Virginia Department of Environmental Quality

Bacteria Total Maximum Daily Load (TMDL) Development for the Elizabeth River Watershed

Prepared by

THE Louis Berger Group, INC.
2445 M Street, NW Washington, DC 20037

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Executive Summary

This report addresses nine segments of the Elizabeth River that have been listed on the 2008 Impaired Waters - 303(d) List for recreation use due to exceedances of the criteria for enterococcus bacteria. Out of the nine impaired segments, five segments are located in the Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, and Paradise Creek (Cause Group Code G15E-02-02-BAC), two in the Lower and Upper Western Branch (Cause Group Code G15E-04-01-BAC), one in the Upper Lafayette (Cause Group Code G15E-05-02-BAC), and one in the Indian River (Cause Group Code G15E-02-05-BAC).

Description of the Study Area

The bacteria impaired segments are located within the borders of the Cities of Chesapeake, Virginia Beach, Portsmouth, Norfolk and Suffolk. The major roadways that run through the watershed are Routes 664, 64, 264 464 and 564. Route 664 runs from north to south through the middle of the watershed, and becomes Route 64 at the eastern boundary of the watershed. Route 264 runs from south to east and across the middle of the watershed. Route 464 run from south to north in the center portion of the watershed, ending in the city of Portsmouth.

Applicable Water Quality Standards

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "water quality standards means 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.)."

VA DEQ specifies the following criteria for recreational uses (VA DEQ, 2008) of waterbodies located in saltwater or in a transition zone:

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

Watershed Characterization

The first TMDL watershed, which includes the Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Indian River, Broad Creek, has a drainage area of 82,735 acres. The second TMDL watershed, which includes the Western Branch watershed, has a drainage area of 23,951 acres. The third TMDL watershed, which includes the Lafayette River watershed, has a drainage area of 10,304 acres. The fourth TMDL watershed, which includes Paradise Creek, has a drainage area of 1,716 acres. The land use characterization for the Elizabeth River watershed was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2005 Land Use Dataset. Dominant land uses in the watershed are developed (58%) and wetlands (24%). By TMDL watershed, dominant land uses are developed (55%) and wetlands (28%) in TMDL #1, developed (59%) and wetlands (21%) in TMDL #2, developed (78%) and water (12%) in TMDL #3, and developed (92%) and wetlands (4%) in TMDL #4.

Potential sources of bacteria include run-off from grazing livestock, agricultural practices, industrial waste, residential waste, and pet waste. Some of these sources are driven by dry weather and others are driven by wet weather. The potential bacteria sources in the watershed were identified and characterized and were found to include MS4 permitted facilities, failed septic systems, sanitary sewer overflows, marinas, livestock, wildlife, and pets.

Based on data obtained from VA DEQ, there are eight MS4 permits held in the Elizabeth River TMDL watershed: four Phase I MS4 permits and four Phase II MS4 permits. An inventory of livestock, wildlife, and pets was collected from data provided by the cities, the Census of Agriculture (2007), the Virginia Department of Game and Inland Fisheries (VDGIF), the American Veterinary Medical Association (AVMA), as well as from information from other sources.

TMDL Technical Approach

A simplified volumetric model approach[1] (simplified tidal prism bacteria model), developed for small coastal basins, was selected to estimate current bacteria loads, to calculate allocation, and to determine reductions for each source (VA DEQ, 2006). The model is a Microsoft EXCEL spreadsheet that calculates bacteria loads present in the estuary based on a 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
- maximum bacteria concentration measured in the estuary and at the boundary.

TMDL Calculations

The TMDL represents the maximum amount of a pollutant that the stream can contain 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 (non-point source allocation); and

MOS = margin of safety.

The margin of safety (MOS) is a required component of the TMDL, which accounts 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 the geometric mean enterococci standard of 35 counts per 100 mL and the single maximum standard of 104 counts per 100 mL with zero percent exceedance.

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[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 Sanitary (DSS), Virginia Institute of Marine Sciences (VIMS), United States Geological Survey, Virginia Polytechnic University, James Madison University, and Tetra Tech.

Waste Load Allocation

Since no municipal permitted facilities discharge into the bacteria impaired watersheds, no waste load was allocated to permitted facilities. However, in order to account for future growth, one percent of the LA of each TMDL watershed was allocated to each TMDL watershed (**Table E-1**). There are eight MS4 permit holders within the TMDL watersheds of the Elizabeth River. Of the eight, four are Phase I MS4 permit holders and the remaining four are Phase II permit holders. A waste load allocation was applied to MS4 permit holders based on the urban area of their covered areas within each TMDL watershed. For MS4 permit holders where its covered area was not available, the waste allocation was aggregated with the waste allocation of other MS4 permit holder. The WLA including existing load and required reduction for each MS4 permit holder is shown **Tables E-2** through **E-5.**

Table E-1: Allocated Waste Load per TMDL Watershed for Future Growth

TMDL Watershed	WLA for Future Growth (1% of the LA) (count/day)
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	8.45E+11
TMDL #2 Western Branch	1.64E+11
TMDL #3 Lafayette River	2.05E+11
TMDL #4 Paradise Creek	7.45E+08

Table E-2: Waste Load Allocation for Enterococci per MS4 Permit for TMDL #1				
MS4 Permit Holder	**MS4 Permit #**	**Existing Load**	**Allocated Load**	**Required Reduction**
		counts/day	**counts/day**	**%**
City of Norfolk (Phase 1)*	VA0088650	2.48E+14	1.18E+13	95%
City of Portsmouth (Phase 1)	VA0088668	9.28E+13	4.42E+12	95%
City of Chesapeake (Phase 1)	VA0088625	6.38E+14	3.04E+13	95%
City of Virginia Beach (Phase 1)	VA0088676	2.16E+14	1.03E+13	95%
Portsmouth Naval Medical Center (Phase 2)	VAR040045	1.99E+12	9.48E+10	95%
	Total	1.20E+15	5.70E+13	95%
*Including Norfolk State University (Phase II) permit holder				

Table E-3: Waste Load Allocation for Enterococci per MS4 Permit for TMDL #2				
MS4 Permit Holder	**MS4 Permit #**	**Existing Load**	**Allocated Load**	**Required Reduction**
		counts/day	**counts/day**	**%**
City of Portsmouth (Phase 1)	VA0088668	2.10E+14	9.77E+12	95%
City of Chesapeake (Phase 1)	VA0088625	2.11E+14	9.86E+12	95%
City of Suffolk (Phase 2)	VA0090892	4.47E+12	2.08E+11	95%
	Total	4.25E+14	1.98E+13	95%

Table E-4: Waste Load Allocation for Enterococci per MS4 Permit for TMDL #3				
MS4 Permit Holder	**MS4 Permit #**	**Existing Load**	**Allocated Load**	**Required Reduction**
		counts/day	**counts/day**	**%**
City of Norfolk (Phase 1)	VA0088650	2.00E+14	1.03E+13	95%

Table E- 5: Waste Load Allocation for Enterococci per MS4 Permit for TMDL #4

MS4 Permit Holder	MS4 Permit #	Existing Load	Allocated Load	Required Reduction
		counts/day	counts/day	%
City of Portsmouth (Phase 1)	VA0088668	1.01E+13	4.79E+11	95%
City of Chesapeake (Phase 1)	VA0088625	1.12E+11	5.34E+09	95%
Scott Center Annex	VAR040114	4.01E+11	1.91E+10	95%
	Total	1.06E+13	5.04E+11	95%

Load Allocation

The reduction of loadings from non-point sources (livestock, wildlife, pet, failed septic system) including livestock, pets, and wildlife direct deposition, that are not covered under MS4 area and the non-urban area of the MS4 was incorporated into the load allocation. In addition, the total load from SSOs was included in the load allocation. The load allocation for the Elizabeth River watershed TMDLs are based on the proportion of the bacteria sources (livestock, wildlife, septic system, pets, and sanitary sewer overflows). The proportions were derived from bacteria loads that were estimated using EPA's bacteria indicator tool for bacteria loads originating from livestock, wildlife, septic system, and pets and spreadsheet calculations for bacteria loads originating from sanitary sewer overflows (Chapter 3.5). A complete reduction of all human sources (septic system, sanitary sewer overflows) is required, since enterococci from human sources are considered a serious concern in estuaries (VA DEQ, 2005). Reductions for wildlife are applied when the reduction of controllable loads (humans, livestock, and pets) does not achieve the water quality standard for the estuary (VA DEQ, 2005). However, the TMDL does not recommend reductions in wildlife populations. The enterococci TMDL allocations by different source categories that would meet the single sample maximum enterococci standard of 104 count/100mL for the Elizabeth River watershed per TMDL watershed are presented in **Table E-6**.

Summaries of the TMDL allocation plans are presented in **Table E-7**. Minor differences in current loads are due to rounding.

Table E- 6: Distribution of Enterococci Under Existing Conditions, TMDL Allocation, and Reduction

TMDL Watershed	Source	Current Load (count/day)	Allocated Load (count/day)	Required Reduction (%)
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River	Livestock	5.55E+14	2.41E+11	100%
	Wildlife	2.66E+14	8.39E+13	68%
	Failed Septic System	2.17E+10	0.00E+00	100%
	Pet	7.59E+14	3.29E+11	100%
	Sanitary Sewer Overflows	9.53E+13	0.00E+00	100%
	Total	**1.67E+15**	**8.45E+13**	**95%**
TMDL #2 Western Branch	Livestock	5.30E+12	2.39E+09	100%
	Wildlife	7.49E+13	1.63E+13	78%
	Failed Septic System	2.32E+10	0.00E+00	100%
	Pet	2.32E+14	1.05E+11	100%
	Sanitary Sewer Overflows	1.95E+13	0.00E+00	100%
	Total	**3.32E+14**	**1.64E+13**	**95%**
TMDL #3 Lafayette River	Livestock	2.40E+09	4.26E+07	98%
	Wildlife	1.74E+13	1.74E+13	0%
	Failed Septic System	2.56E+10	0.00E+00	100%
	Pet	1.77E+14	3.14E+12	98%
	Sanitary Sewer Overflows	2.04E+14	0.00E+00	100%
	Total	**3.98E+14**	**2.05E+13**	**95%**
TMDL #4 Paradise Creek	Livestock	0.00E+00	0.00E+00	-
	Wildlife	2.13E+11	7.41E+10	65%
	Failed Septic System	1.07E+09	0.00E+00	100%
	Pet	1.26E+12	4.16E+08	100%
	Sanitary Sewer Overflows	8.65E+10	0.00E+00	100%
	Total	**1.56E+12**	**7.45E+10**	**95%**

Table E-7: Elizabeth River Watershed TMDL Allocation Plan Loads (count/day)				
TMDL Watershed	**WLA** (MS4s within urban area and 1% of LA for future growth)	**LA** (SSOs, Non MS4s and non-urban MS4s)	**MOS** (Margin of safety)	**TMDL**
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River	**5.78E+13**	**8.45E+13**	**IMPLICIT**	**1.42E+14**
TMDL #2 Western Branch	**2.00E+13**	**1.64E+13**	**IMPLICIT**	**3.64E+13**
TMDL #3 Lafayette River	**1.05E+13**	**2.05E+13**	**IMPLICIT**	**3.11E+13**
TMDL #4 Paradise Creek	**5.04E+11**	**7.45E+10**	**IMPLICIT**	**5.79E+11**

Consideration of Seasonal Variability

The Clean Water Act requires that a TMDL be established with consideration of seasonable variations. This includes variations of the hydrologic flow regime and the water quality. The seasonable variation was accounted for by the incorporation of monthly sampling and long-term data record in estimating existing conditions.

Consideration of Critical Conditions

The critical condition can be thought of as the “worst case” scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. The Elizabeth River bacteria reductions were developed using the maximum measured bacteria concentration within the impaired waterbody and a stringent bacteria criterion (90th percentile). These two elements; the use of the maximum measured bacteria concentration along with a stringent bacteria criterion insures that the critical conditions are accounted for the bacteria impaired segments of the Elizabeth River watershed.

Public Participation

Watershed stakeholders had opportunities to provide input and participated in the development of the TMDL during two public meetings held in the watershed. Both meetings were held in Virginia Beach, Virginia, and occurred on August 26th, 2009 February 23, 2010. There were three technical advisory committees on the Elizabeth River Bacteria TMDL. All three were held in Virginia Beach, Virginia, and occurred on April 3, 2009, December 14, 2009, and February 5, 2010.

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 water bodies that are violating water quality standards. TMDLs represent the total pollutant loading that a waterbody can contain 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 in-stream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point 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 (DCR), the Department of Mines, Minerals, and Energy (DMME), 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 of 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, administers the National Pollution Discharge Elimination System (NPDES) permit systems for municipal and industrial facilities, and coordinates public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs statewide through the use of federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for 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 that 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 VA DEQ to develop and implement TMDLs for listed waters (DEQ, 2001a). 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

This report addresses nine segments of the Elizabeth River that have been listed on the 2008 Impaired Waters - 303(d) List for recreation use due to exceedances of the criteria for enterococcus bacteria. Out of the nine impaired segments, five segments are located in the Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, and Paradise Creek (Cause Group Code G15E-02-02-BAC), two in the Lower and Upper Western Branch (Cause Group Code G15E-04-01-BAC), one in the Upper Lafayette (Cause Group Code G15E-05-02-BAC), and one in the Indian River (Cause Group Code G15E-02-05-BAC). Overall, the report develops four TMDL allocations in which impaired segments with direct hydrologic connection are combined. (**Table 1-1** shows the impaired segments pursuant to 2008 VA DEQ 303(d) list and organized by TMDL.):

- TMDL #1: TMDL allocation for the bacteria impaired segments of the Upper Mainstem (VAT-G15E_ELI01A06), Lower Southern Branch (VAT-G15E_SBE03A06), Lower Eastern Branch (VAT-G15E_EBE02A06), Indian River (VAT-G15E_IND01A02), and Broad Creek (VAT-G15E_BRO01A02).

- TMDL #2: TMDL allocation for the bacteria impaired segments of the Lower Western Branch (VAT-G15E_WBE02A00) and the Upper Western Branch (VAT-G15E_WBE01A02).

- TMDL #3: TMDL allocation for the bacteria impaired segment of the Upper Lafayette River (VAT-G15E_LAF01A06).

- TMDL #4: TMDL allocation for the bacteria impaired segment of Paradise Creek (VAT-G15E_PAR01A06).

Table 1-1: Enterococcus Impaired Segment Identification for the Elizabeth River

TMDL Watershed	Segment Name	2008 Assessment Unit	Cycle First Listed	Source	Estuary Size (miles^2)
TMDL #1	Upper Mainstem	VAT-G15E_ELI01A06	2006	Unknown	0.48
	Lower Southern Branch	VAT-G15E_SBE03A06	1998	Unknown	0.58
	Lower Eastern Branch	VAT-G15E_EBE02A06	1998	Unknown	1.02
	Indian River	VAT-G15E_IND01A02	2006	Unknown	0.268
	Broad Creek	VAT-G15E_BRO01A02	2006	Unknown	0.37
TMDL #2	Lower Western Branch	VAT-G15E_WBE02A00	2004	Unknown	1.46
	Upper Western Branch	VAT-G15E_WBE01A02	2004	Unknown	0.56
TMDL #3	Upper Lafayette River	VAT-G15E_LAF01A06	2002	Unknown	1.558
TMDL #4	Paradise Creek	VAT-G15E_PAR01A06	2006	Unknown	0.06
Total					**6.356**

The impaired segments cover 6.356 square miles of the Elizabeth River. **Figure 1-1** presents the locations of the enterococcus impaired segments of the Elizabeth River.

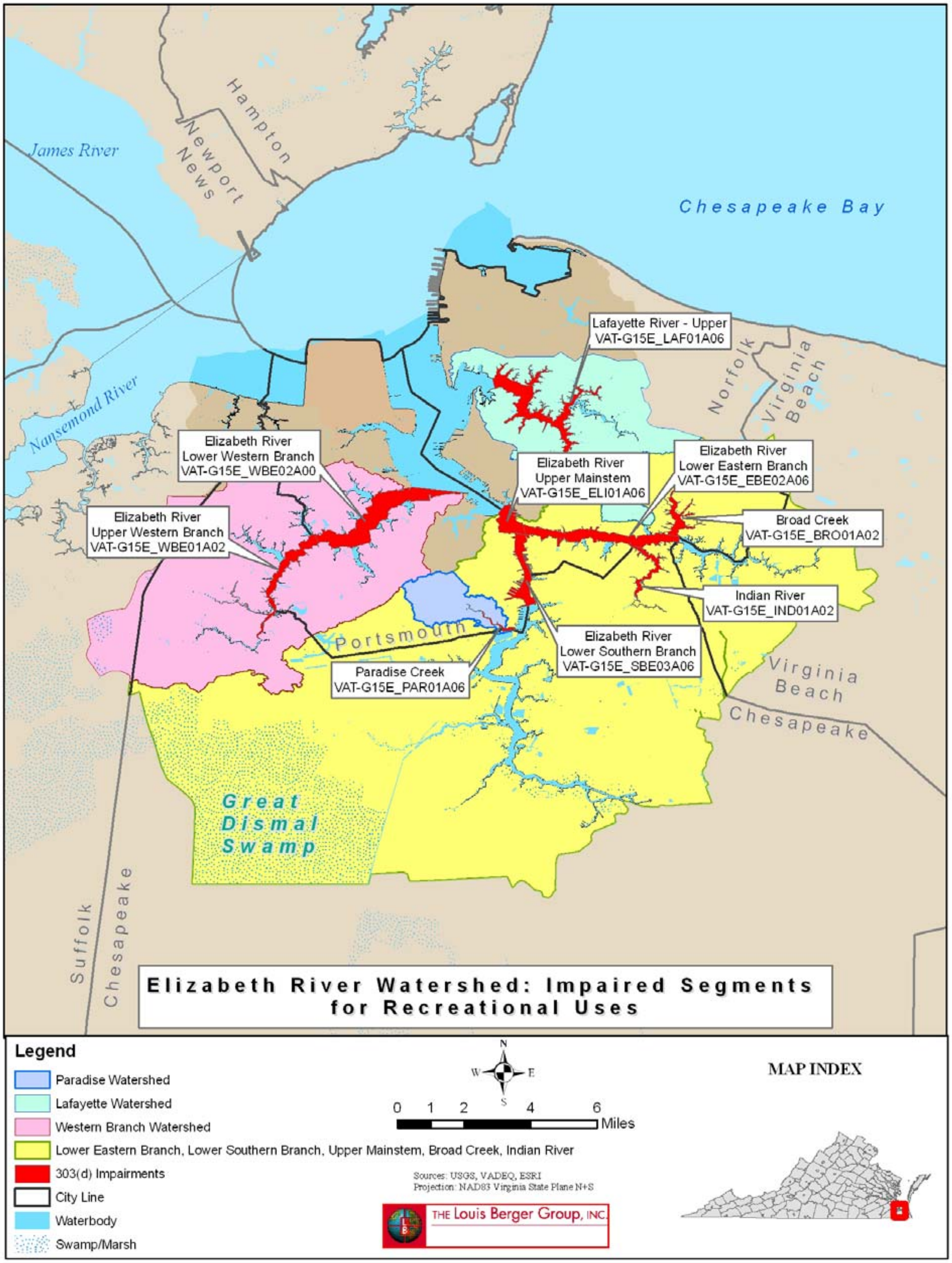

Figure 1-1: Location of the TMDL Impaired Segments for Recreational Uses in the Elizabeth River Watershed

1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term "water quality standards means 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 Virginia Water Quality Standards (9 VAC 25-260-10):

> *"all state waters 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 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

VA DEQ specifies the following criteria for recreational uses (VA DEQ, 2008) of 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 per 100ml of water for two or more samples over a calendar month nor shall it exceed the single sample maximum of 104 counts per 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.

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 bacteria impaired segments within the Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Indian River, Broad Creek (TMDL #1), Western Branch watershed (TMDL #2), Lafayette River watershed (TMDL #3), and Paradise Creek watershed (TMDL #4) are presented. This information was used to characterize the estuary and its watershed and to inventory and characterize the potential point and non-point 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) Regulatory information that describe government standards regarding water quality standards (stormwater and MS4 permits, etc).

(2) Hydrographic data that describe physical conditions within the estuary, such as the estuary network and connectivity, and the estuary 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 enterococcus sources.

(4) Environmental monitoring data that describe estuarine flow and water quality conditions in the bacteria impaired segments of the Elizabeth River.

Table 2-1 shows the various data types and the data sources used in the four bacteria TMDL watersheds.

Table 2-1: Inventory of Data and Information Used in the Elizabeth River Watershed

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	NRCS Watershed Boundary Dataset
	Land use/land cover	NLCD 2005
	Soil data (*soildatamart*)	USGS
	Topographic data (USGS-30 meter DEM)	USGS
Hydrographic data	Stream network and reaches (RF3)	NHD
	Bathymetry Data	NOAA Navigation Charts
Weather data	Information, data, reports, and maps that can be used to support bacteria source identification and loading	NCDC
Watershed activities/ uses data and information related to enterococci production	Livestock inventory, grazing, stream access, and manure management	Census of Agriculture 2007, City of Chesapeake, City of Norfolk, City of Portsmouth, City of Virginia Beach, SWCD
	Wildlife inventory	VDGIF
	Septic systems inventory and failure rates	VA DEQ , U.S. Census Bureau, City of Chesapeake, City of Norfolk, City of Portsmouth, City of Suffolk, City of Virginia Beach
	Pet estimates	National pet estimates per household, U.S. Census Bureau
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMRs)	VA DEQ, EPA Permit Compliance System
Environmental monitoring data	Ambient instream monitoring data	VA DEQ
	Bacteria Source Tracking Data	VA DEQ
	Stream flow data	USGS
	Tidal Data	NOAA

Notes:
DEM: Digital Elevation Model
EPA: Environmental Protection Agency
NCDC: National Climatic Data Center
NHD: National Hydrography Dataset
NLCD: National Land Coverage Data
NOAA: National Oceanic and Atmospheric Association
NRCS: Natural Resources Conservation Service
RF3: Reach File Version 3.0
SWCD: Soil and Water Conservation District
USGS: U.S. Geological Survey
VA DEQ: Virginia Department of Environmental Quality
VDGIF: Virginia Department of Game and Inland Fisheries
VDH-DSS: Virginia Department of Health Department of Shellfish Sanitation

2.2 Watershed Description and Identification

The bacteria impaired segments are located within the borders of the Cities of Chesapeake, Virginia Beach, Portsmouth, Norfolk and Suffolk. As shown in **Figure 2-1**, the major roadways that run through the watershed are Routes 664, 64, 264 464 and 564. Route 664 runs from north to south through the middle of the watershed, and becomes Route 64 at the eastern boundary of the watershed. Route 264 runs from south to east and across the middle of the watershed. Route 464 run from south to north in the center portion of the watershed, ending in the city of Portsmouth.

The watershed description and identification is provided separately for each TMDL watershed. As detailed in Chapter 1.2.1, there are four TMDL watersheds where TMDL allocations are developed in this report. **Figure 2-1** shows the boundary of each TMDL watershed and the existing VA DEQ bacteria monitoring stations as well as NOAA's tidal stations in the entire watershed.

The first TMDL watershed, which includes the Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Indian River, Broad Creek, is located within the borders of the Cities of Chesapeake, Portsmouth, Virginia Beach and Norfolk and has a drainage area of 82,735 acres.

The second TMDL watershed which includes the Western Branch watershed is located within the borders of the Cities of Suffolk, Chesapeake and Portsmouth and has a drainage area of 23,951 acres.

The third TMDL watershed which includes the Lafayette River watershed is located within the border of the City of Norfolk and has a drainage area of 10,304 acres.

The fourth TMDL watershed which includes Paradise Creek is located within the border of the City of Portsmouth and has a drainage area of 1,716 acres.

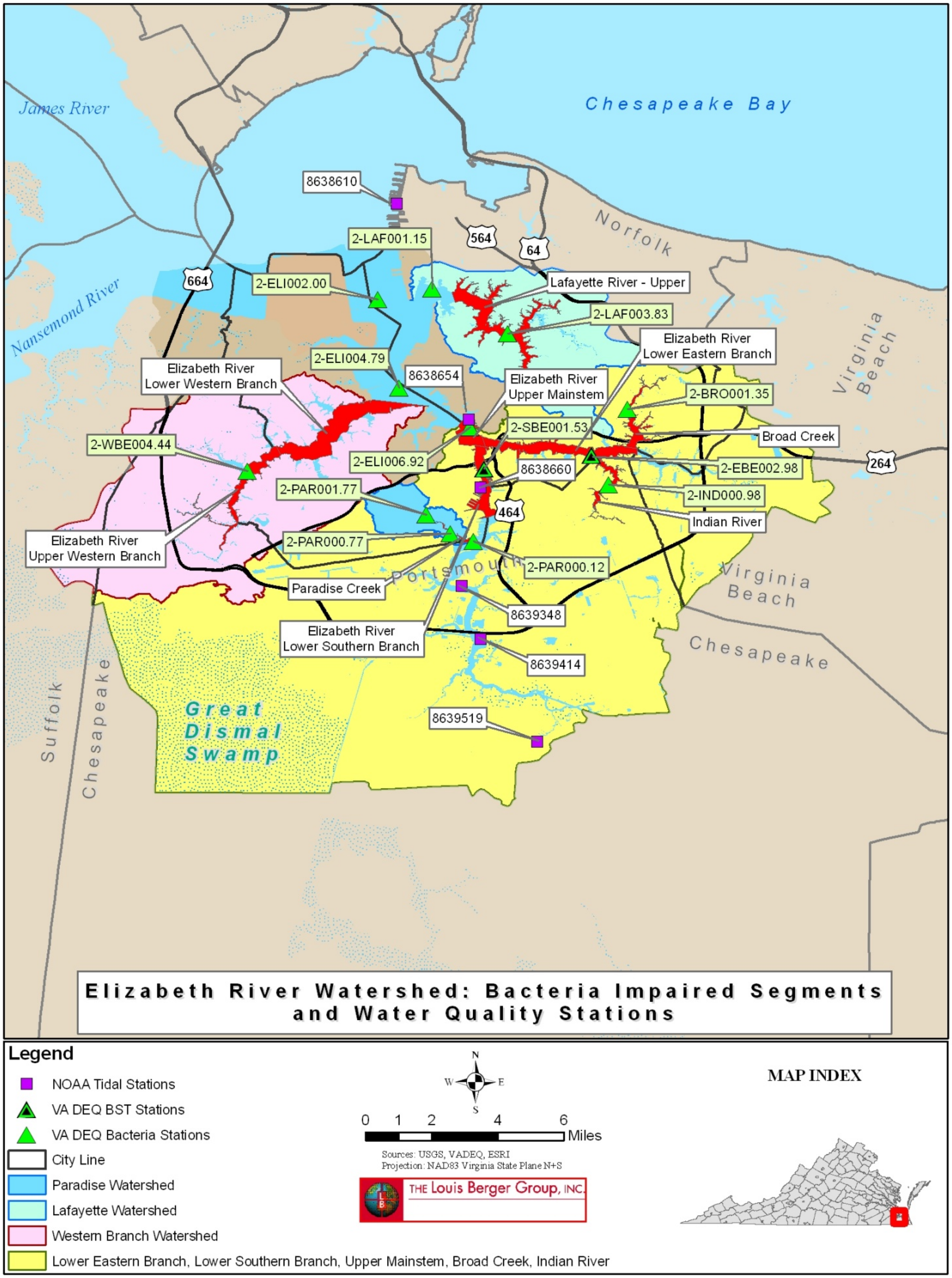

Figure 2-1: Overview Map of the Elizabeth River Watershed

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 -4 to 17 feet above mean sea level.

2.2.2 Soil Types and Soil Hydrologic Groups

The following section details soil type and hydrologic group by each TMDL watershed. The soil type characterization is based on data obtained from *soildatamart*, a USGS approved program that is a multi-purpose environmental analysis system integrating GIS, national watershed data, and environmental assessment and modeling tools.

The hydrologic soil groups are also based on data obtained from *soildatamart*. 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 2-2**. The term "not identified" in the hydrologic group breakdown refers to those classes defined as water, since water does not belong to any hydro group.

Table 2-2: 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.
C/D	Combination of Hydrologic Soil Groups C and D.

2.2.2.1 TMDL #1 (Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek and Indian River)

There are 35 soil associations located in the watershed (**Table 2-3**). The dominant soil series within the watershed are Tomotley (19.4%) and Nimmo (18.6%).

Table 2-3: Soil Types within the TMDL #1 Watershed

Soil Type	Total Acres	Percentage
Tomotley	11,197	19.4
Nimmo	10,710	18.6
Udorthents	8,598	14.9
Pungo	7,620	13.2
Portsmouth	5,869	10.2
Chickahominy	1,772	3.1
Dragston	1,460	2.5
Munden	1,319	2.3
Arapahoe	1,282	2.2
Acredale	1,095	1.9
Rappahannock	1,010	1.8
Bertie	783	1.4
Pactolus	535	0.9
Tetotum	511	0.9
Augusta	432	0.7
Wando	409	0.7
Psamments	396	0.7
Pocaty	342	0.6
Nawney	324	0.6
Bojac	303	0.5
Chapanoke	272	0.5
State	263	0.5
Gertie	236	0.4
Chesapeake	212	0.4
Axis	205	0.4
Dorovan	183	0.3
Yeopim	116	0.2
Deloss	88	0.2
Aquents	34	0.1
Hyde	17	<0.1
Conetoe	17	<0.1
Torhunta	12	<0.1
Rumford	7	<0.1
Weeksville	6	<0.1
Beaches	1	<0.1
TOTAL*	**57,636**	**100**

*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water or not identified.

The major hydrologic groups within the TMDL #1 watershed are D, with 35% of the watershed containing these soils. Soil group D is classified as having very slow infiltration rates. Soils are clayey, have a high water table, or shallow to impervious cover. The second major hydrologic group within the watershed is group B/D, with 22% of the watershed containing these soils. Soil group B/D is defined as having moderate to very slow infiltration rates. Soils are deep to moderately deep as well as clayey, moderately well and well-drained soils with moderately coarse textures and some impervious cover. **Table 2-4** summarizes the total percentages of hydrologic groups for the TMDL #1 watershed.

Table 2-4: Hydrologic Groups within the TMDL #1 Watershed

Hydrologic Soil Group	Total Acres	Percentage of Watershed
A	1,392	2
B	2,221	3
B/D	18,473	22
C	3,472	4
D	28,788	35
Not Identified	28,389	34
Total	**82,735**	**100**

2.2.2.2 TMDL #2 (Western Branch)

There are 25 soil associations located in the watershed (**Table 2-5**). The dominant soil series within the watershed are Nimmo (22.9%) and Tomotley (17.2%).

Table 2-5: Soil Types within the TMDL #2 Watershed

Soil Type	Total Acres	Percentage
Nimmo	3,917	22.9
Tomotley	2,943	17.2
Chickahominy	1,762	10.3
Udorthents	1,323	7.8
Torhunta	1,210	7.1
Munden	1,042	6.1
State	1,016	6.0
Dragston	972	5.7
Bojac	841	4.9
Weston	593	3.5
Conetoe	488	2.9
Rappahannock	280	1.6
Axis	238	1.4
Nawney	155	0.9
Nansemond	67	0.4
Aquents	66	0.4
Arapahoe	58	0.3
Bertie	25	0.1
Kalmia	19	0.1
Kenansville	17	0.1
Pactolus	16	0.1
Pocaty	13	0.1
Tetotum	4	<0.1
Wando	2	<0.1
Pungo	1	<0.1
TOTAL*	**17,068**	**100**

*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water or not identified.

The major hydrologic groups within the Western Branch Watershed are D, with 35% of the watershed containing these soils. Soil group D is classified as having very slow infiltration rates. Soils are clayey, have a high water table, or shallow to an impervious cover. The second major hydrologic group within the watershed is group B/D, with 13% of the watershed containing these soils. Soil group B/D is defined as having moderate to very slow infiltration rates. Soils are deep and moderately deep as well as clayey, moderately well and well-drained soils with moderately coarse textures and some impervious cover. **Table 2-6** summarizes the total percentages of hydrologic groups for the Western Branch watershed.

Table 2-6: Hydrologic Groups within the TMDL #2 Watershed		
Hydrologic Soil Group	**Total Acres**	**Percentage of Watershed**
A	590	2.5
B	2,920	12.2
B/D	3,003	12.5
C	2,280	9.5
D	8,481	35.4
Not Identified	6,677	27.9
Total	**23,951**	**100.0**

2.2.2.3 TMDL #3 (Lafayette River)

There are six soil associations located in the watershed (**Table 2-7**). The dominant soil series within the watershed are Nimmo (37.8%) and Chickahominy (33.6%).

Table 2-7: Soil Types within the TMDL #3 Watershed		
Soil Type	**Total Acres**	**Percentage**
Nimmo	2,810	37.8
Chickahominy	2,500	33.6
State	1,037	14.0
Udorthents	700	9.4
Axis	373	5.0
Munden	11	0.1
TOTAL*	**7,431**	**100**

*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water or not identified.

The major hydrologic groups within the Lafayette River Watershed are D, with 75.6% of the watershed containing these soils. Soil group D is classified as having very slow infiltration rates. Soils are clayey, have a high water table, or shallow to an impervious cover. The second major hydrologic group within the watershed is group B, with 10.2% of the watershed containing these soils. Soil group B is defined as having moderate infiltration rates. Soils are deep and moderately deep, moderately well and well-drained soils with moderately coarse textures. **Table 2-8** summarizes the total percentages of hydrologic groups for the Lafayette River watershed.

Table 2-8: Hydrologic Groups within the TMDL #3 Watershed

Hydrologic Soil Group	Total Acres	Percentage of Watershed
B	1,049	10.2
D	7,792	75.6
Not Identified	1,463	14.2
Total	**10,304**	**100.0**

2.2.2.4 TMDL #4 (Paradise Creek)

There are six soil associations located in the watershed (**Table 2-9**). The dominant soil series within the watershed are Nimmo (53.8%) and Udorthents (16.6%).

Table 2-9: Soil Types within the TMDL #4 Watershed

Soil Type	Total Acres	Percentage
Nimmo	755	53.8
Udorthents	233	16.6
Tomotley	192	13.7
Chickahominy	96	6.8
Munden	73	5.2
Axis	55	3.9
TOTAL*	**1,404**	**100**

*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water or not identified.

The major hydrologic groups within the Paradise Creek Watershed are D, with 81.1% of the watershed containing these soils. Soil group D is classified as having very slow infiltration rates. Soils are clayey, have a high water table, or shallow to an impervious cover. The second major hydrologic group within the watershed is group B/D, with 11.2% of the watershed containing these soils. Soil group B/D is defined as having moderate to very slow infiltration rates. Soils are deep and moderately deep as well as clayey, moderately well and well-drained soils with moderately coarse textures and some impervious cover. **Table 2-10** summarizes the total percentages of hydrologic groups for the Paradise Creek watershed.

Table 2-10: Hydrologic Groups within the TMDL #4 Watershed		
Hydrologic Soil Group	**Total Acres**	**Percentage of Watershed**
B	73	4.3
B/D	192	11.2
D	1,391	81.1
Not Identified	59	3.5
Total	**1,716**	**100.0**

2.2.3 Land Use Characterization

The land use characterization for the Elizabeth River watershed was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2005 Land Use Dataset. Brief descriptions of land use classifications are presented in **Table 2-11**. The distribution of land uses in the entire watershed and each TMDL watershed, by land area and percentage, are presented in **Tables 2-12** through **2-16**. **Figure 2-2** depicts the land use distribution within the entire Elizabeth River watershed.

Table 2-11: Descriptions of Land Use Types	
Land Use Type	**Description**
Open Water	All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Estuarine Emergent Wetlands	Includes all tidal wetlands dominated by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens). Wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent and that are present for most of the growing season in most years. Perennial plants usually dominate these wetlands. Total vegetation cover is greater than 80 percent.
Estuarine Forested Wetland	Includes all tidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Estuarine Scrub/Shrub Wetland	Includes all tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is equal to or greater than 0.5 percent. Total vegetation coverage is greater than 20 percent.
Palustrine Aquatic Bed	Includes tidal and nontidal wetlands and deepwater habitats in which salinity due to ocean-derived salts is below 0.5 percent and which are dominated by plants that grow and form a continuous cover principally on or at the surface of the water. These include algal mats, detached floating mats, and rooted vascular plant assemblages. Total vegetation cover is greater than 80 percent.
Palustrine Emergent Wetland	Includes all tidal and nontidal wetlands dominated by persistent emergent vascular plants, emergent mosses or lichens, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Plants generally remain standing until the next growing season. Total vegetation cover is greater than 80 percent.
Palustrine Forested Wetland	Includes all tidal and nontidal wetlands dominated by woody vegetation greater than or equal to 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent.
Palustrine Scrub/Shrub Wetland	Includes all tidal and non tidal wetlands dominated by woody vegetation less than 5 meters in height, and all such wetlands that occur in tidal areas in which salinity due to ocean-derived salts is below 0.5 percent. Total vegetation coverage is greater than 20 percent. The species present could be true shrubs, young trees and shrubs, or trees that are small or stunted due to environmental conditions (Cowardin et al. 1979).
Unconsolidated Shore	Unconsolidated material such as silt, sand, or gravel that is subject to inundation and redistribution due to the action of water. Characterized by substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce a number of landforms representing this class.
Developed, Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.

Table 2-11: Descriptions of Land Use Types

Land Use Type	Description
Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Cultivated Crops	Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Barren Land (Rock/Sand/Clay)	Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.
Grassland	Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Scrub/Shrub	Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Source: Coastal NLCD Classification Scheme, NOAA Coastal Services Center	

2.2.3.1 Land Use Characterization for the Elizabeth River Watershed

Land use characterization for the Elizabeth Watershed was based on land cover data from the NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed by land area and percentage are presented in **Table 2-12**. Dominant land uses in the watershed are developed (58%) and wetlands (24%). **Figure 2-2** depicts the land use distribution within the entire Elizabeth River watershed.

Table 2-12: Land Use within the Elizabeth River Watershed

General Land Use Category	Specific Land Use Type	Acres	Total Acres	Percentage of Watershed (%)	Total Percent (%)
Developed	High Intensity Developed	7,700	68,887	6%	58%
	Medium Intensity Developed	13,048		11%	
	Low Intensity Developed	32,322		27%	
	Developed Open Space	15,816		13%	
Agriculture	Cultivated Crops	4,537	5,370	4%	5%
	Pasture/Hay	833		<1%	
Forest	Deciduous Forest	3,137	5,462	3%	5%
	Evergreen Forest	1,764		1%	
	Mixed Forest	560		<1%	
Wetlands	Estuarine Emergent Wetland	2,588	28,735	2%	24%
	Estuarine Forested Wetland	<1		<1%	
	Estuarine Scrub/Shrub Wetland	87		<1%	
	Palustrine Emergent Wetland	357		<1%	
	Palustrine Forested Wetland	23,589		20%	
	Palustrine Scrub/Shrub Wetland	2,113		2%	
Water	Palustrine Aquatic Bed	5	6,909	<1%	6%
	Water	6,905		6%	
Other	Barren Land	150	3,344	<1%	3%
	Grassland (not used in agriculture)	625		<1%	
	Scrub/Shrub	2,514		2%	
	Unconsolidated Shore	55		<1%	
Total		**118,707**		**100%**	**100%**

Differences in totals are due to rounding

2.2.3.2 Land Use Characterization for TMDL #1: Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River

Land use characterization for the Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek and Indian River Watershed was based on land cover data from the NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed by land area and percentage are presented in **Table 2-13**. Dominant land uses in the watershed are developed (55%) and wetlands (28%). **Figure 2-2** depicts the land use distribution within the entire Elizabeth River watershed.

Table 2-13: Land Use within the Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River Watershed (TMDL #1)					
General Land Use Category	**Specific Land Use Type**	**Acres**	**Total Acres**	**Percentage of Watershed (%)**	**Total Percent (%)**
Developed	High Intensity Developed	5,471	45,163	7%	55%
	Medium Intensity Developed	9,138		25%	
	Low Intensity Developed	20,383		11%	
	Developed Open Space	10,171		12%	
Agriculture	Cultivated Crops	4,248	4,951	5%	6%
	Pasture/Hay	703		1%	
Forest	Deciduous Forest	1,919	3,270	2%	4%
	Evergreen Forest	1,007		1%	
	Mixed Forest	344		<1%	
Wetlands	Estuarine Emergent Wetland	1,823	23,194	2%	28%
	Estuarine Forested Wetland	<1		<1%	
	Estuarine Scrub/Shrub Wetland	63		<1%	
	Palustrine Emergent Wetland	267		<1%	
	Palustrine Forested Wetland	19,972		<1%	
	Palustrine Scrub/Shrub Wetland	1,070		24%	
Water	Palustrine Aquatic Bed	3	4,003	1%	5%
	Water	4,000		5%	
Other	Barren Land	138	2,155	<1%	3%
	Grassland (not used in agriculture)	366		<1%	
	Scrub/Shrub	1,606		2%	
	Unconsolidated Shore	46		<1%	
Total		**82,736**		**100%**	**100%**
Differences in totals are due to rounding					

2.2.3.3 Land Use Characterization for TMDL #2: Western Branch

Land use characterization for the Western Branch Watershed was based on land cover data from the NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed by land area and percentage are presented in **Table 2-14**. Dominant land uses in the watershed are developed (59%) and wetlands (21%). **Figure 2-2** depicts the land use distribution within the entire Elizabeth River watershed.

Table 2-14: Land Use within the Western Branch Watershed (TMDL #2)					
General Land Use Category	**Specific Land Use Type**	**Acres**	**Total Acres**	**Percentage of Watershed (%)**	**Total Percent (%)**
Developed	High Intensity Developed	1,186	14,059	5%	59%
	Medium Intensity Developed	1,745		7%	
	Low Intensity Developed	7,070		30%	
	Developed Open Space	4,058		17%	
Agriculture	Cultivated Crops	289	418	1%	2%
	Pasture/Hay	129		1%	
Forest	Deciduous Forest	1,052	1,821	4%	8%
	Evergreen Forest	573		2%	
	Mixed Forest	196		1%	
Wetlands	Estuarine Emergent Wetland	518	4,930	2%	21%
	Estuarine Forested Wetland	<1		<1%	
	Estuarine Scrub/Shrub Wetland	16		<1%	
	Palustrine Emergent Wetland	48		<1%	
	Palustrine Forested Wetland	3,327		14%	
	Palustrine Scrub/Shrub Wetland	1,021		4%	
Water	Palustrine Aquatic Bed	1	1,656	<1%	7%
	Water	1,655		7%	
Other	Barren Land	9	1,065	<1%	4%
	Grassland (not used in agriculture)	258		1%	
	Scrub/Shrub	793		3%	
	Unconsolidated Shore	5		<1%	
Total		**23,951**		**100%**	**100%**
Differences in totals are due to rounding					

2.2.3.4 Land Use Characterization for TMDL #3: Lafayette River

Land use characterization for the Lafayette River Watershed was based on land cover data from the NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed by land area and percentage are presented in **Table 2-15**. Dominant land uses in the watershed are developed (78%) and water (12%). **Figure 2-2** depicts the land use distribution within the entire Elizabeth River watershed.

Table 2-15: Land Use within the Lafayette River Watershed (TMDL #3)					
General Land Use Category	**Specific Land Use Type**	**Acres**	**Total Acres**	**Percentage of Watershed (%)**	**Total Percent (%)**
Developed	High Intensity Developed	932	8,082	9%	78%
	Medium Intensity Developed	1,875		18%	
	Low Intensity Developed	4,090		40%	
	Developed Open Space	1,185		12%	
Forest	Deciduous Forest	156	354	2%	3%
	Evergreen Forest	183		2%	
	Mixed Forest	16		<1%	
Wetlands	Estuarine Emergent Wetland	209	542	2%	5%
	Estuarine Scrub/Shrub Wetland	7		<1%	
	Palustrine Emergent Wetland	38		<1%	
	Palustrine Forested Wetland	267		3%	
	Palustrine Scrub/Shrub Wetland	20		<1%	
Water	Palustrine Aquatic Bed	1	1,230	<1%	12%
	Water	1,229		12%	
Other	Barren Land	2	97	<1%	1%
	Grassland (not used in agriculture)	<1		<1%	
	Scrub/Shrub	91		1%	
	Unconsolidated Shore	4		<1%	
Total		**10,304**		**100%**	**100%**
Differences in totals are due to rounding					

2.2.3.5 Land Use Characterization for TMDL #4: Paradise Creek

Land use characterization for the Paradise Creek Watershed was based on land cover data from the NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed by land area and percentage are presented in **Table 2-16**. Dominant land uses in the watershed are developed (92%) and wetlands (4%). **Figure 2-2** depicts the land use distribution within the entire Elizabeth River watershed.

Table 2-16: Land Use within the Paradise Creek Watershed (TMDL #4)					
General Land Use Category	**Specific Land Use Type**	**Acres**	**Total Acres**	**Percentage of Watershed (%)**	**Total Percent (%)**
Developed	High Intensity Developed	111	1,584	6%	92%
	Medium Intensity Developed	291		17%	
	Low Intensity Developed	779		45%	
	Developed Open Space	402		23%	
Forest	Deciduous Forest	10	16	1%	1%
	Evergreen Forest	1		<1%	
	Mixed Forest	5		<1%	
Wetlands	Estuarine Emergent Wetland	37	69	2%	4%
	Estuarine Scrub/Shrub Wetland	2		<1%	
	Palustrine Emergent Wetland	4		<1%	
	Palustrine Forested Wetland	23		1%	
	Palustrine Scrub/Shrub Wetland	3		<1%	
Water	Water	20	20	1%	1%
Other	Barren Land	1	27	<1%	2%
	Grassland (not used in agriculture)	2		<1%	
	Scrub/Shrub	24		1%	
	Unconsolidated Shore	<1		<1%	
Total		**1,716**		**100%**	**100%**
Differences in totals are due to rounding					

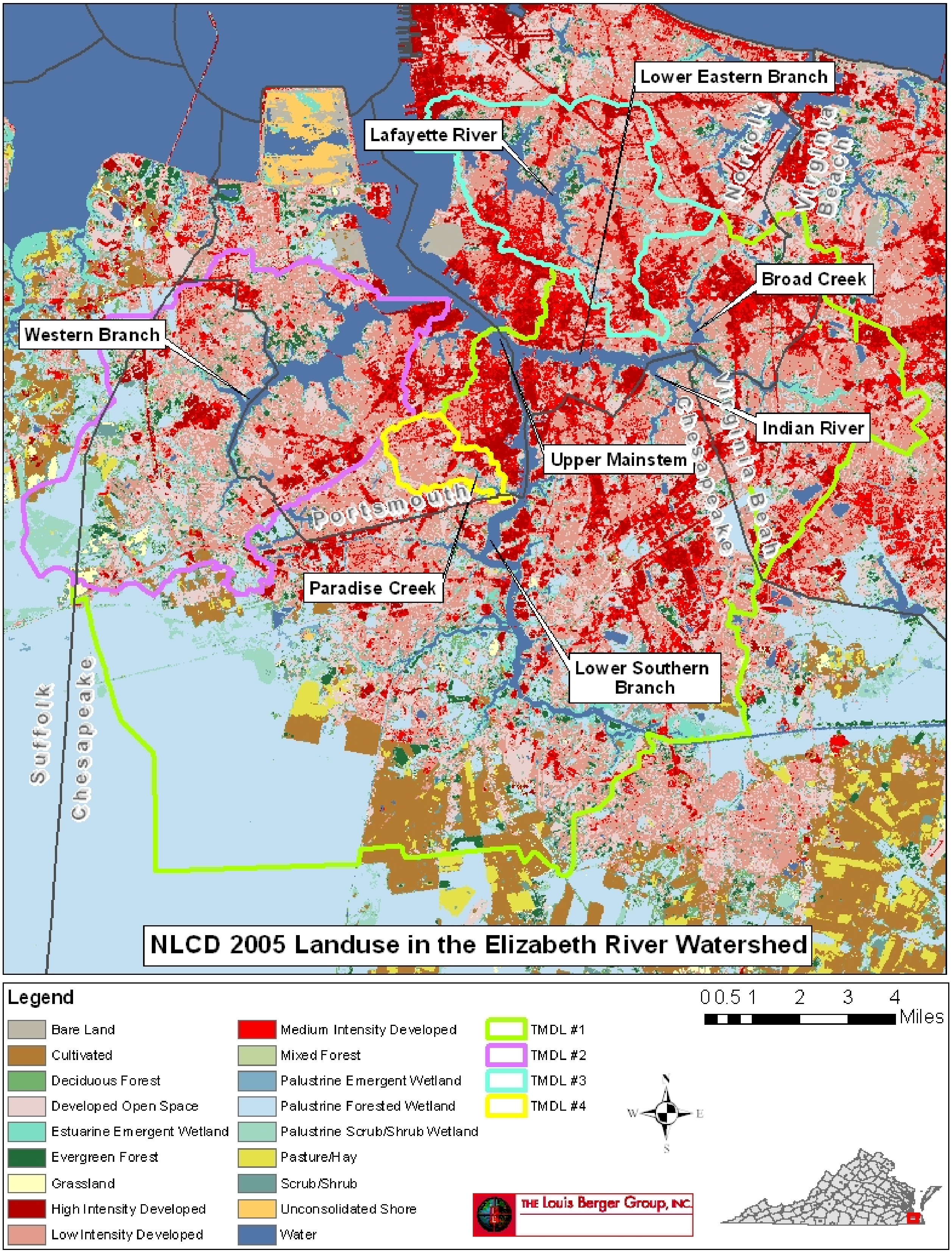

Figure 2-2: Land Use in the Elizabeth River Watershed

2.3 Stream Flow and Estuary Volume Data

Stream Flow
There has been no stream flow monitored in this watershed.

Estuary volume and tidal data
The estuary volume of Elizabeth River was computed using NOAA navigation charts and GIS data from their website. Data was available for most of the estuary's impaired segments, excluding some upstream portions of impaired segments. In areas where no navigational charts were available, depths were extrapolated. **Table 2-17** summarizes the drainage area, surface area, and volume for each bacteria impaired segment. The calculated volumes for the estuary in Elizabeth River are presented in Chapter 3. The tide data were retrieved from NOAA's *Tides and Currents* website and include mean tidal range and the time range of data collected. The watershed contains six NOAA tidal stations with available data as shown in **Figure 2-1**. The NOAA tidal stations are summarized in **Table 2-18.**

Table 2-17: Volume Summary for the Elizabeth River

TMDL Watershed	Waterbody	Average Depth of Waterbody (m)	Surface Area (m^2)[1]	Volume (m^3)[2]
TMDL #1	Upper Mainstem	4.4	1,000,828	4,400,193
	Lower Southern Branch	4.3	5,258,503	22,474,811
	Lower Eastern Branch	2.2	3,674,195	10,560,247
	Broad Creek	0.8	684,384	547,543
	Indian River	1.4	658,165	535,579
TMDL #2	Western Branch	1.7	5,236,465	9,365,440
TMDL #3	Lafayette River	1.3	5,046,896	7,169,837
TMDL #4	Paradise Creek	0.9	146,650	130,759

[1] Surface area is based on the sum of three estuary segments of varying width and length.

[2] Volume is based on the sum of three estuary segments of varying depth and surface area.

Table 2-18: Existing NOAA Tidal Stations in the Elizabeth River Watershed

Name	Station ID	Location	Mean Tidal Range (feet)	Date of Tidal Information
Sewells Point, Hampton	8638610	NW mouth of ER	2.3	1960 - 1978
Norfolk Amc	8638654	Mainstem ER	1.4	1/1973 – 12/1973
Portsmouth, Norfolk Naval Shipyard	8638660	Southern Branch ER	1.6	1/1979 – 12/1986
Money Point	8639348	Southern Branch ER	1.6	1/1998 – 12/2002
Deep Creek Entrance	8639414	Trib of Southern Branch ER	5.2	2/1978 – 8/1978
Bells Mill Creek	8639519	Trib of Southern Branch ER	7.5	5/1991 – 5/2000

2.4 Ambient Water Quality Data

Environmental monitoring efforts in the Elizabeth River watershed have been conducted by the Virginia Department of Environmental Quality (VA DEQ). The following sections summarize and present the available enterococci and fecal coliform monitoring data within and at the boundaries of the TMDL watersheds. Enterococcus is the bacteria indicator for recreational impaired segments. **Table 2-19** illustrates a summary of these monitoring efforts, according to VA DEQ's station ID numbers. The location of the water quality monitoring stations is depicted in **Figure 2-1.**

Table 2-19: Summary of Sampling Events, Location, and Bacteria Station ID (VA DEQ)				
Stream	**Station ID**	**Bacteria Sampled**	**Sample Date**	
			First	**Last**
Upper Mainstem	2-ELI006.92	Enterococci	7/25/2002	6/2/2009
		Fecal Coliform	1/22/1998	6/2/2009
	2-ELI004.79	Enterococci	8/15/2002	6/2/2009
		Fecal Coliform	1/22/1998	6/2/2009
	2-ELI002.00	Enterococci	7/23/2002	6/16/2009
		Fecal Coliform	3/21/1994	6/16/2009
Broad Creek	2-BRO001.35	Enterococci	9/24/2002	6/4/2009
		Fecal Coliform	7/9/1992	6/4/2009
Indian River	2-IND000.98	Enterococci	7/31/2002	5/19/2009
		Fecal Coliform	1/29/1998	5/19/2009
Lower Eastern Branch	2-EBE002.98	Enterococci	7/25/2002	6/2/2009
		Fecal Coliform	1/22/1998	6/2/2009
Paradise Creek	2-PAR001.77	Enterococci	10/14/2003	6/17/2009
		Fecal Coliform	10/14/2003	6/17/2009
	2-PAR000.77	Enterococci	10/14/2003	6/17/2009
		Fecal Coliform	10/14/2003	6/17/2009
	2-PAR000.12	Enterococci	10/14/2003	6/17/2009
		Fecal Coliform	10/14/2003	6/17/2009
Lower Southern Branch	2-SBE001.53	Enterococci	8/15/2002	6/2/2009
		Fecal Coliform	8/25/1994	6/2/2009
Western Branch	2-WBE004.44	Enterococci	8/15/2002	6/2/2009
		Fecal Coliform	1/22/1998	6/2/2009
Lafayette River	2-LAF003.83	Enterococci	8/15/2002	6/2/2009
		Fecal Coliform	1/22/1998	6/2/2009
	2-LAF001.15	Enterococci	8/15/2002	6/2/2009
		Fecal Coliform	1/22/1998	6/2/2009

The following sections summarize and present the available monitoring data for enterococci used in the bacteria TMDL development for the impaired segments within the Elizabeth River watershed. **Table 2-20** shows a summary of all available enteroccoci data including the number of exceedances for VA DEQ's enterococci criterion Single Sample Maximum (SSM). VA DEQ's enterococci criterion geometric mean could not be applied, since requirements of at least two measurements per calendar month for calculating geometric mean for enterocci were not met.

Table 2-20: Summary of VA DEQ Enterococci Bacteria Events and Exceedances for the Elizabeth River

Stream	Station ID	Sample Date		No. of Samples	Min[1]	Max[1]	Average	Exceedances[2] SSM[3]	
		First	Last		count/100mL	count/100mL	count/100mL	#	%
Mainstem	2-ELI006.92	7/25/2002	6/2/2009	80	10	520	58	10	13
	2-ELI004.79	8/15/2002	6/2/2009	79	10	550	38	4	5
	2-ELI002.00	7/23/2002	6/16/2009	75	10	100	26	0	0
Broad Creek	2-BRO001.35	9/24/2002	4/9/2009	39	25	2000	554	33	85
Indian River	2-IND000.98	7/31/2002	5/19/2009	38	20	2000	324	36	95
Lower Eastern Branch	2-EBE002.98	7/25/2002	6/2/2009	81	10	1800	96	10	12
Paradise Creek	2-PAR001.77	10/14/2003	6/17/2009	67	180	2000	986	67	100
	2-PAR000.77	10/14/2003	6/17/2009	66	25	2000	544	49	74
	2-PAR000.12	10/14/2003	6/17/2009	65	25	2000	269	25	38
Lower Southern Branch	2-SBE001.53	8/15/2002	6/2/2009	78	10	1800	141	18	23
Upper Western Branch	2-WBE004.44	8/15/2002	6/2/2009	78	10	2000	135	13	17
Lafayette River	2-LAF003.83	8/15/2002	6/2/2009	80	10	550	70	15	19
	2-LAF001.15[4]	8/15/2002	1/0/1900	78	10	250	27	1	1

[1]Enterococci detection range is between 10 and 2000 count values per 100 mL. Therefore, recorded count values of 2000 could be greater than 2000 and count values of 25 could be less than 25.

[2] Requirements of at least two measurements per months for calculating geometric mean for enterococci were not met

[3] Single Sample Maximum enterococci bacteria of 104 count/100mL

[4] Station not in impaired segment

The VA DEQ enterococci bacteria data were reclassified based on tide conditions (ebb, low, flood, and high) in order to determine if trends in enterococci water quality data exist (**Table 2-21, Table 2-22**). Low and high tides are defined as conditions when water changes directions and no net-current occurs. They are also referred to as low slack tide (low) and high slack tide (high). As shown in **Table 2-21, Table 2-22,** and figures in Appendix A, the single sample maximum criterion was exceeded more during low and ebb tides compared to high and flood tidal events. This may indicate that bacterial contamination originated in the Elizabeth River watershed, since the larger fraction of exceedances occurred during low slack and ebb tides when virtually no bacterial loading or only a small amount of bacteria loading from downstream could affect the sample.

Table 2-21: Summary of VA DEQ Enterococci Bacteria Events and Exceedances Under Ebb and Low Tide for the Elizabeth River

Station ID	No. of Samples		Average		Exceedances[2]			
			EBB	Low[1]	Ebb SSM[3]		Low SSM[3]	
	Ebb	Low[1]	count/100mL	count/100mL	No	%	No	%
2-ELI006.92	32	6	74	31	4	13	0	0
2-ELI004.79	27	4	48	41	2	7	1	25
2-ELI002.00	30	3	31	25	0	0	0	0
2-BRO001.35	11	3	470	990	9	82	3	100
2-IND000.98	11	10	286	217	7	64	7	70
2-EBE002.98	36	4	56	30	4	11	0	0
2-PAR001.77	31	6	1043	1442	31	100	6	100
2-PAR000.77	23	10	578	884	17	74	9	90
2-PAR000.12	21	13	346	137	10	48	3	23
2-SBE001.53	11	5	134	115	3	27	1	20
2-WBE004.44	29	5	116	115	5	17	1	20
2-LAF003.83	20	8	75.5	85	4	20	2	25
Total	**303**	**85**	**3298**	**4129**	**97**	**32**	**33**	**39**

[1] Low = samples collected under slack tide between the change from ebb to flood tide

[2] Requirements of at least two measurements for calculating geometric mean for enterococci were not met

[3] Single Sample Maximum enterococci bacteria of 104 count/100mL

Table 2-22: Summary of VA DEQ Enterococci Bacteria Events and Exceedances Under Flood and High Tide for the Elizabeth River

Station ID	No. of Samples		Average		Exceedances[2]			
			Flood	High[1]	Flood SSM[3]		High SSM[3]	
	Flood	High[1]	count/100mL	count/100mL	No	%	No	%
2-ELI006.92	37	4	53	21	6	16	0	0
2-ELI004.79	42	4	33	30	1	2	0	0
2-ELI002.00	38	4	23	25	0	0	0	0
2-BRO001.35	24	1	541	475	20	83	1	100
2-IND000.98	16	1	426	180	9	56	1	100
2-EBE002.98	38	3	148	18	6	16	0	0
2-PAR001.77	30	0	835	0	30	100	0	0
2-PAR000.77	32	1	435	250	22	69	1	100
2-PAR000.12	27	4	306	56	12	44	0	0
2-SBE001.53	34	8	132	154	7	21	2	25
2-WBE004.44	40	4	161	30	7	18	0	0
2-LAF003.83	44	7	69	45	8	18	1	14
Total	**447**	**45**	**3185**	**1306**	**128**	**29**	**6**	**13**

[1] High = samples collected under slack tide between the change from ebb to flood tide

[2] Requirements of at least two measurements for calculating geometric mean for enterococci were not met

[3] Single Sample Maximum enterococci bacteria of 104 count/100mL

2.4.1 VA DEQ Bacteria Source Data

Bacteria Source Tracking (BST) sampling was conducted by VA DEQ at two locations over a ten-month period from January 2006 to December 2006 in the impaired segment of the Elizabeth River watershed: at the downstream boundary of the impaired segment of Lower Eastern Branch at station 2-EBE002.98, and the Lower Southern Branch at station 2-SBE001.53. These two BST stations are shown in **Figure 2-1**. The results of the BST sampling are presented in **Appendix D**.

2.4.2 VDH-DSS Shoreline Sanitary Survey Data

The shoreline sanitary survey is used as a tool to identify non-point source contribution to bacteria problems. VDH-DSS surveyed the Elizabeth River Watershed in 2004 and 2006. Included in these shoreline surveys were the Cities of Virginia Beach and Norfolk. The results of the shoreline survey can be found in Appendix C.

2.5 Bacteria Source Assessment

This section focuses on characterizing the sources that potentially contribute to the bacteria loading in the TMDL watershed. These sources include permitted facilities, septic systems, Sanitary Sewer Overflows (SSOs), livestock, biosolids, wildlife, and pets. These source estimates were implicitly linked to the modeling framework described in Chapter 3.

2.5.1 Permitted Facilities

Based on data obtained from VA DEQ, there are 145 permitted facilities in the Elizabeth River Watershed. Out of the 145 permitted facilities, 51 are individual permitted facilities (47 industrial permit type, 5 municipal) and the remaining 94 general permitted facilities (construction, cooling, petrol, Ready Mix, car wash domestic). **Appendix A** presents all permitted facilities within the Elizabeth River watershed. The locations of the individual and general permitted facilities are presented in **Figure 2-3**. Note that facilities for which there was no latitude or longitude data are not included in **Figure 2-3**. The available flow data and enterococci data for those permitted facilities with available enterococci data were analyzed and compared to their permit bacteria limit. Discharge Monitoring Reports (DMR) for each of the individual permitted facilities discharging into Elizabeth River were obtained and analyzed for bacteria. However, it should be noted that none of the five municipal permitted facilities discharge into the bacteria impaired watersheds.

In addition to the individual and general permits**,** Municipal Separate Storm Sewer Segment (MS4) permits have been issued to cities and other facilities within the Elizabeth River Watershed. Overall, there are eight MS4 permits held in the Elizabeth River TMDL watershed: four Phase I MS4 permits and four Phase II MS4 permits. The areas covered by each of the MS4 permits are depicted in **Figure 2-4**. **Table 2-23** lists the MS4 permit holders located within the Elizabeth River TMDL watershed.

Table 2-24 presents the four Phase I MS4 and one Phase II MS4 permit holders and the area occupied by each MS4 locality per TMDL watershed. **Table 2-25** presents the two Phase II MS4s located within the TMDL watersheds of the Elizabeth River.

Table 2-23: Phase I and II MS4 Permits in the Elizabeth River TMDL Watershed

MS4 Permit Holder	Phase	Permit Number	Jurisdiction	Acreage
City of Chesapeake	I	VA0088625	City of Chesapeake	224,078
City of Norfolk	I	VA0088650	City of Norfolk	28,862
City of Portsmouth	I	VA0088668	City of Portsmouth	17,544
City of Virginia Beach	I	VA0088676	City of Virginia Beach	165,245
City of Suffolk	II	VA0090892	City of Suffolk	8,401
Scott Center Annex	II	VAR040114	City of Portsmouth	61
Portsmouth Naval Medical Center	II	VAR040045	City of Portsmouth	60
Norfolk State University	II	VAR040097	City of Norfolk	-*

*No area is available.

Table 2-24: Phase I and II MS4 Permit Acreage by Locality per TMDL Watershed

TMDL Watershed	MS4 Permit Holder	Permit Number	Acreage within the Elizabeth River Watershed
TMDL #1 Upper Mainstem Lower Southern Branch Lower Eastern Branch Broad Creek Indian River	City of Norfolk	VA0088650	8,119
	City of Portsmouth	VA0088668	3,574
	City of Chesapeake	VA0088625	59,330
	City of Virginia Beach	VA0088676	9,286
TMDL #2 Western Branch	City of Portsmouth	VA0088668	7,938
	City of Chesapeake	VA0088625	12,153
	City of Suffolk	VA0090892	522
TMDL #3 Lafayette River	City of Norfolk	VA0088650	9,143
TMDL #4 Paradise Creek	City of Portsmouth	VA0088668	1,678
	City of Chesapeake	VA0088625	25
TOTAL			**111,768**

Table 2-25: Phase II MS4 Permits within the Elizabeth River TMDL Watersheds

TMDL Watershed	Jurisdiction	Property Name	Permit Number	Acreage within the Elizabeth River Watershed
TMDL #1 Upper Mainstem Lower Southern Branch Lower Eastern Branch Broad Creek Indian River	City of Portsmouth	Portsmouth Naval Medical Center	VAR040045	60
	City of Norfolk	Norfolk State University	VAR040097	-*
TMDL #2 Western Branch	-	-	-	-
TMDL #3 Lafayette River	-	-	-	-
TMDL #4 Paradise Creek	City of Portsmouth	Scott Center Annex	VAR040114	61
Total				**121**
*No area is available.				

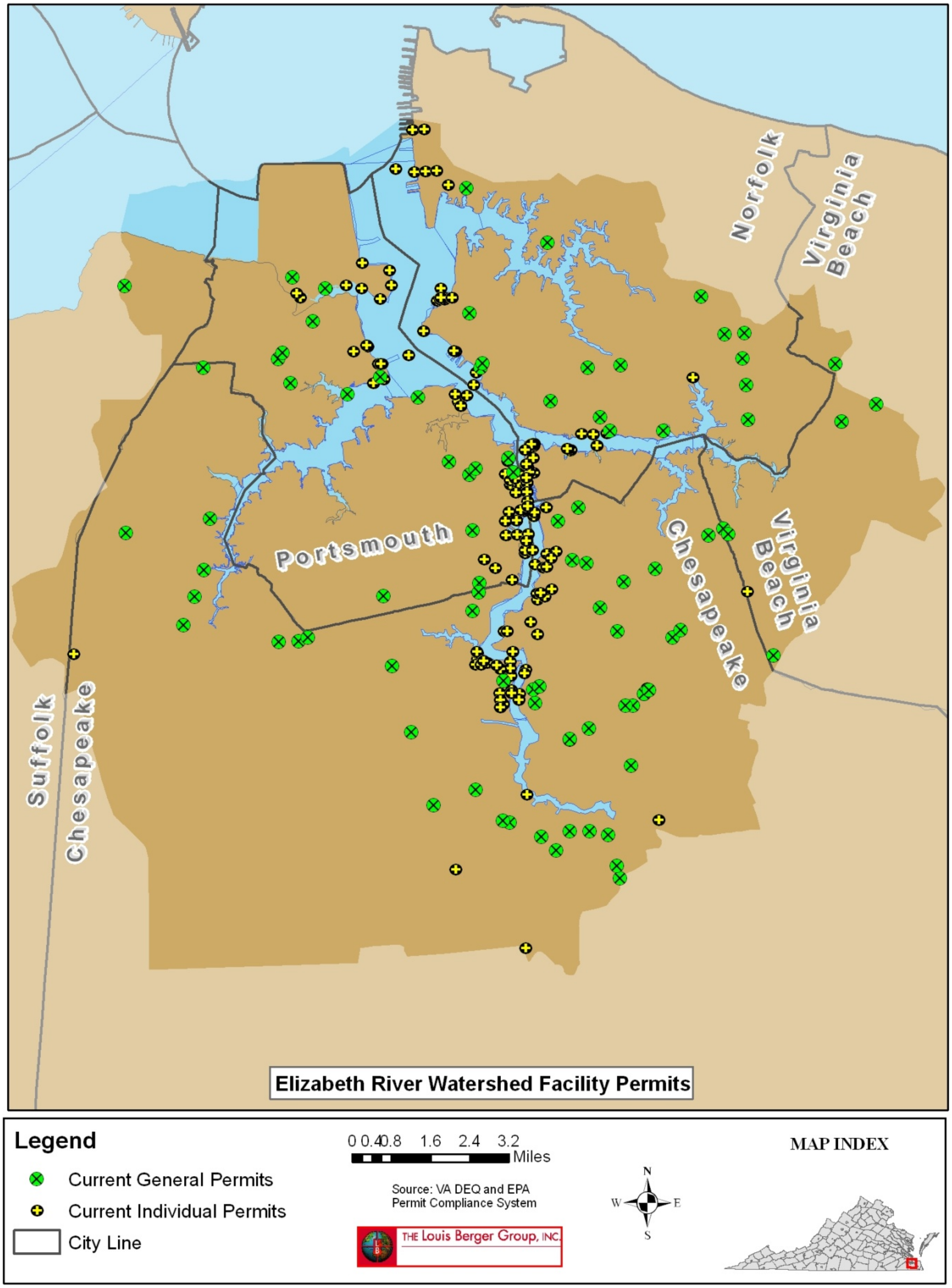

Figure 2-3: Location of Permitted Facilities in the Elizabeth River Watershed

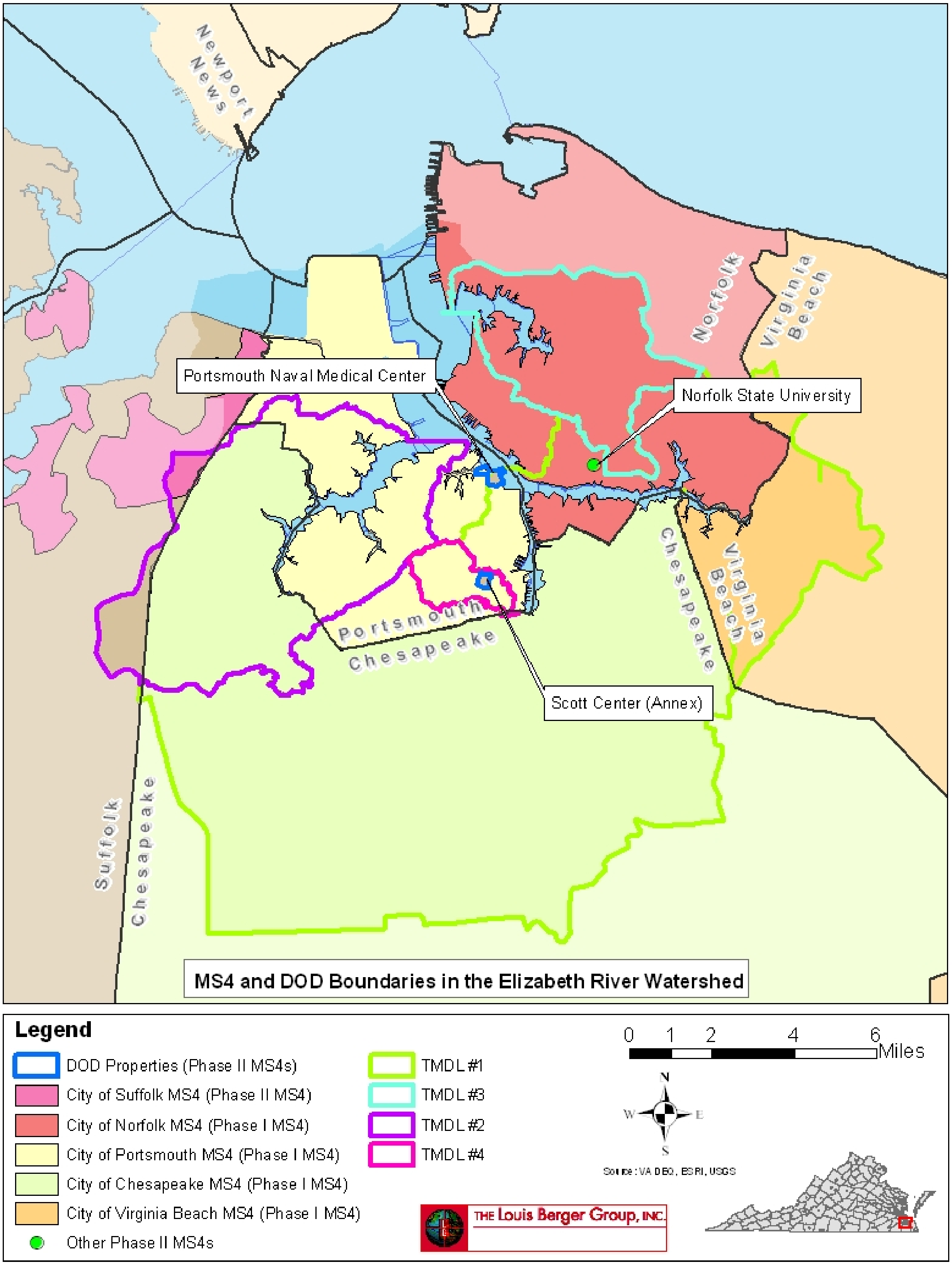

Figure 2-4: Location of Phase I and Phase II MS4s in the Elizabeth River Watershed

2.5.2 Sanitary Sewer System, Septic Tanks, and Straight Pipes

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.

Data on the population, the number of houses and the distribution of houses on sewer systems, septic systems and other means (considered to be straight pipes) in the Elizabeth River watershed was provided by the Cities of Chesapeake, Norfolk, Portsmouth, and Virginia Beach. The City of Suffolk also provided data on the number of houses and the distribution of houses on sewer systems, septic systems and other means. The population of the City of Suffolk within the Elizabeth River watershed was calculated by multiplying the US Census Bureau's 2008 estimate for the average number of people per household in Virginia by the total number of houses in the watershed.

In order to determine the amount of bacteria 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 the septic failure rate of 12% (VA DEQ, 2005). The 12% septic failure rate is a default value when Virginia Department of Health (VDH) information regarding septic failure rates in the watershed is unavailable. **Table 2-26** shows the population and septic estimates per TMDL watershed. These estimates were calculated by determining the percentage of the watershed within each county.

Table 2-26: Population Estimates per TMDL Watershed							
TMDL Watershed	**City**	**Population**	**Number of Houses**	**Number of Houses Public Sewer**	**Number of Houses on Septic Systems**	**Number of Houses on "Other Means"**	**Number of Houses with a Failing Septic System**
TMDL #1 Upper Mainstem Lower Southern Branch Lower Eastern Branch Broad Creek Indian River	Chesapeake	140,832	42,363	42,213	150	0	18
	Norfolk	43,531	15,714	15,680	34	0	4
	Portsmouth	26,425	7,932	7,927	5	0	0
	Virginia Beach	48,298	17,316	17,268	48	0	0
Total (TMDL #1)		**259,086**	**83,325**	**83,088**	**237**	**0**	**22**
TMDL #2 Western Branch	Chesapeake	37,027	11,671	11,567	104	0	12
	Portsmouth	40,858	14,184	14,115	69	0	0
	Suffolk	691*	272	239	33	0	4
Total (TMDL #2)		**78,576**	**26,127**	**25,921**	**206**	**0**	**16**
TMDL #3 Lafayette River	Norfolk	76,439	30,225	30,109	116	0	14
Total (TMDL #3)		**76,439**	**30,225**	**30,109**	**116**	**0**	**14**
TMDL #4 Paradise Creek	Portsmouth	9,360	2,927	2,925	2	0	0
Total (TMDL #4)		**9,360**	**2,927**	**2,925**	**2**	**0**	**0**

Based on estimates provided by the City of Chesapeake, the City of Norfolk, the City of Portsmouth, the City of Suffolk and the City of Virginia Beach.
* Calculated using the average number of people per house in Virginia (U.S. Census 2008) multiplied by the Number of Houses

2.5.3 Marinas

Marinas and heavy boating can contribute to bacteria loads when their waste is not adequately collected in pump stations or the pump station does not work properly. Within the Elizabeth River watershed, there are 18 marinas that operate sanitary pump outs for 2,730 vessel slips (City of Virginia Beach, Jan. 2009). Of the 18 marinas, 10 received grants to fund pump outs, and 11 provide dump stations.

2.5.4 Sanitary Sewer Overflows (SSOs)

Sanitary Sewer Overflows (SSOs) are discharges of raw sewage from municipal and non-municipal sanitary sewer systems. SSOs can release untreated sewage into basements or out of manholes and onto city streets, playgrounds and into streams before it can reach a treatment facility. SSOs are often caused by blockages in sewer lines and breaks in the sewer lines (EPA, 2009).

Based on data provided by VA DEQ, there were 2039 SSOs incidents reported in the Elizabeth River watershed between October 2004 and December 2009. The data set consisted of reported SSO release from five cities (Portsmouth, Chesapeake, Virginia Beach, Norfolk, and Suffolk) and non-municipally sources ("non-SSORS"). The released incident location data was geo-coded to identify and delineate the reported SSO incidents within each TMDL watershed. **Figure 2-5** shows the locations of SSOs that were reported between October 2004 and December 2009 within the Elizabeth River TMDL watersheds. **Table 2-27** shows a summary of the total number of SSOs within each TMDL watershed between 2005 and 2009 (2004 was not used because it was an incomplete year).

Data were not used in instances where the number of releases was reported with zero values. The database indicates that 100% of the reported SSO volume may have been recovered and/or pumped back to the waste treatment facility and that no discharge made it to surface waters. During the development of the SSORS reporting system, DEQ agreed to accept a "-1" indicator in extreme situations where the quantity is truly unknown. For example, a -1 may be reported following an extreme storm event in which there is significant flooding and widespread power outages. An estimation of the spill is not possible in these situations. Therefore, no data were considered when a -1 was reported.

Table 2-27: Number of SSO Releases within each TMDL Watershed between 2005 and 2009

TMDL	Stream	Total Number of SSO Releases	Number of Releases with Zero Values	Number of Releases with Negative Values (-1)	Net Number of Releases
TMDL #1	Eastern and Southern Branch	501	254	36	211
TMDL #2	Western Branch	181	82	24	75
TMDL #3	Lafayette River	85	4	32	49
TMDL #4	Paradise River	78	25	24	29
	Total	845	365	116	364

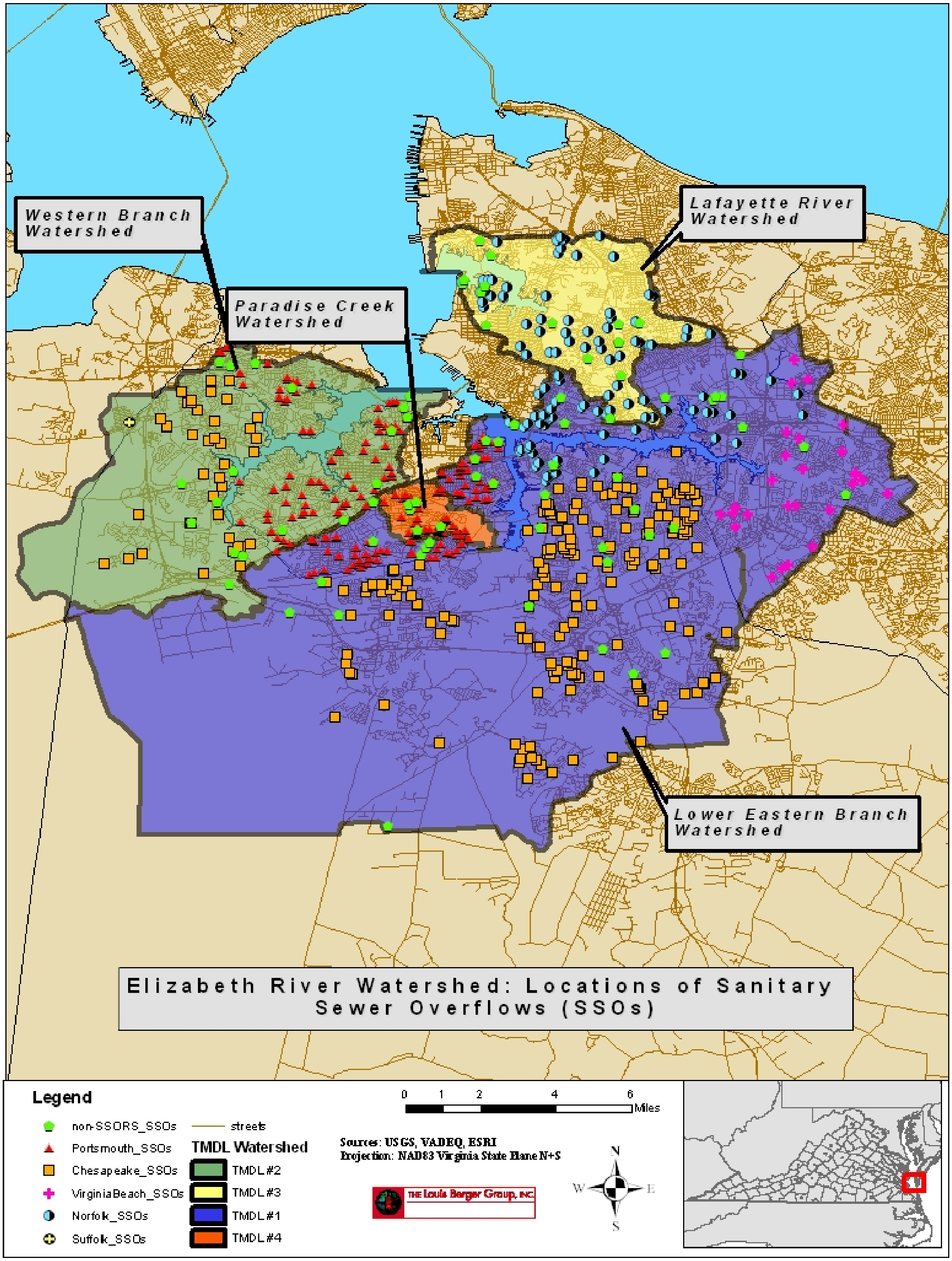

Figure 2-5: Locations of SSOs in the Elizabeth TMDL watersheds

2.5.5 Livestock

An inventory of the livestock of the Elizabeth River watershed was conducted using data and information provided by the Cities of Chesapeake, Norfolk, Portsmouth, Suffolk and Virginia Beach. Livestock estimates per TMDL watershed are shown in **Table 2-28**.

Table 2-28: Livestock Present per TMDL Watershed

TMDL Watershed	City	Cattle	Pigs	Poultry	Horses	Sheep
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	Chesapeake	200	75	0	100	0
	Norfolk	0	0	0	0	0
	Portsmouth	0	0	0	0	0
	Virginia Beach	0	0	0	0	0
Total (TMDL #1)		**200**	**75**	**0**	**100**	**0**
TMDL #2 Western Branch	Chesapeake	0	0	0	150	0
	Portsmouth	0	0	0	0	0
	Suffolk	0	0	0	15	0
Total (TMDL #2)		**0**	**0**	**0**	**165**	**0**
TMDL #3 Lafayette River	Norfolk	2	11	24	2	0
Total (TMDL #3)		**2**	**11**	**24**	**2**	**0**
TMDL #4 Paradise Creek	Portsmouth	0	0	0	0	0
Total (TMDL #4)		**0**	**0**	**0**	**0**	**0**

Data based on estimates provided by the City of Chesapeake, the City of Norfolk, the City of Portsmouth, the City of Suffolk and the City of Virginia Beach.

2.5.6 Zoos

Zoos may contribute to bacteria loading if the animal waste on its property is not collected thoroughly and deposited properly. The Virginia Zoological Park in Norfolk is the only zoo located within the Elizabeth River watershed. According to a staff member from the zoo, the animal feces is picked up daily and disposed of off appropriate sites. Generally, surface runoff flows to drop inlets and is conveyed to a duck pond that overflows into the Elizabeth River. On their property, the zoo has established several BMPs for capturing storm runoff from new animal exhibits and other impervious areas. The installation of additional BMPs at drop inlets is planned.

2.5.7 Wildlife

Similar to livestock contributions, wildlife contributions of bacteria 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 the Elizabeth River watershed 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 wildlife in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. The number of animals in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. Typical wildlife densities are presented in **Table 2-29**. Wildlife per TMDL watershed is shown in **Table 2-30**.

Table 2-29: Wildlife Densities in the TMDL Watersheds[1]

Wildlife Type	Population Density	Habitat Requirements
Deer	0.047 animals/acre	Entire watershed minus high and medium intensity developed, and water
Raccoon (low density)	10/square mile	Upland forest
Raccoon (high density)	50/square mile	Bottomland forest, marsh, swamp, along streams
Muskrat (low density)	2 animals/mile	16/mile of ditch or medium sized stream intersecting agriculture crop fields, 8/mi of medium sized stream intersecting pasture fields, 10/mi of pond or lake edge, 50/mi of slow-moving river
Muskrat (high density)	15 animals/mile	
Muskrat (average density)	10 animals/mile	
Nutria (Adult)	18.5/mile	Streams and rivers
Nutria (Youth)	66/mile	
Goose	0.02 animals/acre	Entire Watershed
Canada Goose	http://migbirdapps.fws.gov/	Based on particular strata for watershed area
Mallard		
Wood Duck		
Black Duck		

[1] Source: Virginia Department of Game and Inland Fisheries, VA DEQ

Table 2-30: Wildlife Present per TMDL Watershed									
TMDL Watershed	**Residential Geese**	**Canada Geese[1]**	**Black Duck[1]**	**Wood Duck[1]**	**Mallard[1]**	**Deer[2]**	**Raccoon[3]**	**Muskrat[3]**	**Nutria[4]**
TMDL #1 Upper Mainstem Lower Southern Branch Lower Eastern Branch Broad Creek Indian River	1,655	164	0	0	164	2,056	3,164	945	3,134
TMDL #2 Western Branch	479	46	0	0	46	578	926	397	836
TMDL #3 Lafayette River	206	19	0	0	19	51	378	213	395
TMDL #4 Paradise Creek	34	3	0	0	3	24	29	23	43

[1] Based on the Atlantic Flyway Breeding Waterfowl Survey of migrating birds (DGIF)

[2] Based on DGIF population density of 0.047animals/acre (Acreages of entire watershed minus high and medium intensity developed, and water)

[3] Based on information from the Virginia Department of Game and Inland Fisheries (DGIF)

[4] Based on data from the VA DEQ

2.5.8 Pets

The two types of domestic pets that were considered as potential sources of bacteria in the Elizabeth River 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 (American Veterinary Medical Association or AVMA). Based on these estimates, the number of dogs and cats per watershed are shown in **Table 2-31**.

Table 2-31: Pets Present per TMDL Watershed			
TMDL Watershed	**Households[1]**	**Dogs[2]**	**Cats[2]**
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	83,325	45,245	49,412
TMDL #2 Western Branch	26,127	14,187	15,493
TMDL #3 Lafayette River	30,225	16,412	17,923
TMDL #4 Paradise Creek	2,927	1,589	1,736
TOTAL	**142,604**	**77,433**	**84,564**

[1] Provided by the City of Chesapeake, the City of Norfolk, the City of Portsmouth, the City of Suffolk and the City of Virginia Beach

[2] Based on the number of households multiplied by pet unit numbers per household (Source: American Veterinary Medical Association)

3.0 Modeling Approach

This section describes the modeling approach used in the TMDL development. The primary focus 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 water body that can:

- represent a bacteria water quality model for small coastal basins
- represent the watershed hydrologic characteristics and tidal volume in steady state
- represent the non-point sources of bacteria and their respective contribution
- use kinetic data (die-off rate of bacteria)
- 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 the Elizabeth River Watershed in areas designated by VA DEQ (2008). The designated areas are brackish waters and tidally influenced by an unrestricted connection to the Chesapeake Bay.

3.3 Modeling Strategy

3.3.1 Model Selection and Approach

A simplified model approach (simplified tidal prism bacteria model), jointly developed by EPA, VA DEQ, VA DCR, Maryland Department of the Environment (MDE), VDH-DSS, Virginia Institute of Marine Sciences (VIMS), United States Geological Survey, Virginia Polytechnic University, James Madison University, and Tetra Tech, was selected to estimate present bacteria loads for small coastal basins, and to calculate allocation and needed reductions of each source (VA DEQ, 2005, 2006). A spreadsheet model, which is run in Microsoft EXCEL, calculates estuaries' bacteria loads based on steady state mass balance in the estuary over a tidal period. (The prevailing tide in the estuary of the Elizabeth River Watershed is the lunar semi-diurnal (M2) tide with a tidal period of 12.42 hours.) Tidal exchange in this case is between the estuary (Elizabeth River Watershed) and the Chesapeake Bay (referred to as 'ocean' in the model). The steady state condition of the model mirrors average conditions of the estuary system and incorporates the following assumptions:

1. Water is incompressible
2. Water is completely mixed:
    a. Density variations due to temperature and salinity changes by saline and freshwater inflow are negligible
    b. Variations of bacteria concentration are negligible
3. The saline volume flowing into the estuary is based on an average tidal range, the surface area of the estuary, and an average fraction of incoming new ocean water
4. The volume of water flowing out the estuary 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. Bacteria is decayed through a combined daily first order kinetic rate

The water balance in the estuary under steady state is defined as follows (the change of the total volume of water in the estuary (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 estuary 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 estuary 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 estuary from the ocean during flood (tidal prism) is corrected by the average fraction of incoming new ocean water (ocean tidal exchange ratio):

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

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 estuary and ocean and defined by the following equation by Fischer et al. (1979) (Guo and Lordi, 2000):

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

In which S_f = Average salinity of ocean water entering the estuary during flood [ppt]

S_e = Average salinity of estuary water leaving the estuary during ebb [ppt]

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

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 estuary from the ocean through the inlet during flood tide and is computed through the surface area of the estuary and the mean tidal range. The mean tidal range is defined as the mean difference between high and low tidal levels.

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

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

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

When equation (1) is formulated as mass balance for bacteria and a total daily death rate for bacteria 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 = Bacteria concentration entering the estuary through flood tide which was not released from the estuary on the previous ebb tide [COUNT/100mL]

C_b = Bacteria concentration leaving the estuary through ebb tide which did not enter from the estuary on the previous flood tide [COUNT/100mL]

C_f = Bacteria concentration from the watershed and the local area in the estuary during tidal cycle [COUNT/100mL]

k_b = Total death rate for enterococci in estuary [day^{-1}]

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

In this TMDL, a total death rate for enterococci of 1.73 day^{-1} was applied based on a study by EPA (2007) in the New York-New Jersey harbor estuaries.

3.3.2 Estimation of the Current Daily Load Capacity of the Bay

When Q_fC_f equals L_t (total load capacity of the estuary) 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 estuary [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 enterococci bacteria unit counts/100mL into counts/m^3)

Equation (6) is used to calculate the current daily load capacity for enterococci bacteria in the estuary. The daily load capacity is calculated separately for the maximum geometric mean and single maximum value measured in the estuary (C_b) and at the boundary between the estuary and the Chesapeake Bay (C_0). The current load capacity with the highest load is used for the load allocation to account for critical conditions.

3.3.3 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 enterococci bacteria (C_c), the following equation yields:

$$L_t = (C_c(Q_b + k_b V_b) - Q_0 C_c) * f_{conv} \qquad (7)$$

In which C_c = Concentration of enterococci bacteria for VA criteria of geometric mean and singe maximum value

Equation (7) is used to calculate the allowable daily load for enterococci bacteria in the estuary based on VA DEQ criteria for enterococci in saltwater and transition zone. 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 enterococci load in the watershed.

3.4 Volume Estimations

Four volumes of water needed to be considered for developing the bacteria TMDL for the Elizabeth River Watershed:

- Volume of water at sea level in the estuary
- Volume of water entering the estuary through flood tide
- Volume of water flowing out of the estuary 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, in the estuary of the Elizabeth River watershed was computed using NOAA navigation charts and GIS data from the NOAA website. Data was available for most of the estuary's impaired segments, excluding some upstream portions of impaired segments. The results are discussed in Section 2.3.

3.4.2 Volume of Water Entering the Estuary

The volume of water entering the estuary through flood tide was computed by applying equation (2) and (4). The surface area was estimated based on bathymetry data, and the mean tidal ranges for the Elizabeth River Watershed were obtained from NOAA's website "Tide and Currents" (NOAA, 2006). The tidal stations "Norfolk Amc," "Sewells Point, Hampton," and "Portsmouth, Norfolk Naval Shipyard" were used for the mean tidal range of the Elizabeth River TMDLs. An ocean tidal exchange ratio of 0.5 was selected for the estuary based on the average 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 estuary surface area, the mean tidal range, and the calculated incoming volume for the estuary of Elizabeth River.

Table 3-1: Estimated Estuary Surface Area and Calculated Incoming Volume for the Estuary of the Elizabeth River Watershed

TMDL Watershed	Surface Area	Mean Tidal Range[1]	Calculated Volume (Q_0)
	m^2	m	m^3/tidal cycle
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	11,276,075	0.43	2,405,863
TMDL #2 Western Branch	5,236,465	0.43	1,117,252
TMDL #3 Lafayette River	5,046,896	0.70	1,769,038
TMDL #4 Paradise Creek	146,650	0.49	35,759

3.4.3 Volume of Water Flowing out of the Estuary

The volume of water flowing out of the estuary through flood tide was computed by applying equation (1). **Table 3-2** shows the volume of water leaving the Elizabeth River estuary by TMDL watershed.

Table 3- 2: Estimated Volume of Water Leaving the Estuary of the Elizabeth River Watershed	
TMDL Watershed	**Calculated Volume (Q_b)**
	m^3/tidal cycle
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	2,407,004
TMDL #2 Western Branch	1,117,348
TMDL #3 Lafayette River	1,769,056
TMDL #4 Paradise Creek	35,760

3.4.4 Volume of Net Freshwater

Freshwater input to an estuary is defined by the net downstream flow from the tributaries and direct contribution from adjoining areas. The volume of fresh water entering the estuary of the Elizabeth River watershed was estimated based on average flow measurements over ten years (1999 through 2008). However, continuous flow measurements collected in the freshwater section of the Elizabeth River were not used, due to the lack of a USGS gauging station in the watershed. The closest USGS gauging station with similar size of drainage area, distribution of land use, and with available continuous flow data is USGS station 02049500 at Blackwater River near Franklin, VA. This USGS station is approximately thirty miles away from the Elizabeth River watershed. Based on the long-term average flow at USGS 02049500, a unit flow rate was computed and applied to each TMDL watershed to obtain the total volume of water entering the estuary. **Table 3-3** shows the computed unit freshwater flow rate per m^2 and the volume of freshwater per tidal cycle for the Elizabeth River watershed for each TMDL watershed.

Table 3- 3: Drainage Area and Freshwater Inflow Volume for the Estuaries of the Elizabeth River Watershed		
TMDL Watershed	**Drainage Area**	**Volume**
	m^2	m^3/tidal cycle*
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	334,826,645	1,141
TMDL #2 Western Branch	96,928,248	95.60
TMDL #3 Lafayette River	41,697,641	18
TMDL #4 Paradise Creek	6,943,334	0
*Based on a lunar semi-diurnal (m^2) tide with a tidal period of 12.42 hours		

3.5 Enterococci Sources Representation

This section demonstrates which enterococci 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, straight pipes, sanitary sewer overflows, and permitted dischargers), livestock, wildlife, and pets.
2. Sources within the estuary include waterfowl and boat traffic. There are 18 marinas in the watershed with 2,730 vessel slips.
3. Downstream boundary source from the boundary between estuary and the Chesapeake Bay.

The first two sources were accounted for in a conglomerated number, combining all enterococci sources, represented by the maximum enterococci concentration measured at stations 2-BRO001.35 (TMDL #1), 2-WBE004.44 (TMDL #2), 2-LAF003.83 (TMDL #3) and 2-PAR001.77 (TMDL #4). These stations are located within the estuary of each TMDL watershed. Individual bacteria sources such as human sources, pets, livestock, and wildlife were accounted using the Environmental Protection Agency's (EPA) Bacterial Indicator Tool to distribute enterococci loadings among the various sources for all four TMDL watersheds. The EPA Bacterial Indicator Tool is a spreadsheet model using

Microsoft Excel that estimates daily accumulated bacteria loads per source. The Bacterial Indicator Tool employs user supplied land use acreage, animal population, septic systems and unit load data to estimate the fecal coliform loads from various sources in a watershed environment. It is assumed that the distribution of enterococci load is identical to the distribution of fecal coliform load from the same source categories. Thus, the Fecal Tools results were used to estimate the enterococci distribution for septic system, pet, livestock and wildlife bacteria sources in each TMDL watershed.

For bacteria sources originating from sanitary sewer overflows (SSOs), bacteria loads for each TMDL watershed were estimated based on measured SSO volume releases provided from the sanitary sewer overflow reporting system (SSORS) by VA DEQ. For each TMDL watershed, time series of daily accumulative SSO volume releases were developed for the time period between 2005 and 2009. The accumulative SSO volume releases was based on the net daily reported SSO releases only. Incidents coded as “-1” were not included in this analysis, since they were determined that these were extreme events; a total of 116 incidents. The daily cumulative SSO volumes were used to develop cumulative frequency distribution (CFD) curves (CFDs depict the percentage of days for which the cumulative SSO volume was equaled or exceeded. The CFDs also show the range of available data for SSO volume that was released at a day of an incident for each TMDL watershed). The CFD curves for each TMDL watershed are shown in Appendix E.

SSO daily loads were estimated using the following assumptions:

- The daily accumulative released SSO volume for each TMDL watershed equals the 5th percentile in the CFD. The 5th percentile was selected in order to be protective 95% of the time. This would include SSO releases triggered under dry weather and wet weather conditions. However, isolated incidents such as the impact of hurricanes would not be covered in the 5th percentile.
- The fecal coliform concentration in raw sewage is 2,700,000 colonies/100mL and is based on local data (provided by HRSD).
- The estimated SSO enterococci load are presented as a daily load.

The third source is represented by the maximum enterococci measurements taken at the boundary station 2-ELI004.79 for TMDL #1, TMDL #2 and TMDL #4, and at the boundary station 2-LAF001.15 for TMDL #3. Both boundary stations are located in the Chesapeake Bay, within close proximity to the mouth of the Elizabeth River.

Table 3-4 shows the maximum enterococci concentration at stations located in the estuary and boundary of the Elizabeth River watershed. The table also shows whether VA DEQ standard for enterococci concentration is exceeded.

Table 3- 4: Maximum Concentration of Enterococci in the Estuary of the Elizabeth River (2004 - 2007)

TMDL Watershed	Location	Station	Value (count /100mL)	Exceeds SSM standard: 104 count /100mL[1]
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River	Estuary	2-BRO001.35	2000	Yes
	Boundary[2]	2-ELI-004.79	550	Yes
TMDL #2 Western Branch	Estuary	2-WBE004.44	2000	Yes
	Boundary[2]	2-ELI-004.79	550	Yes
TMDL #3 Lafayette River	Estuary	2-LAF003.83	2000	Yes
	Boundary[2]	2-LAF001.15	2000	Yes
TMDL #4 Paradise Creek	Estuary	2-PAR001.77	2000	Yes
	Boundary[2]	2-ELI-004.79	550	Yes

[1] Requirements of at least two measurements for calculating geometric mean 35 count /100mL for enterococci were not met

[2]Station is located at the boundary between the TMDL Watershed and the Chesapeake Bay

In order to determine the relative contributions of enterococci loads from different nonpoint sources, a spreadsheet based analysis tool, EPA's Bacterial Indicator Tool was used. The Tool employs user supplied land use acreage, animal population (livestock, wildlife, and pets), septic systems and unit load data to estimate the fecal coliform loads from various sources in a watershed environment. Relative contributions of enterococci loads from different nonpoint sources (including estimated SSO loads) were then calculated in the Elizabeth TMDL watersheds as shown in **Table 3-5** and **Figures 3-1** through **Figure 3-4**. It is assumed that the distribution of entercocci load is identical to the distribution of fecal coliform load from the same source categories.

Table 3- 5: Estimated Bacterial Contribution by Source and TMDL Watershed					
TMDL Watershed	**Livestock**	**Wildlife**	**Failed septic System**	**Pets**	**SSOs**
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Indian River, Broad Creek, Upper Mainstem	33.1%	15.9%	<0.1%	45.3%	5.7%
TMDL #2 Western Branch	1.6%	22.6%	<0.1%	69.9%	5.9%
TMDL #3 Lafayette River	0.0%	4.4%	<0.1%	44.4%	51.2%
TMDL #4 Paradise Creek	0.0%	13.7%	<0.1%	80.7%	5.5%

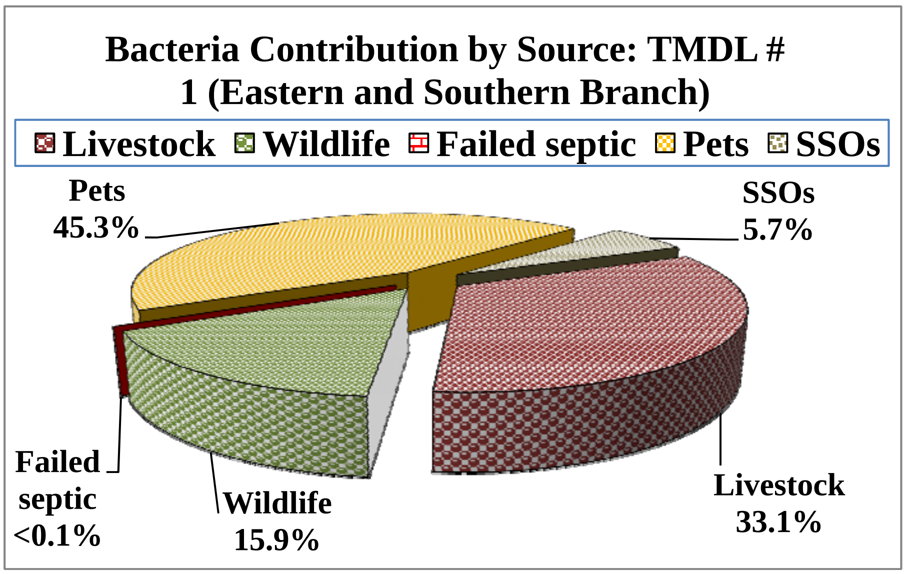

Figure 3-1: Distribution of Bacteria Loads by Source in TMDL #1

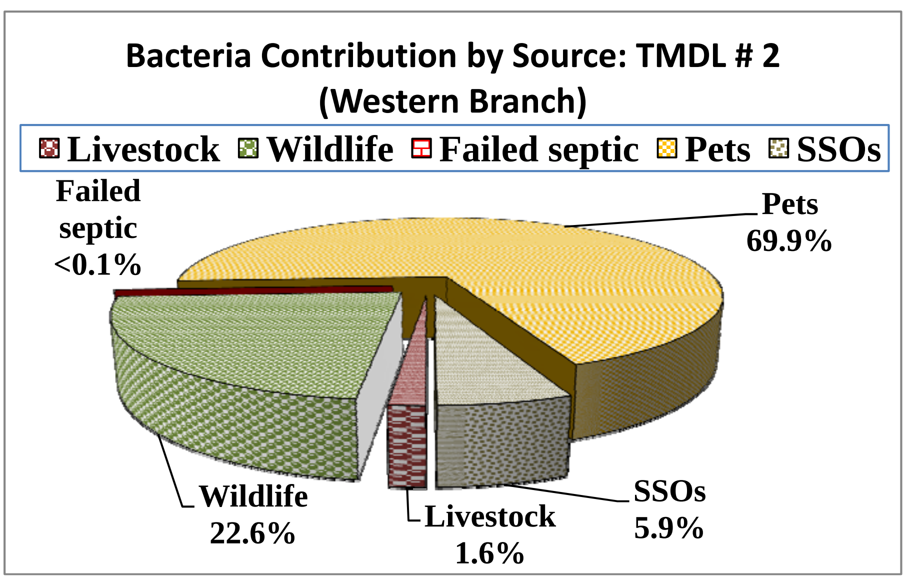

Figure 3-2: Distribution of Bacteria Loads by Source in TMDL #2

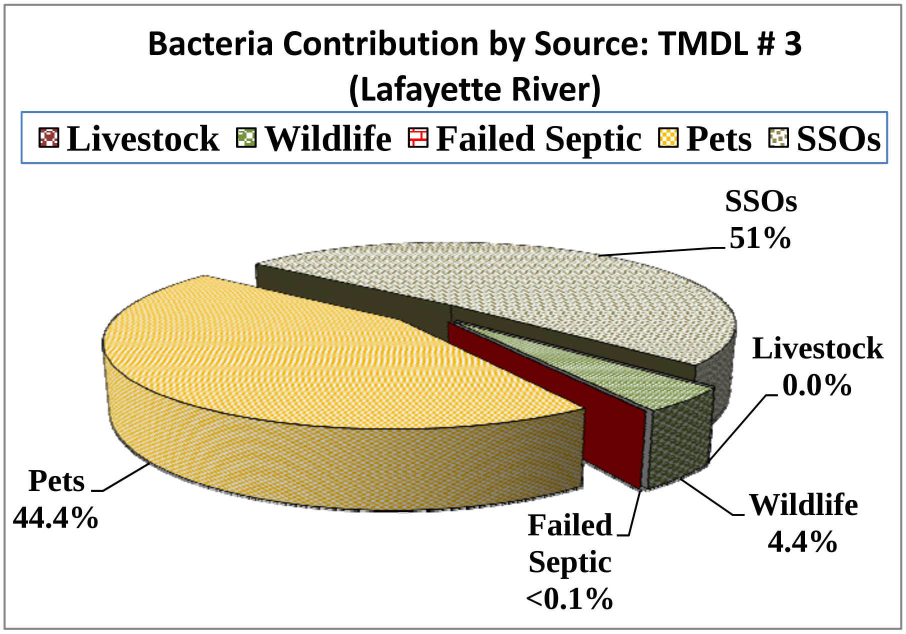

Figure 3-3: Distribution of Bacteria Loads by Source in TMDL #3

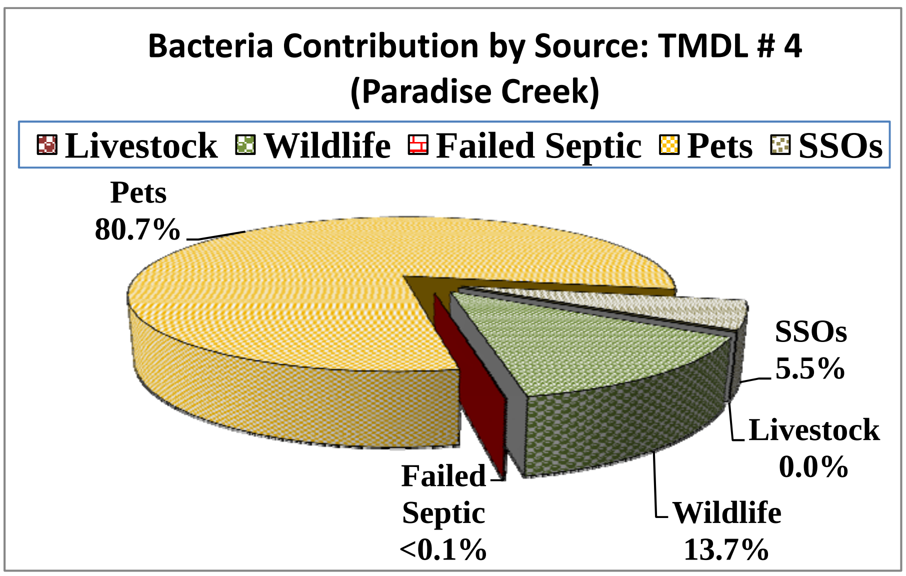

Figure 3-4: Distribution of Bacteria Loads by Source in TMDL #4

4.0 TMDL Allocation

The allocation analysis for the bacteria impaired segments of the Elizabeth River watershed is the third stage in TMDL development. Its purpose is to develop a framework for reducing enterococci loading under the existing watershed conditions so that water quality standards can be met. In this section, TMDL allocations will be presented for the recreational impaired segments of the Elizabeth River: the Upper Mainstem, Lower Eastern Branch, Lower Southern Branch, Broad Creek and Indian River (TMDL #1, Cause Group Code G15E-02-02-BAC); the Western Branch (TMDL #2, Cause Group Code G15E-04-01-BAC); the Lafayette River (TMDL #3, Cause Group Code G15E-05-02-BAC); and Paradise Creek (TMDL #4, (Cause Group Code G15E-02-05-BAC).

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 (non-point 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, which accounts 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 requires that allocations meet the bacteria standard geometric mean of 35 count/100mL and the single sample maximum of 104 MPN/100mL at any time. Conservative assumptions such as using the worst case geometric mean and highest instantaneous enterococci exceedances in load calculations are further examples of an implicit MOS.

4.2 Load Allocation Development

The reduction of loadings from non-point sources (livestock, wildlife, pet, failed septic system) including livestock, pets, and wildlife direct deposition, that are not covered under MS4 area and the non-urban area of the MS4 was incorporated into the load allocation. In addition, the total load from SSOs was included in the load allocation. Based on the simulation results from the simplified tidal prism bacteria model, enterococci loadings (daily load capacity of the bay) were estimated in the estuary of the Elizabeth River in order to obtain the current load and allowable load. The current load is based on the maximum value of the geometric mean and the single sample maximum that was measured at monitoring stations 2-BRO001.35, 2-WBE004.44, 2-LAF003.83, and 2-PAR001.77. The allowable load is based on VA DEQ criteria for enterococci for the geometric mean and single sample maximum. However, only the single sample maximum was applied in this TMDL, since the geometric mean calculation requires at least two measurements per 30 days. The required percent load reduction for the Elizabeth River watershed was estimated by subtracting the allowable load from the current load, dividing it by the current load, and multiplying it by 100. **Table 4-1** shows the estimated model results of the current load, allowable load, and reduction for the single sample maximum for the Elizabeth watershed. The single sample maximum values were used to calculate the load allocation and the TMDLs in the Elizabeth River watershed.

Table 4-1: Current Load, Allowable Load, and Required Reduction Based on the Single Maximum Value for the Elizabeth River Watershed

TMDL Watershed	Station	Maximum Enterococci (count/100mL)	Current Load (counts/day)	Allowable Load (counts/day)	Required Reduction (%)
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River	2-EBE002.98	2000	2.80E+15	1.42E+14	94.9%
TMDL #2 Western Branch	2-WBE004.44	2000	7.32E+14	3.64E+13	95.0%
TMDL #3 Lafayette River	2-LAF003.83	2000	5.98E+14	3.11E+13	94.8%
TMDL #4 Paradise Creek	2-PAR001.77	2000	1.21E+13	5.79E+11	95.2%

4.3 Waste Load Allocation

Since no municipal permitted facilities discharge into the bacteria impaired watersheds, no waste load was allocated to permitted facilities. However, in order to account for future growth, one percent of the LA of each TMDL watershed was allocated to each TMDL watershed. There are eight MS4 permit holders within the TMDL watersheds of the Elizabeth River. Of the eight, four are Phase I MS4 permit holders and the remaining four are Phase II permit holders. A waste load allocation was applied to MS4 permit holders based on the urban area that is located within each TMDL watershed. For MS4 permit holders where no area was available, the waste allocation was aggregated with the waste allocation of the respective MS4 permit holder.

4.4 Allocation Plan and TMDL Summary

Load Allocation

The reduction of loadings from non-point sources (livestock, wildlife, pet, failed septic system) including livestock, pets, and wildlife direct deposition, that are not covered under MS4 area and the non-urban area of the MS4 was incorporated into the load allocation. In addition, the total load from SSOs was included in the load allocation. The load allocation for the Elizabeth River watershed TMDLs are based on the proportion of the bacteria sources (livestock, wildlife, septic system, pets, and sanitary sewer overflows). The proportions were derived from bacteria loads that were estimated using EPA's bacteria indicator tool for bacteria loads originating from livestock, wildlife, septic system, and pets and spreadsheet calculations for bacteria loads originating from sanitary sewer overflows (Chapter 3.5). The SSO bacteria loads in the Elizabeth River TMDL watershed were included in the Load Allocation of the TMDL and not the Waste Load Allocation for several reasons. Municipal sanitary sewer collection systems within the TMDL areas are not operated under a VPDES permit. HRSD's sanitary sewage collection system can transfer flows among several WWTPs. While SSOs are a point source discharge, assigning a WLA to a specific permit is not feasible. Also, assigning a WLA for SSOs could be interpreted that there is an acceptable amount that can be discharged to the River. The purpose of the consent orders with the cities and HRSD is to control releases, not "allow an amount". Finally, WLAs are reserved for VPDES permitted discharges such as MS4s and other facility types. The SSO load will not be included as part of any MS4 WLA. The limit of the MS4 permit is to control stormwater and SSOs are not regulated under the MS4 program. While SSOs may be released to the River through stormwater systems, it is not within the scope of the MS4 program to correct leaking sanitary sewers or prevent SSOs.

A complete reduction of all human sources (septic system, sanitary sewer overflows) is required, since enterococci from human sources are considered a serious concern in estuaries (VA DEQ, 2005). Reductions for wildlife are applied when the reduction of controllable loads (humans, livestock, and pets) does not achieve the water quality standard for the estuary (VA DEQ, 2005). However, the TMDL does not recommend reductions in wildlife populations. The enterococci TMDL allocations by different source categories that would meet the single sample maximum enterococci standard of 104 count/100mL for the Elizabeth River watershed per TMDL watershed are presented in **Table 4-2**.

Table 4-2: Load Allocation and Required Reductions for each TMDL Watershed				
TMDL Watershed	**Source**	**Current Load (count/day)**	**Allocated Load (count/day)**	**Required Reduction (%)**
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River	Livestock	5.55E+14	2.41E+11	100%
	Wildlife	2.66E+14	8.39E+13	68%
	Failed Septic System	2.17E+10	0.00E+00	100%
	Pet	7.59E+14	3.29E+11	100%
	Sanitary Sewer Overflows	9.53E+13	0.00E+00	100%
	Total	**1.67E+15**	**8.45E+13**	**95%**
TMDL #2 Western Branch	Livestock	5.30E+12	2.39E+09	100%
	Wildlife	7.49E+13	1.63E+13	78%
	Failed Septic System	2.32E+10	0.00E+00	100%
	Pet	2.32E+14	1.05E+11	100%
	Sanitary Sewer Overflows	1.95E+13	0.00E+00	100%
	Total	**3.32E+14**	**1.64E+13**	**95%**
TMDL #3 Lafayette River	Livestock	2.40E+09	4.26E+07	98%
	Wildlife	1.74E+13	1.74E+13	0%
	Failed Septic System	2.56E+10	0.00E+00	100%
	Pet	1.77E+14	3.14E+12	98%
	Sanitary Sewer Overflows	2.04E+14	0.00E+00	100%
	Total	**3.98E+14**	**2.05E+13**	**95%**
TMDL #4 Paradise Creek	Livestock	0.00E+00	0.00E+00	-
	Wildlife	2.13E+11	7.41E+10	65%
	Failed Septic System	1.07E+09	0.00E+00	100%
	Pet	1.26E+12	4.16E+08	100%
	Sanitary Sewer Overflows	8.65E+10	0.00E+00	100%
	Total	**1.56E+12**	**7.45E+10**	**95%**

Waste Load Allocation and TMDL

Since no municipal permitted facilities discharge into the bacteria impaired watersheds, no waste load was allocated to permitted facilities. However, in order to account for future growth, one percent of the LA of each TMDL watershed was allocated to each TMDL watershed. To account for future growth in the TMDL watersheds, one percent of the LA of each TMDL watershed was allocated to the WLA (**Table 4-3**).

Waste load allocations were also applied to eight MS4 permit holders in the Elizabeth River watershed: the City of Norfolk (VA0088650), the City of Virginia Beach (VA0088675), the City of Chesapeake (VA0088625), the City of Suffolk (VA0090892), the City of Portsmouth (VA0088668), the Portsmouth Naval Medical Center (VAR040045), the Scott Center Annex (VAR040114), and Norfolk State University (VAR040097), which discharge runoff (including bacteria) into the estuary of the Elizabeth River. The bacteria loads were allocated to the MS4 permit holders using an area weighted approach. Each MS4 permit holder was allocated a bacteria load based on the urban area that is covered in each TMDL watershed. For the MS4 permit holder with no information on its covered area, Norfolk State University (VAR040097), the bacteria load was aggregated with the Phase I MS4 permit holder, City of Norfolk. **Table 4-4** through **4-7** presents the waste load allocation for each MS4 permit holder within each TMDL watershed.

Summaries of the TMDL allocation plans are presented in **Table 4-8**. Minor differences in current loads are due to rounding.

Table 4-3: Allocated Waste Load per TMDL Watershed for Future Growth

TMDL Watershed	WLA for Future Growth (1% of the LA) (count/day)
TMDL #1 Upper Mainstem, Lower Southern Branch, Lower Eastern Branch, Broad Creek, Indian River	8.45E+11
TMDL #2 Western Branch	1.64E+11
TMDL #3 Lafayette River	2.05E+11
TMDL #4 Paradise Creek	7.45E+08

Table 4-4: Waste Load Allocation for MS4 Permit Holders Discharging within TMDL #1				
MS4 Permit Holder	**MS4 Permit #**	**Existing Load**	**Allocated Load**	**Required Reduction**
		counts/day	**counts/day**	**%**
City of Norfolk (Phase 1)*	VA0088650	2.48E+14	1.18E+13	95%
City of Portsmouth (Phase 1)	VA0088668	9.28E+13	4.42E+12	95%
City of Chesapeake (Phase 1)	VA0088625	6.38E+14	3.04E+13	95%
City of Virginia Beach (Phase 1)	VA0088676	2.16E+14	1.03E+13	95%
Portsmouth Naval Medical Center (Phase 2)	VAR040045	1.99E+12	9.48E+10	95%
	Total	1.20E+15	5.70E+13	95%
*Including Norfolk State University (Phase II) permit holder				

Table 4-5: Waste Load Allocation for MS4 Permit Holders Discharging within TMDL #2				
MS4 Permit Holder	**MS4 Permit #**	**Existing Load**	**Allocated Load**	**Required Reduction**
		counts/day	**counts/day**	**%**
City of Portsmouth (Phase 1)	VA0088668	2.10E+14	9.77E+12	95%
City of Chesapeake (Phase 1)	VA0088625	2.11E+14	9.86E+12	95%
City of Suffolk (Phase 2)	VA0090892	4.47E+12	2.08E+11	95%
	Total	4.25E+14	1.98E+13	95%

Table 4-6: Waste Load Allocation for MS4 Permit Holders Discharging within TMDL #3				
MS4 Permit Holder	**MS4 Permit #**	**Existing Load**	**Allocated Load**	**Required Reduction**
		counts/day	**counts/day**	**%**
City of Norfolk (Phase 1)	VA0088650	2.00E+14	1.03E+13	95%

Table 4-7: Waste Load Allocation for MS4 Permit Holders Discharging within TMDL #4				
MS4 Permit Holder	MS4 Permit #	Existing Load	Allocated Load	Required Reduction
		counts/day	counts/day	%
City of Portsmouth (Phase 1)	VA0088668	1.01E+13	4.79E+11	95%
City of Chesapeake (Phase 1)	VA0088625	1.12E+11	5.34E+09	95%
Scott Center Annex (Phase 2)	VAR040114	4.01E+11	1.91E+10	95%
	Total	1.06E+13	5.04E+11	95%

Table 4-8: Elizabeth River Watershed TMDL Allocation Plan Loads (count/day)				
TMDL Watershed	WLA (MS4s within urban area and 1% of LA for future growth)	LA (SSOs, Non MS4s and non-urban MS4s)	MOS (Margin of Safety)	TMDL
TMDL #1 Lower Eastern Branch, Lower Southern Branch, Upper Mainstem, Broad Creek, Indian River	**5.78E+13**	**8.45E+13**	**IMPLICIT**	**1.42E+14**
TMDL #2 Western Branch	**2.00E+13**	**1.64E+13**	**IMPLICIT**	**3.64E+13**
TMDL #3 Lafayette River	**1.05E+13**	**2.05E+13**	**IMPLICIT**	**3.11E+13**
TMDL #4 Paradise Creek	**5.04E+11**	**7.45E+10**	**IMPLICIT**	**5.79E+11**

4.5 Consideration of Seasonal Variability

The Clean Water Act requires that a TMDL be established with consideration of seasonable variations. This includes variations of the hydrologic flow regime and the water quality. The seasonable variation was accounted for by the incorporation of monthly sampling and long-term data record in estimating existing conditions.

4.6 Consideration of Critical Conditions

The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. The Elizabeth River bacteria reductions were developed using the maximum measured bacteria concentration within the impaired waterbody and a stringent bacteria criterion (90th percentile). These two elements; the use of the maximum measured bacteria concentration along with a stringent bacteria criterion insures that the critical conditions are accounted for the bacteria impaired segments of the Elizabeth River watershed.

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 enterococci 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. “Per the Chesapeake Bay act, 5 year pump outs of septic tanks are mandatory and regulated by the counties.” In sewered areas, reducing the loading from leaking sewer lines could be accomplished through a sanitary sewer inspection and management program.

To reduce fecal loading from pets, pet education on managing pet waste may be effective. Pet poop-scooping education and septic systems for large kennels or hunt clubs could be beneficial.

Education could be made available to homeowners, farmers, and businesses concerning the importance of maintaining the Chesapeake Bay Act’s requirement of observing a 100’ riparian buffer along all creeks and tributaries of the Bay. Protecting existing buffers in addition to restoring buffers which have been destroyed are potentially inexpensive but exceptionally effective methods of reducing runoff which carry with it bacteria, nutrients, and even chemicals to surface waters. Riparian buffers serve as “strainers” which prevent the entry of such components to the waterway.

The SSOs evaluated in this report are associated with the sanitary sewer collections systems of the HRSD and the municipalities within each TMDL area. Prior to the development of this TMDL, consent orders were issued requiring HRSD and municipalities to evaluate their collection system and develop plans to eliminate SSOs. This TMDL will not affect the execution of these orders. A summary of these orders and their requirements are described below.

The State Water Control Board issued HRSD and thirteen satellite municipal collection systems (the cities of Chesapeake, Hampton, Newport News, Poquoson, Portsmouth, Suffolk, Virginia Beach and Williamsburg; the counties of Gloucester, Isle of Wight, and

York; the James City Service Authority; and the town of Smithfield) a special order by consent effective September 26, 2007. The overarching goal of the order is to reduce the occurrence of sanitary sewer overflows in the regional sanitary sewer system.

In general the order provides for conducting a regional sanitary sewer system evaluation including flow, pressure, and rainfall monitoring and conducting Sanitary Sewer Evaluation Studies (SSES) in identified basins pursuant to the Regional Technical Standards (the regional Technical Standards are incorporated into the order as Attachment 1 and provide detailed requirements to ensure a consistent regional approach for completion of the work required by the order). Data obtained from the studies will be used in the development of a regionally integrated, calibrated and dynamic flow model. System maintenance is addressed by the development of Management, Operations, and Maintenance Programs for HRSD and each municipality. Deficiencies identified by the SSES must be considered and if appropriate, scheduled for rehabilitation or replacement in the development of Rehabilitation Plans. In addition, to address adequate capacity to collect, convey, and treat peak flows in the regional sanitary sewer system during wet weather, a Regional Wet Weather Management Plan will be developed and implemented to define improvements in the regional system necessary to meet wastewater transmission and treatment needs to 2030.

To date, HRSD and the satellite municipalities have submitted flow monitoring plans for approval by DEQ and implemented flow monitoring for SSES basin identification. Flow Evaluation Reports, SSES Reports, and Management, Operations, and Maintenance Plans have been submitted to DEQ and are in the review and approval process. By November 26, 2010, HRSD and each satellite municipality must develop a calibrated dynamic model of their system. SSES field activities are currently being undertaken and must be completed by November 26, 2011. Based on the results of the SSES field activities, the parties must submit Condition Assessment Reports and Rehabilitation Plans by November 26, 2012. The final plan required by the consent order is submittal of the Regional Wet Weather Management Plan by November 26, 2013. The order also provides for submittal of annual progress reports on November 1.

Although the City of Norfolk collects and transmits their sanitary sewer to HRSD for treatment it is not included in the September 26, 2007 consent order. Norfolk and HRSD are subject to a previously executed consent order (effective date March 17, 2005) addressing sanitary sewer overflows in the City of Norfolk. Norfolk has previously conducted a SSES of their system and developed a schedule for rehabilitation which is being implemented. Norfolk is voluntarily submitting flow data and information required for inclusion in the regional flow model.

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

VA DEQ will continue sampling at the established bacteriological monitoring stations, and continue to use this data 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 Non-point 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 non-point 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 Elizabeth River watershed TMDLs would not have been possible without public participation, which included two sets of public meetings and three sets of Technical Advisory Committee meetings (TAC) held in Virginia Beach within the Elizabeth River watershed. A public notice was published in a local paper for each set of meetings and email invitations publicized the meeting. The public notices for the meetings were also posted in the Virginia Register and signs displayed meeting date, time and location information at bridges throughout the watershed. The following is a summary of the meetings.

Public Meeting #1. This meeting was held on August 26, 2009 in Virginia Beach, Virginia.

Public Meeting #2. This meeting was held on February 23, 2010 in Virginia Beach, Virginia.

Technical Advisory Committee Meeting #1. This meeting was held on April 3, 2009 in Virginia Beach, Virginia.

Technical Advisory Committee Meeting #2. This meeting was held on December 14, 2009 in Virginia Beach, Virginia.

Technical Advisory Committee Meeting #3. This meeting was held on February 5, 2010 in Virginia Beach, Virginia.

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8.0 Glossary

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

Allocations. That portion of receiving water's loading capacity attributed to one of its existing or future pollution sources (non-point or point) or to natural background sources. (A wasteload allocation [WLA] is that portion of the loading capacity allocated to an existing or future point source, and a load allocation [LA] is that portion allocated to an existing or future non-point source or to natural background levels. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.)

Ambient water quality. Natural concentration of water quality constituents prior to mixing of either point or non-point source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.

Anthropogenic. Pertains to the [environmental] influence of human activities.

Bacteria. Single-celled microorganisms. Bacteria of the coliform group are considered the primary indicators of fecal contamination and are often used to assess water quality.

Bacterial source tracking (BST). A collection of scientific methods used to track sources of fecal contamination.

Biosolids. Also known as Sewage sludge, is the name for the solid, semisolid, or liquid materials removed during the treatment of domestic sewage in a treatment facility. Biosolids include, but are not limited to, solids removed during primary, secondary, or advanced wastewater treatment, scum, domestic septage, portable toilet pumpings, Type III marine sanitation device pumpings, and sewage sludge products. When properly treated and processed, sewage sludge becomes "biosolids" which can be safely recycled and applied as fertilizer to improve and maintain productive soils and stimulate plant growth.

Best management practices (BMPs). Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally non-point source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Clean Water Act (CWA). The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.

Concentration. Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).

Contamination. The act of polluting or making impure; any indication of chemical, sediment, or biological impurities.

Cost-share program. A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remainder of the costs is paid by the producer(s).

Critical condition. The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.

Designated uses. Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.

Domestic wastewater. Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.

Drainage basin. A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.

Existing use. Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).

Fecal Coliform. Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract.

Geometric mean. A measure of the central tendency of a data set that minimizes the effects of extreme values.

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Infiltration capacity. The capacity of a soil to allow water to infiltrate into or through it during a storm.

Interflow. Runoff that travels just below the surface of the soil.

Loading, Load, Loading rate. The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time.

Load allocation (LA). The portion of a receiving waters loading capacity attributed either to one of its existing or future non-point sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and non-point source loads should be distinguished (40 CFR 130.2(g)).

Loading capacity (LC). The greatest amount of loading a water body can receive without violating water quality standards.

Margin of safety (MOS). A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving water body (CWA section 303(d)(1)©). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mean. The sum of the values in a data set divided by the number of values in the data set.

Monitoring. Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

Narrative criteria. Non-quantitative guidelines that describe the desired water quality goals.

Non-point source. Pollution that originates from multiple sources over a relatively large area. Non-point sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.

Numeric targets. A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.

Point source. Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water waterbody or river.

Pollutant. Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).

Pollution. Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Poultry Litter. A material used as bedding in poultry operations. Common litter materials are woodshavings, sawdust, peanut hulls, shredded sugar cane, straw, and other dry, absorbent, low-cost organicmaterials. After use, the litter consists primarily of poultry manure, but also contains the original littermaterial, feathers, and spilled feed.

Privately owned treatment works. Any device or system that is (a) used to treat wastes from any facility whose operator is not the operator of the treatment works and (b) not a publicly owned treatment works.

Public comment period. The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).

Publicly owned treatment works (POTW). Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a state or municipality. This definition includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW providing treatment.
Raw sewage. Untreated municipal sewage.

Receiving waters. Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.

Riparian areas. Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.

Riparian zone. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.

Runoff. That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Septic system. An on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.

Sewer. A channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers handle both.

Slope. The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).

Stakeholder. Any person with a vested interest in the TMDL development.

Surface area. The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.

Surface runoff. Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of non-point source pollutants.

Surface water. All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.

Topography. The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.

Total Maximum Daily Load (TMDL). The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for non-point sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state’s water quality standard.

VADEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Virginia Pollutant Discharge Elimination System (NPDES). The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.

Wasteload allocation (WLA). The portion of a receiving waters' loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation (40 CFR 130.2(h)).

Wastewater. Usually refers to effluent from a sewage treatment plant. See also **Domestic wastewater**.

Wastewater treatment. Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.

Water quality. The biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.

Water quality criteria. Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water quality standard. Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation statement.

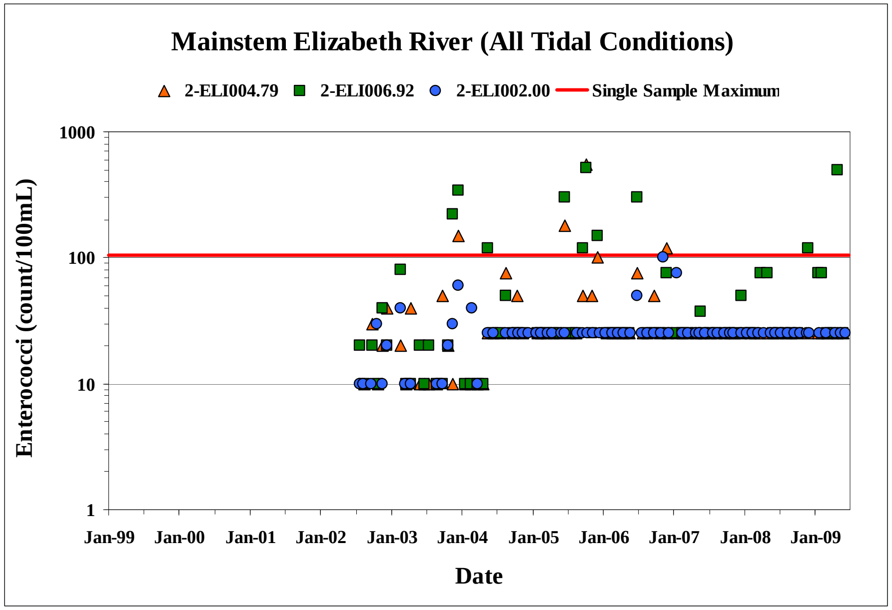
Watershed. A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

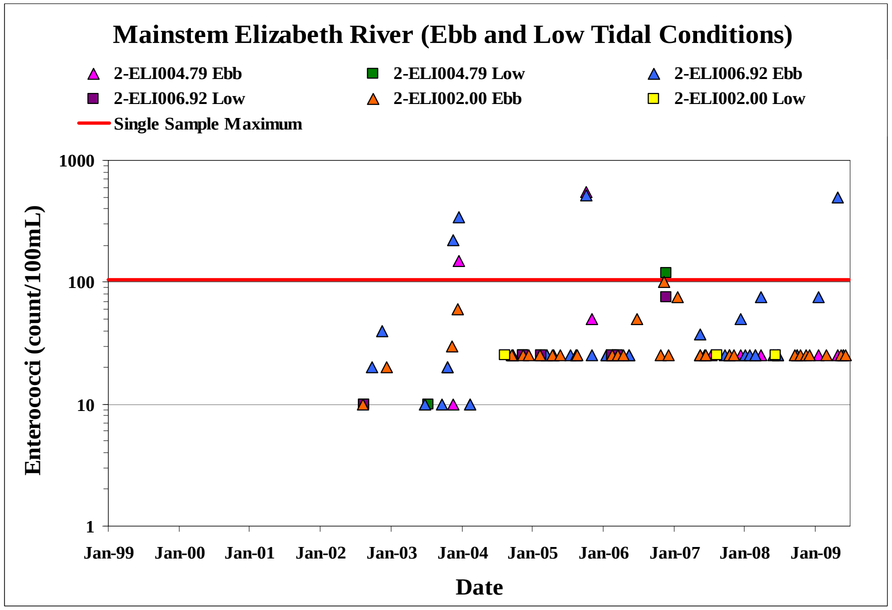
WQIA. Water Quality Improvement Act.

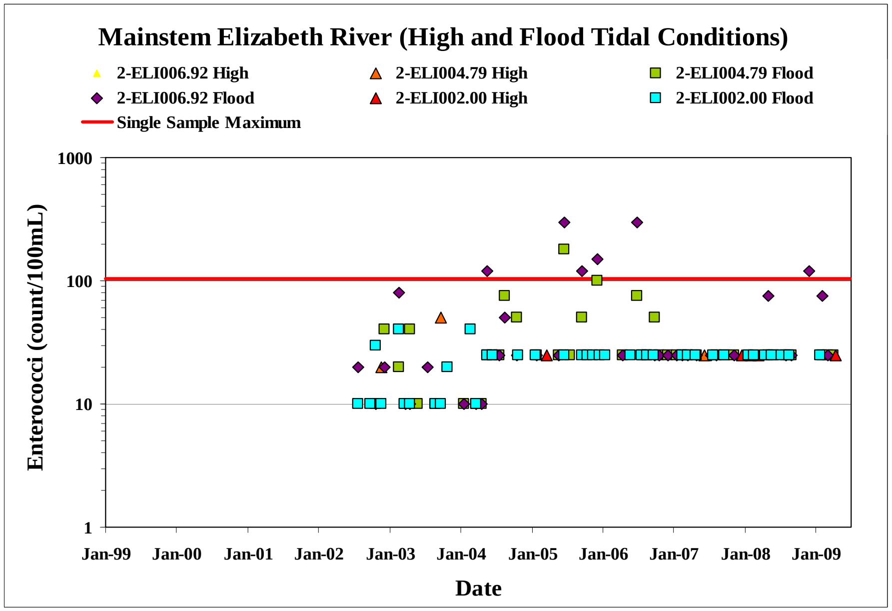
APPENDIX A:

Water Quality Graphs

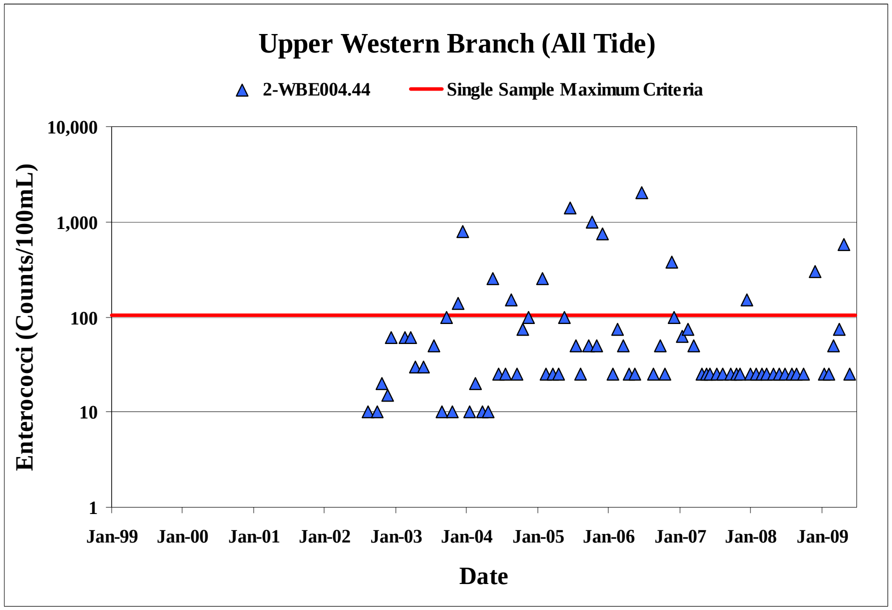
Elizabeth River Mainstem:

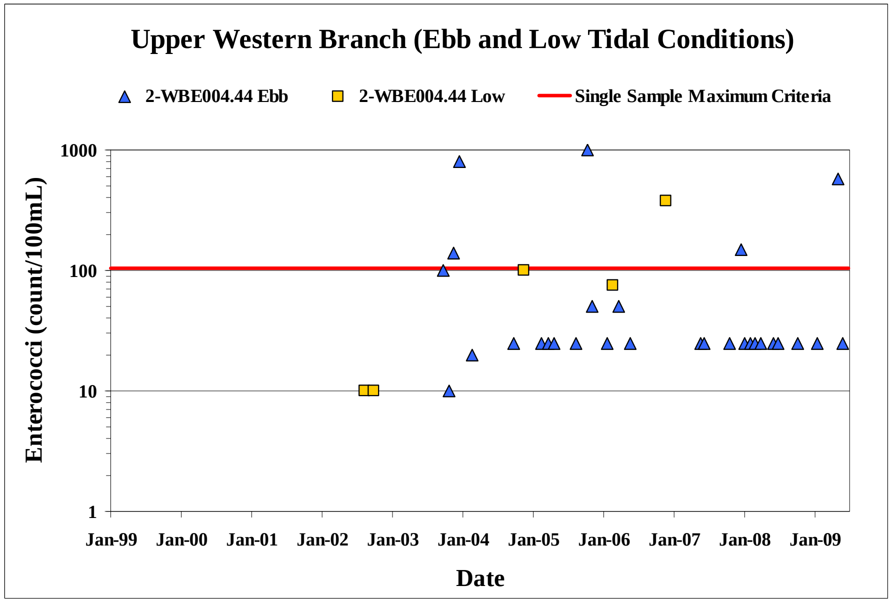


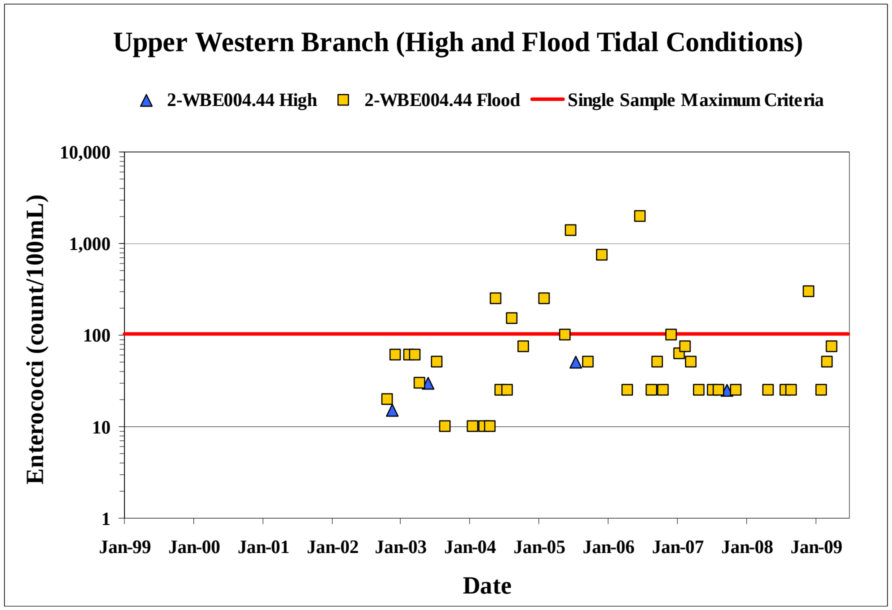




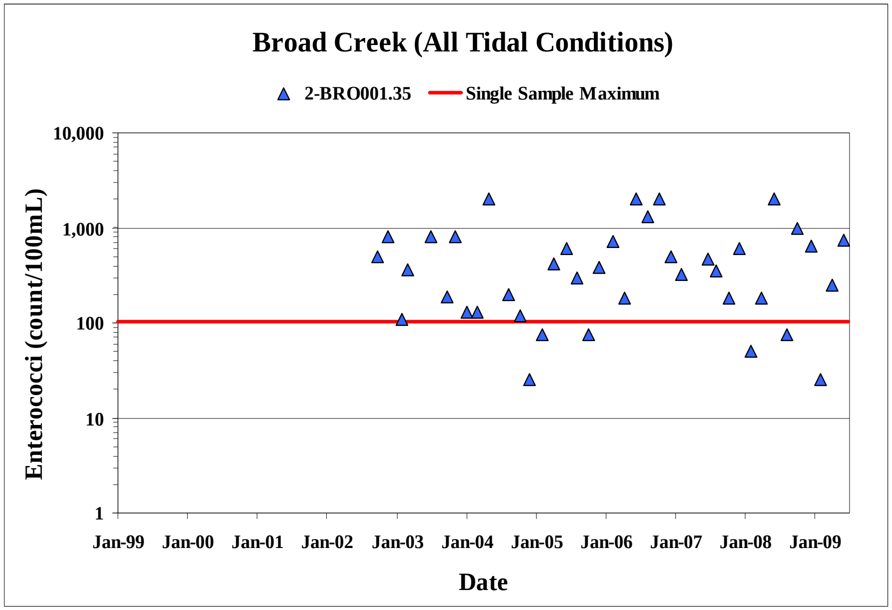
Elizabeth River Upper Western Branch:

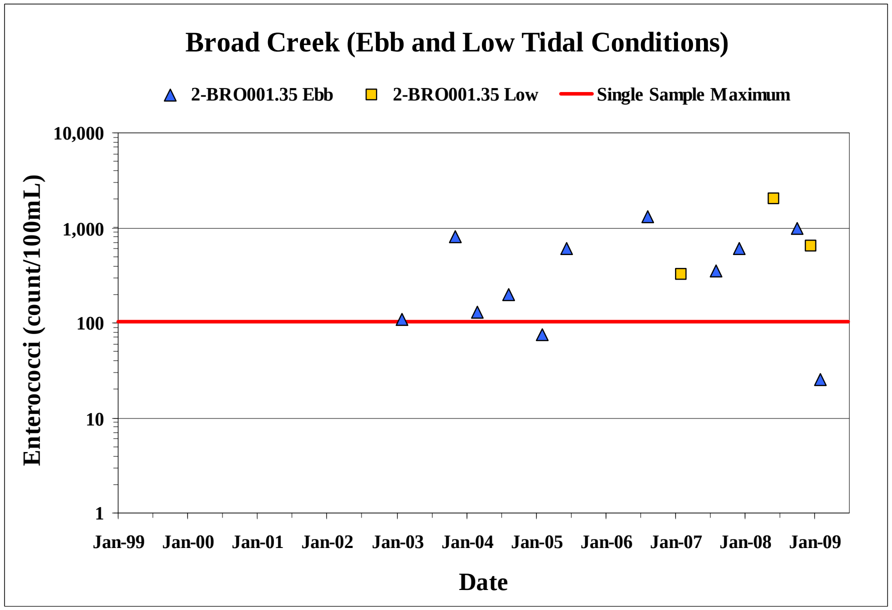


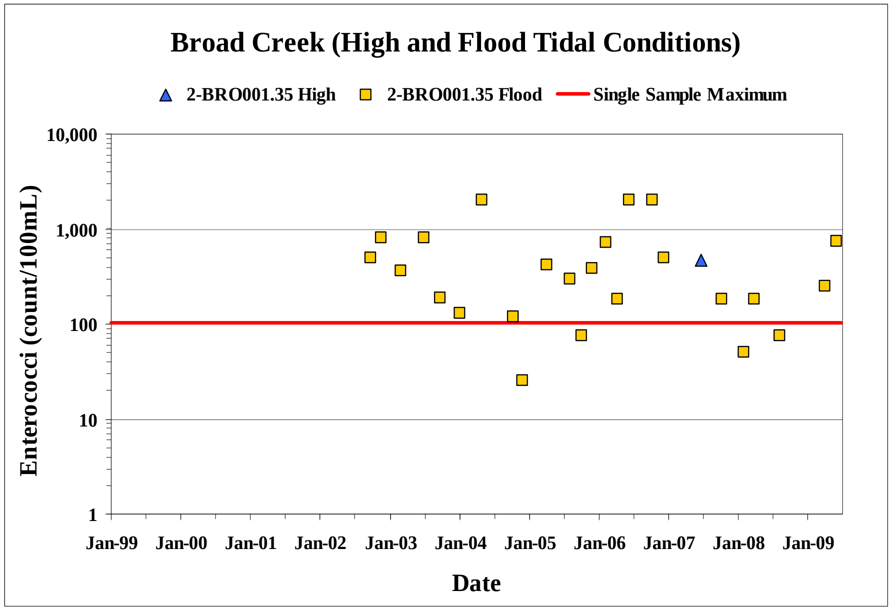




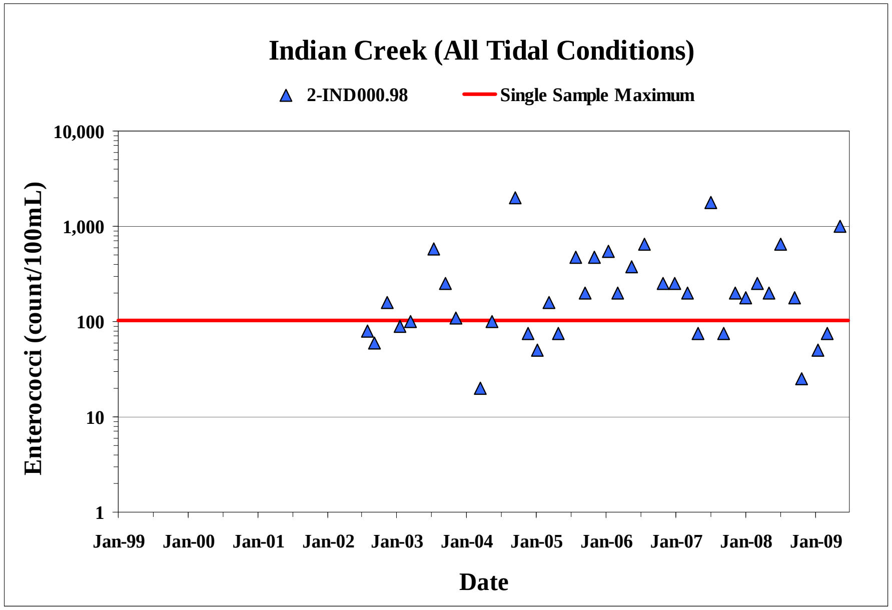
Elizabeth River Broad Creek:

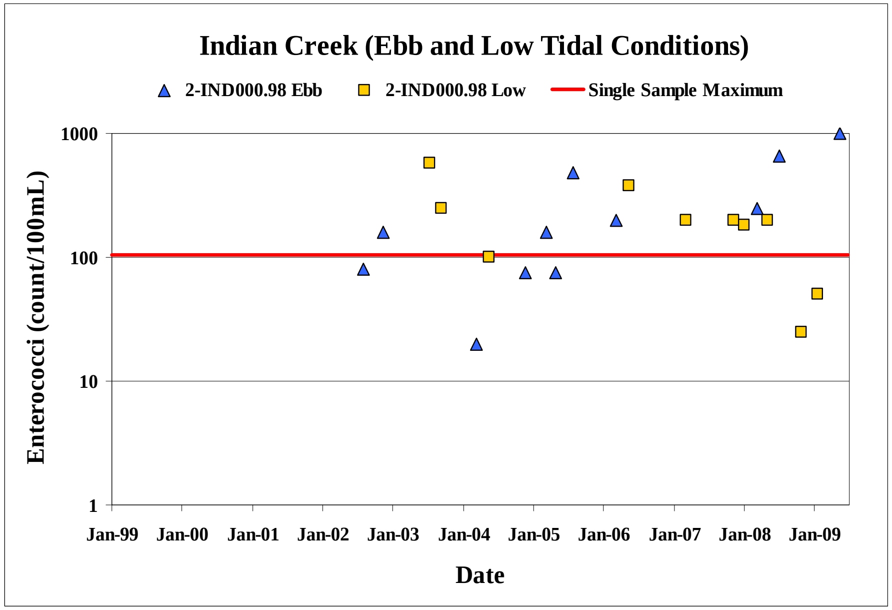


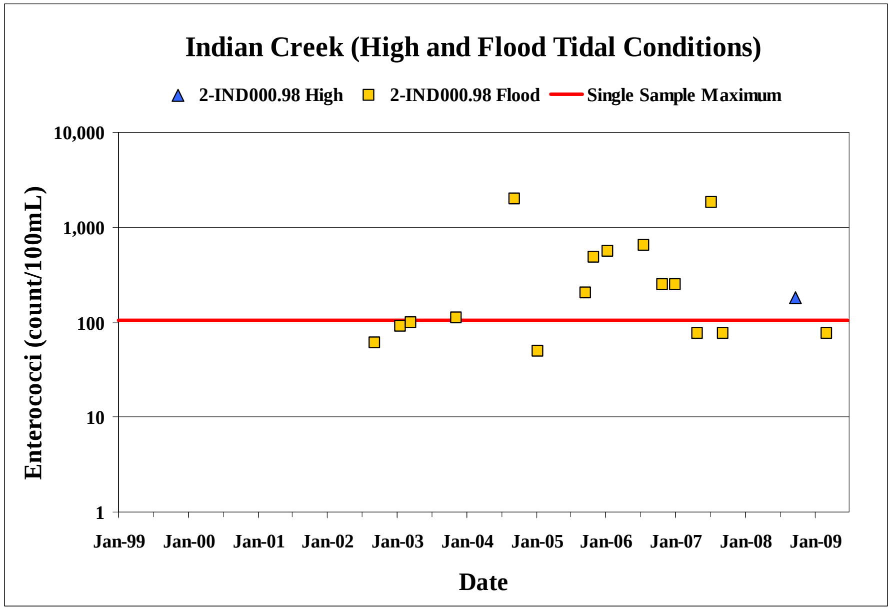




Elizabeth River Indian Creek:







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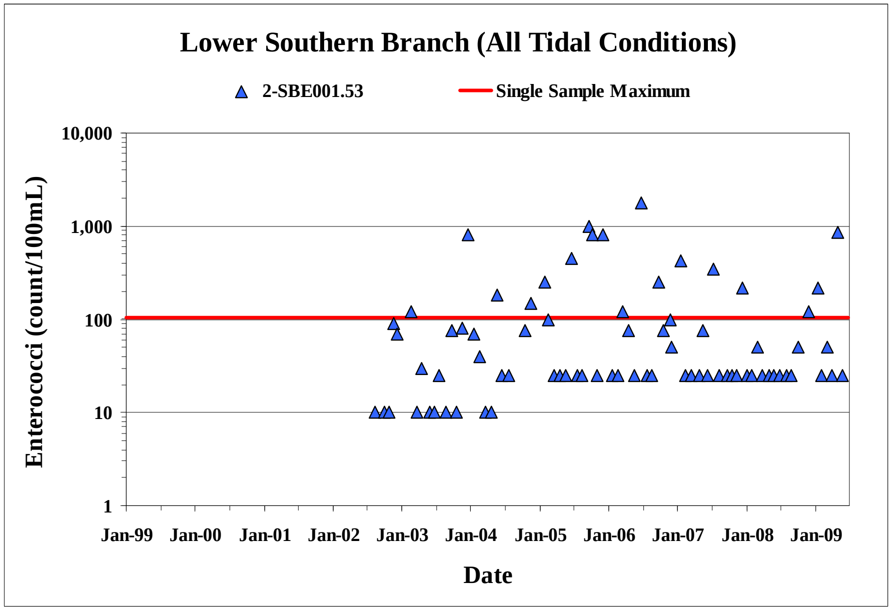

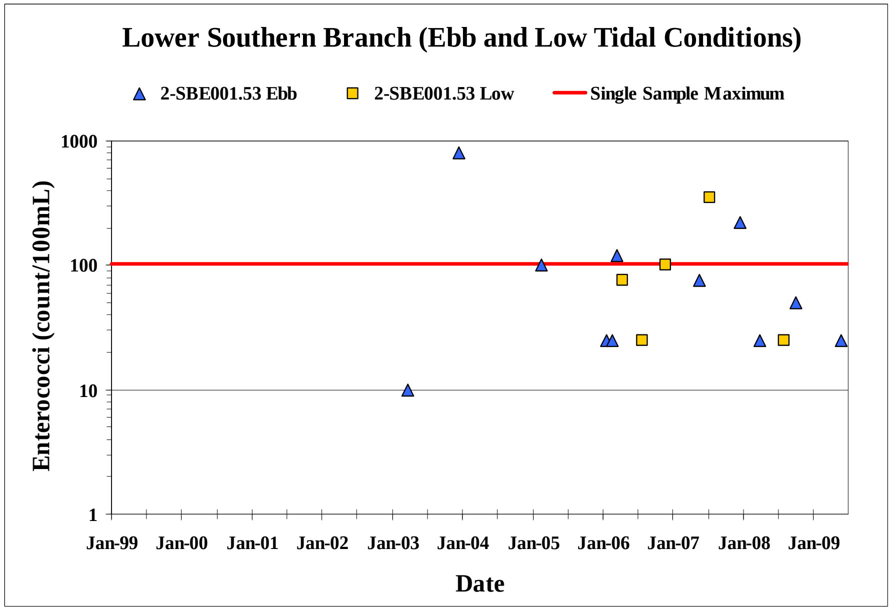

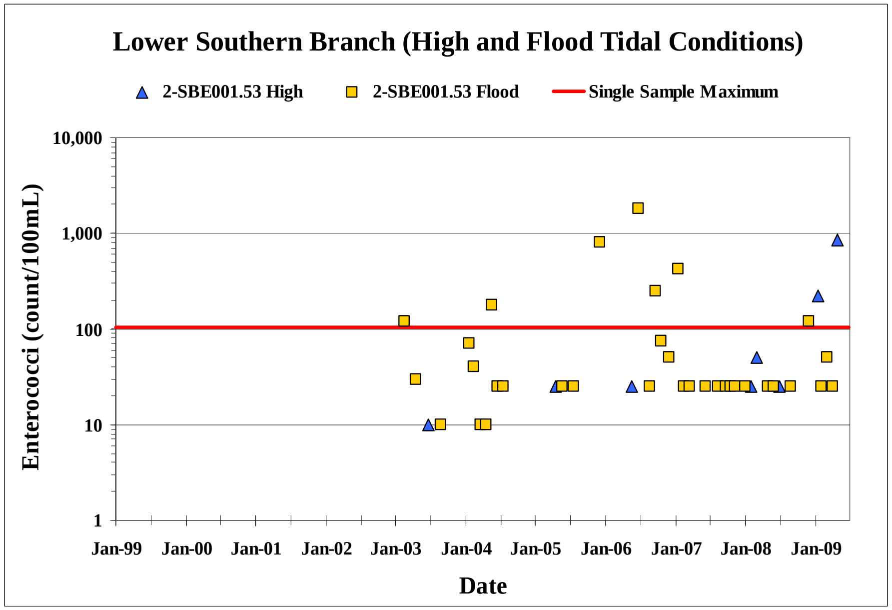

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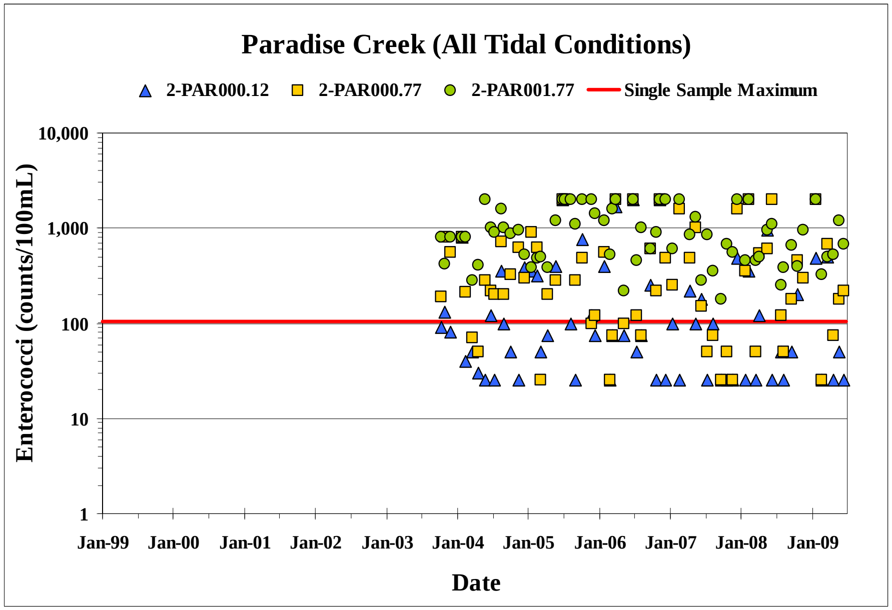
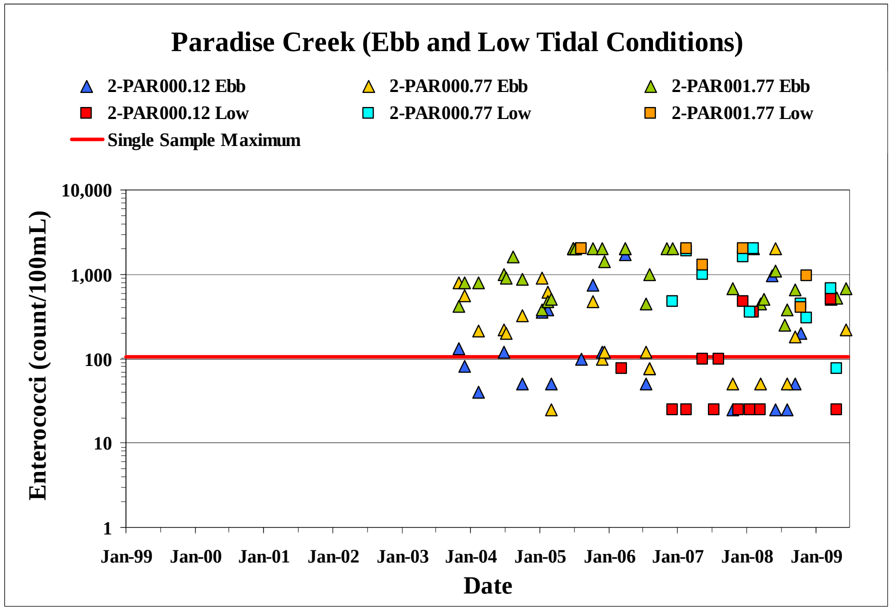
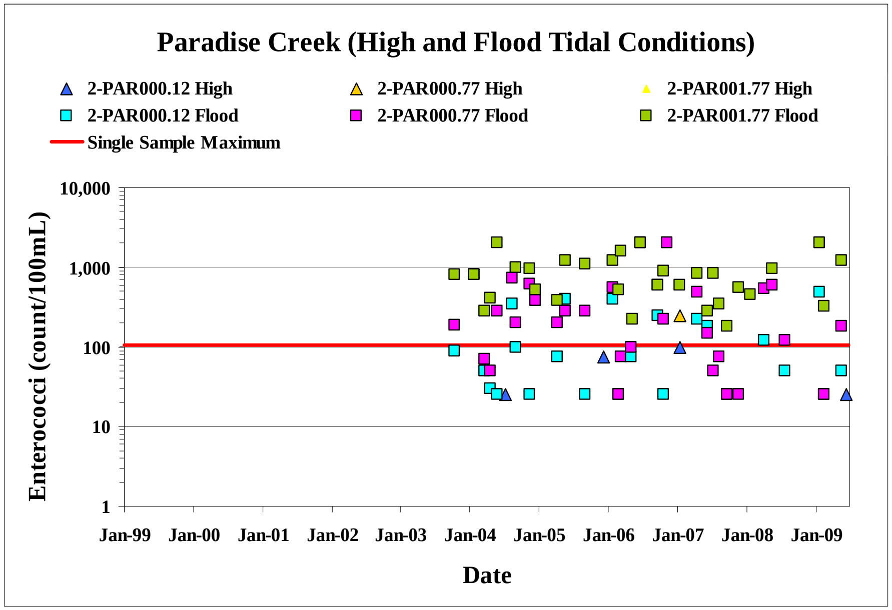
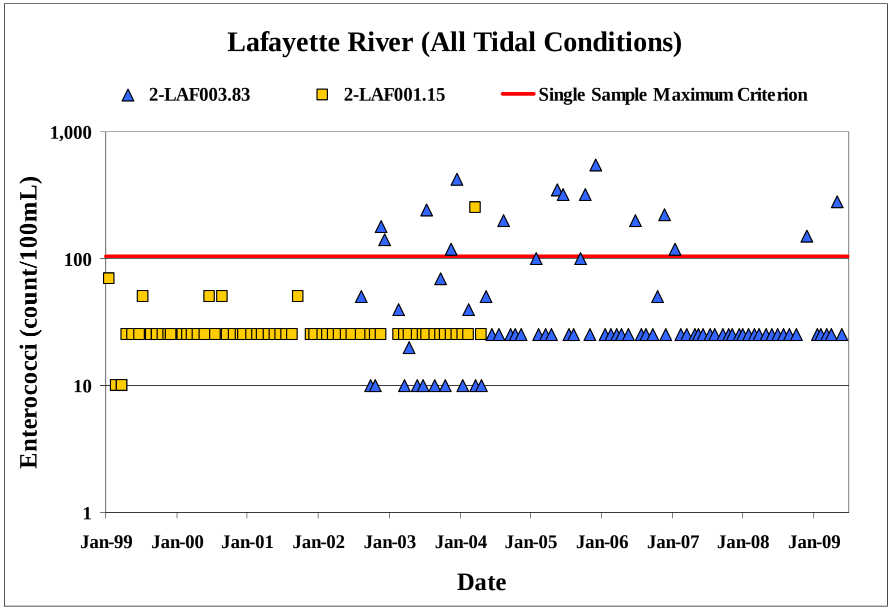
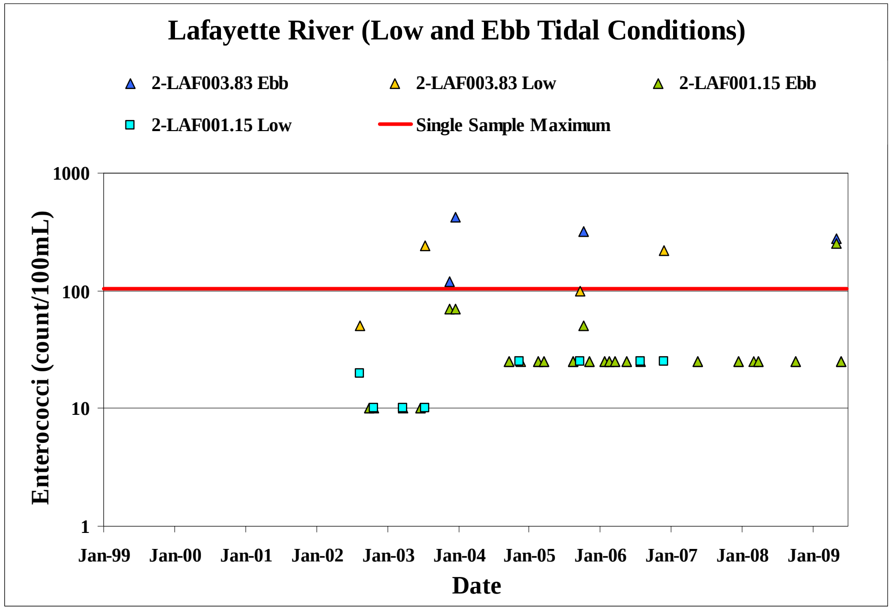


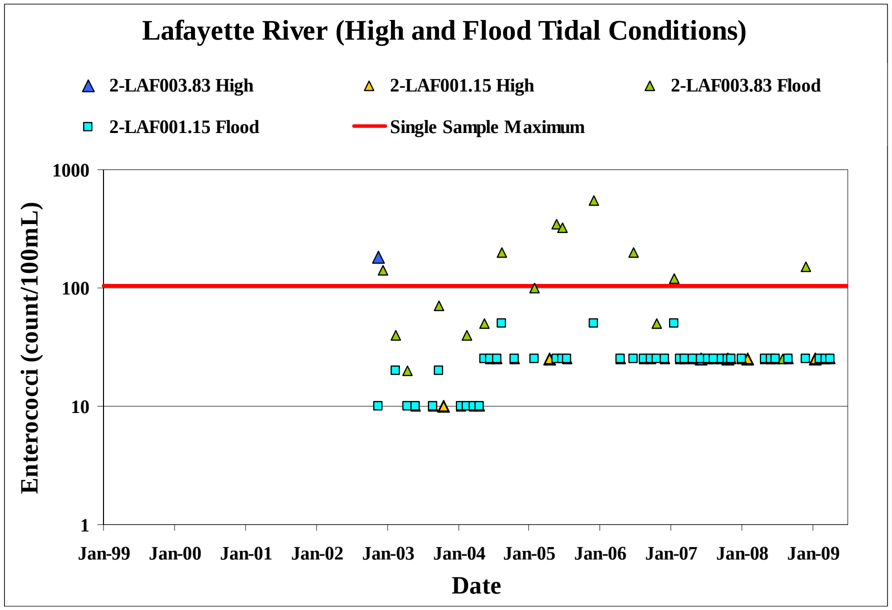




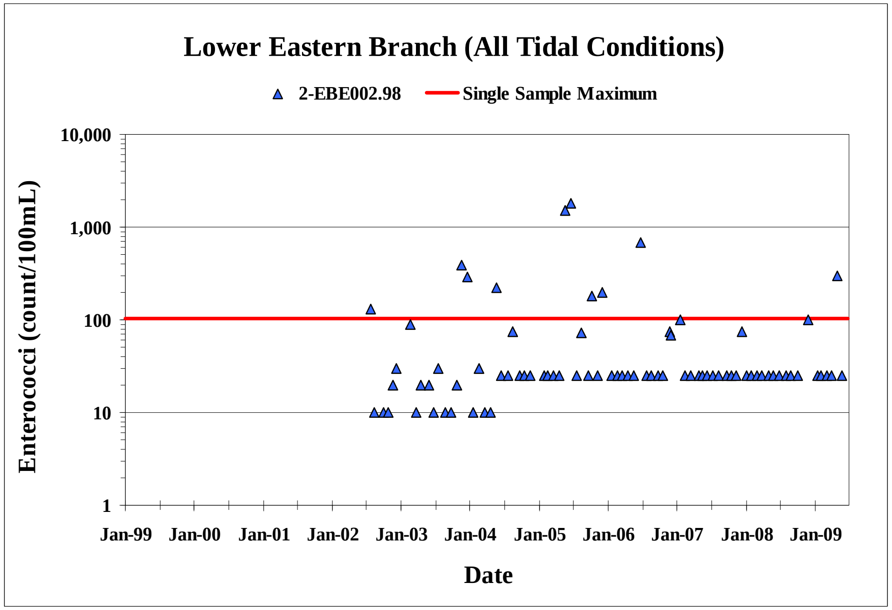
Elizabeth River Lafayette River:

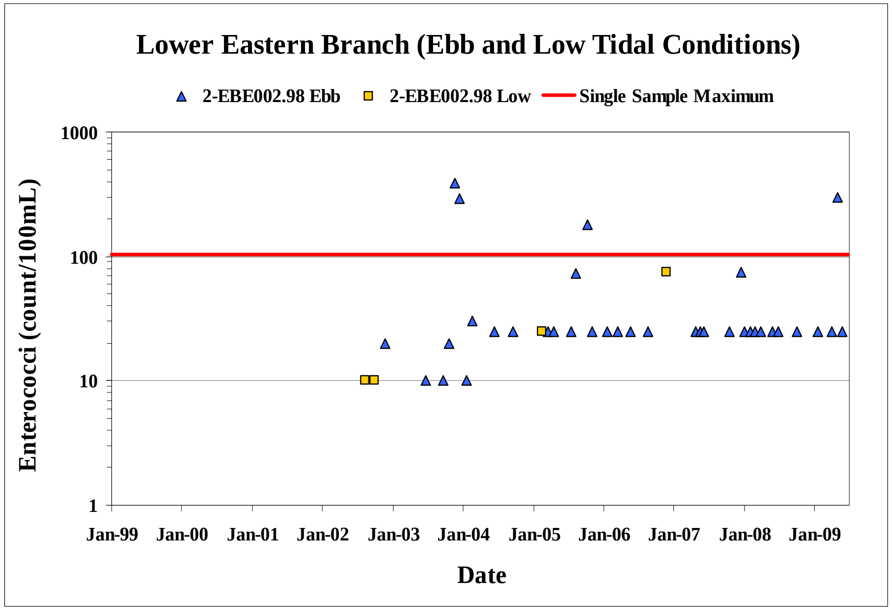


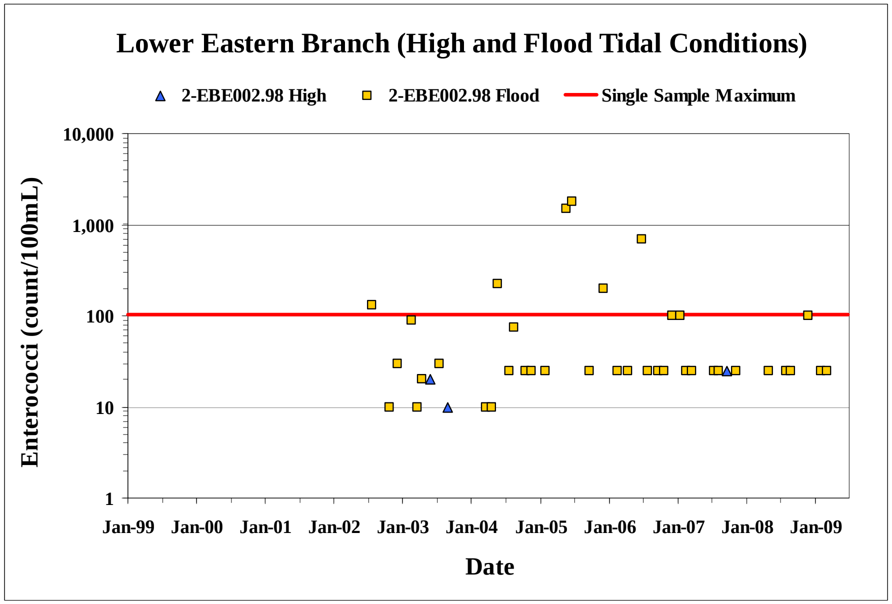




Elizabeth River Lower Eastern Branch







APPENDIX B:

Permitted Facilities

General Permitted Facilities within the Elizabeth River Watershed					
Permit #	**Permit Type**	**Facility Name**	**Receiving stream**	**Max Daily Flow (Gal/D)**	**Expiration Date**
VAG750175	Car wash	Atlantic Coastal Contractors Incorporated	Southern Branch Elizabeth River	700	10/2012
VAG750143	Car wash	Griffins and More	Eastern Branch of Elizabeth River	184	10/2012
VAG750140	Car wash	Howells Motor Freight Incorporated - Portsmouth	Storm Sewer to Julian Creek SB of Elizabeth River	1,000	10/2012
VAG750131	Car wash	Norfolk City - Public Works - Municipal Car Wash	SW Retention Pond w/ no apparent discharge	2,500	10/2012
VAG750166	Car wash	TFC Recycling	Mill Dam Creek to Southern Branch	100	10/2012
VAG750153	Car wash	Triangle Rent A Car LLC - Virginia Beach	Virginia Beach Storm Drain	100	10/2012
VAG750157	Car wash	Williams Hand Car Wash Inc	Unnamed Trib to Broad Creek	325	10/2012
VAG250103	Cooling	Columbia Gas Transmission Corp - Chesapeake	Vepco Canal to Deep Creek Canal	28,820	03/2013
VAG250104	Cooling	ECPI - Virginia Beach	UT to Eastern Branch Elizabeth River	237	03/2013
VAG250119	Cooling	ECPI - Virginia Beach	UT to Eastern Branch Elizabeth River	720	03/2013
VAG250120	Cooling	Sentara - Norfolk General Hospital	Elizabeth River - Eastern Branch	3,500	03/2013
VAG403061	Domestic	Commercial Ready Mix Products - 1125 Victory Blvd	Paradise Creek to Elizabeth River	800	08/2011
VAG840060	NMMM	Branscome Inc - Chesapeake - Dominion Borrow Pit	Lindsey Canal		06/2014
VAG840072	NMMM	Vico Construction Corp - Southern Pines Borrow Pit	UTRIB to Mains Creek		06/2014
VAG830326	Petrol	7 Eleven 23219	Storm Drain To Southern Branch Eliz R	82,000	02/2013
VAG830336	Petrol	7 Eleven 24025	Broad Creek	65,000	02/2013
VAG830300	Petrol	7 Eleven 29166	Unnamed Lake	144,000	02/2013
VAG830341	Petrol	7-Eleven #22751	Storm drain which flows to Jones Creek	50,000	02/2013
VAG830092	Petrol	US Navy - Craney Island - Fuel Terminal	Craney Island Creek	7,200	02/2013
VAG830098	Petrol	US Navy - Craney Island - Fuel Terminal	Craney Island Creek	4,320	02/2013
VAG830188	Petrol	US Navy - Naval Station Norfolk	Willoughby Bay	86,400	N/A
VAG830220	Petrol	Wilco 781	Trib. to Sterns Cr. (Trib to W. Branch Eliz.)	7,200	02/2013

General Permitted Facilities within the Elizabeth River Watershed					
Permit #	**Permit Type**	**Facility Name**	**Receiving stream**	**Max Daily Flow (Gal/D)**	**Expiration Date**
VAG110280	Ready Mix	Bayshore Concrete Products Corp. - Chesapeake	UT to Southern Branch Elizabeth River		09/2013
VAG110037	Ready Mix	Capital Concrete Incorporated - Chesapeake	King Creek		09/2013
VAG110036	Ready Mix	Capital Concrete Incorporated - Norfolk	Elizabeth		09/2013
VAG110244	Ready Mix	Commercial Ready Mix Products - 1125 Victory Blvd	Paradise Creek		02/2013
VAG110279	Ready Mix	Commercial Ready Mix Products - Coast Guard Blvd	UT to Craney Island Creek		09/2013
VAG110035	Ready Mix	TCS Materials - Gilmerton	Newton Creek to SB of Elizabeth River	14,400	09/2013
VAG110119	Ready Mix	Titan Virginia Ready Mix LLC - Campostella	Ohio Crk.		09/2013
VAG110119	Ready Mix	Titan Virginia Ready Mix LLC - Campostella	E. Br. E. River		09/2013
VAR100307	SW Construction	Ash Hill Estates	Unnamed trib Southern Branch Elizabeth River		N/A
VAR100315	SW Construction	Battlefield Commons Condominiums	Newton Creek to SB Elizabeth River		N/A
VAR100179	SW Construction	BBB LLC	Southern Branch of Elizabeth River		N/A
VAR101224	SW Construction	Bells Mill Garden	Ditch to UTRIB SB Elizabeth River		N/A
VAR100188	SW Construction	Bishops Green	Hoffler Creek		N/A
VAR100371	SW Construction	Bon Secours - DePaul Medical Center	Unnamed trib to Lafayatte River		N/A
VAR100021	SW Construction	Branscome Inc - Chesapeake - Dominion Borrow Pit	Elizabeth River - Southern Branch		N/A
VAR100185	SW Construction	Bryant Farms Subdivision	UTRIB to New Mill Creek		N/A
VAR100351	SW Construction	Camelot Section 9	Deep Creek Canal		N/A
VAR100186	SW Construction	Campostella Square	Indian River		N/A
VAR101104	SW Construction	Cavalier Industrial Park - Chesapeake Properties	Western Branch of Elizabeth River		N/A
VAR101313	SW Construction	Cavalier Industrial Park - Office/Warehouse	Ditch to UTRIB WB of the Elizabeth River		N/A
VAR100431	SW Construction	Cedar Manor Assisted Living	SB of the Elizabeth River		N/A
VAR101367	SW Construction	Checkered Flag Motor Car Company Inc - Toyota	Storm Sewer to Kemps Lake		N/A

General Permitted Facilities within the Elizabeth River Watershed					
Permit #	**Permit Type**	**Facility Name**	**Receiving stream**	**Max Daily Flow (Gal/D)**	**Expiration Date**
VAR100177	SW Construction	Chesapeake City - Georgetown Primary School	Eastern Branch of the Elizabeth River		N/A
VAR100178	SW Construction	Chesapeake City - Sparrow Road Intermediate	Eastern Branch of the Elizabeth River		N/A
VAR100444	SW Construction	Chesapeake Deep Water Terminal Incorporated	Southern Branch of Elizabeth River		N/A
VAR100458	SW Construction	Chesbay Distributing Company Incorporated	UTRIB to Goose Creek to WB of Elizabeth River		N/A
VAR101225	SW Construction	Churchland Croft Subdivision	Ditch to Lilly Creek to WB Elizabeth River		N/A
VAR101387	SW Construction	Cottages at Great Bridge	Ditch to Southern Banch Elizabeth River		N/A
VAR101297	SW Construction	Crestwood Subdivision	Ditch to Newton Creek		N/A
VAR100368	SW Construction	Dominion Lakes Subdivision	unknown ditch to Mains Creek		N/A
VAR101247	SW Construction	Estes Express Lines - Chesapeake	Mill Dam Creek		N/A
VAR100365	SW Construction	Farm Fresh Shopping Center - Chesapeake	Southern Branch Elizabeth River		N/A
VAR100181	SW Construction	Food Lion - Taylor Road	Elizabeth River		N/A
VAR100006	SW Construction	Gleming Property (Emerald Woods)	Goose Creek		N/A
VAR100151	SW Construction	Hickory Hill Borrow Pit	Eason's Ditch to Saint Bridges Ditch		N/A
VAR100152	SW Construction	Holly Glen Condominiums	Indian Creek		N/A
VAR100367	SW Construction	Ida Barbour	Storm water pond to S. Branch Elizabeth River		N/A
VAR100450	SW Construction	Independence Technology Center I	Drainage ditch to Newton Creek		N/A
VAR100014	SW Construction	Jolliff Middle School	Goose Creek		N/A
VAR100509	SW Construction	Lowes of Norfolk	Broad Creek		N/A
VAR100453	SW Construction	Lowes of West Chesapeake	Bailey Creek		N/A
VAR450695	SW Construction	Michael A. Glasser - Residence	Bells Mill Creek		N/A
VAR100007	SW Construction	Mill Creek Harbor Subdivision	utrib to New Mill Creek		N/A
VAR100171	SW Construction	New Mill Landing	New Mill Creek		N/A
VAR100440	SW Construction	Norfolk City - WTP - 37th Street	storm sewer to Elizabeth River		N/A
VAR100195	SW	Norfolk International	Elizabeth River		N/A

General Permitted Facilities within the Elizabeth River Watershed					
Permit #	Permit Type	Facility Name	Receiving stream	Max Daily Flow (Gal/D)	Expiration Date
	Construction	Terminals			
VAR100187	SW Construction	North Creek Subdivision	Ditch to St. Julians Creek		N/A
VAR100468	SW Construction	NRHA - Central Brambleton Conservation Project	Lafayette River		N/A
VAR100173	SW Construction	Oily Waste Collection System & Wharf	Southern Branch of the Elizabeth River		N/A
VAR100410	SW Construction	Portsmouth - Ocean Marine Yacht and Marina	Southern Branch of Elizabeth River		N/A
VAR100506	SW Construction	Portsmouth City - Municipal Building - Social Serv	culvert to SB Scotts Creek to SB Elizabeth River		N/A
VAR100164	SW Construction	River Pointe Village	Carney Creek		N/A
VAR100359	SW Construction	Scottsfield Estates	Knots Creek		N/A
VAR100430	SW Construction	Subdivision of Cedar Pines	Horse Run Ditch to SB of Elizabeth River		N/A
VAR101145	SW Construction	Tarleton Oaks at Tallwood Subdivsion	UTRIB to Eastern Branch of Elizabeth River		N/A
VAR100493	SW Construction	Towers-Perrin	UTRIB to Ditch to Lake Darden		N/A
VAR100352	SW Construction	Transmontaigne Product Svs Inc - Norfolk Dry Bulk	Southern Branch Elizabeth River		N/A
VAR100502	SW Construction	Twin Oaks Two	Broad Creek		N/A
VAR100355	SW Construction	US Navy - Naval Station Norfolk	Willoughby Bay		N/A
VAR100411	SW Construction	VDOT Suffolk - 0164 124 F04 C501	Western Branch of Elizabeth River		N/A
VAR100306	SW Construction	VDOT Suffolk - 0264 122 F08 C502 C503	Broad Creek		N/A
VAR101286	SW Construction	VDOT Suffolk - 0337 122 F14 C502	Boush Creek		N/A
VAR100475	SW Construction	VDOT Suffolk - I 64	BMP within Loop C		N/A
VAR100319	SW Construction	VDOT Suffolk - U000 122 122 C501	Lafayette River		N/A
VAR100321	SW Construction	VDOT Suffolk - U000 124 V04 C501	Carney Creek		N/A
VAR100421	SW Construction	Vico Construction Corp - Southern Pines Borrow Pit	King's Creek		N/A
VAR100318	SW Construction	VPA - Portsmouth Marine Terminal	Elizabeth River		N/A
VAR101388	SW Construction	Walmart Stores - Norfolk	Sewer system to Broad Creek		N/A

General Permitted Facilities within the Elizabeth River Watershed					
Permit #	**Permit Type**	**Facility Name**	**Receiving stream**	**Max Daily Flow (Gal/D)**	**Expiration Date**
VAR101253	SW Construction	Walmart Way Shopping Center	Sewer to Ditch to Newton Creek		N/A
VAR101245	SW Construction	Waters Edge At River Front (formerly Harbor View)	Ditch to UTRIB to Streeter Creek		N/A
VAR101172	SW Construction	Weaver Springs	Bailey Creek		N/A
VAR100533	SW Construction	Westbury Phase 2A/2B	Storm sewer to SB Elizabeth River		N/A

Individual Permitted Facilities within the Elizabeth River Watershed				
Facility Name	**Permit #**	**Permit Type**	**Receiving stream**	**Total Design Flow (MGD)**
Allied Terminals Incorporated - Chesapeake	VA0053686	Industrial	Elizabeth River, Southern Br	0.0200
Apex Oil Company - Chesapeake Terminal Division	VA0053473	Industrial	Scuffletown Creek to Elizabeth River, Southern Branch	0.8500
Arc Terminals Holdings LLC	VA0058572	Industrial	Southern Branch Elizabeth River	0.0031
Associated Naval Architects	VA0087599	Industrial	Elizabeth River, Western Branch	0.0600
Atlantic Energy Incorporated	VA0074454	Industrial	Deep Creek Canal to S BR Elizabeth River	0.0014
		Industrial	St. Julian Creek to S BR Elizabeth River	0.0014
Atlantic Metrocast Inc - Portsmouth	VA0004189	Industrial	Southern Branch Elizabeth River	0.0320
		Industrial	Paradise Creek	0.0320
BAE Systems Norfolk Ship Repair Inc	VA0004383	Industrial	South Branch, Elizabeth River	0.1000
BASF Corporation - Portsmouth	VA0003387	Industrial	Elizabeth River	1.5000
Chesapeake City - Lake Gaston WTP	VA0091405	Industrial	Utrib to Goose Creek to WB Liz Rive	1.0000
Chesapeake City - Northwest River WTP	VA0088404	Industrial	Elizabeth River	4.8000
Citgo Petroleum Corporation - Chesapeake Terminal	VA0054623	Industrial	Elizabeth River, Southern Branch	0.0230
Coastal Precast Systems	VA0089818	Industrial	Elizabeth River, Southern Branch	0.0009
Cogentrix Virginia Leasing Corporation	VA0074781	Industrial	Elizabeth River	0.6590
Colonna Marine LLC - Colonna Yachts	VA0004391	Industrial	Elizabeth River, Eastern Branch	0.0100
Colonnas Shipyard Inc	VA0053813	Industrial	Eastern Branch, Elizabeth River	0.1200
		Industrial	Pescara Creek to Eastern Branch Elizabeth River	0.1200
Columbia Gas Transmission	VA0092185	Industrial	Deep Creek to SB Elizabeth	0.0288

Individual Permitted Facilities within the Elizabeth River Watershed				
Facility Name	**Permit #**	**Permit Type**	**Receiving stream**	**Total Design Flow (MGD)**
Corp - Chesapeake			River	
Dominion - Chesapeake Energy Center	VA0004081	Industrial	Deep Creek to Elizabeth River	
Earl Industries LLC - Harper Avenue	VA0089699	Industrial	Elizabeth River	0.010
GE Mobile Water Incorporated	VA0053554	Industrial	Broad Creek	0.064
Hess Corporation - Chesapeake Terminal	VA0053082	Industrial	Elizabeth River, Southern Branch	0.800
HRSD - Army Base Sewage Treatment Plant	VA0081230	Municipal	Elizabeth River	18.220
HRSD - Virginia Initiative	VA0081281	Municipal	Elizabeth River	40.010
		Municipal	Unnamed Tributary to Elizabeth River	40.010
IMTT - Virginia	VA0056138	Industrial	Deep Creek Canal to the Southern Branch Elizabeth River	0.041
		Industrial	Deep Creek Canal	0.041
JH Miles and Company Incorporated	VA0003263	Industrial	Elizabeth River	0.546
Kinder Morgan Operating LP C - ERT	VA0081418	Industrial	Southern Branch Elizabeth River	0.073
		Industrial	Internal to 001, No Direct Discharge	0.073
		Industrial	Internal to 001, At Waterfront	0.073
Kinder Morgan Southeast Terminals - Chesapeake	VA0053911	Industrial	Unknown Tributary to Milldam Creek to South Branch Elizabeth River	0.091
		Industrial	Surface Ditch to South Branch Elizabeth River	0.091
Lyon Shipyard Incorporated	VA0085855	Industrial	Eastern Branch Elizabeth River	0.007
Lyon Shipyard Incorporated - Claiborne Ave	VA0004405	Industrial	Elizabeth River, Eastern Branch	0.173
Lyon Shipyard Incorporated - Sealift Drydock	VA0089168	Industrial	Eastern Branch, Elizabeth River	0.015
Metro Machine Corporation	VA0073091	Industrial	Elizabeth River, Eastern Branch	1.400
Norfolk Oil Transit Incorporated	VA0054828	Industrial	Elizabeth River	1.400
Norfolk Southern Railway Company - Lamberts Point	VA0003409	Industrial	Elizabeth River	1.400
Ocean Marine Yacht Center	VA0090778	Industrial	Southern Branch, Elizabeth River	1.400
Perdue Grain and Oilseed LLC - 501 Barnes	VA0004448	Industrial	Southern Branch Elizabeth River	1.400
		Industrial	Jones Cr, S. Br. Elizabeth	1.400
Port Allen Marine Services Incorporated	VA0086533	Industrial	Elizabeth River, Southern Branch	1.400
Shillelagh Estates	VA0091758	Municipal	Herring Ditch/Bells Mill Ck/SB Eliz	1.400
SPSA - Refuse Derived Fuel	VA0089923	Industrial	Paradise Creek	1.400

Individual Permitted Facilities within the Elizabeth River Watershed				
Facility Name	**Permit #**	**Permit Type**	**Receiving stream**	**Total Design Flow (MGD)**
Plant				
The Samaritan House	VA0091693	Municipal	Unknown Tirbutary to New Mill Creek	1.400
TransMontaigne Product Services Inc - Terminal 1	VA0023272	Industrial	Southern Branch, Elizabeth river	1.400
		Industrial	Southern Branch, Elizabeth River	0.035
		Industrial	Southern Branch, Elizabeth River	0.050
Transmontaigne Product Svs Inc - Norfolk Dry Bulk	VA0091561	Industrial	Southern Branch Elizabeth River	0.050
Tri Port Terminals Incorporated	VA0083313	Industrial	S. Branch Elizabeth	0.010
US Amines LLC - Portsmouth	VA0090298	Industrial	Western Branch of Elizabeth River	0.141
US Navy - Craney Island - Fuel Terminal	VA0005487	Industrial	Craney Island Creek to Elizabeth R.	2.200
		Industrial	Craney Island Creek	0.001
		Industrial	Craney Island Creek	0.004
		Industrial	Elizabeth River	0.004
		Industrial	Craney Island Creek	0.060
		Industrial	Unknown Tributary to Craney Island Creek	0.700
US Navy - Craney Island WWTP	VA0089605	Industrial	Elizabeth River	0.750
US Navy - Naval Station Norfolk	VA0004421	Industrial	Elizabeth River	2.200
		Industrial	Elizabeth River	2.700
		Industrial	Willoughby Bay	2.700
		Industrial	Bousch Creek @ Willoughby Bay	2.700
		Industrial	Norfolk MS4	2.700
		Industrial	Masons Creek	2.700
		Industrial	Bousch Creek	2.700
		Industrial	Internal to 003	2.700
		Industrial	Internal to 024	2.700
		Industrial	Internal to 024	2.700
		Industrial	Internal to outfall 034	2.700
		Industrial	Internal to outfall 034	2.700
		Industrial	Internal to outfall 114	2.700
		Industrial	Bousch Creek	2.700
		Industrial	Internal to permitted outfall	2.700
		Industrial	Bousch Creek	2.700
US Navy - Norfolk Naval Shipyard	VA0005215	Industrial	Elizabeth River, Southern Branch	2.700
		Industrial	Elizabeth River, Southern Branch	2.030
		Industrial	Paradise Creek to Elizabeth River	2.030

Individual Permitted Facilities within the Elizabeth River Watershed				
Facility Name	**Permit #**	**Permit Type**	**Receiving stream**	**Total Design Flow (MGD)**
VDOT - Downtown Elizabeth River Tunnel	VA0005851	Industrial	Southern Branch of the Elizabeth River	2.030
VDOT - Hampton Roads Bridge Tunnel I-564	VA0005835	Industrial	Unnamed Tributary to Willoughby Bay	2.030
VDOT - Midtown Elizabeth River Tunnel	VA0005860	Industrial	Main Branch of the Elizabeth River	0.220
Virginia Beach City - Landfill No 2	VA0086169	Industrial	UTRIB to Indian River	0.004

APPENDIX C:

Shoreline Sanitation Survey

VHD-DSS Sanitary Survey						
Survey ID	**Survey Date**	**Pollution ID**	**Name**	**City/County**	**Potential Pollution Source**	**Direct Discharge (Y/N)**
1	2004	Boating Activity	HRSD - Virginia Initiative Sewage Treatment Plant	Norfolk	Injected chlorination and dechlorination is being discharged into the Elizabeth River	Y
1-a	2004	Boating Activity	Virginia Beach Fishing Center	Virginia Beach	Boating services provided are fuel, water and electricity. Sanitary services provided. Sewage disposal is to HRSD	N
2	2004	Boating Activity	Ria Mar Condominiumns	Norfolk	Sanitary facilities are at condominium members' residences. No pump-out facilities or portable toilet dump stations	N
2-a	2004	Boating Activity	Old Dominion University Sailing Center	Norfolk	Boating services provided are ramp, electricity and water. No portable toilet dump stations.	N
3	2006	Boating Activity	Walden Brothers Marina	Deltaville	Available on-site are 63 seasonal slips/moorings, 6 transient slips/moorings, 15 dry storage spaces, fuel, electricity, water, repair, solid waste containers, restroom, dump station, and sewage holding tank pump out facilities.	N
3-a	2004	Boating Activity	Inlet Station Marina	Virginia Beach	Boating services provided are fuel, electricity and water. Sanitary facilities are provided. Sewage disposal is to HRSD	N
4	2004	Boating Activity	Old Dominion University Rowing	Norfolk	No portable toilet dump facilities are available. Sewage disposal is to HRSD treatment plant	N
4-a	2006	Domestic Sanitary	Bay Marine, Ltd.	Deltaville	Discharge from outfall of sewage	Y

VHD-DSS Sanitary Survey						
Survey ID	**Survey Date**	**Pollution ID**	**Name**	**City/County**	**Potential Pollution Source**	**Direct Discharge (Y/N)**
		Pollution			treatment facility	
5	2004	Boating Activity	Private Pier	Norfolk	There are no sanitary facilities, no boat holding tank pump-out facilities and no portable toilet dump station facilities provided at this site	N
5-a	2006	Boating Activity	Batley's Seafood	Deltaville	Private dock. Available on-site is electrical service	N
5-b	2004	Boating Activity	Virginia Beach Marlin Club Marina	Virginia Beach	Boating services provided are water and electricity. Sanitary facilities are provided. Boat holding tank pump-out facilities and a portable toilet dump station are present at this location.	N
6	2004	Boating Activity	Knitting Mill Creek Yacht Club	Norfolk	Portable toilet dump stations facilities and boat holding tank pump-out facilities are available	N
6-a	2006	Boating Activity	Private Dock	Deltaville	Available on-site was electricity and restroom facilities at the residence.	N
6-b	2004	Boating Activity	Virginia Beach Public Works Department	Virginia Beach	Sanitary facilities are available to employees within the large boat building.	N
7	2004	Boating Activity	American Legion Post 60 Marina	Norfolk	Portable toilet dump stations facilities and boat holding tank pump-out facilities are available	N
7-a	2006	Industrial Waste	Norton's Marina	Deltaville	On-site was 1 x 2000 gallon tank of gasoline and 1 x 1000 gallon tank of diesel without berms.	N
7-b	2004	Boating Activity	United States Navy Boat Ramp (SEAL	Virginia Beach	No boats present at time of survey. Chain link fence around compound	N

VHD-DSS Sanitary Survey						
Survey ID	**Survey Date**	**Pollution ID**	**Name**	**City/County**	**Potential Pollution Source**	**Direct Discharge (Y/N)**
			Team)			
8	2004	Boating Activity	Tidewater Boat Club	Norfolk	No portable toilet dump facilities are available	N
8-a	2006	Contributes Pollution	Residence	Deltaville	Lid on tank and wall on concrete tank is broken with pieces missing. Sanitary notice issued 6/16/06	N
8-b	2004	Boating Activity	Owls Creek Public Boat Ramp	Virginia Beach	Boating services provided are 3 in-out boat ramps with finger piers. Sanitary facilities provided. There are no boat holding tank pump-out facilities and no portable toilet dump station present at this location.	N
9	2004	Boating Activity	Mack's Pier	Norfolk	No portable toilet dump facilities are available	N
9-a	2006	Domestic Sanitary Pollution	Residence	Deltaville	Waste is flowing from an open pipe onto ground surface and draining into Broad Creek. Sanitary notice issued 6/16/06	Y
9-b	2004	Boating Activity	Harbor Point Condominiums	Virginia Beach	Boating services provided are water, electricity and fuel. No portable toilet dump station present.	N
10	2004	Boating Activity	Norfolk Municipal Pier	Norfolk	Boating services provided are water and electricity at slips, and diesel fuel	N
10-a	2006	Boating Activity	Broad Creek Marina	Deltaville	Available on-site are 20 seasonal slips/moorings, electricity, water, solid waste containers, restroom, dump station and sewage holding tank pump out facilities	N
10-b	2004	Boating Activity	Virginia Beach	Virginia Beach	Boating services provided are water,	N

VHD-DSS Sanitary Survey						
Survey ID	**Survey Date**	**Pollution ID**	**Name**	**City/County**	**Potential Pollution Source**	**Direct Discharge (Y/N)**
			Fishing Center		electricity and fuel. There are no boat holding tank pump-out facilities and no portable toilet dump station at this location.	
11	2004	Boating Activity	Charles Bashera	Norfolk	This marina shares sanitary facilities with the municipal marina which serves as a portable dump station	N
11-a	2006	Boating Activity	Walter's Marina	Deltaville	Available on-site are 12 seasonal slips/moorings, electricity, water, solid waste containers, restroom, and dump station facilities	N
11-b	2004	Industrial Waste	Hampton Roads Sanitary District	Virginia Beach	Dumps effluent discharge to the Atlantic Ocean through a 14,594' long 66" diameter pipe with diffusion of effluent along the final 2400'.	Y
12	2004	Boating Activity	Norfolk Yacht and Country Club	Norfolk	Sanitary facilities provided, sewage disposal is to treatment plant	N
12-a	2006	Contributes Pollution	Residence	Deltaville	2-story white siding with light gray shingles, green shutters, green trim and an addition on the rear of the house. A black pipe extends from the addition and runs into ground. No signs of discharge.	N
16	2006	Contributes Pollution	Residence	Deltaville	A black pipe extends from the addition and runs into ground. No signs of discharge.	N
17	2006	Contributes Pollution	Middlesex County Dock Broad Creek	Deltaville	Available are 5 seasonal slips/moorings, electricity, water,	N

VHD-DSS Sanitary Survey						
Survey ID	**Survey Date**	**Pollution ID**	**Name**	**City/County**	**Potential Pollution Source**	**Direct Discharge (Y/N)**
					solid waste containers and restroom facilities	
18	2006	Boating Activity	Chesapeake Cove Marina	Deltaville	Available on-site 37 seasonal slips/moorings, fuel, electricity, water, repair, solid waste containers, restroom, dump station and sewage holding tank pump out facilities	N
19	2006	Boating Activity	J&M Marina	Deltaville	Available on-site 50 seasonal slips/moorings, 17 dry storage spaces, ramp, electricity, water, solid waste containers, and restroom facilities	N
20	2006	Boating Activity	Coastal Marine, Inc	Deltaville	12 seasonal slips/moorings, electricity, water, repair, solid waste containers, and restroom facilities	N
21	2006	Boating Activity	Deltaview Yachting Center	Deltaville	Available on-site 190 dry storage spaces, fuel, electricity, water, repair, solid waste containers, restroom, dump station, and sewage holding tank pump out facilities.	N
22	2006	Boating Activity	Norview Marina	Deltaville	Available on-site are 110 seasonal slips/moorings, 188 dry storage spaces, fuel, ramp, electricity, water, repair, solid waste containers, restroom, and sewage holding tank pump out facilities.	N
23	2006	Boating Activity	Regatta Point Yacht Club	Deltaville	Available on-site are 80 seasonal slips/moorings, electricity, water, solid waste	N

VHD-DSS Sanitary Survey						
Survey ID	**Survey Date**	**Pollution ID**	**Name**	**City/County**	**Potential Pollution Source**	**Direct Discharge (Y/N)**
					containers, restroom, dump station, and sewage holding tank pump out facilities	
24	2006	Boating Activity	Schroeder Yacht Systems	Deltaville	Available on-site are 180 dry storage spaces, ramp, electricity, water, repair, solid waste containers, 1 Port-a-john, and the use of restroom facilities located adjacent to this property.	N
25	2006	Boating Activity	Stingray Point Marina	Deltaville	Available on-site are 178 seasonal slips/moorings, electricity, water, solid waste containers, restroom, dump station, and sewage holding tank pump out facilities	N
26	2006	Contributes Pollution	Residence	Deltaville	Trailer-white with blue, aqua and gray trim. Sewer hose runs under ground. No signs of discharge	N
27	2006	Kitchen or Laundry Waste	Residence	Deltaville	Lid on grease trap is broken, sanitary notice issued 7/7/06	N
34	2006	Contributes Pollution	Residence	Deltaville	Wastewater discharging from sewer valve onto ground surface. Sanitary notice issued 7/14/06	N

APPENDIX D:

Bacteria Source Tracking

Bacteria Source Tracking (BST) sampling was conducted by VA DEQ at two locations over a ten-month period from January 2006 to December 2006 in the impaired segment of the Elizabeth River watershed: at the downstream boundary of the impaired segment of Lower Eastern Branch at station 2-EBE002.98, and the Lower Southern Branch at station 2-SBE001.53. These two BST stations are shown in **Figure 2-1** of chapter 2. The objective of the BST study was to identify the sources of bacteria in the listed segments of Elizabeth River Watershed. The BST analysis was performed by MapTech, which uses E. coli for the source assessment in estuaries. According to MapTech, E. coli and enterococci bacteria show similar results in the source assessment and therefore E. coli can also be used for the BST in enterococci impaired streams (VA DEQ, September 2007).

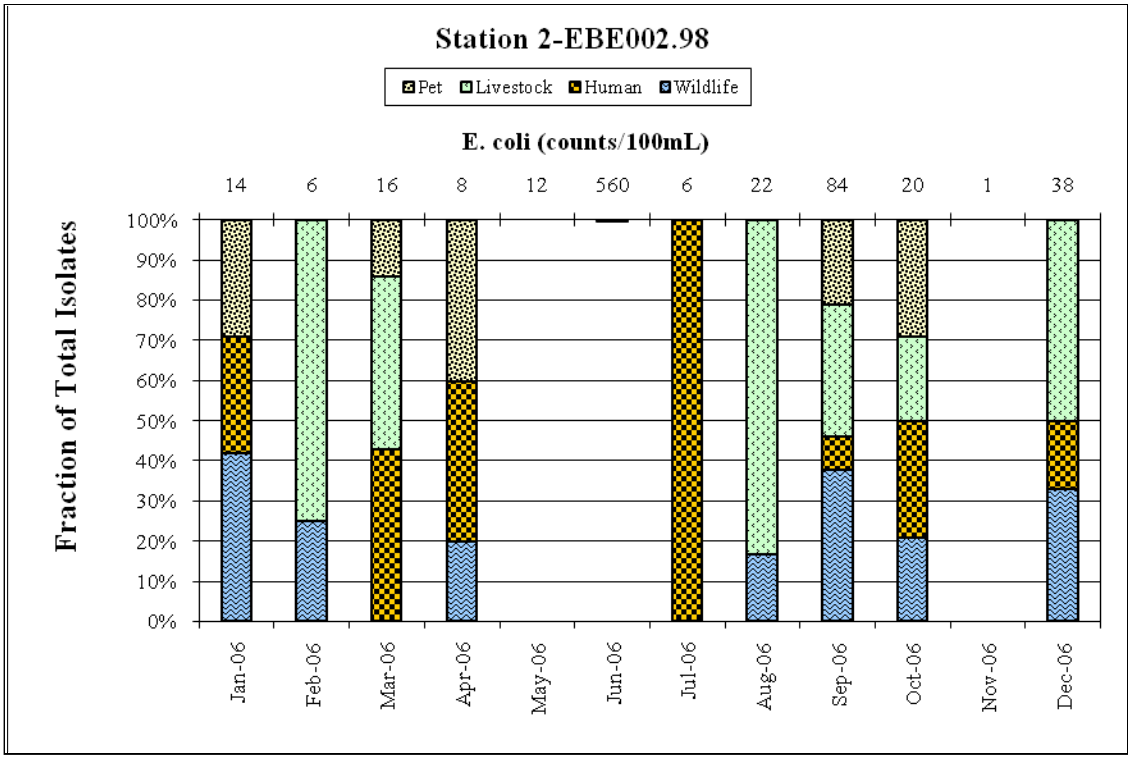
There are various methodologies used to perform BST, which fall into three major categories: molecular, biochemical and chemical. Molecular (genotype) methods are referred to as “DNA fingerprinting,” and are based on the unique genetic makeup of different strains, or subspecies, of bacteria. Biochemical (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, a biochemical method, was used for the Elizabeth River TMDLs. 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 bacterial isolates. For the Elizabeth River watershed, the maximum number of bacterial isolates per sample is 56.

BST data was collected once monthly in 2006 at monitoring stations 2-SBE001.53 and 2-EBE002.98. Overall, the results from these sampling periods indicate that bacteria from human, livestock, wildlife, and pet sources are present in Elizabeth River. Results from all sampling events at the monitoring stations are presented in **Table D-1** and depicted in **Figure D-1**.

The BST data were classified by dry and wet weather collecting conditions in order to assess if wet conditions impacted the distribution of the BST data (wet weather conditions were defined when precipitation occurred one day before and the day of sampling). The precipitation data were obtained from the weather station at Norfolk International Airport, VA. Based on this definition, the BST data was not collected under wet conditions.

Table D- 1: BST Sampling Events within the Elizabeth River Watershed							
Station	**Date**	**Enumeration**	**Isolates**	**Fraction of Source**			
		E. coli (counts/100mL)		**Wildlife**	**Human**	**Livestock**	**Pets**
2-EBE002.98	1/25/2006	14	7	42%	29%	0%	29%
	2/22/2006	6	4	25%	0%	75%	0%
	3/22/2006	16	7	0%	43%	43%	14%
	4/19/2006	8	5	20%	40%	0%	40%
	5/22/2006	12	9	NVI	NVI	NVI	NVI
	6/28/2006	560	56	NVI	NVI	NVI	NVI
	7/31/2006	6	1	0%	100%	0%	0%
	8/23/2006	22	6	17%	0%	83%	0%
	9/27/2006	84	24	38%	8%	33%	21%
	10/25/2006	20	14	21%	29%	21%	29%
	11/28/2006	1	NVI	NVI	NVI	NVI	NVI
	12/6/2006	38	6	33%	17%	50%	0%
2-SBE001.53	1/25/2006	22	11	46%	9%	9%	36%
	2/22/2006	8	5	60%	20%	20%	0%
	3/22/2006	16	12	17%	25%	41%	17%
	4/19/2006	10	9	44%	0%	0%	56%
	5/22/2006	8	4	NVI	NVI	NVI	NVI
	6/28/2006	310	31	NVI	NVI	NVI	NVI
	7/31/2006	10	1	0%	100%	0%	0%
	8/23/2006	14	5	40%	20%	40%	0%
	9/27/2006	70	24	58%	0%	17%	25%
	10/25/2006	20	13	0%	8%	92%	0%
	11/28/2006	26	9	45%	22%	33%	0%
	12/6/2006	12	5	20%	40%	40%	0%
NA = Not Analyzed, NP = Not Provided							
NVI = No Viable Isolates							



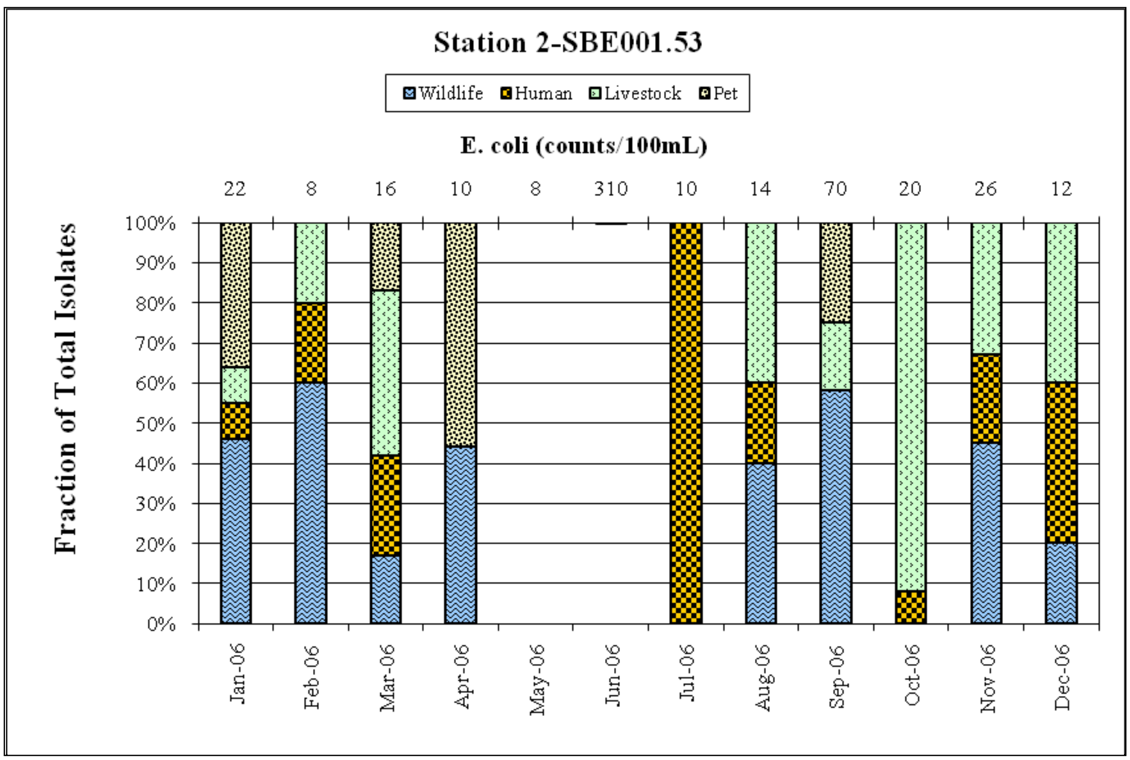


Figure D- 1: BST Variability within the Elizabeth River Watershed

Weighted Average of BST Sources

In order to eliminate some of the high variability in BST results, a method was developed by VA DEQ, which computes a weighted average based on the fraction of each bacteria source (wildlife, human, livestock, and pets). The weighted average for each source is calculated by dividing the total number of biochemical responses to antibiotics of each source (wildlife, human, livestock, or pet) with the total number of responses to antibiotics from all sources (the sum of all the sources). The total number of biochemical responses to antibiotics for each source for each sample is obtained by multiplying the total number of isolates with the bacterial enumeration (E. coli in counts/100mL) and with the fraction of the source. The total number of biochemical responses to antibiotics for each source for all samples is obtained by multiplying the total number of isolates with the bacterial enumeration (E. coli in counts/100mL) and with the fraction of the source.

The weighted average of each source represents the fraction of bacterial source in the watershed. **Table D-2, Figure D-2** and **Figure D-3** depict the calculated weighted average for each station.

Table D- 2: Calculated Weighted BST Fractions*

Station	Wildlife	Human	Livestock	Pets
2-SBE001.53	47%	5%	26%	22%
2-EBE002.98	34%	12%	35%	19%

*The weighted average was calculated using sample data with greater than 5 isolates in order to provide a more accurate representation of the distribution.

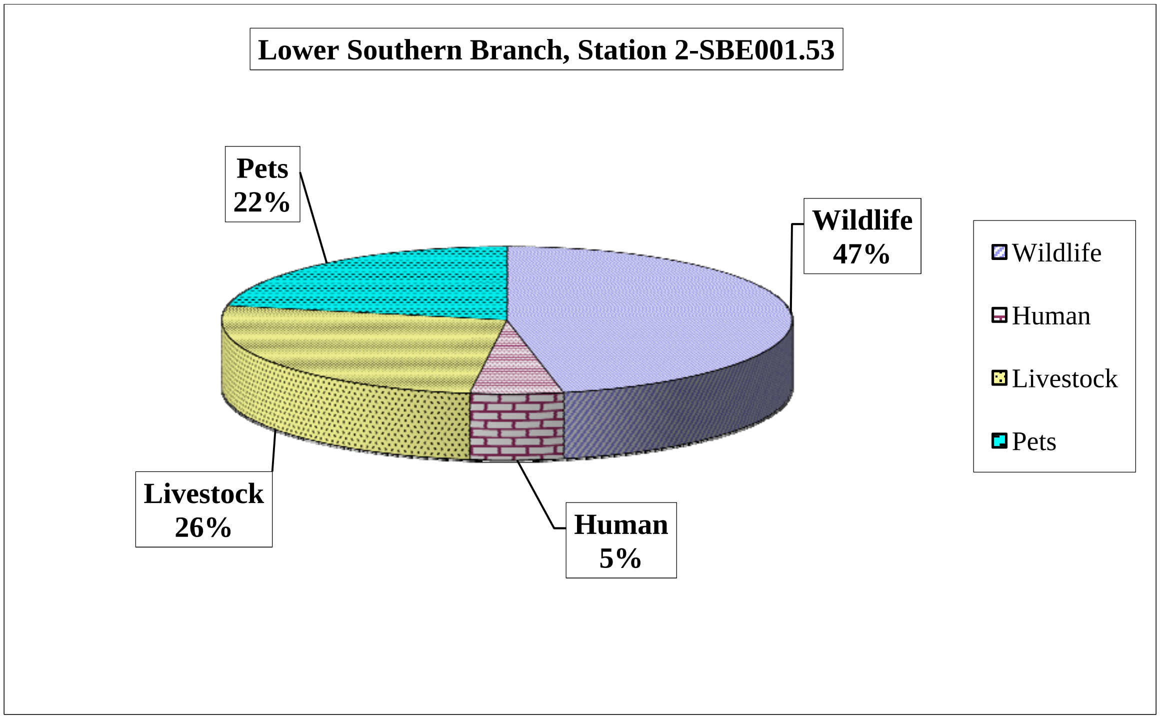


Figure D- 2: Weighted BST Results at Station 2-SBE001.53 (Lower Southern Branch, TMDL #1)

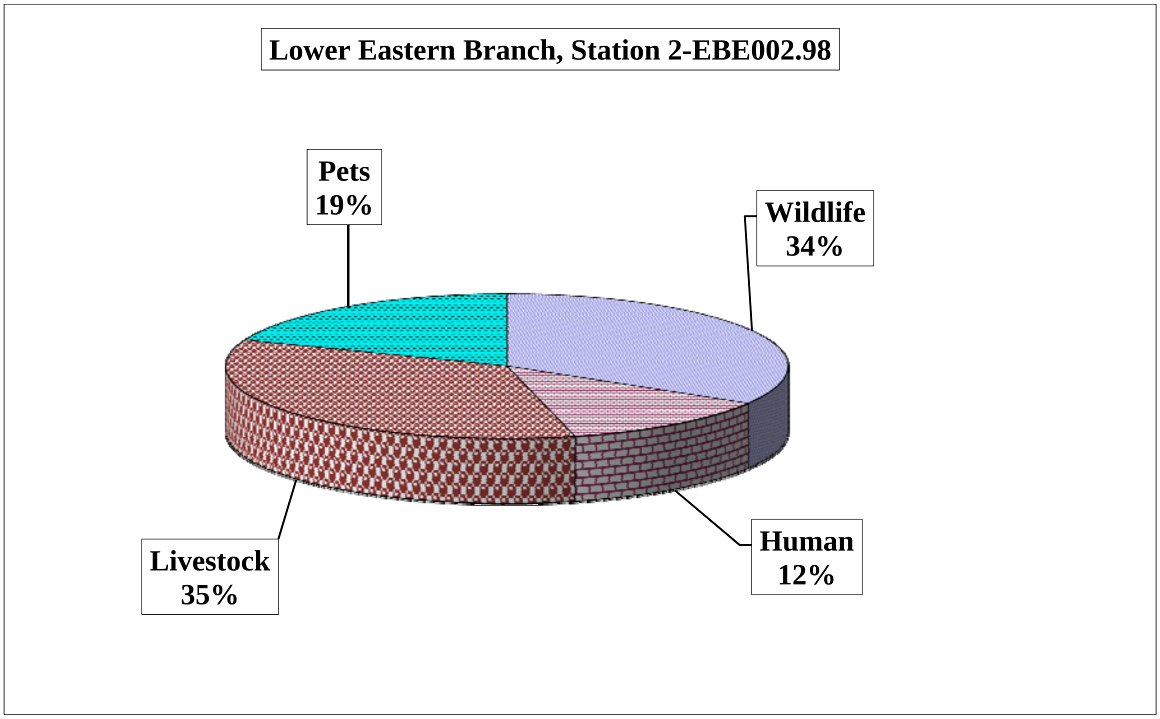


Figure D- 3: Weighted BST Results at Station 2-EBE002.98 (Lower Eastern Branch, TMDL #1)

APPENDIX E:

Sanitary Sewer Overflow Volume Cumulative Frequency Curves for each TMDL Watershed

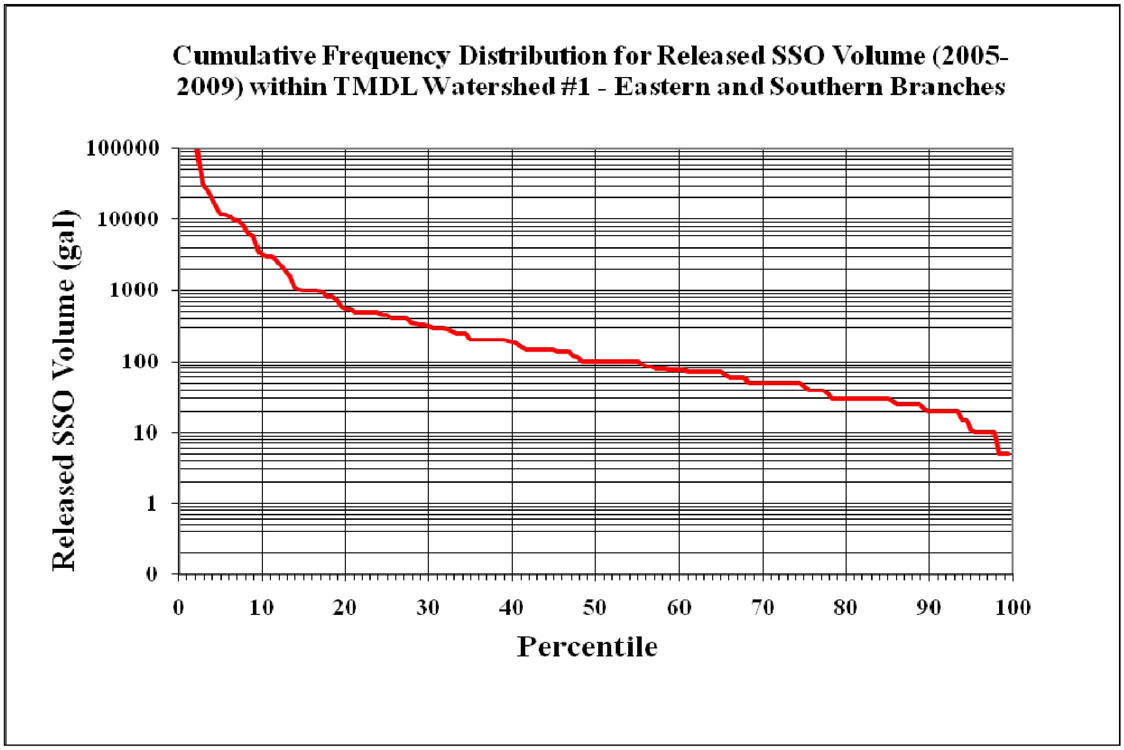


Figure E- 1: Cumulative Frequency Distribution for Released SSO Volume in TMDL#1

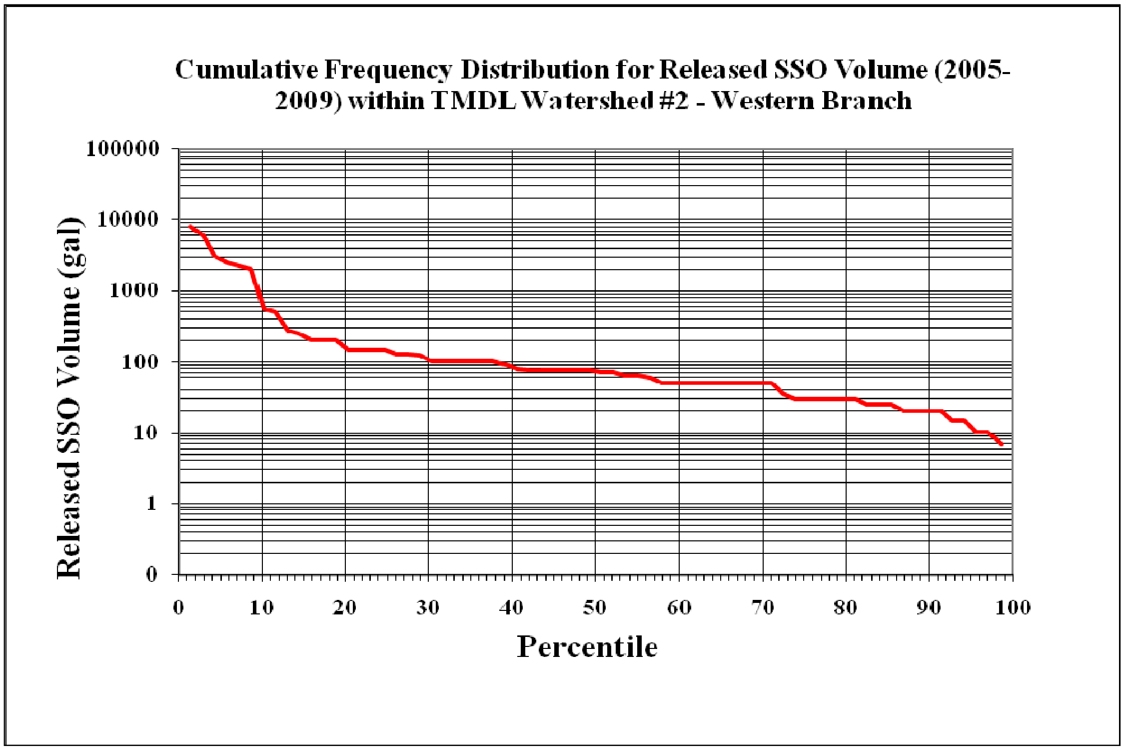


Figure E- 2: Cumulative Frequency Distribution for Released SSO Volume in TMDL#2

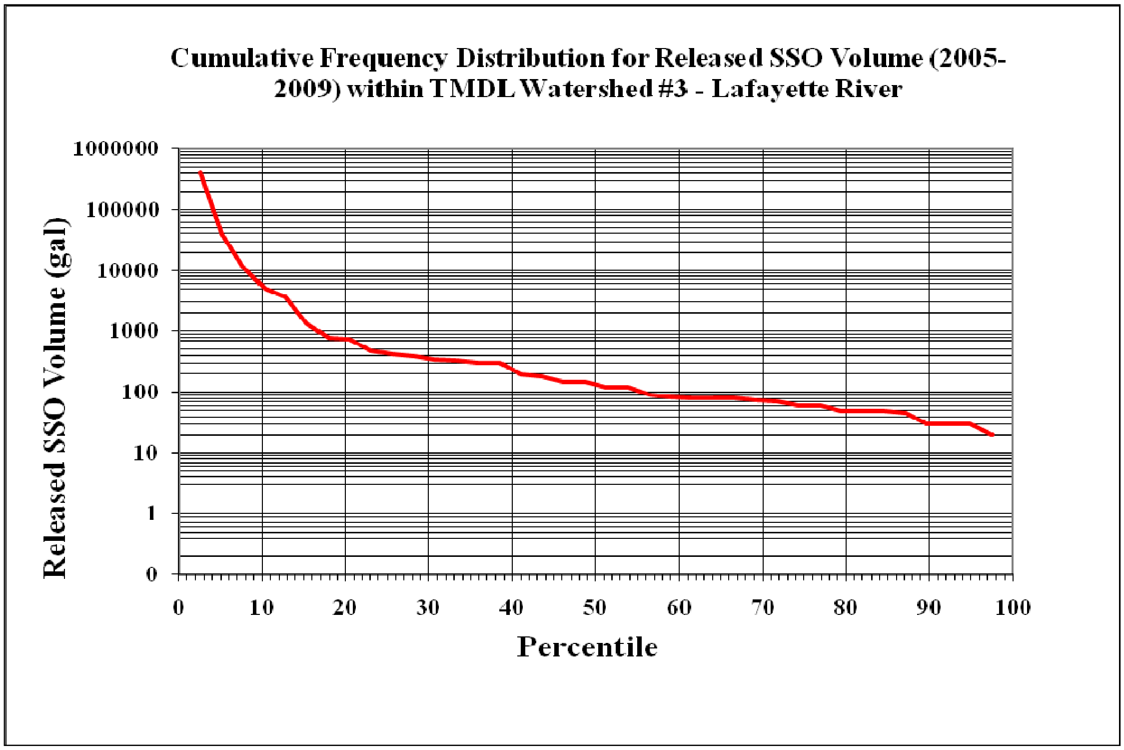


Figure E- 3: Cumulative Frequency Distribution for Released SSO Volume in TMDL#3

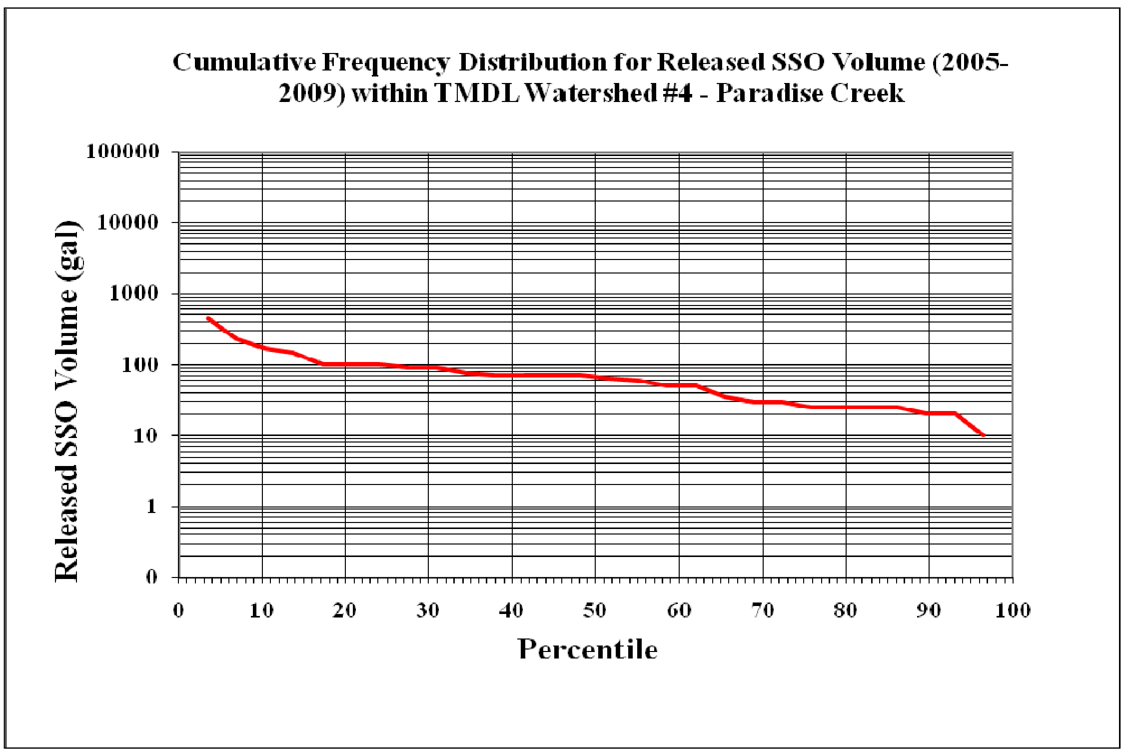


Figure E- 4: Cumulative Frequency Distribution for Released SSO Volume in TMDL#4