Virginia Department of Environmental Quality

Bacteria Total Maximum Daily Load (TMDL) Development for the Hungars Creek Watershed

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Executive Summary

This report presents the development of the bacteria TMDL for the Hungars Creek watershed, located in Northampton County. Hungars Creek was placed on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report as impaired for recreational use and shellfishing use.

Description of the Study Area

The Hungars Creek Watershed is located within the borders of Northampton County on the west coast of the Delmarva Peninsula, Virginia. The watershed is approximately 1,939 acres. The major road that runs through the watershed is interstate Route 622, located in the northern portion of the watershed.

Impairment Description

Hungars Creek was placed on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report as impaired for recreational use (TMDL segment ID VAT-C14E-01), and as impaired for shellfishing use (TMDL segment ID VAT-C14E-11). According to the VADEQ 303(d) lists, the cause of impairment for both of these segments is fecal coliform, but the source of fecal coliform is unknown. The TMDL segment has a total length of 1.5 miles beginning from approximately 0.4 miles upstream of the Route 622 crossing and ending approximately 1.1 miles downstream of the Route 622 crossing. This river segment incorporates the impaired segment VAT-C14E-01 listed as impaired for recreational use since 1998 and the impaired segment VAT-C14E-11 listed as impaired for shellfishing use since 1998.

Applicable Water Quality Standards

The impaired segment in Hungars Creek is listed not supporting shellfishing and primary contact recreational uses.

The Virginia Water Quality Standards, as amended (9 VAC 25-260) September 11, 2007, specify the following criteria for shellfish waters:

"The geometric mean fecal coliform value shall not exceed an MPN (most probable number) of 14 per 100 milliliters. The 90th percentile shall not exceed an MPN of 43 for a 5-tube, 3-dilution test or 49 for a 3-tube, 3-dilution test"

The Virginia Water Quality Standards, as amended (9 VAC 25-260) September 11, 2007, specify the following criteria for recreational uses for waterbodies located in saltwater or in a transition zone:

- *"Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 ml of water."*

- *Enterococci bacteria shall not exceed a geometric mean of 35 counts/100ml of water for two or more samples over a calendar month nor shall exceed the single sample maximum of 104 counts/100ml of water.*

The fecal coliform bacteria shall not apply when enterococci bacteria sampling has a minimum of 12 data points or when sampling was performed after June 30, 2008. For the purposes of this TMDL, the shellfish water criteria were applied because these criteria are more restrictive water standards than those for recreational uses.

Watershed Characterization

Land use characterization for the Hungars Creek watershed was based on land cover data from the NLCD 2001 Land Use Dataset. Dominant land uses in the watershed were found to be agricultural (54%) and forest (39%), which account for a 93% of the total land area in the watershed.

Potential sources of fecal coliform include run-off from livestock grazing, manure applications, industrial processes, residential, and domestic pets waste. Potential fecal coliform sources located in the Hungars Creek watershed were identified and characterized and were found to include failed septic systems and straight pipes, livestock, wildlife, and pets.

Based on data obtained from the VA DEQ, there are no permitted facilities located in the Hungars Creek watershed. An inventory of livestock, wildlife, and pets was conducted using data provided by the Center for Coastal Resource Management (CCRM). Based on a VDH-DSS survey of Hungars Creek watershed, there were two potential sources of environmental pollution. They include one private boat ramp and pier at an in-out ramp boating service as well as four trash dumpsters and five recycling bins located 50' from Hungars Creek.

Bacteria Source Tracking

As part of the TMDL development, Bacteria Source Tracking (BST) sampling was conducted at one station (86-14) in Hungars Creek. The objective of the BST study was to identify the sources of fecal coliform in the listed segment of Hungars Creek. After identifying these sources, this information was used in the model set-up, and in the distribution of fecal coliform loadings among the various sources. Station 86-14 is located in the segment of Hungars Creek that is impaired for shellfish use. BST sampling was conducted here on a monthly basis between 2003 and 2004. Results from this sampling period indicate that bacteria from human, livestock, wildlife, and pet sources are present in Hungars Creek.

TMDL Technical Approach

A simplified model approach[1] was selected to estimate present fecal coliform loads for small coastal basins, to calculate allocation, and to find needed reductions for each source (VA DEQ, 2005, 2006). The model is a Microsoft EXCEL spreadsheet that calculates estuary fecal coliform loads based on the steady state mass balance in the bay over a tidal period. The model incorporates the following:

- volume of water at sea level in the bay,
- volume of water entering the bay through flood tide,
- volume of water flowing out of the bay through ebb tide,
- volume of net freshwater over a tidal cycle, and
- the maximum fecal coliform concentration measured in the estuary and at the boundary between Hungars Creek and the Chesapeake Bay

[1] This model was jointly developed by EPA, VA DEQ, Virginia Department of Conservation and Recreation (DCR), Maryland Department of the Environment (MDE), Virginia Department of Shellfish and Sanitation (DSS), Virginia Institute of Marine Sciences (VIMS), United States Geological Survey, Virginia Polytechnic University, James Madison University, and Tetra Tech.

TMDL Calculations

The TMDL represents the maximum amount of a pollutant that the stream can receive without exceeding the water quality standard. The load allocation for the selected scenarios was calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = wasteload allocation (point source contributions);

LA = load allocation (nonpoint source allocation); and

MOS = margin of safety.

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. The MOS was implicitly incorporated in this TMDL. Implicitly incorporating the MOS required that allocation scenarios be designed to meet a 30-day geometric mean fecal coliform standard of 14 MPN/100 mL and the 90th percentile fecal coliform standard of 49 MPN/100 mL with zero percent exceedance.

Hungars Creek Waste Load, Load Allocation, and TMDL

The load allocation is based on Bacteria Source Tracking (BST) results for livestock, wildlife, human, and pets. Waste load allocations in watersheds where there are no individual VPDES permitted facilities with bacteria effluent limitations are usually represented in the TMDL as 1% of the Total Maximum Daily Load. This 1% is then subtracted from the Load allocations. This is reflected in **Table E-1** which shows the fecal coliform TMDL allocation plan for Hungars Creek.

A summary of the TMDL allocation plan for Hungars Creek is presented in **Table E-2**.

Table E-1: Hungars Creek: Distribution of Fecal Coliform under Existing Conditions, TMDL Allocation, and Reduction

Source	BST [1] Distribution (% of total load)	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
Livestock	16	4.34E+10	6.07E+07	100
Wildlife	23	6.23E+10	5.37E+10	13
Human	40	1.08E+11	0.00E+00	100
Pets	21	5.69E+10	7.97E+07	100
Point Source[2]	-	-	5.44E+08	0
Total	100	2.71E+11	5.44E+10	80

[1] Average of 12 samples taken between October 2003 and September 2004
[2] there are no individual VPDES municipal point source dischargers; the WLA includes 1 percent of the total NPS allocations to account for future growth

Table E-2: Hungars Creek TMDL Allocation Plan Loads (MPN/day)

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
5.44E+08	**5.38E+10**	**IMPLICIT**	**5.44E+10**

1.0 Introduction

1.1 Background

1.1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (VA DEQ). VA DEQ works in coordination with the Virginia Department of Conservation and Recreation (VA DCR), the Virginia Department of Mines, Minerals, and Energy (VDMME), and the Virginia Department of Health (VDH) to develop and regulate a more effective TMDL process. VA DEQ is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. VA DEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA), passed by the Virginia General Assembly in 1997, and coordinates public participation throughout the TMDL development process. The role of VA DCR is to initiate nonpoint source pollution control programs statewide through the use of federal grant money. VDMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH monitors waters for fecal coliform, classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of bacterial contamination (VA DEQ, 2001).

As required by the Clean Water Act and WQMIRA, VA DEQ develops and maintains a listing of all impaired waters in the state, which details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the 303(d) List of Impaired Waters. In addition to 303(d) List development, WQMIRA directs DEQ to develop and implement TMDLs for listed waters (VA DEQ, 2001). Once TMDLs have been developed, they are distributed for public comment and then submitted to the EPA for approval.

1.2 Impairment Listing

1.2.1 VA DEQ Impairment Listing

Hungars Creek was placed in Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report as impaired for recreational use (TMDL segment ID VAT-C14E-01), and as impaired for shellfishing use (TMDL segment ID VAT-C14E-11). According to the VA DEQ 303(d) list, the cause of impairment for both of these segments is fecal coliform, but the source of fecal coliform is unknown. The TMDL segment has a total length of 1.5 miles beginning from approximately 0.4 miles upstream of the Route 622 crossing and ending approximately 1.1 miles downstream of the Route 622 crossing. This river segment incorporates the impaired segment VAT-C14E-01 listed as impaired for recreational use since 1998 and the impaired segment VAT-C14E-11 listed as impaired for shellfishing use since 1998. **Table 1-1** summarizes the details of the impaired segments and condemnation area and **Figure 1-1** presents their locations.

Table 1-1: Details of the Bacteria TMDL for Hungars Creek

Segment ID	Clean Water Act Use: Not Supporting	Condemnation No.	Segment Size (mi^2)	Initial Listing Date	Impairment Source
VAT-C14E-11	Shellfishing	136C	0.09	1998	unknown
VAT-C14E-01	Recreation	-	0.02	1998	unknown

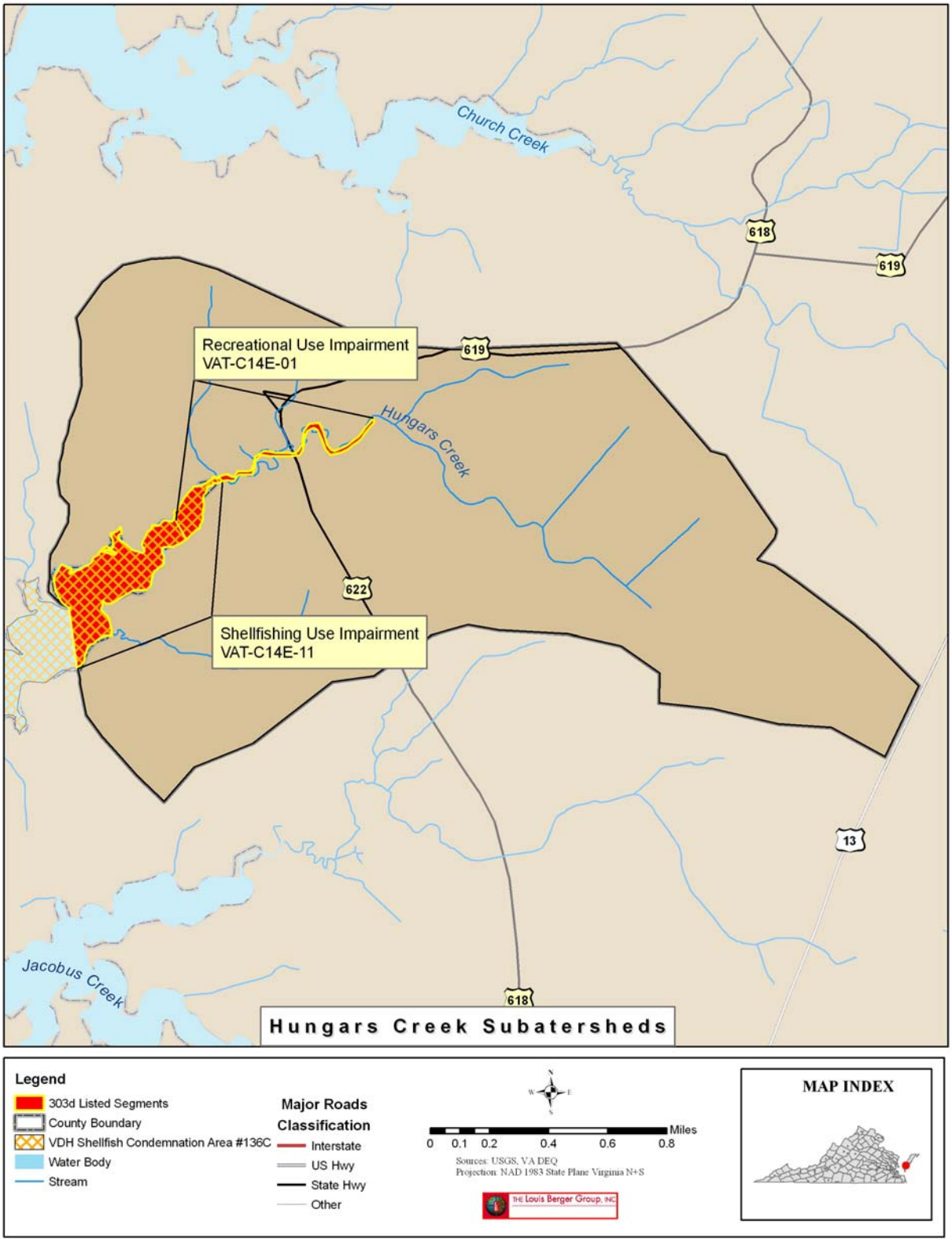

Figure 1-1: Location of the Hungers Creek Bacteria Impaired Segments

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and the water quality criteria necessary to support those uses. According to the Virginia Water Quality Standards as amended (9 VAC 25-260), September 11, 2007, water quality standards are defined as:

> *"provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

1.3.1 Designated Uses

According to the Virginia Water Quality Standards as amended (9 VAC 25-260) September 11, 2007:

> *"all state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish."*

1.3.2 Applicable Water Quality Criteria

The Virginia Water Quality Standards, as amended (9 VAC 25-260) September 11, 2007, specify the following criteria for recreational uses for waterbodies located in saltwater or in a transition zone:

- *"Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 ml of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 ml of water."*

- *Enterococci bacteria shall not exceed a geometric mean of 35 counts/100ml of water for two or more samples over a calendar month nor shall exceed the single sample maximum of 104 counts/100ml of water.*

The fecal coliform bacteria criteria shall not apply when enterococci bacteria samples are at a minimum of 12 data points, or when sampling was performed after June 30, 2008.

For shellfish waters, the Standards specify the following criteria:

> *"In all open ocean or estuarine waters capable of propagating shellfish or in specific areas where public or leased private shellfish beds are present, and including those waters on which condemnation or restriction classifications are established by the State Department of Health the following criteria for fecal coliform bacteria shall apply:*
>
> *The geometric mean fecal coliform value for a sampling station shall not exceed an MPN (most probable number) of 14 per 100 milliliters. The 90th percentile shall not exceed an MPN of 43 for a 5-tube, 3-dilution test or 49 for a 3-tube, 3-dilution test."*

1.3.3 Classification of Virginia's Shellfish Growing Areas

The Virginia Department of Health, Division of Shellfish Sanitation (VDH-DSS) is responsible for classifying shellfish waters and protecting the health of bivalve shellfish consumers. The VDH- DSS follows the requirements of the National Shellfish Sanitation Program (NSSP), which is regulated by the U.S. Food and Drug Administration. The NSSP conducts a shoreline survey to classify waters for shellfish growing. The NSSP shoreline survey locates pollution sources within the shellfish growing watersheds through a property-by-property inspection of onsite sanitary waste disposal facilities in un-sewered sections of watersheds. Investigations of other pollution sources such as wastewater treatment plants (WTP), marinas, livestock operations, landfills, etc. are also carried out. Information from this survey is compiled into a written report complete with maps showing the location of real or potential pollution sources found, and is sent to the various agencies that are responsible for regulating these concerns in the city or county.

Once an onsite problem is identified, local health departments (LHDs), and/or other state and local agencies may play a role in the process of correcting the deficiencies.

In addition, fecal coliform concentrations in water samples are analyzed near shellfish beds in order to verify the findings of the shoreline surveys and to define the border between approved and condemned (unapproved) waters. The VDH-DSS collects monthly seawater samples at over 2,000 stations in the shellfish growing areas of Virginia. Though they continuously monitor sample data for unusual events, they formally evaluate shellfish growing areas on an annual basis. The annual review uses data from the 30 most recent samples (typically taken over 30 months) collected randomly with respect to weather. The data are assessed to determine whether the samples are in compliance with water quality standards. If the water quality standards are exceeded, the shellfish area is closed for the harvest of shellfish that go directly to market. Those areas that marginally exceed the water quality standard and are closed for the direct marketing of shellfish are eligible for harvest of shellfish under permit from the Virginia Marine Resources Commission and VDH-DSS. The permit establishes controls that in part require a 15-days shellfish depuration in clean waters or in specially-designed and licensed on-shore facilities. Shellfish that may be growing in highly polluted areas such as the immediate vicinity of a wastewater treatment facility (prohibited waters) are not allowed to be moved to clean waters for depuration.

2.0 Watershed Description and Source Assessment

In this section, the types of data available and information collected for the development of the TMDL for the Hungars Creek Watershed are presented. This information was used to characterize the stream and its watershed and to inventory and characterize the potential point and nonpoint sources of bacteria in the watershed.

2.1 Data and Information Inventory

A wide range of data and information were used in the development of this TMDL. Categories of data that were used include the following:

(1) Physiographic data that describe physical conditions (i.e., topography, soils, and land use) within the watershed

(2) Hydrographic data that describe physical conditions within the stream, such as the stream reach network and connectivity, and the stream and estuary channel depth, width, slope, and elevation

(3) Data related to uses of the watershed and other activities in the basin that can be used in the identification of potential fecal coliform sources

(4) Environmental monitoring data that describe stream flow and water quality conditions in the condemned area

Table 2-1 shows the various data types and the data sources used in the Hungars Creek Watershed TMDL development.

Table 2-1: Inventory of Data and Information Used in the Hungars Creek Watershed

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	USGS, VA DEQ
	Land use/land cover	NLCD
	Soil data (SSURGO)	NRCS
	Topographic data (USGS-30 meter DEM, USGS Quads)	USGS
Hydrographic data	Stream network and reaches (RF3)	NHD, Field surveys
	Bathymetry Data	VIMS
Watershed activities/ uses data and information related to fecal coliform production	Information, data, reports, and maps that can be used to support fecal coliform source identification and loading	VDH-DSS Shoreline Surveys State, county, and city governments, local groups and stakeholders
	Livestock inventory	VA DCR, NRCS, VA DEQ, VIMS, local SWCDs
	Wildlife inventory	VIMS, CCRM
	Septic systems inventory and failure rates	U.S. Census Bureau
	Straight pipes	U.S. Census Data
	Shoreline Sanitary Surveys	VDH-DSS
Environmental monitoring data	Ambient in-stream monitoring data	VA DEQ, VDH-DSS
	Bacteria Source Tracking Data	VA DEQ

Notes:
CCRM: Center for Coastal Resources Management
VIMS: Virginia Institute of Marine Science
VA DCR: Virginia Department of Conservation and Recreation
VA DEQ: Virginia Department of Environmental Quality
VDGIF: Virginia Department of Game and Inland Fisheries
EPA: Environmental Protection Agency
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Data
NRCS: Natural Resources Conservation Service
SWCD: Soil and Water Conservation District
USGS: United States.Geological Survey
VDH-DSS: Virginia Department of Health, Division of Shellfish Sanitation

2.2 Watershed Description and Identification

The Hungars Creek Watershed is located within the borders of Northampton County. The watershed is approximately 1,939 acres and Northampton County is approximately 105,187 acres. As shown in **Figure 2-1**, the major road that runs through the watershed is State Hwy Route 622, located in the northern portion of the watershed.

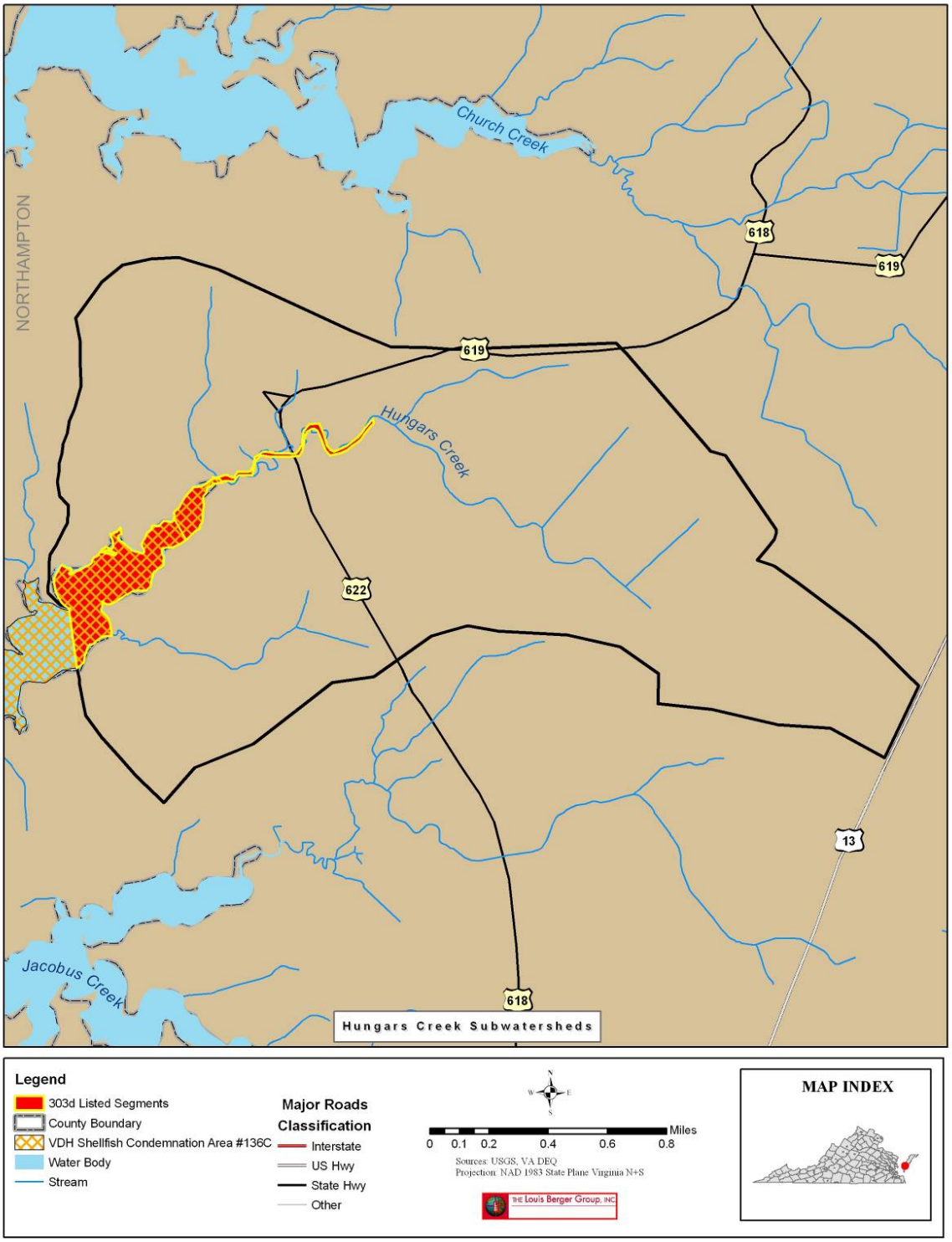

Figure 2-1: Location and Boundary of the Hungars Creek Watershed

2.2.1 Topography

A digital elevation model (DEM) based on USGS National Elevation Dataset (NED) was used to characterize topography in the watershed. NED data were obtained from the National Map Seamless Data Distribution System maintained by the USGS Eros Data Center. Elevation within the watershed ranges from 0 to 39 feet (0 to 12 meters) above mean sea level.

2.2.2 Soils

The Hungars Creek Watershed soil characterization was based on the Natural Resource Conservation Service (NRCS) Soil Survey Geographic (SSURGO) database. There are ten general soil associations within the watershed (**see Table 2-2**). The three dominant soil types in the watershed are the Bojac fine sandy loams (BoA), Nimmo sandy loams (NmA), and Munden sandy loams (MuA). Bojac fine sandy loams, which compose 38% of the soils in the watershed, are nearly level to gently sloping, very deep, well drained soils. Nimmo sandy loams, composing 18% of the soils in the watershed, are level to gently sloping, very deep, poorly drained soils. Munden sandy loams, which make up 15% of the watershed, are nearly level to gently sloping, very deep moderately well drained soils.

Table 2-2: Soil Types within the Hungars Creek Watershed

Map Unit	Soil Type	Acres	Percentage of Watershed
Bhb	Bojac loamy sand	113	6
BkA	Bojac sandy loam	90	5
BoA	Bojac fine sandy loam	742	38
ChA	Chincoteague silt loam	63	3
DrA	Dragston fine sandy loam	28	2
MoD	Molena loamy sand	144	7
MuA	Munden sandy loam	287	15
NmA	Nimmo sandy loam	355	18
PoA	Polawana loamy sand	56	3
W	Water	61	3
Grand Total		**1939**	100

The hydrologic soil groups within the watershed are presented in **Table 2-3**. The hydrologic soil groups represent different levels of infiltration capacity of the soils. Hydrologic soil group “A” designates soils that are well to excessively well drained, whereas hydrologic soil group “D” designates soils that are poorly drained. This means that soils in hydrologic group “A” allow a larger portion of the rainfall to infiltrate and

become part of the ground water system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-4**.

Table 2-3: Hydrologic Soil Groups within the Hungars Creek Watershed

Hydrologic Soil Group	Total Acres	Percentage of Watershed
A	144	7
A/D	56	3
B	1232	64
C	28	1
D	418	22
Not Identified	61	3
Total	**1,939**	**100**

Table 2-4: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover
A/D	Combination of Hydrologic Soil Groups A and D

2.2.3 Land Use

Land use characterization for the Hungars Creek Watershed was based on land cover data from the NLCD 2001 Land Use Dataset. The distribution of land uses in the watershed by land area and percentage is presented in **Table 2-5**. Dominant land uses in the watershed were found to be agricultural (54%) and forest (39%), which account for 93% of the total land area in the watershed. Brief descriptions of land use classifications are presented in **Table 2-6**. **Figure 2-2** depicts the land use distribution within the Hungars Creek Watershed.

Table 2-5: Land Use within the Hungars Creek Watershed

General Land Use Category	Specific Land Use Types	Acres	Percent of Watershed	Total Percent
Water/ Wetlands	Open Water	54	3	6
	Woody Wetlands	29	1	
	Emergent Herbaceous Wetlands	37	2	
Developed	Developed, Open Space	9	<1	54
	Developed, Low Intensity	2	<1	
	Developed, Medium Intensity	2	<1	
Agriculture	Pasture/Hay	462	24	
	Cultivated Crops	577	30	
Forest	Deciduous Forest	366	19	39
	Evergreen Forest	338	17	
	Mixed Forest	52	3	
Other	Barren Land	11	1	1
Total		**1,939**	**100**	**100**

Table 2-6 Descriptions of Land Use Types

Land Use Type	Description
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water.
Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential	Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.
Commercial/ Industrial/ Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crop	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.
Quarries/Strip Mines/Gravel Pits	Areas of extractive mining activities with significant surface expression.
Transitional	Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)
Urban/Recreationa l Grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Source: Multi-Resolution Land Characteristics Consortium NLCD

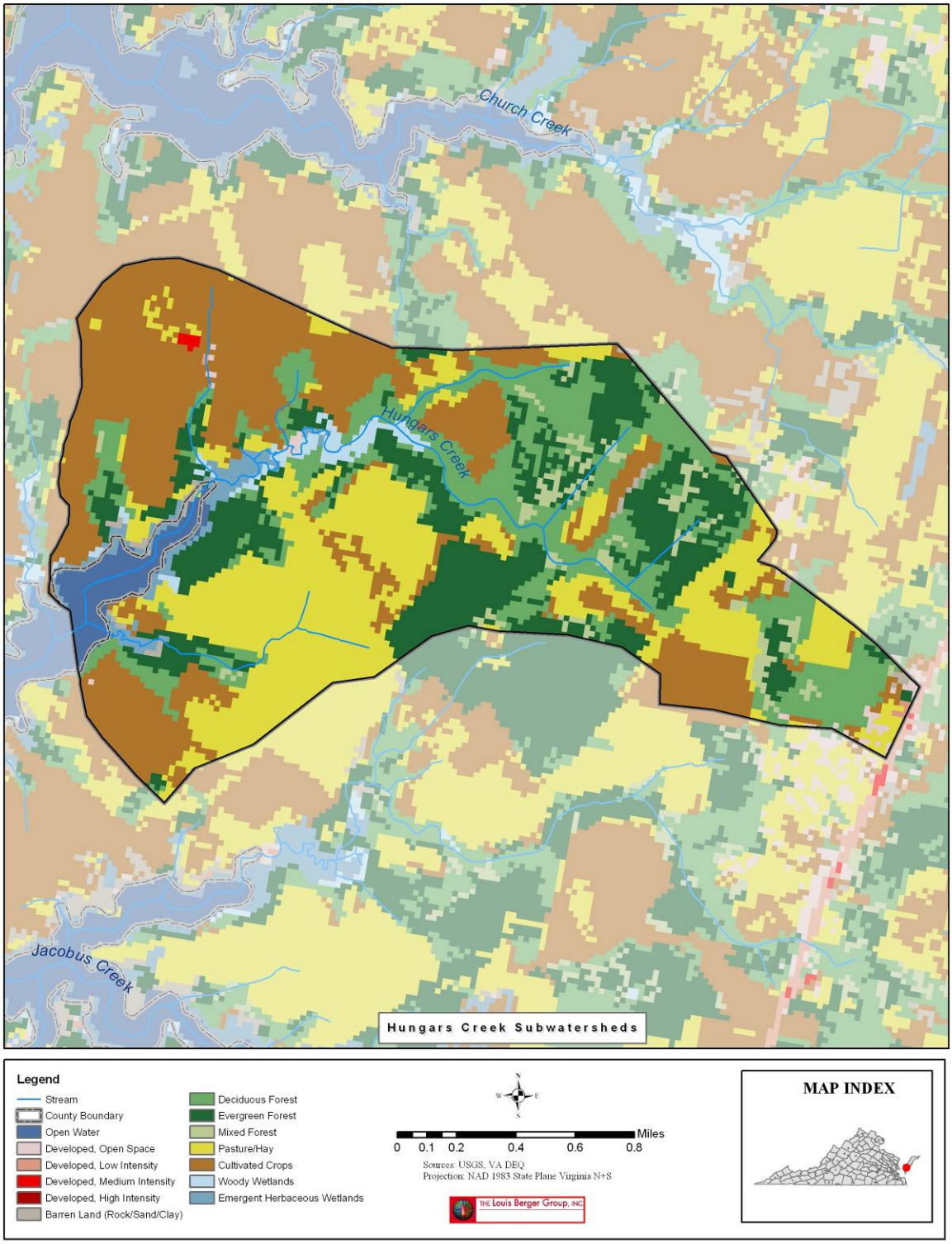

Figure 2-2: Land Use in the Hungars Creek Watershed

2.3 Ambient Water Quality Data

Environmental monitoring efforts in the Hungars Creek Watershed have been conducted by the Virginia Department of Environmental Quality (VA DEQ) and the Virginia Department of Health, Division of Shellfish Sanitation (VDH-DSS). Water quality data were obtained from both VA DEQ and VDH-DSS. The locations of the water quality monitoring stations are depicted in **Figure 2-3**.

The following sections will summarize and present the available monitoring data used in the bacteria TMDL development for the shellfishing impaired segment and for the recreation impaired segment of the Hungars Creek Watershed.

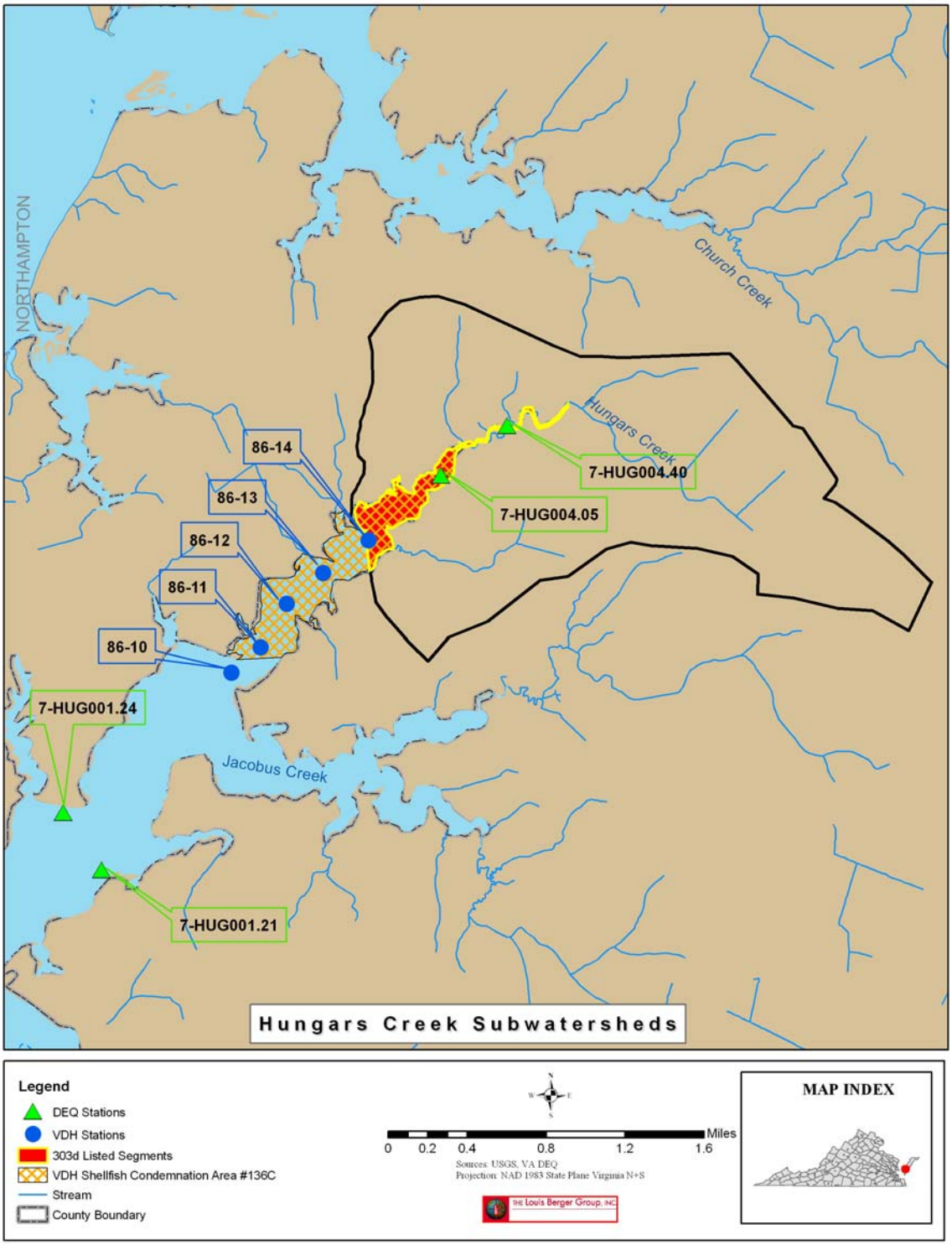

Figure 2-3: Hungars Creek Watershed DEQ and VDH Water Quality Stations

2.3.1 VA DEQ Bacteria Water Quality Data

VA DEQ conducted sampling at four water quality monitoring stations located within the Hungars Creek Watershed. One of the four water quality monitoring stations (7-HUG004.05) is located in the condemnation area and both recreation and shellfish use impaired segments of the Hungars Creek Watershed. One of the four water quality monitoring stations (7-HUG004.40) is located in the recreation use impaired segment, only. Since the recreation impaired segment of Hungars Creek is located in the transition zone, measurements for both fecal coliform and enterococci are used as the bacterial indicator and assessed for compliance with Virginia water quality standards (geometric mean and single sample maximum). However, enterococci data is not available for these stations and fecal coliform data is only available for station 7-HUG004.40. Only the single sample maximum criterion was applied to the fecal coliform data (instantaneous maximum), because the total samples taken per month did not meet the requirement for VA DEQ's standard for geometric mean, which requires that at least two samples be taken over a thirty day period. In total, 46 percent of the fecal coliform measurements exceeded the single sample maximum criterion (**Table 2-7** and **Figure 2-4**).

Table 2-7: VA DEQ Fecal Coliform Data in the Estuary of Hungars Creek

Hungar Creek	Station	Date Range	No. of Samples	Min	Max	Avg	Geo. Mean[1] Exceedances		Inst. Max (SSM)[2] Exceedances	
				counts/100mL	counts/100mL	counts/100mL	No.	%	No.	%
Impaired Segment	7-HUG004.40	1997-2003	39	100	2000	579	-	-	18	46
	7-HUG004.05	No data								

[1]Geometric mean fecal coliform concentration of 200 counts/100 ml of water for two or more samples taken during any calendar month.

[2] Instantaneous maximum enterococci bacteria concentration of 400 counts/100 ml (SSM = Single Sample Maximum)

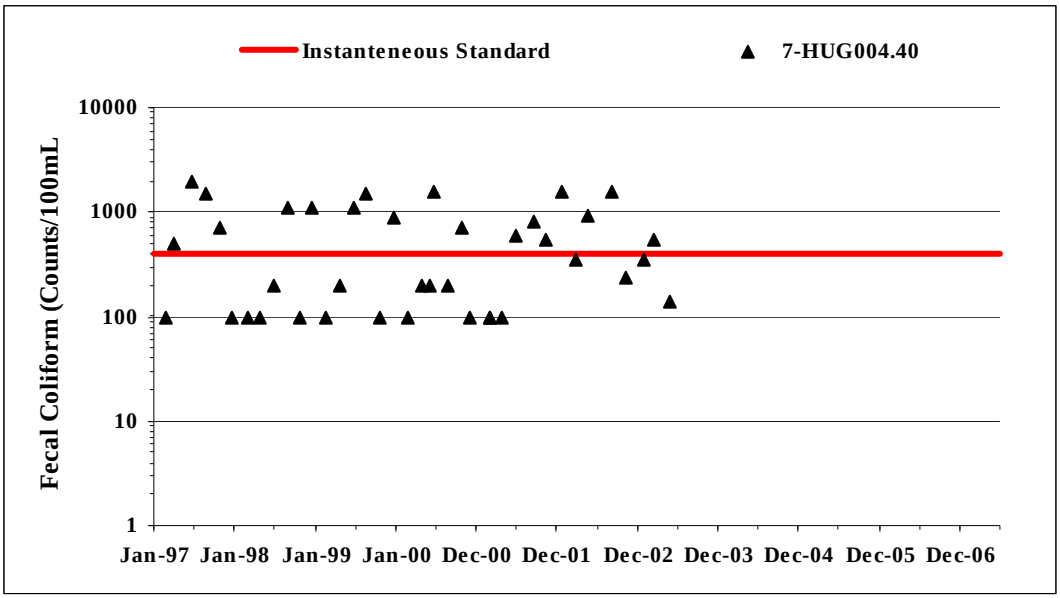

Figure 2-4: Fecal Coliform Counts in the Estuary of Hungars Creek

2.3.2 VDH-DSS Water Quality Data

VDH-DSS conducted fecal coliform sampling at four water quality monitoring stations located in the condemned area of the Hungars Creek Watershed and at one station located approximately one mile downstream from the condemned area (**Figure 2-3**). One of the stations (86-14) is located within the shellfish use impaired segment of Hungars Creek. VDH-DSS also collected samples for salinity, temperature, conductivity, field pH, and dissolved oxygen. The fecal coliform data was analyzed using the Most Probable Number method (MPN). **Table 2-8** shows a summary of the data collected at VDH-DSS stations located in the impaired segment of Hungars Creek and the boundary stations. The bolded stations listed in **Table 2-8** were used for the development of the shellfish bacteria TMDL.

Table 2-8: Data Range and Counts for Fecal Coliform of VDH-DSS Stations

Stream	Location	Station	Count	Range
Hungars Creek	Impaired Segment	**86-14***	45	2003 - 2006
	Boundary**	**86-13***	45	2003 - 2006
		86-12*	45	2003 - 2006
		86-11*	45	2003 - 2006
		86-10	45	2003-2006

* Station is also located within condemnation area #136C

** located downstream from the impaired segment

The geometric mean and 90th percentile values were computed based on the last 30 measurements (usually over last 30 months) of fecal coliform data collected at each monitoring station. All computed geometric mean and 90th percentile values were assessed for compliance with Virginia water quality standards (**Table 2-9**, **Figure 2-5**, and **Figure 2-6)**.

The highest percentage of exceedances of the VA standard for geometric mean and 90th percentile were generally found at the stations furthest upstream (station 86-14, 86-13 and 86-12) (**Figure 2-5** and **Figure 2-6**). In contrast, the station furthest downstream in the condemned area showed no exceedances for the geometric mean and a 6% exceedance for the 90th percentile VDH standard. The station located outside the condemned area showed no exceedances for both the geometric mean and the 90th percentile VDH standard. This indicates that the most likely source for fecal coliform originated in the watershed rather than from tidal inputs.

Table 2-9: Exceedances of the Geometric Mean and 90th Percentile at VDH Stations in the Impaired Segment and Boundary Area

Hungars Creek	**Station**	**Number of Values**	**Number of Geometric Mean** Exceedances	**Number of 90th Percentile** Exceedances
Impaired Segment	86 - 14*	15	15	15
Boundary**	86 – 13*	15	15	15
	86 – 12*	15	6	15
	86 – 11*	15	0	6
	86 - 10	15	0	0
	Total number of values	60	36	51
	Total % Exceedances		**60.0**	**85.0**

* Station is located within condemnation area #136C

**located downstream from the impaired segment

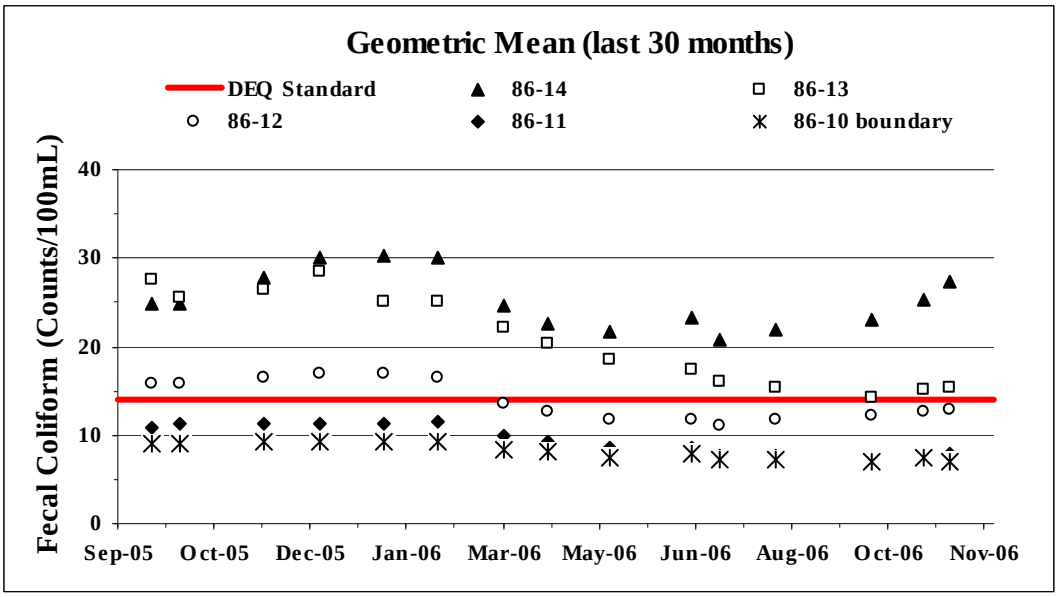

Figure 2-5: Geometric Mean of Fecal Coliform Samples Collected at VDH-DSS Stations

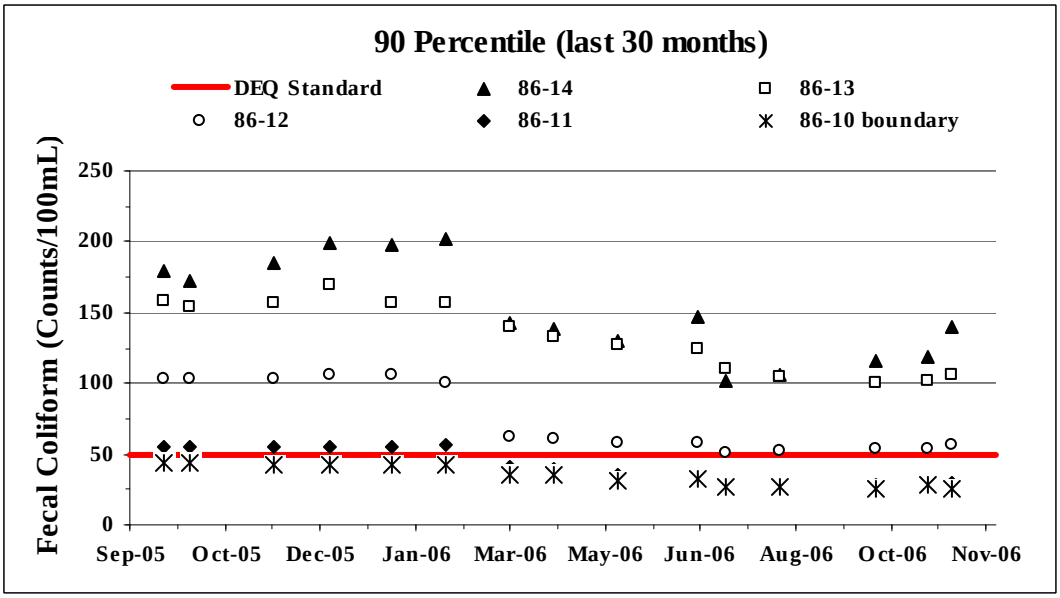

Figure 2-6: 90th Percentile of Fecal Coliform Samples Collected at VDH-DSS Stations

On several occasions the fecal coliform data were classified by flood, ebb, low or high tide collecting conditions in order to assess if tide conditions impacted the distribution of the BST data. Under ebb tide conditions, direction of water flow is out of the estuary, towards the bay. Therefore, any fecal coliform present in the estuary at ebb or low tide would most likely have come from the watershed. Under flood conditions, water is moving into the estuary, from the bay. Therefore, at flood or high tide, bay waters are a

possible source of fecal coliform. Tide condition data were collected by VA DEQ at the time of sampling. Based on this analysis, three of nine exceedences occurred under flood conditions and six of nine exceedences occurred under ebb conditions. There were no exceedences at low or high tide. This also indicates that the bacteria source is most likely from the watershed.

2.3.3 Bacteria Source Tracking Data

As part of the TMDL development, Bacteria Source Tracking (BST) sampling was conducted at one location in the watershed. The objective of the BST study was to identify the sources of fecal coliform in the listed segment of Hungars Creek. After identifying these sources, this information was used in the model set-up, and in the distribution of fecal coliform loadings among the various sources. The BST was also used in the development of the load allocations.

There are various methodologies used to perform BST, which fall into three major categories: molecular, biochemical and chemical. Molecular (genotype) methods are referred to as "DNA fingerprinting," and are based on the unique genetic makeup of different strains, or subspecies, of fecal coliform bacteria. Biochemical (phenotype) methods are based on detecting biochemical substances produced by bacteria. The type and quantity of these substances are measured to identify the bacteria source. Chemical methods are based on testing for chemical compounds that are associated with human wastewaters, and are restricted to determining if sources of pollution are human or non-human.

The Antibiotic Resistance Analysis (ARA) method of BST was used for the Hungars Creek TMDL. ARA has been the most widely used and published BST method to date and has been employed in Virginia, Florida, Kansas, Oregon, South Carolina, Tennessee, and Texas. Advantages of ARA include low cost per sample, and fast turnaround times for analyzing samples. The method can also be performed on large numbers of isolates; typically, 48 isolates per unknown source such as an in-stream water quality sample.

BST was conducted monthly between 2003 and 2004 at one station on the shellfish impaired segment of Hungars Creek. Results from this sampling period indicate that bacteria from human, livestock, wildlife, and pet sources are present in Hungars Creek.

During each sampling season, a total of 12 sampling events were conducted at station 86-14. This station is located in the impaired segment approximately 2.5 miles from the mouth of Hungars Creek (**Figure 2-3**). Four categories of fecal bacteria sources were considered: wildlife, human, livestock and pet. Results from all 12 sampling events at the station are presented in **Table 2-10** and results are depicted in **Figure 2-7** and **Figure 2-8**.

Table 2-10: BST Sampling Events within the Hungars Creek Watershed

Station	Date of Sample	Number of Isolates	Wildlife	Human	Livestock	Pet
86-14	10/6/2003	24	71%	21%	0%	8%
	11/6/2003	24	4%	92%	4%	0%
	12/4/2003	12	25%	50%	8%	17%
	1/5/2004	24	4%	63%	21%	12%
	2/19/2004	5	0%	0%	60%	40%
	3/30/2004	24	33%	17%	33%	17%
	4/1/2004	24	21%	42%	25%	12%
	5/13/2004	24	12%	33%	17%	38%
	6/29/2004	24	42%	25%	8%	25%
	712/2004	24	42%	46%	8%	4%
	8/10/2004	24	21%	0%	4%	75%
	9/23/2004	24	4%	88%	8%	0%
		Average	**23%**	**40%**	**16%**	**21%**

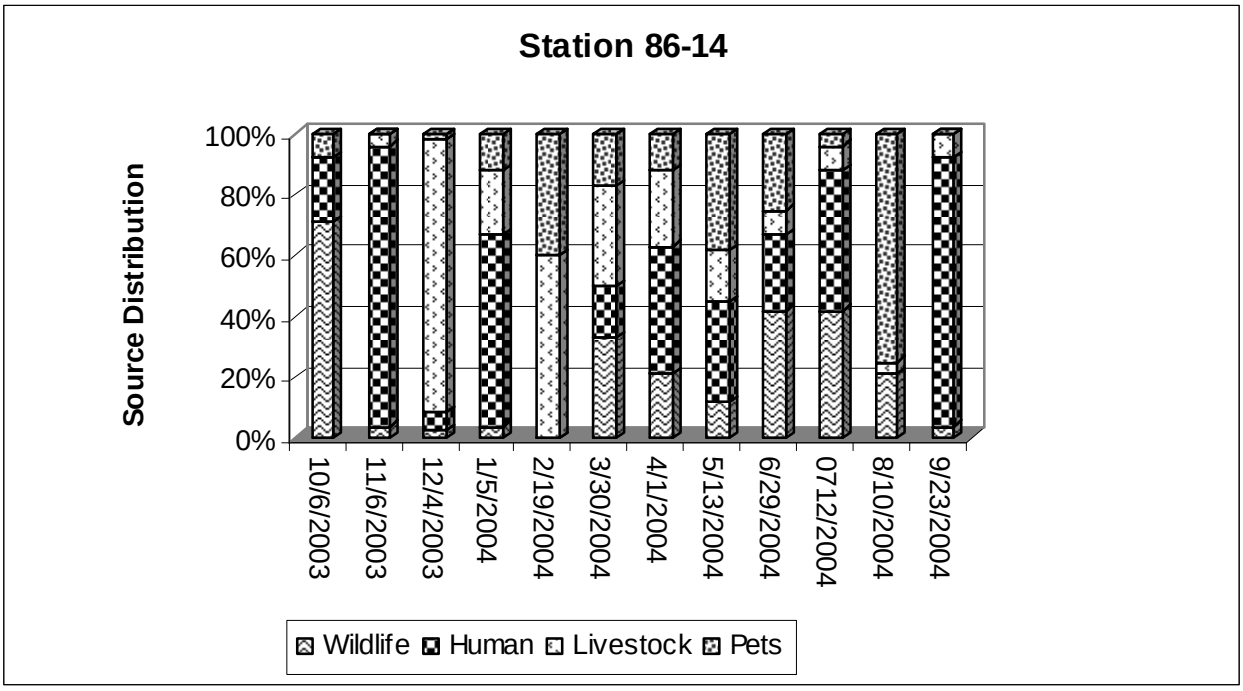

Figure 2-7: BST Results (by date) within the Hungars Creek Watershed

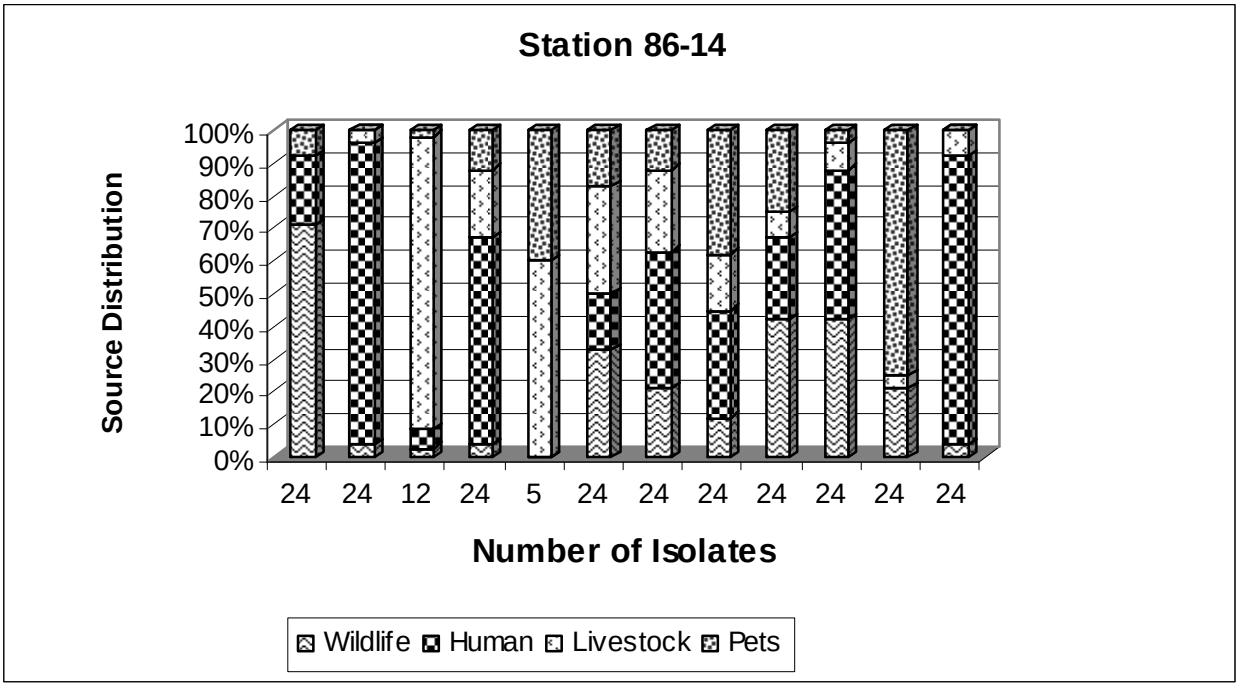

Figure 2-8: BST Results (by number of isolates) within the Hungars Creek Watershed

2.4 Fecal Coliform Source Assessment

This section focuses on characterizing the sources that potentially contribute to the fecal coliform loading in the Hungars Creek Watershed. These sources include permitted facilities, sanitary sewer systems and septic systems, livestock, wildlife, pets, and land application of manure and biosolids. Chapter 3 includes a detailed presentation of how these sources are incorporated and represented in the model.

2.4.1 Permitted Facilities

Based on data obtained from the VA DEQ, there are no permitted dischargers in the Hungars Creek Watershed.

2.4.2 Extent of Sanitary Sewer Network

Houses can be connected to a public sanitary sewer, a septic tank, or the sewage can be disposed by other means. Estimates of the total number of households using each type of waste disposal are presented in the next section.

2.4.3 VDH-DSS Shoreline Sanitary Survey Data

The shoreline survey is used as a tool to identify nonpoint source contribution to bacteria problems. The most recent VDH-DSS survey of Hungars Creek watershed in November

through December of 2005 noted 2 potential sources of environmental pollution (**Table 2-11** and **Figure 2-9).** The term "direct discharge" in **Table 2-11** indicates that the sanitary source has a direct impact on shellfish waters.

Table 2-11: VDH-DSS Sanitary Survey

Survey ID	Pollution Type	Name	City/County	Potential Pollution Source	Direct Discharge (Y/N)
2	Potential Boating Activity	Vaucluse Shore Association	Northampton	Private boat ramp and pier, in-out ramp boating service. No boat holding tank pump-out facilities or dump station facilities provided.	N/A
3	Solid Waste Dumpsite	Public satellite dumpster location	Northampton	4 trash dumpsters and 5 recycling bins located 50' from Hungars Creek	Y

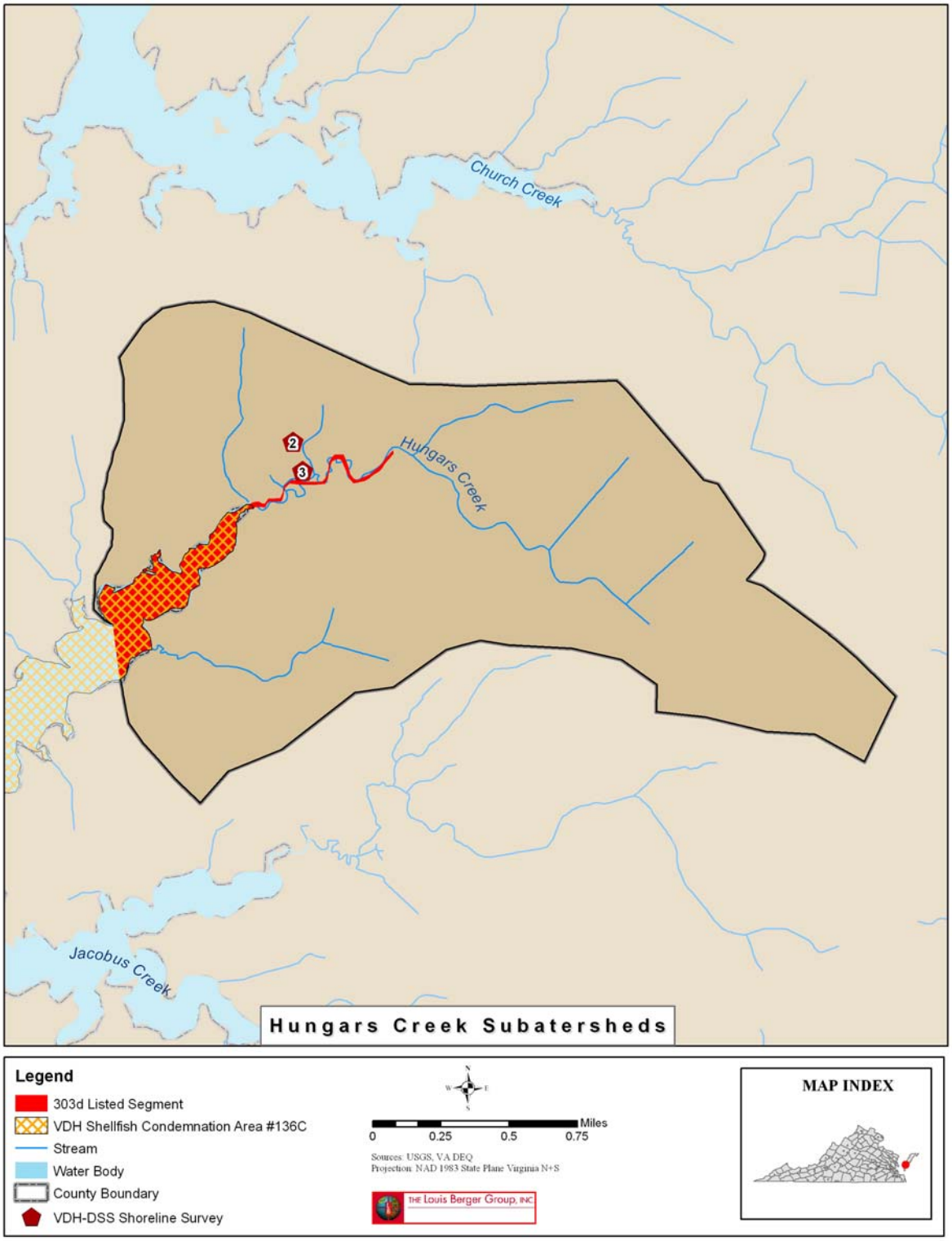

Figure 2-9: VDH-DSS Sanitary Survey within the Hungars Creek Watershed

2.4.4 Population Estimates

The 2004 U.S. Census Bureau census track data for Northampton County were reviewed to establish the population growth rates and number of housing units in the watershed. The 1990 census data documents the distribution of houses on sewage systems, septic systems, and other means (considered to be straight pipes). These 1990 estimated distributions were applied to the 2004 population and housing unit numbers for each watershed. A summary of the census data and population estimates used for the Hungars Creek Watershed are presented in **Table 2-12**. In order to determine the amount of fecal coliform contributed by human sources, it is necessary to estimate the failure rates of septic systems. The number of failing septic systems in the watershed was based on the US Census data. The number of households in each watershed were determined from US Census Bureau data and then multiplied by a septic failure rate of 12% (VADEQ, 2005).

Table 2-12: Population Estimates in the Hungars Creek Watershed*

Population	Number of Houses	Houses on Public Sewer	Houses on Septic Systems	Houses on Other Means	Failing Septic Systems**
182	82	12	62	8	7

*Source: 2004 and 1990 US Census Data
** Based on a 12% failure rate

2.4.5 Livestock

An inventory of the livestock the Hungars Creek Watershed was conducted using data and information provided by United States Department of Agriculture (USDA) National Agricultural Statistics Service, Virginia's Department of Conservation and Recreation, NRCS, Virginia Agricultural Statistics Service (2002), the 2001 Virginia Equine Report, Soil and Water Conservation Districts (SWCD), as well as field surveys. This information has been summarized into a database by subwatershed by CCRM (Center for Costal Resource Management). This database was used to determine the livestock inventories shown in **Table 2-13.**

Table 2-13: Livestock Types Present in the Hungars Creek Watershed*	
Animal Type	**Total**
Cattle	6
Pigs	4
Chickens	2
Horses	2
Sheep	1

*Source: CCRM

2.4.6 Wildlife

Similar to livestock contributions, wildlife contributions of fecal coliform can be indirect or direct. Indirect sources are those that are carried to the stream from the surrounding land via rain and runoff events, whereas direct sources are those that are directly deposited into the stream.

The wildlife inventory for this TMDL was developed based on a number of information and data sources, including habitat availability, Department of Game and Inland Fisheries (DGIF) harvest data and population estimates; and stakeholder comments and observations. The number of animals in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. This information has been summarized into a database by subwatershed by CCRM. Information from this database was used to determine the wildlife inventory shown in **Table 2-14.**

Table 2-14: Wildlife Inventory for the Hungars Creek Watershed*	
Animal Type	**Total**
Ducks	89
Geese	66
Deer	93
Raccoons	68

*Source: CCRM

2.4.7 Pets

The two types of domestic pets that were considered as potential sources of bacteria in this watershed were cats and dogs. The number of pets residing in the watershed was estimated by determining the number of households in the watershed, and multiplying this number by national average estimates of the number of pets per household which are 0.543 dogs per household and 0.593 cats per household (AVMA). Based on these estimates, the numbers of dogs and cats estimated to reside within the watershed are shown in **Table 2-15**.

Table 2-15: Pet Inventory for the Hungars Creek Watershed*	
Dogs	**Cats**
39	42

*Source: AVMA

3.0 Modeling Approach

This section describes the modeling approach used in the TMDL development for Hungars Creek. The primary focus of this chapter is on the sources represented in the model, assumptions used, and model set-up.

3.1 Modeling Goals

The goals of the modeling approach were to develop a predictive tool for the waterbody that can:

- represent a fecal coliform water quality model for small coastal basins
- represent the watershed hydrologic characteristics and tidal volume in steady state
- represent the nonpoint sources of fecal coliform and their respective contribution
- use kinetic data (die-off rate of fecal coliform)
- estimate the in-stream pollutant loadings under steady state
- allow for direct comparisons between the in-stream conditions and the water quality standard

3.2 Modeling Area

Modeling is applied for Hungars Creek in areas designated by VA DEQ (VA 303(d) list of 1998) and VDH (condemnation zone #136C). The designated areas are saline and are tidally influenced by an unrestricted connection to the Chesapeake Bay.

3.3 Modeling Strategy

A simplified model approach, jointly developed by EPA, VA DEQ, VA DCR, Maryland Department of the Environment (MDE), VDH, VIMS, United States Geological Survey (USGS), Virginia Polytechnic University, James Madison University, and Tetra Tech, was selected to estimate present fecal coliform loads for small coastal basins, to calculate allocation, and needed reductions for each source (VA DEQ, 2004, 2006a). The model is a Microsoft EXCEL spread sheet that calculates estuary fecal coliform loads based on steady state mass balance in the bay over a tidal period (The prevailing tide in the estuary of Hungars Creek is the lunar semi-diurnal (M2) tide with a tidal period of 12.42 hours). The steady state condition of the model mirrors average condition of the bay system and incorporates the following assumptions:

1. Water is incompressible
2. Water is completely mixed:
    a. Density variations because of temperature and salinity changes by saline and freshwater inflow are negligible
    b. Variations of fecal coliform concentration are negligible
3. The saline volume flowing into the bay is based on an average tidal range, the surface area of the bay, and an average fraction of incoming new ocean water
4. The volume of water flowing out the bay is the sum of assumption Nr. 1, 2 and 3
5. Average freshwater flow is estimated based on observed freshwater flow per unit area from USGS flow gauge station in vicinity
6. The source precipitation and sink evaporation are negligible
7. Fecal coliform is decayed through a combined daily first order kinetic rate

The water balance in the bay under steady state is defined as follows (the change of the total volume of water in the bay (V_b) from one tidal cycle to the next is zero; $\frac{dV_b}{dT} = 0$):

$$0 = Q_0 - Q_b + Q_f \qquad (1)$$

In which Q_0 = Volume of water entering the bay through flood tide which was not released from the estuary on the previous ebb tide [m^3 per tidal cycle]

Q_b = Volume of water flowing out of the bay through ebb tide which did not enter the estuary on the previous flood tide [m^3 per tidal cycle]

Q_f = Volume of net freshwater over a tidal period [m^3 per tidal cycle]

Q_0 is obtained when the volume of water which flows into the bay from the ocean during flood (tidal prism) is corrected by the average fraction of incoming new ocean water (ocean tidal exchange ratio):

$$Q_0 = \beta * Q_T \qquad (2)$$

In which Q_T = tidal prism [m^3 per tidal cycle]

β = Ocean tidal exchange ratio [-]

The ocean tidal exchange ratio is quantified through salinity levels in the bay and ocean and defined by the following equation by Fischer et al. (1979) (Guo and Lordi, 2000):

$$\beta = \frac{S_f - S_e}{S_0 - S_e} \qquad (3)$$

In which S_f = Average salinity of ocean water entering the bay during flood [‰]

S_e = Average salinity of bay water leaving the bay during ebb [‰]

S_0 = Salinity of the water at the ocean site [‰]

Based on simulation runs with the Tidal Prism Water Quality Model (TPWQM) in Virginia coastal embayments by Kuo et al. (1998), the ocean tidal exchange ratio ranged between 0.3 and 0.7.

The tidal prism is the volume of water flowing into the bay from the ocean through the inlet during flood tide and is computed through the surface area of the bay and the mean tidal range. The mean tidal range is defined as the mean difference between high and low tidal levels.

$$Q_T = TD_{ave} * SA_B \qquad (4)$$

In which TD_{ave} = Mean tidal range [m per tidal cycle]

SA_B = Water surface area of the bay [m^2]

When equation (1) is formulated as mass balance for fecal coliform and a total daily death rate for fecal coliform is enclosed, the following equation can be formulated ($\frac{dV_bC}{dT} = 0$):

$$0 = Q_0C_0 - Q_bC_b + Q_fC_f - k_bV_bC_b \qquad (5)$$

In which C_0 = Fecal coliform concentration entering the bay through flood tide which was not released from the bay on the previous ebb tide [MPN/100mL]

C_b = Fecal coliform concentration leaving the bay through ebb tide which did not enter from the bay on the previous flood tide [MPN/100mL]

C_f = Fecal coliform concentration from the watershed and the local area in the bay during tidal cycle [MPN/100mL]

k_b = Total death rate for fecal coliform in bay [day^{-1}]

V_b = Mean total volume of water in the bay [m^3]

3.3.1 Estimation of the Current Daily Load Capacity of the Bay

When Q_fC_f equals L_t (total load in fresh water) and equation (5) is solved for L_t, the following equation yields:

$$L_t = (C_b(Q_b + k_bV_b) - Q_0C_0) * f_{conv} \qquad (6)$$

In which L_t = Estimated daily load capacity of the bay [counts/day]

f_{conv} = Conversion factor: 24/12.42 * 10^4 (the factor 24/12.42 accounts for the remaining 11. 38 hrs out of 24 hrs, the factor 10^4 converts fecal coliform unit counts/100mL into counts/m^3)

Equation (6) is used to calculate the current daily load capacity for fecal coliform in the bay. The daily load capacity is calculated separately for the maximum geometric mean and the 90th percentile measured in the bay (C_b) and at the boundary between bay and Chesapeake Bay (C_0). The current load capacity with the highest load is used for the load allocation to account for critical conditions.

3.3.2 Estimation of the Allowable Daily Load Capacity of the Bay

When C_b and C_0 in equation (6) are substituted with VA DEQ criterion for fecal coliform (C_c), the following equation yields:

$$L_t = (C_c(Q_b + k_bV_b) - Q_0C_c) * f_{conv} \qquad (7)$$

In which C_c = Concentration of fecal coliform for VA criteria of geometric mean and 90th percentile

Equation (7) is used to calculate the allowable daily load for fecal coliform in the bay based on VA DEQ criteria for fecal coliform in shellfish waters. The allowable daily load capacity is computed for the criterion with the highest current load capacity.

The difference between the current and the allowable daily load capacity is the required reduction of fecal coliform load in the watershed.

3.4 Volume Estimations

Four volumes of water needed to be considered for developing the fecal coliform TMDL for the Hungars Creek watershed:

- Volume of water at sea level in the bay
- Volume of water entering the bay through flood tide
- Volume of water flowing out of the bay through ebb tide
- Volume of net freshwater over a tidal cycle

3.4.1 Volume of Water at Sea Level

The volume of water at sea level was estimated based on bathymetry measurements in the estuary of Hungars Creek. The estimated volume for the estuary is 82,406 m^3.

3.4.2 Volume of Water Entering the Bay

The volume of water entering the bay through flood tide was computed applying equation (2) and (4). The surface area was estimated based on bathometry data and the mean tidal ranges for the Hungars Creek watershed were obtained from NOAA's website "Tide and Currents" (NOAA, 2006). The tidal station "Nassawadox Creek" was used for the mean tidal range of Hungars Creek. An ocean tidal exchange ratio of 0.5 was selected for the estuary based on the maximum reported range from model test runs with the Tidal Prism Water Quality Model (TPWQM) in Virginia coastal embayments by Kuo et al. (1998).

Table 3-1 shows the estimated surface area and the mean tidal range for the estuary.

Table 3-1: Estimated Surface Area, Mean Tidal Range, and Calculated Incoming Volume for the Estuary of Hungars Creek

Estuary	Surface Area	Mean Tidal Range[1]	Calculated Volume (Q_0)
	m^2	m	m^3/tidal cycle
Hungars Creek	261,535	0.55	71,744

[1] Value based on NOAA station "Nassawadox Creek "

3.4.3 Volume of Water Flowing Out of the Bay

The volume of water flowing out of the bay through flood tide was computed applying equation (1) and solving for Q_b. This calculation yielded a volume of 75,203 m^3/tidal cycle.

3.4.4 Volume of Net Freshwater

The volume of fresh water entering the estuary of Hungars Creek was estimated based on average flow measurements over ten years (1994 through 2007). The closest USGS gauging station with available flow data that possesses a similar drainage area, distribution of land use, and elevation range is USGS 01677000 at Ware Creek near Toano, VA. The USGS station is approximately 40 miles away from Hungars Creek. Based on the average flow at the USGS station, the flow rate per square meter was computed and applied to the Hungars Creek watershed for obtaining the total volume of water entering the estuaries. **Table 3-2** shows the volume of water for the Hungars Creek watershed including the flow rate per square meter and the drainage area of the Hungars Creek watershed.

Table 3-2: USGS Flow Rate and Freshwater Volume for the Estuary of Hungars Creek

Flow Rate at USGS 01677000 [1]	Volume [2]
m^3/sec m^2	m^3/tidal cycle
9.86E-09	3,459

[1]Based on mean flow over 10 years (1986 - 1995) of 0.16 m^3/sec and a drainage area of 16,291,025 m^2
[2]Based on a drainage area of 7,846,887 m^2

3.5 Fecal Coliform Sources Representation

This section demonstrates which fecal coliform sources were included or represented in the model. In a tidally influenced system, three potential main sources need to be accounted for:

1. Sources from the watershed include human sources (failed septic systems permitted facilities), livestock, wildlife, and pets.
2. Sources within the estuary enclose only waterfowl.
3. Downstream boundary source from the boundary between estuary and the mouth of the bay.

The first two sources were accounted in a conglomerated number represented by fecal coliform measurements in the estuary. However, the individual sources such as human sources, pets, livestock, and wildlife are accounted through Bacteria Source Tracking (BST). The information of the BST was used to distribute fecal coliform loadings among the various sources.

The third source is represented by fecal coliform measurements taken at or close to the boundary between the estuary and bay.

Table 3-3 shows the maximum fecal coliform geometric mean and 90th percentile at each station located in the estuary and boundary of Hungars Creek. The table also shows whether VA DEQ standards for fecal coliform are exceeded. The maximum geometric mean and 90th percentile of fecal coliform are based on measurements of fecal coliform from 2003 to 2006. The bold values in the table are values used in the model for calculating the total daily load capacity.

Table 3-3: Maximum Geometric Mean and 90th Percentile for Hungars Creek in the Impaired Bacteria Segment (2003 - 2006)

Location	Station	Geometric Mean	Exceeds Geometric Standard: 14 MPN/100mL	90th Percentile	Exceeds 90th Percentile Standard: 49 MPN/100mL
Bacteria Impaired Segment	86 - 14*	**30**	Yes	**203**	Yes
Boundary**	86 - 13*	**28**	Yes	**170**	Yes
	86 - 12*	17	Yes	106	Yes
	86 - 11*	12	No	56	Yes
	86 - 10	9	No	44	No

* Station is also located within condemnation area #136C

** located downstream from the impaired segment

Note: Bold numbers were used in the model for calculating the TMDL

4.0 Allocation

The allocation analysis for the condemnation area of Hungars Creek is the third stage for the TMDL development. Its purpose was to develop the framework for reducing fecal coliform loading under the existing watershed conditions so water quality standards can be met. The TMDL represents the maximum amount of pollutant that the stream can receive without exceeding the water quality standard. The load allocations for the selected scenarios were calculated using the following equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

Where,

WLA = waste load allocation (point source contributions);

LA = load allocation (nonpoint source allocation); and

MOS = margin of safety.

Typically, several potential allocation strategies would achieve the TMDL endpoint and water quality standards. Available control options depend on the number, location, and character of pollutant sources.

4.1 Incorporation of Margin of Safety

The margin of safety (MOS) is a required component of the TMDL to account for any lack of knowledge concerning the relationship between effluent limitations and water quality. According to EPA guidance (*Guidance for Water Quality-Based Decisions: The TMDL Process, 1991*), the MOS can be incorporated into the TMDL using two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS will be implicitly incorporated into this TMDL. Implicitly incorporating the MOS will require that allocation needs to meet the 30-month geometric mean of 14 MPN/100mL and the 90th percentile of 49 MPN/100mL any time.

4.2 Waste Load Allocation

There are no permitted wastewater treatment facilities located in the Hungars Creek watershed. However, waste load allocations in watersheds where there are no individual VPDES permitted facilities with bacteria effluent limitations are usually represented in the TMDL as 1% of the Total Maximum Daily Load.

4.3 Load Allocation Development

The reduction of loadings from nonpoint sources, including livestock, pets, and wildlife direct deposition, is incorporated into the load allocation. Fecal coliform loadings (daily load capacity of the bay) were calculated in the estuary of the Hungars Creek watershed to obtain the current load and allowable load. The current load is the maximum value of the 30 month geometric mean and 90th percentile computed between 2003 and 2006. The required percent load reduction for the Hungars Creek watershed is estimated by subtracting the allowable load from the present load, dividing it by the current load, and multiplying it by 100. **Table 4-1** and **Table 4-2** show the computed model results of current load, allowable load, and reduction for the geometric mean and 90th percentile for the Hungars Creek watershed. The maximum values of the 90th percentile were used to calculate the load allocation and the TMDL in the watershed, since they represented the maximum current loads.

Table 4-1: Current Load, Allowable Load, and Required Reduction Based on the Geometric Mean for Fecal Coliform

Creek	Condemnation Area	Station	Volume (m^3)	Geometric Mean[1] (MPN/100mL)	Current Load (Counts/day)	Allowable Load (Counts/day)	Required Reduction
Hungars	136C	86-14	82,406	30	3.61E+10	1.55E+10	56.9%

[1] Maximum geometric mean based on measurements between 2003 and 2006

Table 4-2: Current Load, Allowable Load, and Required Reduction Based on the 90th Percentile for Fecal Coliform

Creek	Condemnation Area:	Station	Volume (m3)	90th Percentile[1] (MPN/100mL)	Current Load (Counts/day)	Allowable Load (Counts/day)	Required Reduction
Hungars	136C	86-14	82,406	203	2.71E+11	5.44E+10	79.9%

[1] Maximum 90th percentile based on measurements between 2003 and 2006

4.3.1 Hungars Creek Allocation Plan and TMDL Summary

The load allocation is based on Bacteria Source Tracking (BST) results for livestock, wildlife, human, and pets. The BST results are averages based on 12 samples taken at a VDH-VSS station between October 2003 and September 2004. Waste load allocations in watersheds where there are no individual VPDES permitted facilities with bacteria effluent limitations are usually represented in the TMDL as 1% of the Total Maximum Daily Load. This 1% is then subtracted from the Load allocations. This is reflected in **Table 4-3** which shows the fecal coliform TMDL allocation plan for Hungars Creek.

The requirements to meet the 90th percentile water quality standard of 49 MPN/100mL for Hungars Creek are:

- 100 % reduction of the human sources (failed septic systems and straight pipes).
- 100 % reduction of loading from livestock.
- 100 % reduction of loading from pets.
- 13 % reduction of loading from wildlife

A summary of the TMDL allocation plan for Hungars Creek is presented in **Table 4-4**.

Table 4-3: Hungars Creek: Distribution of Fecal Coliform under Existing Conditions, TMDL Allocation, and Reduction

Source	BST [1] Distribution (% of total load)	Existing Load (Counts/day)	Allocated Load (Counts /day)	Required Reduction (%)
Livestock	16	4.34E+10	6.07E+07	100
Wildlife	23	6.23E+10	5.37E+10	13
Human	40	1.08E+11	0.00E+00	100
Pets	21	5.69E+10	7.97E+07	100
Point Source[2]	-	-	5.44E+08	0
Total	100	2.71E+11	5.44E+10	80

[1] Average of 12 samples taken between October 2003 and September 2004
[2] there are no individual VPDES municipal point source dischargers; the WLA includes 1 percent of the total NPS allocations to account for future growth

Table 4-4: Hungars Creek TMDL Allocation Plan Loads (MPN/day)

WLA (Point Sources)	LA (Nonpoint sources)	MOS (Margin of safety)	TMDL
5.44E+08	**5.38E+10**	**IMPLICIT**	**5.44E+10**

5.0 TMDL Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the bacteria impairments on the watershed. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels in the waterbody. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the recent "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf With successful completion of implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

5.1 Staged Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. For example, in agricultural areas of the watershed, the most promising management practice is livestock exclusion from waterbodies. This has been shown to be very effective in lowering fecal coliform concentrations in waterbodies, both by reducing the cattle deposits themselves and by providing additional riparian buffers.

Additionally, in both urban and rural areas, reducing the human fecal loading from failing septic systems should be a primary implementation focus because of its health implications. This component could be implemented through education on septic tank pump-outs, as well as a septic system repair/replacement program and the use of alternative waste treatment systems. In urban areas, reducing the loading from leaking sewer lines could be accomplished through a sanitary sewer inspection and management program.

The iterative implementation of BMPs in the watershed has several benefits:

1. It enables tracking of water quality improvements following BMP implementation through followup monitoring;
2. It provides a measure of quality control, given the uncertainties inherent in computer simulation modeling;
3. It provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements;
4. It helps ensure that the most cost effective practices are implemented first; and
5. It allows for the evaluation of the adequacy of the TMDL in achieving water quality standards.

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

5.2 Link to ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality.

5.3 Reasonable Assurance for Implementation

5.3.1 Follow-Up Monitoring

VDH-DSS will continue sampling at the established bacteriological monitoring stations in accordance with its shellfish monitoring program. VADEQ will continue to use data from these monitoring stations and related ambient monitoring stations to evaluate improvements in the bacterial community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

5.3.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ also submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will

be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

5.3.3 Implementation Funding Sources

One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. Section 319 funding is a major source of funds for Virginia's Nonpoint Source Management Program. Other funding sources for implementation include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

5.3.4 Addressing Wildlife Contributions

In some waters for which TMDLs have been developed, water quality modeling indicates that even after removal of all of the sources of bacteria (other than wildlife), the stream will not attain standards under all flow regimes at all times. **However, neither the Commonwealth of Virginia, nor EPA are proposing the elimination of wildlife to allow for the attainment of water quality standards.** This is obviously an impractical and wholly undesirable action. While managing over-populations of wildlife remains as an option to local stakeholders, the reduction of wildlife or changing a natural background condition is not the intended goal of a TMDL.

Based on the above, EPA and Virginia have developed a TMDL strategy to address the wildlife issue. The first step in this strategy is to develop a reduction goal. The pollutant reductions for the interim goal are applied only to controllable, anthropogenic sources identified in the TMDL, setting aside any control strategies for wildlife. During the first implementation phase all controllable sources would be reduced to the maximum extent practicable using the staged approach outlined above. Following completion of the first phase, DEQ would re-assess water quality in the stream to determine if the water quality

standard is attained. This effort will also evaluate if the technical assumptions were correct.

In some cases, the effort may never have to go to the second phase because the water quality standard exceedances attributed to wildlife may be very small and fall within the margin of error. If water quality standards are not being met, a special study called a Use Attainability Analysis (UAA) may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources. The outcomes of the UAA may lead to the determination that the designated use(s) of the waters may need to be changed to reflect the attainable use(s). To remove a designated use, the state must demonstrate 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of bacterial contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10). All site-specific criteria or designated use changes must be adopted as amendments to the water quality standards regulations. Watershed stakeholders and EPA will be able to provide comment during this process. Additional information can be obtained at http://www.deq.state.va.us/wqs/WQS03AUG.pdf .

6.0 Public Participation

The development of the Hungars Creek TMDL would not have been possible without public participation. Two public meetings and one TAC were held within the watershed. The following is a summary of the meetings.

Public Meeting No. 1. The first public meeting was held at the Eastern Shore Agriculture Research and Extension Center, Virginia on June 30, 2007 to present the process for TMDL development, the Hungars Creek impaired segment, data that caused the segment to be on the 303(d) list, data and information needed for TMDL development, and preliminary findings. Although the meeting was publicized, no one attended. Copies of the presentation were available for public distribution.

Public Meeting No. 2 and TAC. This meeting was held on December 19, 2007 at the Eastern Shore Agriculture Research and Extension Center, Virginia. At this meeting, the revised source assessment, model development, and TMDL allocations were presented. Copies of the presentation were available for public distribution.

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