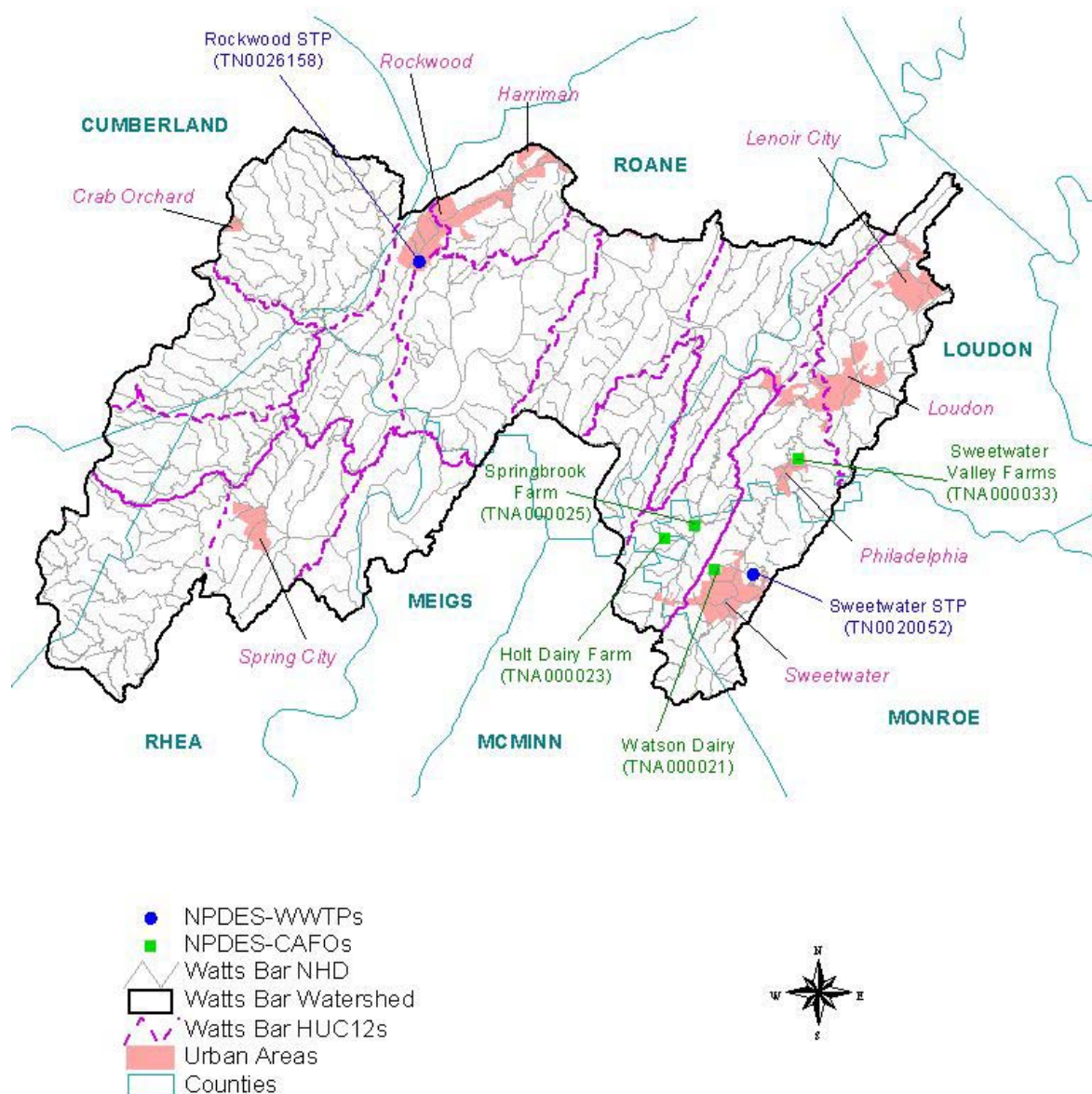


Figure 6. NPDES Regulated Point Sources in and near the Watts Bar Watershed.

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 pathogen loading are primarily associated with agricultural and urban land uses. The vast majority of waterbodies identified on the Final 2004 303(d) list as impaired due to pathogens 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. Fecal coliform loads due to deer are estimated by EPA to be 5.0×10^8 counts/animal/day.

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.

Potential data sources related to livestock operations include the 2002 Census of Agriculture, which was compiled for the Watts Bar Watershed utilizing the Watershed Characterization System (WCS). WCS is an Arcview geographic information system (GIS) based program developed by USEPA Region IV to facilitate watershed characterization and TMDL development. Livestock information provided in WCS is based on the ratio of watershed pasture area to county pasture area applied to the livestock population within the county. Livestock data for *E. coli*-impaired watersheds is summarized in Table 6. Populations were rounded to the nearest 25 cows, 50 poultry, and 5 hogs, sheep, and horses.

Table 6. Livestock Distribution in the Watts Bar Watershed

Subwatershed	Livestock Population (WCS)					
	Beef Cow	Milk Cow	Poultry	Hogs	Sheep	Horse
Paint Rock Creek	600	100	1,050	10	15	90
Mud Creek	224	100	57,800	5	0	120
Greasy Branch	150	50	14,400	0	0	60
Pond Creek	1,175	425	84,200	15	20	420
Bacon Creek	200	75	0	0	5	85
Sweetwater Creek	1,825	675	110,500	25	30	720
Black Creek	175	0	0	5	5	30
Steekee Creek	300	100	0	0	10	30
Hines Creek	450	150	0	0	10	45
Polecat Creek	325	100	0	0	10	55
Caney Creek	125	0	0	0	0	25

7.2.3 Failing Septic Systems

Some coliform loading in the Watts Bar 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 Watts Bar 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.

Table 7. Population on Septic Systems in the Watts Bar Watershed

Subwatershed	Population on Septic Systems	Subwatershed	Population on Septic Systems
Paint Rock Creek	2,203	Black Creek	1,248
Mud Creek	627	Steekee Creek	450
Greasy Branch	339	Hines Creek	771
Pond Creek	2,416	Polecat Creek	610
Bacon Creek	398	Caney Creek	698
Sweetwater Creek	3,640		

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. Black Creek has the highest percentage of urban land area for impaired waterbodies in the Watts Bar watershed, with 11.4%. Land use for the Watts Bar impaired drainage areas is summarized in Figures 7 thru 10 and tabulated in Appendix A.

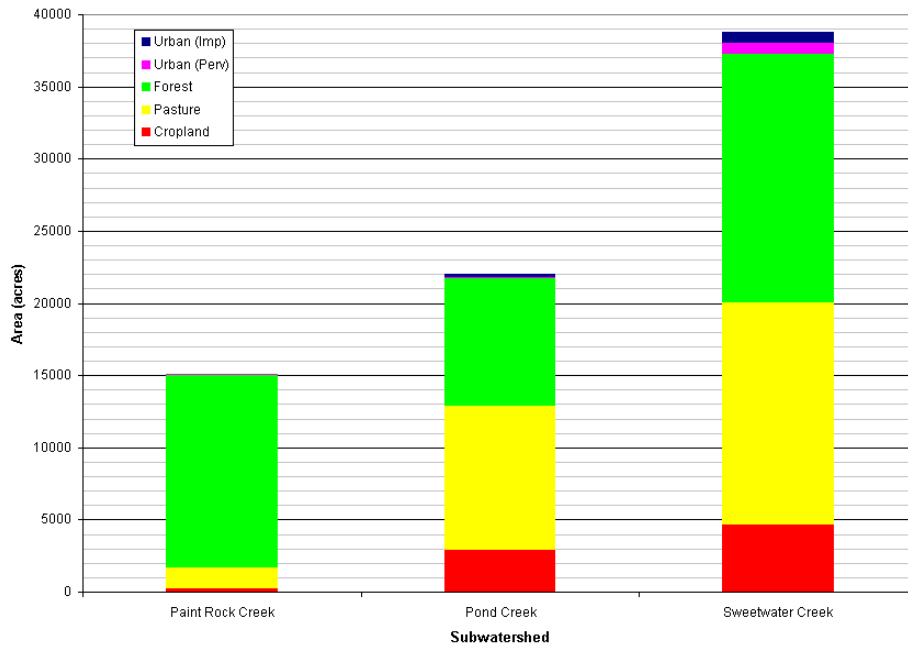


Figure 7. Land Use Area of Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Greater Than 10,000 Acres.

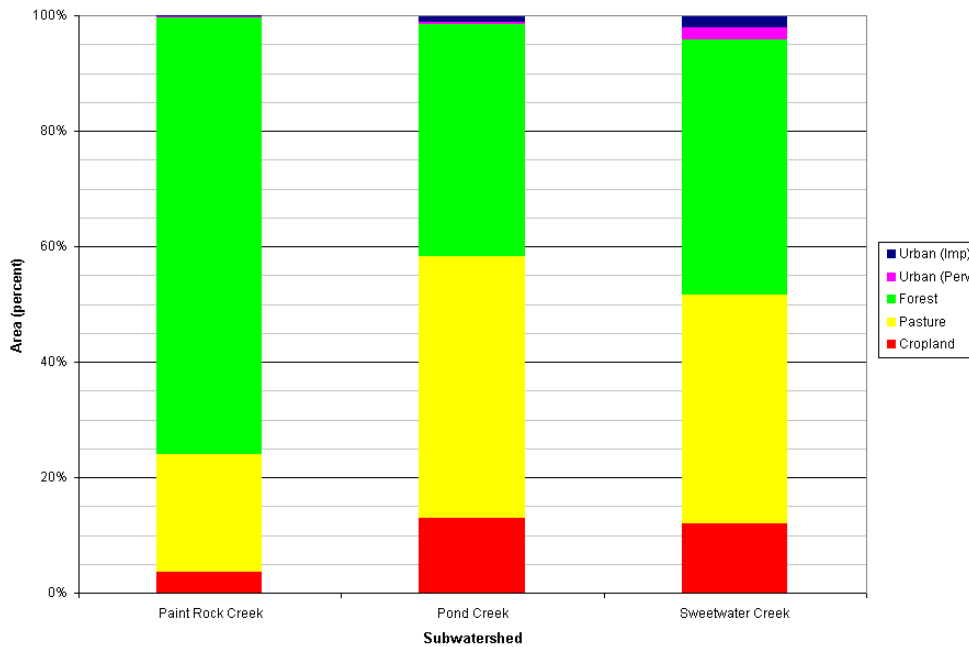


Figure 8. Land Use Percent of the Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Greater Than 10,000 Acres.

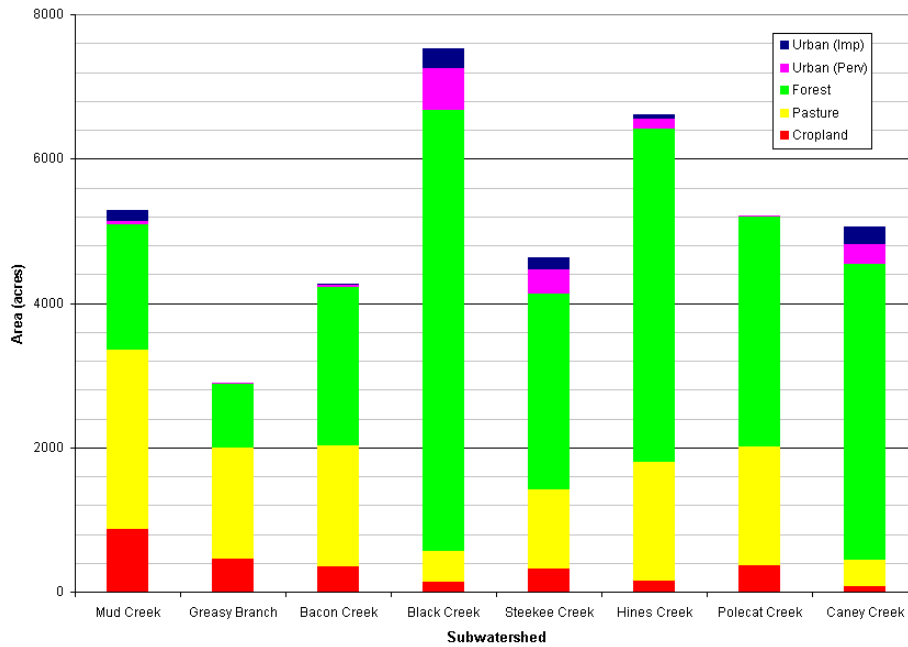


Figure 9. Land Use Area of Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Less Than 10,000 Acres.

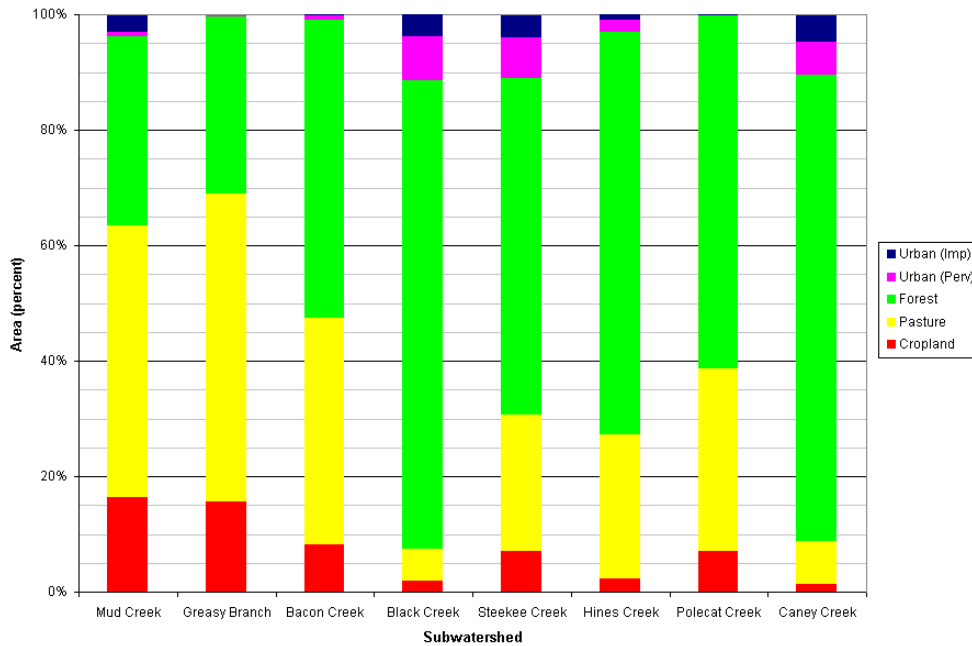


Figure 10. Land Use Percent of the Watts Bar Pathogen-Impaired Subwatersheds – Drainage Areas Less Than 10,000 Acres.

8.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

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:

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

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.

This document describes pathogen 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. TMDL analyses are performed primarily on a 12-digit hydrologic unit area (HUC-12) basis for subwatersheds containing 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, the pathogen TMDL is expressed as the percent reduction in instream loading required to decrease existing E. coli or fecal coliform concentrations to desired target levels. Target concentrations are equal to the desired water quality goals (see Section 5.0) minus the appropriate MOS. WLAs & LAs for precipitation-induced loading sources are also expressed as required percent reductions in pathogen loading. Allocations for loading that is independent of precipitation (WLAs for WWTFs and LAs for “other direct sources”) are expressed as counts/day.

8.2 TMDL Analysis Methodology

Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from qualitative assumptions based on scientific principles to numerical computer modeling.

TMDLs for the Watts Bar Watershed were developed using load duration curves for analysis of impaired waterbodies. 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 targets, and the portion of the waterbody flow regime represented by these existing loads. Load duration curves were 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 and fecal coliform targets according to the methods described in Appendix C.

8.3 Critical Conditions and Seasonal Variation

The critical condition for non-point source fecal coliform loading is an extended dry period followed by a rainfall runoff event. During the dry weather period, fecal coliform 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 pathogens appears to be dominant (see Section 9.3 and Table 11).

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 not collected during all seasons.

8.4 Margin of Safety

There are two methods for incorporating an MOS in the 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.

An explicit MOS, equal to 10% of the E. coli and fecal coliform water quality goals (ref.: Section 5.0), was utilized for TMDL analysis. Explicit MOS and the resulting target concentrations are shown in Table 8.

Table 8. Explicit MOS and Target Concentrations

Pollutant	WQ Goal Type	WQ Goal	Explicit MOS	Target
		[cts./100mL]	[cts./100mL]	[cts./100mL]
E. coli	Maximum	941	94	847
	30-Day Geometric Mean	126	13	113
Fecal Coliform	Maximum	1,000	100	900
	30-Day Geometric Mean	200	20	180

8.5 Determination of TMDLs

E. coli and fecal coliform load reductions were calculated for impaired segments in the Watts Bar Watershed using Load Duration Curves to evaluate compliance with the maximum target concentrations (Appendix C). When sufficient data were available, load reductions were also developed to achieve compliance with the 30-day geometric mean target concentrations (Appendix C). All of the instream load reductions for a particular waterbody were compared and the largest required load reduction was selected as the TMDL. These TMDL load reductions for the impaired segments are shown in Table 9 and are applied to the entire HUC-12 subwatershed in which the impaired waterbodies are located. 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.

8.6 Determination of WLAs & LAs

WLAs & LAs are developed in Appendix E for point sources and nonpoint sources respectively. TMDLs, WLAs, & LAs for Watts Bar Watershed impaired waterbodies are summarized in Table 10.

Table 9. Determination of TMDLs for Impaired Waterbodies, Watts Bar Watershed

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	Required Load Reduction [%]				
			Based on Target Maximum Concentration		Based on 30-day Geometric Mean Concentration		TMDL
			Fecal Coliform	E. Coli	Fecal Coliform	E. Coli	
0306	Paint Rock Creek	TN06010201011 – 1000	NA	>51.9		89.0	89.0
0305	Mud Creek	TN06010201013 – 0100	94.8	96.8			99.1
	Greasy Branch	TN06010201013 – 0200	86.7	98.5			
	Pond Creek	TN06010201013 – 1000 & 2000	95.4	99.1			
0304	Bacon Creek	TN06010201015 – 0100	72.9	59.0			89.1
	Sweetwater Creek	TN06010201015 – 1000	84.4	89.1			
0503	Black Creek	TN06010201040 – 0600		40.1			40.1
0302	Steekee Creek	TN06010201065 – 1000		>65.0		91.0	91.0
0303	Hines Creek	TN06010201087 – 1000		21.8		77.4	92.3
	Polecat Creek	TN060102011149 – 1000		>59.1		92.3	
0402	Caney Creek	TN060102011621 – 1000		>65.0			>65.0

Table 10. WLAs & LAs for Watts Bar Watershed, Tennessee

HUC-12 Subwatershed (06010201__) or Drainage Area	Impaired Waterbody Name	Impaired Waterbody ID	WLAs				LAs	
			WWTFs ^a (Monthly Avg.)	Leaking Collection Systems ^b	CAFOs	MS4s ^c	Precipitation Induced Nonpoint Sources	Other Direct Sources ^d
			E. Coli					
			[cts./day]	[cts./day]	[cts./day]	[% Red.]	[% Red.]	[cts./day]
0306	PAINT ROCK CREEK	TN06010201011 – 1000	NA*	NA	NA	89.0	89.0	0
0305	MUD CREEK	TN06010201013 – 0100	NA*	NA	0	99.1	99.1	0
	GREASY BRANCH	TN06010201013 – 0200						
	POND CREEK	TN06010201013 – 1000 & 2000						
0304	BACON CREEK	TN06010201015 – 0100	7.154 x 10 ⁹	0	0	89.1	89.1	0
	SWEETWATER CREEK	TN06010201015 – 1000						
0503	BLACK CREEK	TN06010201040 – 0600	7.869 x 10 ⁹	0	NA	NA	40.1	0
0302	STEEKEE CREEK	TN06010201065 – 1000	NA*	NA	NA	91.0	91.0	0
0303	HINES CREEK	TN06010201087 – 1000	NA*	NA	NA	92.3	92.3	0
	POLECAT CREEK	TN060102011149 – 1000						
0402	CANEY CREEK	TN060102011621 – 1000	NA*	NA	NA	NA	>65.0	0

Note: NA = Not Applicable.

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

a. WLAs for WWTFs expressed as E. coli loads (counts/day).

b. The objective for leaking collection systems is a waste load allocation of zero. It is recognized, however, that a WLA of 0 counts/day may not be practical. For these sources, the WLA is interpreted to mean a reduction in coliform 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.

d. The objective for all “other direct sources” is a load allocation of zero. It is recognized, however, that for leaking septic systems a LA of 0 counts/day may not be practical. For these sources, the LA is interpreted to mean a reduction in coliform loading by the application of best management practices, consistent with the requirement that these sources not contribute to a violation of the water quality standard for E. coli.

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 Watts Bar 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. 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 expressed as average loads in counts per day. WLAs are derived from facility design flows and permitted fecal coliform and E. coli limits.

In order to meet water quality criteria for the Watts Bar Watershed, all STPs must meet the provisions of their NPDES permits, including elimination of bypasses and overflows.

9.1.2 NPDES Regulated Municipal Separate Storm Sewer Systems (MS4s)

For 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, 2002) was issued on February 27, 2003 and requires 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

For discharges into impaired waters, the proposed Small MS4 General Permit (ref: <http://www.state.tn.us/environment/wpc/stormh2o/MS4II.php>) requires that SWMPs include a section describing how discharges of pollutants of concern will be controlled to ensure that they do not cause or contribute to instream exceedances of water quality standards. Specific measures and BMPs to control pollutants of concern must also be identified. In addition, MS4s must

implement the WLA provisions of an applicable TMDL and describe methods to evaluate whether storm water controls are adequate to meet the WLA.

Implementation of the coliform WLAs for MS4s in this TMDL document will require effluent or instream monitoring to evaluate SWMP effectiveness with respect to reduction of pathogen loading.

9.1.3 NPDES Regulated Concentrated Animal Feeding Operations (CAFOs)

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 be 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/>.

In order to meet water quality criteria for Pond Creek and Sweetwater Creek, all CAFOs must be permitted as required by the Tennessee Water Quality Control Act.

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. Local citizen-led and implemented management measures offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. 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.

BMPs have been utilized in the Watts Bar 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 Watts Bar watershed during the TMDL evaluation period. The TDA keeps a database of BMPs implemented in Tennessee. Those listed in the Watts Bar 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.

Within the Watts Bar watershed, the UT Agricultural Extension Service is the lead organization for a project located in Pond Creek. The objective of the project is to identify nonpoint source impairments from agriculture, implement agricultural BMPs that will improve water quality, and restore the Pond Creek watershed to the condition of fully supporting its designated uses. Planned activities include installation of BMPs, formation of a stakeholder watershed management group, development of a watershed management plan, and monitoring of changes in water quality on a monthly basis. The project will be funded, in part, through a Tennessee Department of Agriculture (TDA) Nonpoint Source Program 319 grant. Additional information about this project is included in Appendix F.

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 non-point problems. The *E. coli* load duration analysis was utilized for implementation planning. The *E. coli* load duration curve for each pathogen-impaired subwatershed (Figures 12 thru 19) was analyzed to determine the frequency with which water quality monitoring data exceed the *E. coli* target maximum concentration of 847 counts/100 mL (standard – MOS) under five flow conditions (low, dry, mid-range, moist, and high).

Table 11 presents Load Duration analysis statistics for *E. coli* in the Watts Bar Watershed and 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, non-point sources, or a combination of each. Results indicate the implementation strategy for Black Creek and Caney Creek will require BMPs targeting primarily sources dominant during low-flow/dry conditions, while the implementation strategy for the remaining subwatersheds will require BMPs targeting non-point sources (dominant under high flow/runoff conditions). 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 Watts Bar subwatersheds 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 Watts Bar Watershed.

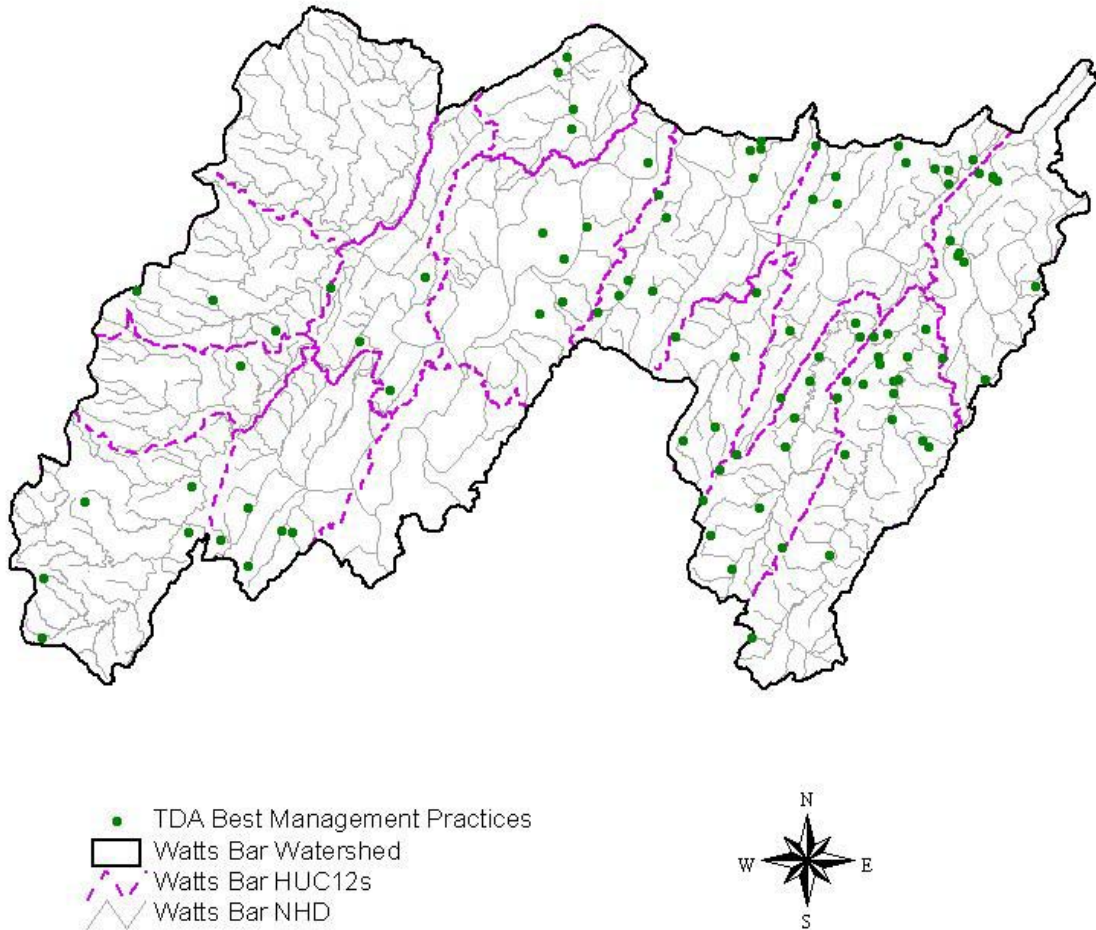


Figure 11. Tennessee Department of Agriculture Best Management Practices located in the Watts Bar Watershed.

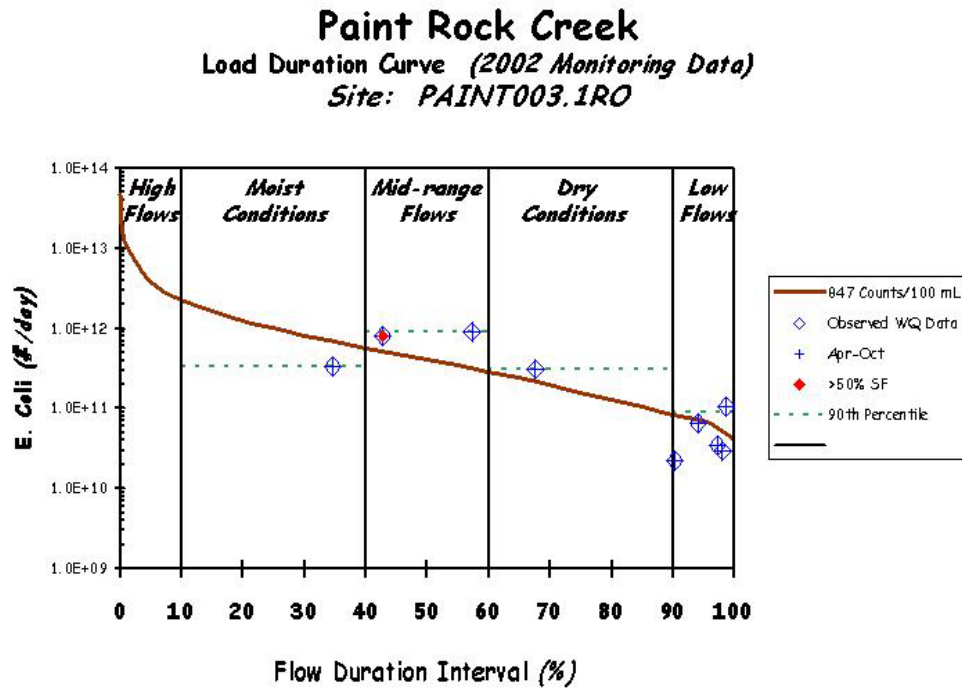


Figure 12. Load Duration Curve for Paint Rock Creek

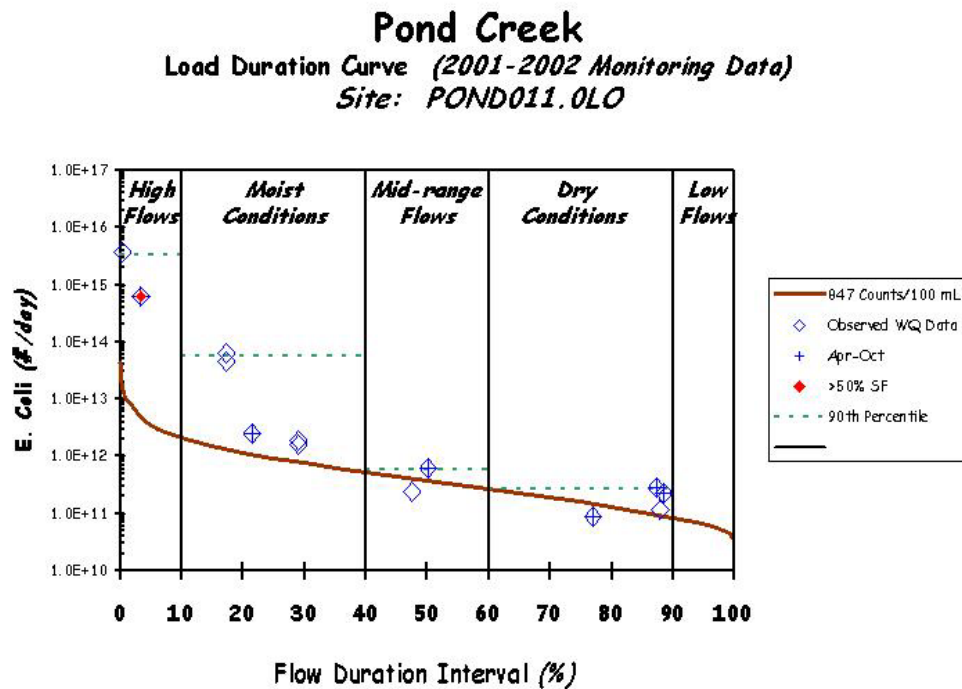


Figure 13. Load Duration Curve for Pond Creek

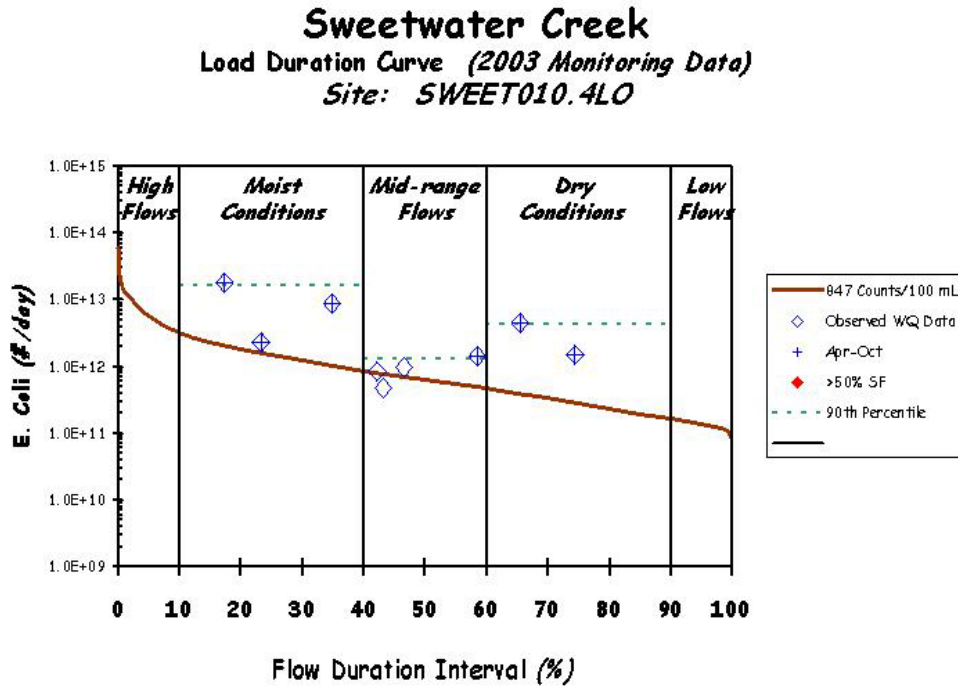


Figure 14. Load Duration Curve for Sweetwater Creek at Mile 10.4

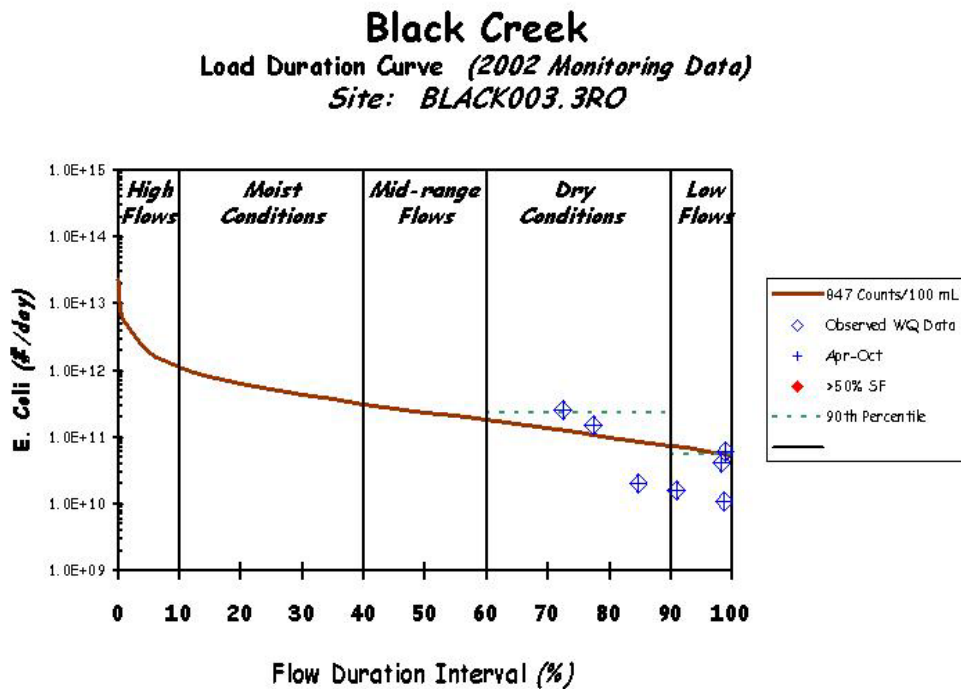


Figure 15. Load Duration Curve for Black Creek

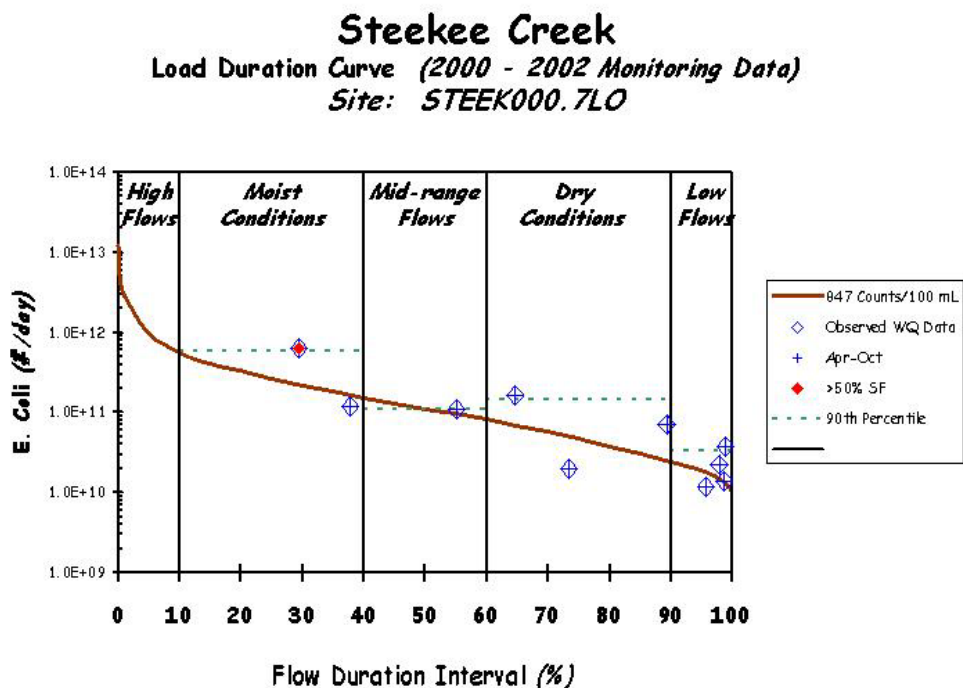


Figure 16. Load Duration Curve for Steekee Creek

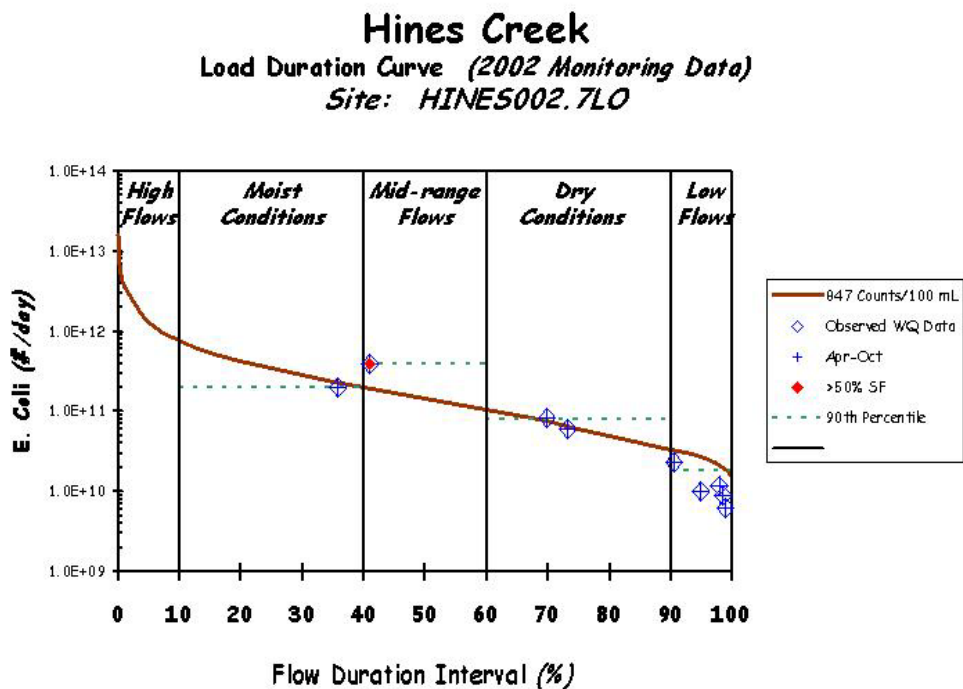


Figure 17. Load Duration Curve for Hines Creek

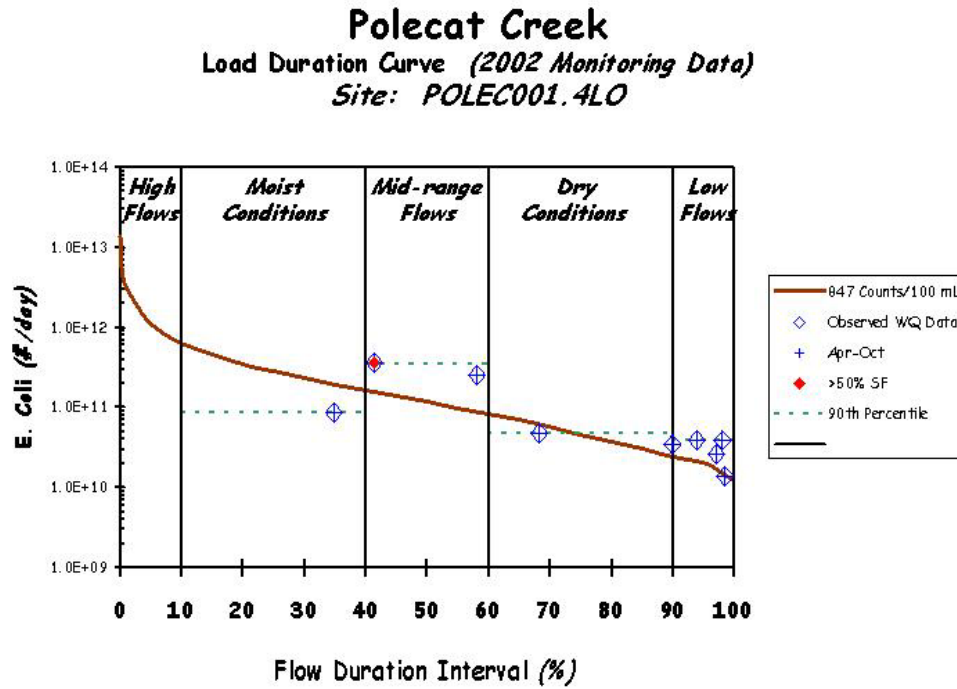


Figure 18. Load Duration Curve for Polecat Creek

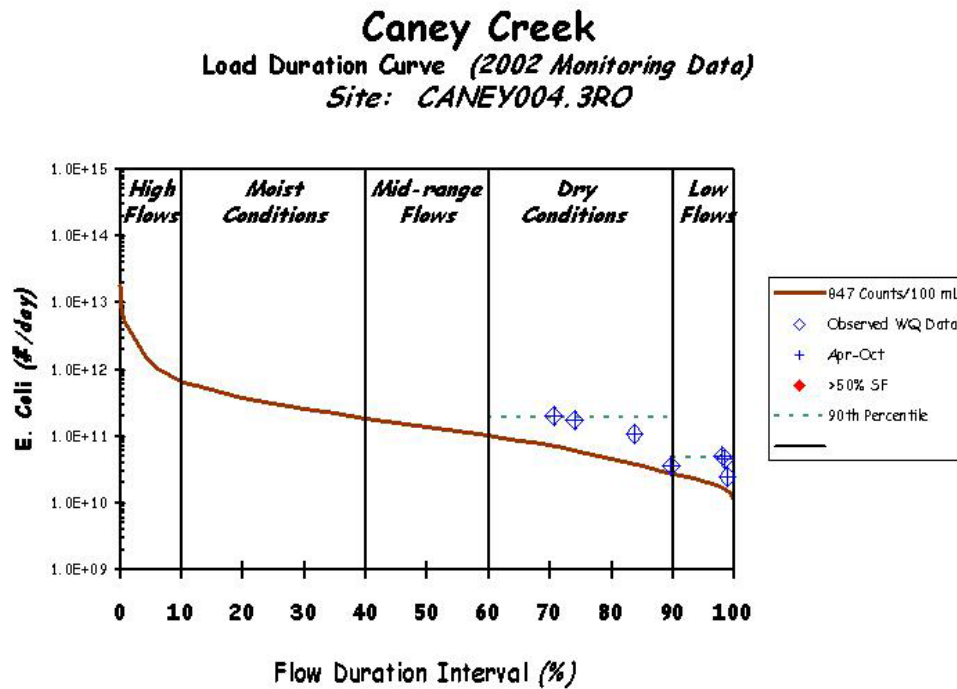


Figure 19. Load Duration Curve for Caney Creek

Table 11. Load Duration Curve Summary for E.Coli and/or Fecal Coliform Impaired Segments

Flow Condition		High	Moist	Mid-range	Dry	Low
% Time Flow Exceeded		0-10	10-40	40-60	60-90	90-100
Sweetwater Creek at Mile 10.4	% Samples > 941 Counts/100 mL ¹	NA	100.0	50.0	100.0	NA
Caney Creek	% Samples > 941 Counts/100 mL ¹	NA	NA	NA	100.0	100.0
Example Implementation Strategies						
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 ²				M	H	H
Pasture Management/Land Application of Manure ²		H	H	M	L	
Riparian Buffers ²			H	H	H	
		Potential for source area contribution under given hydrologic condition (H: High; M: Medium; L: Low)				

¹ Tennessee maximum daily water quality standard for E.coli (941 Counts/100 mL).

² 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 Watts Bar 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 fecal coliform and/or *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.

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.

Additional sampling for both fecal coliform and *E. coli* is recommended to aid in a better understanding of the relationship between fecal coliform concentration and *E. coli* concentration.

Monitoring events for Pond Creek and its tributaries have occurred during all flow conditions. 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.

Examination of monitoring data for all subwatersheds except Pond Creek indicates that few sampling events have occurred during moist conditions or periods of high flow. Additional monitoring and assessment activities are recommended for these subwatersheds, especially the Black Creek and Caney Creek subwatersheds. Once additional monitoring representing all seasons and a full range of flow and meteorological conditions has been obtained, the required load reductions may be revised.

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 *E. coli* 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/bacsork.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 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 Watts Bar 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) A letter was sent to Lena Beth Carmichael, Pond Creek Watershed Project Coordinator, advising her of the proposed TMDLs and their availability on the TDEC website. Ms. Carmichael is working with farmers in the Pond Creek watershed and other agencies to improve management and facilities of their farms.
- 4) Letters were sent to WWTFs located in or near pathogen-impaired subwatersheds in the Watts Bar 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:

Rockwood STP (TN0026158)
Sweetwater STP (TN0020052)

- 5) 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 Lenoir City (TNS077798)
Loudon County, Tennessee (TNS075591)
Tennessee Dept. of Transportation (TNS077585)

- 6) Notice of the availability of the Proposed TMDL was sent to the Oak Ridge Reservation (ORR) Local Oversight Committee (LOC). The ORR-LOC is a non-profit regional organization that represents the interests of local governments regarding Department of Energy's environmental management program and the operation of the Oak Ridge Reservation. The Watts Bar Reservoir Fish Advisory study was a special project of the CAP in conjunction with state and federal agencies to address concerns of the counties on Watts Bar Reservoir regarding the effects of PCB contamination on fishing and other recreational activities.
- 7) A draft copy of the proposed TMDL was sent to the Department of Biosystems Engineering and Environmental Science, University of Tennessee at Knoxville (UTK), Tennessee. Monitoring data for Pond Creek and its tributaries was provided as part of a contract between UTK and the Department of Agriculture. Also, UTK is working with one of the farmers (Holt Dairy Farms) in the Pond Creek watershed to develop the Nutrient Management Plan required for their CAFO permit.

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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e-mail: Vicki.Steed@state.tn.us

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

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