Virginia Department of Environmental Quality

Shellfish Bacteria Total Maximum Daily Load (TMDL) Development Chuckatuck Creek and Brewers Creek Watershed

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Executive Summary

This report addresses one bacteria impairment within the shellfish condemnation area 062-080A that has been listed on the Total Maximum Daily Load Priority List and 303(d) List of Impaired Waters for shellfish since 1998 (TMDL segment ID VAT-G11E-16) due to violations of the fecal coliform criteria for shellfish waters. The shellfish impairment includes Chuckatuck Creek and Brewers Creek.

Description of the Study Area

The bacteria impaired segment is located within the borders of Isle of Wight County and the independent City of Suffolk. The major roadways that intersect the watershed are US Highway 258 which runs east to west then north to south delineating a portion of the northern watershed boundary, US Highway 17 which runs north to south through the northeast portion of the watershed, State Highway 628 which runs north to south delineating a segment of the eastern watershed boundary, and State Highway 10 which travels north to south and delineates a portion of the northwestern watershed boundary. Located near the watershed is the city of Smithfield.

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 and VDH specify the following criteria for shellfish waterbodies (VA DEQ, 2008):

"In all open ocean or estuarine waters capable of propagating shellfish or in specific areas where public or leased private shellfish beds are present, and including those waters on which condemnation or restriction classifications are established by the State Department

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

Watershed Characterization

The bacteria impaired segment within the Chuckatuck Creek and Brewers Creek watershed cover 17,809 acres. The land use characterization for the Chuckatuck Creek and Brewers Creek 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 agriculture (32%), wetlands (26%), and forest (26%).

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, livestock, wildlife, and pets.

Based on data obtained from City of Suffolk and Isle of Wight County, there are two MS4 permits in the Chuckatuck Creek and Brewers Creek watershed. An inventory of livestock, wildlife, and pets was collected from data provided by 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.

Bacteria Source Tracking

As part of the TMDL development, Bacteria Source Tracking (BST) sampling was conducted by VDH-DSS over a twelve-month period from October 2004 to September 2005 at two VDH-DSS monitoring stations (62-10 and 62-9.1A). These samples were analyzed in order to identify the sources of bacteria found in the listed segment, the results of which were used in the TMDL development. Results from this sampling period indicate that bacteria from human, livestock, wildlife, and pet sources are present in the impaired segments.

TMDL Technical Approach

A simplified volumetric model approach[1], 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 fecal coliform standard of 14 MPN/100 mL and the 90th percentile standard of 49 MPN/100 mL with zero percent exceedance.

[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 Health-Division of Shellfish and Sanitation (DSS), Virginia Institute of Marine Sciences (VIMS), United States Geological Survey, Virginia Polytechnic University, James Madison University, and Tetra Tech.

Waste Load Allocation

There are two MS4 permits located in the Chuckatuck Creek and Brewers Creek watershed, the Isle of Wight County and the City of Suffolk. One percent of the total TMDL was assigned to the WLA to account for future growth. The allocated waste load for future growth is $3.17x10^{11}$ MPN/day. For the two MS4 permits within the Chuckatuck and Brewers Creeks watershed, the existing load, the allocated load, and the required percent reduction are shown in **Table E-1.**

Table E-1: Waste Load Allocation for MS4 Permits within the Chuckatuck Creek and Brewers Creek TMDL Watershed

MS4	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction
Isle of Wight County (VAR040020)	3.13E+11	1.10E+10	96%
City of Suffolk (VAR040029)	4.27E+12	1.50E+11	96%
Total	**4.58E+12**	**1.61E+11**	**96%**

Load Allocation

The reduction of loadings from non-point sources, including livestock, pets, and wildlife direct deposition, was incorporated into the load allocation. Fecal coliform loadings (daily load capacity of the estuary) were calculated in the estuary of the Chuckatuck Creek and Brewers Creek watershed in order to obtain the current load and allowable load. The current load is the maximum value of the geometric mean and 90^{th} percentile based on measurements at monitoring stations inside the estuary. The allowable load is the maximum value of the geometric mean and 90^{th} percentile based on VA DEQ standards for fecal coliform. The required percent load reduction for the Chuckatuck Creek and Brewers Creek watershed was estimated by subtracting the allowable load from the current load, dividing it by the current load, and multiplying it by 100. The maximum values of the 90^{th} percentile were used to calculate the load allocation and the TMDL in the watershed, since they represented the maximum percent reductions.

The load allocation is based on Bacteria Source Tracking (BST) results for livestock, wildlife, human, and pets. A complete reduction of all human sources is required, since fecal coliform 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. Allocations are developed using the proportion of these sources in the BST data. The fecal coliform TMDL allocations by BST source categories that would meet the 90th percentile fecal coliform standard of 49 MPN/100mL for the Chuckatuck Creek and Brewers Creek watershed are provided in **Table E-2.** A summary of the TMDL allocation plan for the Chuckatuck and Brewers Creeks watershed is presented in **Tables E-3**. Minor differences in current loads are due to rounding.

Table E-2: Distribution of Fecal Coliform Under Existing Conditions, TMDL Allocation, and Reduction in the Chuckatuck and Brewers Creeks Watershed for Non-point Sources

Source	BST * Allocation (% of total load)	Current Load (MPN/day)	Allocated Load (MPN /day)	Required Reduction (%)
Livestock	39%	3.45E+14	0.0	100%
Wildlife	29%	2.59E+14	3.12E+13	88%
Human	7%	6.34E+13	0.0	100%
Pets	25%	2.21E+14	0.0	100%
Total	**100%**	**8.88E+14**	**3.12E+13**	**96%**

* Average of samples taken between 2004 and 2005

Table E-3: The Chuckatuck and Brewers Creeks TMDL Allocation Plan Loads (MPN/day)

WLA (Two MS4s and 1% of the total TMDL load for future growth)	LA (Non-point sources)	MOS (Margin of safety)	TMDL
4.79E+11*	**3.12E+13**	**IMPLICIT**	**3.17E+13**

*consists of the loads from VAR040020 of 1.10E+10 MPN/day, VAR040029 of 1.50E+11 MPN/day, and 1% of the total TMDL load for future growth of 3.17E+11 MPN/day

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 Chuckatuck Creek and Brewers Creek reductions were developed using the maximum measured bacteria concentration within the impaired waterbody and a stringent bacteria criterion (90^{th} percentile). These two elements; the use of the maximum measured bacteria concentration along with a stringent bacteria criterion insure that the critical conditions are accounted for the Chuckatuck Creek and Brewers Creek.

Public Participation

Watershed stakeholders had opportunities to provide input and participate in the development of the TMDL during two public meetings held in the watershed. The first meeting was held on November 9, 2009 at the Suffolk Public Works Department in Smithfield, Virginia. The second public meeting was also held at the Suffolk Public Works Department, on February 24, 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 exceeding 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 instream 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 VADEQ Impairment Listing

This report addresses one bacteria impairment within the shellfish condemnation area 062-080A that has been listed on the Total Maximum Daily Load Priority List and 303(d) List of Impaired Waters for shellfish since 1998 (TMDL segment ID VAT-G11E-16) due to violations of the fecal coliform criteria for shellfish waters. The shellfish impairment includes Chuckatuck Creek and Brewers Creek.

Table 1-1 shows the shellfish impaired segment of the waterbodies where a bacteria TMDL will be developed.

Table 1- 1: List of Waterbodies Requiring TMDL Development

Cause Group Code	Shellfish Condemnation Area	Assessment Unit	Segment Name	Impairment	Estuary Area (mi^2)
G11E-16-SF	062-080A	VAT-G11E_CKT01A04	Chuckatuck Creek and Brewers Creek	Fecal Coliform	1.45

The impaired segment covers 1.45 square miles of the Chuckatuck Creek and Brewers Creek. **Figure 1-1** presents the location of the impaired segment of the Chuckatuck Creek and Brewers Creek.

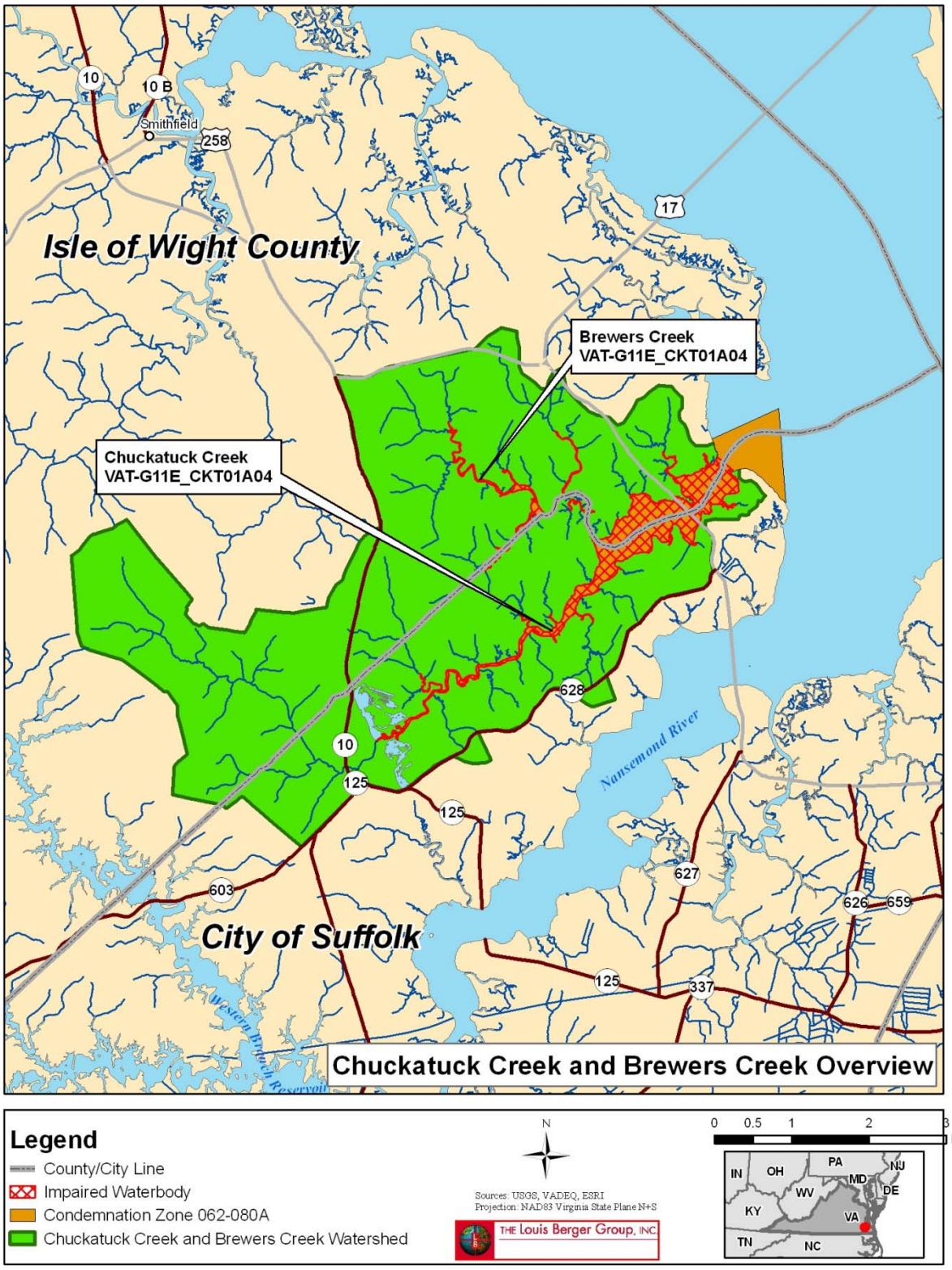

Figure 1- 1: Overview of the Bacteria Impaired Segment of the Chuckatuck Creek and Brewers Creek

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 and VDH specify the following criteria for shellfish waterbodies (VA DEQ, 2008):

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

1.3.3 Classification of Virginia's Shellfish Growing Areas

The Virginia Department of Health, Division of Shellfish Sanitation (VDH-DSS) is responsible for classifying shellfish waters and protecting the health of bivalve shellfish consumers. The VDH- DSS follows the requirements of the National Shellfish Sanitation Program (NSSP), which is regulated by the U.S. Food and Drug Administration. The NSSP conducts a shoreline survey to classify shellfish growing waters. The NSSP shoreline survey locates sources of pollution within the shellfish growing watersheds through a property-by-property inspection of the onsite sanitary waste disposal facilities of most properties on un-sewered sections of watersheds, and investigates other sources of pollution such as wastewater treatment plants (WTP), marinas, livestock operations, landfills, etc. Information from this survey is compiled into a written report with a map showing the location of the sources of real or potential pollution found that is sent to the various agencies responsible for regulating these concerns in the city or county. Once an onsite problem is identified, local health departments (LHDs), and/or other state and local agencies may play a role in the process of correcting the deficiencies.

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

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 segment of the Chuckatuck Creek and Brewers Creek 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) Physiographic data that describe physical conditions (i.e., topography, soils, and land use) within the watershed

(2) Hydrographic data that describe physical conditions within the 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 fecal coliform sources

(4) Environmental monitoring data that describe estuarine flow and water quality conditions in the estuary

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

Table 0-1: Inventory of Data and Information Used in the Chuckatuck Creek and Brewers Creek Watershed

Data Category	Description	Source(s)
Watershed physiographic data	Watershed boundary	NRCS Watershed Boundary Dataset
	Land use/land cover	NLCD 2005
	Soil data (SSURGO, STATSGO)	NRCS
	Topographic data (USGS-30 meter DEM)	USGS
Hydrographic data	Stream network and reaches (RF3)	NHD
	Bathymetry Data	NOAA
Weather data	Information, data, reports, and maps that can be used to support fecal coliform source identification and loading	NCDC
Watershed activities/ uses data and information related to fecal coliform production	Livestock inventory, grazing, stream access, and manure management	Census of Agriculture 2007
	Wildlife inventory	VA DGIF
	Septic systems inventory and failure rates	VA DEQ , Census Bureau
	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	VADEQ, VDH-DSS
	Bacteria Source Tracking Data	VDH-DSS
	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
SSURGO: Soil Survey Geographic Database
STATSGO: State Soil Geographic Database
USGS: U.S. Geological Survey
VA DEQ: Virginia Department of Environmental Quality
VA DGIF: Virginia Department of Game and Inland Fisheries
VDH-DSS: Virginia Department of Health Department - Department of Shellfish Sanitation

2.2 Watershed Description and Identification

The bacteria impaired segment is located within the borders of Isle of Wight County and the independent City of Suffolk and has a drainage area of 17,809 acres. As shown in **Figure 2-1**, the major roadways that intersect the watershed are US Highway 258 which runs east to west then north to south delineating a portion of the northern watershed boundary, US Highway 17 which runs north to south through the northeast portion of the watershed, State Highway 628 which runs north to south delineating a segment of the eastern watershed boundary, and State Highway 10 which travels north to south and delineates a portion of the northwestern watershed boundary.

Figure 2-1 shows the boundary of the TMDL watershed including the existing VDH-DSS bacteria monitoring stations.

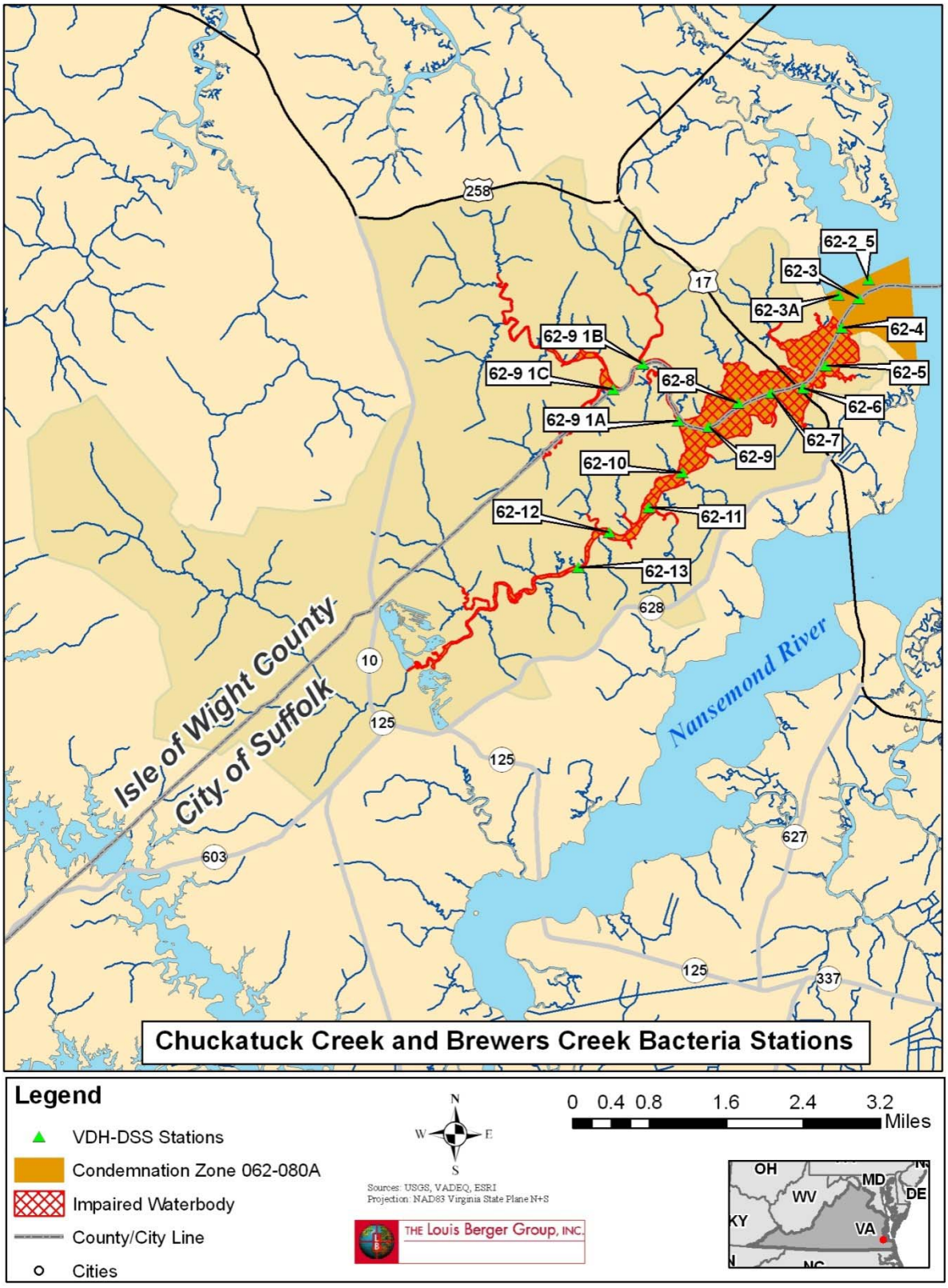

Figure 0-1: Overview Map of the Watershed Draining into the Bacteria Impaired Segment including VDH Bacteria Monitoring Stations

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 TMDL watershed ranges from -1 to 27 feet above mean sea level.

2.2.2 Soils Types and Hydrologic Soil Groups

The following section details soil type and hydrologic group within the Chuckatuck Creek and Brewers Creek 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 0-2: 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 Chuckatuck Creek and Brewers Creek

There are thirty-two soil associations located in the watershed (**Table 2-3**). The dominant soil types within the watershed are Slagle (18%) and Nansemond (9.3%).

Table 0-3: Soil Types within Chuckatuck Creek and Brewers Creek		
Soil Type	**Total Acres**	**Percentage**
Slagle	2,991	18.0
Nansemond	1,545	9.3
Tetotum	1,252	7.5
Bohicket	1,106	6.6
Emporia	1,103	6.6
Myatt	1,081	6.5
Yemassee	958	5.8
Uchee	901	5.4
Kenansville	800	4.8
Chickahominy	709	4.3
State	672	4.0
Kinston	642	3.9
Peawick	633	3.8
Nevarc and Remlik	606	3.6
Dragston	306	1.8
Nawney	238	1.4
Tomotley	185	1.1
Udorthents	173	1.0
Kalmia	165	1.0
Suffolk	127	1.0
Rumford	78	<1
Goldsboro	64	<1
Wahee	54	<1
Rains	49	<1
Levy	48	<1
Dogue	39	<1
Weston	32	<1
Uchee-Peawick	26	<1
Chipley	22	<1
Eunola	12	<1
Alaga	7	<1
Peawick-Slagle	3	<1
TOTAL*	**16,625**	**100**

*The difference in the total and the watershed drainage area is the area of the watershed that is occupied by water. Water is not included as a soil type.

The major hydrologic group within the Chuckatuck Creek and Brewers Creek Watershed is group C, with 49.6% of the watershed containing these soils. Soil group C is defined as having moderate to slow infiltration rates. Soils contain layers impeding downward movement of water or soils with moderately fine or fine textures. The second major hydrologic group within the watershed is group D, with 22.9% of the watershed containing these soils. Soil group D is defined as having very slow infiltration rates. Soils are clayey, have a high water table, or are shallow to an impervious cover. **Table 2-4** summarizes the total percentages of hydrologic groups for the Chuckatuck Creek and Brewers Creek soils.

Table 0-4: Hydrologic Groups within the Chuckatuck and Brewers Creek Watershed

Hydrologic Soil Group	Total Acres	Percentage of Watershed
A	1,734	9.7
B	1,106	6.2
B/D	876	4.9
C	8,833	49.6
D	4,077	22.9
Not Identified	1,183	6.6
Total	**17,809**	**100**

2.2.3 Land Use

The land use characterization for the TMDL watershed was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2005 Land Use Dataset. The distribution of land uses in the watershed, by land area and percentage, are presented in **Table 2-5**. Brief descriptions of land use classifications are presented in **Table 2-6**. Dominant land uses in the watershed are agriculture (32%), wetlands (26%), and forest (26%). **Figure 2-2** depicts the land use distribution within the Chuckatuck Creek and Brewers Creek TMDL watershed.

Table 0-5: Land Use within the Chuckatuck Creek and Brewers Creek Watershed					
General Land Category	**Specific Land Use Type**	**Acres**	**Total Acres**	**Percentage of Watershed (%)**	**Total Percent (%)**
Developed	High Intensity Developed	47	971	<1	5
	Medium Intensity Developed	88		<1	
	Low Intensity Developed	353		2.0	
	Developed Open Space	483		2.7	
Agriculture	Cultivated Crops	4,828	5,611	27.1	32
	Pasture/Hay	783		4.4	
Forest	Deciduous Forest	1,658	4,618	9.3	26
	Evergreen Forest	2,097		11.8	
	Mixed Forest	864		4.9	
Wetlands	Estuarine Emergent Wetland	826	4,611	4.6	26
	Estuarine Forested Wetland	<1		<1	
	Estuarine Scrub/Shrub Wetland	<1		<1	
	Palustrine Emergent Wetland	103		<1	
	Palustrine Forested Wetland	3,411		19.2	
	Palustrine Scrub/Shrub Wetland	257		1.4	
Water	Palustrine Aquatic Bed	4	1,198	<1	7
	Open Water	1,193		6.7	
Other	Barren Land	2	800	<1	4
	Grassland (not used in agriculture)	172		<1	
	Scrub/Shrub	620		3.5	
	Unconsolidated Shore	5		<1	
Total		**17,809**		**100**	**100**

Table 0-6: 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 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.
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.
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.
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.

Table 0-6: Descriptions of Land Use Types	
Land Use Type	**Description**
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 by NOAA Coastal Services Center

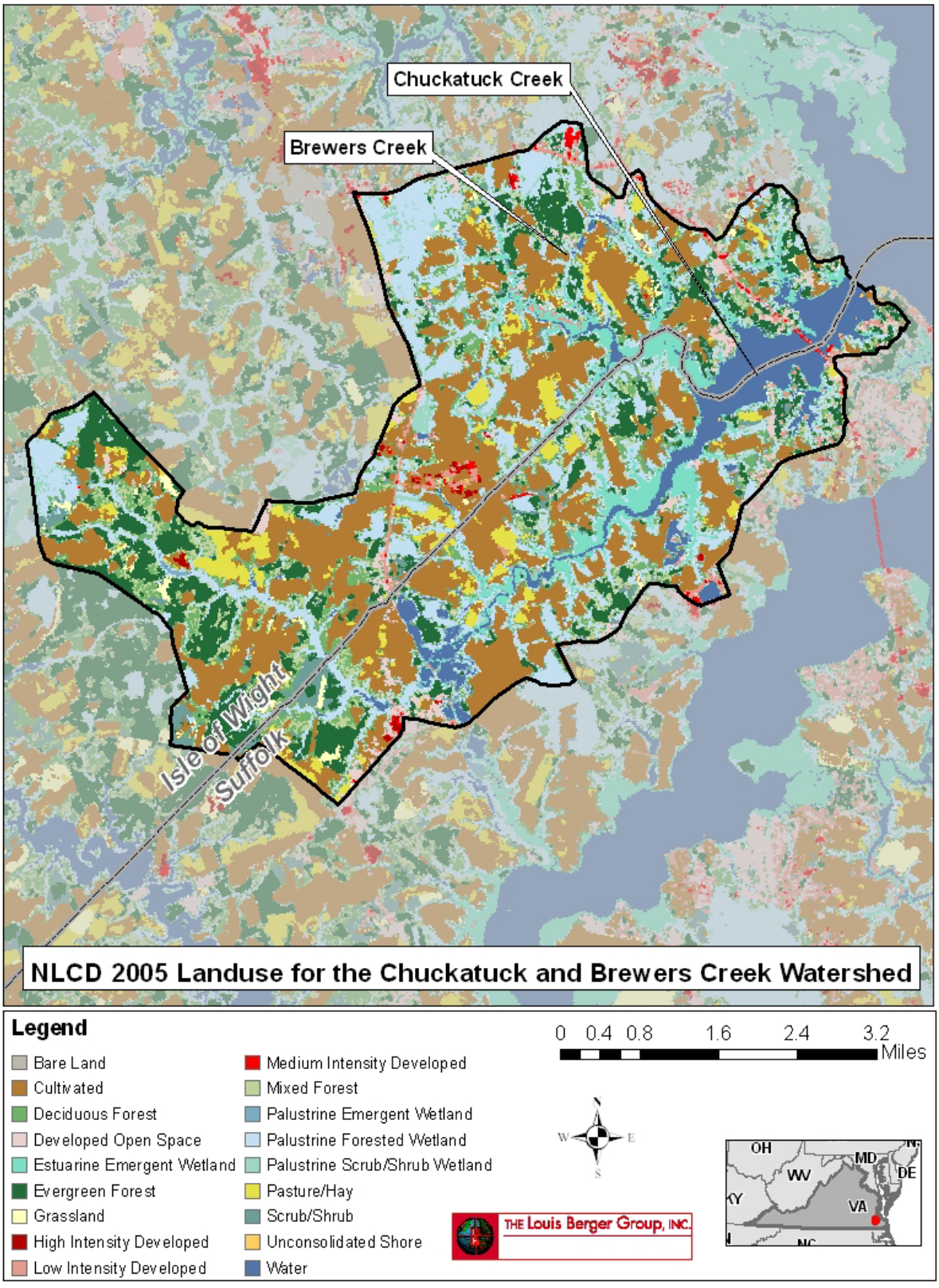

Figure 0-2: Land Use in the Chuckatuck Creek and Brewers Creek Watershed

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 the TMDL watershed was estimated using the USGS National Elevation Dataset, NED, and is based on cross section measurements within the tidal portions of the TMDL watershed. **Table 2-7** summarizes the results of the volume data including average depth and surface area for the TMDL watershed.

The closest station with available tide data is located in the Hampton Roads Bay, close to the town of Sewells Point, VA. The tide data were retrieved from NOAA's Tides and Currents website and include mean tidal range between 1960 and 2001. **Table 2-8** shows the mean tidal range for this station.

Table 0-7: Estuary Volume of the Chuckatuck Creek and Brewers Creek Watershed

Waterbody	Assessment Unit	Average Depth (m)	Surface Area (m^2)[1]	Volume (m^3)[2]
Chuckatuck Creek and Brewers Creek	VAT-G11E_CKT01A04	5.4	3,041,866	16,969,568

[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 0-8: Existing NOAA Tidal Stations in the Chuckatuck Creek and Brewers Creek Watershed

Name	Station ID	Location	Mean Tidal Range (feet)	Date of Tidal Information
Sewells Point, VA	8638610	Hampton Roads Bay	2.43	1960-2001

2.4 Ambient Water Quality Data for Fecal Coliform

Environmental monitoring efforts for collecting fecal coliform data in the TMDL watershed have been conducted by the Virginia Department of Environmental Quality (VA DEQ) and the Virginia Department of Health-Department of Shellfish and Sanitation (VDH-DSS). However, VA DEQ only collected fecal coliform data once. As a result, fecal coliform data from the VA DEQ was not used in this TMDL. VDH-DSS water quality data was provided by the VA DEQ. All available data for bacteria, located within the TMDL watershed and at the boundary of the impaired watershed, were analyzed and compared to VA DEQ bacteria standards for shellfish. **Table 2-9** summarizes the available VDH-DSS data according to station ID. The location of the bacteria monitoring stations is depicted in **Figure 2-1** at the beginning of the chapter. The following sections summarize and present the available bacteria monitoring data within and at the boundaries of the TMDL watershed.

Table 0-9: Summary of VA DEQ and VDH-DSS Monitoring Stations, Location and Sample Date

Waterbody	Station ID	Sample Date		Agency
		First	Last	
Atlantic Ocean/Mouth of Chuckatuck Creek	62-3	5/18/1989	8/10/2009	VDH-DSS
	62-2_5	5/18/1989	2/10/2003	
	62-3A	5/18/1989	2/10/2003	
Chuckatuck Creek (current stations)	62-4	12/13/1984	8/10/2009	
	62-5	12/13/1984	8/10/2009	
	62-6	12/13/1984	8/10/2009	
	62-7	12/13/1984	8/10/2009	
	62-8	12/13/1984	8/10/2009	
	62-9	12/13/1984	8/10/2009	
	62-10	12/13/1984	2/10/2003	
	62-11	12/13/1984	2/10/2003	
	62-12	12/13/1984	2/10/2003	
	62-13	12/13/1984	2/10/2003	
Brewers Creek (discontinued stations)	62-9_1A	12/13/1984	2/10/2003	
	62-9_1B	12/13/1984	2/10/2003	
	62-9_1C	12/13/1984	2/10/2003	
Chuckatuck Creek (discontinued station)	2-CKT005.75	4/19/2000	4/19/2000	VA DEQ

2.4.1 VDH-DSS Bacteria Water Quality Data

VDH-DSS conducted sampling for fecal coliform at 16 monitoring stations within the Chuckatuck Creek and Brewers Creek watershed. Out of the 16 stations, 3 monitoring stations are located within Brewers Creek (62-9_1A to 62-9_1C). The remaining 13 monitoring stations are located within Chuckatuck Creek. The analysis of the fecal coliform data is based on the VDH-DSS approach, which calculates the geometric mean and 90th percentile values using the last 30 months of data (usually the last 30 collection events). All available fecal coliform data were analyzed from January 1999 through July 2007 to calculate the geometric mean and 90th percentile values. The most recent fecal coliform values were not included in the analysis, since VDH changed its method analyzing fecal coliform after August 2007. The computed geometric mean and 90th percentile values were then compared to the VA DEQ water quality criteria for shellfish waters. The results of this analysis are shown in **Table 2-10**, which summarize the maximum geometric mean and 90th percentile measurements between January 1999 and July 2007. The maximum value is shown in order to include the worst case condemnation. **Table 2-11** summarizes the results of the analysis for the entire fecal coliform data set for all tidal conditions. Stations that did not have enough data to calculate the exceeded geometric mean and/or exceeded 90th percentile (2-CKT005.75) are not included in the tables. The results of the analysis for the entire fecal coliform data set are also shown in several figures in Appendix B. It should be noted that the boundary stations located at the mouth of Chuckatuck show considerably lower fecal coliform concentrations and as a result less exceedances than the estuary stations within Brewers and Chuckatuck Creek. This may indicate that the majority of the fecal coliform sources originate within the Chuckatuck Creek watershed.

Table 0-10: VDH-DSS Maximum Values of Geometric Mean and 90th Percentile Exceedances for Fecal Coliform					
Waterbody	**Station ID**	**Geometric Mean**	**Station Exceeded Geometric Mean Standard: 14 MPN**	**90th Percentile**	**Station Exceeded 90th Percentile Standard: 49 MPN**
Atlantic Ocean/Mouth of Chuckatuck Creek	62-3	14	**No**	41	**No**
	62-2_5	9	**No**	52	**Yes**
	62-3A	12	**No**	64	**Yes**
Chuckatuck Creek	62-4	17	**Yes**	97	**Yes**
	62-6	18	**Yes**	113	**Yes**
	62-6	17	**Yes**	80	**Yes**
	62-7	19	**Yes**	124	**Yes**
	62-8	23	**Yes**	114	**Yes**
	62-9	28	**Yes**	195	**Yes**
	62-10	53	**Yes**	474	**Yes**
	62-11	48	**Yes**	328	**Yes**
	62-12	108	**Yes**	586	**Yes**
	62-13	113	**Yes**	731	**Yes**
Brewers Creek	62-9_1A	41	**Yes**	203	**Yes**
	62-9_1B	77	**Yes**	454	**Yes**
	62-9_1C	145	**Yes**	1,335	**Yes**

Table 0-11: VDH-DSS Fecal Coliform Exceedances Under All Tidal Conditions								
Stream	**Station ID**	**Sample Date**		**No. of Samples**	**Exceedances**			
		First	**Last**		**Geometric Mean**		**90th Percentile**	
					#		#	
Atlantic Ocean/Mouth of Chuckatuck Creek	62-3	1/20/1999	7/19/2007	63	0	**0%**	0	**0%**
	62-2-5	1/20/1999	2/10/2003	18	0	**0%**	5	**28%**
	62-3A	1/20/1999	2/10/2003	18	0	**0%**	10	**56%**
Chuckatuck Creek	62-4	1/20/1999	7/19/2007	63	10	**16%**	45	**71%**
	62-5	1/20/1999	7/19/2007	63	17	**27%**	54	**86%**
	62-6	1/20/1999	7/19/2007	63	18	**29%**	32	**51%**
	62-7	1/20/1999	7/19/2007	63	31	**49%**	36	**57%**
	62-8	1/20/1999	7/19/2007	63	45	**71%**	63	**100%**
	62-9	1/20/1999	7/19/2007	63	56	**89%**	61	**97%**
	62-10	1/20/1999	2/10/2003	18	18	**100%**	18	**100%**
	62-11	1/20/1999	2/10/2003	18	18	**100%**	18	**100%**
	62-12	1/20/1999	2/10/2003	18	18	**100%**	18	**100%**
	62-13	1/20/1999	2/10/2003	18	18	**100%**	18	**100%**
Brewers Creek	62-9_1A	1/20/1999	2/10/2003	18	18	**100%**	18	**100%**
	62-9_1B	1/20/1999	2/10/2003	18	18	**100%**	18	**100%**
	62-9_1C	1/20/1999	2/10/2003	18	14	**78%**	14	**78%**

2.4.2 VDH-DSS Bacteria Source Data

As part of the TMDL development, Bacteria Source Tracking (BST) sampling was conducted by VDH-DSS over a twelve-month period from October 2004 to September 2005 at two VDH-DSS monitoring stations, 62-10 and 62-9_1A (**Figure 2-1**). Samples were checked for precipitation events three days before the sampling occurred. There was no significant precipitation prior to the sample dates. The purpose of the BST study was to identify the sources of bacterial contamination within the Chuckatuck Creek and Brewers Creek watershed. The BST analysis was performed by MapTech (Map Tech, Inc., Dec. 2006).

Overall, the results from BST indicate that bacteria from human, livestock, wildlife, and pet sources are present in Chuckatuck Creek and Brewers Creeks. Results from all sampling events at the monitoring stations are presented in **Appendix C** in **Table C-1** and depicted in **Figure C-1**.

2.4.2.1 Arithmetic Average of BST Sources

In order to eliminate some of the high variability in BST results, an arithmetic average was computed based on the fraction of each bacteria source (wildlife, human, livestock, and pets). However, collection events with a low number of isolates (February 7, 2008 for both stations) were not used in calculating the arithmetic average.

The arithmetic average of each source represents the fraction of bacterial source in the watershed and is applied in this bacterial TMDL in order to distribute non-point source allocations of bacteria. **Table 2-12** depicts the computed arithmetic average based on BST data obtained from each station. **Figure 2-3** and **Figure 2-4** depict the arithmetic BST at monitoring stations 62-10 and 62-9.1A.

Table 0-12: Computed BST Fractions

Waterbody	Station	Wildlife	Human	Livestock	Pets
Chuckatuck Creek	62-10	43%	27%	8%	23%
Brewers Creek	62-9_1A	35%	32%	6%	27%
Average		**39%**	**29%**	**7%**	**25%**

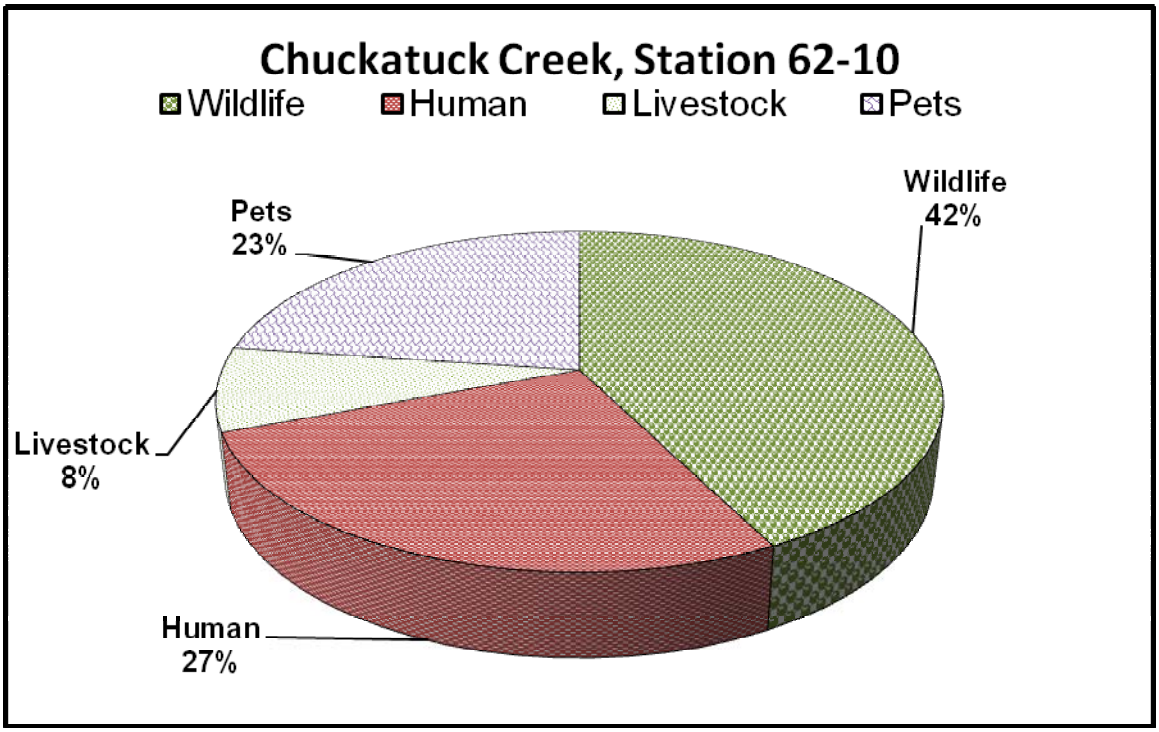

Figure 0-3: BST Results at Station 62-10 (Chuckatuck Creek)

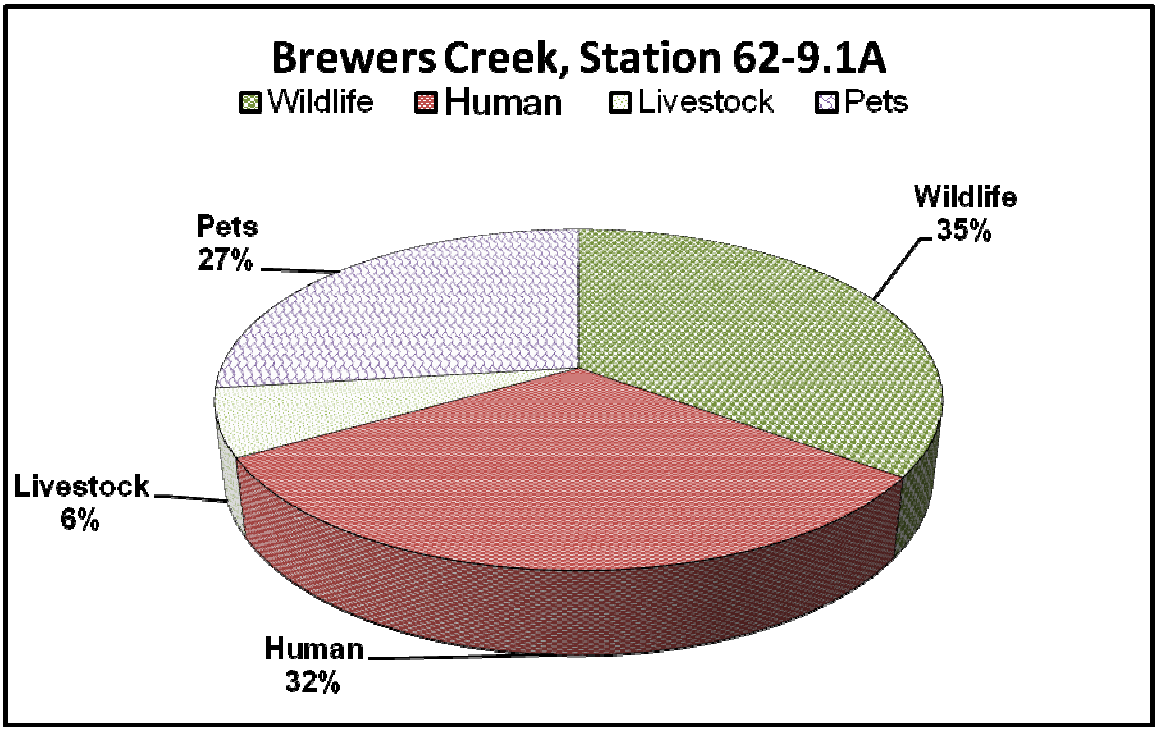

Figure 0-4: BST Results at Station 62-9.1A (Brewers Creek)

2.4.3 VDH-DSS Shoreline Sanitary Survey Data

The shoreline survey is used as a tool to identify non-point source contribution to bacteria problems. VDH-DSS surveyed the Chuckatuck Creek watershed from 2004 to 2005. The results of the shoreline surveys can be found in Appendix A.

2.5 Bacteria Source Assessment

This section focuses on characterizing the sources that potentially contribute to the bacteria loading in the TMDL watershed. The sources include septic systems, livestock, wildlife, and pets. Sanitary Sewer Overflows (discharges of raw sewage from municipal and non-municipal sanitary sewer systems) are also potential sources for bacteria. However, no Sanitary Sewer Overflows have been reported within the watershed. There are no permitted facilities within the TMDL watershed.

2.5.1 Regulated MS4 Permits

There are two MS4 permits located within the Chuckatuck Creek and Brewers Creek watershed, the Isle of Wight County and the City of Suffolk. The locations of the MS4 permits are shown in **Figure 2-5**. The Isle of Wight County MS4 permit occupies 32 acres of the TMDL watershed. The City of Suffolk MS4 permit occupies 472 acres of the TMDL watershed. In total, 504 acres or approximately 3% of the Chuckatuck Creek and Brewers Creek watershed is occupied by MS4 permits.

Figure 0-5: Regulated MS4 Permits within the Chuckatuck Creek and Brewers Creek TMDL 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 this section.

Data on the number of houses and the distribution of houses on sewer systems, septic systems and other means (considered to be straight pipes) was provided by City of Suffolk and Isle of Wight County. The population in the watershed was then 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 calculated by multiplying the number of houses on septic systems by a 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 2-13** shows the estimated amount of failing septic systems for the TMDL watershed.

Table 0-13: Population Estimates for the Chuckatuck Creek and Brewers Creek TMDL Watershed

County	Population[1]	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[3]
Isle of Wight[4]	2,870	1,130[2]	111[2]	1,019[2]	0[2]	122
City of Suffolk	2,200	866[4]	17[4]	849[4]	0[4]	102
TOTAL	**5,070**	**1,996**	**128**	**1,868**	**0**	**224**

[1] Calculated using the average number of people per house in Virginia (U.S. Census 2008) multiplied by the Number of Houses

[2] Data provided by Isle of Wight County

[3] Based on a septic failure rate of 12% (VA DEQ 2005)

[4] Data provided by the City of Suffolk

2.5.3 Livestock

An inventory of the livestock of the Chuckatuck and Brewers Creek watershed was conducted using data and information provided by Isle of Wight County. Livestock information was available for both the City of Suffolk and Isle of Wight County. Livestock estimates in the watershed are shown in **Table 2-14**.

Table 0-14: Livestock Present in the Chuckatuck Creek and Brewers Creek Watershed

County/City*	Cattle	Pigs	Poultry	Horses	Sheep
Isle of Wight and City of Suffolk	113	1,350	0	45	0
* Data provided by Isle of Wight County					

2.5.4 Wildlife

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

The wildlife inventory for the TMDL watershed were developed based on a number of information and data sources, including habitat availability, Department of Game and Inland Fisheries (DGIF) harvest data and population estimates; and stakeholder comments and observations. The number of animals in the watershed was estimated by combining typical wildlife densities with available stream wildlife habitat. Typical wildlife densities in this watershed are presented in **Table 2-15**. Information from these databases was used to determine the wildlife inventory for the City of Suffolk and Isle of Wight County for the TMDL watershed in **Table 2-16**.

Table 0-15: Wildlife Densities in the TMDL Watershed[1]		
Wildlife type	**Population Density**	**Habitat Requirements**
Deer	0.025 animals/acre	Entire watershed
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	
Beaver (low density)	1.0/mile	Permanent streams and rivers
Beaver (high density)	14.5/mile	
Beaver (average density)	4.8/mile	
Residential Goose	0.02 animals/acre	Entire Watershed
Canadian Goose	http://migbirdapps.fws.gov/	Based on particular strata for watershed area
Mallard		
Wood Duck		
Black Duck		
Wild Turkey	0.01 animals/acre	Entire watershed excluding urban land uses

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

Table 0-16: Wildlife Present in the Chuckatuck Creek and Brewers Creek Watershed									
County	**Residential Geese***	**Canada Geese****	**Black Duck****	**Wood Duck****	**Mallard****	**Deer*****	**Raccoon***	**Muskrat***	**Beaver***
Isle of Wight	214	22	0	0	22	281	568	237	41
City of Suffolk	128	13	0	0	13	165	476	177	31
TOTAL	**341**	**34**	**0**	**0**	**34**	**446**	**1,044**	**414**	**72**

*Based on information from the Virginia Department of Game and Inland Fisheries (DGIF)
**Based on the Atlantic Flyway Breeding Waterfowl Survey of migrating birds (DGIF)
***Deer density provided by a district game biologist with the DGIF

2.5.5 Pets

The two types of domestic pets that were considered as potential sources of bacteria in this watershed were cats and dogs. The number of pets residing in the watershed was estimated by determining the number of households in the watershed, and multiplying this number by national average estimates of the number of pets per household which are 0.543 dogs per household and 0.593 cats per household (American Veterinary Medical Association). Based on these estimates, the numbers of dogs and cats estimated to reside within watershed are shown in **Table 2-17**.

Table 0-17: Pet Inventory for the Chuckatuck Creek and Brewers Creek Watershed

County	Households	Dogs***	Cats***
Isle of Wight	1,130*	614	670
City of Suffolk	866**	470	514
TOTAL	**1,996**	**1,084**	**1,184**

* Provided by Isle of Wight County

** Provided by the City of Suffolk

*** 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 to Chuckatuck and Brewers Creeks in areas designated as impaired for fecal coliform (VA DEQ, 2008). The designated areas are saline waters and tidally influenced by an unrestricted connection to the Chuckatuck Creek.

3.3 Modeling Strategy

3.3.1 Model Selection and Approach

A simplified model approach, 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, 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 Chuckatuck and Brewers Creeks is the lunar semi-diurnal (M2) tide with a tidal period of 12.42 hours). Tidal Exchange in the case of the Chuckatuck and Brewers Creeks segment is between this segment and the downstream open water segment. The steady state condition of the model mirrors average condition of the estuary system and incorporates the following assumptions:

1. Water is incompressible
2. Water is completely mixed:
    a. Density variations because of temperature and salinity changes by saline and freshwater inflow are negligible
    b. Variations of 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 [MPN/100mL]

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

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

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

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

Data on death rates for fecal coliform in salt water are of limited availability. In this TMDL, a total death rate for fecal coliform of 1.85 day^{-1}, the midpoint of the range (0.70 to 3.0 day^{-1}) given by Thomann and Mueller (1987), was applied.

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 [MPN/day]

f_{conv} = Conversion factor: 24/12.42 * 10^4 (the factor 24/12.42 accounts for the remaining 11.38 hrs out of 24 hrs, the factor 10^4 converts fecal coliform bacteria unit MPN/100mL into MPN/m^3)

Equation (6) is used to calculate the current daily load capacity for fecal coliform 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 Chuckatuck Creek (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 fecal coliform 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 fecal coliform bacteria for VA criteria of geometric mean and singe maximum value

Equation (7) is used to calculate the allowable daily load for fecal coliform bacteria in the estuary based on VA DEQ criteria for fecal coliform 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 fecal coliform load in the watershed.

3.4 Volume Estimations

Four volumes of water needed to be considered for developing the bacteria TMDLs for Chuckatuck and Brewers Creeks:

- 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 were estimated using the USGS National Elevation Dataset, NED, and is based on cross section measurements within the tidal portions of the estuarine reaches of the Chuckatuck and Brewers Creeks watershed. The average bathymetric data are discussed in Section 2.3.

3.4.2 Volume of Water Entering the Estuary

The volume of water entering each estuary through flood tide was computed by applying equation (2) and (4). The surface area was estimated based on cross section measurements and the mean tidal ranges for the Chuckatuck and Brewers Creek watershed were obtained from NOAA's website "Tide and Currents" (NOAA, 2006). The tidal station "Sewells Point, VA" (Station #8638610) was used for the mean tidal range of Chuckatuck and Brewers Creek. 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 and the calculated incoming volume of the estuaries of Chuckatuck Creek and Brewers Creek for a mean tidal range of 0.74 meters (a value based on NOAA station "Sewells Point, VA").

Table 3-1: Estimated Estuary Surface Area and Calculated Incoming Volume for the Estuary of Chuckatuck and Brewers Creeks

Waterbody	Surface Area	Calculated Volume (Q_0)
	m^2	m^3/tidal cycle
Chuckatuck and Brewers Creeks	3,041,866	1,126,500

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 Chuckatuck Creek and Brewers Creek estuary.

Table 3-2: Estimated Volume of Water Leaving the Estuary of Chuckatuck and Brewers Creeks

Waterbody	Calculated Volume (Q_b)
	m^3/tidal cycle
Chuckatuck and Brewers Creeks	1,165,316

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 estuaries of the Chuckatuck Creek and Brewers Creek were estimated based on average flow measurements over a 48-year period (1942-1989) at the USGS 02048000 Blackwater River at Zuni, VA gage. Based on the long-term average flow at USGS 02048000, a unit flow rate of per square meter was computed and applied to the Chuckatuck and Brewers Creek 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 Chuckatuck and Brewers Creeks watersheds.

Table 3-3: Drainage Area and Freshwater Inflow Volume for the Estuaries of the Chuckatuck and Brewers Creeks

Waterbody	Drainage Area	In Flow Volume*
	m^2	m^3/tidal cycle**
Chuckatuck Creek and Brewers Creek estuary	72,070,761	38,816

*Based on a unite flow rate at USGS 02048000 of 1.205×10^{-8} m^3/sec m^2

**Based on a lunar semi-diurnal (m^2) tide with a tidal period of 12.42 hours

3.5 Fecal coliform Sources Representation

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

1. Sources from the watershed include human sources (failed septic systems and permitted dischargers), livestock, wildlife, and pets.
2. Sources within the estuary include waterfowl and boat traffic.
3. Downstream boundary source from the boundary between the estuary and Chuckatuck Creek.

The first two sources were accounted for in an agglomerated number, combining all fecal coliform sources, represented by the maximum fecal coliform concentration measured at a representative station inside the estuary of Chuckatuck and Brewers Creeks. However, the individual sources such as human sources, pets, livestock, and wildlife were accounted for through Bacteria Source Tracking (BST) data, also collected at one station in each impaired segment. Stations inside the estuaries are considered to represent bacteria sources originating from point and non-point sources in the drainage areas of the impaired segments. The BST data was used to distribute fecal coliform loadings among the various sources.

The third source is represented by the maximum fecal coliform measurement taken at the boundary stations located in near the mouth of the Chuckatuck Creek and Brewers Creek estuaries.

Tables 3-4 and **3-5** respectively show the maximum fecal coliform at stations located in the estuary and at the boundary of the impaired segments. The table also shows whether VA DEQ standards for fecal coliform concentrations are exceeded. Both values are used in the model for calculating the total daily load capacity.

Table 3-4: Maximum Concentration of Fecal Coliform in the Estuary of the Chuckatuck and Brewers Creeks

Location	Station	Geometric Mean [1] (MPN/100mL)	Exceeds Geometric Standard[1]: 14 MPN/100mL	90th Percentile Value (MPN /100mL)	Exceeds 90th Percentile standard: 49 MPN /100mL
Chuckatuck and Brewers Creeks	62-9_1C	145	Yes	1,335	Yes

[1] Requirements of at least two measurements for calculating geometric mean 14 MPN/100mL for fecal coliform were not met

Table 3-5: Maximum Concentration of Fecal Coliform at the Downstream Boundaries of the Estuaries

Location	Station	Geometric Mean [1] (MPN/100mL)	Exceeds Geometric Standard[1]: 14 MPN/100mL	90th Percentile Value (MPN /100mL)	Exceeds 90th Percentile standard: 49 MPN /100mL
Chuckatuck and Brewers Creeks Estuary	62-3	14	No	41	No

[1] Requirements of at least two measurements for calculating geometric mean 14 MPN/100mL for fecal coliform were not met

4.0 TMDL Allocation

The allocation analysis for the bacteria impaired segment of Chuckatuck Creek is the third stage in TMDL development. Its purpose is to develop a framework for reducing fecal coliform loading under the existing watershed conditions so that water quality standards can be met. The TMDL represents the maximum amount of pollutant that the stream can contain 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 (EPA, 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 14 MPN/100mL and the 90th Percentile Standard of 49 MPN/100mL at any time.

4.2 Waste Load Allocation

There are two MS4 permits located in the Chuckatuck and Brewers Creeks watershed, the Isle of Wight County and the City of Suffolk. In order to account for future growth in the Chuckatuck and Brewers Creeks watershed, a 1% waste load was allocated to the TMDL watershed.

4.3 Load Allocation Development and Scenarios

The reduction of loadings from non-point sources, including livestock, pets, and wildlife direct deposition, was incorporated into the load allocation. Fecal coliform loadings (daily load capacity of the estuary) were calculated in the estuary of Chuckatuck and Brewers Creeks in order to obtain the current load and allowable load. The current load is the maximum value of the geometric mean and 90th percentile based on measurements at monitoring stations inside the estuary. The allowable load is the maximum value of the geometric mean and 90th percentile based on VA DEQ standards for fecal coliform. The required percent load reduction for the Chuckatuck and Brewers Creeks watershed was estimated by subtracting the allowable load from the current load, dividing the remainder by the current load, and multiplying by 100. **Table 4-1** shows the computed model results of the current load, allowable load, and reduction for the 90th percentile for the Chuckatuck Creek watershed. The maximum values of the 90th percentile were used to calculate the load allocation and the TMDL in the watershed, since they represented the maximum current loads.

Table 4- 4: Current Load, Allowable Load, and Required Reduction Based on the Maximum 90th Percentile Value

Creek	Station	Volume (m^3)	Max 90th Percentile (MPN/100mL)	90th Percentile Standard (MPN/100mL)	Current Load (MPN/day)	Allowable Load (MPN/day)	Required Reduction (%)
Chuckatuck Creek and Brewers Creek Estuaries	62-9_1C	16,969,568	1,335	49	8.93E+14	3.17E+13	96.4%

4.4 Allocation Plan and TMDL Summary

Waste Load Allocation

To account for future growth in the TMDL watersheds, one percent of the total TMDL was assigned to the WLA. The allocated waste load for future growth is 3.17x1011 MPN/day.

Waste load allocations were also applied to two MS4 permit holders in the Chuckatuck and Brewers Creeks watershed: Isle of Wight County (VAR040020) and City of Suffolk (VAR040029). 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 the TMDL watershed. The WLA for each MS4 is shown in **Table 4-2**.

Table 4- 5: Waste Load Allocation for MS4 Permits within the Chuckatuck Creek and Brewers Creek TMDL Watershed

MS4	Existing Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction
Isle of Wight County (VAR040020)	3.13E+11	1.10E+10	96%
City of Suffolk (VAR040029)	4.27E+12	1.50E+11	96%
Total	**4.58E+12**	**1.61E+11**	

Load Allocation and TMDL

The load allocation is based on Bacteria Source Tracking (BST) results for livestock, wildlife, human, and pets. A complete reduction of all human sources is required, since fecal coliform 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. Allocations are developed using the proportion of these sources in the BST data. The fecal coliform TMDL allocations by BST source categories that would meet

the 90th percentile fecal coliform standard of 49 MPN/100mL for the Chuckatuck and Brewers Creeks watershed is provided in **Table 4-3**. Summaries of the TMDL allocation plans for the Chuckatuck and Brewers Creeks watershed is presented in **Tables 4-4**. Minor differences in current loads are due to rounding.

Table 4- 6: Distribution of Fecal Coliform Under Existing Conditions, TMDL Allocation, and Reduction in the Chuckatuck and Brewers Creeks Watershed for Non-point Sources

Source	BST * Allocation (% of total load)	Current Load (MPN/day)	Allocated Load (MPN/day)	Required Reduction (%)
Livestock	39%	3.45E+14	0.0	100%
Wildlife	29%	2.59E+14	3.12E+13	88%
Human	7%	6.34E+13	0.0	100%
Pets	25%	2.21E+14	0.0	100%
Total	**100%**	**8.88E+14**	**3.12E+13**	**96%**

* Average of samples taken between 2004 and 2005

Table 4- 7: The Chuckatuck and Brewers Creeks TMDL Allocation Plan Loads (MPN/day)

WLA (Two MS4s and 1% of the total TMDL load for future growth)	LA (Non-point sources)	MOS (Margin of safety)	TMDL
4.79E+11*	**3.12E+13**	**IMPLICIT**	**3.17E+13**

*consists of the loads from VAR040020 of 1.10E+10 MPN/day, VAR040029 of 1.50E+11 MPN/day, and 1% of the total TMDL load for future growth of 3.17E+11 MPN/day

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 Chuckatuck Creek and Brewers Creek reductions were developed using the maximum measured bacteria concentration within the impaired waterbody and a stringent bacteria criterion (90^{th} percentile). These two elements; the use of the maximum measured bacteria concentration along with a stringent bacteria criterion insure that the critical conditions are accounted for the Chuckatuck Creek and Brewers Creek.

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 in the watershed. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor water quality to determine if water quality standards are being attained.

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

5.1 Staged Implementation

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

Additionally, in both urban and rural areas, reducing the human fecal loading from failing septic systems should be a primary implementation focus because of its health

implications. This component could be implemented through education on septic tank pump-outs, as well as a septic system repair/replacement program and the use of alternative waste treatment systems. 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 iterative implementation of BMPs in the watershed has several benefits:

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

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

5.2 Link to ongoing Restoration Efforts

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

5.3 Reasonable Assurance for Implementation

5.3.1 Follow-Up Monitoring

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

5.3.2 Regulatory Framework

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

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

5.3.3 Implementation Funding Sources

Appropriate funding sources will be identified in the implementation plan process. One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. Section 319 funding is a potential 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, the Virginia Water Quality Improvement Fund, "National Fish & Wildlife Foundation" and "VA Environmental Endowment, Chesapeake Bay Restoration". 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 after best management practice implementation, 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 Chuckatuck Creek and Brewers Creek TMDL would not have been possible without public participation, which included two sets of public meetings held within the watershed. A public notice was published in a local paper for each set of public meetings and email invitations publicized the public meeting. The public meetings were also posted in the Virginia Register and on posters displayed on public streets throughout the watershed. Stakeholders attended the public meetings. The following is a summary of the meetings.

Public Meeting #1. This meeting was held on November 9, 2009 at the Suffolk Public Works Department in Suffolk, Virginia. A total of 9 people attended the first public meeting. Copies of the presentation were available for public distribution.

Public Meeting #2. This meeting was held on February 24, 2010 at the Suffolk Public Works Department in Suffolk, Virginia. A total of 11 people attended the second public meeting. Copies of the presentation were available for public distribution.

7.0 References

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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:

Shoreline Sanitation Survey

COMMONWEALTH of VIRGINIA
Department of Health
DIVISION OF SHELLFISH SANITATION
109 Governor Street, Room 614-B
Richmond, VA 23219
Ph: 804-864-7487
Fax: 804-864-7481

CHUCKATUCK CREEK
Growing Area # 062
Isle of Wight County and City of Suffolk
Shoreline Sanitary Survey

Date: 9 February 2005
Survey Period: August 10, 2004 – January 26, 2005
Total Number of Properties Surveyed: 1818
Surveyed By: S.E. Naylor

SECTION A: GENERAL

This survey area extends from Reference Point 63 at the most prominent northeast point above the northern boundary of Ballard Marsh to Reference Point 64 at Barrel Point, including the James River shoreline between these two points, Ballard Creek, Kings Creek, Cooper Creek, Batten Bay, Ragged Island Creek, Chuckatuck Creek, Winall Creek, Muddy Cove (Smith Neck Creek), Brewers Creek (Creer Creek and Green Swamp Creek), Sleepy Lake, and all of their tributaries.

The topography of the area is characterized by a band of marshlands adjacent to the James River. The band exceeds one mile in width in one section, including Ballard Creek, Kings Creek, Cooper Creek, and Ragged Island Creek and extends along both shores of Chuckatuck Creek and its tributaries. Elevations rise from less than 10' around the marshlands to a maximum of 30' at the southwestern edge of the survey boundary.

The population is sparse except for concentrations around the communities of Carisbrooke, Crittenden, Eclipse, Sleepy Lake, Chuckatuck and along Route 17. Growth in the area can be described as moderate to heavy. Substantial growth has taken place in the Eagle Creek Development near the James River Bridge. The majority of properties within this survey boundary are served by on-site sewage disposal systems, although a sewage force main has been installed from Smithfield (growing area #61) to the Hampton Roads Sanitation District (HRSD), Nansemond Treatment Facility. Most of the new developments in the Chuckatuck Creek watershed area have been hooked to the public sewer line. The economy of the area is based on small businesses, a relatively small fishing industry, and a dwindling number of farms.

Meteorological data indicated that 22.74" of rain fell during the survey period. A monthly breakdown follows:

August 10-31	8.53"	November	3.56"
September	3.19"	December	2.33"
October	2.81"	January 1-26	2.32"

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
www.vdh.virginia.gov/shellfish

Boating activity is moderate, with recreational boaters comprising the majority of the activity. The properties surveyed between Highway 17 and Barrel Point in Eclipse and Crittenden are scheduled to be connected to city sewerage within the next two years. The G. House Water Treatment Works (prop #91) is classified as an industrial waste facility in this report. The plant is located within the survey boundary, but the effluent discharges into Cedar Creek, a tributary of the Nansemond River (growing area #63).

Copies of bacteriological, hydrographical, and shellfish closure data are available at the area field office for review. Copies of the current condemnation notices and maps are available via the internet at http://www.vdh.virginia.gov/oehs/shellfish/.

This report lists only those properties which have a sanitary deficiency or have other environmental significance. ***"DIRECT"*** indicates that the significant activity or deficiency has a direct impact on shellfish waters. Individual field forms with full information on properties listed in this report are on file in the Richmond Office of the Division of Shellfish Sanitation and are available for reference until superseded by a subsequent resurvey of the area. Data in the report is also made available to local health departments and other agencies to address items that may be out of compliance with their regulatory programs.

SECTION B: SEWAGE POLLUTION SOURCES

SEWAGE TREATMENT FACILITIES

-None-

ON-SITE SEWAGE DEFICIENCIES

2. CONTRIBUTES POLLUTION – 11463 Auckland Court, Carrollton 23314. Dwelling- light brown and white faux wood siding trailer with brown trim. No contact. Effluent erupting from septic tank onto ground surface. Sanitary Notice issued 8-10-04 to field #37.

3. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 12027 Smith's Neck Road, Carrollton 23314. Dwelling- cream aluminum siding, 1 story with green trim. 5 persons. Laundry wastes discharged through underground pipe to drainage ditch. Sanitary Notice issued 8-11-04 to field #51.

5. CONTRIBUTES POLLUTION – Brown's Lane, Carrollton 23314. Dwelling- white wood siding 1 story (second house on right). No contact. Effluent erupting from drainfield onto ground surface then draining into adjacent ditch. Sanitary Notice issued 8-11-04 to field #60.

6. CONTRIBUTES POLLUTION – 12143 Smith's Neck Road, Carrollton 23314. Dwelling- white aluminum siding 1 story. 3 persons. Vent stack on side of house was broken at its base, contents erupting out onto ground surface. Sanitary Notice issued 8-12-04 to field #70.

7. CONTRIBUTES POLLUTION – 12273 Smith's Neck Road, Carrollton 23314. Dwelling- white aluminum siding, 1 story with red trim. 2 persons. Effluent erupting from side of drainage ditch adjacent to drainfield. Sanitary Notice issued 8-12-04 to field #86.

8. CONTRIBUTES POLLUTION – 12289 Smith's Neck Road, Carrollton 23314. Dwelling- brick 1 story with black shutters. 4 persons. PVC pipe between septic tank and distribution box was damaged. Area around pipe has been dug up and effluent is leaking into hole. Sanitary Notice issued 8-12-04 to field #88.

14. CONTRIBUTES POLLUTION – 12633 Smith's Neck Road, Carrollton 23314. Dwelling- white wood siding, house trailer with red shutters. 2 persons. Effluent erupting from drainfield to ground surface 25' from ditch. Sanitary Notice issued 8-20-04 to field #120.

15. CONTRIBUTES POLLUTION – 12645 Smith's Neck Road, Carrollton 23314. Dwelling- white aluminum siding house trailer. No contact. Effluent erupting from drainfield to ground surface, then draining into ditch. Sanitary Notice issued 8-20-04 to field #121.

16. CONTRIBUTES POLLUTION – 22385 Vellines Lane, Carrollton 23314. Dwelling- beige aluminum siding 1 story with red shutters. 2 persons. Effluent erupting from drainfield onto ground surface 15' from drainage ditch at 2' elevation. Sanitary Notice issued 8-20-04 to field #128.

17. CONTRIBUTES POLLUTION – 22409 Vellines Lane, Carrollton 23314. Dwelling- brick 2 story with green shutters. 2 persons. Effluent erupting from septic tank and drainfield onto ground surface. Sanitary Notice issued 8-20-04 to field #131.

18. CONTRIBUTES POLLUTION – 22427 Vellines Lane, Carrollton 23314. Dwelling- natural wood siding frame 1 story. 2 persons. Effluent erupting from end of drainfield onto ground surface 10' from drainage ditch at 1' elevation. Sanitary Notice issued 8-20-04 to field #132.

24. CONTRIBUTES POLLUTION, ***DIRECT*** – 11 Thorley Street, Carrollton 23314. Dwelling- cream wood siding 2 story. 5 persons. Effluent erupting from end of drainfield onto ground surface. Trench had been dug allowing effluent to drain directly into lake feeding Ragged Island Creek at 6' elevation. Sanitary Notice issued 8-27-04 to field #282.

25. CONTRIBUTES POLLUTION – 3 Windmere View, Carrollton 23314. Dwelling- yellow vinyl siding 2 story. 2 persons. Effluent erupting from end of drainfield onto ground surface 25' from lake at 5' elevation. Sanitary Notice issued 8-30-04 to field #308.

26. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes), ***DIRECT*** – 1020 Whippingham Parkway, Carrollton 23314. Dwelling- brown wood siding 2 story. No contact. Laundry wastes discharge through 2" hose into ditch that drains to Ragged Island Creek. Sanitary Notice issued 9-1-04 to field #340.

28. CONTRIBUTES POLLUTION – 14380 Green Pasture Lane, Carrollton 23314. Dwelling- red wood siding 2 story with brown trim and yellow barn. No contact. Effluent erupting from end of drainfield onto ground surface. Sanitary Notice issued 9-2-04 to field #358.

29. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 14575 Whippingham Parkway, Carrollton 23314. Dwelling- yellow vinyl siding 1 story with brown trim. 1 person. Laundry wastes drain to ditch through 4" underground white PVC pipe. Sanitary Notice issued 9-2-04 to field #365.

30. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 23074 Channell Way, Carrollton 23314. Dwelling- blue-gray wood siding 1 story with white trim. No contact. Broken, make-shift wooden lid covering grease trap, contents exposed. Sanitary Notice issued 9-2-04 to field #368.

32. CONTRIBUTES POLLUTION – 14443 Carrollton Boulevard, Carrollton 23314. Business- Village Store. Dwelling- brick, 1 story apartment building and white vinyl siding, 1 story house. 5 persons. Effluent erupting from shared septic tank onto ground surface. Sanitary Notice issued 9-3-04 to field #379.

35. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 24113 Sugar Hill Road, Carrollton 23314. Dwelling- light green vinyl siding 1 story with white trim. 1 person. Laundry wastes drain through 2" underground white PVC pipe onto ground surface. Sanitary Notice issued 9-7-04 to field #407.

37. CONTRIBUTES POLLUTION – 14544 Bay View Drive, Carrollton 23314. Dwelling- gray wood siding 2 story with white trim. No contact. Effluent erupting onto ground surface from 4" PVC pipe between house to septic tank. Sanitary Notice issued 9-7-04 to field #421.

38. CONTRIBUTES POLLUTION – 14518 Bay View Drive, Carrollton 23314. Dwelling- brick 2 story with brown and red wood trim. 2 persons. Effluent erupting from drainfield onto ground surface 8' from drainage ditch at 2' elevation. Sanitary Notice issued 9-7-04 to field #422.

42. CONTRIBUTES POLLUTION – 24400 Pine Tree Lane, Carrollton 23314. Dwelling- brick ranch style 1 story with green shutters. No contact. Clean-out pipe to drainfield was broken at time of survey approximately 250' from Chuckatuck Creek at 25' elevation. Sanitary Notice issued 9-9-04 to field #477.

44. CONTRIBUTES POLLUTION – 24210 Sugar Hill Road, Carrollton 23314. Dwelling- white aluminum siding house trailer with white detached garage. 2 persons. Effluent erupting from end of drainfield onto ground surface 15' from ditch at 7' elevation. Sanitary Notice issued 9-10-04 to field #492.

47. CONTRIBUTES POLLUTION – 15517 Carrollton Boulevard, Carrollton 23314. Dwelling- white vinyl siding 1 story with red trim. No contact. Poor-fitting, makeshift wooden lid covering septic tank. Sanitary Notice issued 9-13-04 to field #540.

48. CONTRIBUTES POLLUTION – 24027 Peach Tree Lane, Carrollton 23314. Dwelling- brick 2 story with cream trim. 3 persons. Effluent erupting from drainfield onto ground surface approximately 200' from lake at 4' elevation. Sanitary Notice issued 9-14-04 to field #555.

49. CONTRIBUTES POLLUTION – 15487 Laurelwood Drive, Carrollton 23314. Dwelling- brick 1 story with white trim and shutters. No contact. Effluent erupting from drainfield onto ground surface 20' from drainage ditch at 3' elevation. Sanitary Notice issued 9-14-04 to field #579.

51. CONTRIBUTES POLLUTION – 16101 Carrollton Boulevard, Carrollton 23314. Dwelling- brick 2 story apartment building with 8 units. 8+ persons. Effluent erupting from drainfield onto ground surface 100' from Chuckatuck Creek at 20' elevation. Sanitary Notice issued 9-16-04 to field #595.

52. CONTRIBUTES POLLUTION – 24301 Bush Creek Circle, Carrollton 23314. Dwelling- brick 2 story with cream trim and detached garage. 2 persons. Effluent erupting from drainfield onto ground surface 100' from Chuckatuck Creek at 25' elevation. Sanitary Notice issued 9-16-04 to field #599.

53. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes), ***DIRECT*** – 16228 Muddy Cove Circle, Carrollton 23314. Dwelling- natural wood siding 1 ½ story. 2 persons. Laundry wastes discharge directly to Chuckatuck Creek through underground pipe at 6" elevation. Sanitary Notice issued 9-16-04 to field #606.

54. CONTRIBUTES POLLUTION – 24168 J.A. Newsome Court, Carrollton 23314. Dwelling- tan aluminum siding house trailer. 1 person. Septic wastes from trailer draining directly to ground surface underneath foundation. Sanitary Notice issued 9-20-04 to field #639.

56. CONTRIBUTES POLLUTION – 15606 Carrollton Boulevard, Carrollton 23314. Dwelling- white wood siding 2 story with black shutters. No contact. Lid was removed from septic tank, temporary wood cover over tank. Sanitary Notice issued 9-21-04 to field #661.

57. CONTRIBUTES POLLUTION - 15542 Carrollton Boulevard, Carrollton 23314. Dwelling- gray aluminum siding 1 story with red shutters. No contact. Effluent erupting from septic tank cleanout pipe onto ground surface. Sanitary Notice issued 9-21-04 to field #666.

58. CONTRIBUTES POLLUTION – 15411 Rollingwood Drive, Carrollton 23314. brick 1 ½ story with green shutters. No contact. Effluent erupting from drainfield onto ground

surface 150' from Smith Neck Creek at 10' elevation. Sanitary Notice issued 9-21-04 to field #672.

60. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 15385 Cedar Grove Road, Carrollton 23314. Dwelling- brick ranch style 1 story with black shutters. No contact. Laundry wastes discharge through 2" black flexible hose from back door to ground surface. Sanitary Notice issued 9-22-04 to field #685.

61. CONTRIBUTES POLLUTION – 104 Kay Court, Carrollton 23314. Dwelling- brick 2 story with white trim. 2 persons. Effluent erupting from drainfield onto ground surface in front yard 50' from Brewer's Creek at 3' elevation. Sanitary Notice issued 10-5-04 to field #901.

62. CONTRIBUTES POLLUTION – 106 Cannon Drive, Carrollton 23314. Dwelling- red wood siding 1 story with white shutters. 2 persons. Effluent erupting from drainfield onto ground surface 15' from drainage ditch at 2' elevation. Sanitary Notice issued 10-7-04 to field #947.

63. CONTRIBUTES POLLUTION – 15344 Carrollton Boulevard, Carrollton 23314. Dwelling- white construction block 1 story with enclosed screen front porch. Vacant. Effluent erupting from septic tank and drainfield onto ground surface. Sanitary Notice issued 10-7-04 to field #957.

66. CONTRIBUTES POLLUTION – Tan Road, Smithfield 23430. Dwelling- gray aluminum siding trailer. Vacant. Effluent erupting from septic tank onto ground surface. Sanitary Notice issued 10-25-04 to field #1063.

67. CONTRIBUTES POLLUTION – 21305 Lankford Lane, Smithfield 23430. Dwelling- white vinyl siding 2 story with gray shutters and 2 gray sheds. 4 persons. Effluent erupting from drainfield onto ground surface 100' from Brewer's Creek at 15' elevation. Sanitary Notice issued 10-25-04 to field #1067.

68. CONTRIBUTES POLLUTIONS (Kitchen or Laundry Wastes) – 22065 Spady Lane, Smithfield 23430. Dwelling- gray asbestos siding 2 story with red shutters and two barns. 1 persons. Lid to grease trap missing, contents exposed. Sanitary Notice issued 10-26-04 to field #1076.

71. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 21159 Lankford Lane, Smithfield 23430. Dwelling- brick 1 story with white trim. 1 person. Laundry wastes discharge to ground surface via underground 2" white PVC pipe. Sanitary Notice issued 10-26-04 to field #1090.

72. CONTRIBUTES POLLUTION - 21291 Lankford Lane, Smithfield 23430. Dwelling- white asbestos siding 1 story with gray shutters and white shed. No contact. Broken septic tank lid, contents erupting onto ground surface. Sanitary Notice issued 10-26-04 to field #1091.

75. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 17293 Riddick Road, Smithfield 23430. Dwelling- brick 1 story with white trim. 2 persons. Laundry wastes drain to ground surface from under house via 4" black pipe. Sanitary Notice issued 10-27-04 to field #1114.

79. CONTRIBUTES POLLUTION – 1703 Cherry Grove Road North, Suffolk 23432. Dwelling- yellow vinyl siding 1 story with green trim. 2 persons. Effluent erupting from end of drainfield onto ground surface. Sanitary Notice issued 10-28-04 to field #1152.

80. CONTRIBUTES POLLUTION – 117 Windy Pine Lane, Suffolk 23432. Dwelling- brick 2 story with blue trim. 2 persons. Effluent erupting from drainfield onto ground surface. Sanitary Notice issued 10-28-04 to field #1154.

81. CONTRIBUTES POLLUTION – 1845 Palomino Trail, Suffolk 23432. Dwelling- brick 2 story with black shutters. No contact. Effluent erupting from drainfield onto ground surface. Sanitary Notice issued 11-1-04 to field #1163.

83. CONTRIBUTES POLLUTION – 1873 Horseshoe Point Road, Suffolk 23432. Dwelling- tan brick 2 story with taupe trim. No contact. Effluent erupting from drainfield onto ground surface. Sanitary Notice issued 11-1-04 to field #1169.

84. CONTRIBUTES POLLUTION – 1875 Mustang Trail, Suffolk 23432. Dwelling- blue wood siding 1 story with red trim. 3 persons. Effluent erupting to ground surface from cracked PVC pipe entering septic tank 150' from Brewers Creek at 10' elevation. Sanitary Notice issued 11-1-04 to field #1175.

89. CONTRIBUTES POLLUTION – 1114 Brock Lane, Suffolk 23432. Dwelling- white aluminum siding house trailer with brown trim and porch addition. No contact. Effluent erupting from drainfield onto ground surface. Sanitary Notice issued 11-3-04 to field #1234.

92. CONTRIBUTES POLLUTION – 6658 Crittenden Road, Suffolk 23432. Dwelling- white vinyl siding 2 story with white trim. 5 persons. Effluent erupting from end of drainfield onto ground surface. Sanitary Notice issued 11-15-04 to field #1294.

94. CONTRIBUTES POLLUTION – 1701 Pine Acres Lane, Suffolk 23432. Dwelling- yellow vinyl siding 1 story with white shutters and trim. No contact. Effluent erupting from drainfield onto ground surface then into drainage ditch. Sanitary Notice issued 11-15-04 to field #1303.

95. CONTRIBUTES POLLUTION – 1712 Pine Acres Lane, Suffolk 23432. Dwelling- white vinyl siding 1 story with black trim. 3 persons. Effluent erupting from septic tank onto ground surface. Overflow effluent from drainfield drains to ditch in front yard via underground 2" PVC pipe; and

CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – Laundry wastes drain from back of house to ground surface via 2" black pipe. Sanitary Notice issued 11-15-04 to field #1305.

96. CONTRIBUTES POLLUTION – 6753 Crittenden Road, Suffolk 23432. Dwelling- brick 2 story with black shutters and white trim. 2 persons. Effluent erupting from septic tank onto ground surface in sunroom. Sanitary Notice issued 11-15-04 to field #1307.

97. CONTRIBUTES POLLUTION – 6777 Crittenden Road, Suffolk 23432. Dwelling- brick 1 story with white awnings. 1 person. Effluent erupting from septic tank onto ground surface and into roadside ditch. Sanitary Notice issued 11-15-04 to field #1310.

98. CONTRIBUTES POLLUTION – 6817 Crittenden Road, Suffolk 23432. Dwelling- white wood siding 1 story. 1 person. Effluent erupting from septic tank onto ground surface. Sanitary Notice issued 11-15-04 to field #1311.

99. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 6829 Crittenden Road, Suffolk 23432. Dwelling- yellow asbestos siding 1 story with green awnings. 2 persons. Laundry wastes drain to ground surface from house via 2" black hose. Sanitary Notice issued 11-15-04 to field #1312.

100. CONTRIBUTES POLLUTION – 6837 Crittenden Road, Suffolk 23432. Dwelling- beige vinyl siding 1 story with white trim. 2 persons. Effluent from septic tank is directly piped underground to clogged drainage ditch. Sanitary Notice issued 11-15-04 to field #1313.

101. CONTRIBUTES POLLUTION – 6851 Crittenden Road, Suffolk 23432. Dwelling- tan construction block 1 story. 2 persons. Effluent erupting from septic tank onto ground surface 25' from wetland marsh. Sanitary Notice issued 11-15-04 to field #1316.

102. NO FACILITIES – 6853 Crittenden Road, Suffolk 23432. Dwelling- green wood siding 1 story. 1 person. Indoor incinerating toilet is no longer functioning. Sanitary Notice issued 11-16-04 to field #1317.

104. CONTRIBUTES POLLUTION – 7049 Crittenden Road, Suffolk 23432. Dwelling- brick 1 story with white wood siding. No contact. Effluent erupting from drainfield onto ground surface 15' from drainage ditch in front yard. Sanitary Notice issued 11-16-04 to field #1324.

105. CONTRIBUTES POLLUTION – 1820 Cotton Farm Lane, Suffolk 23432. Dwelling- brick 2 story with blue shutters. No contact. Effluent erupting from septic tank onto ground surface above lid. Sanitary Notice issued 11-17-04 to field #1360.

109. CONTRIBUTES POLLUTION – 1713 Macedonia Road, Suffolk 23432. Dwelling- white vinyl siding 2 story with black shutters. No contact. Poor-fitting, make-shift metal lid covering septic tank. Sanitary Notice issued 11-17-04 to field #1375.

110. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 8301 Hudgins Circle, Suffolk 23432. Dwelling- yellow vinyl siding 1 story with brown trim. 2 persons. Laundry wastes discharge from house to ditch in backyard via 4" underground pipe. Sanitary Notice issued 11-19-04 to field #1380.

112. CONTRIBUTES POLLUTION – 8368 Hudgins Circle, Suffolk 23432. Dwelling- white brick 1 story with brown shutters. 1 person. Effluent erupting from drainfield onto ground surface 15' from drainage ditch in front yard. Sanitary Notice issued 11-19-04 to field #1388.

113. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 8308 Hudgins Circle, Suffolk 23432. Dwelling- white vinyl siding 1 story with red trim. 1 person. Laundry wastes erupting from end of drainfield onto ground surface, and into drainage ditch in backyard. Sanitary Notice issued 11-19-04 to field #1391.

114. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 8371 Crittenden Road, Suffolk 23432. Dwelling- white wood siding 2 story with black roof. Vacant. Poor-fitting, make-shift lid covering grease trap. Sanitary Notice issued 11-19-04 to field #1397.

115. CONTRIBUTES POLLUTION – 8401 Crittenden Road, Suffolk 23432. Dwelling- brick 1 story with white trim. 2 persons. Effluent erupting from septic tank onto ground surface. Sanitary Notice issued 11-19-04 to field #1399.

116. CONTRIBUTES POLLUTION – 1761 Sawmill Point Road, Suffolk 23436. Dwelling- white vinyl siding 1 story with red shutters. No contact. Effluent erupting from septic tank onto ground surface and into drainage ditch. Sanitary Notice issued 11-30-04 to field #1403.

117. CONTRIBUTES POLLUTION – 1741 Sawmill Point Road, Suffolk 23436. Dwelling- white vinyl siding 1 story with black shutters. 2 persons. Poor-fitting, make-shift wooden lid covering septic tank. Sanitary Notice issued 11-30-04 to field #1406.

118. CONTRIBUTES POLLUTION – 1737 Sawmill Point Road, Suffolk 23436. Dwelling- white vinyl siding 1 story with white trim. 1 person. Poor-fitting, make-shift wooden lid covering septic tank; and

    CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – Laundry wastes drain from house to ground surface via 2" black hose. Sanitary Notice issued 11-30-04 to field #1410.

119. CONTRIBUTES POLLUTION – 1721 Sawmill Point Road, Suffolk 23436. Dwelling- green vinyl siding 2 story with black shutters. 3 persons. Septic tank lid broken, contents exposed. Sanitary Notice issued 11-30-04 to field #1414.

121. CONTRIBUTES POLLUTION – 1634 Holly Point Lane, Suffolk 23436. Dwelling- brick 2 story with gray shutters. 4 persons. Effluent erupting from distribution box onto ground surface 75' from wetland area. Sanitary Notice issued 12-3-04 to field #1440.

122. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 1400 Moore's Point Lane, Suffolk 23436. Dwelling- gray brick 1 story with white trim. No contact. Laundry wastes discharge to ground surface via underground pipe 75' from Chuckatuck Creek at 30' elevation. Sanitary Notice issued 12-3-04 to field #1452.

124. CONTRIBUTES POLLUTION – 1636 Moore's Point Road, Suffolk 23436. Dwelling- white vinyl siding 2 story with blue shutters. No contact. Effluent erupting from septic tank onto ground surface 35' from drainage ditch at 4' elevation. Sanitary Notice issued 12-8-04 to field #1518.

125. CONTRIBUTES POLLUTION – 1940 Hobson Drive, Suffolk 23436. Dwelling- green asbestos siding 2 story with white trim. 2 persons. Effluent erupting from end of drainfield onto ground surface 2' from drainage ditch at 4" elevation. Sanitary Notice issued 12-8-04 to field #1524.

126. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 1745 Mt. Lebanon Avenue, Suffolk 23436. Dwelling- white vinyl siding 1 story with brown trim. 1 person. Laundry wastes discharge to ground surface via underground 4" black pipe. Sanitary Notice issued 12-8-04 to field #1532.

128. CONTRIBUTES POLLUTION – 1525 Sleepy Lake Parkway, Suffolk 23433. Dwelling- brick 1 story with black shutters. 2 persons. Effluent erupting from end of drainfield onto ground surface 10' from drainage ditch. Sanitary Notice issued 12-15-04 to field #1587.

129. CONTRIBUTES POLLUTION – 1500 Timber Trail, Suffolk 23433. Dwelling- brick 1 story with brown trim. 3 persons. Effluent erupting from drainfield onto ground surface 30' from Sleepy Lake at 3' elevation. Sanitary Notice issued 12-17-04 to field #1615.

132. CONTRIBUTES POLLUTION – 8647 Crittenden Road, Suffolk 23433. Dwelling- blue wood siding 2 story with white trim. No contact. Effluent erupting from drainfield onto ground surface 35' from retention pond at 3' elevation. Sanitary Notice issued 1-3-05 to field #1659.

135. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 1512 White Dogwood Trail, Suffolk 23433. Dwelling- green wood siding 2 story with white trim. 3 persons. Laundry wastes discharge to ground surface via garden hose approximately 300' from Chuckatuck Creek. Sanitary Notice issued 1-6-05 to field #1691.

136. CONTRIBUTES POLLUTION – 9113B Eclipse Drive, Suffolk 23433. Dwelling- brick (duplex) 1 story with white trim. No contact. Effluent erupting from drainfield and septic tank to ground surface 2' from drainage ditch at 3' elevation; and

    CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – Laundry wastes discharge from house into ditch via 4" black hose. Sanitary Notice issued 1-7-05 to field #1698.

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137. CONTRIBUTES POLLUTION – 9277 Eclipse Drive, Suffolk 23433. Dwelling- blue vinyl siding 2 story with white trim. 2 persons. Effluent erupting from drainfield onto ground surface 50' from marsh at 3'elevation. Sanitary Notice issued 1-7-05 to field #1708.

138. CONTRIBUTES POLLUTION – 9345 Eclipse Drive, Suffolk 23433. Dwelling- brick 1 story with green trim. 2 persons. Effluent erupting from drainfield onto ground surface 75' from marsh at 9' elevation. Sanitary Notice issued 1-7-05 to field #1716.

140. CONTRIBUTES POLLUTION – 9348 Eclipse Drive, Suffolk 23433. Dwelling- brick and white vinyl siding 2 story with black shutters. 2 persons. Effluent erupting from distribution box onto ground surface 100' from Chuckatuck Creek at 12' elevation. Sanitary Notice issued 1-7-05 to field #1726.

141. CONTRIBUTES POLLUTION – 9328 Eclipse Drive, Suffolk 23433. Dwelling- yellow vinyl siding 2 story with white trim. No contact. Effluent erupting from drainfield onto ground surface 45' from Chuckatuck Creek at 12' elevation. Sanitary Notice issued 1-10-05 to field #1729.

142. CONTRIBUTES POLLUTION – 9320 Eclipse Drive, Suffolk 23433. Dwelling- brick 1 story with white trim. 1 person. Effluent erupting from drainfield onto ground surface 25' from marsh at 9' elevation. Sanitary Notice issued 1-10-05 to field #1731.

144. CONTRIBUTES POLLUTION – 9308 Dixon Road, Suffolk 23433. Dwelling- cream vinyl siding 2 story with green shutters. 5 persons. Effluent erupting from drainfield onto ground surface and into ditch. Sanitary Notice issued 1-10-05 to field #1757.

145. CONTRIBUTES POLLUTION – 9323 Rivershore Drive, Suffolk 23433. Dwelling- 1 story log cabin. No contact. Effluent erupting from end of drainfield onto ground surface. Sanitary Notice issued 1-24-05 to field #1761.

146. CONTRIBUTES POLLUTION – 9327 Rivershore Drive, Suffolk 23433. Dwelling- brick 2 story with cream vinyl trim. No contact. Effluent erupting from drainfield onto ground surface. Sanitary Notice issued 1-24-05 to field #1763.

149. CONTRIBUTES POLLUTION – 9215 Wigneil Street, Suffolk 23433. Dwelling- brick ranch style 1 story with brown trim. No contact. Effluent erupting from septic tank onto ground surface and draining into ditch. Sanitary Notice issued 1-25-05 to field #1786.

150. CONTRIBUTES POLLUTION – 9326 Rivershore Drive, Suffolk 23433. Dwelling- white wood siding 2 story with detached garage. 2 persons. Lid of septic tank removed, effluent erupting to ground surface 35' from drainage ditch at 1' elevation. Sanitary Notice issued 1-25-05 to field #1790.

151. CONTRIBUTES POLLUTION – 9240 Dixon Road, Suffolk 23433. Dwelling- white aluminum siding 2 story with green shutters. 1 person. Effluent erupting from septic tank onto ground surface. Sanitary Notice issued 1-25-05 to field #1792.

152. CONTRIBUTES POLLUTION – 1725 Pike Street, Suffolk 23433. Dwelling- brick 1 story with white vinyl trim. No contact. Effluent erupting from end of drainfield onto ground surface. Sanitary Notice issued 1-25-05 to field #1799.

153. CONTRIBUTES POLLUTION – 1721 Pike Street, Suffolk 23433. Dwelling- brick 1 story with gray vinyl trim. 1 person. Effluent erupting from drainfield onto ground surface. Sanitary Notice issued 1-25-05 to field #1800.

154. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 9206 Dixon Road, Suffolk 23433. Dwelling- white asbestos siding 1 ½ story with brown shutters. No contact. Laundry effluent erupting from crack in tank onto ground surface. Sanitary Notice issued 1-26-05 to field #1803.

155. CONTRIBUTES POLLUTION – 9215 Dixon Road, Suffolk 23433. Dwelling- log cabin 2 story with green trim. No contact. Effluent erupting from drainfield onto ground surface 10' from drainage ditch at 3' elevation. Sanitary Notice issued 1-26-05 to field #1805.

156. CONTRIBUTES POLLUTION (Kitchen or Laundry Wastes) – 9280 Eclipse Drive, Suffolk 23433. Dwelling- white vinyl siding 2 story with red shutters and yellow detached garage. No contact. Laundry waste water erupting from tank onto ground surface. Sanitary Notice issued 1-26-05 to field #1810.

POTENTIAL POLLUTION

1. 21353 Wigwam Circle, Carrollton 23314. Dwelling- white vinyl siding 1 story with black shutters. No contact. Area over drainfield is soft and shallow. No evidence of discharge at time of survey.

4. 12035 Smith's Neck Road, Carrollton 23314. Dwelling- white vinyl siding 1 story with black trim. 4 persons. Occupant stated that septic system often backs up in the winter. No evidence of discharge at time of inspection.

11. 12519 Smith's Neck Road, Carrollton 23314. Dwelling- brick 1 story with white trim and carport. 3 persons. Owner stated that there is a septic odor in house and that laundry wastes may drain to ground surface. No evidence of discharge at time of survey.

13. 22302 Yellow Rock Lane, Carrollton 23314. Dwelling- brick 1 story with taupe trim and red doors. 3 persons. Owner stated that septic system works poorly after wet weather. No evidence of discharge at time of survey.

21. 6 Little Hampton Lane, Carrollton 23314. Dwelling- brick 1 story with cream shutters and white trim. 3 persons. Owner stated that septic system works poorly after wet weather. No evidence of discharge at time of survey.

22. 4 Little Hampton Lane, Carrollton 23314. Dwelling- brick and beige vinyl siding 2 story with blue shutters. 2 persons. Owner stated that septic system works poorly in wet weather. No evidence of discharge at time of survey.

23. 19 St. Catherine Drive, Carrollton 23314. Dwelling- yellow vinyl siding 1 ½ story with green shutters. 3 persons. Owner stated that septic system works poorly in wet weather. No evidence of discharge at time of survey.

27. 1018 Whippingham Parkway, Carrollton 23314. Dwelling- light brown wood siding 2 story with brown trim. No contact. 2" white pipe with direct access to lake in backyard. No evidence of discharge at time of survey.

30. 23074 Channell Way, Carrollton 23314. Dwelling- blue-gray wood siding 1 story with white trim. No contact. 2" white PVC pipe in house foundation. Liquid running out onto ground surface, source is unknown.

31. 22490 Channell Way, Carrollton 23314. Dwelling- brick 1 story with white trim. 4 persons. Area over drainfield soft and shallow, owner stated that she had a water leak.

40. 24383 Mouring Drive, Carrollton 23314. Dwelling- tan wood siding 1 story with white trim. 2 persons. Owner stated that system backs up during wet weather and effluent erupts from septic tank lid. No evidence of discharge at time of survey.

45. 23502 Sugar Hill Road, Carrollton 23314. Dwelling- white aluminum siding doublewide house trailer with blue shutters. No contact. Area over drainfield soft and shallow. No evidence of discharge at time of survey.

50. 8 Merritt Cove, Carrollton 23314. Dwelling- brick 2 story with white shutters and blue doors. No contact. Underground 4" white PVC pipe exiting house foundation to 4" black flexible pipe that directly enters tributary of Chuckatuck Creek at 25' elevation. No evidence of discharge at time of survey.

55. 24155 J.A. Newsome Court, Carrollton 23314. Dwelling- white aluminum siding doublewide house trailer with green trim. No contact. Area over septic tank soft and muddy, algae layer is present over some of the surface. No evidence of discharge at time of survey.

59. 15384 Rollingwood Drive, Carrollton 23314. Dwelling- brick ranch style 1 story with white shutters and trim. 1 person. Owner stated system works poorly in wet weather. No evidence of discharge at time of survey.

60. 15385 Cedar Grove Road, Carrollton 23314. Dwelling- brick ranch style 1 story with black shutters. No contact. Area over drainfield soft and deeply rutted. No evidence of discharge at time of survey.

64. 15038 Carrollton Boulevard, Carrollton 23314. Business- white construction block 1 story kennel. 2 employees. Kennel has the capacity for 42 dogs, at time of survey there were no animals.

82. 1849 Palomino Trail, Suffolk 23432. Dwelling- gray vinyl siding 2 story with white shutters and trim. 2 persons. Puddles and green vegetation over drainfield area, rest of yard is brown and dry. There was no odor or algae mat associated with standing water.

88. 1120 Brock Lane, Suffolk 23432. Dwelling- yellow vinyl siding 1 story with red shutters and yellow garage. No contact. Area over drainfield is soft and covered by algae mat. No evidence of discharge at time of survey.

103. 6891 Crittenden Road, Suffolk 23432. Dwelling- tan faux wood vinyl siding 1 story with white door. No contact. Dark standing water around house foundation with a slight septic odor. Drainfield area appears dry.

107. 1840 Cotton Farm Lane, Suffolk 23432. Dwelling- tan vinyl siding 2 story with green shutters and detached garage. No contact. Area over drainfield is soft and shallow, evidence of past eruption. No discharge at time of survey.

108. 1848 Cotton Farm Lane, Suffolk 23432. Dwelling- yellow vinyl siding 1 story with white shutters and trim. 1 person. Area over drainfield is soft and shallow. Owner stated systems backs up into the house after wet weather. No evidence of discharge at time of survey.

123. 1616 West Road, Suffolk 23436. Dwelling- brick 1story with green shutters and white trim. 3 persons. Owner stated septic tank effluent backs up into house during wet weather. No evidence of discharge at time of survey.

127. 1760 Mt. Lebanon Avenue, Suffolk 23436. Dwelling- brick 1 story with white awnings and red detached garage. 2 persons. Terra cotta pipe entering drainage ditch on side yard. Owner stated kitchen wastes discharged through this pipe at one time. No discharge at time of survey.

130. 1613 Upton's Place, Suffolk 23433. Dwelling- brick 1 story with red shutters and cream trim with detached garage. 2 persons. Owner stated that septic system works poorly in wet weather. No evidence of discharge at time of survey.

131. 1608 Cornus Court, Suffolk 23433. Dwelling- brick 1 story with green shutters. 1 person. Hole dug in side yard with a slight septic odor. Owner stated the hole is for drainage during heavy rainfall events.

147. 9388 Mullican Drive, Suffolk 23433. Dwelling- white brick 2 story with white trim. 1 person. Area over drainfield is covered by tall, green vegetation and there is a slight septic odor. Unable to assess discharge due to frozen ground.

148. 9212 Wigneil Street, Suffolk 23433. Dwelling- brown natural wood siding 2 story with green door. No contact. Area over drainfield is wet and spongy. Unable to assess discharge due to frozen ground.

SECTION C: NON-SEWAGE WASTE SITES

INDUSTRIAL WASTES

34. Toler Contracting Company, 24019 Sugar Hill Road, Carrollton 23314. Business: contracting and trucking company. 4 employees. Located on property were two 500 gallon diesel fuel tanks and one 250 gallon waste oil tank. All tanks are above ground with berms.

65. Turner Farms, 15529 New Towne Haven Lane, Carrollton 23430. Agriculture: cotton farming. 3 employees. Located on property were one 20,000 gallon liquid fertilizer tank, and one 10,000 gallon diesel fuel tank. Both tanks are above ground without berms.

69. Breezy Point, 21158 Lankford Lane, Smithfield 23430. Business: logging company. 4 employees. Located on property was one 500 gallon diesel fuel above ground tank without a berm.

90. 696 Cherry Grove Road North, Suffolk 23432. Dwelling- white vinyl siding 2 story and multiple farm outbuildings. 2 persons. Located on property were one 300 gallon gasoline tank, one 1000 gallon diesel fuel tank, and one 3000 gallon liquid fertilizer tank. All tank are located above ground without berms.

91. ***DIRECT –*** Occupant: G. Robert House Water Treatment Facility. Owner: City of Suffolk, c/o Albert Moore, Director, Dept of Public Utilities, P.O. Box 1858, Suffolk 23439. Public- water treatment plant. 20 employees. No treatment is necessary for the brine waste discharged from the Electrodialysis Reversal Process, because it discharges into a salt-water environment. Effluent discharges to Cedar Creek, a tributary of the Nansemond River (growing area #63). Currently operating under VPDES Permit #VA0076473 from the Department of Environmental Quality.

133. 1500 Steeple Drive, Suffolk 23433. Business: Volvo Penta, marine engine research. 5 employees. Located on property were one 1000 gallon gasoline fuel tank and one 1000 gallon diesel fuel tank. Both tanks are above ground with berms.

134. Johnson & Sons Seafood, end of White Dogwood Trail, Suffolk 23433. Marine: private dock for watermen to unload fish and crab catches. 3 employees. Located on property were one 1000 gallon gasoline fuel tank and one 1000 gallon diesel fuel tank. Both tanks are above ground and double walled.

SOLID WASTE DUMPSITES

46. Clayton's Auto Parts, 15465 Carrollton Boulevard, Carrollton 23314. Business: automobile salvage yard. Located on site were approximately 6 acres of cars and car parts. All cars were drained of fuel and oils before being brought to the site.

111. 8355 Hudgins Circle, Suffolk 23432. Business: automobile junkyard and car garage. Located on site were approximately ¼ acres of car parts and car fluids. Owner uses property to work on cars.

SECTION D: BOATING ACTIVITY

MARINAS

134. Johnson & Sons Seafood, end of White Dogwood Trail, Suffolk 23433. Owner: Thomas Hazelwood, 9256 Eclipse Drive, Suffolk 23433. Private dock for watermen to unload fish and crab catches. 3 employees. 9 slips/moorings and 5 dry storage spaces. Present at time of survey were 1 work boat greater than 26'in wet storage; and 1 work boat less than 26' and 2 work boats greater than 26' in dry storage. Boating services provided are fuel, water and electricity. A portable toilet, serviced monthly by "All Virginia Environmental Solutions," is provided as sanitary facilities. There are no boat holding tank pump-out facilities or dump station facilities provided at this location.

OTHER PLACES WHERE BOATS ARE MOORED

133. Volvo Penta, 1500 Steeple Drive, Suffolk 23433. Owner: Volvo Penta, 1300 Volvo Penta Drive, Chesapeake 23320. Private test facility for research and the development of Volvo marine engines and out-drives. 5 employees. 12 slips/ 18 dry storage spaces. Present at time of survey were 25 pleasure boats under 26' and 4 pleasure boats over 26' in dry storage. Boating services provided are fuel, water, electricity, repair and a boat ramp. Sanitary facilities available are 3 commodes and 2 lavatories. Sewage disposal is by septic tank with drainfield, which was in satisfactory condition at time of survey. There are no boat holding tank pump-out facilities or dump station facilities provided at this location.

139. Hazelwood's Pier, west end of Eclipse Drive, Suffolk 23433. Owner: Thomas Hazelwood, 9256 Eclipse Drive, Suffolk 23433. Private dock for watermen to unload fish and crab catches. No contact. 9 slips/moorings. Present at time of survey were 2 pleasure boats less than 26' in wet storage. Sanitary facilities available are 1 vault privy for men and 1 vault privy for women, which appear to be in very poor condition at time of survey. There is no dump station facilities provided at this location. And there is an exemption to the requirement to provide boat holding tank pump-out facilities.

143. Arthur L. Latimer, 9362 Dixon Drive, Suffolk 23433. Private pier. No contact. Present at time of survey were 3 pleasure boats under 26'. Boating services provided are water and electricity. Has an exemption to the requirement to provide sanitary facilities, boat holding tank pump-out facilities and dump station facilities.

UNDER SURVEILLANCE

85. Cherry Grove, 1878 Cherry Grove Road, Suffolk 23432. Owner: Cherry Grove Association. Marine: community ramp and pier. No contact. There are no slips or moorings for boats at this facility. The only boating service provided is an in-out ramp. There are no sanitary facilities, and no boat holding tank pump-out facilities at this location.

SECTION E: CONTRIBUTES ANIMAL POLLUTION

9. 12030 Macklesfield Court, Carrollton 23314. Dwelling- light gray vinyl siding 2 story with blue shutters and matching detached garage. No contact. Present at time of survey were 7 kenneled hunting dogs. Waste disposal is unknown.

10. 12180 Kings Creek Court, Carrollton 23314. Dwelling- white vinyl siding 2 story with black shutters and metal garage/barn. 2 persons. Present at time of survey were 5 corralled horses and 4 dogs in pens. Waste disposal is unknown.

12. 23566 Yellow Rock Lane, Carrollton 23314. Dwelling- white vinyl siding 2 story with blue shutters. No contact. Present at time of survey were 2 horses and 5 goats confined to fenced pastures, and 5 free range chickens. Waste disposal is unknown.

19. 12438 Grand Square, Carrollton 23314. Dwelling- gray construction block 1 story with white vinyl trim. 2 persons. Present at time of survey were 11 goats and 8 chickens confined to fenced pastures. Animal wastes are left on fields.

20. 13111 Smith's Neck Road, Carrollton 23314. Dwelling- white vinyl siding 1 story with light blue shutters. 2 persons. Present at time of survey were approximately 30 hunting dogs. Animal wastes are collected and mixed into the gardens.

33. 15028 N&N Brown Way, Carrollton 23314. Dwelling- gray vinyl siding 2 story with white trim. 2 persons. Present at time of survey were 25 free range fowl. Animal wastes are left on ground.

36. 24362 Bayford Road, Carrollton 23314. Dwelling- light gray vinyl siding 2 story with white trim. 1 person. Present at time of survey were 2 horses and 3 goats confined to pastures, and approximately 25 free-range turkeys and chickens 50' from marsh. Animal wastes are left on ground.

39. ***DIRECT -*** 14442 Bay View Drive, Carrollton 23314. Dwelling- brick 2 story with white trim with taupe vinyl horse stable. 1 person. Present at time of survey were 3 horses with direct access to drainage ditch to Ragged Island Creek. Manure is spread on fields as fertilizer.

41. 24503 Batten Bay Lane, Carrollton 23314. Dwelling- slate blue wood siding 2 story with white trim and red wood barn. No contact. Present at time of survey were 5 horses confined to fenced pastures approximately 300' from Batten Bay. Waste disposal is unknown.

43. 24266 Sugar Hill Road, Carrollton 23314. Dwelling- brick 1 story with white trim and black shutters. No contact. Present at time of survey were 16 hunting dogs in individual pens 50' from Winall Creek. Waste disposal is unknown.

45. 23502 Sugar Hill Road, Carrollton 23314. Dwelling- white aluminum siding doublewide house trailer with blue shutters. No contact. Present at time of survey were 25 chickens in coops. Waste disposal is unknown.

69. 21158 Lankford Lane, Smithfield 23430. Dwelling- natural wood siding 2 story and matching 2 story shop building. 4 persons. Present at time of survey were 7 hunting dogs confined to pens. Wastes are collected and disposed with other household trash.

70. ***DIRECT -*** Location: Pasture on Lankford Lane located adjacent to 21081. Owner: 21158 Lankford Lane, Smithfield 23430. Present at time of survey were 5 horses fenced directly next to marsh. Manure is left on fields.

73. 21060 Tan Road, Smithfield 23430. Dwelling- tan aluminum siding trailer and multiple farm buildings. No contact. Present at time of survey were 19 pigs and 4 goats confined to fenced pastures. Waste disposal is unknown.

74. ***DIRECT –*** Pasture between Riddick Road and Lankford Lane, Smithfield 23430. Present at time of survey were 30 cows with direct access to stream that feeds Brewer's Creek. Manure is left on fields.

76. 21090 Roft Lane, Smithfield 23430. Business- hay distributor. 4 employees. Present at time of survey were approximately 60 goats and 5 horses confined to fenced pastures. Manure is left on fields.

77. 17373 Riddick Road, Smithfield 23430. Dwelling- brick 1 story with white shutters and red barn. No contact. Present at time of survey were 3 horses and 2 goats confined to fenced pastures. Also present were approximately 50 fowl including chickens, geese and ducks with direct access to ponds on property.

78. 1015 Cherry Grove Road North, Suffolk 23432. Dwelling- gray vinyl siding 2 story and orange barn with metal roof. 3 persons. Present at time of survey were 5 horses confined to pastures 15' from Green Swamp Creek tributary. Manure is land applied to fields.

86. 1770 Cherry Grove Road North, Suffolk 23432. Agriculture: brown wood siding stable. 1 employee. Present at time of survey were 13 horses confined to pastures 50' from Chuckatuck Creek. Manure is collected and land applied to fallow fields.

87. Liberty Point Arabians, 1712 Cherry Grove Road North, Suffolk 23432. Agriculture: tan wood paneled horse stable. 2 employees. Present at time of survey were 17 horses and 1 goat confined to pastures 100' from Chuckatuck Creek. Manure is collected and land applied to fallow fields.

93. 6735 Crittenden Road, Suffolk 23432. Agriculture: white wooden barn and horse stable. 2 employees. Present at time of survey were 18 horses and 1 donkey confined to fenced in pastures greater than 500' from a tributary of Chuckatuck Creek. Manure is collected from stables and spread on fields.

106. 1824 Cotton Farm Lane, Suffolk 23432. Dwelling- taupe stucco 2 story with stone trim and gray horse stable. 2 persons. Present at time of survey were 5 horses confined to fenced in pastures 100' from a tributary of Chuckatuck Creek. Manure is collected from stables and spread on fields.

120. ***DIRECT –*** 1700 Sawmill Point Road, Suffolk 23436. Dwelling- beige asbestos siding 2 story with white shutters and trim. 2 persons. Present at time of survey were 10 cows with direct access to Chuckatuck Creek. Manure is left on fields.

SUMMARY

Area # 062
Chuckatuck Creek
9 February 2005

SECTION B: SEWAGE POLLUTION SOURCES
1. SEWAGE TREATMENT FACILITIES

0 – DIRECT - None
0 – INDIRECT - None
0 – B.1. TOTAL

2. ON-SITE SEWAGE DEFICIENCIES – Correction of deficiencies in this section is the responsibility of the local health department.

1 – CONTRIBUTES POLLUTION, DIRECT - # 24
76 – CONTRIBUTES POLLUTION, INDIRECT - # 2, 5, 6, 7, 8, 14, 15, 16, 17, 18, 25, 28, 32, 37, 38, 42, 44, 47, 48, 49, 51, 52, 54, 56, 57, 58, 61, 62, 63, 66, 67, 72, 79, 80, 81, 83, 84, 89, 92, 94, 95, 96, 97, 98, 100, 101, 104, 105, 109, 112, 115, 116, 117, 118, 119, 121, 124, 125, 128, 129, 132, 136, 137, 138, 140, 141, 142, 144, 145, 146, 149, 150, 151, 152, 153, 155
2 – CP (Kitchen or Laundry Wastes), DIRECT - # 26, 53
20 – CP (Kitchen or Laundry Wastes), INDIRECT - # 3, 29, 30, 35, 60, 68, 71, 75, 95, 99, 110, 113, 114, 118, 122, 126, 135, 136, 154, 156
0 – NO FACILITIES, DIRECT - None
1 – NO FACILITIES, INDIRECT - # 102
100 – B.2. TOTAL

3. POTENTIAL POLLUTION – Periodic surveillance of these properties will be maintained to determine any status change.

28 – POTENTIAL POLLUTION - # 1, 4, 11, 13, 21, 22, 23, 27, 30, 31, 40, 45, 50, 55, 59, 60, 64, 82, 88, 103, 107, 108, 123, 127, 130, 131, 147, 148

SECTION C: NON-SEWAGE WASTE SITES
1. INDUSTRIAL WASTE SITES

1 – DIRECT - # 91
6 – INDIRECT - # 34, 65, 69, 90, 133, 134
7 – C.1. TOTAL

2. SOLID WASTE DUMPSITES

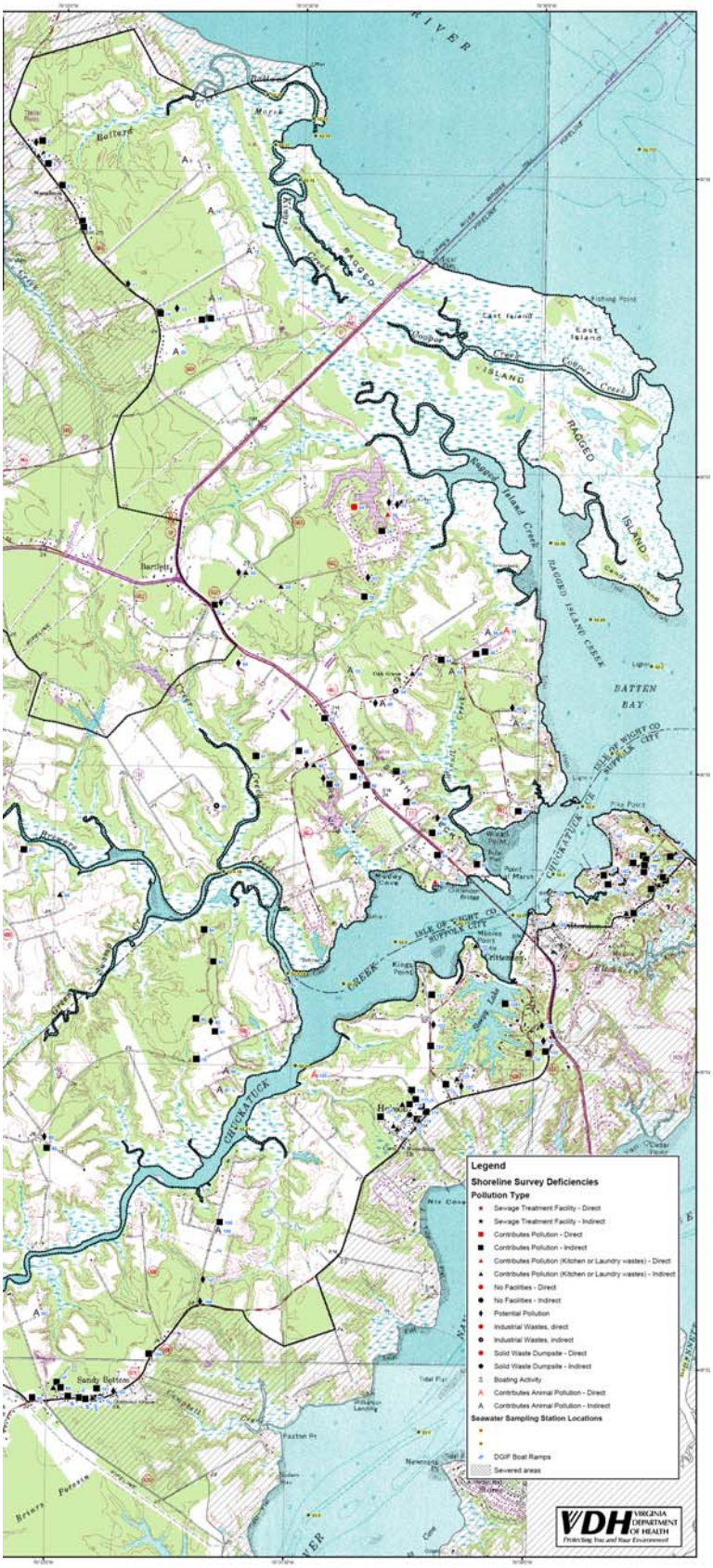
0 – DIRECT – None
2 – INDIRECT - # 46, 111
2 – C.2. TOTAL

SECTION D: BOATING ACTIVITY

1 – MARINAS - # 134
3 – OTHER PLACES WHERE BOATS ARE MOORED - # 133, 139, 143
1 – UNDER SURVEILLANCE - # 85
5 – D. TOTAL

SECTION E: CONTRIBUTES ANIMAL POLLUTION

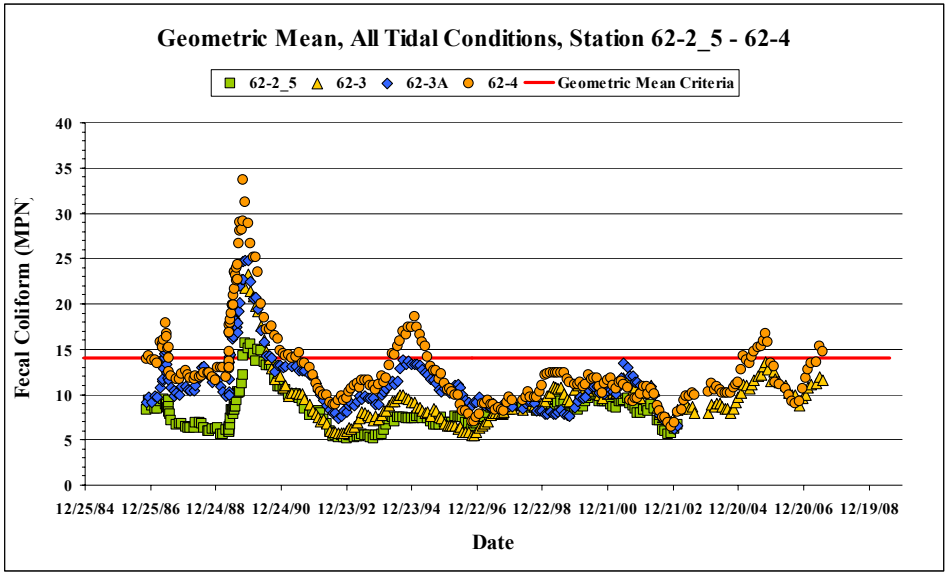
4 – DIRECT - # 39, 70, 74, 120
19 – INDIRECT - # 9, 10, 12, 19, 20, 33, 36, 41, 43, 45, 69, 73, 76, 77, 78, 86, 87, 93, 106
23 – E. TOTAL

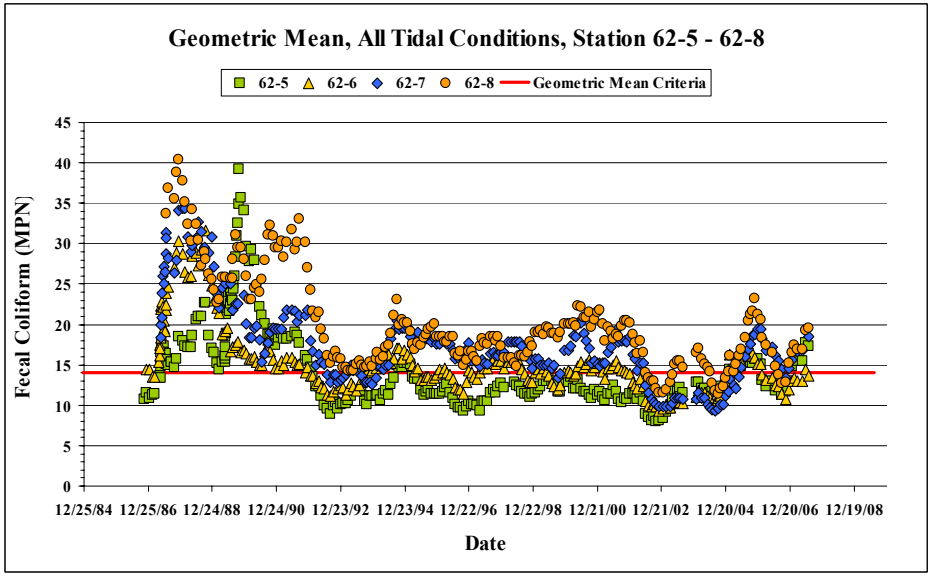

Legend
Shoreline Survey Deficiencies
Pollution Type
Sewage Treatment Facility - Direct
Sewage Treatment Facility - Indirect
Contributes Pollution - Direct
Contributes Pollution - Indirect
Contributes Pollution (Kitchen or Laundry wastes) - Direct
Contributes Pollution (Kitchen or Laundry wastes) - Indirect
No Facilities - Direct
No Facilities - Indirect
Potential Pollution
Industrial Wastes, direct
Industrial Wastes, indirect
Solid Waste Dumpsite - Direct
Solid Waste Dumpsite - Indirect
Boating Activity
Contributes Animal Pollution - Direct
Contributes Animal Pollution - Indirect
Seawater Sampling Station Locations
DGIF Boat Ramps
Severed areas
VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
BATTEN BAY
RAGGED ISLAND
CHUCKATUCK CREEK
Sandy Bottom

APPENDIX B

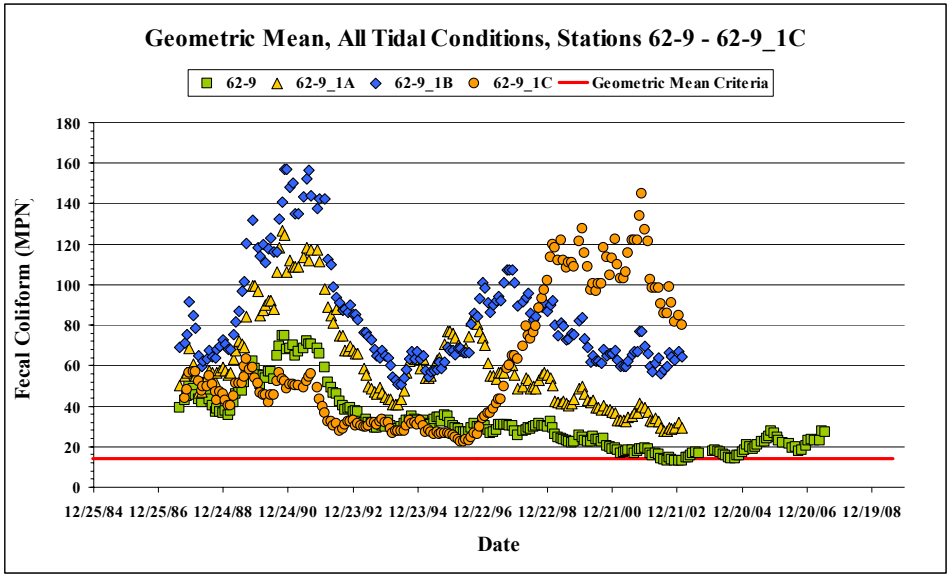
Water Quality Graphs for Fecal Coliform

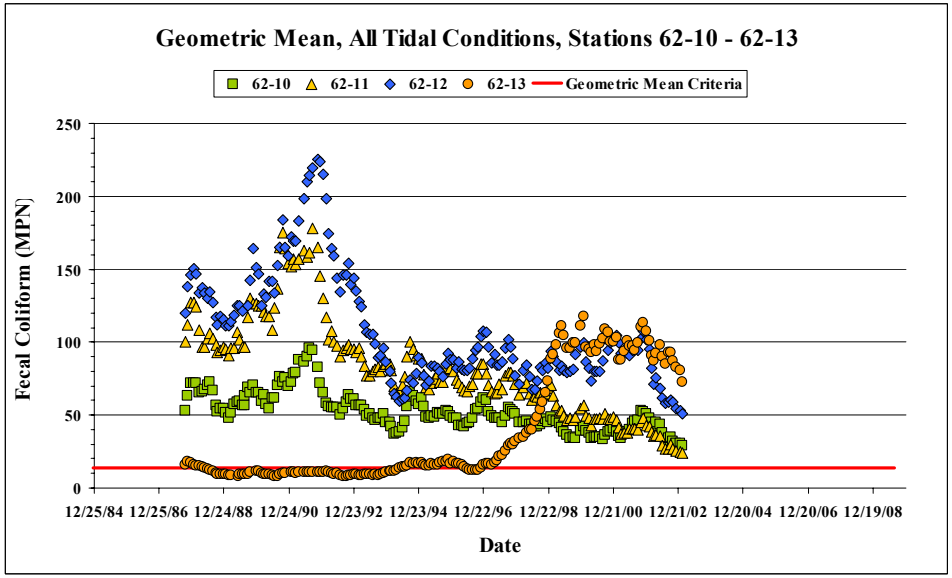
Geometric Mean, All Tidal Conditions: Stations 62-2_5 to 62-8



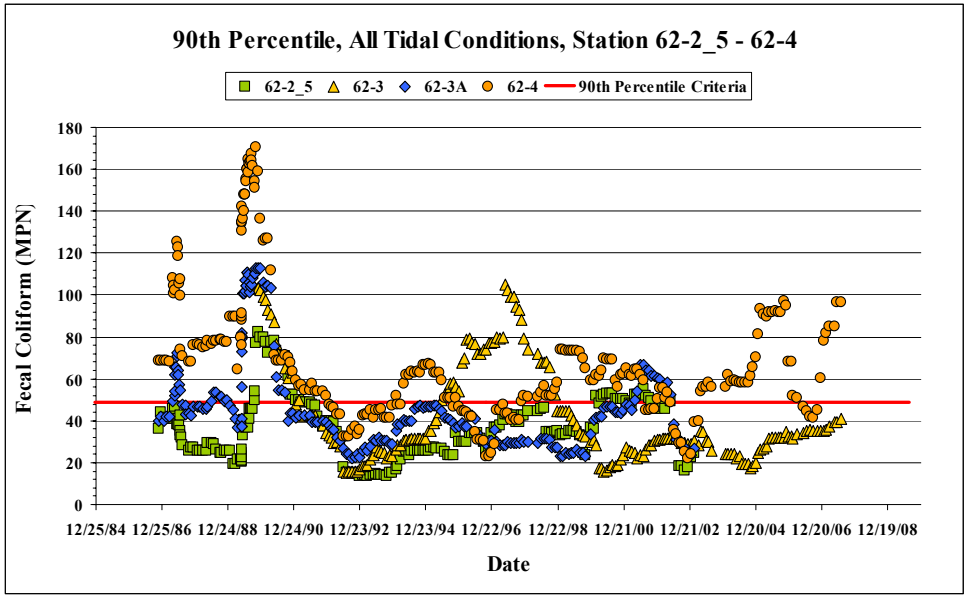


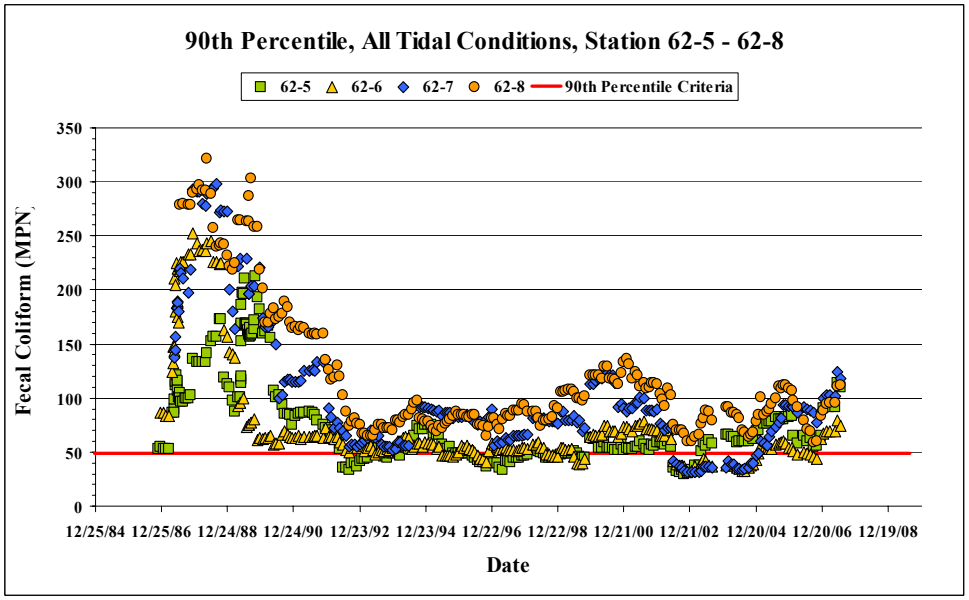
Geometric Mean, All Tidal Conditions, Stations 62-9 to 62-13



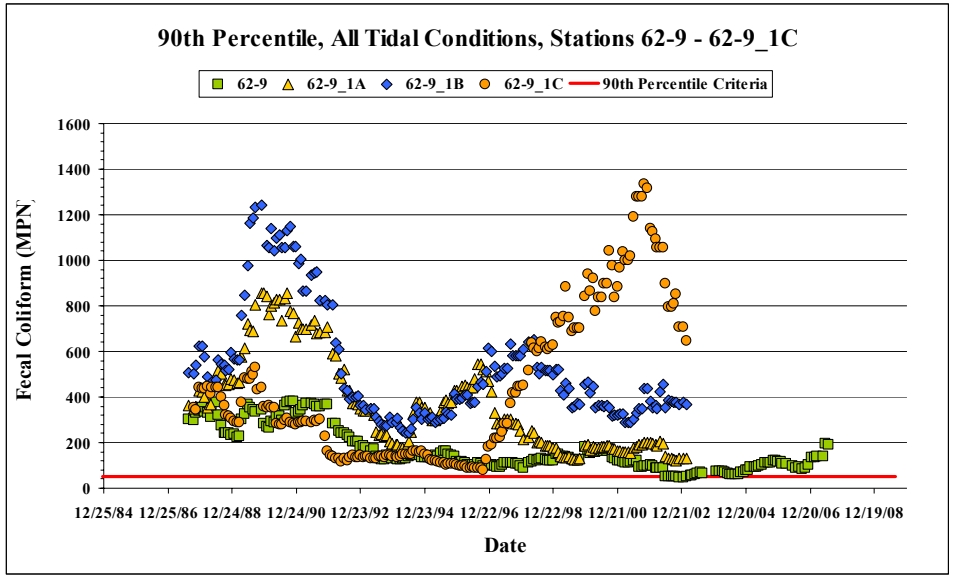


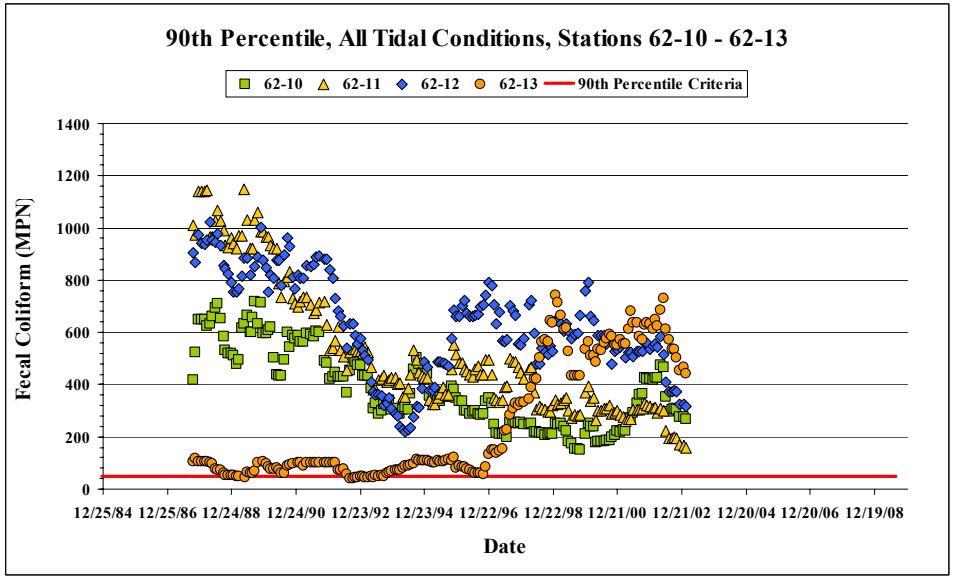
90th Percentile, All Tidal Conditions, Stations 62-2_5 to 62-8





90th Percentile, All Tidal Conditions, Stations 62-9 to 62-13





APPENDIX C:

Bacteria Source Tracking Data

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 Chuckatuck Creek and Brewers Creek. 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 Chuckatuck Creek and Brewers Creek watershed, the maximum number of bacterial isolates per sample is 24. Results from all sampling events at the monitoring stations are presented in **Table C-1** and depicted in **Figure C-1**.

Table C- 1: BST Sampling Events within the Chuckatuck and Brewers Creek Watershed[1]						
Station	**Date**	**Isolates**	**Wildlife**	**Human**	**Livestock**	**Pets**
Chuckatuck Creek, Station 62-10	10/25/2004	24	12%	76%	4%	8%
	11/22/2004	24	100%	0%	0%	0%
	12/21/2004	24	92%	8%	0%	0%
	1/19/2005	21	33%	57%	10%	0%
	2/7/2005	3	67%	33%	0%	0%
	3/22/2005	22	5%	95%	0%	0%
	4/19/2005	24	0%	25%	17%	58%
	5/18/2005	24	100%	0%	0%	0%
	6/16/2005	24	92%	8%	0%	0%
	7/27/2005	16	26%	12%	31%	31%
	8/29/2005	12	8%	8%	25%	59%
	9/26/2005	24	0%	4%	0%	96%
Brewers Creek, Station 62-9.1A	10/25/2004	24	12%	76%	0%	12%
	11/22/2004	24	100%	0%	0%	0%
	12/21/2004	22	41%	45%	14%	0%
	1/19/2005	23	44%	26%	26%	4%
	2/7/2005	5	80%	0%	20%	0%
	3/22/2005	24	17%	79%	4%	0%
	4/19/2005	24	17%	17%	0%	66%
	5/18/2005	24	83%	17%	0%	0%
	6/16/2005	24	42%	50%	8%	0%
	7/27/2005	13	0%	38%	0%	62%
	8/29/2005	11	9%	0%	18%	73%
	9/26/2005	24	21%	0%	0%	79%

[1] No E. coli data was available (BST is cultured with the indicator E. coli)

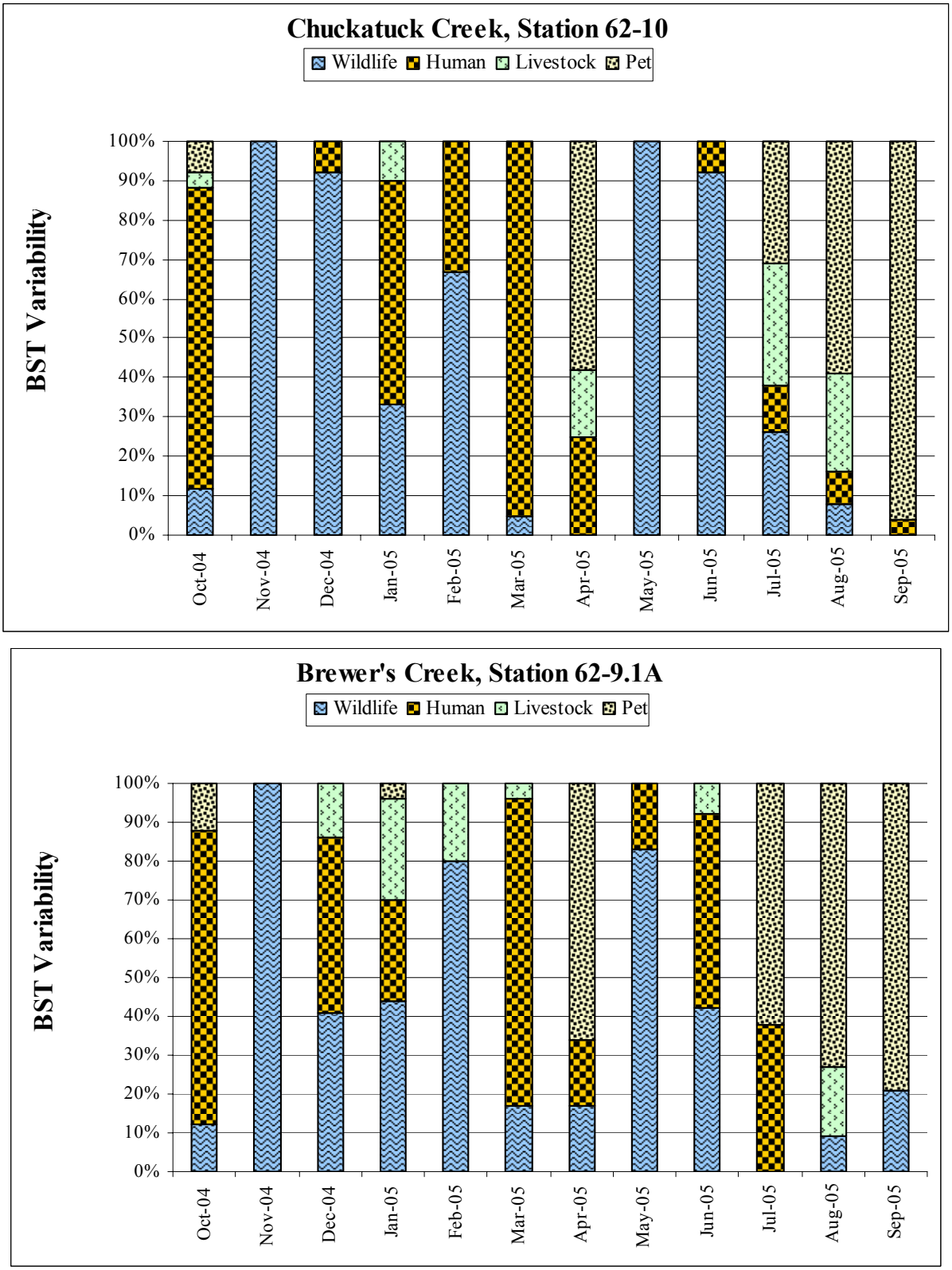


Figure C- 1: BST Results within TMDL Watersheds at Monitoring Stations 62-10 and 62-9.1A