REGIONAL WATER SUPPLY PLAN

NORTHERN NECK PLANNING DISTRICT
(PDC #17)

Counties of Lancaster, Northumberland, Richmond and Westmoreland, and incorporated towns of Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, and White Stone

Northern Neck
PLANNING DISTRICT COMMISSION
Serving Virginia's Lancaster, Northumberland, Richmond, and Westmoreland Counties

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1.0 INTRODUCTION AND BACKGROUND

The NNPD includes the Counties of Lancaster, Northumberland, Richmond and Westmoreland, and incorporated towns of Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, and White Stone (i.e., the Planning Region). Grant funds administered through DEQ were used to support this plan development.

1.1 Legal and Regulatory Background

A systematic water supply planning effort in Virginia was undertaken by state and local governments in response to the 2002 drought. The overall objective of water supply planning is to identify water sources and use, current and future water demand, threats and opportunities for meeting future demands, and integrating this information throughout the entire Commonwealth.

The Code of Virginia, as amended by Senate Bill 1221 in 2003 (Section 62.1-44.38:1) requires the development of a comprehensive statewide water supply planning process. The Local and Regional Water Supply Planning Regulation (9 VAC 25-780) was developed to implement the mandates of this section of the Code. The purpose of this regulation is to protect the health, safety and welfare of citizens by requiring local and regional water supply planning. The goal of the Regulation is to establish a basic set of criteria that each local or regional water supply plan must contain so that they may plan for and provide adequate water to their citizens in a manner that balances the need for environmental protection and future growth.

Each water supply plan submitted by Virginia localities (local or regional plan) will be reviewed by DEQ, and a recommendation provided to the State Water Control Board (Board) whether each water supply plan complies with the Regulation 9 VAC 25-780 et sec. Regulation 9 VAC 25-780-50.D requires that water supply plans be reviewed within five years of compliance determination to assess the plans' adequacy in addressing the Regulation, given then-current water supply planning issues. Any significant changes in water supply issues that are identified at the 5-year compliance review will require the submission of an amended water supply plan. Regulation 9 VAC 25-780-50.E requires that each water supply plan be revised and resubmitted to the DEQ every 10 years.

In addition to administering the requirements of 9 VAC 25-780, DEQ has provided assistance for preparing local and regional water supply plans in the form of grants and workshops.

1.2 Regional Water Supply Planning for the Northern Neck

The DEQ encourages jurisdictions to participate in regional water supply planning efforts. The NNPD notified DEQ of the intent for the Northern Neck (NN) localities participate in a Regional Plan. The Code of Virginia was amended by House Bill 552 in 2006 (Section 62.1-44-38:1) to clarify that the Board shall not prohibit a town from entering into a regional water supply plan with an adjacent county. Grant funds administered through DEQ were used to support this plan development.

1.3 Purpose of this Report

This report is the final report of a regional water supply plan for the Counties of Lancaster, Northumberland, Richmond and Westmoreland, and incorporated towns of Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, and White Stone (i.e., the Planning Region). The purpose of this report is to depict and assess current and future water supply conditions in the Northern Neck and contribute to the development of a comprehensive statewide water supply planning process that would (1) ensure that adequate and safe drinking water is available to all citizens of the Commonwealth, (2) encourage, promote, and protect all other beneficial uses of the Commonwealth's water resources, and (3) encourage, promote, and develop incentives for alternative water sources.

The first phase of the planning process focused on the collection of water supply and water use information, identification of environmental resources affecting the development and use of water supplies, and a projection of future water demand by residents, agricultural operations, and commercial, industrial, and institutional users. The second phase of the planning process focused on identifying existing or potential future problems in ensuring that adequate water supplies are available for the many current and future users. Where the analysis identifies future demands that exceed expected water supplies, the planning process will evaluate alternative actions that will help to avoid or eliminate future water supply problems.

The reader will find that the subject matter of this report is heavily weighted to consideration of ground water issues. Ninety-six (96) of the 102 sources identified in this WSP are ground water suppliers and 100% of the community water supplies on the NN are derived from ground water.

1.4 Introduction to Primary Water Supply Plan Data

The underpinning of this regional WSP is the water source and water use data for the Northern Neck region. Data utilized for this WSP were collected from public domain and private sources. This WSP includes all water data available as of the time of this report was prepared. **Section 3** provides a detailed discussion of the performed data collection efforts, their limitations and results. The WSP data are provided in digital electronic format in **Appendix A**, and in hard copy format in **Appendix B**. The WSP data are presented in summary tables (DEQ Water Supply Plan forms).

Detailed discussion and analysis of water source and water use data for the Northern Neck will be provided in **Sections 4.0 and 5.0** of this WSP.

2.0 GEOGRAPHY AND NATURAL RESOURCES OF THE NORTHERN NECK PLANNING DISTRICT

The Northern Neck (NN) peninsula is one of Virginia's three tidewater peninsulas along the western shore of the Chesapeake Bay (**Figure 2-1**).

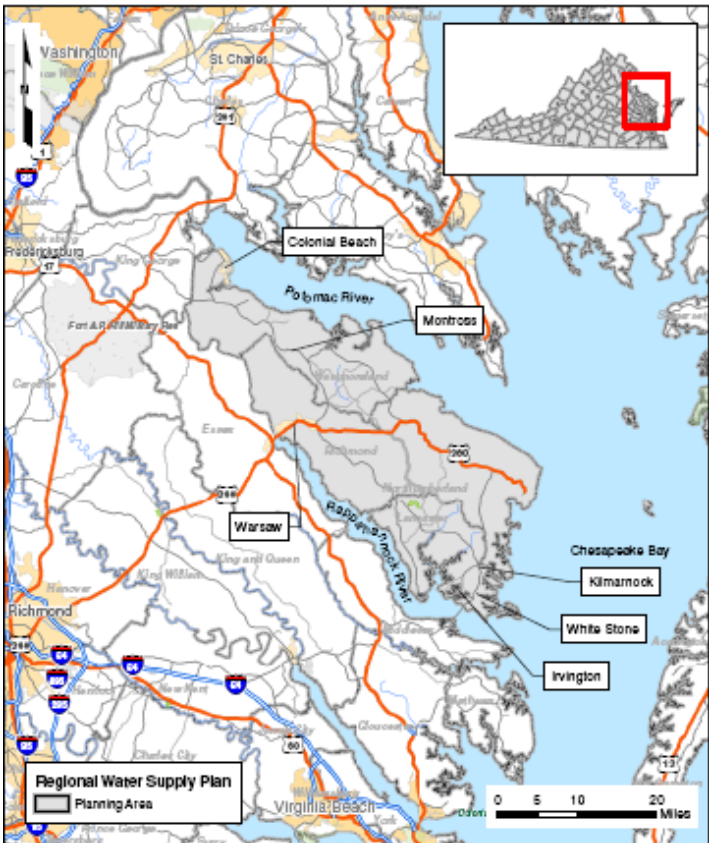


Figure 2-1: Northern Neck Planning District (Regional Water Supply Planning Area)

The NN encompasses approximately 745 square miles (476,800 acres), and is bound by the Potomac River on the north, the Chesapeake Bay on the east, the Rappahannock River to the south, and Essex and King George Counties on the west. The NN is approximately 65 miles northeast of Richmond, Virginia (**Figure 2-1**). Based on total land mass, Lancaster County is the smallest county in the planning area with 133 square miles. Westmoreland County is the largest at 229 square miles. Northumberland and Richmond Counties are comparable at 192 and 191 square miles, respectively.

Throughout the region there are over 1,210 miles of water front, including small bays, creeks and inlets, which, in combination with the Chesapeake Bay, are a major resource to the area (NNPDC, 2003a). These bodies of water provide employment for fishermen and for workers at seafood processing plants throughout the Northern Neck. Water-

related and other natural resources are abundant, making this district one of the most important for environmental and conservation planning in the Chesapeake Bay watershed. In recent years, however, the deteriorating water quality of the Chesapeake Bay has jeopardized the harvest of oysters, crabs, clams and other seafood (NNPDC, 2003a). Efforts to reduce levels of pollutants in the Chesapeake Bay have been coordinated under the Chesapeake Bay Preservation Act (discussed in more detail later in this WSP), which aims to regulate the development and agricultural use of coastal areas and non-tidal wetlands.

2.1 Population

Table 2-1 and **Table 2-1a** summarize population and housing data for the NN. The NN is a rural district with an estimated population of 58,421 in 2007, including incorporated towns (**Table 2-1**). According to census data, the NN had the second-lowest population of Virginia's twenty-one planning districts, and the eighth fastest in population growth (NNPDC, 2003a). Westmoreland County is the most populous of the Northern Neck's four counties, followed by Lancaster, Northumberland, and Richmond County (**Table 2-1**). **Table 2-1** summarizes latest census population data, estimates for 2007 (Weldon Cooper Center, 2009), and population projections for next decades (Virginia Employment Commission, 2009). **Table 2-1a** presents demographic data in terms of population (counties only; Weldon Cooper Center, 2009) and housing units. **Table 2-1b** shows data and estimations of the ratio of population served by community systems and by private wells. A detailed discussion of calculations, assumptions and estimations for this table is presented in **Section 4.6** of this WSP. Demand projections were estimated using a per-capita use method, population forecasting and assumptions on community water systems (**Section 7.0**).

Table 2-1. Northern Neck Population: Census and Projected Populations
Northern Neck Regonal Water Supply Plan

Locality +	April 1, 2000 Census*	Final 2007*	% Change (2000 to 2007)	2010 Projection**	% Change (2007 to 2010)	2020 Projection**	2030 Projection**
County of Lancaster	13,842	13,715	-1%	13,628	-1%	13,503	13,387
County of Northumberland	12,259	12,897	5%	13,420	4%	14,587	15,821
County of Richmond	10,184	10,532	3%	10,682	1%	11,228	11,818
County of Westmoreland	20,261	21,277	5%	21,836	3%	23,849	25,933
TOTALS:	**56,546**	**58,421**	3%	**59,567**	2%	**63,166**	**66,959**

*SOURCE: Weldon Cooper Center, January 22, 2007 Updated Demographic Data for Virginia
**SOURCE: State Demographer Projections,Virginia Employment Commission, 2009
+ Includes incorporated towns.

Table 2-1a. Demographic Data from 2000 Census for the Northern Neck

			Area in square miles			Density per square mile of land	
	2000 Population	Housing units	Total area	Water area	Land area	Population	Housing units
Lancaster	11,567	6,498	231.4	98.2	133.1	86.9	48.8
Northumberland	12,259	8,057	285.7	93.4	192.3	63.7	41.9
Richmond	8,809	3,512	216.4	24.9	191.5	46.0	18.3
Westmoreland	16,718	9,286	252.6	23.5	229.2	72.9	40.5
Total:	**49,353**	**27,353**	**986.0**	**239.9**	**746.1**		

Source: U.S. Census Bureau, Census 2000 Summary File 1

Table 2-1b. Estimate of Community and non-Community Water Service

County	# Service Connections [1]	Population Served [1]	Population per Connection	Total Population [2]	Estimatd Population Served by Private Wells
LANCASTER	2,811	6,509	2.3	11,565	5,056
NORTHUMBERLAND	1,958	5,060	2.6	13,161	8,101
RICHMOND COUNTY	708	3,425	4.8	9,695	6,270
WESTMORELAND	5,280	10,756	2.0	16,741	5,985
Total:	**10,757**	**25,750**	**2.4**	**51,163**	**25,413**

SOURCES:
[1] Community water systems, VDH Permit database (Appendix A)
[2] Weldon Cooper Center, 2007, county population not including incorporated towns.

2.2 Physiography

The NN falls within two subprovinces of the Coastal Plain of Virginia (**Figure 2-2**).

Figure 2-2: Physiographic Sub-provinces (NNRHMP, 2005). Red Ellipse Identifies the Northern Neck Region

The Upland Subprovince (CU) is characterized by low slopes and gentle drainage divides. Steep slopes develop in areas dissected by streams. Steep slopes also are present where the upland meets the Potomac and Rappahannock Rivers (elevations range from 60 to 250 feet above sea level). The other subprovince is the Lowland Subprovince (CL), which is the flat, low-relief region along major rivers and near the Chesapeake Bay (elevations range from 0-60 feet above sea level).

Quaternary age sediments in the Virginia Coastal Plain were deposited 10,000 years to 1.8 m.y. ago in sequences associated with sea-level fluctuations that resulted from changes in continental glaciation. Present-day physiographic topography is related to shallow structural features associated with sediment deposition in step-like succession of terraces separated by intervening scarps that parallel the coast line and major streams. Terraces decrease in altitude toward the coast and major streams, and decrease in age with lower altitude. The scarps initially were cut into the older formations as shorelines, now obscured in places by erosional processes. The Suffolk scarp is one of the most extensive features, trending from the City of Suffolk northward through the Northern Neck, and represents a widespread topographic boundary between areas generally below 50-ft altitude to the east and higher altitudes to the west. The Suffolk scarp and some other landward scarps in proximity to Chesapeake Bay exhibit an arcuate alignment and coincide with the margin of the Chesapeake Bay impact crater. Continued sediment compaction and associated subsidence possibly created one or more embayments across the crater during the Pleistocene Epoch, with shorelines positioned along the crater margin (Powars and Bruce, 2000).

2.3 Climate

The present-day climate of the Northern Neck is generally classified as temperate semi maritime. Winters are generally mild and summers are warm and humid. Average temperatures in the Northern Neck are about 77 degrees Fahrenheit in the summer and 38 degrees in the winter (**Figure 2-3**).

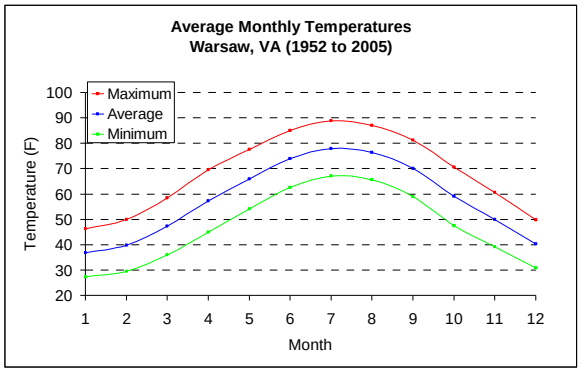


Figure 2-3. Distribution of Monthly Temperatures in the NN, Recorded from 1952 to 2005 (NCDC, 2007)

Mountains to the west produce blocking and steering effects on storms and air masses from the Great Lakes. The Chesapeake Bay and its tributaries provide a buffer to atmospheric changes and allow for breezes that offset humidity. Precipitation is typically received throughout the year in the NN (**Figure 2-4**), with maximum typically occurring in July, and the minimum in February (NCDC, 2007).

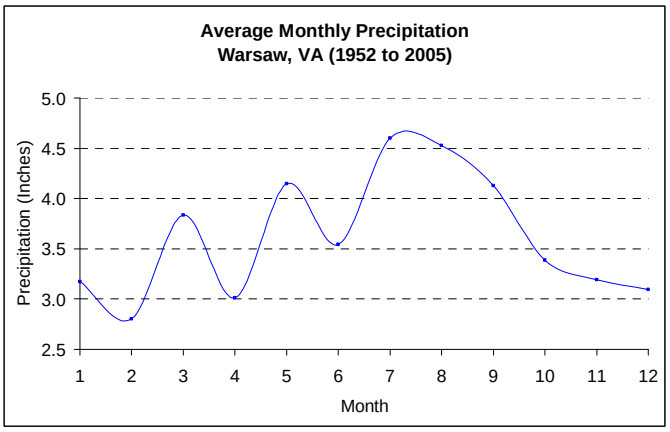


Figure 2-4. Average of Total Monthly Precipitation in the NN, Recorded from 1952 to 2005 (NCDC, 2007)

The annual mean precipitation, as determined over a thirty year period at the Eastern Virginia Research Station in Warsaw, is 43.4 inches (NCDC, 2007). During an average year, 27.3 inches of precipitation falls during the growing season (April to October) and 16.1 inches fall during the winter as snow (NCDC, 2007). The growing season typically encompasses approximately 200 days per year, defined as the period between the average

date of the last freezing temperature in spring (April 15) and the average date of the first freezing temperature in fall (October 26).

While normal precipitation patterns in Virginia typically provide sufficient, but not excessive precipitation to meet water supply demands (see discussion regarding ground water aquifer recharge later in this WSP), the Commonwealth is also subject to flooding from intense storm events, and periods of drought.

The USGS defines meteorological drought as an interval of time, generally on the order of months or years, during which the actual moisture supply at a given place cumulatively falls short of climatically appropriate moisture supply (USGS, 2007a). Hydrologic drought typically refers to periods of below-normal streamflow and/or depleted reservoir storage, and water-supply drought refers to periods when water demand exceeds water availability. A USGS analysis of droughts since 1930 indicates that drought occurs in Virginia, on average, about once every 10 years (USGS, 2007a). However, the record shows considerable variation in both duration and severity. The 2002 drought in Virginia prompted legislative action for Commonwealth-wide water supply planning, culminating in efforts such as the WSP for the NN.

Flooding is a more frequent and more localized event than drought in Virginia. Most flooding is a result of hurricanes and large tropical storms. Virginia is located on the Atlantic Coast in the path of cyclonic storms that move northeastward from the Gulf of Mexico and the Caribbean Sea and of moisture that moves inland from the Atlantic Ocean. These weather systems provide needed rainfall to the State but occasionally cause severe flooding. Intense rainfall is characteristic of cyclonic storms that pass through the Gulf of Mexico and then move northeastward along the Atlantic coast.

2.4 Soils

The discussion of soils that are typically found in the NN will be presented in this WSP with a focus toward relationships to water quality. Pollutants generally affect water quality through two different methods: run-off and leaching. Run-off refers to water that is not absorbed by the soil, but drains by overland flow (natural or man-made drainage courses) to surface water. Run-off rapidly carries sediment and pollution to surface water bodies. Leaching, in contrast, refers to water that is absorbed through the soil and percolates downward to recharge ground water resources. Leaching typically does not transport sediment to a notable extent, but can distribute pollution to ground water which may discharge to surface water bodies.

The amount of run-off or leaching in a region is typically dependent upon the amount of land cover. Areas with a higher percentage of development are more susceptible to run-off pollution due to increased amounts of imperious land cover (i.e., parking lots, buildings, roads). In addition, if soils found in the developed areas are highly erodible, there is increased susceptibility to pollution. Rural areas typically have more farm and forest land and may have increased susceptibility to pollutant leaching because of the extensive pervious ground water recharge areas. Furthermore, agricultural fields are also

very susceptible to erosion and runoff. Since phosphorus is commonly associated with soil particles, this is one of the major sources of phosphorus pollution.

Impacts from run-off are complicated by the types of soils present in different areas of the region. Highly erodible soils have the potential to become a source of pollution in times of large run-off events, such as heavy rainstorms. This combination of high run-off and the presence of highly erodible soils can result in a higher concentration of sediments entering surface waters. Furthermore, individual occurrences of pollution through leaching can be worsened through the presence of highly permeable soils.

The NN region is primarily characterized by low-density development, resulting in relatively more open space (farmland and forest). See **Section 6.0** of this WSP for more information on land use and land cover. On a regional basis, infiltration and leaching of pollutants from soils is likely a more chronic threat to water quality than run-off (see nitrate and pesticide leaching potential of soils in **Section 6.0** of this WSP). The suitability of a soil for various types of land development and/or the installation of septic tanks is important for protecting water quality. A major consideration for NN water quality protection is the high nitrate concentrations and the type and amount of agricultural chemicals used on farmlands. Of wells sampled for nitrate levels on the Delmarva Peninsula from 1999 to 2001, approximately one-third exceeded the EPA's Maximum Contaminant Level (MCL) of 10 mg/L (Denver et al. 2004).

The continued implementation of the Chesapeake Bay Preservation Act, and its required land use practices, has been instrumental in reducing erosion and runoff into water (see **Section 6.0**), although there are many places where the RPA is not being enforced. Use of county ordinances will further assist in directing development to locations with facilities or suitable land (NNPDC, 2003b). Prime agricultural soils are desirable for development because of being cleared, percolation capacities, good elevation and access to roads. **Table 2-2**, below, summarizes the amount of prime agricultural land available in the Northern Neck. However, these lands should be protected to the extent possible in order to maintain open space and agricultural capacity.

Table 2-2. Agricultural Soil Quality in the NN

Agricultural Soil Quality
Available in the Northern Neck

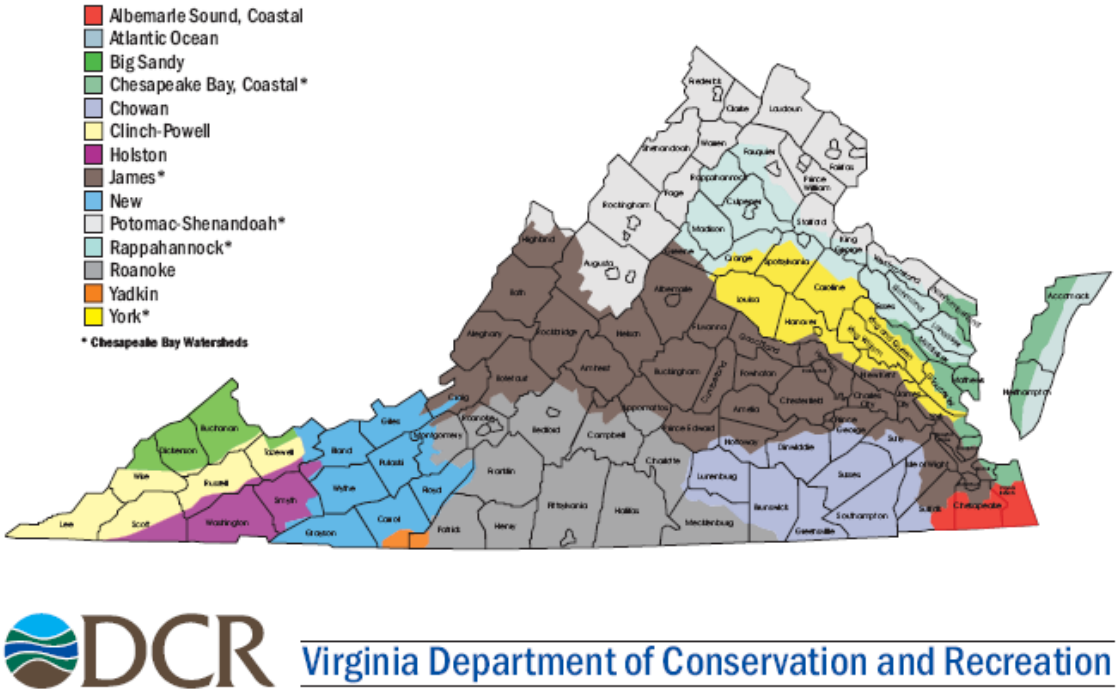
Locality	Acreage	% of Total
Lancaster County		
Prime Soils	50,980	56.1
Non-prime soils	39,889	43.9
Total	90,869	100.0
Northumberland County		
Prime Soils	72,144	56.4
Non-prime Soils	55,056	43.6
Total	128,000	100.0
Richmond County		
Prime Soils	55,085	44.8
Non-prime Soils	67,795	55.2
Total	122,880	100.0
Westmoreland County		
Prime soils	74,015	49.1
Non-prime Soils	76,795	50.9
Total	150,895	100.0
Northern Neck Region		
Prime Soils	252,224	51.2
Non-prime Soils	240,420	48.8
Total	492,644	100.0

The NN region is too large, and the types of soils too diverse, to allow for a meaningful characterization of soils in the context of this regional WSP. The Natural Resources Conservation Service (NRCS, 2007) provides an Internet-based soil survey with map-based query functionality to allow for planners to evaluate soil data in a particular local. A summary of soil types for each County is provided in **Appendix C** of this WSP.

Awareness of the soil properties as they relate to existing and future land uses should be considered in long-term water resources planning. Furthermore, the Comprehensive Plans for the NN counties provide a significant resource for understanding soils and related development potential. The Northern Neck Soil and Water Conservation District Office should also be contacted as a resource for water resource planning and protection.

2.5 Watersheds

A watershed is the total land area that drains water into a given river, lake, estuary or other body of water. A watershed can be quite large (e.g., the Chesapeake Bay watershed) or small (e.g., the watershed of a local stream). The NN lies within three major watersheds (**Figure 2-5**): the Potomac-Shenandoah watershed (grey), the Rappahannock watershed (light blue), and the Chesapeake Bay-Coastal watershed (light green). The Great Wicomico River, the Corrotoman River, and numerous creeks flow through the NN. The shoreline is marked by numerous inlets and coves.



DCR Virginia Department of Conservation and Recreation

Figure 2-5: Major Watersheds in Virginia
(Figure taken from: http://www.dcr.virginia.gov/soil_&_water/documents/wshedsclr.pdf)

Potomac-Shenandoah watershed

The Potomac-Shenandoah watershed spans 5,702 square miles, the third largest in Virginia, and is fed mainly by the Potomac River and the North and South Forks of the Shenandoah River.

The Lower Potomac watershed is part of the larger Potomac-Shenandoah watershed, and borders the northern geographic boundary of the NN (see profile below, **Figure 2-6**).

Chesapeake Bay Program
A Watershed Partnership

The Lower Potomac Watershed

AREA MAP

WATERSHED STATS

Population[1]	
1970	139,467
1980	192,769
1990	261,881
2000	329,061
2010	377,361
2020	426,228
Political Boundaries[2]	
Maryland	10%
Virginia	2%
Major Water Bodies[3]	
Potomac River	
Zekiah Swamp Run	
Mattawoman Creek	
Aquia Creek	
Saint Marys River	
Nanjemoy Creek	

WATERSHED MAP

Map 1: The Lower Potomac watershed

Sources:
[1] U.S. Bureau of the Census and state-based population projections
[2] U.S. Geological Survey
[3] EPA River Reach Files
[4] National Land Cover Dataset, 1993
[5] National Land Cover Dataset, 1993
[6] Mid-Atlantic Regional Earth Science Application Center, University of Maryland, 2000

LAND COVER STATS

1993 Land Cover (sq.mi.)[4]	
Total Area	1,814
Open Water	450
Developed	68
Low Int. Developed	59
High Int. Developed	2
High Int. Comm./Indust	8
Cultivated	335
Hay/Pasture	115
Row Crops	219
Other Grass	1
Natural Vegetation	944
Forest	857
Everg. Forest	157
Deciduous	495
Mixed Forest	206
Wetland	87
Woody Wetland	65
Emergent/Herbaceous	22
Barren	16
Quarries, strip mines	4
Bare rock	0
Transitional	12
1993 Land Cover (%)[5]	
Open Water	24.8%
Developed	3.8%
Cultivated	18.5%
Natural Vegetation	52.1%
Forest	47.3%
Wetland	4.8%
Barren	0.9%
2000 Impervious Surface (%)[6]	
Impervious	1.12%

Figure 2-6: General Characteristics of the Lower Potomac Watershed

Figure taken from: http://www.chesapeakebay.net/wspv31/(xynbfq45uvjowq55ooddf0ap)/WspAbout.aspx?basno=5&topic=5

Rappahannock watershed

The major tributaries draining the Rappahannock water shed include the Rappahannock River, Rapidan River and Hazel River. The NN is drained by a subsection of the Rappahannock watershed, termed the Lower Rappahannock watershed (see profile below).

Chesapeake Bay Program
A Watershed Partnership

The Lower Rappahannock Watershed

AREA MAP

WATERSHED STATS

Population[1]	
1970	60,630
1980	83,022
1990	109,535
2000	131,599
2010	146,380
2020	161,156
Political Boundaries[2]	
Caroline (VA)	22%
Essex (VA)	90%
Fredericksburg (VA)	100%
King And Queen (VA)	0%
King George (VA)	38%
Lancaster (VA)	88%
Middlesex (VA)	62%
Major Water Bodies[3]	
Rappahannock River	
Cat Point Creek	
Hoskins Creek	
Mill Creek	
Totuskey Creek	
Piscataway Creek	

WATERSHED MAP

Map 1: The Lower Rappahannock watershed

Sources:
[1] U.S. Bureau of the Census and state-based population projections
[2] U.S. Geological Survey
[3] EPA River Reach Files
[4] National Land Cover Dataset, 1993
[5] National Land Cover Dataset, 1993
[6] Mid-Atlantic Regional Earth Science Application Center, University of Maryland, 2000

LAND COVER STATS

1993 Land Cover (sq.mi.)[4]	
Total Area	1,157
Open Water	165
Developed	27
Low Int. Developed	21
High Int. Developed	1
High Int. Comm./Indust	5
Cultivated	286
Hay/Pasture	122
Row Crops	164
Other Grass	0
Natural Vegetation	660
Forest	598
Everg. Forest	93
Deciduous	320
Mixed Forest	185
Wetland	62
Woody Wetland	39
Emergent/Herbaceous	23
Barren	19
Quarries, strip mines	2
Bare rock	0
Transitional	17
1993 Land Cover (%)[5]	
Open Water	14.3%
Developed	2.3%
Cultivated	24.7%
Natural Vegetation	57.0%
Forest	51.7%
Wetland	5.4%
Barren	1.6%
2000 Impervious Surface (%)[6]	
Impervious	1.05%

Figure 2-7: General Characteristics of the Lower Rappahannock Watershed

Figure taken from: http://www.chesapeakebay.net/wspv31/(xynbfq45uvjowq55ooddf0ap)/WspAbout.aspx?basno=6&topic=5

Chesapeake Bay, Coastal watershed

The Chesapeake Bay - Coastal Watershed is comprised of the lower Chesapeake Bay and the Piankatank River basin. The Bay-Coastal watershed is part of the larger Chesapeake Bay watershed (see profile below), which is a major regional watershed that stretches across six states (New York, Pennsylvania, Maryland, Delaware, Virginia and West Virginia - and the District of Columbia).

Chesapeake Bay Program
A Watershed Partnership

The Chesapeake Bay Watershed

AREA MAP

WATERSHED MAP

Map 1: The Chesapeake Bay watershed

Sources:
[1] U.S. Bureau of the Census and state-based population projections
[2] U.S. Geological Survey
[3] EPA River Reach Files
[4] National Land Cover Dataset, 1993
[5] National Land Cover Dataset, 1993
[6] Mid-Atlantic Regional Earth Science Application Center, University of Maryland, 2000

WATERSHED STATS

Population[1]	
1970	11,793,163
1980	12,784,860
1990	14,274,651
2000	15,594,241
2010	16,709,043
2020	17,766,832
Political Boundaries[2]	
District Of Columbia	100%
Delaware	29%
Maryland	93%
New York	11%
Pennsylvania	49%
Virginia	55%
West Virginia	15%
Major Water Bodies[3]	
York River	
Susquehanna River	
Rappahannock River	
Potomac River	
Patuxent River	
James River	

LAND COVER STATS

1993 Land Cover (sq.mi.)[4]	
Total Area	66,388
Open Water	2,863
Developed	2,409
Low Int. Developed	1,819
High Int. Developed	224
High Int. Comm./Indust	366
Cultivated	18,895
Hay/Pasture	7,025
Row Crops	11,724
Other Grass	145
Natural Vegetation	41,608
Forest	39,901
Everg. Forest	3,842
Deciduous	28,023
Mixed Forest	8,036
Wetland	1,707
Woody Wetland	1,113
Emergent/Herbaceous	594
Barren	599
Quarries, strip mines	241
Bare rock	2
Transitional	356
1993 Land Cover (%)[5]	
Open Water	4.3%
Developed	3.6%
Cultivated	28.5%
Natural Vegetation	62.7%
Forest	60.1%
Wetland	2.6%
Barren	0.9%
2000 Impervious Surface (%)[6]	
Impervious	1.76%

Figure 2-8: General Characteristics of the Chesapeake Bay Watershed

Figure taken from: http://www.chesapeakebay.net/wspv31/(xynbfq45uvjowq55ooddf0ap)/WspAbout.aspx?basno=1&topic=5

2.6 Hydrology of Water Supplies on the Northern Neck

A hydrologic balance refers to the relationship between the amount of precipitation received in a watershed or region, and the volume of water that is ultimately available to recharge ground water systems and maintain the flow of rivers and streams. Following a precipitation event, a certain amount of storm water runs immediately into adjacent rivers and streams or evaporates directly from the surface, while the remainder percolates into the soil. Within the soil, plants remove a certain volume of water for their use, transpiring that water directly back to the atmosphere. Transpiration is the dominant pathway returning water to the atmosphere. Infiltration is the second dominant path, amounting to about 1/4 to 1/3 of the rainfall. Evaporation and runoff are both small under normal circumstances. Most of the water that flows in streams after rains originates as ground water that discharged into the stream because the water table was elevated due to the rain (base flow). The water that remains in the soil is available to infiltrate downward into surface and\or confined aquifers. Water in the surface aquifer moves laterally to recharge wells or maintain flows in the adjacent streams. Over-use of water resources (over-pumping of ground water from wells; excessive withdrawal from surface water intakes) disturbs the hydrologic balance.

Water engineers commonly refer to a “water budget” to quantify the portion of the hydrological balance that is available for consumptive use. Approximately one-quarter of the precipitation falling on Virginia percolates into the soil to maintain well yields and recharge river flows (see Section 6.0 for discussion on ground water recharge). This water must then be budgeted among different consumers – fish and other aquatic organisms, for instance, require the maintenance of specific minimum flows in order to maintain feeding, breeding, and other types of habitat necessary for life; humans within the immediate area that may rely on sustained yields from wells or reservoirs; other humans and aquatic organisms living downstream that rely on continued flows to recharge the systems essential for their well-being. The calculation of a water budget for this regional WSP is beyond the scope of this WSP but may be required to support alternatives analyses for potential new water resources on the NN on a case by case basis.

2.7 Ground Water Hydrogeology

Ground water is the primary source of water supply in the NN Planning Region. Therefore, the following discussion on ground water hydrogeology provides a more extensive summary than the other background elements presented in this section.

2.7.1 Hydrogeologic Framework

The NN region of Virginia is situated in the Coastal Plain geologic and physiographic province extending from the ‘Fall Line” to the Atlantic Ocean. The Coastal Plain is underlain by an eastward-thickening wedge of unconsolidated or light- to moderately cemented sediments that overlie older basement bedrock. The sediments are roughly characterized as an alternating sequence of relatively permeable silt and sand aquifers, and less-permeable clay and silt aquitards. The total sediment thickness increases from west to east, ranging from approximately 1,500 feet in western Westmoreland County to more than 3,500 feet in eastern Northumberland County (Meng and Harsh, 1988).

Recently Completed USGS Research Core in Northumberland County

Prior to expanding this discussion on the local and regional hydrogeology, it is noted that the following characterization does not include data collected by a recently completed USGS research core hole drilled into the Middle Potomac aquifer, at Surprise Hill, near Reedville, Northumberland County. The data from this study are too preliminary to warrant valuable conclusions.

Drilling began in March, 2007 and was completed in 2008. The core hole penetrates to 1,087 feet in depth to sample the Coastal Plain sediments underlying the eastern NN. Preliminary information provided to the public by USGS / DEQ suggests that the data from this core will require the current hydrogeologic framework underlying the eastern NN to be reinterpreted. The USGS plans to install monitoring wells in the vicinity of the core, to be completed at varying depths to intersect each primary aquifer (to be completed according to final interpretation of the coring data). Ground water elevation data and water samples for water quality analyses will be collected from the wells in the future (Ground water Virginia, 2009).

USGS Regional Aquifer System Analysis

The U.S. Geological Survey (USGS) Regional Aquifer System Analysis (RASA) defined seven major confined aquifers and eight confining units (aquitards) underlying the NN, in addition to the shallow unconfined Columbia aquifer (Meng and Harsh, 1988). The Brightseat and Upper Potomac aquifers are often characterized as a single aquifer. Figure 2-6, below, illustrates a Hydrogeologic cross section to provide a general conceptualization of the RASA, specifically in the area of the NN (Harsh and Laczniak, 1999).

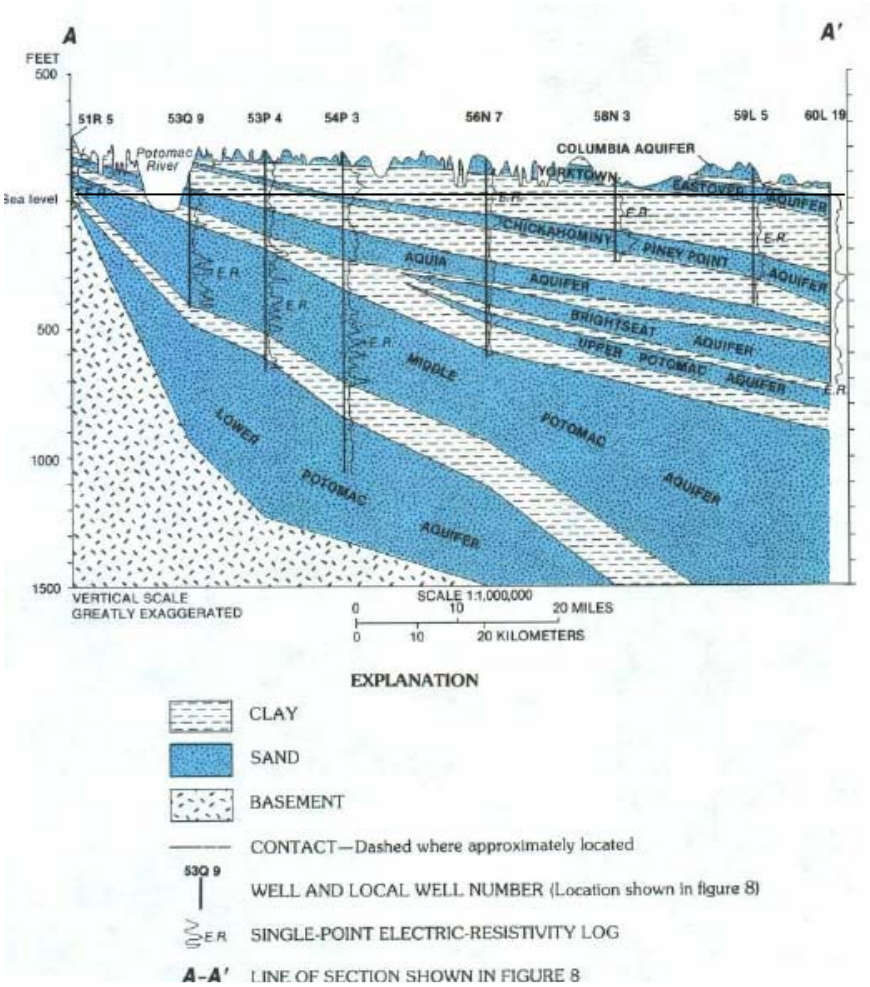


Figure 2-9: Generalized Hydrogeologic Cross Section (Taken from Figure 2 of Harsh and Laczniak, 1999)

The location of the hydrogeologic cross section shown in Figure 2-9, above, is shown by the blue line A-A' in Figure 2-10, below. The cross section extends through several boreholes in the NN, with the exception that large portions of Richmond and Lancaster Counties are not represented by the boreholes.

Figure 2-10: Location of Hydrogeologic Cross Section (Taken from Figure 8 of Harsh and Laczniak, 1999)

Not all of the RASA-defined hydrogeologic units are present beneath the entire NN. Specifically, the Brightseat-Upper Potomac aquifer is thin or absent in the easternmost

portion of the NN (Meng and Harsh, 1988). Approximate altitude of the tops and thicknesses of theses units are provided in Table 2-3, below.

Table 2-3

ALTITUDE AND THICKNESS OF RASA-DEFINED AQUIFERS ON THE NORTHERN NECK OF VIRGINIA

Aquifer	Western Westmoreland County (well 53P4)		Eastern Northumberland County (well 60L19)	
	Altitude of Top (ft ASL)	Approximate Thickness (ft)	Altitude of Top (ft ASL)	Approximate Thickness (ft)
Yorktown-Eastover	+160 (surficial)	50	-100	40
Chickahominy-Piney Point	-14	30	-356	140
Aquia	-160	100	-574	30
Brightseat-Upper Potomac	not present	0	-678	220
Middle Potomac	-324	410	–1000[a]	>700
Lower Potomac	-890	480	less than –1700[a]	--

[a]Interpolated on hydrogeologic cross-section (Meng and Harsh ,1988).

Table from Table 1 of Malcolm Pirnie, 2000.

Recent Changes to the RASA-based Hydrogeologic Framework

In the RASA-based hydrogeologic framework, the Potomac formation was conceptually divided into lower, middle, and upper aquifers that were separated by confining units. It is not possible, however, to identify significant regionally-extensive fine-grained layers within the Potomac Formation, and it is difficult to correlate low-resistivity signals between electric logs separated by more than several thousand feet (Heywood, 2006). This suggests that regionally-extensive confining units within the Potomac Formation do not exist. The trend toward lumping the middle and lower Potomac aquifers is further supported by recently updated ground water flow modeling for the Coastal Plain region. A digital numerical model of the ground-water-flow system in the Virginia Coastal Plain was constructed as part of RASA program of the U.S. Geological Survey (McFarland, 1998). The model was revised based on reinterpretations of the Coastal Plain hydrogeologic framework by subsequent studies.

Chesapeake Bay Impact Crater

Major reinterpretations of RASA has occurred over the last few years resulting from investigations into a comet or meteorite impact crater that is buried beneath Coastal Plain sediments in what is now the lower Chesapeake Bay (Figure 2-11, below) Approximately 35 million year ago, a comet or meteorite impact on what was then a shallow shelf of the western Atlantic Ocean created the Chesapeake Bay impact crater. The crater is now covered by Virginia's central to outer Coastal Plain sediments and the lower Chesapeake Bay.

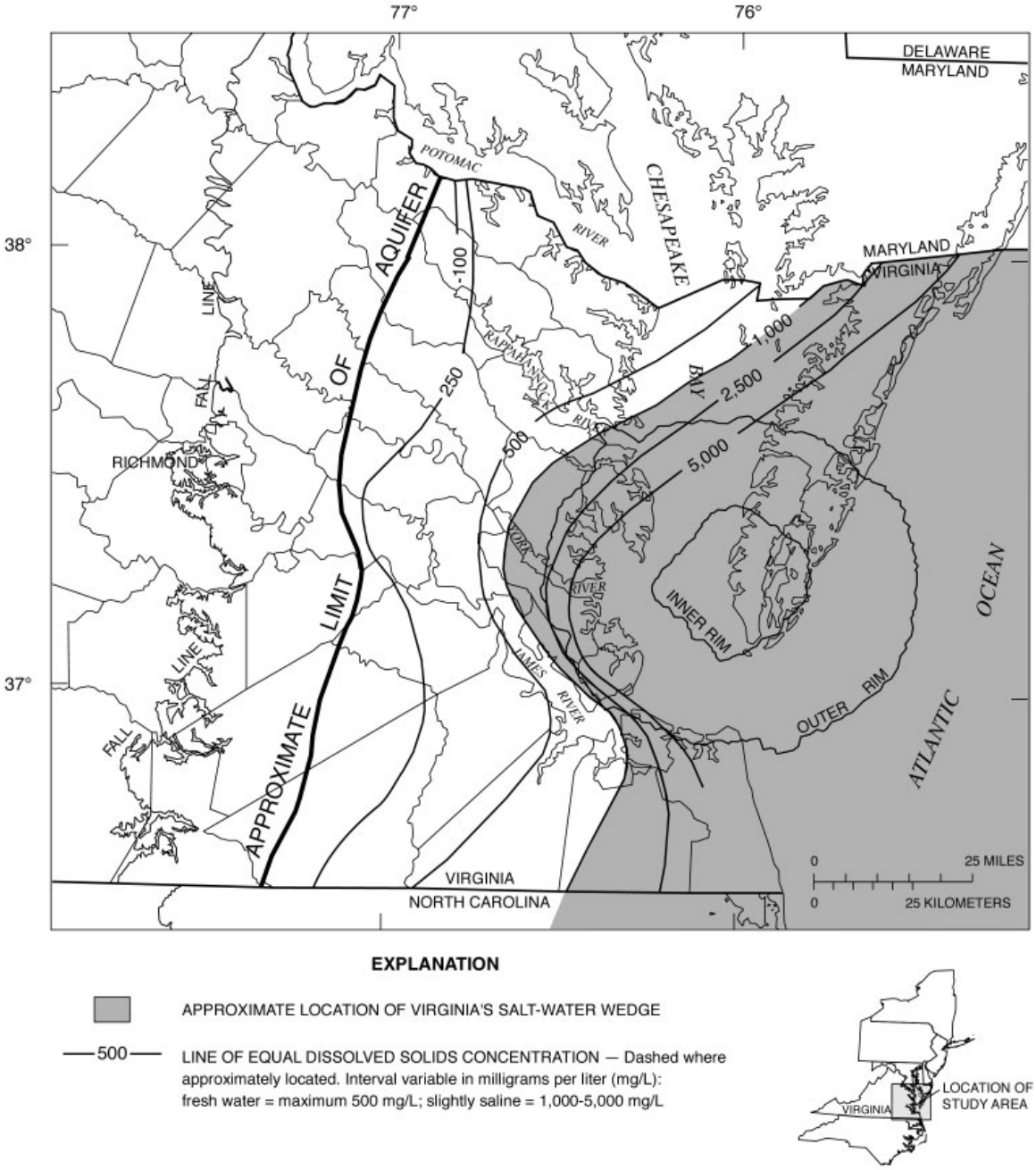


Figure 2-11: Approximate Location of the Buried Chesapeake Bay Impact Crater Including Effects on Dissolved Solids in Ground water (taken from Figure 18 of Powars and Bruce, 2000)

As described by Powars and Bruce (2000):

> *The impactor sliced through the water column, penetrated the full thickness of the existing Coastal Plain sediments, impacted the basement rock, and vaporized, creating a catastrophic explosion that set off trains of gigantic tsunamis and sent tremendous amounts of steam and ejecta into the atmosphere. The basement rocks lining the crater cavity were melted, and the basement rocks in a region beneath and around the crater were faulted and fractured. The impact produced an inverted, sombrero-shaped, 56-miwide complex crater that was immediately filled with chaotically mixed sediments and rim collapse material and eventually buried by younger sedimentary deposits.*

The structural and stratigraphic features associated with the impact crater influence local and regional hydrogeologic framework, ground water flow direction, and water quality in the eastern area of the NN. Emplacement and mixing of the lithically heterogeneous Exmore tsunami-breccia with seawater and its subsequent burial, primarily by very fine-grained deposits (in the structural low), has apparently altered regional flow paths, possibly causing differential flushing of freshwater over and/or around the primarily fine-grained deposits filling the crater (Powars and Bruce, 2000). Compaction also may have contributed to the relatively low permeability of the Exmore tsunami breccia (Powars and Bruce, 2000).

It is typically observed that ground water occurring at great depths is too saline for use as potable water. However, ground water at relatively shallow depths in southeastern Lancaster County (i.e., at depths where ground water in the western areas of the NN is potable) is too saline for use as potable water (NAPS, 2007b). The occurrence of saline ground water in southeastern NN appears to be related to the impact crater, as discussed above. Review of Figure 2-11 illustrates the crater rim, and iso-concentration lines for total dissolved solids in ground water (a measure of salinity) showing ground water with a high concentration of dissolved solids underlying the southeastern NN.

According to Powars and Bruce (2000), the buried outer rim of the crater appears to act as a boundary and/or mixing zone separating ground water of high salinity within the outer rim from fresher, lower salinity water located beyond the outer rim (Figure 2-8). A similar transition zone aligning ground-water quality with the crater's outer rim is seen in all the RASA-defined aquifers of the eastern Coastal Plain, except the Yorktown-Eastover and Columbia aquifers (Powars and Bruce, 2000). This water-quality information was compiled before the discovery of the impact crater and, therefore, determined independently (Focazio, et al, 1993). It should be noted, however, that data from inside the crater are limited.

2.7.2 General Discussion on Ground Water Quality on the Northern Neck

The following discussion on ground water quality in the NN is based on interpretation of unpublished, but detailed water quality data from domestic water supplies on the NN

(NAPS, 2003b; **Appendix C**). Domestic (community) drinking water quality in the NN is generally determined by substances that are dissolved, suspended or otherwise incorporated into ground water. The substances can be derived from naturally occurring and naturally variable sources such as dissolution of minerals and gasses, chemical or microbial processes, and mixing of fresh water and brackish or saline water. In addition, human-influenced materials or processes can affect water quality (e.g., septic effluent).

The water quality data evaluated by NAPS (2003b) demonstrates three fairly distinct ground water quality clusters, which can be associated with three separate aquifer systems underlying the NN. Water quality varies primarily by depth, with a shallow aquifer occurring less than 200 feet below ground surface (bgs), an intermediate aquifer occurring in from 200 to 500 feet bgs, and an underlying deep artesian aquifer. In Richmond and Westmoreland counties (western part of NN), only two aquifers are evident from the perspective of ground water quality variation (i.e., a shallow unconfined aquifer and an artesian aquifer characteristic of the deeper water quality).

In summary, total dissolved solids, on average, increases with depth. The deep artesian aquifer contains the oldest water, which has had more time to undergo chemical reactions that affect water quality. The shallow aquifer is dominated by sodium, calcium, chloride and bicarbonate. With time, as water flows downward and eastward through the aquifers, calcium carbonate dissolves and increases the calcium and bircarbonate content of ground water. Also, calcium is retained and sodium released through chemical reactions, increasing the sodium concentration of deeper ground water. Few data are available from greater depths in the NN aquifers, but in general it is assumed that deeper water is older, and dominated even more by sodium and chloride, rendering it non-potable.

The shallow unconfined aquifer derives water from precipitation and mixing with brackish water. The general chemistry of the shallow aquifer is relatively dilute, variable in composition, containing most of the common major elements characterizing ground water. Minor element components iron and nitrate, as well as organic material and microbial systems lead to relatively high potential for poor water quality in the shallow unconfined aquifer (i.e., impacts from septic systems or agricultural fertilization), particularly if drinking water wells are improperly installed and completed. Note that nitrate concentrations exceeding 1 mg/L in drinking water can cause “blue baby syndrome” in infants.

The intermediate aquifer (artesian) in Northumberland and Lancaster counties is relatively dilute. Major elements are slightly higher than observed in the shallow aquifer (when not mixed with brackish water), but sulfate is typically less concentrated than either the shallow or deep aquifers.

The deep artesian aquifer is typically sodium-bicarbonate type water. A few high-chloride samples in the data set evaluated for this discussion suggest salt-water intrusion from deeper strata is occurring. Many water samples in this data set that were taken from the deep aquifer exceeded EPA-recommended maximum sodium concentration of 200

mg/L for potable water, as well as the 20 mg/L limit suggested for individuals on a sodium-restricted diet.

More detailed discussion on the primary aquifers underlying the NN, and published water quality data to support the documentation of local hydrogeology, is provided in the following sub-section.

2.7.3 Primary Aquifers of the Northern Neck Region

Approximately 25% of the NN populace use shallow wells that tap the water table aquifer. Deeper private wells, and all public water supplies, rely on artesian aquifers (i.e., major community well intakes are 600 feet below ground surface, on average (Form 3-A; Appendix B). The shallow artesian aquifer is at depths of several hundred feet below ground surface, whereas the deep artesian aquifer is typically encountered at a depth of approximately 600 feet below ground surface. Below the deep artesian aquifer the water becomes too saline for use as a potable water source (NAPS, 2007a).

The following discussion summarizes the primary aquifers underlying the NN which comprise 100% of the public water supply. The information presented below was taken in large part from the Northern Neck Ground water Quality Management Plan (NNPDC, 2003b) and other published sources. The following notes apply to all water quality tables presented below:

- EPA MCL – Environmental Protection Agency's Maximum Contaminant Level (enforceable, maximum permissible level of a contaminant in water that is delivered to any user of a public water system);
- VA Antidegrad. – Virginia Antidegradation Standard policy for ground water (intended to regulate activities affecting ground water in order to maintain ambient water quality);
- EPA SMCL – Environmental Protection Agency's Secondary Maximum Contaminant Level (not enforceable, aesthetics such as taste and odor or limits on properties that affect use of the water such as chemical aggressiveness that dissolves plumbing fixtures, or forms solid deposits on such fixtures).

Columbia Aquifer (unconfined water table aquifer)

The Columbia Aquifer, also referred to as the Surficial Aquifer by McFarland and Bruce (2006) and others is unconfined and consists generally of fluvial-deltaic and estuarine inter-bedded gravel, sand, silt and clay, with some layers of sand showing red or rusty color due to the oxidized iron deposits (NNPDC, 2003b). The Columbia or Surficial Aquifer is stratigraphically above the Yorktown confining unit and includes many formations (Bacons Castle, Tabb, Shirley, Windsor, Charles City, Chuckatuck) from Pliocene to Pleistocene age. This aquifer is exposed at the land surface over most of the Northern Neck, and can be seen in numerous outcrops along eroding shorelines and through the Suffolk Scarp. The Columbia is included in the Virginia DEQ Coastal Plain Ground water Model.

This aquifer is an important water supply source in the eastern Coastal region primarily for domestic water supplies. As a result of being the first water bearing layer, this shallow aquifer is tapped by many residents and small businesses using shallow dug and bored wells. The water table aquifer is generally recharged directly by precipitation, and therefore is the most vulnerable of all the aquifers to leachable contamination. Nelms and others (2003) determined from a study of chlorinated fluorocarbons, tritium, and carbon isotopes that the wells completed within 100 feet of the ground surface in the Coastal Plain are susceptible to surface contamination sources.

The surficial aquifer yields only small supplies (5 to 20 gallons per minute; 7,200 to 28,800 gallons per day) of moderately soft water (Malcolm Pirnie, 2000). DEQ (2005) reported a total use of 0.43 MGD for the Columbia Aquifer. Also, the uppermost aquifer system is accessed by shallow wells, which are the least expensive to construct. This aquifer is a significant and sustainable source for minor supplies of domestic ground water in the NN, supplying ground water to farms, institutions, residences and other small users in the region.

The chemistry of water from the Columbia or Surficial Aquifer varies depending on the aquifer lithology, proximity of brackish or salty surface water, depth of the well in the aquifer, and landuse near the well. In general, water from the Surficial Aquifer tends to have a low pH, medium to high iron, high dissolved oxygen, relatively low total dissolved solids, and low alkalinity. The major ion chemistry is typically a sodium or calcium bicarbonate water except at depth or near shorelines where chloride can be the dominant anion.

Yorktown-Eastover Aquifer

The Yorktown-Eastover aquifer is unconfined near the Fall Line, and becomes confined by the Yorktown confining unit further eastward (Figure 2-6). McFarland and Bruce (2006) limit the Yorktown-Eastover Aquifer to the eastern one-third of the Northern Neck where the formation is overlain by younger sediments. The stratigraphically equivalent fluvial-deltaic sediments to the west as part of the Surficial Aquifer due to the hydraulic connection with younger sediments. Even when this aquifer is confined, it is exposed in certain stream valleys and deep ravines. This aquifer more than likely also provides vertical recharge to lower aquifers. The aquifer consists of thick beds of sand, intermixed with silt. In the west, the sands are separated by thin, discontinuous clay layers that thicken and become more extensive to the east (Focazio et al, 1993). Thickness ranges from approximately 6 feet at the fall line to 100 feet in the Tidewater Counties.

Ground water in the Yorktown-Eastover Aquifer is a moderately hard calcium bicarbonate type water. Sodium concentrations generally increase to the east. Table 2-4, below, summarizes water quality in this aquifer, along with water quality standards. Based on the results provided in this table, with the exception of Hardness (exceeds VA Anti-degradation standard) the median values for water quality parameters comply with federal and state water quality standards, where available (note that iron is reported in micrograms/liter, but the SMCL is in milligrams/liter). All of the data in Table 2-4. are

from wells completed in the Yorktown-Eastover Aquifer south of the Rappahannock River.

			Concentration or value					
		# of Samples	Minimum	Median	Maximum	EPA SMCL	EPA MCL	VA AntiDegrad.
pH		22	5.6	7.3	8.1	6.5 - 8.5		6.5- 9.0
Hardness	(mg/l as CaCo3)	25	62	170	812	no standard		120
Calcium	(milligram per liter)	26	8.9	58	260	no standard		
Magnesium	(milligram per liter)	26	0.8	6.2	39	no standard		
Sodium	(milligram per liter)	25	4.7	28	561	no standard		100
Potassium	(milligram per liter)	25	0.2	6.2	21	no standard		
Alkalinity	(mg/l as CaCo3)	26	76	230	630	no standard		30-500
Sulfate	(milligram per liter)	26	2	10	130	250		50
Chloride	(milligram per liter)	28	3	18	1,200	250		50
Fluoride	(milligram per liter)	24	<0.1	<0.1	1	2	4	1.4
Silica	(milligram per liter)	19	7	20	40	no standard		
Solids	(sum of constituents, mg/l)	19	154	306	2,233	500		1000
Nitrogen	(nitrite + nitrate, mg/l)	16	<0.10	<0.10	0.26		10	
Iron	(microgram per liter)	20	4	140	5,500	0.3		

(modified from Focazio, Speiran, and Rowan, 1993)

Table 2-4. Summary of Water Quality, Yorktown-Eastover Aquifer (Taken from NNPDC, 2003b).

Chickahominy-Piney Point Aquifer

The aquifer physical characteristics include glauconitic quartz sands of a dark-green to gray-green colors and shell beds that range from a couple of inches to several feet thick. Local well drillers characterize this aquifer as being "black and white sands, shell rock, limestone and dark silty clay" (NNPDC, 2003b). The aquifer thickens to at least 165 feet in the north central Coastal Plain, and then tapers to nonexistence near the Eastern Shore (Meng and Harsh, 1988) (Figure 2-6).

Ground water in the Chickahominy-Piney Point Aquifer is a moderately hard sodium bicarbonate type water. Concentrations of sodium, chloride, alkalinity, sulfate, and dissolved solids generally increase to the east. Table 2-5, below, summarizes water quality in the aquifers, along with water quality standards. Based on the results provided in this table, median values for water quality parameters comply with federal and state water quality standards, where available (note that iron is reported in micrograms/liter, but the SMCL is in milligrams/liter).

			Concentration or value					
		# of Samples	Minimum	Median	Maximum	EPA SMCL	EPA MCL	VA AntiDegradation
pH		23	5.6	8.1	9.4	6.5 - 8.5		6.5- 9.0
Hardness	(mg/l as CaCo3)	27	14	53	400	no standard		120
Calcium	(milligram per liter)	27	1.1	13	100	no standard		
Magnesium	(milligram per liter)	27	0.8	3.6	110	no standard		
Sodium	(milligram per liter)	27	3.3	61	2,900	no standard		100
Potassium	(milligram per liter)	24	0.9	8	79	no standard		
Alkalinity	(mg/l as CaCo3)	27	76	160	770	no standard		30-500
Sulfate	(milligram per liter)	27	4.8	7.4	350	250		50
Chloride	(milligram per liter)	34	1.3	6	4,800	250		50
Fluoride	(milligram per liter)	25	<0.1	0.6	2.5	2	4	1.4
Silica	(milligram per liter)	26	20	34	59	no standard		
Solids	(sum of constituents, mg/l)	24	154	229	5,210	500		1000
Nitrogen	(nitrite + nitrate, mg/l)	18	<0.10	<0.10	0.35		10	
Iron	(microgram per liter)	20	<10	50	3,200	0.3		

(modified from Focazio, Speiran, and Rowan, 1993)

Table 2-5. Summary of Water Quality, Chickahominy-Piney Point Aquifer (Taken from NNPDC, 2003b).

Aquia Aquifer

The Aquia is exposed at ground surface near the Fall Line, and slopes eastward at an average of 10 feet per mile (NNPDC, 2003b) (Figure 2-6). This aquifer is lense-shaped and reaches its maximum thickness of 125 feet near King George and becomes narrower eastward, where it is only 26 feet thick in Reedville (NNPDC, 2003b). Physical characteristics of the aquifer include very fine to medium fine glauconite and quartz sands, with small amounts of shell and clay. Local well drillers describe the aquifer material as “fine black or green sands”, or as “caving sands” (NNPDC, 2003b). Focazio et al (1993) does not report water quality data for the Aquia Aquifer, therefore no summary table is provided in this section.

Brightseat/Upper Potomac Aquifer

Older hydrogeologic reports for the eastern Coastal Plain recognized the Brightseat Aquifer as a separate hydrogeologic unit. According to NNPDC (2003b) the Brightseat Aquifer is surrounded by confining units and does not outcrop within the Coastal Plain region (Figure 2-6). This aquifer is lense-shaped (lenticular), approximately 76 feet thick near Montross, Westmoreland County and narrows to the west and south (NNPDC, 2003b) (Figure 2-6). East of Montross, the aquifer thickens to more than 400 feet (NNPDC, 2003b). Alternating beds of sand, silt and clay distinguish the physical characteristics of the aquifer, along with fine to medium quartz sand, and dark silty clay (Focazio et al, 1993). Well drillers describe this aquifer as “the white sand” (NNPDC, 2003b). Water quality data for the Brightseat Aquifer is included with the Upper Potomac Aquifer, discussed below.

More recent investigations have grouped the the Brightseat with the Upper Potomac Aquifer, which are sometimes undifferentiated in scientific characterization of NN hydrogeology. However, for purposes of description in this WSP, both aquifers are represented. As with the Brightseat Aquifer, the Upper Potomac aquifer is not present west of the Northern Neck, and thickens to 130 feet in Montross, thins again further east

to 70 feet in Reedville (NNPDC, 2003b) (Figure 2-6). The physical makeup of this aquifer is very similar to the Brightseat Aquifer, consisting of very fine to medium quartz sand with wood and shell fragments and dark silty clay (Meng and Harsh, 1988). The local well drillers describe the sediments of this aquifer as “easily penetrated”, and “fine white sands, commonly with wood fragments” (NNPDC, 2003b).

The major ion chemistry of ground water from the Brightseat/Upper Potomac Aquifer varies from west to east, down the dip of the aquifer. Due to mineralization water chemistry transitions from a calcium bicarbonate water in the western part of the aquifer to a sodium chloride type water in the east. Total dissolved solids are less than 500 mg/L except in the southeast tip of the Northern Neck. Elevated fluoride levels are found in the south central part of the Northern Neck. Table 2-6, below, summarizes water quality in this aquifer, along with water quality standards. Based on the results provided in this table, with the exception of sodium and fluoride (exceed Va. Anti-degradation standards), and total dissolved solids (exceeds SMCL), the median values for water quality parameters comply with federal and state water quality standards, where available (note that iron is reported in micrograms/liter, but the SMCL is in milligrams/liter).

			Concentration or value					
		# of Samples	Minimum	Median	Maximum	EPA SMCL	EPA MCL	VA AntiDegrad.
pH		52	6.7	8.2	8.7	6.5 - 8.5		6.5- 9.0
Hardness	(mg/l as CaCo3)	62	2	12	450	no standard		120
Calcium	(milligram per liter)	62	<0.1	2.8	1,100	no standard		
Magnesium	(milligram per liter)	62	<0.1	1.2	59	no standard		
Sodium	(milligram per liter)	62	4.8	210	3,000	no standard		100
Potassium	(milligram per liter)	62	2	10	60	no standard		
Alkalinity	(mg/l as CaCo3)	62	89	360	850	no standard		30-500
Sulfate	(milligram per liter)	62	0.6	16	407	250		50
Chloride	(milligram per liter)	73	0.8	20	4,400	250		50
Fluoride	(milligram per liter)	59	<0.1	2.4	6.3	2	4	1.4
Silica	(milligram per liter)	59	1.1	16	54	no standard		
Solids	(sum of constituents, mg/l)	60	98	541	7,960	500		1000
Nitrogen	(nitrite + nitrate, mg/l)	29	<0.10	<0.10	60		10	
Iron	(microgram per liter)	32	<0.10	30	8,200	0.3		

(modified from Focazio, Speiran, and Rowan, 1993)

Table 2-6. Summary of Water Quality, Brightseat- Upper-Potomac Aquifers (Taken from NNPDC, 2003b).

<u>Middle Potomac Aquifer</u>

This aquifer begins near the Fall Line, and thickens eastward to eventually become more than 900 feet thick in the Eastern portion of the Coastal Plan (Figure 2-6). Physical characteristics of the aquifer include sediments of medium sand, silt and clay, which are inter-lensed (Meng and Harsh, 1988). Ground water from the deeper reaches of the Middle Potomac in the eastern NN can be too saline for potable use. Thus, this aquifer is generally utilized as a potable water source except in the western reaches of the NN.

The major ion chemistry of the Middle Potomac Aquifer is very similar to the Brightseat/Upper Potomac Aquifer. Concentrations of major ion constituents are generally higher in the Middle Potomac Aquifer. Table 2-7, below, summarizes water quality in this aquifer, along with water quality standards. Based on the results provided

in this table, median values for water quality parameters comply with federal and state water quality standards, where available (note that iron is reported in micrograms/liter, but the SMCL is in milligrams/liter). As noted above, ground water salinity typically increases in the deeper sections of the Middle Potomac Aquifer in the western NN.

			Concentration or value					
		# of Samples	Minimum	Median	Maximum	EPA SMCL	EPA MCL	VA AntiDegrad.
pH		56	6.4	7.8	8.9	6.5 - 8.5		6.5- 9.0
Hardness	(mg/l as CaCo3)	71	<1	10	570	no standard		120
Calcium	(milligram per liter)	71	0.2	2.5	120	no standard		
Magnesium	(milligram per liter)	71	<0.1	0.9	65	no standard		
Sodium	(milligram per liter)	71	4.4	94	3,000	no standard		100
Potassium	(milligram per liter)	70	2	7	43	no standard		
Alkalinity	(mg/l as CaCo3)	71	24	190	676	no standard		30-500
Sulfate	(milligram per liter)	71	2.3	13	280	250		50
Chloride	(milligram per liter)	83	0.8	3.4	5,000	250		50
Fluoride	(milligram per liter)	67	<0.1	1.1	6.3	2	4	1.4
Silica	(milligram per liter)	68	13	26	53	no standard		
Solids	(sum of constituents, mg/l)	69	95	261	8,682	500		1000
Nitrogen	(nitrite + nitrate, mg/l)	28	<0.10	<0.10	0.37		10	
Iron	(microgram per liter)	33	<10	160	3,800	0.3		

(modified from Focazio, Speiran, and Rowan, 1993)

Table 2-7. Summary of Water Quality, Middle Potomac Aquifer (Taken from NNPDC, 2003b).

<u>Lower Potomac Aquifer</u>

This is the deepest aquifer in the Northern Neck, and reaches 3000 feet in thickness under the Eastern Shore (Figure 2-6). Physical characteristics of the sediments of this aquifer include thick interbedded sequences of coarse sand, clayey sand, and clay (Meng and Harsh, 1988). Lignitic (wood) material is also prevalent in these sediments (NNPDC, 2003b). Well drillers describe the sediments in this aquifer as “coarse gray sands” that sometimes exhibit “gravels” and “light to drab-colored clays” (NNPDC, 2003b).

The major ion chemistry of the Lower Potomac Aquifer is very similar to the overlying Middle Potomac and Brightseat/Upper Potomac Aquifers. The higher dissolved solids concentrations are attributed to the greater age of the water, the increase ground water flow path distance, and salt water intrusion. Table 2-8, below, summarizes water quality in this aquifer, along with water quality standards. Based on the results provided in this table, with the exception of median iron concentration, the median values of the other reported water quality parameters comply with federal and state water quality standards, where available.

			Concentration or value					
		# of Samples	Minimum	Median	Maximum	EPA SMCL	EPA MCL	VA AntiDegrad.
pH		12	6.8	7.7	8.4	6.5 - 8.5		6.5- 9.0
Hardness	(mg/l as CaCo3)	13	2	31	3,345	no standard		120
Calcium	(milligram per liter)	13	0.4	9	960	no standard		
Magnesium	(milligram per liter)	13	0.2	2	230	no standard		
Sodium	(milligram per liter)	13	13	73	8,100	no standard		100
Potassium	(milligram per liter)	13	2	10	94	no standard		
Alkalinity	(mg/l as CaCo3)	13	42	160	557	no standard		30-500
Sulfate	(milligram per liter)	13	0.6	14	580	250		50
Chloride	(milligram per liter)	13	2.1	12	17,000	250		50
Fluoride	(milligram per liter)	13	<0.1	0.3	3.8	2	4	1.4
Silica	(milligram per liter)	13	12	19	40	no standard		
Solids	(sum of constituents, mg/l)	12	123	284	27,100	500		1000
Nitrogen	(nitrite + nitrate, mg/l)	7	<0.10	<0.10	<0.10		10	
Iron	(microgram per liter)	8	40	370	16,000	0.3		

(modified from Focazio, Speiran, and Rowan, 1993)

Table 2-8. Summary of Water Quality, Lower-Potomac Aquifer (Taken from NNPDC, 2003b).

Hydrogeologic Characteristics

Data on aquifer transmissivity, specific capacity and well yield in the NN region were taken from interpretive hydrogeologic and modeling reports published by the USGS, DEQ, and the Maryland Geological Survey. Where data are represented, the values are relatively consistent, with the exception of a large range in reported transmissivity (likely due to variability in aquifer thickness). Table 2-9, below, summarizes available hydrogeologic characteristics for the primary aquifers underlying the NN.

SUMMARY OF HYDROGEOLOGIC CHARACTERISTICS OF MAJOR AQUIFERS ON THE NORTHERN NECK OF VIRGINIA AND NEARBY PARTS OF MARYLAND

Hydrogeologic unit	Horizontal hydraulic conductivity (ft/day)	Transmissivity (ft^2/day)	Storage coefficient	Specific capacity (gpm/ft)	Well yield (gpm)	Source
Columbia	18	~500	--	--	--	Harsh and Laczniak, 1990
	--	--	--	--	5-20	SWCB, 1978
Yorktown-Eastover aquifer	15	~500	6E-1 to 8E-4	--	--	Harsh and Laczniak, 1990
	--	--	--	--	5-20	SWCB, 1978
Chickahominy-Piney Point aquifer	--	100—700	--	--	--	Achmad and Hansen, 1997
	25	~1,000	--	--	--	Harsh and Laczniak, 1990
	--	--	3E-4 to 4E-10	--	--	Hansen, 1972
Aquia aquifer	--	500—2,000	1E-4 to 2E-4	--	--	Achmad and Hansen, 1997
	40	1,000-2,000	--	--	--	Harsh and Laczniak, 1990
	--	--	1E-4 to 4E-4	--	--	Hansen, 1972
Brightseat--Upper Potomac aquifer	33	1,000—4,000	--	--	--	Harsh and Laczniak, 1990
Middle Potomac (Lower Patapsco) aquifer	3.8—62	190—3,500	3E-5 to 5E-5	--	--	Andreasen, 1999
	52	8,000—12,000	2E-4 to 2E-3	--	--	Harsh and Laczniak, 1990
Lower Potomac (Patuxent) aquifer	2—70	230—4,400	1E-4—5E-5	--	--	Andreasen, 1999
	41	4,000—10,000	5E-4 to 2E-3	--	--	Harsh and Laczniak, 1990
Upper artesian system—eastern N. Neck	--	--	--	0.1—0.6	20—75	SWCB, 1978
Upper artesian system—western N. Neck	--	<134—880	--	0.1—2.1	20—110	SWCB, 1978
Principal artesian system—eastern N. Neck	--	530-4,600	--	1.0—15.7	40—503	SWCB, 1978
Principal artesian system—western N. Neck	--	290—4,000	--	0.5—12.9	40—844	SWCB, 1978

Table 2-9. Summary of Hydrogeologic Characteristics of Majors Aquifers Underlyng the Planning Region (Table taken form Malcolm Pirnie, 2000)

From **Table 2-9**, above, and the discussion provided in Malcom Pirnie (2000), the following information summarizes ground water production potential for the NN:

- The Columbia and Yorktown-Eastover aquifers (relatively shallow, water table aquifers) are poorly to moderately productive on the NN, with horizontal hydraulic conductivity less then 20 feet/day and transmissivity about 500 feet feet^2/day. This results in well yields of 5 to 20 gpm (7,200 to 28,800 gallons per day), sufficient for many domestic supplies.

The deeper Chickahominy-Piney Point Aquifer (shallow artesian aquifer) is more productive, with a hydraulic conductivity of about 25 ft/day and a transmissivity of up to 1,000 feet^2/day. This aquifer is capable of providing well yields of 10 to 40 gpm (14,400 to 57,600 gallons per day).

- The Aquia, Brightseat, and Potomac aquifers (primary artesian aquifers) are relatively productive on the NN, with hydraulic conductivity ranging from 40 to 60 ft/day and transmissivities ranging from 500 to 10,000 feet^2/day. These aquifers thicken from west to east, such that transmissivity also increases from west to east. Most large production wells in the western part of the NN are screened in the Aquia and Middle Potomac aquifers, and yield 20 to 500 gpm (28,800 to 720,000 gallons per day). Most large production wells in the eastern part of the NN are screened in the, Aquia and/or Brightseat-Upper Potomac aquifers, and yield 20 to 800 gpm (28,800 to 1,152,000 gallons per day). The Chickahominy-Piney Point aquifer provides public water supplies for some small towns and private supplies for low-density residential development in some rural areas. As discussed earlier, the Potomac aquifer is typically too saline (total dissolved solids >500 mg/L) for potable uses beneath much of the eastern portion of the NN.

Aquifer Recharge

The potable ground water aquifers underlying the NN are replenished (i.e., recharged) by a portion of the precipitation that falls on the ground surface, and infiltrates downward into the ground. The shallow unconfined aquifer is primarily recharged in this manner. Non-potable (i.e., saline) water may recharge the deep confined aquifers under scenarios where over-pumping of freshwater occurs, allowing sea water or deep ancient saline ground water to infiltrate the aquifer. See Figure 2-12, below, for illustrations of these concepts.

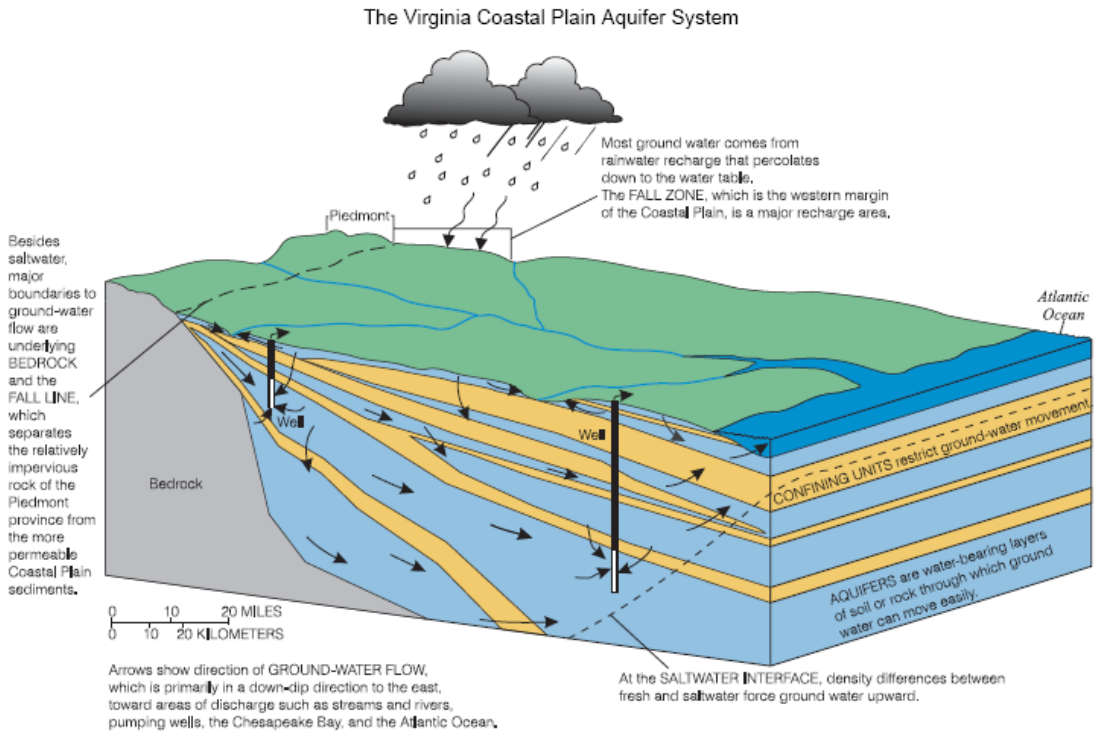


Figure 2-12: Conceptual Representation of the Coastal Plain Aquifer Recharge and Ground water Flow (taken from USGS, 1999)

Annual precipitation over the NN region averages 43.4 inches per year. On an annual basis, most of the precipitation received is intercepted (~31 inches per year) by vegetation and is returned to the atmosphere through transpiration or evaporation. As well, some precipitation flows directly into surface water bodies (in some topographic and geologic environments, surface water bodies can discharge into the ground water aquifer, but that is not likely the case in the NN). The remaining amount of precipitation that is received infiltrates downward through the unsaturated zone to recharge the shallow unconfined water table aquifer (estimated at approximately 12 inches per year)

The shallow unconfined aquifer recharges relatively rapidly. Figure 2-13, below, illustrates measured ground water level in a USGS monitoring well located in Western Westmoreland County, which is completed in the unconfined water table aquifer at a depth of approximately 22 feet below ground surface.

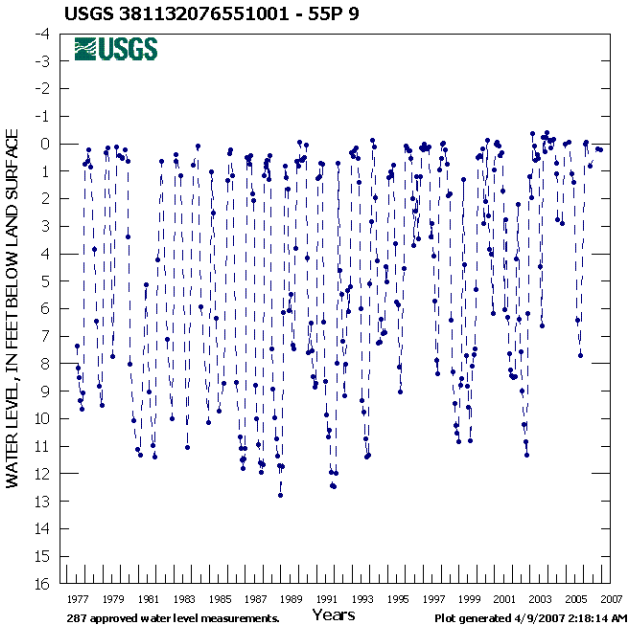


Figure 2-13: Ground Water Level in USGS Monitoring Well in Westmoreland County (taken from USGS, 2007b)

The water level fluctuations primarily correspond to seasonal precipitation, whereby more precipitation provides more recharge to the aquifer, resulting in an increase in the water level. During times of less precipitation, the ground water level decreases. The water level fluctuates during the course of a year, in general, demonstrating a relatively rapid response to precipitation. Thus, drought conditions tend to more rapidly and more severely affect shallow wells that derive ground water from the unconfined aquifer.

The relatively rapid aquifer recharge does not occur for the deeper artesian aquifers. Recharge of potable water to the artesian aquifers generally occurs very slowly as 1) water infiltrates downward through leaky low-permeability confining layers (aquitards), 2) infiltration and downgradient (e.g., from high to low topography) flow of ground water recharged by precipitation received near the western extent of the Coastal Plain (the Fall Line; west of the NN) where the formations are closer to the surface, and 3) ground water from the underlying crystalline bedrock. In other words, ground water pumped from the principal NN artesian aquifers once fell on the region as precipitation and slowly percolated down, across several relatively impermeable layers (confining layers, or aquitards), all the while flowing eastward (seaward) at depths of hundreds of feet. This is a slow process, and thus the water pumped today from these aquifers is many thousands of years old.

3.0 APPROACH TO COLLECTING WATER SOURCE AND WATER USE INFORMATION – SOURCES USED AND COLLECTION METHODOLOGY

The underpinning of the WSP is water source and water use data for the Northern Neck region. Data utilized for this WSP were collected from public domain and private sources, summarized as described below. A total of 102 community and self-supplied water sources were identified in the NN. Ninety-six (96) of the 102 sources are ground water suppliers. 100% of the community water supplies on the NN are derived from ground water.

The WSP data are provided in digital electronic format in **Appendix A**, and in hard copy format in **Appendix B**. The WSP data are presented in summary tables (DEQ Water Supply Plan forms). For each water source included in the data deliverables (**Appendix A** and **Appendix B**), the source of the data is identified (i.e., if the data were derived solely from the DEQ and VDH databases, or from the VDH file review, the survey, or some combination thereof).

3.1 Electronic Data from DEQ for Water Withdrawal Reporting Regulations

Water Withdrawal Reporting Regulations (9 VAC 25-200-30) applies to water sources that withdraw ground water or surface water in Virginia (including the Potomac River abutting Virginia) where the average daily withdrawal during any single month exceeds 10,000 gallons per day. Reportable withdrawals include, but are not limited to, those for public water supply, manufacturing, mining, commercial, institutional, livestock watering, artificial fish culture, and steamelectric power generation uses. The regulations also apply to every user withdrawing ground or surface water for the purpose of irrigating crops whose withdrawal exceeds 1 million gallons in any single month. Water source and withdrawal data for suppliers within the NN were provided by the DEQ and are included in digital format in **Appendix A**. The WSP data are presented in summary tables (DEQ Water Supply Plan forms). The same data are presented in hard copy format in **Appendix B**.

3.2 Virginia Department of Health Data and Records

Initial data collection included data provided by the VDH in digital format from Public Water Supply permits, Annual Water Use reports, and Well Construction permits. Summary tables of data on community, non-community, and non-transient non-community sources in the NN are included in this WSP in digital format in **Appendix A**, and in hard copy format in **Appendix B** of this report.

On February 12, 2007, EEE Consulting conducted a file review at the Virginia Department of Health, East Central Field Office, located in Richmond, Virginia. EEE provided a Freedom of Information Request (FOIA) form to VDH, prior to conducting the file review. 12 VAC 5-630-220 of the Private Well Regulations requires a written permit from VDH prior to construction, alteration, rehabilitation, abandonment or

extension of a private well, and further requires a written inspection statement pursuant to 12 VAC 5-630-310 and 12 VAC 5-630-330 prior to placing a new well in service. Private well drillers are required to file a Water Well Completion Report (GW-2) upon completion of a new well. The Virginia Water works Regulations (12 VAC5-590 et seq) require that operators of public water supplies that rely on either surface or ground water obtain a permit from VDH prior to construction or expansion of treatment works and distribution systems. Also, VDH internal "Ground water System Sanitary Survey Reports" and "Engineering Description Sheets" were used to obtain data.

3.3 Northern Neck Water Supply Survey

Survey forms were designed specifically for community and self-supplied water sources identified in the NN. The sources were identified from the DEQ and VDH databases referenced above. The surveys were designed to provide data specifically required by 9 VAC 25-780, and additional data to be used for disaggregated water demand forecasting. The community source survey was sent to all community sources identified in the DEQ and VDH databases, regardless of water withdrawal volumes. The self-supplied survey was sent to all self-supplied source that were identified in the DEQ database as withdrawing >300,000 gallons of water per month at anytime between 2001 through 2005 (the span of time covered by the DEQ database). The survey submittals were followed by telephone and email contacts by EEE and the NNPDC, where possible. Sources that were sent a survey, but did not reply, and did not have a telephone or email contact number identified or easily accessible, were not contacted as a follow-up on the survey (i.e., no second mailing of surveys was conducted).

3.4 Northern Neck Local Government Documentation

Non-quantitative and semi-quantitative information sources for the WSP included planning documents derived from the Northern Neck localities, referenced in the pertinent text below. Also, water supply planning information derived from the Middle Peninsula of Virginia, and Southern Maryland (representing extra-regional water sources and withdrawal) were included in this WSP. A full bibliography is included in the last section of this WSP.

3.5 Northern Neck Water Supply Steering Committee

Periodic meetings were held with the NN Water Supply Steering Committee to discuss water supply planning for the NN. The Committee is comprised of representatives from the NNPDC, local governments in the NN, regional economic development personnel, regional representatives of the VDH, representatives of DEQ, and representatives of local public interest groups within the NN.

3.6 Data Collection Limitations

While the DEQ Water Withdrawal Permit data (summary tables presented in digital format in **Appendix A** and in hard copy format in **Appendix B**) provide a significant source of data for the WSP, data gaps were observed in the DEQ database. Certain major water suppliers had not reported 2005 withdrawal data to DEQ at the time this information/data was provided to EEE.

The NNPDC received approximately 25% return on the water supply surveys designed specifically to support this WSP. **Table 3-1** lists all identified community and self-supplied water sources (withdrawing >300,000 gallons/month), with shaded text denoting those suppliers that returned the NN water supply planning survey.

Table 3-1. Community Water Sources and Self-Supplied Sources Withdrawing >300,000 gallons per month
Northern Neck Regional Water Supply Plan

Community Sources		
ADAMS GROVE [2]	**GLEBE POINT [2, 4]**	**PLACID BAY ESTATES [1]**
BALL POINT [4]	GRANVILLE BAY SUBDIVISION	PLEASANT VIEW ESTATES [4]
BAY QUARTER SHORES [2] [3]	GREEN, THE	**POTOMAC WESTMORELAND SHORES [2]**
BELL ACRES [4]	**HEATHSVILLE [2, 4]**	**Rappahannock Westminster - Canterbury, Inc [1]**
Bells Cove [1]	**Heritage Point [1]**	REEDVILLE MANOR
BERKLEY BEACH-EBB TIDE BEACH [2] [3]	**Highbank [1]**	REEDVILLE [4]
BLACK STUMP [4]	**Horner's Beach [1]**	RIVERBEND ESTATES [4]
BLEAK HALL [2]	**INDIAN CREEK ESTATES [2] [3] [4]**	**Sandy Point Subdivision [1]**
BON HARBOURS [2, 4]	**IRVINGTON COMMUNITY OF [2] [3] [4]**	SCHOOLHOUSE MEADOWS [4]
BROWNS STORE [4]	**JETTYS REACH [2]**	**SHERWOOD FOREST SHORES [2] [3]**
Bunker Hill [4]	**KINGSLAND [2] [3] [4]**	**Sloop Point [1]**
BURGESS [2, 4]	**KINSALE, TOWN OF [2] [4]**	**Springfield Beach [1]**
BUSHFIELD [2, 4]	**LANCASTER COURTHOUSE [2] [4]**	**STRATFORD HARBOUR [3]**
CABIN POINT AND GLEBE HARBOUR [2]	*LANCASTER SHORES [3] [4]*	Tides Golf Lodge, Golden Eagle HOA [4]
CALLAO [2] [3] [4]	LAUREL POINT	TOWLES LANDING
CALLAO SHOPS AND APARTMENTS	LEE DALE SHORES	**Town of Kilmarnock [1]**
CHESAPEAKE BAY ESTATES [4]	**LEWISETTA [1]**	**Town of Montross [1]**
Chesapeake Cove [1]	LITTLE BAY ASSOCIATES	UPPER BAY VIEW ESTATES
CHURCHFIELDS [4]	**LIVELY, COMMUNITY OF [2] [3] [4]**	**Va. DOC - Haynesville CC [1]**
COLONIAL BEACH, TOWN OF [2] [3]	LOCKSLEY HALL ESTATES	**VINEYARD GROVE [1]**
CORBIN-LEWIS ESTATES [4]	**LOTTSBURG [2] [4]**	*WARSAW, TOWN OF [3]*
CORROTOMAN BY THE BAY [2] [3]	LUCOM POINT SUBD	WASHINGTON & LEE HOME FOR THE ELDERLY
COTTAGES AT THE GOLDEN EAGLE	**LUTTRELLVILLE [2] [4]**	**Waverly Subdivision [1]**
COVE COLONY [2, 4]	MALLARD BAY SUBDIVISION [4]	**WEEMS [2] [3] [4]**
DARL SUBDIVISION [2]	**Monroe Bay Estates and Trailer park (Curley Packing) [1]**	WESTBAY
Ditchley Water Works, Inc. [1]	**MONTROSS MOBILE HOME VILLAGE [2]**	**Western Branch Subdivision [1]**
DRIFTWOOD BEACH [2]	MOSQUITO POINT	WESTMORELAND COUNTY INDUSTRIAL PARK
FARNHAM MANOR	NOMINI BAY FARMS [4]	**White Sands Harbour**
FLEETON	NORTHUMBERLAND PLANTATION	**WHITE STONE-WHITE STONE BEACH [2] [3] [4]**
FLOWERING FIELDS	**NORTHUMBERLAND SHORES**	**WICOMICO CHURCH [2] [4]**
Forest Hills Subdivision [1]	**OLD PROSPECT LANDING [2]**	WICOMICO RIDGE [4]
FOXWELLS [2] [3] [4]	**Pine Harbor [1]**	
General Parker Shores [1]		
Self-supplied Ground water and Surface Water Sources (>300Kgals/month)		
Bevans Oyster	**NN Coca Cola [2]**	**Westmoreland State Park [1]**
Golden Eagle Golf Course - Tides Lodge [2]	**Zapata Protein USA [1]**	
Lake Packing Co. [1]		

Notes:
Ground water and surface water source names were derived from Virginia Department of Health permit records (Community systems) and Virginia Department of Environmental Quality withdrawal records (Self-supplied sources). A total of 102 community, or self-supplied (>300k gals/mo) sources identified in DEQ and VDH databases for the NN.
[1] Shaded sources responded to EEE/NNPDC Survey (**25% response**)
[2] Sources in bold / underlined text committed to completing the survey in the near future (which would had increased survey participation to 60%). However they have not responded yet..
[3] Sources in italics are represented in the WSP (to date) by data collected from file review at the Regional VDH Office
[4] Aqua Virginia, Inc. systems; Certain data provided in recently received 2006 DEQ water withdrawal reporting
Attempts to contact remaining sources listed in this table were unsuccessful.

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Of the approximately 25% of surveys returned, much of the requested data were not provided by the water supplier. This is highlighted by review of **Forms 2-A through 3-J** in **Appendix B**, whereby missing data are denoted on the forms.

The NNPDC and EEE made all reasonable efforts to complete the data gaps. Water suppliers that did not respond to the survey were contacted again by telephone and email -- when this information was available -- to encourage them participation. Although some sources committed verbally to completing the survey in the near future (which would have increased the response rate to 60%) no further responses were received. Some factors that clearly affected the data collection efforts were: first, the lack of clear incentives or direct benefits for the water suppliers' participation in the survey and WSP, and second, the absence of a framework to enforce water suppliers' participation. As any other planning process, the Water Supply Plan includes a participatory component. However, the participation is voluntary and the level of information disclosure is the participant's decision. In keeping with the intent of the WSP to be a "living document", this planning tool not only will be subject to a 5-year review but will be also updated as needed in response to major changes in the water supply issues of NN.

Data collection to support this WSP did not specifically account for non-community and non-transient non-community water sources that withdraw less than 300,000 gallons per month, or for surface water systems that withdraw less than 300,000 gallons per month. The VDH database (summary tables in digital format in **Appendix A**, and in hard copy format in **Appendix B**) includes data on non-community and non-transient non-community water sources that withdraw less than 300,000 gallons per month. As required by the Water Supply Planning Regulations, an estimate of ground water users of less than 300,000 gallons per month is provided in the WSP. This WSP includes all water data available as of the time of this report was prepared.

4.0 EXISTING WATER SOURCE INFORMATION (9 VAC 25-780-70)

Water Supply Planning Regulation 9 VAC 25-780-70 requires that a WSP include current information on existing water sources located in the NN. Existing water sources were summarized in **Table 3-1**, which was first presented and discussed in **Section 3.6**. **Table 3-1** lists community water suppliers, and self-supplied water sources (withdrawing >300,000 gallons per month) in the NN, as identified by the VDEQ and VDH. A total of 96 community and six self-supplied (>300K gals/mo) suppliers were identified for the NN by the DEQ and VDH database. **Figure 4-1** illustrates the locations of all community water sources, and self-supplied water sources that withdraw more than 300,000 gallons per month of water.

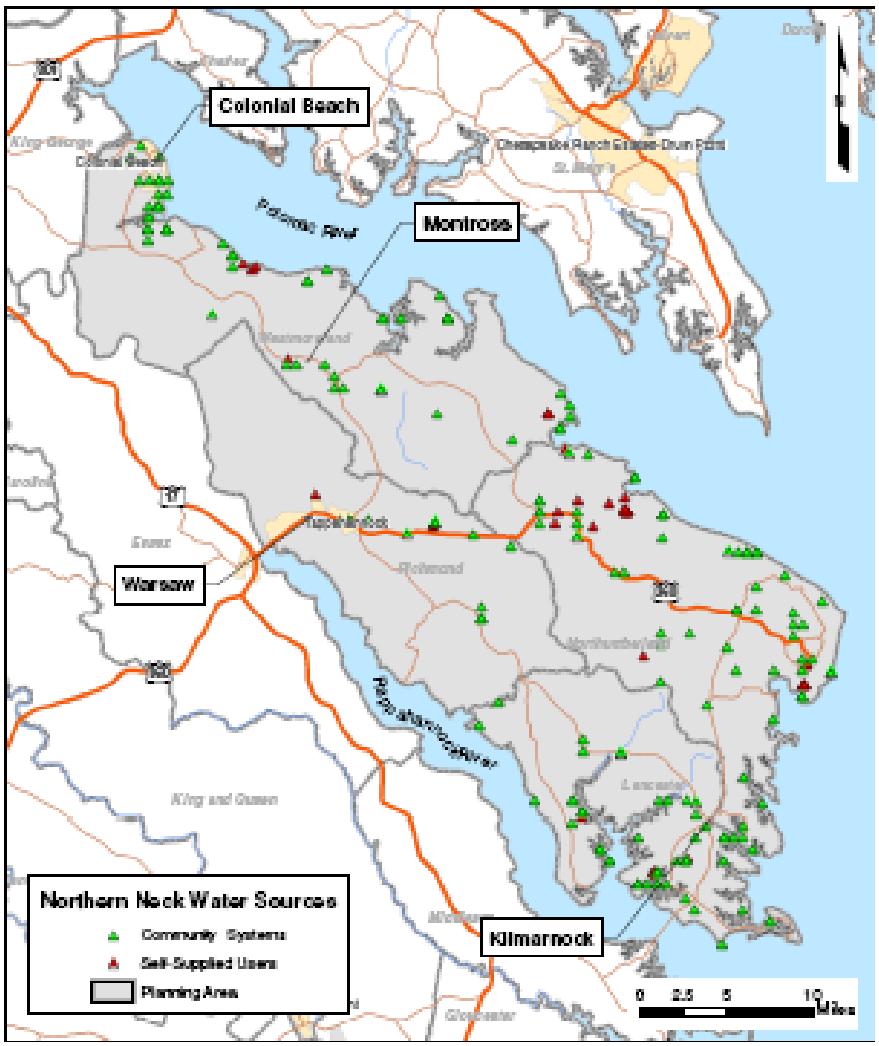


Figure 4-1: Water Sources of the Northern Neck

Water suppliers shown as shaded in **Table 3-1** (data qualifier [1]) provided direct responses to the NN survey prepared by EEE (i.e., survey response of 25%). For these suppliers, data from the DEQ and VDH databases and data from the VDH file review, were used as needed to supplement the required data elements (summary tables in digital format in **Appendix A** and in hard copy format in **Appendix B**).

Suppliers listed in bold/underline text in **Table 3-1** (data qualifier [2]) indicated verbally that they will complete the survey at the earliest opportunity. Such responses would have increased the cumulative survey response to 60%; however, they have not responded to the survey as of the time this report was completed. For these suppliers, data from the DEQ and VDH databases and data from the VDH file review were used for this report (summary tables in digital format in **Appendix A** and in hard copy format in **Appendix B)**. A detailed discussion of the performed data collection efforts, their limitations and results was presented in **Section 3.6**.

Data Suppliers listed in italics in **Table 3-1** (data qualifier [3]) are represented only by data collected during the VDH file review (February 12, 2007). There is overlap in data sources for certain suppliers, where the VDH file review supplements DEQ and VDH database information (see suppliers with both data qualifiers [1] and [2] listed in **Table 3-1**).

Suppliers with data qualifier [4] comprise data from recently received 2006 DEQ water withdrawal permitting report for Aqua Virginia, Inc. systems. The remaining suppliers listed in **Table 3-1** with no data qualifiers have no data associated with them in this report.

4.1 Community Water Systems

All 96 community water supplies on the NN are derived from ground water, which places ground water at the core of this WSP. **Figure 4-2** illustrates community water sources in the Northern Neck Region.

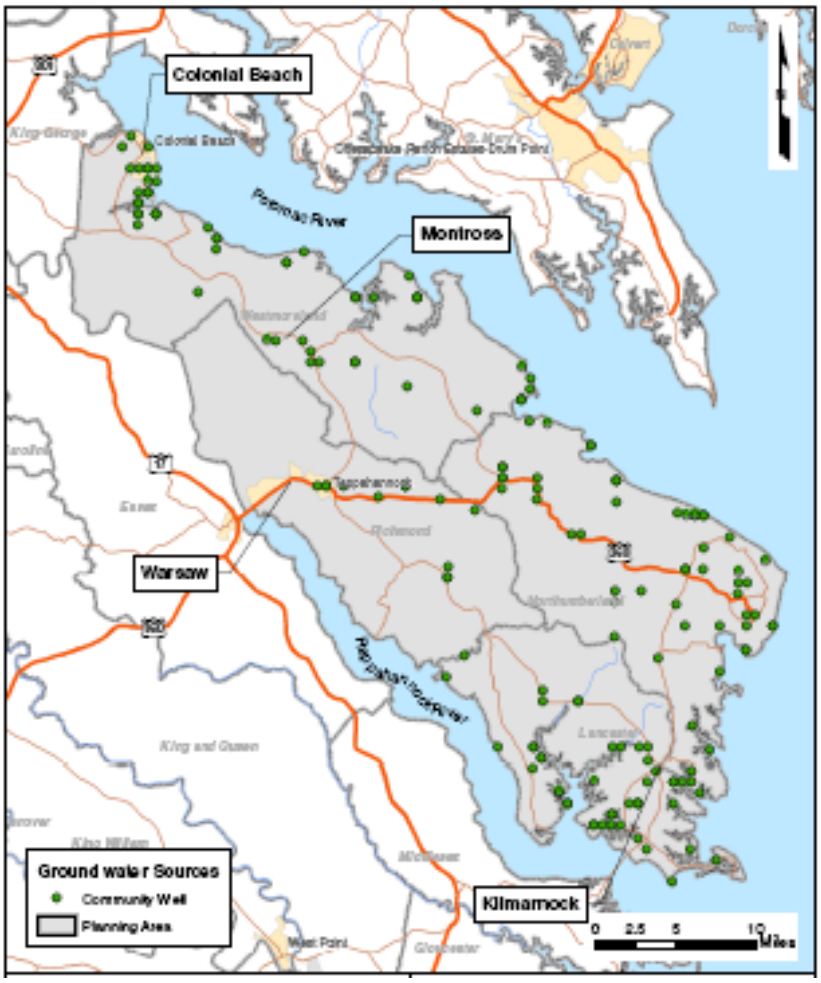


Figure 4-2: Community Ground water Wells

4.1.1 Community Water Systems- Ground Water (9 VAC 25-780-70.B)

As per 9 VAC 25-780-70.B, the WSP data collection activities are designed to document, for each Community system using ground water (all 96 Community systems in the NN), the name and identification number of the well or wells, the well depth, the casing depth, the screen depth (top and bottom) or water zones, the well diameter, the design capacity for the average daily withdrawal and maximum daily withdrawal, the system capacity permitted by Department of Health. The NN is not located within a Ground Water

Management Area (as designated by DEQ), and therefore data derived from ground water withdrawal permits is not available, and does not specifically apply. Future development and 5-year reviews of the WSP should take into consideration the case of a designation of the Planning Area as a Ground Water Management Area. Impacts of such designation would have advantages and disadvantages. Designation may result in an increase in the available data to support water supply planning decisions since any person or entity wishing to withdraw 300,000 or more gallons of ground water per month would be required to apply for a water withdrawal permit. Moreover, besides the limit on the annual amount of ground water that may be withdrawn, the requirements for a permit application include: hydrogeologic information, plans to mitigate impacts to pre-existing users, water conservation and management plans, potential ground water levels and ground water quality monitoring. However, the designation may also result in higher costs for suppliers, increased state resources to process the applications, and enforcement costs and structure since "the responsibility for protecting ground water… is not clearly assigned to a specific agency, and there is no staff solely dedicated to serving the needs of private well and spring owners" (Virginia Association of Soil & Water Conservation Districts, 2002).

100% of the Community water systems in the NN utilize ground water. As discussed above, 96 Community water systems were identified in the NN region by the VDH (**Table 3-1**). Of these 96 community sources, water supply planning data was readily available for 43 community systems at the time this report was completed. **Form 2-A** (**Appendix B**) lists the required data (where available) for the responding community sources. **Figure 4-2** illustrates the locations of the community ground water systems in the NN.

For general characterization purposes, **Table 4-1** lists the NN community ground water sources ranked in descending order by withdrawal, and lists percentage of total reported ground water withdrawal, as well as the cumulative percent of total withdrawal reported by the community source (data reported as per DEQ's Water Withdrawal Reporting Regulations 9 VAC 25-200-30; refer to data in digital format in **Appendix A,** and in hard copy format in **Form 2-A, Appendix B**).

Table 4-1. Water Withdrawal by Community Sources in the Northern Neck
Data Provided by Virginia DEQ, Taken From From Annual Water Withdrawal Reports, as per Regulations 9 VAC 25-200-30
Northern Neck Regional Water Supply Plan

Owner / System	Withdrawal (MGY)	% of Community Withdrawal	Cumulative % of Cummunity Withdrawal
COLONIAL BEACH, TOWN OF COLONIAL BEACH	201.889	27.5%	27.5%
KILMARNOCK, TOWN OF KILMARNOCK	81.895	11.2%	38.7%
WARSAW, TOWN OF WARSAW	70.644	9.6%	48.4%
VIRGINIA, COMMONWEALTH OF UNIT 17 - HAYNESVILLE	43.956	6.0%	54.4%
AQUA VA - DIV OF AQUA AMERICA IRVINGTON [1]	29.828	4.1%	58.4%
AQUA VA - DIV OF AQUA AMERICA Mallard Bay [1]	26.437	3.6%	62.0%
MONTROSS, TOWN OF MONTROSS	26.300	3.6%	65.6%
VIRGINIA AMERICAN WATER CO POTOMAC/WESTMORELAND SHORES	22.568	3.1%	68.7%
MATTOX DEVELOPMENT PLACID BAY ESTATES	18.895	2.6%	71.3%
AQUA VA - DIV OF AQUA AMERICA WHITE STONE [1]	16.452	2.2%	73.5%
VIRGINIA AMERICAN WATER CO STRATFORD HARBOR	13.785	1.9%	75.4%
AQUA VA - DIV OF AQUA AMERICA WEEMS [1]	12.213	1.7%	77.1%
VIRGINIA AMERICAN WATER CO CABIN POINT	12.144	1.7%	78.7%
RAPPA WESTMINSTER-CANTEBURY RAPPA WESTMINSTER-CANTEBURY	10.858	1.5%	80.2%
VIRGINIA AMERICAN WATER CO BERKELEY BEACH/EBB TIDE BEACH	9.973	1.4%	81.6%
REEDVILLE (formerly owned by Blundon and Hinton; sold to Aqua Virginia in 2006)	9.790	1.3%	82.9%
VIRGINIA AMERICAN WATER CO BAY QUARTER SHORES	8.507	1.2%	84.1%
AQUA VA - DIV OF AQUA AMERICA CALLAO [1]	7.606	1.04%	85.1%
AQUA VA - DIV OF AQUA AMERICA LIVELY [1]	7.491	1.02%	86.1%
AQUA VA - DIV OF AQUA AMERICA FOXWELLS [1]	6.474	0.88%	87.0%
CURLEY PACKING CO MONROE BAY ESTATES	6.067	0.83%	87.8%
TIDES GOLF LODGE INC (Greens Complex Well)	5.692	0.78%	88.6%
VIRGINIA AMERICAN WATER CO SHERWOOD FOREST SHORES	5.226	0.71%	89.3%
AQUA VA - DIV OF AQUA AMERICA HEATHSVILLE [1]	4.798	0.65%	90.0%
VIRGINIA AMERICAN WATER CO CORROTOMAN BY THE BAY	4.717	0.64%	90.6%
HERITAGE POINT ASSOCIATION HERITAGE POINT WATER SYSTEM	4.635	0.63%	91.3%
AQUA VA - DIV OF AQUA AMERICA LANCASTER COURT HOUSE [1]	4.392	0.60%	91.9%
AQUA VA - DIV OF AQUA AMERICA Lancaster Courthouse [1]	4.392	0.60%	92.5%
AQUA VA - DIV OF AQUA AMERICA INDIAN CREEK [1]	4.358	0.59%	93.1%
AQUA VA - DIV OF AQUA AMERICA GLEBE POINT [1]	4.351	0.59%	93.6%
AQUA VA - DIV OF AQUA AMERICA BURGESS [1]	3.935	0.54%	94.2%
AQUA VA - DIV OF AQUA AMERICA LOTTSBURG [1]	3.500	0.48%	94.7%
AQUA VA - DIV OF AQUA AMERICA LUTTRELLVILLE [1]	3.152	0.43%	95.1%
AQUA VA - DIV OF AQUA AMERICA KINGSLAND [1]	3.109	0.42%	95.5%
AQUA VA - DIV OF AQUA AMERICA KINSALE [1]	2.908	0.40%	95.9%
AQUA VA - DIV OF AQUA AMERICA CHESAPEAKE BAY ESTATES [1]	2.655	0.36%	96.3%
VIRGINIA AMERICAN WATER CO BLEAK HALL	2.251	0.31%	96.6%
AQUA VA - DIV OF AQUA AMERICA Nomini Bay [1]	2.236	0.31%	96.9%
AQUA VA - DIV OF AQUA AMERICA Bell Acres [1]	1.796	0.25%	97.1%
AQUA VA - DIV OF AQUA AMERICA Corbin Lewis [1]	1.789	0.24%	97.4%
VIRGINIA AMERICAN WATER CO DRIFTWOOD BEACH	1.496	0.20%	97.6%
AQUA VA - DIV OF AQUA AMERICA BON HARBOUR [1]	1.451	0.20%	97.8%
AQUA VA - DIV OF AQUA AMERICA WICOMICO CHURCH [1]	1.191	0.16%	97.9%
VIRGINIA AMERICAN WATER CO GLEBE HARBOUR	1.180	0.16%	98.10%
AQUA VA - DIV OF AQUA AMERICA Rivers Bend Estates [1]	1.141	0.16%	98.26%
AQUA VA - DIV OF AQUA AMERICA COVE COLONY [1]	1.118	0.15%	98.41%
VIRGINIA AMERICAN WATER CO DARL SUBDIVISION	1.112	0.15%	98.56%
AQUA VA - DIV OF AQUA AMERICA Ball Point [1]	1.023	0.14%	98.70%
AQUA VA - DIV OF AQUA AMERICA Black Stump [1]	0.988	0.13%	98.84%
VIRGINIA AMERICAN WATER CO MONTROSS MOBILE HOME VILLAGE	0.971	0.13%	98.97%
VIRGINIA AMERICAN WATER CO JETTY'S REACH	0.883	0.12%	99.09%
AQUA VA - DIV OF AQUA AMERICA Lancaster Shores [1]	0.877	0.12%	99.21%
VIRGINIA AMERICAN WATER CO OLD PROSPECT LANDING	0.856	0.12%	99.33%
AQUA VA - DIV OF AQUA AMERICA School House Meadows [1]	0.837	0.11%	99.44%
AQUA VA - DIV OF AQUA AMERICA Wicomico Ridge [1]	0.831	0.11%	99.55%
AQUA VA - DIV OF AQUA AMERICA BUSHFIELD [1]	0.676	0.09%	99.65%
VIRGINIA AMERICAN WATER CO ADAMS GROVE	0.637	0.09%	99.73%
AQUA VA - DIV OF AQUA AMERICA Brown's Store [1]	0.569	0.08%	99.81%
AQUA VA - DIV OF AQUA AMERICA Pleasant View Estates [1]	0.544	0.07%	99.89%
AQUA VA - DIV OF AQUA AMERICA Churchfields [1]	0.506	0.07%	99.95%
AQUA VA - DIV OF AQUA AMERICA Bunker Hill [1]	0.335	0.05%	100.00%
Estimated Annual Community Groundwater Withdrawal (Million Gallons):	**732.887**		

Notes:

MGY = Withdrawal units in million gallons per year

Shaded sources responded to EEE/NNPDC Survey (13% Community response; 26% overall response)

[1] Data from 2006 DEQ water withdrawal permitting report for Aqua Virginia, Inc., systems (reported as water usage)

Only the shaded community water sources in **Table 4-1** provided direct water supply information for this WSP through their response to the survey created for this effect. Water suppliers that did not respond to the survey were contacted again by telephone and/or email to encourage them to fill out the survey. Although some sources committed verbally to completing the survey in the near future, no additional responses were received. Thus, description of water community systems provided in this section relies on data reported as per DEQ's Water Withdrawal Reporting.

For the community ground water systems represented in **Form 2-A** (**Appendix B**), the following summary information was evaluated from the data.

Table 4-2

Summary of Community Groundwater Wells (See Form 2A, Appendix B)						
Average (mean) values					Average Withdrawal	Withdrawal Units
Well Depth (feet)	Casing Depth (feet)	Well Diameter (inches)	Top of screen (feet)	Bottom of Screen (feet)		
591	574	4	524	581	181,918 66,400,080	gallons / day gallons / year

The average well depth and screen interval for community ground water wells (summarized above) suggests that most community ground water wells withdraw ground water from artesian aquifers that are hundreds of feet below ground surface underlying the NN. This observation is not surprising because the deeper artesian aquifers have higher production capability and offer more ground water quality protection than the shallow unconfined aquifer.

4.1.2 Community Water Systems – Surface Water Reservoirs (9 VAC 25-780-70.C)

As per 9 VAC 25-780-70.C, the WSP includes specific data for community water systems using surface water reservoirs. This data element is not applicable to the NN regional WSP. Based upon water supply planning data for the NN, and discussions with the NN Water Supply Steering Committee, there are no community surface water sources (reservoirs) identified in the NN. All community water sources in the NN are supplied by ground water (**Form 2-B, Appendix B**). As discussed in **Section 10**, water supply planning in the NN localities includes future alternatives to develop surface water reservoirs to supplement ground water sources for domestic and commercial use.

4.1.3 Community Water Systems – Stream Intakes (9 VAC 25-780-70.D)

As per 9 VAC 25-780-70.D, the WSP includes specific data for community water systems using surface water via stream intakes. This data element is not applicable to the NN regional WSP. Based upon water supply planning data for the NN, and discussions with the NN Water Supply Steering Committee, there are no community surface water sources (stream intakes) identified in the NN (**Form 2-C, Appendix B**). All community water sources in the NN are supplied by ground water.

4.2 Self-Supplied Users

Figure 4-3 illustrates the self-supplied water sources that withdraw more than 300,000 gallons per month of water.

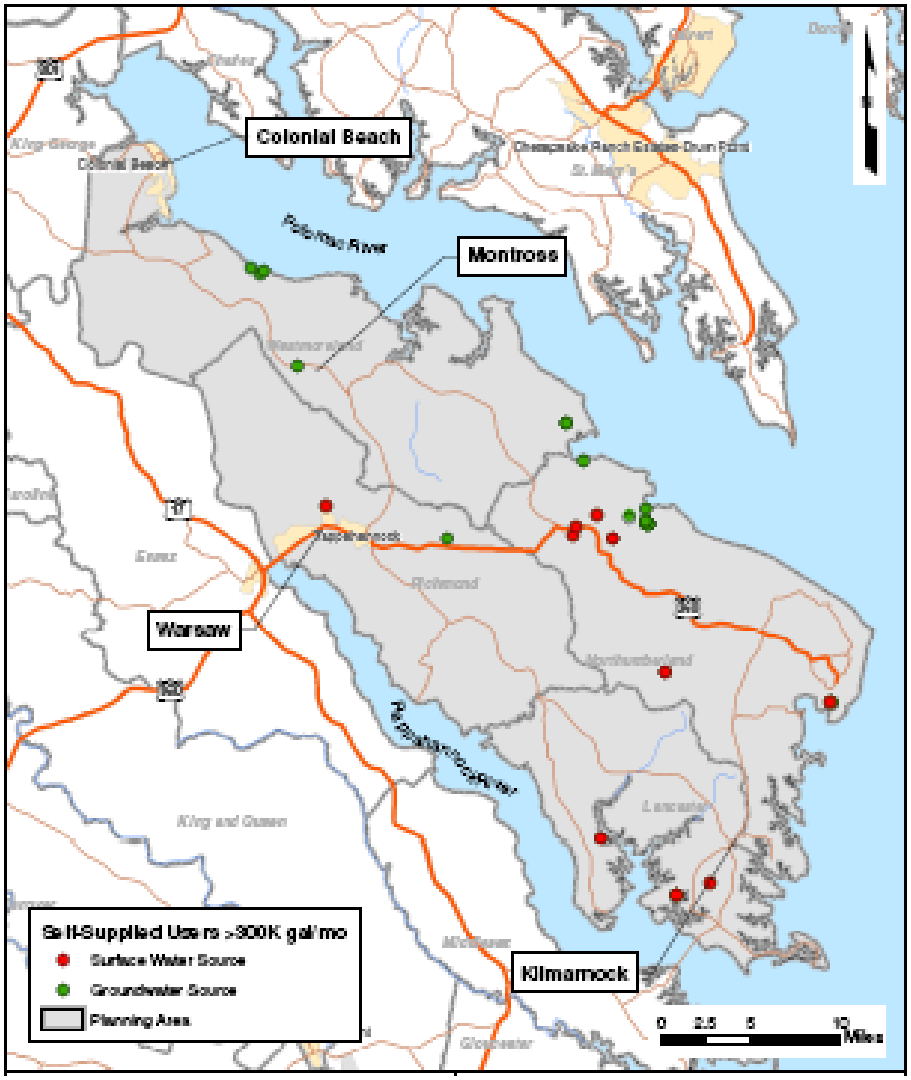


Figure 4-3: Self-Supplied Water Sources that Withdraw >300,000 gallons per month

4.2.1 Self-Supplied Users >300,000 gal/mo of Surface Water for Non-Agricultural Purposes (9 VAC 25-780-70.E)

As per 9 VAC 25-780-70.E, and to the extent that information was available at the time this report was completed, the WSP includes a list of all self-supplied users of more than 300,000 gallons per month of surface water for non-agricultural uses, the name of the water body utilized, the design capacity for the average daily and maximum daily withdrawal, and any limitation on withdrawals established by permits issued by the board, the Department of Health or any other agency (**Form 2-D**; **Appendix B**).

Two self-supplied users were identified and listed in **Form 2-D**, **Appendix B**. The Tides Golf Lodge, Inc. (including Golden Eagle Golf Course), and Zapata Protein, Inc., were identified as self-supplied users that withdraw >300,000 gallons per month of surface water for non-agricultural purposes in the data provide by DEQ and reported by sources as per Water Withdrawal Reporting Regulations 9 VAC 25-200-30 (refer to digital data in digital format in **Appendix A**, and in hard copy format in **Form 2-D, Appendix B**).

- The Tides Golf Lodge, Inc. (including Golden Eagle Golf Course), has not provided water supply planning data directly to EEE or the NNPDC via the surveys (See **Form 2-D**, **Appendix B**). As well, no surface water withdrawal data were reported to DEQ (See summary table in digital format in **Appendix A**, and in hard copy format in **Form 2-D**, **Appendix B**).

- Zapata Protein, Inc., provided data to EEE, but did not differentiate the data by monthly values. Also, the surface water intake location and water body were not identified. Zapata Protein, Inc. indicated an average daily withdrawal of 1.5 MGD (**Form 2-D**; **Appendix B).**

The NNPDC and EEE made all reasonable efforts to complete the data gaps using the survey questionnaire and follow-up contact with self-supplied users. Water suppliers were contacted again by telephone and email to encourage them to fill out the survey. Unfortunately no survey response was obtained.

4.2.2 Self-Supplied Users >300,000 gal/mo of Ground Water for Non-Agricultural Purposes (9 VAC 25-780-70.F)

As per 9 VAC 25-780-70.F, and to the extent that information was available at the time this report was completed, the WSP documents provide the name and identification number of wells, well depth, casing depth, screen depth (top and bottom) or water zones, well diameter, the design capacity for the average daily and maximum daily withdrawal and any limitation on withdrawal established by permits issued by the board, for all self-supplied users of more than 300,000 gallons per month of ground water for non-agricultural uses.

Form 2-E (**Appendix B**) lists 6 self-supplied ground water users that withdraw more than 300,000 gallons per month for non-agricultural purposes, which were identified in data provided by DEQ as reported by sources per Water Withdrawal Reporting Regulations 9 VAC 25-200-30 (refer to summary table in electronic format in **Appendix A**, and in digital format in **Form 2-E, Appendix B**). Of the six self-supplied users listed in **Form 2-E**, only three sources responded to the WSP survey (Lake Packing, Co., Zapata Protein, Inc., and Westmoreland State Park). Only Lake Packing and Westmoreland State Park provided data on daily withdrawals. Their combined average daily withdrawal was reported as 71,502 gallon/ day. Lake Packing provided data for three (3) ground water wells, with well depth and screen intakes ranging from 300 to 660 feet below ground surface (**Form 2-E; Appendix B**). No data were provided for the remaining wells identified for Lake Packing from the DEQ database.

The remaining self-supplied users were contacted by NNPDC and EEE with the purpose of filling out data gaps using the survey questionnaire. Water suppliers were contacted again by telephone and email to encourage them to fill out the survey. Unfortunately no survey response was obtained.

4.3 Water Purchased from Outside the Geographic Boundaries of the Planning Area (9 VAC 25-780-70.G)

As per 9 VAC 25-780-70.G, the WSP documents the amount of ground water or surface water to be purchased from water supply systems outside the geographic boundaries of the NN on a maximum daily and average annual basis, any contractual limitations on the purchase of the water including but not limited to the term of any contract or agreement, the recipient(s) or areas served by the water purchased, and the name(s) of the supplier(s).

Based upon data provided by community and self-supplied sources, and from discussions with the NN Water Supply Steering Committee, currently there are no identified arrangements to purchase water from outside the geographic boundaries of the NN (**Form 2-F, Appendix B**)..

4.4 Water Available for Purchase from Outside the Planning Area (Source >300,000 gal/mo) (9 VAC 25-780-70.H)

As per 9 VAC 25-780-70.H, the WSP documents the amount of water available to be purchased outside the planning area from any source with the capacity to withdraw more than 300,000 gallons per month of surface and ground water, reported on a maximum daily and average annual basis and any contractual limitations on the purchase of the water including but not limited to the term of any contract or agreement, the geographic region(s) that receive the water purchased, and the name(s) of the supplier(s).

This data element is not applicable to the NN regional WSP. Based upon water supply planning data for the NN, and discussions with the NN Water Supply Steering Committee, there are no known arrangements, agreements, or contracts for future purchases of water from outside the geographic boundaries of the NN (**Form 2-G, Appendix B**).

4.5 Agricultural Users of >300,000 gal/mo (9 VAC 25-780-70.I)

As per 9 VAC 25-780-70.I, the WSP includes a list of agricultural users identified by DEQ data (summary table in digital format in **Appendix A**, and in hard copy format in Appendix B) that utilize more than 300,000 gallons per month, an estimate of total agricultural usage by source, whether the use is irrigation or non-irrigation, and whether the source is surface or ground water. Lake Packing Inc. appears to be the sole self-supplied agricultural user of more than 300,000 gallons per month of water (**Form 2-H, Appendix B**).

4.5.1 Ground Water

Lake Packing Inc. reported annual ground water withdrawal of 9.9 MGY (822,916 gal/mo) for irrigation purposes, via the water supply plan survey conducted for this WSP. According to information provided by Lake Packing, the ground water was used to supply one mobile home, irrigation and processing operations. The remaining ground water withdrawal volume that was reported (2,120,000 gallons annually) is apparently used for processing (**Form 2-H**).

4.5.2 Surface Water

Lake Packing Inc. provided data on surface water withdrawal via the water supply plan survey conducted for this WSP. Lake Packing reported 0 gallons of surface water withdrawal (**Form 2-H**; **Appendix B**), which is consistent with the DEQ Water Withdrawal Reporting data (summary table in digital form in **Appendix A**). Discussions with the Steering Committee indicated that agricultural activities conducted by Lake Packing were re-directed since the late 1990s, emphasizing less irrigation for growing, and more processing of canned products. Thus, surface water was not used 2001 through 2006 for irrigation.

4.6 Estimate of Self-Supplied Residences/Businesses Withdrawing <300,000 gal/mo (9 VAC 25-780-70.J)

As per Water Supply Planning Regulation 9 VAC 25-780-70.J, the WSP includes an estimate of the number of residences and businesses that are self-supplied by individual wells withdrawing less than 300,000 gallons per month, and an estimate of the population served by individual wells. This information is summarized on **Form 2-I** (**Appendix B**).

4.6.1 Self-Supplied Residences

In the year 2000, 27,353 housing units were identified in the NN (**Table 2-1a**) with a total population of 49,353 (**Table 2-1**), which is equivalent to 1.8 persons/housing unit (it is assumed that a relatively large number of second homes and vacation homes on the NN result in the relatively low value for persons/housing unit). In 2006, the NN population was 51,163 (**Table 2-1**, county population only; Weldon Cooper Center, 2009), which translates to 28,424 housing units given the 1.8 person/housing unit factor estimated above.

The number of connections for community sources reported by VDH for 2005-2006 is 10,757 (**Table 2-1b**). For purposes of this approximation, it is assumed that one

connection is provided to one housing unit (see caveat below). Therefore, in approximation, the difference between the estimated number of housing units (assuming one private connection per house) and the number of community connections, suggests an estimated 17,666 residences (housing units) are served by private wells in the NN.

Caveat: It is recognized that the terms residence and housing unit are not directly interchangeable in a planning context. Also, the above analysis does not account for commercial connections included in the community systems, nor multi-family housing units that alter the assumed equivalency of one housing unit to one connection.

4.6.2 Businesses that are Self-Supplied and Withdraw <300,000 gal/mo

Review of VDH and DEQ data (summary table in digital format in **Appendix A**; and in hard copy format in **Form 2-I, Appendix B**) indicated that there are 80 business or other organizations in the NN that are listed as non-community or non-transient non-community water suppliers, and which withdraw <300,000 gallons per month of water (i.e., not included in DEQ major withdrawal database; summary table in digital format in **Appendix** A and in hard copy format in **Form 2-I, Appendix B**). Most of the commercial development (e.g., businesses) is located within the NN town jurisdictions and along major transportation corridors, and supplied by community ground water sources (NNPDC, 2003a).

4.6.3 Estimate of Population Served by Self-Supplied Residences

In 2006, the population of the NN was estimated to be 51,163 (**Table 2-1**). Based upon VDH Water Permit data (summary table in digital format in **Appendix A**; and in hard copy format in **Form 2-I, Appendix B**), community water systems supplied a population of 25,750 (**Table 2-1b**). The difference between total population, and the population served by community water systems suggests that the population served by private wells is 25,413 (**Table 2-1b**), representing approximately 50% of the NN population. This assumes that residents in the NN that do not use community water sources are utilizing ground water from private wells for domestic purposes.

4.7 Summary of Available Source Water Assessment Plans and Wellhead Protection Plans (9 VAC 25-780-70.K)

As per 9 VAC 25-780-70.K, the WSP includes, when available, a summary of findings and recommendations from applicable source water assessment plans or wellhead protection programs.

Based upon information provided by the NNPDC, only the Town of Warsaw has developed a Wellhead Protection Program. The other NN jurisdictions have not prepared specific Source Water Assessment Plans, or Wellhead Protection Plans.

4.7.1 Wellhead Protection Plan

The Town of Warsaw prepared a Source Water / Wellhead Protection Plan dated May 2005. The following summarizes the management plan component of the Plan for the Town of Warsaw:

MANAGEMENT PLAN

The Comprehensive Plan of June 6, 2002, set forth goals and objectives for water quality protection. Measures specific to groundwater protection are included here with additions proposed by the VRWA Groundwater Specialist:

- **Continue the cooperative agreement with Richmond County to enact the Chesapeake Bay Preservation Act Program.**
- **Educate and inform the public and development community about water quality protection:**

Letter to media from Town Office requesting businesses and residents to immediately notify Richmond County Fire Department of hazardous waste spills;

Enclose information in the water bill about proper disposal of hazardous waste;

Promote the use of non-toxic means to clear fencerows around wellheads; and

Mail information about proper septic system maintenance to residents in Zone 1 around Well #4.

- **Evaluate and enforce Erosion and Sediment Control laws.**
- **Encourage all agricultural land owners in the Town to revise and update water quality conservation plans as developed by the Northern Neck Soil and Water Conservation District.**
- **Continue to use Low Impact Development Site Design and OnSite Storm Water Management Methods.**
- **Enlist the assistance of the Northern Neck Regional Planning District Commission and the Chesapeake Bay Local Assistance Department in the review of storm water management plans for development projects.**
- **Explore Regional Water Supply Planning potential.**

4.7.2 Source Water Assessment Plan

The Virginia Department of Health was required by the 1996 Amendments to the U.S. EPA's Safe Drinking Water Act (SDWA) to develop a Source Water Assessment Plan (SWAP). The SWAP delineates the boundaries of a source's assessment area, lists an inventory of land use activities of concern and determines relative susceptibility of the sources to the activities.

Results of the SWAP indicate that on November 13, 2008 there were 2,936 active public water systems in Virginia, which provided safe drinking water to more than 80% of Virginia's population. While some water sources had a high level of protection, other public water systems were not in control of the land use activities in their surrounding areas. The Office of Drinking Water (ODW) encourages public waterworks to purchase land or conservation easements to protect drinking water resources.

The SWAP has identified future land use development in source water protection areas as a predominant risk to the viability of public waterworks. The ten most commonly found land use activities in order of occurrence are: on-site sewage system, fuel storage systems, pasture (grazing), crop and fodder production, primary roadways, parking lots, gasoline station/service center, solid waste collection/transfer site, wastewater pump station, and underground storage tanks.

The ODW has been working with a number of other state agencies to distribute and share SWAP data in an effort to bring more awareness to source water protection areas. The Office of Drinking Water also has the ability to provide maps to municipalities showing their source protection areas and maintains a Geographic Information System that can be used to assist in planning future developments to avoid impact on source protection areas.

The SWAP susceptibility study results for the four NN counties, including a map taken from the NNPDC (2003b) that summarizes the SWAP susceptibility results, is provided in **Appendix D** (includes SWAP results from the Town of Warsaw Source Water / Wellhead Protection Plan).

4.7.3 Northern Neck Ground Water Quality Management Plan

The NNPDC has spearheaded a regional approach to water supply protection planning. The Northern Neck Ground water Quality Management Plan (NNPDC, 2003b), which serves as a planning guide, and clearing house for source water assessment and protection, and wellhead protection in the NN region. The purpose of the Ground Water Quality Management Plan is to 1) provide a common knowledge base for making planning decisions regarding ground water protection, 2) allow for input from the NN localities, and 3) identify information gaps, opportunities for further research and strategies to gather additional information for ground water management in the NN. Recommendations included in the Report are summarized as follows:

- Explore possibilities for assisting low-income households with inadequately constructed water wells in Westmoreland and Richmond Counties.

- Analyze evolving denitrifying technologies to economically retrofit existing On-Site Sewage Disposal Systems (septic systems).

- Explore opportunities for involvement in public education initiatives on the proper use of fertilizers, pesticides, and herbicides in residential lawn care (with assistance from Virginia Cooperative extension); proper maintenance of home heating oil tanks, septic systems; home automotive maintenance; and ground water protection in general.

- Explore funding opportunities to financially assist homeowners in locating (and properly decommissioning) abandoned wells and locating and removing underground home heating oil storage tanks.

- Assist, as needed, member locality's county planning commission's regarding ground water protection and wellhead protection issues.

- Encourage and assist member localities, as needed, to develop alternative sources of potable water as a contingency plan to major ground water contamination event. This could be additional storage capacity at existing well sites, or constructing surface water impoundments (drinking water reservoirs).

4.8 Conclusion to Water Source Data Element Required by 9 VAC 25-780-70

This concludes the discussion on data collected for the NN WSP to identify community water sources and self-supplied users that withdraw more than 300,000 gallons per month, as per Water Supply Regulation 9 VAC 25-780-70. **Forms 2-A through 2-J** (**Appendix B**) summarize the data for this element to the extent that information was available at the time this report was completed. The NNPDC and EEE made all reasonable efforts to complete the data gaps using the survey questionnaire and follow-up contact with self-supplied users. Water suppliers were contacted again by telephone and email to encourage them to fill out the survey. Unfortunately no survey response was obtained. **Section 3** provides a detailed discussion of the performed data collection efforts, their limitations and results. The water supply data collected and discussed in this section, along with water use data to be discussed in the next section, form the underpinning of the regional WSP, and will be used not only to characterize sources, but to support water demand forecasting, which is a critical focus of the WSP.

5.0 EXISTING WATER USE INFORMATION (9 VAC 25-780-80)

As per Water Supply Regulation 9 VAC 25-780-80, the WSP includes, at minimum, current information documenting existing water use as listed below. The identities and mapped locations of community and self-supplied water sources addressed in this WSP (with the exception of sources withdrawing <300,000 gallons / month) were discussed in **Section 4.0**, above. Water use information reported below was obtained from VDH data (summary table in electronic format in **Appendix A**, and in hard copy format in **Appendix B**), water supply surveys submitted to the NN sources, and from data gathered by EEE during a file review at the VDH regional office in February 2007. This WSP was developed using all water data available at the time this report was completed. As mentioned before, the NNPDC and EEE made all reasonable efforts to complete the data gaps using the survey questionnaire and follow-up contact with self-supplied users. **Section 3** provides a detailed discussion of the performed data collection efforts, their limitations and results.

5.1 Community Water Systems (9 VAC 25-780-80.B)

As per 9 VAC 25-780-80.B, the WSP addresses the following data elements for community water systems identified in the NN (**Table 4-2; Figure 4-2**). A total of 96 community suppliers were identified for the NN in the DEQ and VDH database. **Form 3-A (Appendix B)** summarizes the following data disaggregated by individual community supplier: population served, number of connections, withdrawal amounts (average daily and maximum daily), and water usage (annual average and monthly average).

5.1.1 Population Served by each Community System

Review of VDH data (summary table in electronic format in **Appendix A**, and in hard copy format in **Appendix B)** indicates that community water sources in the NN serve a population of 25,750 residents (**Table 2-1b**). Data reported by community systems via the NN water supply planning survey specify a service area population of 18,016 (however, as noted above, all community systems are not represented by the survey; the survey had a response rate of 25%) (**Form 3-A; Appendix B**). The survey results provided on **Form 3-A** are segregated by individual community supplier, providing the population covered in the service area. The population served by an individual community system ranges from 9 to 3,200 people, which depicts the diversity in size across community systems.

5.1.2 Connections Served by each Community System

Review of data provided by the VDH (summary table in electronic format in **Appendix A**, and in hard copy format in **Appendix B**) indicates that community water sources in the NN include 10,757 connections (**Table 2-1b**). Data reported by community systems via the NN water supply planning survey specify 7,076 service connections (however, as noted above, all community systems are not represented by the survey; the survey had a response rate of 25%) (**Form 3-A; Appendix B**). The number of connections served by

an individual community system ranges from a lower value of 3 to an upper value of 2,200.

5.1.3 Average and Maximum Daily Withdrawal by each Community System

As noted in previous sections of this report, all community water supplies in the NN are derived from ground water resources. **Form 3-A** (**Appendix B**) lists average and maximum daily water withdrawals for community systems that provided a survey response and includes data obtained during the regional VDH office file review. Based upon data collected for this WSP (**Form 3-A**; **Appendix B**), average and peak daily ground water withdrawals by the represented community sources range from 13,070 to 61,150 gallons per day [0.013 to 0.061 mgd], and 25,090 to 83,666 gallons per day [0.025 to 0.084 mgd], respectively.

Based upon DEQ Water Withdrawal Reporting data (summary table in electronic format in **Appendix A**, and in hard copy format in **Appendix B**) available at the time this report was developed, the estimated total annual ground water withdrawal by community sources was 733 MGY [2.0 mgd] (**Table 4-1**).

5.1.4 Average Water Use for each Community System

Form 3-A (**Appendix B**) lists annual and monthly average ground water use for those community systems that reported this data on the NN water supply survey. As noted previously, all NN community systems are supplied by ground water. Annual water use reported to date for a NN community system ranges from 335,430 gallons per year to 147,959,320 gallons per year [0.4 mgd] (**Form 3A**).

5.1.5 Peak Day Water Use for each Community System

Form 3-B (**Appendix B**) lists the peak daily water withdrawal per month for community systems that reported this information via the NN water supply planning survey. Only 8 of the 96 community sources in the NN answered this section of the survey and out of this only five sources provided water use data. Note that the community sources represented in **Form 3-B** reported peak daily withdrawal, not use, in the survey forms. Reported peak day water use ranged from 580 gallons per day to 299,326 gallons per day. Data shows peak values during the summer months, which is consistent with the growing trend of secondary homes in the Region.

This seasonal trend is consistent with reported trends of total water withdrawal in the NN Region (as per DEQ-permit database). The graph below (**Figure 5-1**) shows corroborating trends in total water withdrawal per month, with increased numbers of days where temperature exceeded 90°F. Also, the withdrawal trends shown in the graph below are likely affected by increased transient populations (i.e., tourism) in the summer months.

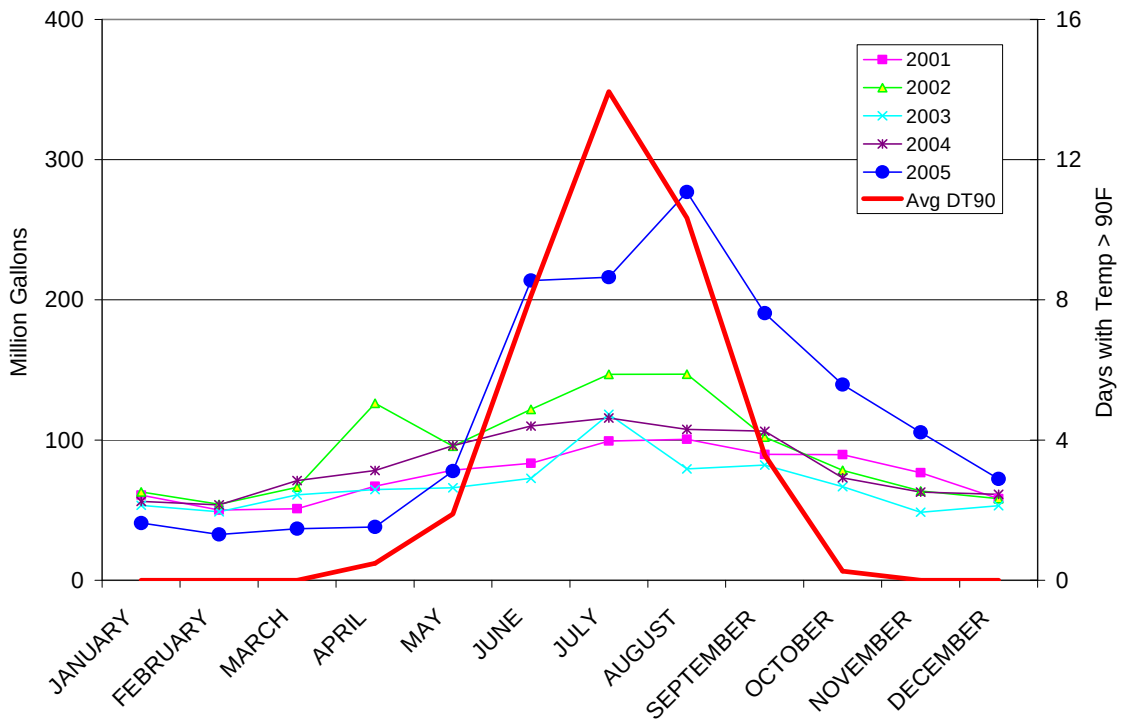


Figure 5-1: Seasonal trends in monthly withdrawals in the Northern Neck Region

5.1.6 Notes Regarding Self –Supplied Sources Withdrawing Within a Community Service Area (Sections 5.1.7 through 5.1.9)

Given the rural nature of the NN, the small and disperse community systems in the Region, and the relative lack of major water withdrawals, it is reasonable to assume that these data elements are not applicable to the NN.

Few community water systems provided service area maps. The maps that were provided represented relatively small community systems, with small service area footprint. This prevents a comprehensive assessment of whether this data element of the WSP is applicable to a particular service area.

The NNPDC and EEE made all reasonable efforts to complete the data gaps using the survey questionnaire and follow-up contact with self-supplied users. **Section 3** provides a detailed discussion of the performed data collection efforts, their limitations and results.

5.1.7 Average Annual Use – Self-Supplied Non-Agricultural Sources Withdrawing >300,000 gal/mo Within a Community Service Area

The community suppliers that returned the NN water supply survey did not identify any self-supplied non-agricultural users withdrawing more than 300,000 gallons per month located within the service area (**Form 3-C**, **Appendix B**).

5.1.8 Average Annual Use – Self-Supplied Agricultural Source >300,000 gal/mo Within a Community Service Area

The Community suppliers that returned the NN water supply survey did not identify any self-supplied agricultural users withdrawing more than 300,000 gallons per month located within the service area (**Form 3-D, Appendix B).**

5.1.9 Self-Supplied Users <300,000 gal/mo Within a Community Service Area

Twenty (20) of the 96 community sources in the NN answered the section of the survey regarding small self-suppliers (<300,000 gal/mo) located within the community system's service area (**Form 3-E, Appendix B**). Two (2) of the community systems that responded to the NN water supply planning survey reported the existence of self-supplied users in their service area (**Form 3-E, Appendix B**). Twenty (20) self-suppliers users were identified based on the information provided by the two community systems.

The large number of small and disperse community systems in the NN, makes reasonable the assumption that community systems in the Region are built to serve a small and predefined set of users. Small, self-supplied users are likely located outside the economically and technically feasible area covered by community systems. Based upon the partial response to the survey, the rural nature of the NN, and the relatively dispersed nature of the community systems, this data element is considered as not applicable for the Regional WSP.

5.1.10 Disaggregated Water Use for each Community System

Form 3-F (**Appendix B**) lists disaggregate volumes of water (one community system reported water use, the remainder reported water withdrawal) for fifty (50) of the 96 community sources in the NN. All water use data were reported as residential use, except for three (3) commercial connections within the service area of one community supplier (Waverly Subdivision, operated by Northern Neck Water, Inc.,). This was the only information available at the time this report was developed, despite the follow-up efforts to encourage water sources to respond to the survey questionnaire.

The data sources used for the WSP, follow-up data collection efforts; their limitations and results were discussed in detail in **Section 3**. The larger community systems (i.e., Colonial Beach) could have provided this level of water use detail via their billing records, had they responded to the survey. However, judging from responses given by community systems to the water supply planning survey (i.e., most only meter water withdrawal at the well; no use metering or billing data are available for disaggregating

water use), and taking into consideration that most of the NN community systems are small in scale, there appears to be little data available to quantify disaggregated water use in the NN.

5.1.11 In-Stream Beneficial Use – Community Source Stream Intake

This data component of the WSP is not applicable to the NN regional WSP. Based upon data collected and evaluated to date for this WSP (identified above), as well as discussions within the NN Water Supply Steering Committee, there are no community water sources that use surface water stream intakes (**Form 3-G, Appendix B**)

5.2 Self-Supplied Users Outside the Community Service Areas

The following notes apply to all Self –Supplied Sources withdrawing outside a Community Service Area (Sections 5.2.1 through 5.2.3)

Assumptions in these sections are based on the rural nature of the NN, the small service footprint and relatively dispersed nature of the community systems, the relative lack of major water withdrawals, and the data available from the survey responses.

Few community water systems provided service area maps. The maps that were provided represented relatively small community systems, with small service area footprint. Furthermore, no data are available for locations of self-supplied users (i.e., private wells), with which to map proximity to a particular community source. This prevents a comprehensive assessment of whether this data element of the WSP is applicable to a particular service area.

The NNPDC and EEE made all reasonable efforts to complete the data gaps using the survey questionnaire and follow-up contact with self-supplied users. **Section 3** provides a detailed discussion of the performed data collection efforts, their limitations and results.

5.2.1 Average Annual Use by Self-Supplied Non-Agricultural Sources >300,000 gal/mo Outside the Community Service Areas (9 VAC 25-780-80.C)

As per 9 VAC 25-780-80.C, the WSP includes an estimate of the water withdrawal on an average annual basis by self-supplied non-agricultural users of more than 300,000 gallons per month of surface and ground water outside the service areas of community water systems (Form 3-H, Appendix B). It is noted that the data collected for this data element are reported in terms of withdrawal, not water usage.

The Tides Golf Lodge, Inc. (including Golden Eagle Golf Course), and Zapata Protein, Inc., were identified as self-supplied users that withdraw >300,000 gallons per month of surface water for non-agricultural purposes in the data provide by DEQ and reported by sources as per Water Withdrawal Reporting Regulations 9 VAC 25-200-30 (refer to digital data in digital format in **Appendix A**, and in hard copy format in **Form 2-D, Appendix B**). The Tides Inn and Golden Eagle Golf Course, and Zapata Protein, reported

a combined total annual surface water withdrawal of 651.2 MGY (1.8 mgd) (**Form 3-H, Appendix B**).

Form 2-E (**Appendix B**) lists 6 self-supplied ground water users that withdraw more than 300,000 gallons per month for non-agricultural purposes, which were identified in data provided by DEQ as reported by sources per Water Withdrawal Reporting Regulations 9 VAC 25-200-30 (refer to summary table in electronic format in **Appendix A**, and in digital format in **Form 2-E, Appendix B**). Of the six self-supplied users listed in **Form 2-E**, only three sources responded to the WSP survey (Lake Packing, Co., Zapata Protein, Inc., and Westmoreland State Park). Only Lake Packing and Westmoreland State Park provided data on daily withdrawals. Their combined ground water withdrawals were 155.26 MGY (0.42 mgd) (**Form 3-H, Appendix B**).

It is assumed that these self-supplied users are located at a relative distance from housing communities, and therefore not located within the service area of a community systems (although the Tides Inn and Golden Eagle Golf Course operate one community well; **Form 2-A** in **Appendix B**). Based upon the partial response to the NN water supply survey, the rural nature of the NN, and the relatively dispersed nature of the community systems, this assumption appears to be reasonable.

5.2.2 Self-Supplied Agricultural Users of >300,000 gal/mo Outside the Community Service Areas (9 VAC 25-780-80.D)

As per 9 VAC 25-780-80.D, the WSP includes an estimate of the water withdrawal on an average annual basis by self-supplied agricultural users of more than 300,000 gallons per month of surface and ground water outside the service areas of community water systems (**Form 3-I**). It is noted that the data collected for this data element were reported in terms of withdrawal, not water usage.

Lake Packing is the only self-supplied agricultural user identified in the NN that withdraws more than 300,000 gallons of water per month. As listed in **Form 2-H** and **Form 3-I** (**Appendix B)**, Lake Packing reported 11.9 MGY (999,583 gal/mo) of ground water for irrigation purposes in 2006. Last report of surface water use for Lake Packing was 19.8 MGY (1,649,396 gal/mo) in 1999. Lake Packing also consumes 2,120,000 gallons per year of ground water for processing operations. The data reported in **Form 3-I** (**Appendix B**) for Lake Packing was taken from the water supply planning survey response provided by Lake Packing. Discussions with the Steering Committee indicated that agricultural activities conducted by Lake Packing were re-directed since the late 1990s, emphasizing less irrigation for growing, and more processing of canned products. Thus, surface water was not used 2001 through 2006 for irrigation.

This self-supplied user appears to be located outside the service area of community systems in the NN. Based upon the partial response to the survey, the rural nature of the NN, and the relatively dispersed nature of the community systems, this assumption appears to be reasonable.

5.2.3 Number and Total Use by Self-Supplied Sources <300,000 gal/mo Outside the Community Service Areas (9 VAC 25-780-80.E)

As per 9 VAC 25-780-80.E, the WSP should provide an estimate of the number of self-supplied users of less than 300,000 gallons per month of ground water and an estimate of the total amount of water used by them on an annual average basis outside the service areas of community water systems (**Form 3-J**, **Appendix B**; **Form 2-I**, **Appendix A**).

As discussed in **Sections 2.1 and 4.6** of this WSP, the total number of residences (housing units) served by private wells is estimated to be 17,666. In addition, 80 businesses were identified to be self-supplied users of <300,000 gallons per month. An estimated 25,413 residents derive their drinking water from private wells (self-supplied, <300,000 gallons/month), suggesting that approximately 696 MGY (1.9 mgd) of ground water is withdrawn/used for non-community drinking water (based on 75 gal/day/person domestic demand factor; discussed later in WSP).

5.3 Conclusion to Water Use Data Element Required by 9 VAC 25-780-80

Approximately 1,596 MGY (4.4 mgd) of ground water is withdrawn from the NN, 2 mgd from community supplies, 1.9 mgd from private wells and 0.4 mgd by the Tides Inn Golf course.

A total of 651.1 MGY of surface water was withdrawn in 2006 by self-supplied non-agricultural sources.

Self-supplied agricultural sources reported **0 MGY** **surface water** withdrawal for 2006. Note, surface water withdrawals only account for self-supplied sources that withdraw>300,000 gallons / month (no data are available for self-supplied surface water users that withdraw <300,000 gallons per month).

Forms 3-A through 3-J (**Appendix B**) are intended to summarize water use data for the NN, in accordance with 9 VAC 25-780-80. However, most available data were reported as withdrawal, not as usage. Therefore, a 100% withdrawal-to-use factor must be assumed herein (except where noted). There are discrepancies in data for certain suppliers between annual reporting values to DEQ, and what was reported to EEE on the survey. As mentioned before, the NNPDC and EEE made all reasonable efforts to complete the data gaps using the survey questionnaire and follow-up contact with self-supplied users. The data sources used for the WSP, follow-up data collection efforts, their limitations and results were discussed in detail in **Section 3**.

6.0 EXISTING WATER RESOURCE CONDITIONS (9 VAC 25-780-90)

In accordance with 9 VAC 25-780-90, the WSP includes a description of environmental conditions characteristic of the NN that are pertinent and critical to water supplies. **Section 2.0** of the WSP highlighted existing geographic, geologic, hydrologic and meteorological conditions characteristic of the NN. The purpose for evaluating the following information (and **Section 2.0**) is to provide a basis for water supply planning for the NN that can be evaluated in concert with water source and water use information provided in **Sections 4.0 and 5.0**.

It is beyond the scope of this regional WSP to provide an in-depth analysis of the all resource conditions on the NN. Instead, information sources and detailed references are included in the elements discussed below, to allow water supply planning efforts to evaluate the environmental and resource conditions in each particular area of the NN during the implementation of the WSP.

In accordance with the WSP Regulations 9 VAC 25-780-90, the conditions addressed herein include the following:

1. State or federal listed threatened or endangered species or habitats of concern;
2. Anadromous, trout and other significant fisheries;
3. River segments that have recreational significance including state scenic river status;
4. Sites of historic or archaeological significance;
5. Unusual geologic formations or special soil types;
6. Wetlands;
7. Riparian buffers and conservation easements;
8. Land use and land coverage including items such as percentage of impervious cover within a watershed and areas where new development may impact water quality of the source;
9. The presence of impaired streams and the type of impairment;
10. The location of point source discharges; and
11. Potential threats to the existing water quantity and quality, other than those from above.

To supplement the specific data sources that will be addressed in the following discussion, it is noted that VDEQ's Coastal Zone Management Program (VDEQ, 2007a) provides a comprehensive GIS-based resource (Coastal GEMS) that can be accessed via the Internet free of charge. Coastal GEMS can be used as a clearinghouse for the following resource information for the NN.

- Shellfish Aquaculture Permit Sites
- Anadromous Fish Streams
- Baylor Grounds (public oyster grounds)

- Fisheries Management Areas
- Impediments to Fish Movement (Dams)
- INSTAR Locations
- Oyster Gardening Sites
- Private Oyster Leases
- Seaside SAV Planting Sites
- State-constructed Oyster Reefs
- Submerged Aquatic Vegetation (SAV)
- Waters with Threatened & Endangered Species
- Wetlands
- CZM/CELCP Acquired Lands
- Forest Cover
- Natural Landscape Assessment
- Nature Conservancy (TNC) Managed Lands
- Critical Wildlife Habitat
- Important Bird Areas
- Migratory Songbird Stopover Habitat
- Scenic Rivers
- Conservation Planning Tools and Examples

6.1 State or Federal Listed Threatened or Endangered Species or Habitats of Concern

The Endangered Species Act (ESA) of 1973 (7 USC 136; 16 USC 1535 et seq.) provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. The Fish and Wildlife Service in the U.S. Department of the Interior and the NOAA Fisheries Service in the U.S. Department of Commerce share responsibility for administration of the ESA. The Fish and Wildlife Service maintains the list of 632 endangered species (326 are plants) and 190 threatened species (78 are plants). Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. The presence of listed threatened or endangered species, or species identified as rare or potential candidates for listing under the ESA, must be considered in planning for future water supply needs. The ESA prohibits any action, administrative or real, that results in a "taking" of a listed species, or adversely affects habitat.

Virginia law protecting rare, threatened, and endangered species may affect the ability to develop water supply resources. A Virginia Water Protection Permit (VWPP) is required for withdrawals from surface waters (VDEQ, 2007e). In evaluating the WPP application, the Virginia Department of Environmental Quality may consult with Virginia agencies responsible for the protection of listed species in the Commonwealth. The Virginia Department of Game and Inland Fisheries (DGIF), Virginia Department of Agriculture and Consumer Services (VDACS), and the Virginia Department of Conservation and Recreation, Division of Natural Heritage (VDCR-DNH) all play a part in evaluating the affect of WPP actions. DGIF has been assigned responsibility for protection of animal species in Virginia, while VDACS oversees the protection of listed plants and insects. Both VDACS and DGIF work closely with DCR-DNH to maintain an inventory of known occurrences of species of concern throughout the Commonwealth.

The mixed pattern of adjoining fields, forests and streams in the NN provides favorable habitat for upland game. White tailed deer, bobwhite quail, turkeys and mourning doves

are prevalent throughout the NN. Red and gray foxes, gray squirrels, rabbits, raccoons, and opossums are also to be found. Numerous muskrats, moderate numbers of beaver and mink, and occasional otters can be found in marshes and streams.

On the NN estuaries, and on the bordering rivers, there are moderate wintering populations of waterfowl, including Canada geese, whistling swans, canvasbacks, scaup, red heads, mallards, black duck, teal, buffle heads, and wood ducks. There are also many kinds of shore and wading birds such as killdeer, snipe rail, bittern, heron, sandpiper, and egret.

The VDCR-DNH lists several threatened or endangered species, and habitats of concern within the NN (VDCR, 2007a), which are summarized **Appendix E**. As of March 2001, the VDCR registered 183 occurrences of 16 rare species and natural communities in the NN. Two species are globally rare and two are federally threatened or endangered. Thirty-seven conservation sites have been identified in the NN; only 3 (8%) have received any level of protection through ownership or management by state, federal and non-government organizations. The VDCR recommends that the 34 currently unprotected conservation sites be targeted for future protection efforts. The appropriate method of protection will vary with each site but may include placing the site on Virginia's Registry of Natural Areas, developing a voluntary management agreement with the landowner, securing a conservation easement through a local land trust, acquiring the site through a locality or local land trust, dedicating the site as a natural area preserve with the current owner, or acquiring the site as a state natural area preserve.

Future water supply planning should include an assessment of potential impacts to listed threatened or endangered species and habitat. A documented occurrence of a rare, threatened or endangered at a proposed project location rarely prevents the approval of a proposed project, but may require project redesign, limitations, or mitigation actions. Typically, the most immediate impact that the presence of rare, threatened, or endangered species and/or suitable habitat will have on the development of water supplies is to limit the amount of withdrawal that may be permitted. The limitation is typically imposed in order to ensure that sufficient water flow is available to maintain the habitat required by the species of concern. Other requirements may include design criteria for intakes to reduce the capture of organisms, their young, or eggs within the water treatment system. As well, restrictions on the time of year that construction may occur may be imposed in order to prevent disruption of breeding for both aquatic and terrestrial species in the project vicinity. The VDCR website (VDCR, 2007a) should be consulted to review any updates to the species list from that provided in **Appendix E** early in the planning period.

6.2 Anadromous, Trout and Other Significant Fisheries

6.2.1 Anadromous Fish Waters

Anadromous fish live in saltwater but return to freshwater to spawn. Striped bass, shad, herring and perch are anadromous fish, which spend much or all of their adult lives swimming in the ocean and must travel upstream in freshwater rivers and streams of the NN to spawn. American eels are catadromous, and travel in the opposite direction,

spending their adult lives in the brackish waters of the estuary then traveling to the Sargasso Sea to spawn. Both migrations require open passage along the watershed's complex network of rivers and streams. Larval fish also depend on the rivers' movement and water quality for adequate sustenance and the shelter of aquatic plants, and to send them downstream, where many eventually enter the Bay and open ocean.

Figure 6-1 illustrates confirmed (red) and potential (green) anadromous fish waters in the NN region. The Potomac and Rappahannock rivers, and several tributaries to the Rappahannock River constitute anadromous fish waters.

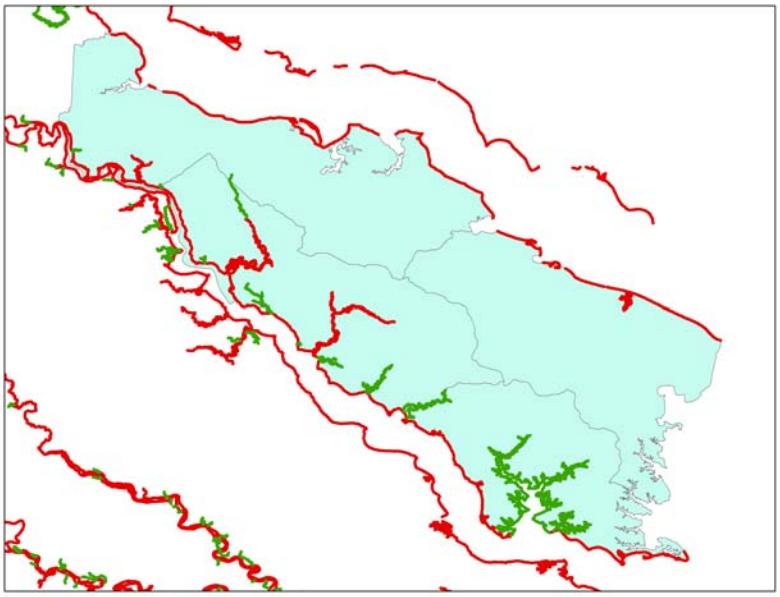


Figure 6-1. Anadromous Fish Waters in the NN (blue shaded area). Red Confirmed anadromous fish migratory river; Green = Potential anadromous fish migratory river

Future water supply planning must consider potential impacts on anadromous fish waters, and the Virginia Department of Game and Inland Fisheries should be contacted early in the planning process (VDGIF, 2007) to determine updates to confirm and potential anadromous fish water ways in the NN, and integrate measures to avoid these waterways during development. As with rare, threatened or endangered species, the presence of anadromous fish habitat at a proposed project location would not be expected to prevent the approval of a proposed project, but could require project redesign, limitations, or mitigation actions. Typically, the most immediate impact is to limit the amount of withdrawal and to require enhanced design criteria for intakes to reduce the capture of organisms, their young, or eggs within the water treatment system. As well, restrictions on the time of year that construction within waterways may occur may be imposed in order to prevent disruption of breeding.

6.2.2 Trout Streams

There are no native or wild trout streams in the NN (VDGIF, 2007c) (**Figure 6-2**). Given optimal trout stream conditions, it is considered unlikely that the NN water ways will host wild and native trout ecosystems in the future.

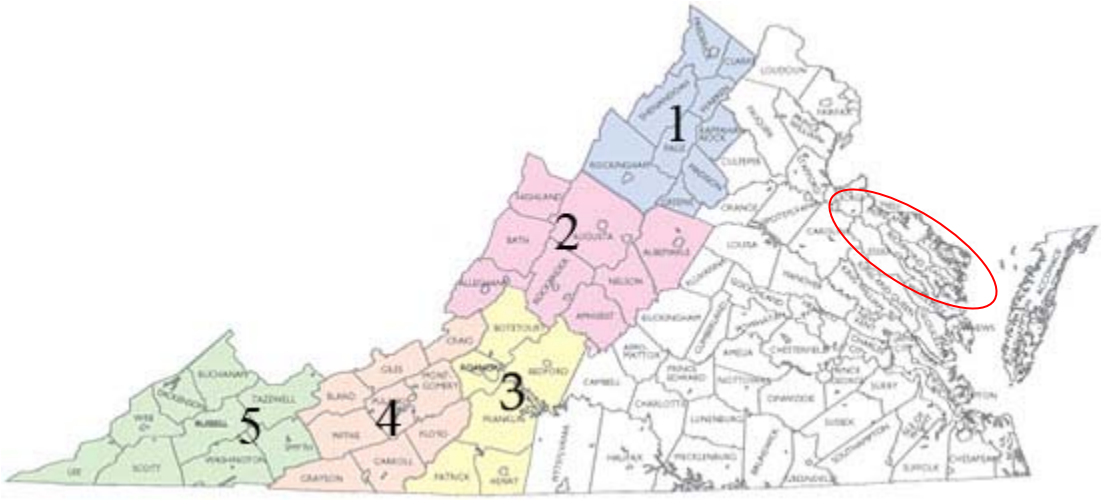


Figure 6-2. Trout Streams in Virginia (none located in the NN; red ellipse)

6.2.3 Northern Neck Fisheries

Recreational fishing and local fisheries are a significant component of the NN economy. The Chesapeake Bay, as well as small bays, creeks and inlets are a major resource to the NN. These water bodies provide employment for fishermen and for workers at seafood processing plants throughout the NN. Recent development pressures and diminished natural resources are a concern for the continued and improved health of the environment. Water quality has a direct relation to economic vitality - the cleaner the water, the healthier the economy. Watermen as well as tourists depend on good water quality. In recent years, however, the deteriorating water quality of the Chesapeake Bay has jeopardized the harvest of oysters, crabs, clams and other seafood.

For this important sector of the Northern Neck's economy to survive, the area must successfully reduce the levels of pollutants in the Chesapeake Bay. Efforts to address impacts to the Chesapeake Bay have culminated in adoption of the Chesapeake Bay Preservation Act (commonly known as the Bay Act). Under the Bay Act, protection of the Bay and its tributaries is to be accomplished through a cooperative state-local program (VDCR, 2007b).

Prior to the Bay Act, in 1976, the U.S. Congress passed the Magnuson Fishery Conservation and Management Act (Magnuson Act), which established a management system to more effectively use the marine fishery resources of the United States. As amended in 1986, the Magnuson Act required regional fishery management councils to evaluate the effects of habitat loss or degradation on their fishery stocks and take actions

to mitigate such damage. In 1996, the renamed Magnuson-Stevens Act went even further, calling for direct action to stop or reverse the continued loss of fish habitats, the identification of habitats essential to managed species, and measures to conserve and enhance this habitat. The Act requires cooperation among NOAA's National Marine Fisheries Service, eight Regional Fishery Management Councils, resource users, federal and state agencies, and others to protect, conserve, and enhance essential fish habitat. The Mid-Atlantic Fisheries Management Council (MAFMC, 2007), and the Virginia Marine Resource Commission (VMRC, 2007) provide further information on fisheries in and near the NN region.

Future water supply planning should evaluate the potential for impacts on NN fisheries by contacting the NNPD, the Mid-Atlantic Fisheries Management Council (MAFMC, 2007), and the Virginia Marine Resource Commission (VMRC, 2007) prior to developing or expanding a water supply in the NN.

6.3 Rivers With Recreational Significance / State Scenic River Status

The Virginia Scenic Rivers Act of 1970 authorized the designation of scenic rivers in the Commonwealth. The Scenic Rivers Program was established to identify, designate and help protect rivers and streams that possess outstanding scenic, recreational, historic and natural characteristics of statewide significance. A focus of the program is to enhance the conservation and wise use of scenic rivers and their attendant corridors. State and federal agencies must take into consideration how projects and programs affect state scenic rivers.

The Rappahannock River is the only river in the NN region that carries Scenic River status, designated as a "worthy" river, designated from Ferry Farm - Mayberry Bridge (near Fredericksburg, Virginia) to the Chesapeake Bay (VDCR, 2007b). The Rappahannock River is one of Virginia's top destinations for smallmouth bass angling, canoeing and camping along an almost completely unspoiled historical river corridor from Ferry Farm - Mayberry Bridge (near Fredericksburg, Virginia) to the Chesapeake Bay. Approximately 24,000 angler visits totaling nearly 100,000 hours of fishing pressure are accommodated annually (VDCR, 2007b).

Development or expansion of a water supply must consider potential impacts on recreational and scenic aspects of rivers and streams in the NN region. Scenic river designation and recreational use of the rivers are factors that must be considered by State and Federal agencies in evaluating permit applications or proposed construction projects. Scenic river designation may affect siting decisions and/or project design for construction projects within the viewshed of the subject river. Recreational fishing and boating depend on the maintenance of minimum flows in the affected waterways, as well as the avoidance of excessive silt and sediment in the waters. Generally, effective erosion and sediment control, storm water management, and nutrient management are important to the maintenance of high quality fishing and boating waters. Water supply planners should contact Virginia Department of Conservation and Recreation (VDCR, 2007b) early in the planning process to determine updates to river designations in the NN, and integrate measures to avoid designated waterways during development.

6.4 Sites of Historic or Archaeological Significance

The National Register of Historic Places, established in 1966 and managed by the National Park Service is the official list of structures, sites, objects, and districts that embody the historical and cultural foundations of the nation. The Virginia Landmarks Register, also established in 1966 and managed by the Department of Historic Resources (VDHR, 2007a), is the state's official list of properties important to Virginia's history. The same criteria are used to evaluate resources for inclusion in each register.

This information should be referred to, and updated, to determine if activities (construction, operation) of a water supply will alter the structures, or change the visual context of the setting. Also, upgrades to water infrastructure (i.e., additional storage capacity) should include an assessment of potential effects to natural resources. **Appendix F** lists properties located in the NN that are included on the Virginia Landmark Register, National Register of Historic Places (VDHR, 2007a). **Appendix F** also presents a listing of sites with archaeological significance in the NN, and serves as a clearinghouse for archaeological information sources that should be accessed during the planning process for new water sources or upgrades to water sources.

6.5 Unusual Geologic Formations or Special Soil Types

Relatively detailed description of the Coastal Plain aquifer system underlying the NN and vicinity was provided in **Section 2.0**. Regarding unusual geologic formations, the Chesapeake Bay Impact Crater influences ground water salinity in southeastern NN. This was discussed in more detail in **Section 2.0** of this WSP. While not unusual in nature, the aquifer system is highlighted in this WSP due to the current dependence on ground water to supply community water systems in the NN.

Soils in the NN region were discussed in **Section 2.0**, where resources were listed for use in deriving specific soil character for a particular area within the NN.

6.6 Wetlands

Wetlands are home to thousands of wetland plants and animals. Ducks and other migratory birds depend on wetlands to nest, feed, rest, and raise their young. Many fish live, feed and spawn in wetlands. Frogs and salamanders depend on wetlands for all or most of their life. Many plants live nowhere else but in wetlands. A recent analysis suggests that 50 percent of North American birds depend on wetlands. An estimated 46 percent of U.S. endangered and threatened species need wetlands to live. Wetlands soils absorb water from precipitation, plants slow the water's flow, and wetlands areas hold and release the water slowly into streams. Natural wetlands filter out chemicals and fertilizer that people have put on their farms, lawns or discharged from their businesses.

Wetlands areas are designated by the National Wetland Inventory, U.S. Fish and Wildlife Service (USFWS), Branch of Habitat Assessment (USFWS, 2007). Wetlands cover 37,890 acres of the region (DCR, 2007 Virginia Outdoors Plan). Water-related and other natural resources are abundant, making this region one of the most important for environmental and conservation planning in the Chesapeake Bay watershed.

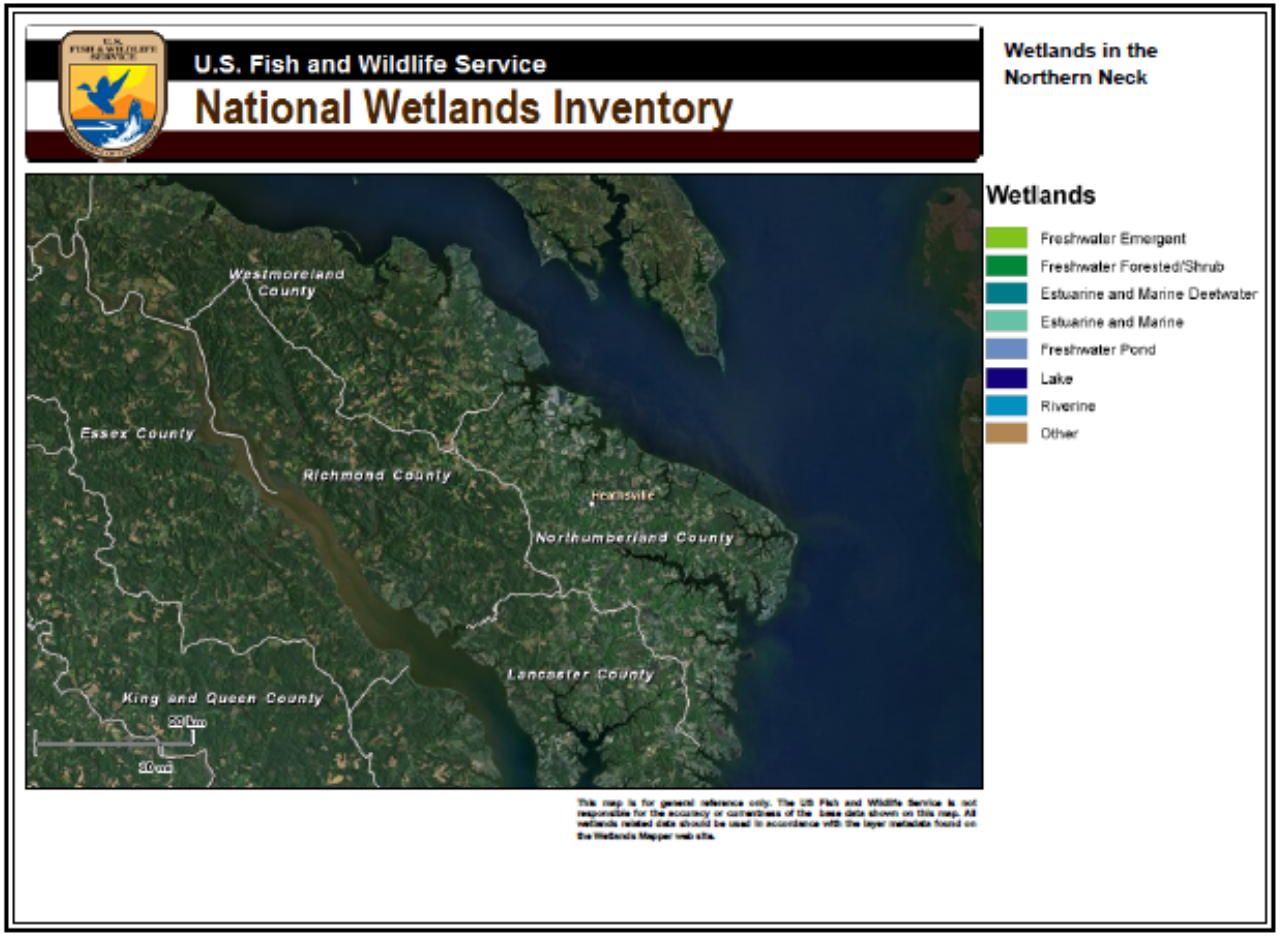
Implementation of this WSP requires continuous update of the designation and status of wetlands in the planning region. Full identification and assessment of wetlands throughout the NN region is better accomplished using available Internet-based visualization tools. The USFWS provides an Internet-based digital mapping program to identify wetlands within a geographic region, with which a specific area of the NN can be evaluated for the occurrence of wetlands (USFWS, 2007). Wetlands in the Northern Neck, as designated by the National Wetlands Inventory, are shown in **Figure 6-3**. Maps of wetlands, in each of the counties, can be generated and updated through the use of internet visualization tools. The maps for the counties of Northumberland and Westmoreland are shown in **Figures 6-4 and 6-5**.

Alteration of wetlands, whether through filling or draining, is now strictly controlled by both Federal and State laws. In Virginia, the Department of Environmental Quality (DEQ) and the U.S. Army Corps of Engineers (USACE) play the dominant role in regulating activities that affect wetlands. The VWPP (referenced earlier in this WSP) is the Commonwealth's process for regulating activities in tidal and non-tidal wetlands (VDEQ, 2007e). The USACE regulates impacts to wetlands under Sections 401 and 404 of the Clean Water Act (USACE-WRTC, 2007). Typically, placement of any fill in a regulated wetland would require a permit from the USACE. Activities such as certain types of excavation in wetlands and placement of fill in isolated wetlands (which may not be under Federal jurisdiction) require a VWPP permit (VDEQ, 2007e). As well, some U.S. Army Corps of Engineers permits are not Section 401-certified, and impacts allowed under these USACE permits also require a Virginia Water Protection permit to ensure State natural resources are protected. Both the USACE and DEQ administer their permit processes in conjunction with the Joint Permit Application process of the Virginia Marine Resources Commission (VMRC, 2007), which is responsible for activities that affect all sub-aqueous bottoms (stream and river beds) in the Commonwealth.

Projects that alter wetlands must demonstrate a lack of other suitable alternatives, and must plan on incorporating mitigating measures that may raise project costs.

The presence of the RPAs, and forested buffers, may limit clearing or development of land for water supply infrastructure if an affected parcel were to be proposed for new development. Therefore, early in the planning process for developing or expanding a water source, the information outlets referenced above should be consulted to determine if the proposed action will affect buffers.

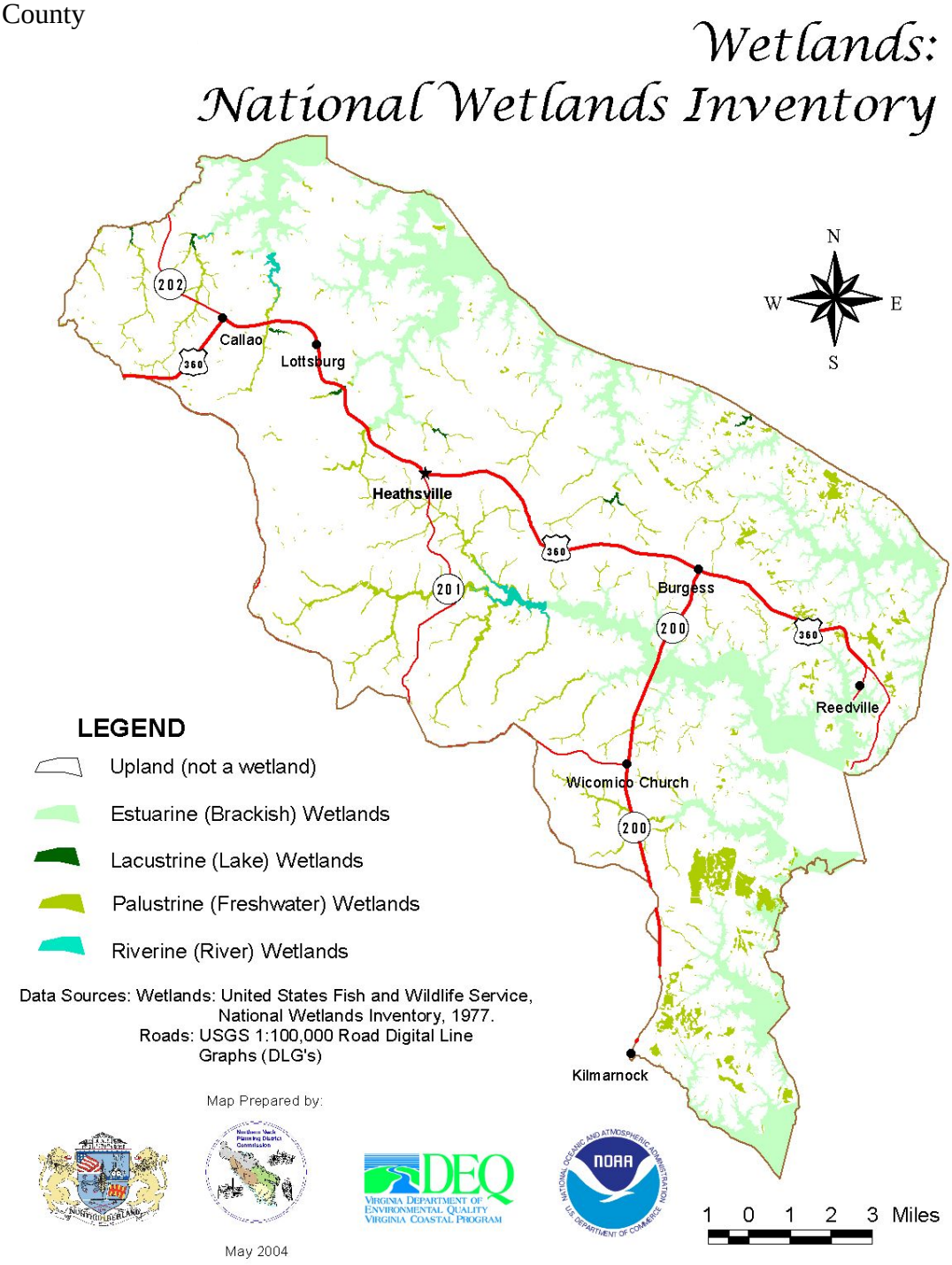
Regional Water Supply Plan



http://www.fws.gov/wetlands/Data/Mapper.html

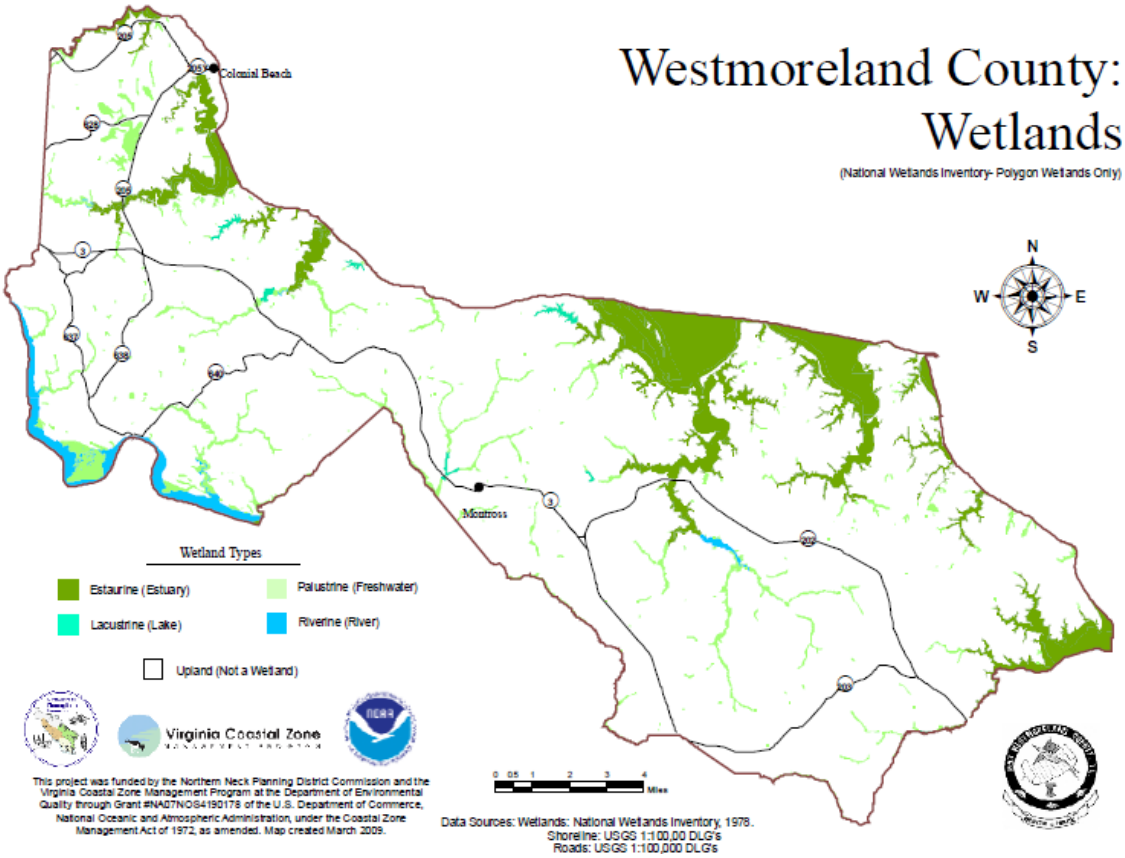
Figure 6.3 – Wetlands in the Northern Neck

Northumberland County



Northumberland County's Comprehensive Plan.

Figure 6-4 Wetlands in Northumberland County



Northern Neck Planning District Commission Virginia Coastal Zone Management Program's PDC Technical Assistance Program Task #45

Figure 6-5 Wetlands in Westmoreland County

6.7 Conservation Easements, Riparian Buffers and Natural Area Preserves in the Northern Neck

6.7.1 Conservation Easements

The Virginia Department of Conservation and Recreation maintains a database for current and future/potential land conservation easements in Virginia (VDCR, 2007c). **Figures 6-6, 6-7 and 6.8** show conservation lands located in the NN region (and surrounding counties). While conservation easements provide some restriction on development options for the registered property, the relatively rural nature of the NN, and the nature of anticipated growth and development are primary drivers for future water supply demand and protection. The location of conservation easements will need to be considered if future development of surface water reservoirs is pursued, or if additional community wells are drilled.

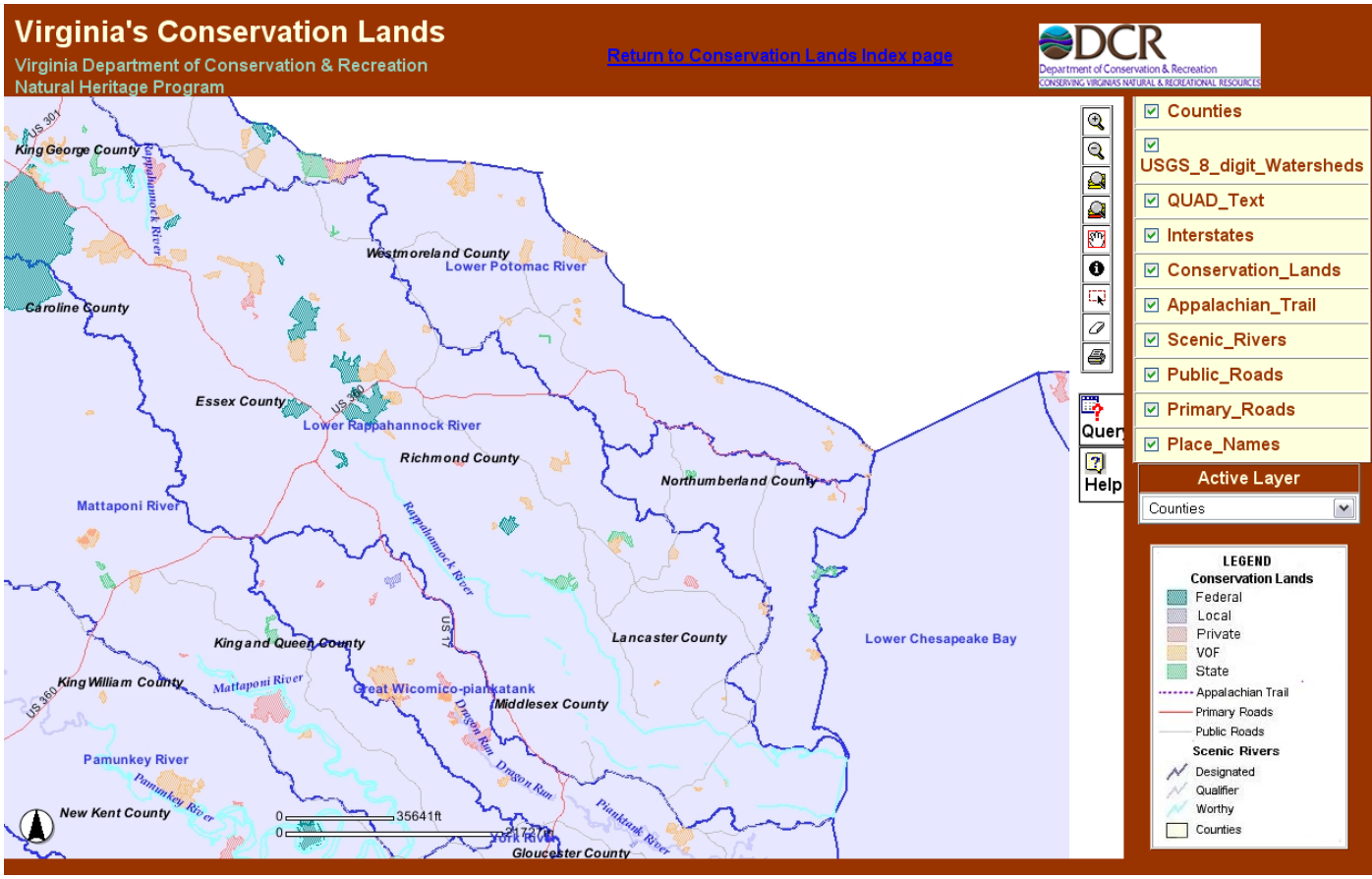
In terms of land conservation, federal land holdings include the Rappahannock River Valley National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service, and the George Washington Birthplace National Monument, managed by the National Park Service. State conservation lands include four natural area preserves and Chilton Woods State Forest. The region has two state parks protected for outdoor recreation and conservation: Belle Isle State Park on the Rappahannock River and Westmoreland State Park on the Potomac River.

Land Trusts Operating in Region 17:

- Virginia Outdoors Foundation
- Northern Neck Land Conservancy
- Chesapeake Bay Foundation
- Potomac Conservancy
- APVA Preservation Virginia
- The 500-Year Forest Foundation

A listing of current and planned conservation easements that correspond to the locations shown on the figure above, were taken from the DCR website (VDCR, 2007c), and presented in **Appendix G**. Acreage values are not split by county or watershed boundaries, and do not include water bodies. Data scale differences may cause discrepancies between tabular and map results; for example, rivers often form county boundaries and are less accurate than parcel boundaries. Parcels along rivers may therefore intersect w/ both counties though really only occurring in one.

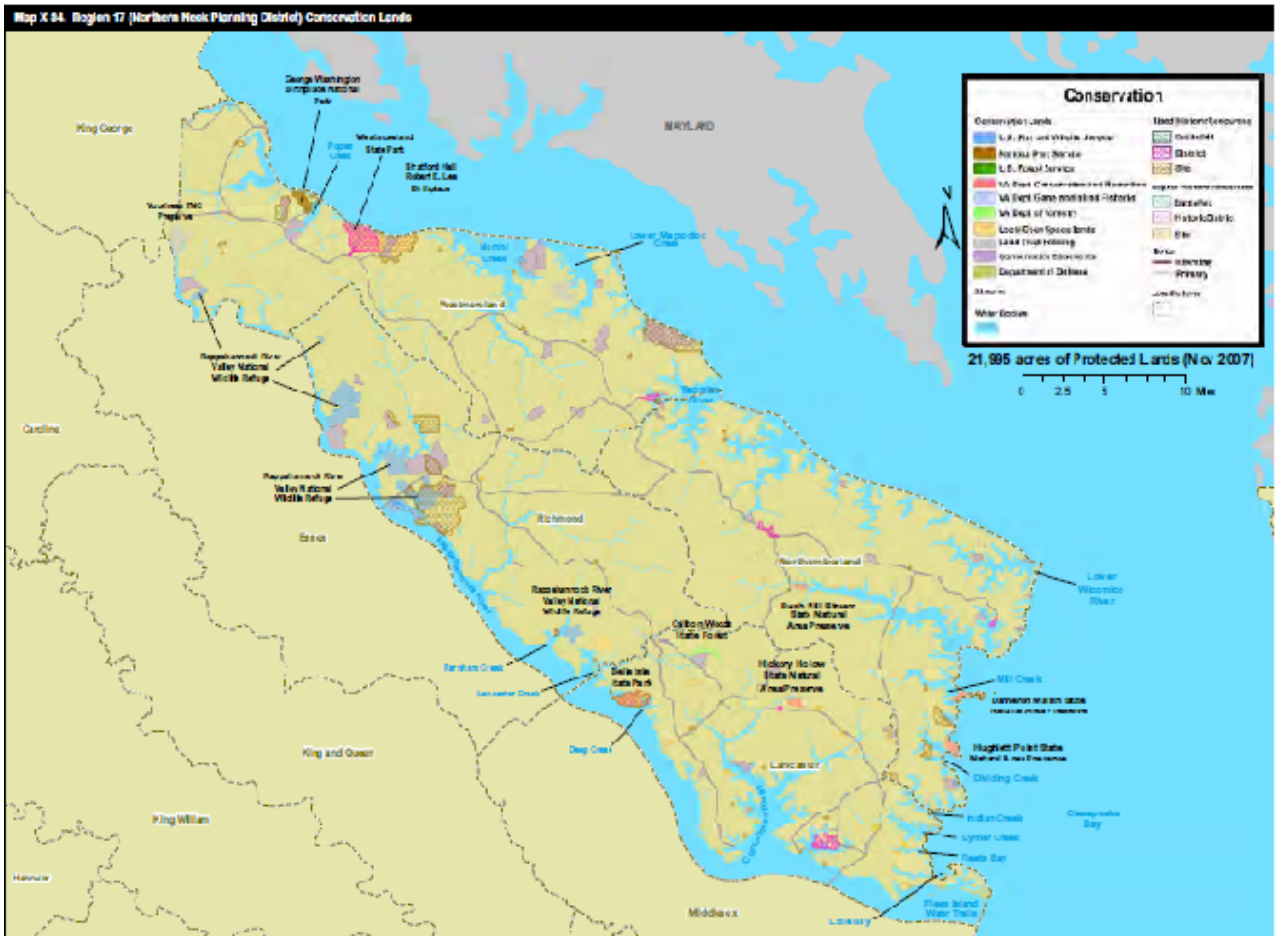
Regional Water Supply Plan



http://www.dcr.virginia.gov/

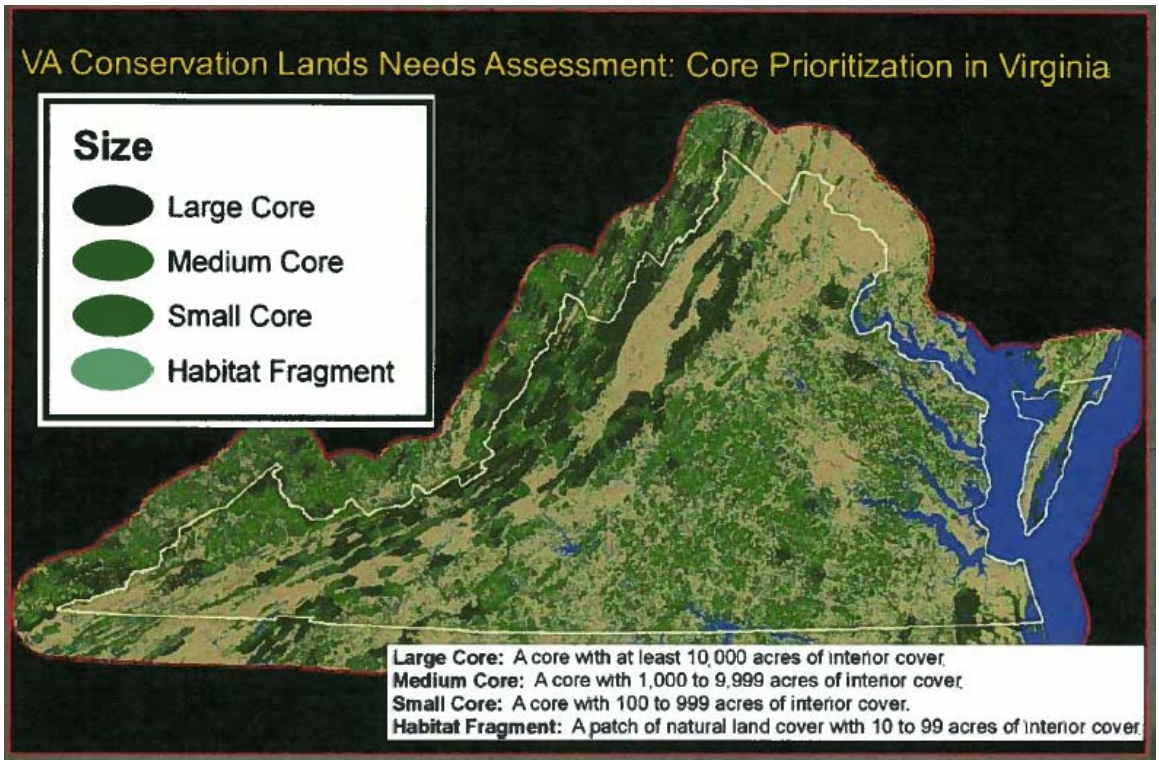
Figure 6-6. Designated and Potential Conservation Easements in the NN

Regional Water Supply Plan



2007 Virginia Outdoors Plan

Figure 6.7 -Northern Neck Conservation Lands



Virginia Department of Conservation and Recreation

Figure 6.8 - Assessment and prioritization of conservation lands in Virginia.

6.7.2 Riparian Buffers

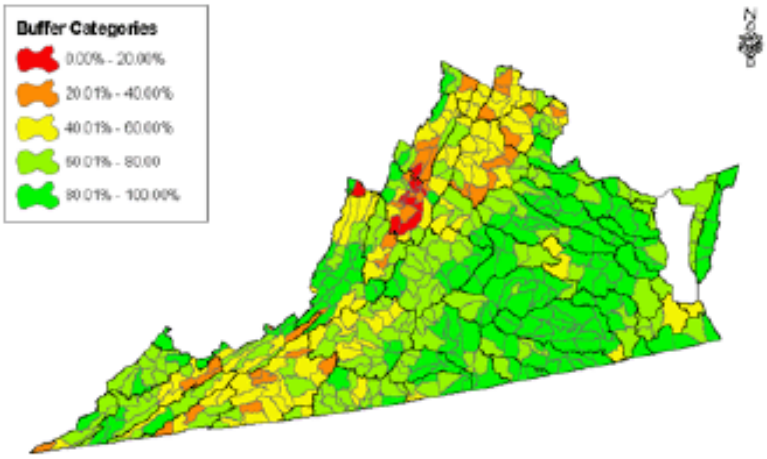
Riparian buffers are vegetated areas adjacent to water bodies such as streams, lakes, rivers, marshes, and shorelines. Buffers are often described as the "last line of defense" for the protection of water quality. These vegetated areas stabilize shorelines and stream banks, filter pollutants from storm water runoff, and provide critical habitat for aquatic species and wildlife. All of these functions are crucial to protecting water quality

Despite protective regulations, many of these buffer areas are being impacted by shoreline development, improper management of buffer vegetation and failure to enforce existing regulations. At greatest risk are buffers in parts of the state that have rapidly growing urban and suburban areas. In 1988, the Virginia General Assembly passed the Chesapeake Bay Preservation Act to protect and improve the water quality of the Chesapeake Bay and its tributaries. The "Bay Act" applies in all 84 cities, counties, and towns in Tidewater Virginia; generally the areas of the state east of Interstate 95.

The Chesapeake Bay Act and Regulations require that a vegetated buffer area not less than 100-feet wide be located adjacent to and landward of all tidal shores, tidal wetlands, non-tidal wetlands connected by surface flow and contiguous to tidal wetlands or along water bodies with perennial flow. These features, including the 100-foot buffer, comprise the Resource Protection Area (RPA), and serve a direct water quality function by removing excess sediment, nutrients, and potentially harmful or toxic substances from ground water and surface water entering the Chesapeake Bay and its tributaries (VDCR, 2007b). Buffers also help to absorb periodic flood surges, and supply thermal protection, food, and cover to fish and other wildlife, stabilize stream-banks and provide recreation and aesthetic values. RPAs are protected under state law and local ordinances. Generally, no development, land disturbance, or vegetation removal is allowed within 100-feet of the water.

The Virginia Department of Forestry (DOF) administers the Riparian Buffer Tax Credit to provide a non-refundable tax credit to private individuals and companies who forebear timber harvesting on land abutting a waterway for a designated period (VDOF, 2007). To qualify for the tax credit, forested buffers must be between 35 and 300 feet wide, and be intact for 15 years. **Figure 6.9** shows the Riparian Forest Buffer Inventory and Analysis for the Commonwealth of Virginia.

The presence of active riparian easements, conservation land easements, or publicly owned conservation area may limit the ability to develop or extend infrastructure needed to extend or expand water systems, and/or to develop new water sources. Consequently, it is imperative to document current easement locations during the planning of new water supply improvements. The DCR database is the most comprehensive guide to the location of easements in the Commonwealth (VDCR, 2007c); however, easement programs are continually expanding the amount and location of protected land, and should be updated for current information during any infrastructure planning activities.



Percent of 14 Digit Watershed's Streams buffered on both sides by at least 100 feet of Forest or Wetlands

Rick L. Day & Raymond C. Crew. Penn State University

Figure 6.9. -Riparian Forest Buffer Inventory and Analysis for the Commonwealth of Virginia

6.7.3 Natural Area Preserves

The following natural area preserves are located within the Northern Neck: Hickory Hollow in Lancaster County and Bush Mill Stream, Dameron Marsh and Hughlett Point in Northumberland County. DCR has, as of November 2006, documented 168 occurrences of 29 rare species and natural communities in the Northern Neck Planning District. Nine species are globally rare and three are federally threatened or endangered. One hundred and one conservation sites have been identified in the district; only 31 sites (31 percent) have received any level of protection through ownership or management by state, federal and non-government organizations.

Northumberland County has three Natural Area Preserves - Bush Mill Stream, Dameron Marsh and Hughlett Point, administered by the Virginia Department of Conservation and Recreation. Public access is provided for passive recreation, education and nature study, but these areas are not intended for active recreational purposes. Their purpose is to protect "…habitat of rare, threatened or endangered plant and animal species, rare or state significant natural communities or geologic sites, and similar features of scientific interest benefiting the welfare of the citizens of the Commonwealth." No sanitary facilities or trash receptacles exist, and vehicles, bicycles, horseback riding and unrestrained pets are prohibited.

Bush Mill Stream, located near the headwaters of the Great Wicomico River off VA 642, incorporates 103 acres of upland forests and wetlands. A Great Blue Heron rookery occupies the treetops in the swamp west of the Preserve. Dameron Marsh off VA 605

extends into the Chesapeake Bay, forming the southern margin of Ingram Bay. It is the largest wetland on the western side of Chesapeake Bay. Hughlett Point is located on Chesapeake Bay at the south end of VA 605, and contains 204 acres of wetlands, beaches, dunes and upland forest communities. It is home to a federally protected insect species, the Northeastern Beach Tiger Beetle, and provides important habitat for waterfowl, songbirds and birds of prey.

A fourth area, Kohl's Island, which incorporates Smith Point itself and a beach to the west of where the Potomac River empties into Chesapeake Bay, is owned by the Virginia Outdoors Foundation. It is also home to the endangered Tiger Beetle. The old entrance to the Little Wicomico River off the Potomac River, which once bordered the western end of the "island," has been built-up by the Corps of Engineers using dredge spoil from the present navigation channel. Planted with grass, it is hoped the connection to the "mainland" will now be permanent. No public access by land exists, or is planned, and access can only be gained by boat.

6.8 Land Use and Land Coverage

Assessing land use and land cover is an important component of water supply planning because they affect the natural water systems' ability to be replenished, and determine where growth in water demand will occur. Where intense urban activity occurs, impervious land cover (pavements and buildings) may occupy a significant percentage of the surface, thus preventing rainfall from percolating into the soil, and instead, running rapidly into adjacent streams and rivers. From a water supply planning perspective, this rapid runoff causes several problems. Because water is not available to recharge ground water, wells may perform less reliably, and a greater variation in stream discharge may be experienced. As well, storm water runoff directly to streams and rivers may carry a greater load of contaminants, thus causing a decrease in water quality.

The NN is primarily rural in nature. Fisheries, agriculture and tourism are the dominant economic drivers for the region. As a result, there is prevalent open space with relatively minimal impervious cover (**Figure 6-10**). Several sections of his WSP address potential impacts on surface water and ground water resources throughout the NN, which are influenced in large measure by land use and topography of the NN (i.e., shallow ground water, erodeable soils, pesticide and nitrate infiltration, aquifer recharge, etc.,).

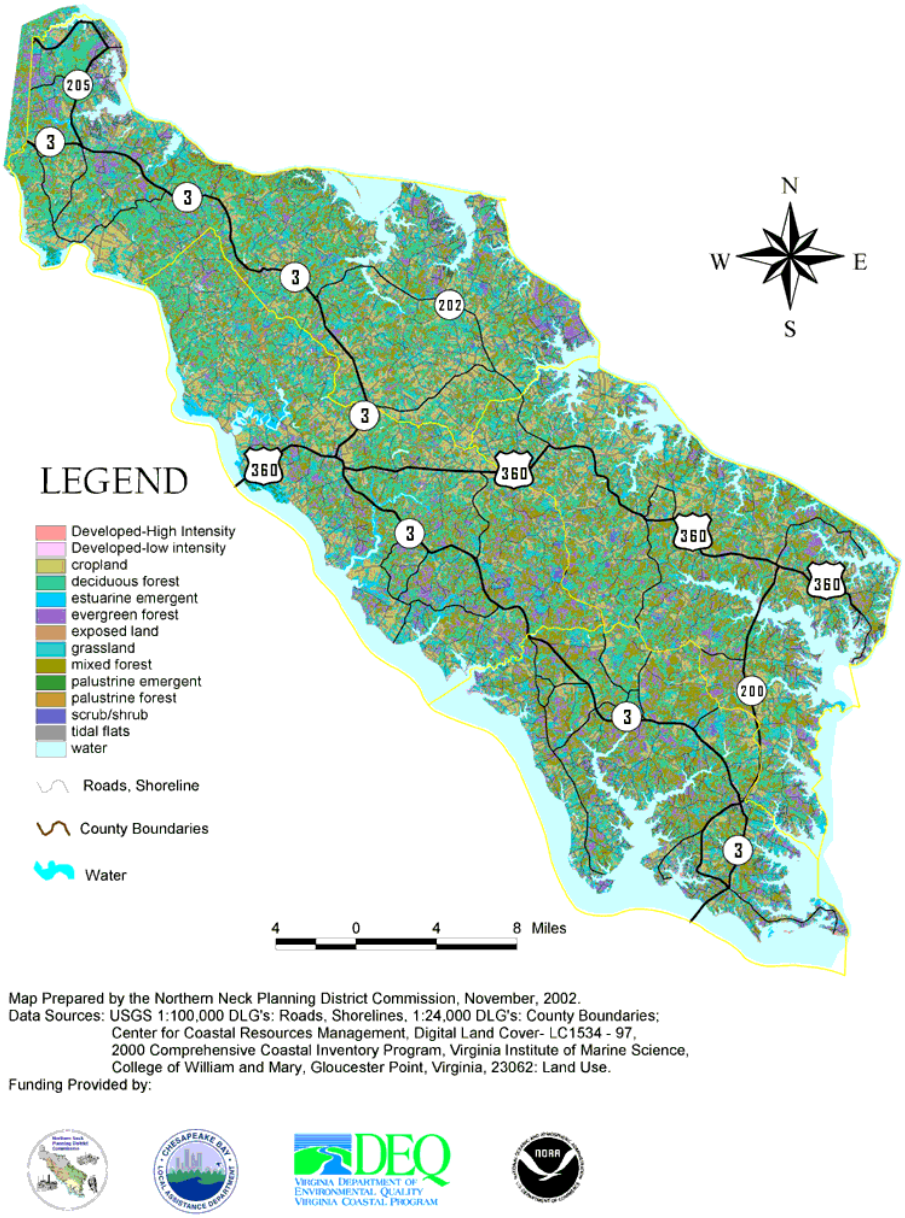


Figure 6-10. Land Use and Land Cover in the NN (taken from NNPDC, 2003b)

Virginia requires localities to adopt storm water management controls to minimize the effect of new development. Typically, storm water management measures may include leaving a portion of a developed property in an undeveloped state, or adding positive controls such as storm water detention basins when new development occurs. Because of the very low percentage of developed land within the planning area, impervious surface is not considered a major restraint on the management of future water supplies in the area. However, locally, on-going development has the potential to affect water systems that depend on ground water. Shallow wells within the area are generally unsuitable for large, sustained demands. As well, withdrawal rate and volume from public water systems may be limited by permit conditions, and as discussed in this WSP may be limited by regional overuse of ground water resources.

6.9 The Presence of Impaired Streams and the Type of Impairment

Information about impaired streams and rivers in Virginia is compiled by the Virginia Department of Environmental Quality and presented to the U.S. Environmental Protection on a bi-annual basis (VDEQ, 2007b). The VDEQ monitors rivers, lakes, and tidal waters in Virginia for pollutants. Over 130 different pollutants are monitored annually to determine whether the waters can be used for swimming, fishing and drinking. Most rivers, lakes and estuaries in Virginia do meet standards as described in biennial 305(b) Water Quality Assessment Reports. Waters that do not meet standards are reported to the citizens of Virginia and the US Environmental Protection Agency (EPA) in the 303(d) Impaired Waters Report (VDEQ, 2007b).

Figure 6-11 identifies the locations of impaired streams (as per 2006 VDEQ 303(d) report classification) in the NN. **Appendix H** lists information about the impaired streams located in the NN. This information is primarily important to water supply planning in the event that surface water supplies are developed to meet future demands. The presence of impaired streams, and the sources of impairment need to be identified early in the planning process for developing new surface water supplies.

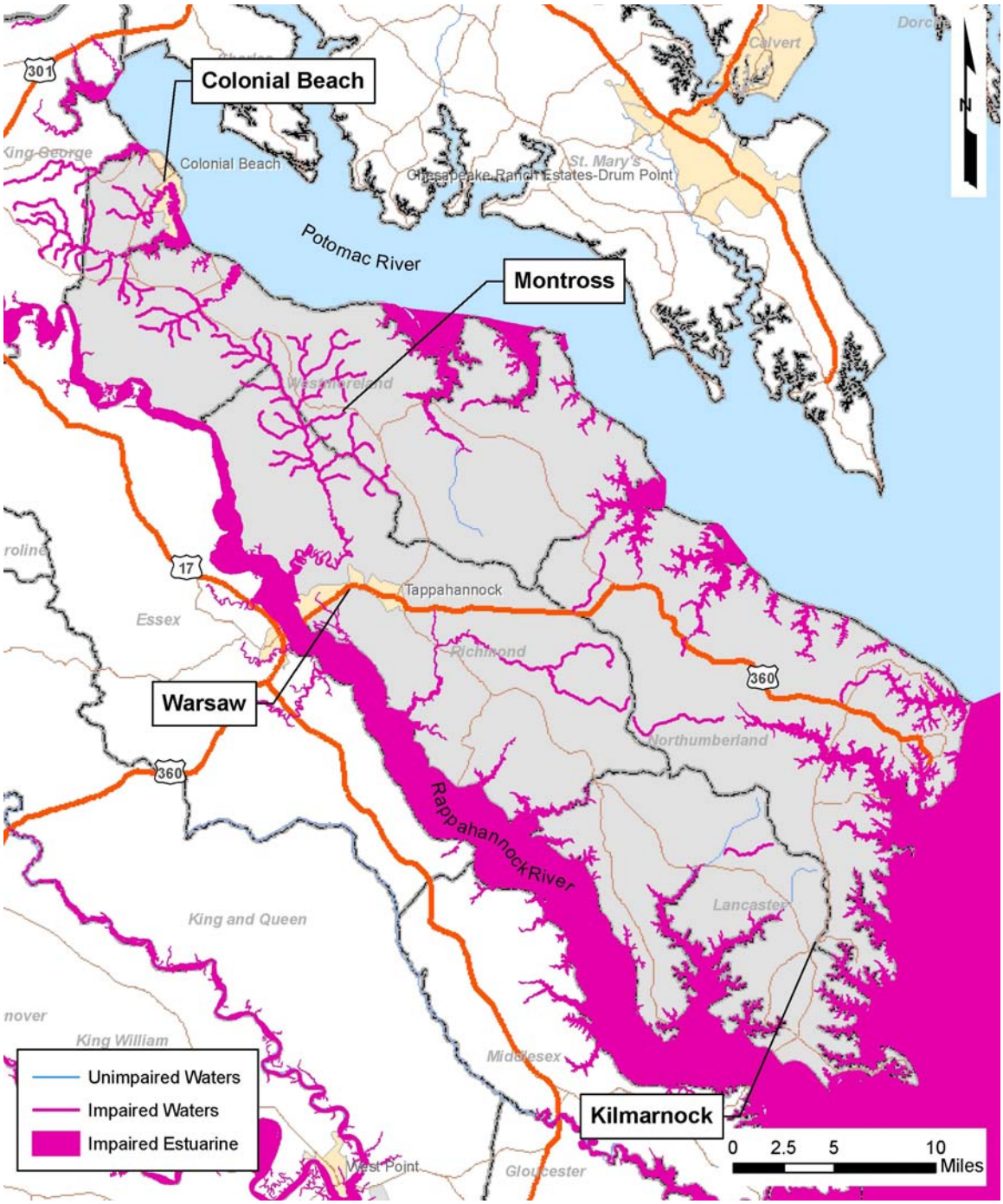


Figure 6-11. Impaired (VDEQ 303(d) Report) Waters in the NN

6.10 Point Source (VPDES and Other) Discharges

6.10.1 VPDES Permitted Discharges

Section 402 of the Clean Water Act established the National Pollutant Discharge Elimination System to limit pollutant discharges into streams, rivers, and bays. In the Commonwealth of Virginia, DEQ administers the program as the Virginia Pollutant Discharge Elimination System (VPDES). Though DEQ requires VPDES permits for all point source discharges to surface waters, the US Environmental Protection Agency maintains authority to review applications and permits for "major" dischargers, a distinction based on discharge quantity and content. **Figure 6-12** shows locations of VPDES permit discharges located within 1,500 feet of a public water supply on the NN. The VPDES locations were determined through the SWAP Susceptibility survey (**Appendix D**).

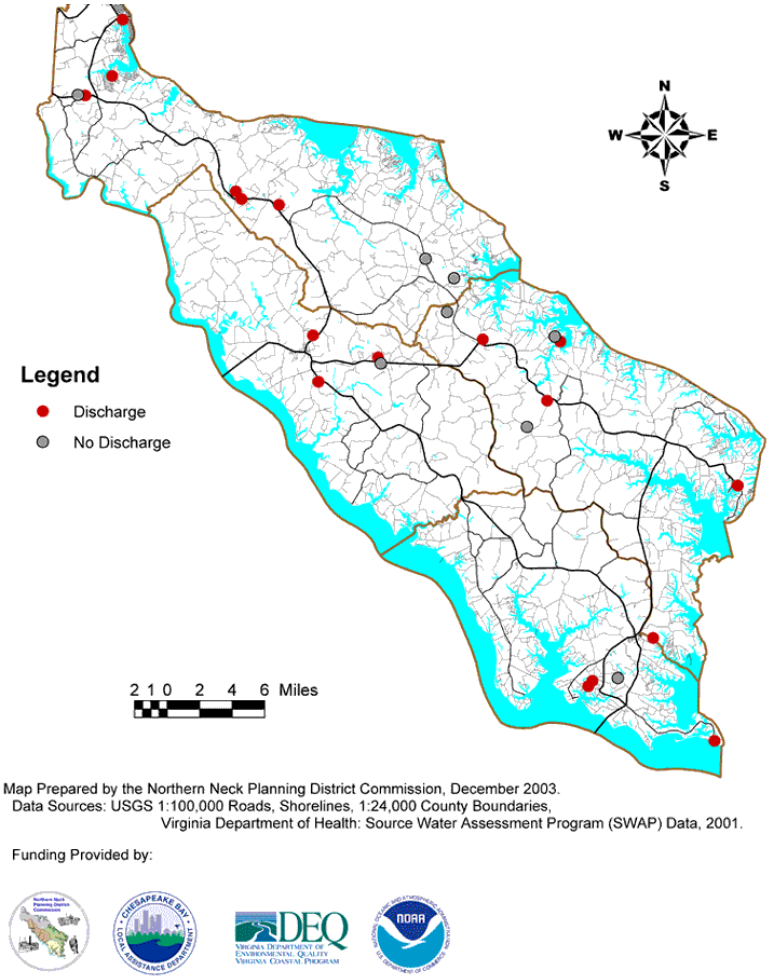


Figure 6-12. VPDES Permit Discharge Locations Within 1,500 feet of a Public Water Source (well) in the NN (taken from NNPDC, 2003b)

6.10.2 Petroleum Storage (Other Point Source Contamination)

In the context of this WSP, point source discharges to land and water are also considered to include underground / leaking underground storage tanks, landfills, many types of hazardous waste sites (not subject to VPDES permitting, however). Under this consideration, point source discharges are differentiated from other sources of potential pollution such as nitrogen leaching from runoff and areal application of fertilizers in that the source of potential pollution is derived from a specific location.

The following sections and associated figures illustrate locations of known point source locations of pollution (actual or potential) sources in the NN. Also refer to the source water assessment susceptibility discussion in **Section 4.0**, and map presented in **Appendix D** that identifies potential pollution sources within 1,500 feet of a public water source. Prior to developing any future water supplies (ground water or surface water), the potential for impact from a contaminant source must be assessed. The following provides critical information on the types of contaminant sources to be identified, and resources with which to assist water planners to undertake the assessment.

Underground Storage Tanks (UST's) are a potential source of ground water contamination, whether for diesel, gasoline, or home heating oil. The VDEQ provides a clearing house of information on Virginia petroleum storage (VDEQ, 2007c). **Figure 6-13** shows locations of known leaking underground storage tanks (LUSTs). **Figures 6-14 and 6-15** shows the locations of known diesel and gasoline storage sites, respectively, on the NN (NNPDC, 2003b). Figures 6-8 and 6-9 represent data from VDEQ sources, and are not intended to represent all USTs on the NN (i.e., do not represent gas stations, marinas, etc.). In general, leaking storage tanks present a potential risk to drinking water quality, particularly in the shallow aquifer, and to streams and other water ways.

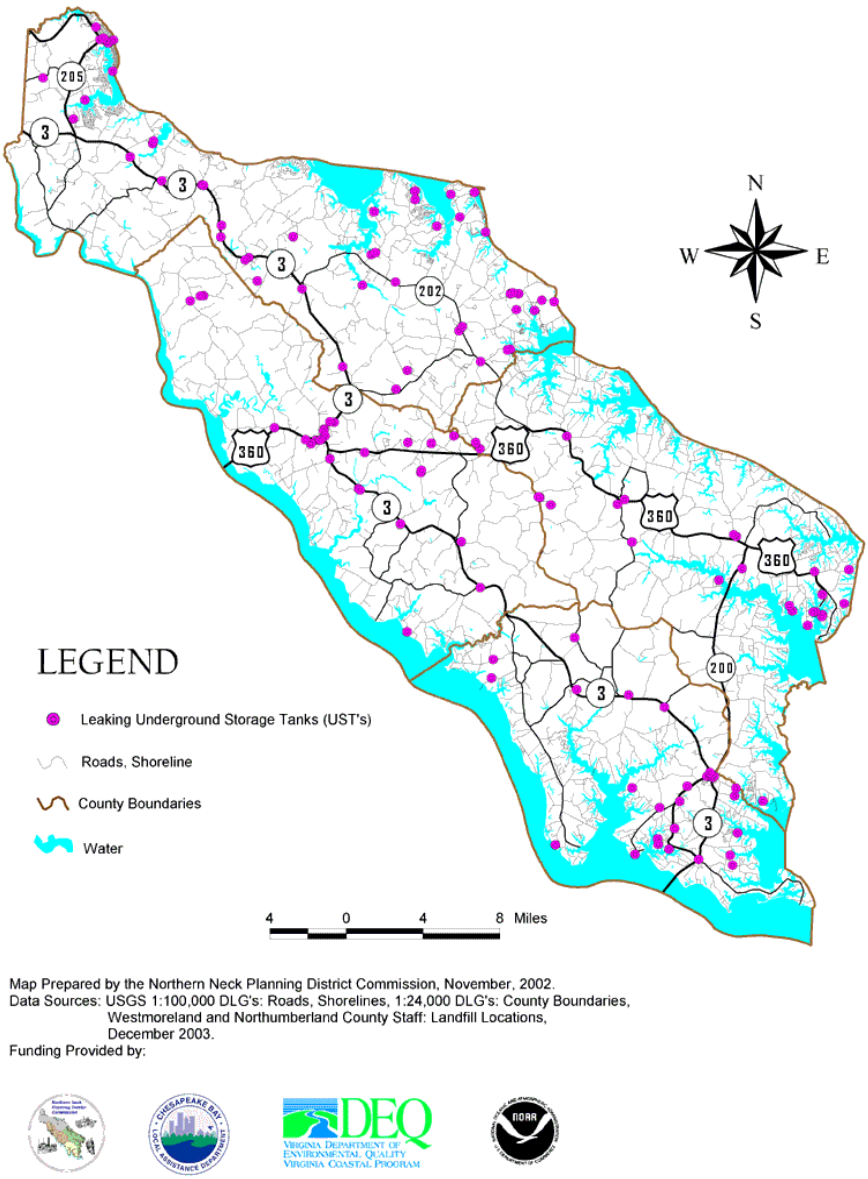


Figure 6-13. Locations of Known Leaking Underground Storage Tanks in the NN (taken from NNPDC, 2003b)

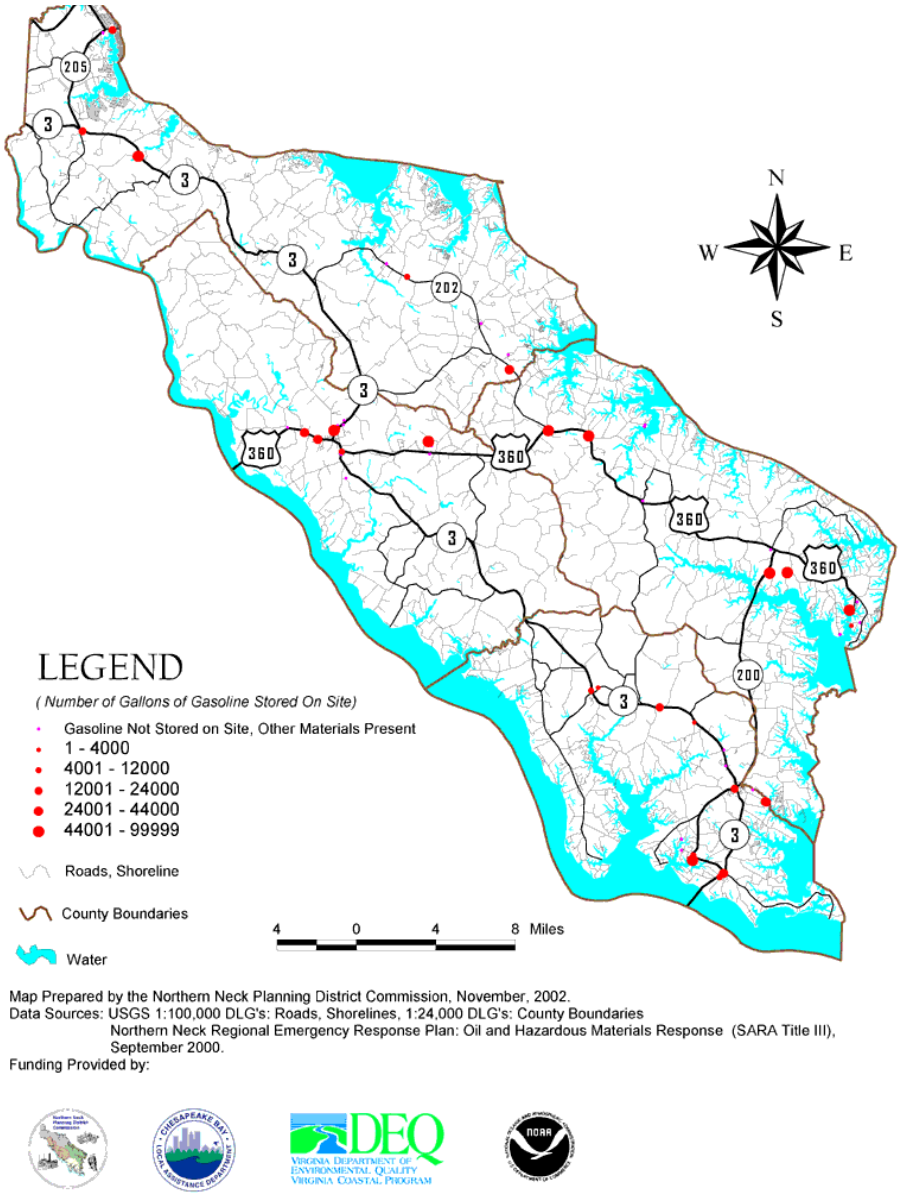


Figure 6-14. Known Gasoline Storage Locations in the NN (taken from NNPDC, 2003b)

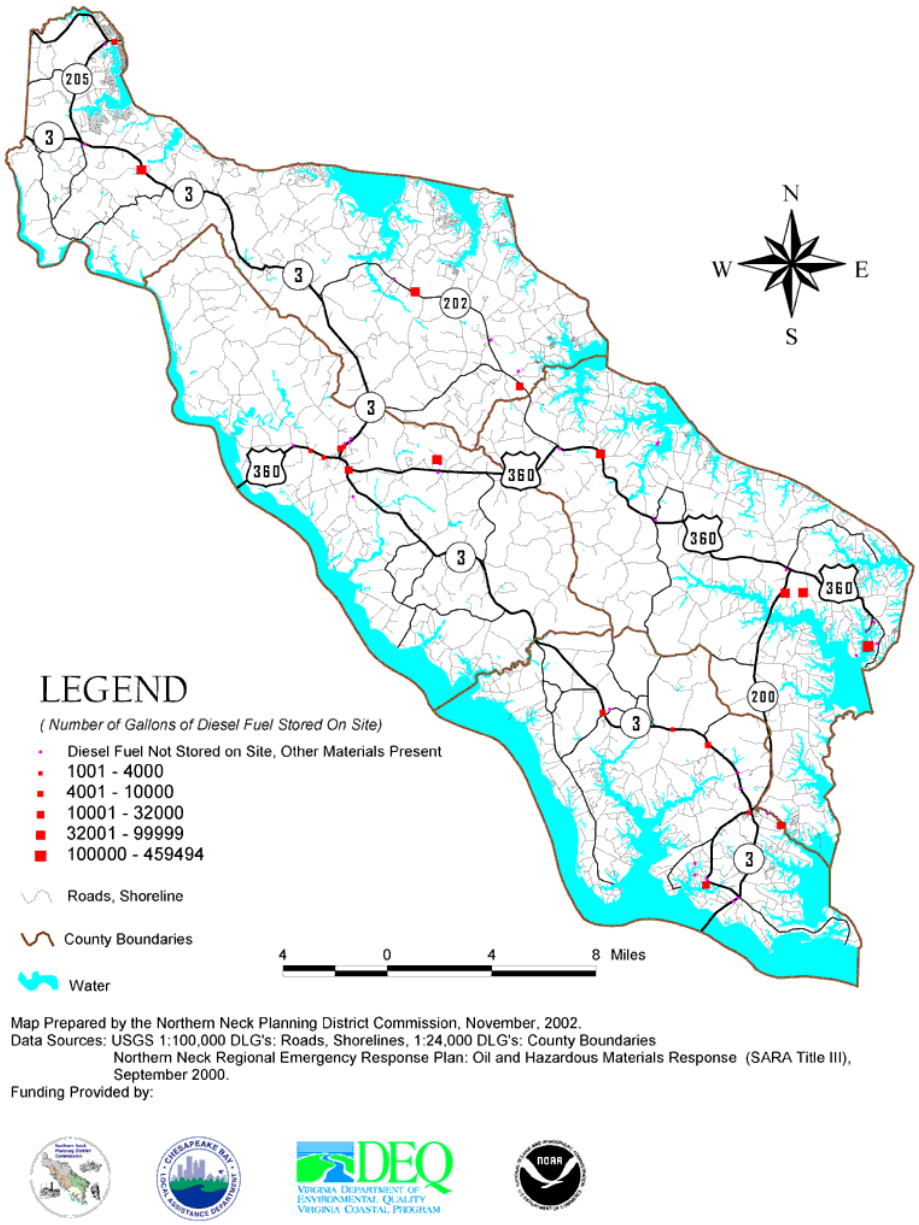


Figure 6-15. Known Diesel Storage Locations in the NN (taken from NNPDC, 2003b)

The Virginia Department of Environmental Quality required replacement of single-walled underground storage tanks (that meet minimum size requirements) by 1999, with double walled underground storage tanks. In addition, DEQ recommends that

Aboveground Storage Tanks (AST's) be used whenever possible, in conjunction with concrete containment areas underneath, to contain any spills or ruptures of the tank. The main advantage of AST's is that visual inspections can be performed relatively easily and frequently, and in the case of gasoline, odor can be an additional clue to leakage. In contrast, UST's do not show obvious signs of leakage while in-place, until a significant volume of its contents are noticed as missing (i.e., a notable decrease in time between fill) by that time, the damage to the surrounding soil, ground water and possibly surface has already occurred.

The regulations described above do not apply to home heating oil tanks, which also are not accounted for in the LUST assessment shown in **Figure 6-14**. The DEQ does not require homeowners to remove their oil tanks once they are no longer in use. It is likely there are many residential home heating oil tanks that are several decades old that could possibly leak on the Northern Neck. The DEQ encourages homeowners to remove the tanks and piping when upgrading their heating systems, however, the costs can range from $600 to $1,200. The cost of digging up and disposing of the home heating oil tanks may discourage homeowners from proper decommissioning of their tanks. As more residents upgrade their heating/air conditioning systems to electric heat pumps or propane, there is also the potential for the oil tanks to be "forgotten" and left in the ground. If the homeowner is not willing to remove the tank then DEQ recommends that, at the very least, the tank should be pumped dry, and filled with an inert substance (sand, gravel or cement slurry) to reduce the chance of collapse at a later date.

6.10.3 Permitted Landfills (Other Point Source Contamination)

Currently, no permitted landfills are operating in the Northern Neck (VDEQ, 2007d). There are five closed permitted landfills located in the NN (**Figure 6-16**): four closed permitted landfills are located in Westmoreland County (Baynesville Sanitary Landfill, Templeman Sanitary Landfill, Westmoreland County Landfill (Permit 161), Washington County Landfill (Permit 316); Northumberland County has one closed permitted landfill, Tri-County Sanitary Landfill (which is located within the drainage of two potential reservoir sites, discussed later in this WSP). Most of the landfills on the Northern Neck were permitted in the 1970's, and thus were not constructed, operated and closed in accordance with the current, relatively stringent, Virginia Solid Waste Management Regulations. More than likely, unless specific problems occur, these sites will never have monitoring wells installed.

Map Prepared by the Northern Neck Planning District Commission, November, 2002.
Data Sources: USGS 1:100,000 DLG's: Roads, Shorelines, 1:24,000 DLG's: County Boundaries, Westmoreland and Northumberland County Staff: Landfill Locations, December 2003.
Funding Provided by:

Figure 6-16. Locations of Permitted Landfills in the NN (taken from NNPDC, 2003b)

There are also many private waste dumps (used before solid waste regulations came into effect). Old landfills can leach harmful chemicals into the ground water, as rainwater percolates through them. Locating these private, un-permitted landfills is next to impossible, the only record of these dumps is from local knowledge, and those with the knowledge are not likely to divulge it, as they may be held liable in the future. Permitted landfills have some safeguards associated with them, so they are not as potentially dangerous as un-permitted illegal dumps.

6.10.4 Hazardous Waste and RCRA Sites (Other Point Source Contamination)

There is one site located in the NN that is registered with the U.S. EPA CERCLA Superfund program (USEPA, 2007a). The Arrowhead Associates/Scovill Corp site is located on 30 acres in the Town of Montross, Westmoreland County, Virginia (**Figure 6-11**). A relatively new Superfund site has been established in Lancaster County (Puddingland Site), however, no information is currently available from the U.S. EPA.

The Wood Preservers, Inc. (WPI) site, a high priority site under US EPA's Resource Conservation and Corrective Action (RCRA) program, is located near the Town of Warsaw, and is an operating wood treating facility (**Figure 6-17**).

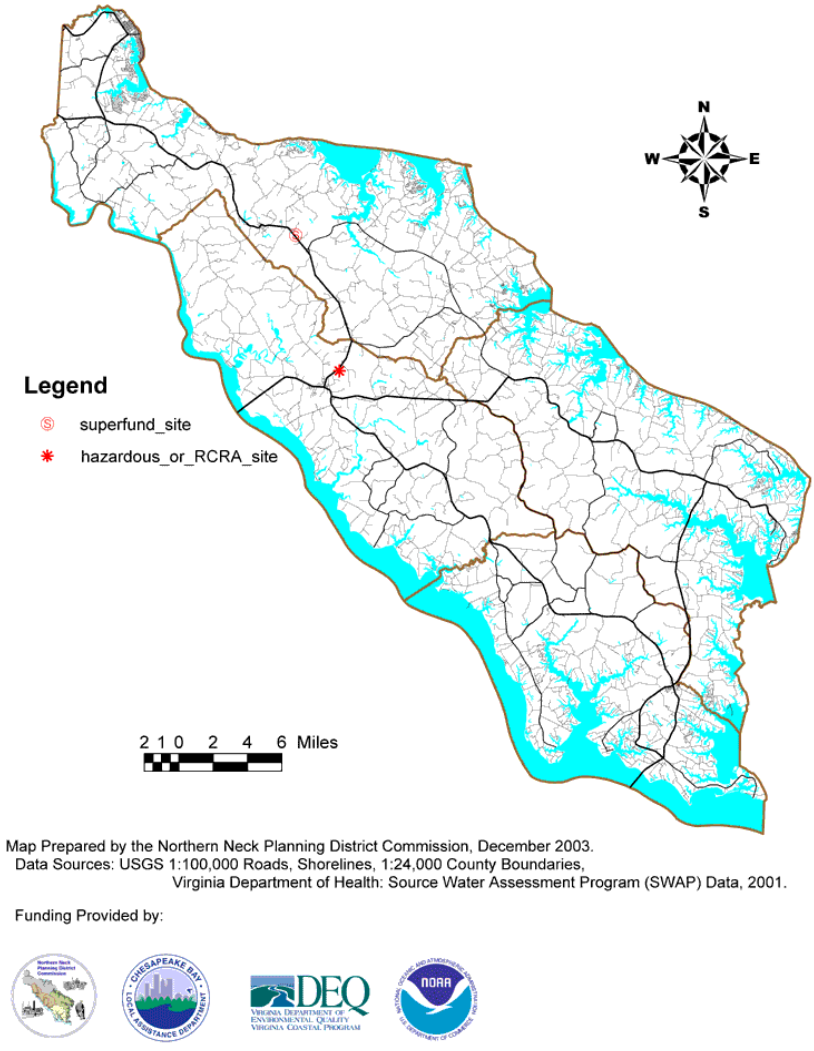


Figure 6-17. Locations of Superfund and RCRA Sites on the NN (taken from NNPDC, 2003b)

These known contaminated sites are in various stages of assessment and remediation, with multimedia impacts that present some level of risk to ground water and surface water resources in the vicinity. Further information on the Superfund site can be obtained from the U.S. Environmental Protection Agency, Region 3, website (USEPA, 2007a) (the Puddingland site may have information from EPA in the near future). Further information

on the RCRA site (and potentially others in the future) can be obtained from USEPA (2007b).

Regional water supply planning efforts from which new water sources or water infrastructure will be developed should review updated information from the US EPA regarding known contaminated sites that may be in the vicinity of the proposed source(s).

6.11 Potential Threats Other Than Those From Above.

6.11.1 Extra-Regional Ground Water Withdrawal

As noted earlier in this WSP, 100% of the public water supply in the NN is currently derived from ground water, highlighting the inherent value of ground water resources to the NN. The risks to ground water supplies include impacts on ground water availability, and ground water quality. As a side note, surface water resources are used primarily for commercial / industrial uses in the NN. While surface water reservoirs are highlighted as potential future water supplies for the NN, the primary focus herein will be on ground water resources and risks.

Approximately 75% of the NN populace derives potable water from artesian aquifers, with the remainder (~25%) relying on shallow wells completed in the unconfined water table aquifer. The artesian aquifers (see **Section 2.0**) are typically encountered between 200 and 900 feet below ground surface within the NN, depending upon the specific aquifer and the location at which a well is drilled.

The depth to ground water is increasing in the artesian aquifers in the NN, as evidenced by increasing depth to water in wells that derive water from the artesian aquifers. Note that the depth to ground water in a well reflects the potentiometric surface, but it is commonly referred to as the water level (i.e., as depth to ground water increases, the water level in a well is lowered). As discussed below, it is clear that an increasing depth to water in NN wells (i.e., lowering of the water level) is being caused by ground water being pumped from artesian aquifers faster than it can be replaced (recharged). Moreover, the primary sources of ground water withdrawal are located outside the jurisdictional boundaries of the NN.

<u>Primary Ground Water Withdrawals Occur from Sources Outside of the NN</u>
Total ground water withdrawal from wells located in the NN is minor when compared to withdrawals from the neighboring Middle Peninsula of Virginia to the south, and Southern Maryland. Recent accounting of total ground water withdrawal from the NN was approximately **<u>4.4 mgd</u>**. In comparison, total ground water withdrawals from the Middle Peninsula and Southern Maryland were **<u>27 and 43 mgd, respectively</u>** (MPPDC, 2002; Maryland, 2004). In other words, users on the Middle Peninsula of Virginia and Southern Maryland withdraw 6-fold to 10-fold, respectively, more ground water than the NN. The Middle Peninsula of Virginia and Southern Maryland (i.e., bounding the NN to the south and north, respectively) are projecting significant growth over the coming decades, and will likely increase ground water exploitation (MMPDC, 2002; Maryland, 2004).

Evidence of Ground Water Level Drawdown Outside the NN

Ground water withdrawals near West Point, Virginia (Middle Peninsula) are known to cause regional drawdown in the Aquia and Potomac aquifers (Harsh and Laczniak, 1999) and land subsidence as a result. The Town of West Point, King William County (Middle Peninsula) is home to the largest industrial ground water user in the region (Smurfit Stone Paper Mill). Ground water levels in the vicinity of the paper mill have been affected by pumping, with a steady decline since the 1930s (MPPDC, 2002). Due to relative proximity to West Point, Virginia (location of a major paper mill) Lancaster and southern Richmond Counties are most affected by these withdrawals.

Similarly, the USGS and Maryland Geological Survey (MGS) have reported significant ground water drawdown in the Aquia aquifer near Lexington Park, Maryland and Solomons Island, Maryland (refer to **Figure 6-18**, below), as well as notable ground water drawdown in the Middle Potomac (lower Patapsco) aquifer centered in Charles County, Maryland (Curtin and others, 1998a, 1998b, 2002, 2005).

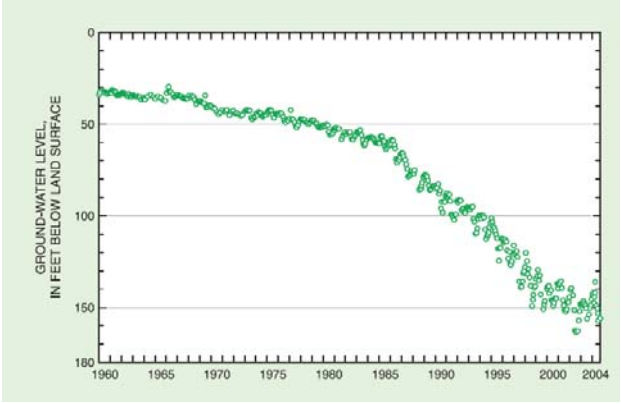


Figure 6-18: Example of Documented Decrease in Water Level in Maryland Since 1964, refer to Figure Caption (taken from Figure 7 of Gerhart and Cleaves, 2005)

Extra-Regional Withdrawals Lead to Ground Water Drawdown on the NN

The hydrogeologic framework in the NN is similar to that comprising the Middle Peninsula of Virginia, and Southern Maryland. Therefore, the relatively large volume of ground water withdrawal from extra-regional sources will affect ground water levels in the NN. **Figure 6-19** presents a schematic cross-section of the water level surface of the regional artesian aquifer system in the NN, and illustrates the effects of extra-regional water withdrawals on the ground water level (taken from NCPP, 2006). Note the steeply sloping "Water Level 2005" line near water withdrawal points at West Point, Va., and Lexington Park MD (**Figure 6-19**). Where ground water is drawn down toward a pumping well, a "cone of depression" is created.

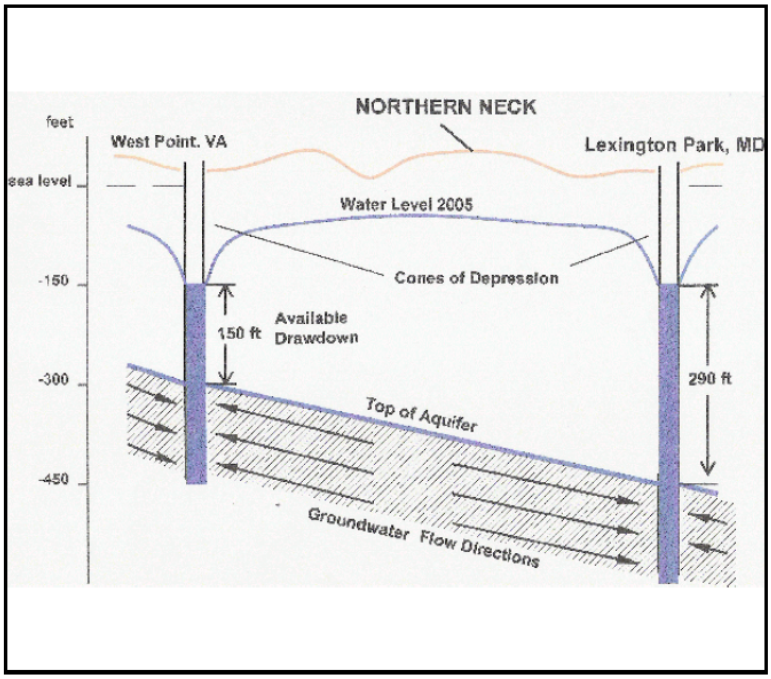


Figure 6-19: Schematic Cross Section Showing the Relationship of Extra-Regional Pumping and Drawdown on the NN Artesian Aquifer System (taken from NCCP, 2006, based on US Geological Survey Data)

As noted by Fletcher (NCPP, 2006):

> *The "Water Level" line approximates the level to which the internal pressure of the aquifer would push confined water up a well drilled into the aquifer, without pumping. The above data translate into approximately 2.5 ft/yr drawdown reduction at West Point and 3.5 ft/yr at Lexington Park. These figures may be higher with increased industrialization, commercialization and population growth in the Middle Peninsula and Southern Maryland.*

Correlation of Ground Water Drawdown Observations and Extra-Regional Withdrawals

From 1989 to 1999, the depth to ground water in the Brightseat-Upper Potomac aquifer (upper artesian aquifer) ranged from 45 to 65 feet below sea level (bsl) in Lancaster County (eastern NN), and was decreasing at a rate of 1.3 feet/year (Malcolm Pirnie, 2000). During this same time, in central Westmoreland County (west-central NN), depth to ground water in the Brightseat-Upper Potomac aquifer was approximately 17 feet bsl, and had also decreased about 1.5 feet/year between 1989 and 1999 (Malcolm Pirnie, 2000). In addition, depth to water in the Middle Potomac aquifer (primary artesian aquifer) averaged 28 feet below sea level in Westmoreland Co (west-central NN) and had decreased at 1.7 feet/year between 1989 and 1999 (Malcolm Pirnie, 2000).

Additional water level observations in Northumberland County document a decline of water levels in monitoring wells of the Northern Neck and Middle Peninsula (represented

by West Point data) for the Brightseat-Upper Potomac artesian aquifer, 1968 to 2004 (NCCP, 2006). As illustrated in **Figure 6-20**, below, the depth to ground water is increasing in USGS observation wells located in the NN and Middle Peninsula (represented by West Point data) that monitor the Brightseat-Upper Potomac aquifer (NCCP, 2006). USGS observation wells are located in Lancaster and Westmoreland Counties, but none are yet located in Richmond or Northumberland Counties. Based on models, the USGS estimates that water levels were about 30 feet above sea level before water began to be withdrawn beginning about the middle of the last century.Also, none of the wells are screened in the Yorktown-Eastover, Chicahominy - Piney Point, or Aquia aquifers. As noted in the recommendations section, later in this WSP, additional monitoring wells should be established in the NN.

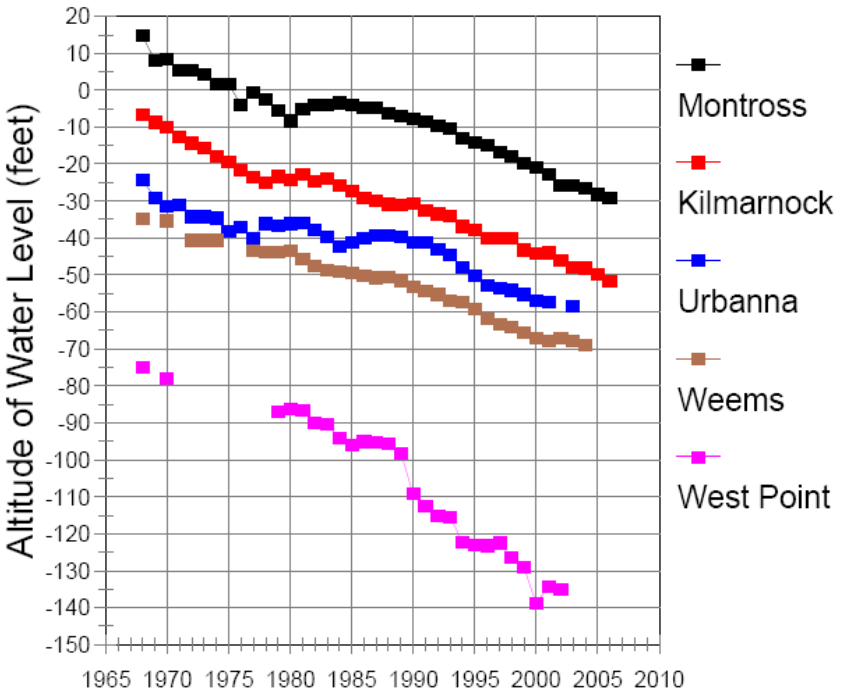


Figure 6-20: Decreasing Water Level in USGS Monitoring Wells on the NN and Middle Peninsula of Virginia (taken from F. W. Fletcher, 2005; based on US Geological Survey Data)

As noted by Fletcher (NCCP, 2006):

> *Because of the physics of aquifers and the measurements, these lines actually represent increasing drawdown over time at each location. If the pumping rate were constant over time, the trend lines would eventually approach horizontal.*

As shown in **Figure 6-21**, below, by extrapolating ground water drawdown from pumping near Lexington Park, Maryland, indicates that the NN (see red ellipse in **Figure 6-15**) experiences 40 feet of ground water lowering (drawdown) in the Aquia aquifer, and

20 feet in the middle-Potomac aquifer in parts of Westmoreland County (Curtin et al, 2002).

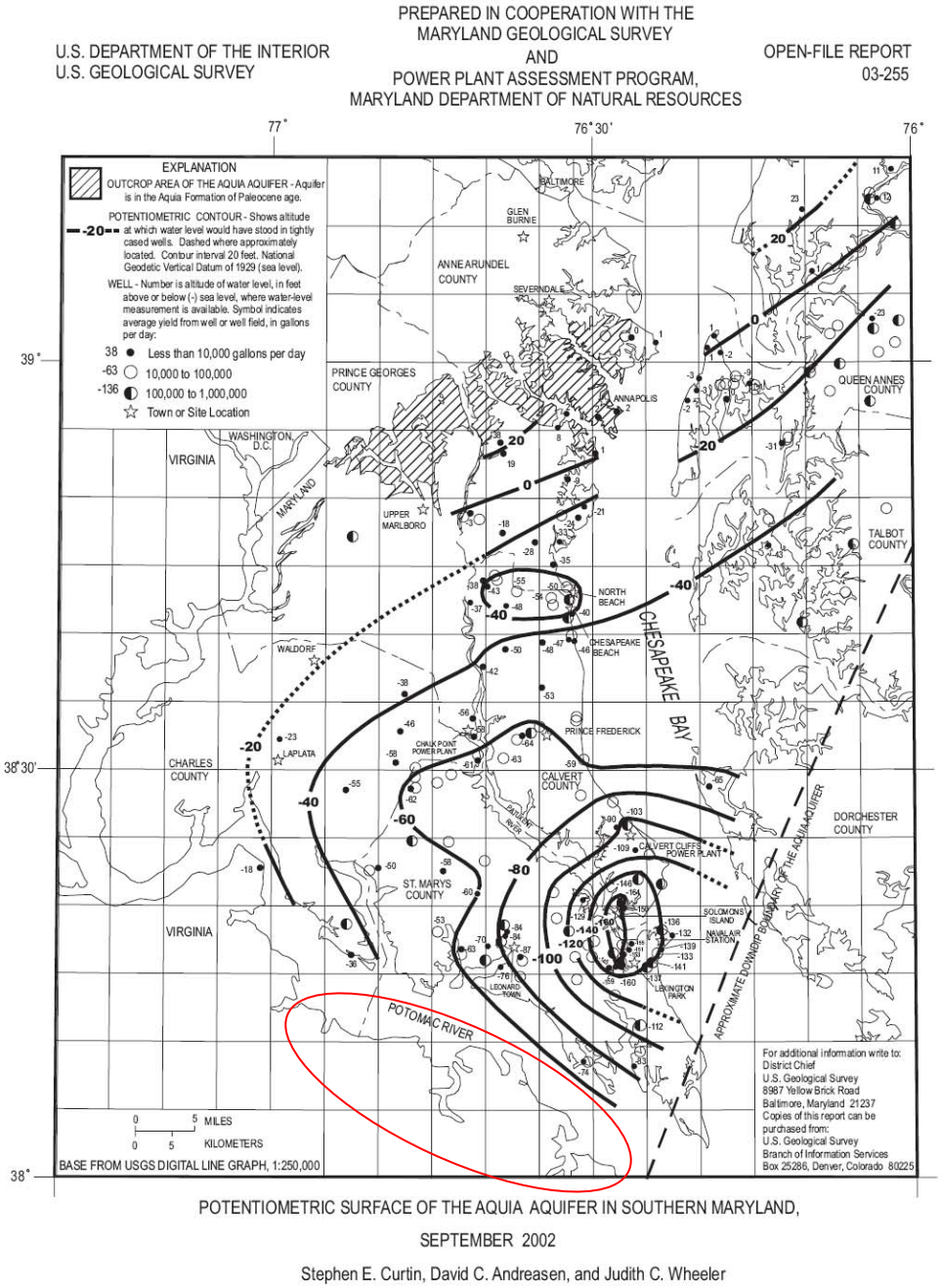


Figure 6-21: Ground water Potentiometric Surface Showing Cone of Depression from Pumping in Maryland, With Extrapolated 20 to 40 feet of Drawdown in Parts of the NN (Red Ellipse). (Figure modified from Curtin et al, 2002)

As noted by NAPS (2003a):

> *In the last three years, 63 artesian wells in Virginia along the Potomac River, immediately south of the cone of depression in Maryland, have*

> *gone dry. The wells were drilled many years ago, to depths of several hundred feet, using small diameter pipe. "Suction pumps" were installed, which are only capable of drawing water up from depths of about 30 feet. Water levels have dropped below the capability of the pumps, causing the wells to go dry. People are now forced to drill new, larger diameter, wells and use different kinds of pumps.*
>
> *Based on the distribution of the wells that have gone dry, there can be no doubt that withdrawals in southern Maryland are responsible. If local effects of the 2002 drought were responsible, wells would be uniformly scattered throughout the Northern Neck, not clustered just southwest of the cone of depression. The drought may, of course, have caused Marylanders to use more water.*

Summary of Risks to NN by Extra-Regional Ground Water Withdrawal

The discussion presented above documents that significant pumping of artesian ground water aquifers in the Middle Peninsula of Virginia and in Southern Maryland is causing significant ground water level drawdown in these areas, and across the NN. With the exception of drought years (i.e., 2002), abundant precipitation continues to fall on the NN to recharge the unconfined aquifer, and given sufficient time, the confined aquifer. However, water from the confined aquifers is being "mined" faster than it can be recharged, due to over-pumping. Over-pumping a confined (artesian) aquifer and "mining" water from the aquifer is not a sustainable practice.

The extra-regional water users withdraw 6-fold to 10-fold more water each day than the entire NN withdrawal. Furthermore, while growth and development in the NN can be characterized as minor, the Middle Peninsula of Virginia and Maryland (in particular) are anticipating significant growth. This will lead to further strain on the artesian aquifers underlying the NN from extra-regional withdrawals.

A concise statement regarding the current situation and difficulties associated with inter-jurisdictional regulation of finite resources is provided by NAPS (2003a):

> *"The fact that current usage of artesian water is not sustainable is an uncontested fact. The solution(s) to problems of over-utilizing finite resources are obviously difficult, and cross political boundaries. The time has come for regional planners to recognize that we cannot continue to "mine" our artesian water at the current rate. We must address this difficult issue on appropriate time scales, certainly more than a few decades. Ground water is a regional resource, not constrained by lines humans draw on maps. Water law can be simply stated: 'First in time is first in right.' Maryland" [and by extension the Middle Peninsula] "is doing nothing illegal in using the water first."*

There are short-term concerns for the NN regarding ground water withdrawal. When ground water is lowered in an aquifer, and therefore in a water supply well, the well must be telescoped and deepened, and the pump set lower in order to operate. At some point,

one cannot "telescope" the well casing deeper due to the limitation of minimum casing size versus pump size. At this point, a costly new well will need to be drilled. As discussed in this WSP, unsustainable ground water pumping that affects (and will likely continue to affect) the NN is primarily occurring from extra-regional sources outside the jurisdictional boundaries of the NN.

Furthermore, there are regional concerns about land subsidence on the order of 2 mm / year resulting from extra-regional ground water withdrawal. This degree of land subsidence may affect water front communities and businesses.

The 1992 Ground Water Management Act established criteria for the creation of Ground water Management Areas (GMA) in Virginia, which required those that withdraw more than 300,000 gallons of water per month to obtain permits. King William County (Middle Peninsula) is home to the largest industrial ground water user in the region, and is the only Middle Peninsula locality included in the GMA. The Act also required that previously exempted agricultural users acquire permits. The GMA should be extended to incorporate the entire Middle Peninsula and the NN.

Furthermore, while Maryland currently regulates ground water withdrawals for major water (prohibiting ground water levels from declining below an 80% management level), projected population and economic growth trends in Maryland (not to mention most of the Virginia Coastal Plan) will place more pressure on regional ground water resources that are already stressed. Additional ground water monitoring wells strategically located on the NN, and a comprehensive monitoring program for the NN, is required to assess the current and future threats to ground water quantity.

6.11.2 Natural Aquifer Contaminants

As discussed in **Section 2.0**, ground water underlying most of the NN is suitable for human consumption and most other uses. However, ground water from deeper artesian aquifers underlying certain regions of the NN (in particular the southeastern portions of the NN; see **Section 2.0**) exceed Federal or State standards with regard to the highly mineralized content of the water (see **Section 2.0**). This is, in part, due to the age of the ground water. Since the majority of the deep ground water on the Northern Neck is old water (thousands of years old or more), it has had time to take on the properties of the surrounding sediments. Dissolved solids and chlorides exceed State standards in the eastern parts of each aquifer. Other problems in the eastern sections of several of these aquifers, is high sulfate concentrations that exceed the US Environmental Protection Agency's (EPA) Secondary Maximum Contaminant Level (SMCL). Parts of the Chickahominy-Piney Point and Potomac aquifers have fluoride levels that exceed the US EPA Maximum Contaminant Level. Also, in localized regions, several aquifers exceed US EPA SMCL for pH. Continued extra-regional pumping of artesian aquifers may likely cause an increase in the salinity of ground water from these aquifers underlying the NN. Therefore, development of additional deep artesian wells for future water supply must assess and account for the potential that naturally-occurring poor water quality may limit the location and pumping rate of well(s) or require expensive treatment (distillation or reverse osmosis).

6.11.3 Septic Systems/Sewage Disposal

Individual homeowner and municipal sewage disposal systems can act to negatively impact ground water supplies. The aquifers most susceptible to contamination from individual sewage disposal systems are the Columbia and the unconfined water table part of the Yorktown-Eastover. Localized soil conditions such as high water tables and highly permeable soils in conjunction with large concentrations of septic systems can threaten the quality of the water table aquifers. An additional concern is the recently approved engineered wastewater treatment systems (see below). **Figure 6-22** shows locations and types of septic systems in the NN.

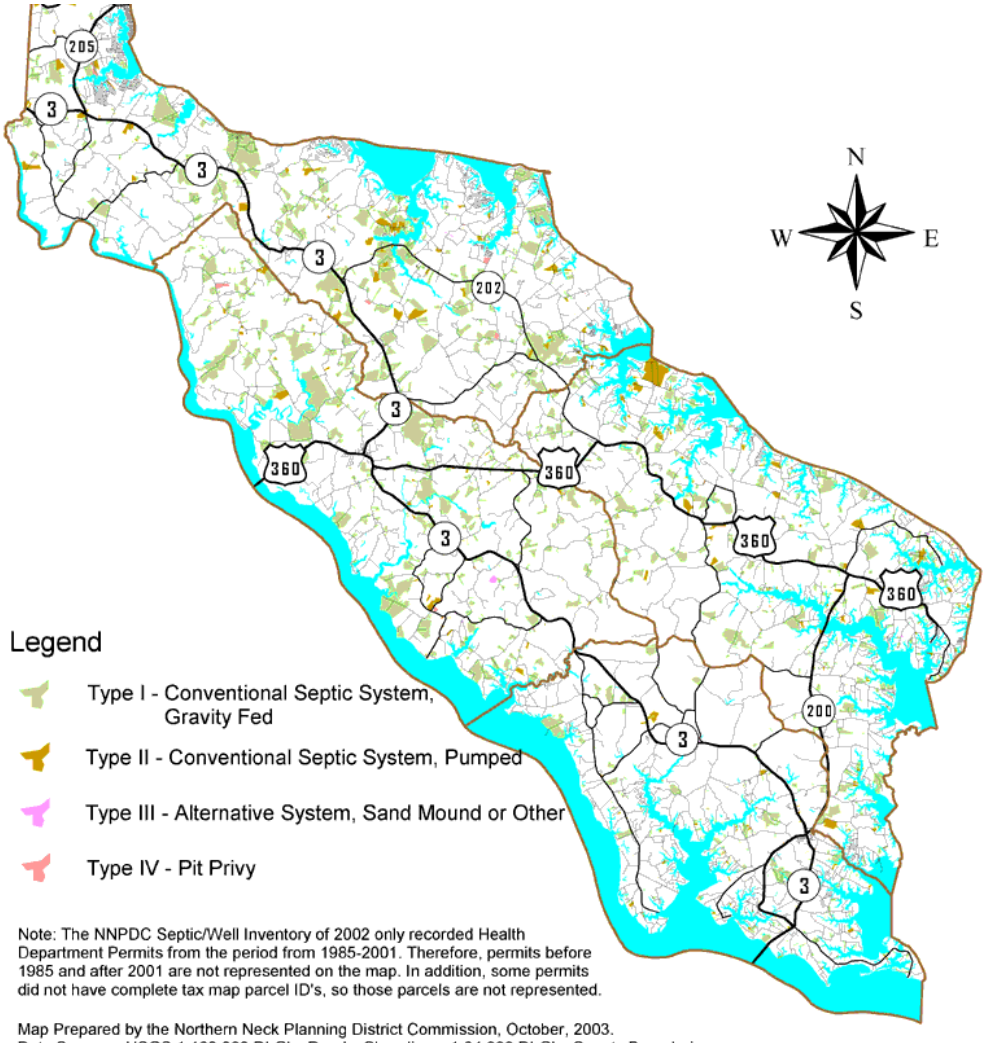


Figure 6-22. Septic Systems in the NN (taken from NNPDC, 2003b)

Sewage Lagoons are another potential source of ground water pollution, and they are located throughout the NN (**Figure 6-23**). All sewage lagoons are supposed to have an impermeable liner, however, some lagoons that are unlined may still exist. Unlined lagoons could lead to seepage of the sewage into underlying ground water aquifers.

Sewage sludge is the name for the solid, semisolid, or liquid materials removed during the treatment of domestic sewage in a treatment facility. Sewage sludge includes, but is 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.

Another problem with regard to sewage lagoons is a critical amount of freeboard (the amount of room from the liquid surface to the top of the containment wall) that a lagoon has before overflowing. If the freeboard is too small (i.e., the lagoon is full), storm events could result in overflow of the lagoon and impact to ground water and surface water, and direct impact to water wells. With full implementation of the Chesapeake Bay Act, including five-year inspection/pump out in all NN localities, it is anticipated that the amount of septage generated will increase. Since most sewage treatment plants in the NN will not accept more septage than they currently handle, it is possible the number of sewage lagoons will increase, if an alternative, cost-effective method of disposal is not found.

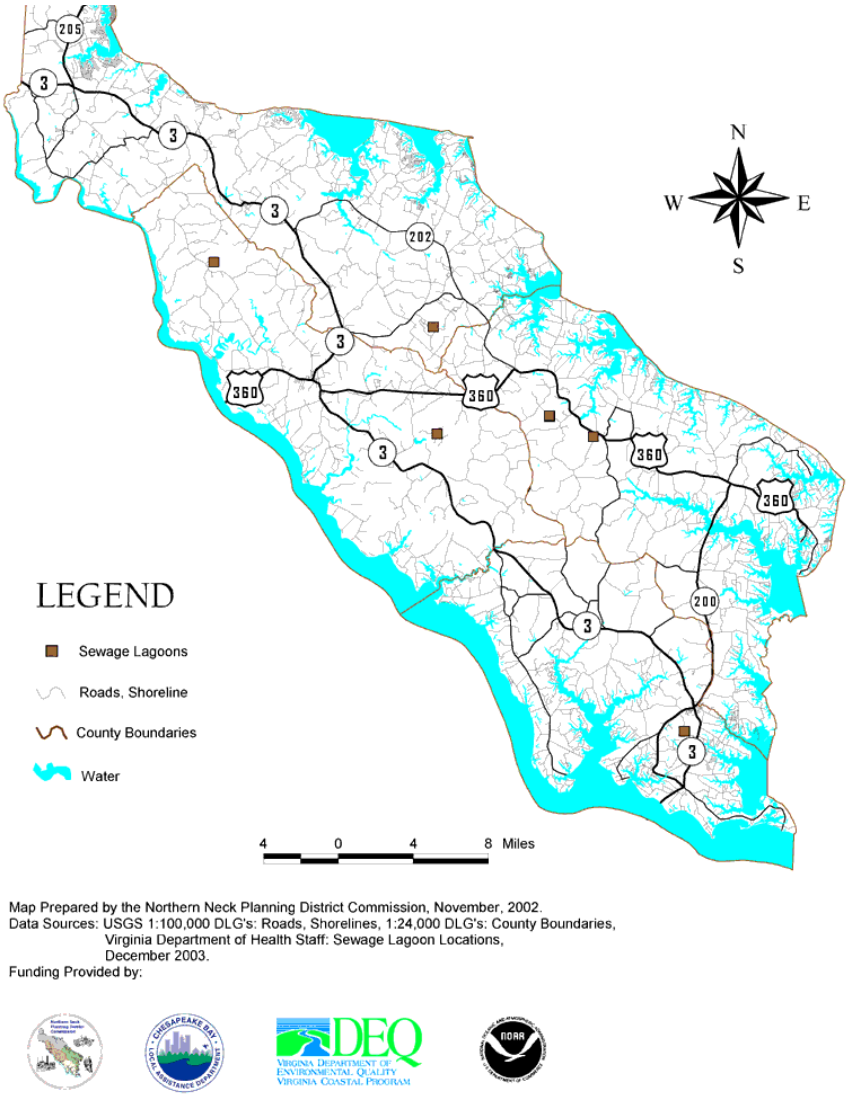


Figure 6-23. Sewage Lagoons in the NN (taken from NNPDC, 2003b)

Current water supplies that rely on the shallow ground water aquifer, and the likelihood for continued development of additional shallow aquifer water sources for individual homeowners (discussed later in this WSP) make it imperative that the potential for sewage impact to the shallow aquifer (and nearby surface waters) be monitored. Current VDH rules and regulations regarding siting and construction of drinking water wells help to mitigate potential impacts. However, many existing shallow wells are not constructed to current standards (SAIF, 2007).

6.11.4 Nitrate, Pesticide and Biosolids Loading

Non-point source pollution derived from the land application of nitrate, pesticides and biosolids (in addition to loading from septic and sewage systems) pose a risk to the quality of shallow unconfined ground water and surface waters. The following discussion highlights these non-point source pollution sources on the NN. Management and mitigation strategies for reducing land applications, or protecting water resources during application and subsequent leaching/run-off are highlighted in the Northern Neck Ground water Quality Management Plan (NNDPC, 2003b).

Nitrate and pesticide are of special concern in the NN, because of the predominance of agricultural land use, and the proliferation of On-site Sewage Disposal Systems (OSDS). **Figure 6-24** illustrates nitrate leaching potential of soils in the NN, while **Figure 6-25** illustrates pesticide leaching potential of soils in the NN. Review of these figures indicates that nitrate leachability potential is high throughout most of the NN, while pesticide leachability potential varies in apparent correspondence to areas with more developed farming activities.

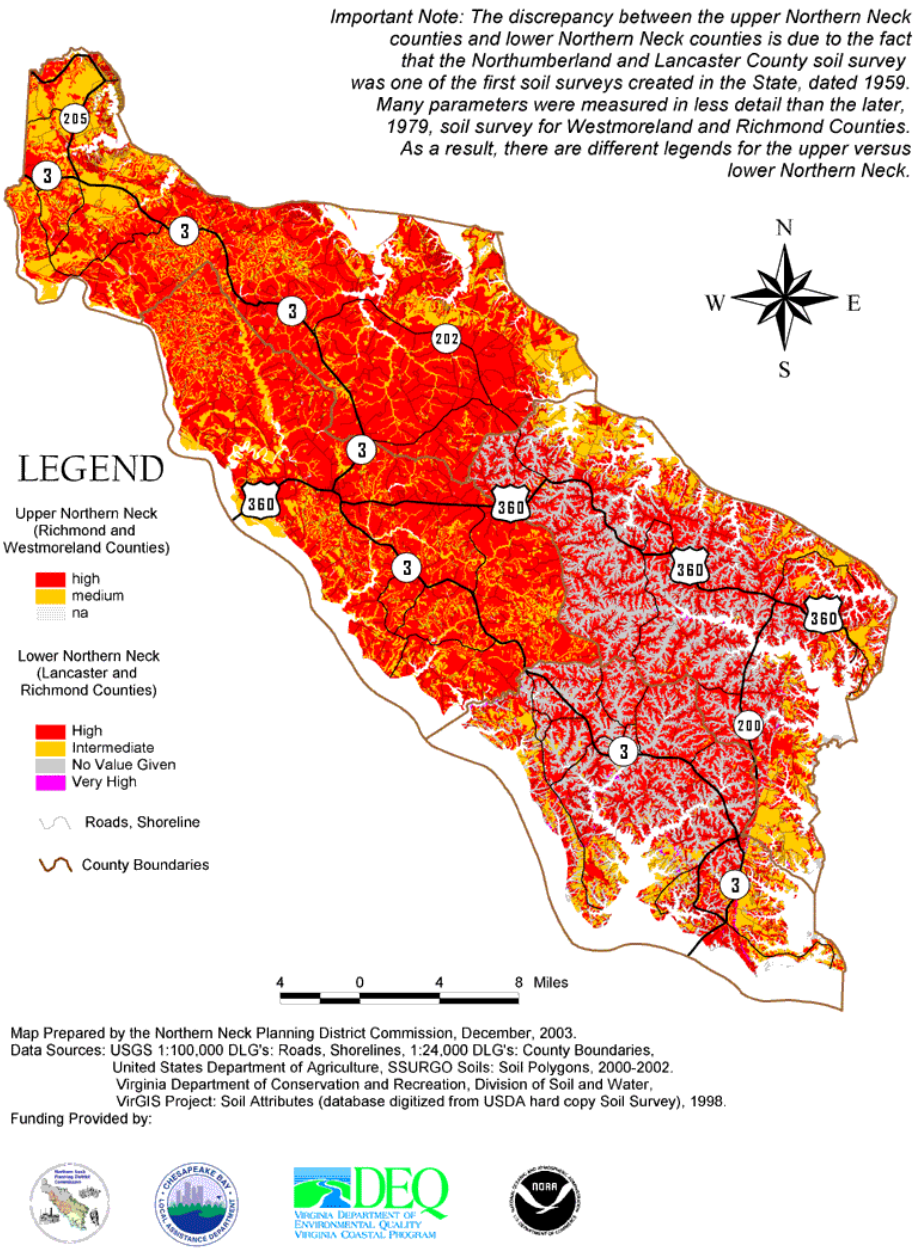
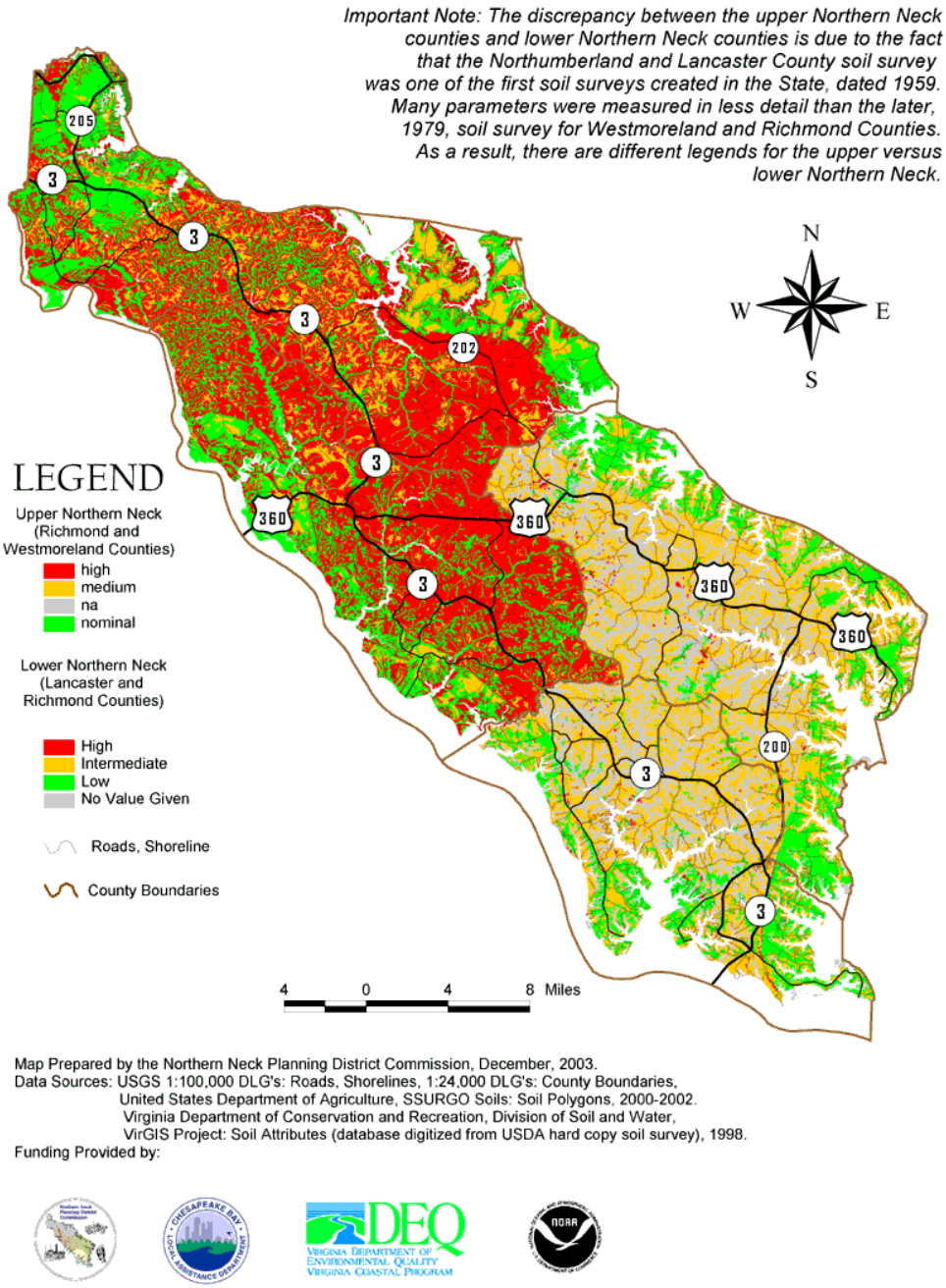


Figure 6-24. Nitrate Leachability Potential of Soils on the NN (taken from NNPDC, 2003b)



Map Prepared by the Northern Neck Planning District Commission, December, 2003.
Data Sources: USGS 1:100,000 DLG's: Roads, Shorelines, 1:24,000 DLG's: County Boundaries,
United States Department of Agriculture, SSURGO Soils: Soil Polygons, 2000-2002.
Virginia Department of Conservation and Recreation, Division of Soil and Water,
VirGIS Project: Soil Attributes (database digitized from USDA hard copy soil survey), 1998.
Funding Provided by:

Figure 6-25. Pesticide Leachability Potential of Soils on the NN (taken from NNPDC, 2003b)

Several studies have evaluated nitrate as a relation to number of OSDS per acre. There is a threshold of density of OSDS's, where they begin to become a large percentage of the recharge of the shallow ground water aquifer, and begin to elevate levels of nitrates above the EPA MCL of 10 mg/liter. These densities range from 0.36 acre to 1.5 acres per OSDS depending on the soils (NNPDC, 2003b). These densities could easily be reached in several waterfront subdivisions in the Northern Neck.

Most of these larger subdivisions are served by deeper artesian community wells, which limits (but does not eliminate) the threat of potable water contamination for these sources. Nearby residents outside the subdivision served by shallow wells, however, have a relatively higher potential for nitrate contaminated drinking water. In addition, the high nitrate ground water will eventually flow to the nearest waterway, and with additional efforts to reduce nutrients in the Chesapeake Bay Watershed, more scrutiny will be given to OSDS's, and their contribution to the overall nitrogen load. See the Northern Neck Water Quality Management Plan (NNPDC, 2003b) for recommendations on limiting the potential for nitrogen loading is presented in the recommendations section of the WSP.

Maintaining a green lawn is important to most homeowners, and many millions of dollars are spent nationwide to achieve that end. Studies indicate that 40-60% of homeowners apply fertilizer, pesticides, herbicides, fungicides and insecticides to their lawns, or hire a lawn care company to do the same. Samples of urban stream water in both dry weather and storm events have found a relatively wide range of herbicides and insecticides present, at the part per billion levels (NNPDC, 2003b). Many studies suggest that the application rates are higher on urban residential land than for agricultural lands. Most agree that homeowner education is the key to reducing the inputs of harmful chemicals into the aquatic system (NNPDC, 2003b).

Farmers in the NN have historically used biosolids (the solids leftover after wastewater treatment) to reduce the cost of crop production. Biosolids are used instead of fertilizer to supplant the nitrogen needs of the crops being grown. Biosolids are free to the farmer, whereas the price of inorganic fertilizer has risen steadily . The economic advantage of using biosolids is readily apparent, but the much larger pollution by nitrogen and phosphorus that occurs compared to chemical fertilizer must also be cost-accounted. Biosolids also add organic matter, which is sorely needed in the sandy soils of the NN.

There are also perceived disadvantages of biosolids, most having to do with improper land application. Applying biosolids to saturated soils, to steep land, before a rain event, less than the required 200 feet from a residence all may cause local water quality problems. The unknown constituents of biosolids are also suspect. Although a report on the "batch" of biosolids is required, no one knows what is actually inside each individual truck that is applying the solids to the land. Repeated applications of biosolids over the years may cause a buildup of heavy metals and/or toxic chemicals in the soil. Farm fields that have a seasonally high water table may also be problematic, and can act as a conduit to the shallow ground water aquifer. See the Northern Neck Water Quality Management Plan (NNPDC, 2003b) for further discussion on biosolids application in the NN.

6.11.5 Abandoned Wells

Proper abandonment of wells is extremely important to protecting the aquifer from contamination, whether it is a shallow or deep aquifer. With the long history of human habitation on the Northern Neck, no doubt there are many improperly abandoned wells throughout the countryside. Each of these improperly abandoned wells could lead to contamination of the aquifer, in fact, for many years people used abandoned wells to dispose of dead farm animals and household trash. Today, hopefully, NN citizens now know better than to put trash into unused wells.

The Virginia Department of Health requires proper abandonment of wells when property owners decide to replace the well. Unfortunately, due to staff limitations, these well closures are often not inspected to verify that the correct abandonment procedures are followed. Although proper well abandonment is the purview of the Virginia Department of Health, local governments can help reinforce the importance of proper well maintenance/abandonment by requiring property owners to identify wells on surveys, requiring abandonment of unused or old wells, and requiring property owners to report any abandoned wells on their property to the local Virginia Department of Health office for cataloging.

In the Northern Neck, most well replacement occurs when a shallow well stops producing quality potable water, or does not produce enough water to meet the user's needs. The new well, usually, is a deeper artesian well that taps into an underlying aquifer for either higher quality or quantity of water. Often, the landowner keeps the shallow well in operation for watering of lawns and gardens, since many of the deeper wells on the Northern Neck, with their higher levels of sodium and chlorides, are not good for irrigating plants. This shallow well is often not maintained properly, and eventually falls into disrepair. With the artesian aquifers in the Northern Neck in a steady state of decline, and no surface impoundments currently being constructed, the shallow aquifer may become more important as a primary source of potable water in the future for individual homeowners.

Early in water supply planning stages for a new source or related infrastructure, a field survey should be conducted in the vicinity of the proposed water source to ensure that no improperly abandoned wells are located nearby. Such wells would represent a high potential for direct pollution input to the aquifer(s) that the well boring encounters. Additionally, if water quality degradation is noted for a particular well that is currently installed and used on the NN, this observation should trigger a field survey to identify whether any improperly abandoned wells are located nearby.

6.11.6 Improper Disposal of Household Hazardous Waste

Due to tightened regulations and prohibitive costs, many rural counties no longer operate their own landfills to dispose of solid waste. In the Northern Neck each of the four counties has switched to waste transfer types of waste collection and disposal. Waste collected at these sites is then carried by a waste carrier to a large regional landfill in King & Queen County. However, due to limitations on the type of waste accepted by the regional landfill and the high costs of collection and proper disposal of household

hazardous waste (including used motor oil, paint thinners, solvents, antifreeze, etc.), improper means for disposing of this type of waste may occur, which in turn becomes a threat to ground water supplies.

6.11.7 A Focus on the Shallow Unconfined Aquifer

The NN recognizes the shallow unconfined aquifer as being a significant ground water supply for private residential and domestic needs. The upper water table aquifers, the Columbia and the Yorktown Eastover Aquifer, are most susceptible to contamination. The threats to ground water quality listed above are of particular concern for the shallow, unconfined aquifer. The preceding discussion in this section of the WSP highlighted several potential pollution sources that may (are) affect the shallow ground water aquifer.

Furthermore, pollution from the sources discussed above can directly infiltrate a private home water system that is not property constructed (i.e., not properly cased or grouted). This is particularly the case if the well and septic system were constructed before modern Health Department regulations (with a minimum separation distance of 100 feet).

SAIF Water Wells, Inc., an organization that is conducting a significant amount of work in the NN focusing on safety and viability of water wells that withdraw ground water from the shallow unconfined aquifer, has presented a briefing on the shallow aquifer water quality and important management aspects for maintaining shallow wells for domestic use (**Appendix I**).

7.0 WATER DEMAND PROJECTION

Future water demand projections were prepared for community water sources in the Planning Region, and estimates were calculated for small self-suppliers. Additionally, future water use of large self-suppliers is discussed. A discussion on the information and methodology used for water demand projections is presented, followed by results and conclusions.

7.1 Introduction

Future water demand projections were calculated using a per-capita method, including population forecasting, assumptions on customers served, and water use practices (AWWA, 2001). Current population calculations were completed for each county in the Planning Region. The total population of the planning region was used to project water demand in the community systems in aggregate volume.

At the time this water supply plan (WSP) was developed, no data were readily available to evaluate disaggregated water use in each community system or county (see **Sections 4.1 and 5.1**). Calculations for water demand projection were based on all available data from survey responses, DEQ and VDH records. A discussion on data collection efforts, limitations and results for the regional WSP was presented in **Section 3.6**.

An aggregate water demand projection for residential self-supplied sources (withdrawing <300,000 gal/mo) was estimated based on similar methodology followed for the community systems.

Large, self-supplied sources (withdrawing >300,000 gal/mo) did not provide sufficient data to allow for a detailed analysis of future water demand. Current water use was estimated for agricultural and non-agricultural users. Only three of the six large self-suppliers identified in the Planning Region responded the survey. DEQ and VDH records were used to estimate water use for the remaining suppliers. Assumptions are presented later in this section for projected water demand.

For the purposes of this WSP, a one hundred year planning period was undertaken (2007 to 2107). The Northern Neck Regional Water Supply Steering Committee (Committee) requested a 100-year planning period to better plan for potential ground water supply deficits due to the impact of extra-regional users. In the Planning Region, ground water resources are impacted by Southern Maryland and the Middle Peninsula of Virginia. Since all community water systems in the Planning Region utilize ground water, any significant change in well yields could severely impact water supplies. A long-term planning period serves to identify the framework in which the new water supply planning efforts should consider, given stresses placed on ground water aquifers underlying the Planning Region.

7.2 Population Projections

The method used to project water demand for community water sources was based on an analysis of population trends, and forecasting in the Planning Region's localities. The per-capita method for demand projection was then applied following the Water Resources Planning Manual of the American Water Works Association (AWWA, 2001). Population data for the Planning Region (including the counties of Lancaster, Northumberland, Richmond and Westmoreland and incorporated towns) were obtained from the decennial census and population estimates of the U.S. Census Bureau's website (U.S. Census Bureau, 2009) and State Demographer Projections (Virginia Employment Commission, 2009). Linear projections of population were used as a surrogate determinant for water demand. More details about the assumptions used are provided in the following subsections.

The per-capita method is considered sufficient for the goal of forecasting the average annual demand (AWWA Manual, 2001). This forecasting method, using simple linear regression, is also recommended due to the long-term forecasting (more than 30 yrs), and the limited data on disaggregated uses. Moreover, per capita models produce satisfactory results as long as the distribution of consumer classes does not change substantially (AWWA Manual, 2001). This is the case of the community water sources in the Northern Neck, which serve primarily residential users.

7.2.1 Population Data

Population trend data for the counties in the Planning Region were taken from the decennial census, U.S. Census Bureau's estimates for 2007, and population projections (State Demographer Projections) found on the websites of the U.S. Census Bureau and the Virginia Employment Commission (VEC). The U.S. Census Bureau provides annual population estimates going back to the year 1970. Additionally, the VEC has a new on-line feature that includes community profiles, in the form of electronic brochures. Summaries of population trends for the Planning Region counties are provided in the brochures (**Appendix J**), which are used to compare population trend estimates calculated herein.

Another reliable source of population data is the Weldon Cooper Center at the University of Virginia. The Weldon Cooper Center is an organization that specializes in collecting, organizing, and projecting population data in the Commonwealth of Virginia. This Center makes available the census data, and yearly intercensal estimates, from 1960 through the current estimate for 2008.

There are slight variations between the population data from the Weldon Cooper Center and the U.S. Census Bureau. A comparative analysis of both data sources for the Planning Region was conducted using data and estimates from the year 1960 through year 2030. The linear regression analysis used data starting from 1960, given the clear population patterns starting in this decade across all localities in the Planning Region. The post-1960 trends can be explained by increased economic growth, the integration of the counties to the local and regional economy, and a broader national trend. Another reason to select the range of years starting in 1960 was the initial comparative analysis

relative to the Weldon Cooper data, which is available online for years 1960 through the present.

Linear regression of both data sets indicated that U.S. Census Bureau and State Demographer data demonstrated slightly higher correlation (i.e., larger correlation coefficient) than the Weldon Cooper data, and are preferred for use in county population trends and projections.

However, Weldon Cooper data were used in this particular WSP, for the population trend analysis of the incorporated towns in the WSP region. The reason is that the needed level of disaggregated data was not readily available through the U.S. Census Bureau, where the common units of analysis for the aggregated downloadable data are the census track, the county, and the city. Community profile brochures are only available at the county and city levels. Population in the incorporated towns was added to the county data, in which the town is located.

7.2.1.1 Population Trend Data

Tables 7-1 through 7-4 list the population trend data for the counties and incorporated towns in the Planning Region. The third column in the tables indicates the percentage increase or decrease in population. State Demographer projections were only available through the year 2030. For the purposes of this WSP, the data were extrapolated to the year 2107 (i.e., a 100-year planning period as requested by the Committee, using the trend shown in previous decennial census and population estimates from the U.S. Census Bureau.

Table 7-1. Lancaster County Population Trend Data[+]

Year	Population	% change from previous date population
1990*	12,884	
2000*	13,842	7%
2007**	13,715	-1%
2010***	13,628	-1%
2020***	13,503	-1%
2030***	13,387	-1%

[+] Includes population of the incorporated towns of Colonial Beach, Kilmarnock, and White Stone (Weldon Cooper Center)
* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)

Table 7-2. Northumberland County Population Trend Data

Year	Population	% change from previous date population
1990*	10,524	
2000*	12,259	16%
2007**	12,897	5%
2010***	13,420	4%
2020***	14,587	9%
2030***	15,821	8%

* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)

Table 7-3. Richmond County Population Trend Data[+]

Year	Population	% change from previous date population
1990*	8,242	
2000*	10,184	24%
2007**	10,532	3%
2010***	10,682	1%
2020***	11,228	5%
2030***	11,818	5%

[+] Includes population of the incorporated town of Warsaw (Weldon Cooper Center)
* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)

Table 7-4. Westmoreland County Population Trend Data

Year	Population	% change from previous date population
1990*	18,994	
2000*	20,261	7%
2007**	21,277	5%
2010***	21,836	3%
2020***	23,849	9%
2030***	25,933	9%

[+] Includes population of the incorporated towns of Colonial Beach and Montross (Weldon Cooper Center)
* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)

The data for each county in the Planning Region were plotted and a trend line established according to the data (**Tables 7-1 through 7-4**).

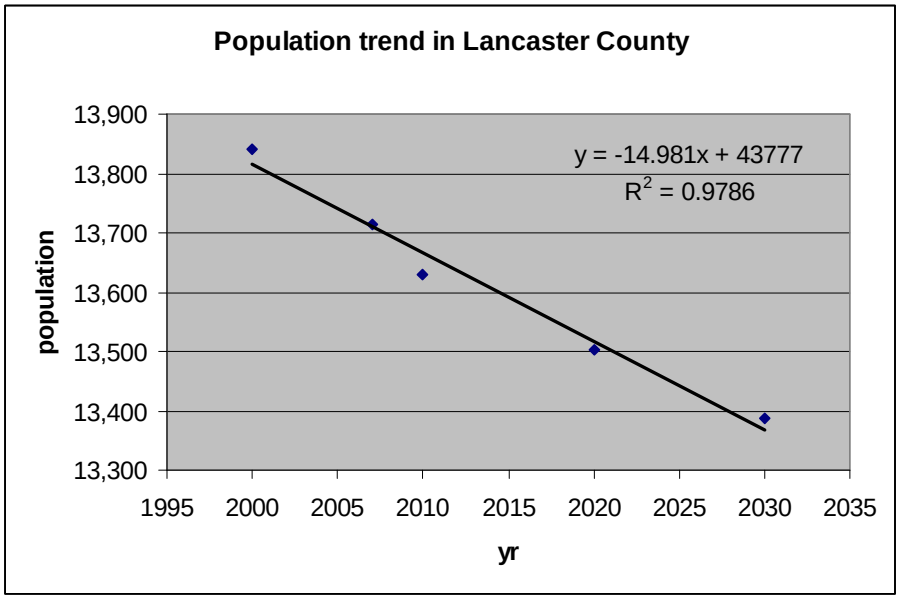


Figure 7-1. Population Trend Graph for Lancaster County.

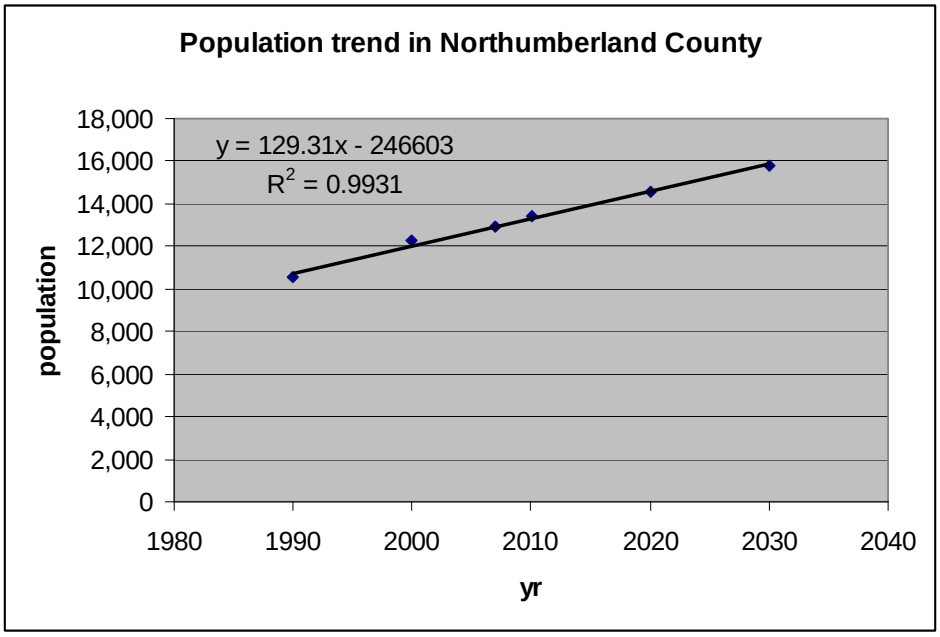


Figure 7-2. Population Trend Graph for Northumberland County

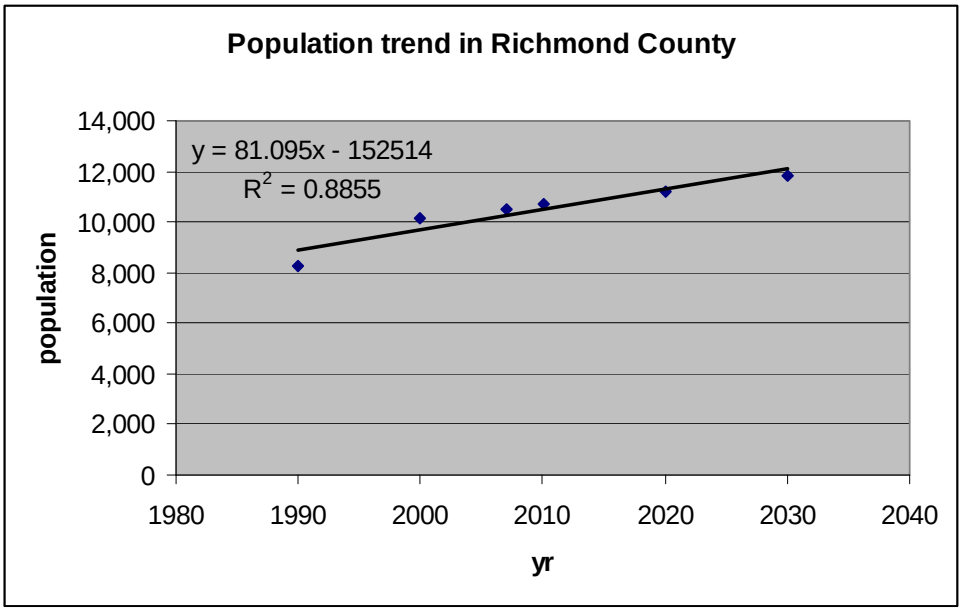


Figure 7-3. Population Trend Graph for Richmond County

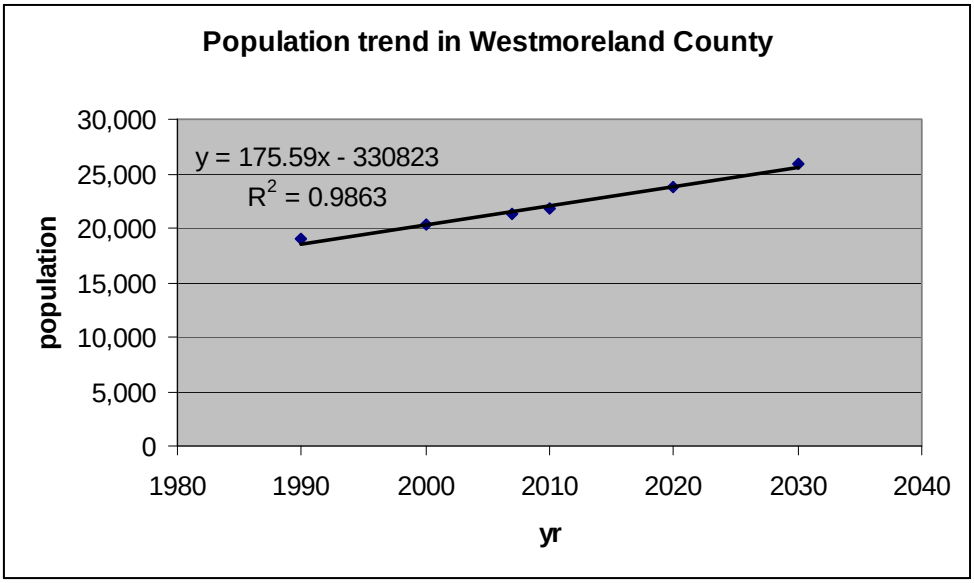


Figure 7-4. Population Trend Graph for Westmoreland County

7.2.1.2 Extrapolation of Population Trends Through Year 2107 (Planning Period)

Extrapolation of population trend data beyond year 2030 was used to project population through the planning period ending 2107. As mentioned earlier, this long-term planning period was requested by the Northern Neck Regional Water Supply Steering Committee ground water since resources in the WSP Planning Region are impacted by extra-regional users. The equations for each trend line (shown in **Figures 7-1 through 7-4**) were used to generate the population projections at the beginning of each decade from 2040 through 2107 (highlighted, bold text in **Tables 7-5 through 7-8**).

Table 7-5. Lancaster County Population Estimates to Year 2107

Year	Population	% change from previous date population
1990*	12,884	
2000*	13,842	7%
2007**	13,715	-1%
2010***	13,628	-1%
2020***	13,503	-1%
2030***	13,387	-1%
2040+	**13,217**	**-1%**
2050+	**13,083**	**-1%**
2060+	**12,950**	**-1%**
2070+	**12,805**	**-1%**
2080+	**12,659**	**-1%**
2090+	**12,525**	**-1%**
2100+	**12,382**	**-1%**
2107+	**12,282**	**-1%**

* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)
+ Extrapolations

Table 7-6. Northumberland County Population Estimates to Year 2107

Year	Population	% change from previous date population
1990*	10,524	
2000*	12,259	16%
2007**	12,897	5%
2010***	13,420	4%
2020***	14,587	9%
2030***	15,821	8%
2040+	**17,195**	**9%**
2050+	**18,361**	**7%**
2060+	**19,655**	**7%**
2070+	**20,894**	**6%**
2080+	**22,172**	**6%**
2090+	**23,431**	**6%**
2100+	**24,669**	**5%**
2107+	**25,567**	**4%**

* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)
+ Extrapolations

Table 7-7. Richmond County Population Estimates to Year 2107

Year	Population	% change from previous date population
1990*	8,242	
2000*	10,184	24%
2007**	10,532	3%
2010***	10,682	1%
2020***	11,228	5%
2030***	11,818	5%
2040+	**12,921**	**9%**
2050+	**13,346**	**3%**
2060+	**14,063**	**5%**
2070+	**14,780**	**5%**
2080+	**15,518**	**5%**
2090+	**16,220**	**4%**
2100+	**16,848**	**4%**
2107+	**17,389**	**3%**

* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)
+ Extrapolations

Table 7-8. Westmoreland County Population Estimates to Year 2107

Year	Population	% change from previous date population
1990*	18,994	
2000*	20,261	7%
2007**	21,277	5%
2010***	21,836	3%
2020***	23,849	9%
2030***	25,933	9%
2040+	**27,381**	**6%**
2050+	**29,379**	**7%**
2060+	**31,294**	**7%**
2070+	**33,145**	**6%**
2080+	**34,953**	**5%**
2090+	**36,778**	**5%**
2100+	**38,711**	**5%**
2107+	**39,979**	**3%**

* Decennial Census (US Census Bureau)
** Estimate (US Census Bureau)
*** State Demographer Projections (Virginia Employment Commission)
+ Extrapolations

7.2.1.3 Summary and Discussion of Population Trends in the Planning Region

Table 7-9 summarizes projected population in the Planning Region through year 2107. The U.S. Census Bureau population projections for year 2010 are included as a baseline for comparison of population trends.

Table 7-9. Projected Population for the Planning Region+

Locality+	Population in 2010	Population in 2107	Percentage of total population in 2107 (%)	Change from 2010 population (%)
Lancaster County	13,628	12,282	13	-10%
Northumberland County	13,420	25,567	27	91%
Richmond County	10,682	17,389	18	63%
Westmoreland County	21,836	39,979	42	83%
TOTAL	**59,567**	**95,216**	**100**	**60%**

+ Includes incorporated towns.

Population trends for the Planning Region, as depicted in graphs and tables in the previous section, are similar to trends shown in the community profile brochures (**Appendix J**) developed by the VEC (Virginia Employment Commission, 2009). This suggests that the population projections presented here are reasonably representative of anticipated future conditions in the Planning Region. Population data in the community profile brochures do not include the most recent population estimates for 2007, which were used in this WSP. The 2007 estimates cause the slight variation between the

community profile brochures and the population analysis presented here. However, similar trends across all counties in the Planning Region prevail in both analyses.

Westmoreland County is the most populous of the four counties in the Planning Region, with roughly 40% of the region's population. Population is next highest in Northumberland County, followed by Lancaster and Richmond counties (**Table 7-9**). Overall population in the Planning Region is expected to increase by approximately 60% during the Planning Period (**Table 7-9**).

Most of the Northern Neck planning district's growth from 1990 to 1996 was due to net immigration, as opposed to a natural increase. The Northern Neck is significantly affected by seasonal population fluctuations due to tourism, part-time residents and seasonal jobs.

Table 7-10 presents the population trend in the Planning Region during the planning period as compared to population trends in the Commonwealth of Virginia. Virginia population trend and projections followed the same linear regression methodology and data sources discussed in this section for the counties in the Planning Region. Population values show a consistently increasing population. The percentage change of the aggregated population is affected by differences in the rate of growth among counties. Overall, the Northern Neck growth rate is smaller than the corresponding state number.

Table 7-10. Estimated population trends in the Northern Neck and the Commonwealth of Virginia

Year	Northern Neck population (counties and towns)	Change from previous estimate (%)	Virginia	Change from previous estimate (%)
1990	50,644		6,189,317	
2000	56,546	12%	7,079,030	14%
2007	58,421	3%	7,698,775	9%
2010	59,567	2%	8,010,239	4%
2020	63,166	6%	8,917,396	11%
2030	66,959	6%	9,825,019	10%
2040	70,714	6%	10,551,220	7%
2050	74,169	5%	11,397,654	8%
2060	77,962	5%	12,343,011	8%
2070	81,623	5%	13,215,233	7%
2080	85,302	5%	14,068,075	6%
2090	88,954	4%	14,935,152	6%
2100	92,610	4%	15,783,591	6%
2107	95,216	3%	16,386,956	4%

7.3 Water Demand Projection

The following discussion presents water demand projections for community water systems and small self-supplied users in the Planning Region. A 100-year planning period was recommended by the Committee, as discussed previously. Insufficient data were provided by large (>300,000 gal/mo) self-supplied users in the water supply planning effort to provide a systematic demand projection, as discussed below.

Water demand projection was conducted using a per-capita method (AWWA, 2001). The per-capita approach is considered sufficient for the goal of forecasting an average annual demand using simple linear regression, considering the long-term forecasting (more than 30 yrs), and the relatively limited data available on disaggregated uses (AWWA, 2001). Per capita models produce satisfactory results as long as the distribution of consumer classes does not change substantially (AWWA Manual, 2001). This is the case of the community water sources in the Planning Region, which primarily serve residential users.

Total population projected through the planning period was segregated into a community supplied population, and a residential self-supplied population. Data from VDH and community supplier surveys (obtained at the time of this plan preparation) provide an estimate of the Planning Region population served by community systems. The difference between total population and community supplied population was assumed to represent the Planning Region population that is served by private wells. This differential in service population was projected into the future to estimate water demand. It is noted that 100% of community water sources in the Planning Region are derived from ground water.

Community and small self-supplied water demand projections were calculated from service population projected to 2107, multiplied by a per capita water use value of 75 gal/ person/ day (gpd/p) (VDH sewerage design criteria; USGS, 1995). Screening analysis of different per-capita water use values was conducted and discussed with the Committee and VDEQ in order to select the most representative per-capita use value for the Planning Region. Per-capita values of 94 gpd/p (Virginia Water Works Regulations), and 59 gpd/p (EEE estimate from community system data) were considered and discussed with the Committee and VDEQ. Ultimately, in consultation with VDEQ, the value of 75 gpd/p was selected as the regional estimate.

General assumptions were made in the water demand projections to overcome data gaps. The first assumption was that water use practices would not vary significantly over the Planning Period (i.e., the per-capita use would not change significantly, merely the number of people and organizations in the Planning Region). The second assumption was that growth in Planning Region would be distributed evenly, affecting the community systems as per population percentages. The third assumption is that relative difference in community population and the population served by private wells would not change significantly over the planning period. While there is insufficient data available to refine these assumptions, the relative limitations and potential risk to long-term demand

projections will be addressed in the Statement of Need portion on this WSP (for example, due to the long time frame of this WSP, it is reasonable to expect that new community systems and extensions of existing community systems will supplant some number of private wells, thus changing the relative percentages of population service). The projected water demand will be reviewed at each 5-year Water Supply Planning update, and the percentages of small, self-supplied users and community users will be updated, along with the projected water demand.

No data were readily available at the time of plan preparation to evaluate disaggregated water demand for community or self-supplied water systems in the Planning Region (see **Sections 4.1 and 5.1**). Therefore, aggregate community water demand, and small self-supplied demand are presented in this WSP.

7.3.1 Projected Community Water Demand

Approximately 50% of the Planning Region population is served by community water sources (see **Section 4.0 and Section 5.0**). Hence, **Table 7-11** lists the estimated population served by community systems (calculated as 50% of the total projected population from **Table 7-10**). These numbers are multiplied by the per-capita water use factor of 75 gpd/p to estimate the corresponding community water demand.

Table 7-11. Estimated population served by community systems and their estimated water demand

Year	Planning Region Population	Estimated population served by community systems*	Water demand (MGD)**
1990	50,644	25,322	1.90
2000	56,546	28,273	2.12
2007	58,421	29,211	2.19
2010	59,567	29,784	2.23
2020	63,166	31,583	2.37
2030	66,959	33,479	2.51
2040	70,714	35,357	2.65
2050	74,169	37,085	2.78
2060	77,962	38,981	2.92
2070	81,623	40,811	3.06
2080	85,302	42,651	3.20
2090	88,954	44,477	3.34
2100	92,610	46,305	3.47
2107	**95,216**	**47,608**	**3.57**

* Approximately 50% of the Planning Region population is served by community systems

** Results from multiplying estimated served population by the per-capita water use factor of 75 gal/ person/ day

The total projected water demand for community systems in the Planning Region by year 2107 is 3.57 MGD.

The projected demand listed in **Table 7-11** for 2007 is 2.19 MGD, which can serve as a calibration point for the projections. Based upon DEQ Water Withdrawal Reporting data (**Section 5.0**), 2007 ground water withdrawal by community sources was 2.0 mgd. This value is similar to the 2007 result listed in **Table 7-11**, suggesting that the community demand projections are representative, given the assumptions presented previously.

This projected water demand for community sources will be refined in the Demand Management discussion (**Section 8** of the full WSP) to take into account water savings derived from demand management measurements. The refined water projection results will then be used to determine if alternative water sources must be evaluated and developed. The analysis will conclude with a statement of need based on refined water projections for community systems and small self-suppliers, discussion of general trends among large self-suppliers, and expected future growth in the region.

7.3.2 Demand Projection for Small Self-Supplied Sources (<300,000 gal/month)

An aggregate water demand projection for small residential self-supplied sources (withdrawing <300,000 gal/mo) was estimated based on methodology similar to that followed for the community systems. As noted, approximately 50% of the Planning Region residents are supplied by community water systems (S**ection 4.0 and Section 5.0)**. The assumption follows that the residents not served by community water systems obtain water from private individual wells. Thus, approximately 50% of the population is self-supplied.

Table 7-12 lists the estimated self-supplied residential population (calculated as 50% of the total projected population). These numbers are multiplied by the per-capita water use factor of 75 gpd/ p to estimate the corresponding water demand.

Table 7-12. Estimated self-supplied population and their estimated water demand

Year	Northern Neck population (counties and towns)	Estimated population served by private wells*	Water demand (MGD)**
1990	50,644	25,322	1.90
2000	56,546	28,273	2.12
2007	58,421	29,211	2.19
2010	59,567	29,784	2.23
2020	63,166	31,583	2.37
2030	66,959	33,479	2.51
2040	70,714	35,357	2.65
2050	74,169	37,085	2.78
2060	77,962	38,981	2.92
2070	81,623	40,811	3.06
2080	85,302	42,651	3.20
2090	88,954	44,477	3.34
2100	92,610	46,305	3.47
2107	**95,216**	**47,608**	**3.57**

* 50% of Planning Region population is assumed to be served by private wells (small, self-supplied source)
** Results from multiplying estimated served population by the per-capita water use factor of 75 gpd/p

<u>The total projected water demand for residential, small self-suppliers in year 2107 is 3.57 MGD</u>.

The projected water demand will be reviewed at each 5-year Water Supply Planning update, and the percentages of small, self-supplied users and community users will be updated, along with the projected water demand.

At the time of preparation of this WSP, no data were readily available to analyze and project water use in self-supplied businesses outside the service area of community systems (see **Sections 4.1 and 5.1**). Review of VDH and DEQ data (**Section 5.0**) indicated that there are 80 business or other organizations in the NN that are listed as non-community or non-transient non-community water suppliers (NTNC), and which withdraw <300,000 gallons per month of water (i.e., these are not included in DEQ major withdrawal database).

7.3.3 Demand Projection for Large Self-Supplied (>300,000 gal/month) Sources Outside Community System Service Areas

Large, self-supplied sources (withdrawing >300,000 gal/mo) did not provide sufficient data to allow for a detailed analysis of future water demand outside the Community Systems. Six (6) large, self-supplied users (>300,000 gallons per month) were identified in the Planning Region. Only three of these water sources responded to the WSP survey.

Lake Packing Inc. is considered the sole self-supplied agricultural user of more than 300,000 gallons per month of water as per DEQ data (Form 2-H and Form 3-I in **Appendix B**) and survey results. Lake Packing reported 11.9 MGY (999,583 gal/mo) of ground water for irrigation purposes in 2006. Last report of surface water use for Lake Packing was 19.8 MGY (1,649,396 gal/mo) in 1999. Lake Packing also consumes 2,120,000 gallons per year of ground water for processing operations.

Large self-suppliers of surface water and ground water for non-agricultural purposes were identified in Forms 2D, 2E and Form 3-H (**Appendix K** of full WSP). Form 3-H focuses on large non-agricultural users of more than 300,000 gallons/ month, outside of the service area of community systems. Form 3-H presents a summary of estimated water use from different sources and years, in an attempt to depict water use given the limited survey response. Based on the water use estimates in Form 3-H, the six large self-suppliers of non-agricultural uses consumed a total of 1.784 MGD of surface water and 0.431 MGD in 2006.

The Steering Committee is not aware of current plans to locate a new industrial development in the Planning Region, or of any plans for significant expansion of current commercial users in the Planning Region, which would dramatically increase water withdrawal inside the NN jurisdictional boundaries. The Steering Committee considers the potential for developing golf courses as the primary factor that would significantly increase water demand within the NN. While this situation could change at any time with the announcement of a major water withdrawer locating or expanding in the NN, domestic water use (from community and private systems) will likely constitute the primary future water demand in the NN.

7.4 Cumulative Demand and Conflict

At the time of preparation of this WSP, information on cumulative demand, use conflict, or in-stream flow information developed pursuant to 9 VAC 25-780-140 G, is not available. The state-wide integrated Water Supply Plan has not been prepared by DEQ, from which analysis will be required to determine the above information.

7.5 Balance of Domestic Consumption, In-stream Uses, and Economic Development

In accordance with 9 VAC 25-780-100, the following discussion addresses the balance among the diverse beneficial uses in the demand projection for the planning period. The term "beneficial use" refers to both in-stream and off-stream uses. In-stream beneficial uses include, but are not limited to, the protection of fish and wildlife resources and habitat, maintenance of waste assimilation, recreation, navigation, and cultural and aesthetic values. Off-stream beneficial uses include, but are not limited to, domestic use (including public water supply), agricultural uses, electric power generation, commercial, and industrial uses.

One aspect of particular interest is how the projected needs of domestic consumption, in-stream uses, and economic development have been accounted for in the demand projection for the planning period. Meeting the Planning Region needs for adequate and safe drinking water is the first purpose of the regulation. Encouraging, promoting and protecting other beneficial uses constitute the second purpose of the regulation, and reflects the interest in both continuous economic development and protection of in-stream uses. Detailed aspects of the community water systems and self-supplied users have been discussed in **Sections 4 and 5**, covering both domestic consumption and water use in economic activities. Environmental sources, description of the Planning Region, in-stream water uses, and environmental conditions in the Planning Region were discussed in **Sections 2 and 7**. The following sub-section will focus on the balance of the three broad water uses as they were considered in the water demand projection.

7.5.1 Domestic consumption

The Steering Committee identified the primary future development trends in the NNPD to be related to increased retirement population, and tourism. This suggests that domestic water demand is the primary planning objective of this WSP.

Domestic consumption was taken into consideration in the overall demand projection for the Planning Region through population forecast using population data from decennial census and population estimates of the U.S. Census Bureau's website (U.S. Census Bureau, 2009) and State Demographer Projections (Virginia Employment Commission, 2009). This method was used with both community water systems and small self-supplied users (withdrawals < 300,000 gallons per month), given that the latter typically serve a single house or a small business. A general assumption was applied to water demand projections of domestic consumption. Water use practices were assumed to be constant over the planning period (e.g. per-capita amount of water). Practices and strategies to promote more efficient use of water will be discussed in **Section 8.0**, regarding water demand management.

7.5.2 Economic activity and economic trends in the Planning Region

Water plays an important role in diverse economic development activities, including those in the agricultural, commercial, and industrial areas. Water demand projections

were estimated using assumptions on the current patterns of water use and economic activities.

A general assumption was applied in the demand projection of community systems in order to address commercial users. Commercial water use inside the service area of community systems was assumed to follow the same pattern as the population growth.
Most of the commercial development (e.g., businesses) is located within the Planning Region town jurisdictions and along major transportation corridors, which are supplied by community ground water sources (NNPDC, 2003a). Thus, these assumptions and water projections take into consideration most small businesses in the region, and their contribution to economic development.

Large, self-supplied sources (withdrawing >300,000 gal/mo) did not provide sufficient data to allow for a detailed analysis of their future water demand. A coarse estimate of total current demand of large self-suppliers was calculated for agricultural and non-agricultural users. Furthermore, general trends are expected in future industrial and agricultural activities, as discussed in **Section 7.4.**

According to county comprehensive plans, rural activities and rural jobs are declining throughout the Planning Region. Maintaining the beauty and rural nature of the Region is very important to the local population, as well as tourists and fisherman, for its use and enjoyment. Recent development pressures and diminished natural resources are a concern for the continued and improved health of the environment.

Non-agricultural users typically comprise commercial or industrial users of water. As mentioned above, commercial users inside the service area of community systems are generally accounted for in the water demand projections of community water systems. It is assumed that commercial activities rely either on local consumers or tourists for the economic base. Therefore, increased water use will result, essentially, from local population growth, unless a significant tourist destination is developed in the Planning Region.

Any new industrial water user will have to be assessed on a case-by-case basis to get authorization for surface and ground water withdrawals according to DEQ and VDH permitting processes. Furthermore, any future water use will be considered in the context of the latest update of this Regional Water Supply Plan.

In general, all localities in the Planning Region strive to maintain a healthy economy into the future, strengthening current business and attracting new ones. A brief description of economic activity in the Planning Region is presented below.

The largest economic sector in the Planning Region is services. This sector increased from 4,045 in 1985 to 4,715 in 1994, accounting for 25.5% of total employment in 1994 (the seventh-highest share of services among all planning districts in the state) (NNPDC, 2003a). Large service employers in the Planning Region include Rappahannock General

Hospital, the Lancashire Nursing Home, Warsaw Health Care Center and the Rappahannock- Westminster-Canterbury Retirement Home.

Tourism and the influx of part-time residents, lead to population increases in the summer months. Thus, the Planning Region is significantly affected by seasonal population fluctuations. Tourism in the Planning Region represented 1.1 percent of Virginia's total travel expenditures in 1995 (NNPDC, 2003a). Per capita outlays in the planning district of $2,321 were much higher than the per capita outlays for the state of $1,508 and were the second highest among the planning districts (NNPDC, 2003a).

The Steering Committee recognizes tourism and retirement destination as important economic drivers that will influence future water demand in the NN. A commitment to resource based tourism, quality of life in the area, and promoting the NN as a retirement designation should continue to provide economic stability of the region.

Besides, many permanent residents in the Planning Region are dependent on services and natural resources for income, and are subject to seasonal work (NNPDC, 2003a). Notably, during the winter months, the Planning Region has the highest unemployment rates in Virginia (NNPDC, 2003a). Consequently, some percentage of the Planning Region population likely travels outside of the region, for short-term or extended periods of time, to work during the winter months.

Three counties, Lancaster, Richmond, and Westmoreland, and the Towns of Kilmarnock and Colonial Beach have established industrial park locations and are either investigating the possibility of, or are in the process of, upgrading their water/sewage treatment systems.

In 2000, the Planning Region was awarded an Enterprise Zone designation through the Virginia Department of Housing and Community Development. The Northern Neck Enterprise Zone is a contiguous, fifty-foot right-of-way that connects designated growth areas in all four Northern Neck counties and the Towns of Warsaw and Kilmarnock. The Northern Neck Enterprise Zone will help to stimulate business and industrial growth by means of state and local tax incentives. The incentives will encourage property investment, business expansion and job creation.

Regarding future economic plans, at the time this WSP was developed, the Committee was not aware of current plans to locate a new industrial development in the Planning Region. As well, the Committee did not foresee any plans for significant expansion of current industrial users in the Planning Region, which would dramatically increase water withdrawal inside the Planning Region jurisdictional boundaries. The Committee considers the potential for developing golf courses as the primary factor that would significantly increase water demand within the Planning Region. While this situation could change at any time with the announcement of a major water withdrawer locating or expanding in the Planning Region, domestic water use (from community and private systems) will likely constitute the primary future water demand in the Planning Region.

In conclusion, economic development is a key goal in the Planning Region, and the local government is taking actions to strengthen existing business and to attract new ones. Given the uncertainty of future economic patterns and their implications for water demand, the best course of action will be to evaluate on a case-by-case basis every new project or the expansion of existing business. As mentioned above, new community supply wells and surface water withdrawals (greater than 300,000 gallons per month) are subject to an evaluation and approval process by VDH and VDEQ. Any future water use will be considered in the context of the Water Supply Plan for the Planning Region. An important consideration is that water savings resulting from the water demand management's practices can provide a safety cushion to allow for increased water demand from economic activities.

7.5.3 In-stream uses

In-stream beneficial uses were described previously, as well as possible effects associated with the operation of the community water systems. The existing environmental conditions related to fish and wildlife resources and habitat, recreation, cultural and aesthetic values are described in **Section 6.0**. Consideration was given to the presence of endangered species, water quality, and special designations of the bodies of water in order to protect habitat, maintain waste assimilation and provide recreational and cultural amenities. Population and economic growth may affect recreation, navigation and waste assimilation activities. Typically, the most immediate actions to protect in-stream uses include: limiting the amount of withdrawals, enhancing design criteria for intakes to reduce the capture of organisms, and selecting adequate timing for construction activities to prevent disruption of breeding activities. Furthermore, adequate wastewater treatment will ensure water quality which is a key element for habitat protection and waste assimilation.

Ground water is used for community water sources within the Planning Region. Typically, community wells are completed in deep, confined aquifers, which do not directly influence surface water streams in the Planning Region. However, SAIF and the Three Rivers Health Department have documented that many residential water wells are constructed in the shallow unconfined aquifer, providing drinking water to residences. These shallow water sources may have a significant aggregate impact on local streams. Expansion or addition of community water systems that derive ground water from deeper aquifers (replacing shallow self-supplied sources) should reduce strain on in-stream uses. However, as noted previously, extra-regional water users (located beyond the Planning Region jurisdictional boundaries) affect the deeper ground water aquifers, which in turn may limit community water sources and directly or indirectly affect in-stream uses as well.

8.0 WATER DEMAND MANAGEMENT (9 VAC 25-780-110)

The following discussion addresses water demand management for the Planning Region, as specified in the Water Supply Regulations 9 VAC 25-780-110.

Water demand management is defined as any socially beneficial measure that reduces or re-schedules average or peak withdrawals from surface or ground water sources while maintaining or mitigating the extent to which return flows are degraded. Demand management differs from traditional supply-oriented approaches that primarily attempt to meet increased demand by increasing supply; the primary objectives of demand management are to rationalize and control water use, reduce waste and increase efficiency and equity.

Demand management programs should be designed based on how the water is used. For example, customer uses of community water supplies can be divided into three categories:

- Domestic (drinking, cooking, cleaning and sanitary use);
- Landscape (lawn and garden irrigation by businesses, parks, governments and homes); and
- Process (cooling, heating, manufacturing, and product use).

Water used for water supply system operation itself and water lost through leaks, evaporation and other causes is a factor of overall demand, but not a direct customer use.

Demand management programs for community systems promote changes in consumer behavior and reduce waste from water loss. Behavior change in consumers can be promoted via education campaigns or through economic instruments such as pricing. More innovative conservation approaches that are gaining acceptance include promotion of alternative supplies such as rainwater harvesting and wastewater reuse.

Increasing resource use efficiency remains the key strategy for water conservation. The primary methods used to increase efficiency include replacing water using equipment with more efficient types and finding and repairing leaks in the distribution system. Replacing or regulating water using equipment and appliances as a conservation strategy is based on the concept that consumers are actually demanding the services that the water resource provides (e.g., clothes washing and hot showers), often called end use. Thus, water demand management programs that are geared toward supporting better end-use will succeed as long as the same level of services is provided to the consumer using less water resources.

Water demand management practices in the Planning Region are discussed below, and used to refine the water demand forecast of community systems and residential, small self-suppliers that was previously presented in **Section 7.0** of the Water Supply Plan.

Residential, small self-suppliers (<300,000 gallons per month) can benefit as well from demand management practices to reduce both water use and water bills. However, not all demand management practices in community systems can be applied to residential, small self-suppliers. The key strategy for these self-suppliers is the use of water efficient technologies. Educational programs, metering systems, and financial incentives to encourage the use of water efficient technologies are the advised course of action.

Water demand management practices can be applied to large self-supplied sources as well. Due to a lack of data provided by major self-supplied (>300,000 gallons per month) sources, quantitative demand management results are not provided herein. Options for outreach to self-supplied sources by jurisdictions, and notable water demand management practices that are used in industry and agriculture are presented below.

8.1 Water Demand Management for Community Sources

8.1.1 Practices to Promote More Efficient Water Use

The following discussion highlights practices used in the Planning Region to address long-term water demand management for community water systems and presents examples of practices used in other jurisdictions that could be adopted by the Northern Neck. The jurisdictions that comprise the Planning Region have adopted the Virginia Uniform Statewide Building Code (USBC). Sections of the USBC promote more efficient water use by specifying limits on flow rates for plumbing fixtures and public lavatories in new or renovated structures. **Table 8-1** below summarizes water savings results when efficient plumbing fixtures and appliances are used in new home / business construction (Dickinson et al, 2003; USEPA, 2007):

Table 8-1. Water Savings Results from use of Efficient Plumbing Fixtures

End Use	Range in Water Savings (gal/d/p)		
Toilets	10	-	16
Showers	3	-	8
Faucets	0.5	-	6
Clothes Washers	5	-	12
Dishwashers	0.5	-	1
Hot Water Demand	5	-	10
Total Indoor Use	**24**	**-**	**53**

In accordance with the USBC, only approved fixtures that conform to low-flow specifications can be installed in new or renovated structures served by community water sources. Enforcement of the provisions of the USBC is the responsibility of the jurisdiction.

8.1.2 Practices to Reduce Water Use

The jurisdictions in the Planning Region currently do not employ systematic practices designed to reduce water use in the community systems across each jurisdiction. Examples of water use reduction practices that may be considered by jurisdictions and community sources in the Planning Region are presented below in Section 8.1.3.

Efforts are made by individual suppliers in the Planning Region to reduce water use. Some examples of individual efforts include the following. Some community systems send occasional educational brochures and notices to individuals encouraging water conservation. In the Haynesville Correctional Center, inmates are monitored to prevent abuse water usage. Lake Packing Co., Inc. & Cowart Seafood Corp use salt water to wash oyster cages. The rinseate is gravity filtered and pumped back into the river.

8.1.3 Demand Management Planning Options

Water demand management options that may be considered by jurisdictions and water suppliers to increase efficiencies and reduce water use are outlined below in **Table 8-2**.

Table 8-2. Benchmarks for Demand Management Measures

Benchmarks for Demand Management Measures (Taken from Table B-4, EPA 2007a)		
Category	**Measure**	**Reduction In End Use**
End-use Audits	General industrial water conservation	10 to 20 percent
	Outdoor residential use	5 to 10 percent
	Large landscape water audits	10 to 20 percent
Retrofits	Toilet tank displacement devices (for toilets using > 3.5 gallons/flush)	2 to 3 gpd/p
	Toilet retrofit	8 to 14 gpd/p
	Showerhead retrofit (aerator)	4 gpd/p
	Faucet retrofit (aerator)	5 gpd/p
	Fixture leak repair	0.5 gpd/p
	Government buildings (indoors)	5 percent
Pressure Management	Pressure reduction, system	3 to 6 percent of total production
	Pressure-reducing valves, residential	5 to 30 percent
Outdoor water-use efficiency	Low water-use plants	7.5 percent
	Lawn watering guides	15 to 20 percent
	Large landscape management	10 to 25 percent
	Irrigation timer	10 gpd/p
Replacements and Promotions	Toilet replacement, residential	16 to 20 gpd/p
	Toilet replacement, commercial	16 to 20 gpd/p
	Showerhead replacement	8.1 gpd/p
	Faucet replacement	6.4 gpcd
	Clothes washers, residential	4 to 12 gpcd
	Dishwashers, residential	1 gpd/p
	Hot water demand units	10 gpd/p
Reuse and Recycling	Cooling tower program	Up to 90 percent
Costing and Pricing	10% increase in residential prices	2 to 4 percent
	10% increase in nonresidential prices	5 to 8 percent
	Increasing-block rate	5 percent
Information and Education	Public education and behavoir changes	2 to 5 percent
water-use regulation	Landscape requirements for new developments	10 to 20 percent in sector
	Graywater reuse, residential	20 to 30 gpd/p
Universal Metering	Connection metering	20 percent
	Submetering	20 to 40 percent
Water accounting and loss control	System audits and leak detection	Based on system

Water demand management measures can be implemented in the context of cost effectiveness. Program implementation costs are offset by savings realized from reduced water volumes which lead to energy savings, reduced system wear-and-tear and maintenance, etc. Furthermore, demand management initiatives can be achieved on a collaborative basis that includes collaboration with water supply managers and customers. Although the responsibility for planning and delivering regional demand management programs currently resides with the jurisdictions that comprise the Planning Region, involvement and support of all stakeholders and participants is critical. Demand

management programs are customer driven - they need to be tailored to the customer's needs and motivations to be effective.

Other principles that should be applied to increase the benefits of the water demand measures include: ensuring equity among consumers; making the greatest impact by concentrating program resources; reducing costs or providing additional benefits by seeking partnerships and avoiding lost opportunities; ensuring program success by monitoring and evaluating program savings and costs; and testing program design with pilot efforts prior to full-scale program implementation.

Demand management measures considered in this section can be usefully grouped into four demand management strategies:

1. Water rate structures;
2. Codes and regulations;
3. Customer incentives;
4. Public information and education

8.1.3.1 Rate Structures

Generally, the greater the cost of water per additional amount used, the less amount customers will use. Structuring water rates to encourage demand management is a key demand management strategy and gives customers more control over their water bills. Rate structures that encourage efficient use include inclining block rates and seasonal rates.

Typically, block rate structures function where the unit price of water increases (typically) with each of several preset consumption blocks for each billing period (typically three to five different tiers or rate blocks). However, this type of rate structure itself, without a significant accompanying customer information program will generally not produce the desired conservation if customers do not understand the rate structure (i.e., the more water used the higher the unit price becomes).

Also, increasing block or tiered rate structure can potentially be "punitive" to large customers, charging them a higher unit rate simply because they are large water users. Industrial or commercial customers already have incentive to reduce costs by increasing water use efficiencies (and energy reduction), and thus a higher unit rate may not increase efficiency, but hurt economic development. Water suppliers should implement usage ranges in block rates for different customer classes, or possibly individual customers in the case of large non-residential customers.

An additional rate structure strategy to promote water conservation is to implement higher rates during peak season (spring and summer months) when water use is higher.

8.1.3.2 Codes and Regulations

As noted above, the jurisdictions that comprise the Planning Region have adopted the USBC, which includes limits on flow rates for plumbing fixtures in new or renovated structures to increase water use efficiency. Additional options for codes and regulations that may be considered by the Planning Region jurisdictions are provided below.

Landscape Codes
Water efficiency landscape codes can be adopted to ensure compliance with a water budget or to plant materials, landscape designs or irrigation systems that must be efficient water use types.

Process Codes
Water efficiency codes can be adopted for commercial and industrial processes, such as cooling designs or recirculation manufacturing uses.

A Water Waste Ordinance
Prohibit wasteful outdoor watering that falls directly onto impervious surfaces.

Peak-Season Demand Management
Water demand typically increases in the spring and summer months. While the demand management programs identified in this WSP are intended to reduce "baseline" demand on a year-round basis, water suppliers should also plan for additional measures to reduce peak-season demands.

Water suppliers have the opportunity to prepare for peak-season demand management each year, with the goal of delaying or off-setting drought contingency actions (See **Section 9.0**). Peak-season demand management included in an overall water conservation program should focus specifically on reducing discretionary water use for irrigation, car washing, pools, etc, which is highest in summer months. To pre-empt, or delay possible water emergencies during high-season water demand periods (see **Section 9.0**); water suppliers may work with local jurisdictions to implement public awareness campaigns, and encourage voluntary water use restrictions during peak-season. For example, suppliers may include notifications with billings from June through September that promote wise water use strategies (e.g., odd-even day water schedules organized by local neighborhoods and businesses), reminding the public of the potential for water supply droughts to occur during any given year, and taking the opportunity to call attention to the Drought Contingency Plan (see **Section 9.0**).

8.1.3.3 Customer Incentives

Customer incentives of diverse types can be offered to consumers: economic, technical assistance, training, among others. Providing customers financial incentives to convert to more water efficient fixtures, technology or behavior is a necessary strategy to overcome the many barriers that sometimes prevent customers from taking actions on their own. These barriers include skepticism about new technologies, lack of adequate economic incentives, lack of available capital, lack of knowledge and too many competing demands

for time. Incentives can take a variety of forms including rebates, technical assistance, low interest loans or even "give-aways" of demand management products.

Incentive programs should undergo rigorous analysis before being implemented. The analyses include technical feasibility, market response and cost effectiveness. The following is a list of incentive programs commonly conducted.

Plumbing Fixture Retrofits
A rebate incentive (e.g., toilet flapper rebate program to provide customers with the incentive to replace existing flappers with early closure model toilets) or give-away (showerheads, aerators) program to encourage homes and businesses to replace old, high use plumbing fixtures with efficient fixtures.

High Efficiency Appliances
Rebates to purchase high efficiency appliances such as washing machines.

Water Efficient Irrigation
Technical assistance, training, irrigation audits, and financial incentives for large commercial irrigators (e.g., a rain sensor ordinance that requires all existing and new customers with irrigation systems to install a rain sensor that measures rainfall and overrides the irrigation cycle of the system).

Water Smart Technology
Technical assistance and financial incentives for commercial, industrial and institutional process demand management measures.

High Irrigation Consumption Audit for Residential Customers
Individual customer audits and financial assistance for single family irrigators with high use.

Reclaimed Water
Financial incentives to use treated effluent to provide industrial process and cooling water.

8.1.3.4. Public Information and Education

Public information and education programs are the backbone of an effective demand management program. Through a variety of messages and media, customers learn why and how they should conserve as well as about demand management programs available to them. The following is a list of ongoing promotion and marketing efforts commonly used.

Enhancing Billing Information
Provide enhancements to make water bills more understandable to customers. The water bill should contain consumer usage in terms of gallons per day. When customers are aware of their daily water use, they are more likely to conserve. Also, provide educational information through, for example, water bill inserts or other means (where

community water use is greater than 100 gallons per capita per day, this should occur at least once a year).

Residential Efficient Plumbing Fixture and Appliance Promotion
Encourage residential customers to remove inefficient plumbing fixtures and appliances and install efficient replacements.

Develop Specific Outreach for Larger Users, Businesses, Landscaping
Community water suppliers typically serve different types of customers, such that specific outreach efforts can be geared to user types to deliver a more effective message. Some specific outreach efforts may include:

- Promote water use efficiency outreach to apartments and businesses.
- Feature the demand management commitment and achievements of businesses, with awards and public recognition.
- Demonstration gardens installed at public places to show how to be water efficient.

Conduct Water Use Audits for Consumers
Water use audits can provide water systems and their customers with information about how water is used and help identify potential conservation strategies. Audits can be particularly effective when targeted towards large volume users, or other selective end use customers (e.g., single family homes with large yards, parks or other large landscapes, etc.).

Public Media Campaign
Educate the public about why and how to conserve water with TV, radio and other media advertising.

Point of Purchase Program
Point-of-purchase promotion for water efficient products.

8.1.4 Practices to Address Water Loss

Water that is lost to leaks, unnecessary system use, and theft or spilling is wasted water. Water loss control measures are designed to minimize water loss within the system.

The large number of community systems in the Planning Region presents difficulties for implementing standard water loss methods across all systems. There are 96 community systems in the NN (all of them using ground water) that supply water to approximately 50% of the Planning Region population (see **Section 4.0 and Section 5.0**). Community systems provided a limited response rate to the WSP survey (only 21 suppliers responded). The responses and limited answers to the follow-up telephone questions did not provide enough data to discuss all current practices to reduce water loss. There are no water/ sewer authorities in the Planning Region and each County or Town runs their own facilities. Each community system has its own infrastructure, metering and/or billing

system, and a small service area. Thus, it is challenging to maintain a standard system to detect, correct and prevent water losses across the Planning Region.

Scattered efforts are made by individual suppliers throughout the Planning Region to reduce water use. Some community systems have ad-hoc procedures to monitor and reduce water losses, although most of the measures are corrective rather than preventive. For example, some systems have maintenance personnel and equipment specifically assigned to respond to water system leaks when observed and reported.

Some examples of individual efforts include the following. In the town of Montross, billing reports are compared monthly against withdrawal numbers. If there is a difference of more than 10%, the fire department is called first to check for usage. Moreover, the town documents all water losses and collects daily data if a leak occurs. In the Haynesville Correctional Center, all meters are calibrated in regular basis. In Rappahannock Westminster-Canterbury, Inc., meters are calibrated regularly and leaks are fixed if detected. In Lake Packing Co., Inc. / Cowart Seafood Corp., all apparent leaks are fixed as soon as detected or reported.

Nonetheless, like all complicated utility systems, additional preventative measures can enhance the ability to reduce water loss. Judging from responses given by community systems to the water supply planning survey, most of them only meter water withdrawal at the well. Installation of new metering systems, where needed, and improvement and regular calibration of the existing ones will be beneficial in improving the community systems' efficiency, customer service, and the ability to detect water losses. Some examples of additional water loss control measures that may be considered by the Planning Region jurisdictions are provided below.

8.1.4.1 Enhancing Water Loss Control

Water suppliers and local Jurisdictions (i.e. the County service authorities, City and town utilities departments) can enhance water loss control measures using a systematic approach identified by the AWWA (AWWA, 2007a). The first step toward a more effective water loss control program is to understand the community system water balance, and target practices to address both "real" water loss (physical losses including leaks, bursts, and overflows) and "apparent" water losses (non-physical losses that include meter inaccuracies and unauthorized consumption such as theft or illegal use). The AWWA (2007a) provides the following recommended format for conceptualizing the water balance (**Table 8-3**).

Table 8-3. Schematic Outline for Developing a Water System Balance (AWWA, 2007a)

System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

Once the community system has an accurate system water balance, the following practices can be implemented for targeted loss control.

- Implement a proactive program to inspect, clean, or perform other maintenance (such as corrosion control) on pipes to prevent leaks from occurring.
- Manage overall system pressure to reduce volume and frequency of water loss.
- Control water level to reduce storage overflow.
- Implement improvements in metering and billing.
    a) Metering plans should describe the metering method(s) used, and establish protocols for maintaining meter accuracy, conducting calibration and repair, and replacing old or inaccurate meters. Inaccurate meters often result in lost revenue for the utility.
        I. Evaluate installation of new metering if none exists.
        II. Develop and schedule a plan to test, calibrate, repair, and replace meters as necessary
        III. Evaluate and replace older meters as necessary.
        IV. Ensure that meters are appropriately sized. If a meter is too large for a customer, it will typically under-register water use, resulting in lower revenues.
- Locate illegal or unregistered connections.

- Regularly employ leak detection equipment to detect leaks along water distribution mains, valves, services, and meters.
- Use remote sensors and telemetry technologies for ongoing monitoring of leak detection at source, transmission, and distribution facilities. This technology can promptly alert operators to leaks, changes in pressure, and problems with equipment.
- Repair leaks when detected. The cost of lost water can be measured in terms of operating costs associated with supplying, treating and delivering the water. Water lost to leakage produces no revenues for the utility. Although repairing leaks may be costly, cost savings will usually pay for the repairs over time.

Critical to an effective water loss control program is monitoring and review. Yearly update of the system's balance and auditing the stop-loss program components is recommended for the community system to maintain acceptable efficiency, and to response to the changing needs of the community.

8.1.5 Conclusion

Effective demand management programs (rate structures, codes, public outreach) should be geared to provide an equitable distribution of benefits to all customer classes, employ a targeted mix of methods to achieve desired results, and be continuously evaluated to optimize program performance.

8.2 Influence of Conservation Measures on Projected Water Demand

The effects of water demand management practices currently employed in the Planning Region, primarily affecting community sources and private domestic wells (large self-supplied users are addressed later) are incorporated into the water demand forecast completed previously in **Section 7.0** of the Water Supply Plan.

8.2.1 Refining the Water Demand Forecast for Community Systems and residential, small self-suppliers.

Current water demand management strategies in this WSP for the Planning Region include the application of the USBC for all new homes and renovated structures. The Planning Area implements water demand management on a systematic basis through adoption of the USBC for all new homes and businesses (**Section 8.1.1**). While water use reduction estimates vary, it is likely that per capita demand for community systems may be reduced by 24 gallons per day per person (g/d/p) (low range, see **Table 8-1**). Future water demand projections for the Planning Region are revised (below) to account for water use savings (both community and private domestic wells) induced by application of demand management practices (e.g. adoption of USBC). Additional water demand practices that may be adopted in the future can provide further water use savings and will be included in the periodic updates to the WSP.

Table 8-4 (below) shows the revised community system water demand forecasting after accounting for population change, implementation of demand management practices and a 15% contingency factor for unaccounted losses. Screening analysis was conducted

using contingency factors of 5% and 15%. These values were discussed with the Committee and VDEQ in order to select the most adequate value for the Planning Region. Ultimately, in consultation with VDEQ, the value of 15% was selected as contingency factor for unaccounted losses in the Region. Application of the USBC in new homes results in a reduction of 24 gallons per day per person (g/d/p).The revised water projection of community system population in 2107 is based upon assumptions presented in **Section 7.0**. A revised water demand for the population served by community systems in the Planning Region, for year 2107, was calculated based on population trends and an adjusted per capita demand. The water demand revision assumes that the increased population from the current period to 2107 (i.e., only new customers) would benefit from the reduced per capita demand rate affected by demand management practices (i.e., implementation of USBC; see above).

Table 8-4. Adjusted demand of community systems after accounting for demand management practices

Year	Northern Neck population	Estimated population served by community systems[+]	Change in population (persons)[++]	% Change population[++]	Cumulative population change (persons)	Water demand of new residences (MGD)*	Cumulative water demand of new residences in community systems (MGD)	Adjusted water demand of community systems (MGD)**	Adjusted water demand of community systems as % or permitted withdrawal***
2007	58,421	29,211						2.19[++]	46.2 %
2010	59,567	29,784	573	2.0 %	573	0.029	0.034	2.22	46.9 %
2020	63,166	31,583	1,800	6.0 %	2,373	0.092	0.139	2.33	49.1 %
2030	66,959	33,479	1,896	6.0 %	4,269	0.097	0.250	2.44	51.5 %
2040	70,714	35,357	1,877	5.6 %	6,146	0.096	0.360	2.55	53.8 %
2050	74,169	37,085	1,728	4.9 %	7,874	0.088	0.462	2.65	55.9 %
2060	77,962	38,981	1,896	5.1 %	9,771	0.097	0.573	2.76	58.3 %
2070	81,623	40,811	1,830	4.7 %	11,601	0.093	0.680	2.87	60.5 %
2080	85,302	42,651	1,840	4.5 %	13,441	0.094	0.788	2.98	62.8 %
2090	88,954	44,477	1,826	4.3 %	15,266	0.093	0.895	3.09	65.1 %
2100	92,610	46,305	1,828	4.1 %	17,095	0.093	1.003	3.19	67.3 %
2107	**95,216**	**47,608**	**1,303**	**2.8 %**	**18,398**	**0.066**	**1.079**	**3.27**	**68.9 %**

[+] Approximately 50% of the Planning Region population is served by community systems.
[++] The numbers in this column represent change with respect to values in the previous year.
[+++] Water demand for the baseline of existing homes, using a per capita rate of **75 g/d/p** (VDH sewerage design criteria; USGS, 1995).
* Results of multiplying the estimated cumulative population change by the adjusted per capita water use factor of **58.65 g/d/p**. This rate results from using the Virginia Uniform Statewide Building Code (**USBC**) in all **new** homes and businesses = 24 gpd/p savings (see **Table 8-1**) as main water management practice. This rate also includes a **15% contingency factor** for unaccounted losses.
** This adjusted demand accounts for all population served by community systems (while new residences follow the USBC, old residences do not).
*** The total permitted withdrawal capacity for community systems in the planning region was estimated at **4.74 MGD**. This number resulted from adding up the VDH Permitted System Capacity of community systems (**Form 2A, Appendix B**) for which information was available.

An unaccounted water loss factor of 15% is applied to the revised per capita demand for future users. This value was selected after consultation with the Committee and VDEQ in order to use the most adequate value for the Planning Region. Thus, the projected water demand for 2107 for community systems reflects the addition of the baseline current water demand and the incremental change associated with population change and revised per capita demand. Finally, **Table 8-4** compares the projected water demand to the total permitted withdrawal for community systems in the Planning Region.

Table 8-5 (below) shows the revised water demand for residential self-suppliers. Just as for community systems, revised projections account for population change, implementation of demand management practices and a 15% contingency factor for unaccounted losses. The same reduction of 24 gallons per day per person (gpd/p) is derived from the application of the USBC.

Table 8-5. Adjusted demand of residential, small self-suppliers after accounting for demand management practices

Year	Northern Neck population	Estimated population served by private wells[+]	Change in population (persons)[++]	% Change population[++]	Cumulative population change (persons)	Water demand of new residences (MGD)*	Cumulative water demand residential, small self suppliers (MGD)	Adjusted water demand of residential, small self suppliers (MGD) **
2007	58,421	29,211						2.19[++]
2010	59,567	29,784	573	2.0 %	573	0.029	0.034	2.22
2020	63,166	31,583	1,800	6.0 %	2,373	0.092	0.139	2.33
2030	66,959	33,479	1,896	6.0 %	4,269	0.097	0.250	2.44
2040	70,714	35,357	1,877	5.6 %	6,146	0.096	0.360	2.55
2050	74,169	37,085	1,728	4.9 %	7,874	0.088	0.462	2.65
2060	77,962	38,981	1,896	5.1 %	9,771	0.097	0.573	2.76
2070	81,623	40,811	1,830	4.7 %	11,601	0.093	0.680	2.87
2080	85,302	42,651	1,840	4.5 %	13,441	0.094	0.788	2.98
2090	88,954	44,477	1,826	4.3 %	15,266	0.093	0.895	3.09
2100	92,610	46,305	1,828	4.1 %	17,095	0.093	1.003	3.19
2107	**95,216**	**47,608**	**1,303**	**2.8 %**	**18,398**	**0.066**	**1.079**	**3.27**

[+] Approximately 50% of the Planning Region population is served by private wells.
[++] The numbers in this column represent change with respect to values in the previous year.
[+++] Water demand for the baseline of existing homes, using a per capita rate of **75 g/d/p** (VDH sewerage design criteria; USGS, 1995).
* Results of multiplying the estimated cumulative population change by the adjusted per capita water use factor of **58.65 g/d/p**. This rate results from using the Virginia Uniform Statewide Building Code (**USBC**) in all **new** homes and businesses = 24 gpd/p savings (see **Table 8-1**) as main water management practice. This rate also includes a **15% contingency factor** for unaccounted losses.
** This adjusted demand accounts for all population served by private wells (while new residences follow the USBC, old residences do not).

In **Table 8-4** and **Table 8-5** the water demand calculations followed the per-capita method described in the demand projection section (see **Section 7.3**). Population estimates for the Planning Region were taken from **Section 7** of this WSP. Some relevant details are summarized here as follows.

Community and small self-supplied water demand projections were calculated from service population projected to 2107, multiplied by a per capita water use value of 75 gal/ person/ day (gpd/p) (VDH sewerage design criteria; USGS, 1995). Screening analysis of different per-capita water use values was conducted and discussed with the Committee and VDEQ in order to select the most representative per-capita use value for the Planning Region. Per-capita values of 94 gpd/ p (Virginia Water Works Regulations), and 59 gpd/ p (EEE estimate from community system data) were considered and discussed with the Committee and VDEQ. Ultimately, in consultation with VDEQ, the value of 75 gpd/ p was selected as the regional estimate.

The revised water use rates incorporate a 15% unaccounted loss to better normalize the per-capita rate (**Tables 8-4 and 8-5**). This value was selected after consultation with the Committee and VDEQ in order to use the most adequate value for the Planning Region. The per-capita values are acknowledged as estimates because certain suppliers' usage rates integrate both commercial and residential usage (commercial usage increases overall water use volume, which is not reflected in additional population).

The refined water demand forecast assumes that only construction beyond 2007 will include water-efficient plumbing and landscaping techniques (i.e., retrofit and renovation are not included in the refined water demand). Thus, only the demand driven by population change subsequent to 2007 will be attenuated by increased efficiencies.

8.2.2 Results of Refined Water Demand Forecast

Revised projected water demands for community sources and residential, small self-suppliers were refined in **Tables 8-4 and 8-5**, taking into account population change, implementation of demand management practices and a 15% contingency factor for unaccounted losses. The refined water projection results for community systems are compared against permitted water use to determine if enough water resources are available to supply community systems in the long term. The adequacy of water supplies will be further discussed in **Section 10** of this WSP, where a statement of need will be provided.

8.2.2.1 Adjusted demand of community systems accounting for demand management practices

Table 8-4 presents the input data and results of the refined water demand projections to year 2107 for community water systems in the Planning Region. This refined water demand takes into account population change, implementation of demand management practices (see **Sections 8.21 and 8.1.3**), and unaccounted losses (see **Section 8.1.4**). The water demand revision assumes that the increased population from the current period to 2107 (i.e., only new customers) would benefit from the reduced per capita demand rate affected by demand management practices (i.e., implementation of USBC; see above).**Table 8-4** also compares future water demand to total permitted withdrawal for community systems in the Planning Region.

Population estimates for the Planning Region were taken from **Section 7** of this WSP and are presented in the second column of **Table 8-4**. Approximately 50% of the Planning Region population is served by community systems, which is presented in column three. The net change in number of persons from one study year to another is shown in column four. Column five in the table indicates the percentage increase in population with respect to the previous year in the years considered in the table. The respective cumulative change in persons follows in column six.

Water demand of population in the new residences is calculated by multiplying the estimated cumulative change in persons by the per capita rate of 58.65 g/d/p. This adjusted rate is the result of the application of the USBC in new homes, which causes a reduction of 24 gallons per day per person (gpd/p) in new and renovated structures (see **Table 8-1**) A 15% unaccounted loss rate was applied to the future water demand forecast for 2007 through 2107 (**Table 8-4**), to account for expansion of community system distribution to accommodate increasing population. It is assumed that unaccounted water losses prior to 2007 are incorporated into the water use data and therefore the estimated per capita demand (**Table 8-4**).

The adjusted water demand of community systems in the Planning Region is calculated by adding the baseline water demand of existing homes to the cumulative demand of new residences following the USBC. Thus, the adjusted demand accounts for new residences using the new per capita rate (58.65 g/d/p) and the old residences using a per capita rate of **75 g/d/p** (VDH sewerage design criteria; USGS, 1995).

The total permitted withdrawal capacity for community systems in the Planning Region was estimated at **4.74 MGD**, according to VDH permitted system capacity of community systems (**Form 2A, Appendix B**) for which information was available. See **Section 8.1.4 and Section 3** for a detailed description of challenges and limitations in the data collection. The last column of **Table 8-4** shows the adjusted water demand of community systems as a percentage of the total permitted withdrawal.

The total adjusted water demand for community systems in the Planning Region by year 2107 is 3.27 MGD. This water demand represents approximately 70% of the total permitted withdrawal capacity for community systems in the Planning Region.

The projected demand listed in **Table 8-4** for 2007 is 2.19 MGD, which can serve as a calibration point for the projections. Based upon DEQ Water Withdrawal Reporting data (**Section 5.0**), 2007 ground water withdrawal by community sources was 2.0 MGD. This value is similar to the 2007 result listed in **Table 7-11** and **Table 8-4**, suggesting that the community demand projections are representative, given the assumptions presented previously.

8.2.2.2 Adjusted demand of residential, small self-suppliers accounting for demand management practices

Table 8-5 presents the input data and results of the refined water demand projections to year 2107 for the residential, self-supplied population in the Planning Region. This refined water demand takes into account population change, implementation of demand management practices (see **Sections 8.21 and 8.1.3**), and unaccounted losses (see **Section 8.1.4**).

The process to calculate the refined water demand is the same that was followed for community systems. The only difference is that there is no total permitted withdrawal for small self-suppliers since the withdrawal of these private wells is so low that it is not required to be reported to VDEQ (only withdrawals > 10,000 gallons/day of ground water or surface water are to be reported).

Columns one through nine in **Table 8-5** follow the same rationale as explained in **Section 8.2.2.1** for **Table 8-4**.

The total adjusted water demand for residential, small self-suppliers in the Planning Region by year 2107 is 3.27 MGD.

8.2.2.3 Analysis of Refined Water Demand Forecast

Table 8-6 summarizes the refined demand forecast results for community systems and private domestic users, and highlights the relative changes. This table incorporates the baseline water demand projections from **Section 7.0** and the estimated savings from applying demand management practices.

Significant water savings are derived from implementing water management practices in community systems and private residential wells, resulting in an adjusted demand of 3.27 MGD by year 2107 (Table 8-6). The original total projected water demand (**Section 7, Table 7-**

11) for community systems in the Planning Region by year 2107 was 3.57 MGD. Water management practices would reduce the projected demand of community systems by 0.3 MGD. Water savings in residences supplied by private wells would amount to 0.3 MGD as well, given that approximately 50% of the population is self-supplied and that the per capita use rate is assumed to be the same for all residences in the Region.

The refined water demand of 3.27 MGD for community systems by year 2107, represents approximately 70% of the total permitted withdrawal capacity for community systems in the Planning Region.

Table 8-6. Summary table of revised water demand for community sources and domestic private wells after accounting for demand management practices

Year	Northern Neck population	Estimated population served by community systems[+]	Estimated population served by private wells[+]	Cumulative population change in the Planning Region (persons)	Adjusted water demand of community systems (MGD)[++]	Adjusted water demand of residential, small self suppliers (MGD)[++]	Adjusted total water demand (community and domestic wells) (MGD)	Original estimate of total water demand (community and domestic wells) (MGD)[*]	Total water savings in community and domestic wells (MGD)	Water savings as % of permitted withdrawal capacity**
2007	58,421	29,211	29,211		2.19	2.19	4.38	4.38	0.00	0.00
2010	59,567	29,784	29,784	1,146	2.22	2.22	4.45	4.47	0.02	0.39
2020	63,166	31,583	31,583	4,745	2.33	2.33	4.66	4.74	0.08	1.64
2030	66,959	33,479	33,479	8,538	2.44	2.44	4.88	5.02	0.14	2.94
2040	70,714	35,357	35,357	12,293	2.55	2.55	5.10	5.30	0.20	4.24
2050	74,169	37,085	37,085	15,748	2.65	2.65	5.31	5.56	0.26	5.43
2060	77,962	38,981	38,981	19,541	2.76	2.76	5.53	5.85	0.32	6.73
2070	81,623	40,811	40,811	23,202	2.87	2.87	5.74	6.12	0.38	8.00
2080	85,302	42,651	42,651	26,881	2.98	2.98	5.96	6.40	0.44	9.26
2090	88,954	44,477	44,477	30,533	3.09	3.09	6.17	6.67	0.50	10.52
2100	92,610	46,305	46,305	34,189	3.19	3.19	6.39	6.95	0.56	11.78
2107	**95,216**	**47,608**	**47,608**	**36,795**	**3.27**	**3.27**	**6.54**	**7.14**	**0.60**	**12.68**

[+] Approximately 50% of the Planning Region population is served by community systems and 50% by private wells.

[++] The adjusted per capita use arte, after applying demand management practices, is 58.65 g/d/p. Water savings from demand management practices were estimated on 24 g/d/p (see Table 8.1). This rate also includes a **15% contingency factor** for unaccounted losses.

* Summarizes demand projection results in **Section 7.0** (see **Tables 7-11** and **7-12**). The baseline per capita use of **75 g/d/p** (VDH sewerage design criteria; USGS, 1995) was used for population served by both, community systems and private wells.

The total permitted withdrawal capacity for community systems in the planning region was estimated at **4.74 MGD. This number resulted from adding up the VDH Permitted System Capacity of community systems (**Form 2A, Appendix B**) for which information was available.

8.2.2.4 Disaggregated Water Demand Projection

No data were readily available at the time of plan preparation to evaluate disaggregated water demand for community or self-supplied water systems in the Planning Region (see **Sections 4.1 and 5.1**). However, it was assumed that all adjusted water demand in **Sections 8.2.2.1** and **8.2.2.2** supplies residences, given that community water sources in the Planning Region primarily serve residential users (see **Section 7.3**). Moreover, private individual wells are assumed to supply a single residence or business.

Moreover, judging from responses given by community systems to the water supply planning survey (i.e., most only meter water withdrawal at the well; no use metering or billing data are available for disaggregating water use), and taking into consideration that most of the NN community systems are small in scale, there appears to be little data available to quantify disaggregated water use in the Planning Region.

8.2.3 Conclusions of Refined Water Demand Forecast

Accounting for population increase and the implementation of water management practices, the community-system water demand would increase from 2.19 MGD in 2007 to 3.27 MGD in 2107 (**Table 8-4**). The net increase in water demand is 1.079 MGD. **The adjusted water demand of 3.27 MGD for community systems by year 2107, represents 69% of the 4.74 MGD** (**Form 2A, Appendix B**) **permitted withdrawal capacity for community systems in the Planning Region.**

Significant water savings are derived from implementing water management practices in community systems and private residential wells. Water savings derived from implementing the USBC in new residences supplied by community systems alone would represent 0.3 MGD, while residential, small self suppliers would save 0.3 MGD. Total water savings of 0.60 MGD in year 2107 would represent 12.68% of the total permitted withdrawal for community systems in the planning region.

Future updates of this WSP should incorporate the latest available data on per capita use and distribution of population served by community systems and by private wells. It is important to recall that the baseline per capita value used in the water demand projections (75 g/d/p; VDH sewerage design criteria, USGS, 1995) is an average estimate to be used across community systems. In fact, the per capita use rate may be higher during the summer season when demand increases due to population influx of tourism and secondary homes. A higher per-capita rate during peak seasons will result in commensurate higher adjusted demand.

. Further discussion of the adequacy of water sources to supply community systems will be provided in the Statement of Need (**Section 10** of this WSP).

8.2.4 Influence of Major Private Self-supplied Users (Self-supplied Demand Projections)

The water demand forecast and demand management discussed in this WSP is primarily focused on community water sources, with the goal of identifying risks to long-term water supplies. Large, self-supplied sources (withdrawing >300,000 gal/mo) did not provide sufficient data to allow for a detailed analysis of future water demand outside the Community Systems. Six (6) large, self-supplied users for industrial and agricultural practices (>300,000 gallons per month) were identified in the Planning Region (see **Section 7.3.3**). Only three of these water sources responded to the WSP survey. However, these private interests have direct economic impetus to implement demand management practices to enhance water use efficiencies, minimize losses, and ensure a long-term stable and reliable water supply.

Lake Packing Inc. is considered the sole self-supplied agricultural user of more than 300,000 gallons per month of water as per DEQ data (Form 2-H and Form 3-I in **Appendix B**) and survey results (see **Section 7.3.3**).

Large self-suppliers of surface water and ground water for non-agricultural purposes were identified in Forms 2D, 2E and Form 3-H (**Appendix** B). Form 3-H focuses on large non-agricultural users of more than 300,000 gallons/month, outside of the service area of community systems. Form 3-H presents a summary of estimated water use from different sources and years, in an attempt to depict water use given the limited survey response. Based on the water use estimates in Form 3-H, the six large self-suppliers of non-agricultural uses consumed a total of 1.784 MGD of surface water and 0.431 MGD of ground water in 2006 (see **Section 7.3.3**).

The Steering Committee is not aware of current plans to locate a new industrial development in the Planning Region, or of any plans for significant expansion of current commercial users in the Planning Region, which would dramatically increase water withdrawal inside the NN jurisdictional boundaries. The Steering Committee considers the potential for developing golf courses as the primary factor that would significantly increase water demand within the NN. While this situation could change at any time with the announcement of a major water withdrawer locating or expanding in the NN, domestic water use (from community and private systems) will likely constitute the primary future water demand in the NN.

Industries and agriculture, constituting the major self-supplied water users, should find it economically beneficial to recycle water, and use lower quality water, wherever possible to reduce fresh water volumes (ground water or surface water). For example, reuse of treated wastewater in the industrial process, use of technology that uses less quantities of water for the same industrial product, and use of rainwater harvesting, will help reduce demand on surface and ground water resources, which in turn reduce potential conflicts with community suppliers over these finite resources.

9.0 DROUGHT RESPONSE AND CONTINGENCY PLAN (9 VAC 25-780-120)

9.1 Introduction

In accordance with Water Supply Planning Regulations, Section 9 VAC 25-780-120, the following discussion presents a Drought Response and Contingency Plan (DRCP) as a component of the WSP.

In general, drought is a period of unusually dry (i.e., a deficit in precipitation received) weather that persists long enough to cause serious problems such as crop damage and/or water supply shortages. In more specific terms, meteorological drought is a measure of departure of precipitation from normal. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location.

The DRCP is focused on identifying drought conditions and implementing appropriate response in order to maintain adequate water supplies in the Planning Region. The successful response to drought conditions in the Planning Region (i.e., implementation of the DRCP) largely depends upon public education and involvement.

There are three graduated stages of response to the onset of drought, including:

- **Drought Watch -** Increase awareness in public and private sector
- **Drought Warning** - Onset of drought is imminent
- **Drought Emergency** - Significant drought event, contamination, equipment failure

Local ordinances adopted by the jurisdictions that are party to the regional WSP support implementation and enforcement of the DRCP (**Appendix K**).

The Commonwealth's Drought Assessment and Response Plan is provided in **Appendix K** of this WSP, as a supporting reference for implementation of this DRCP.

9.1.1 Purpose of the DRCP

The purpose of the DRCP is as follows:

- To provide a contingency plan to manage water supplies during drought conditions and emergency conditions (declared Drought Emergency, contamination event or equipment failure);
- To assist water suppliers to deliver a cost effective, adequate, safe and reliable supply of high quality water;

- To establish an enforceable programmed response for each drought stage (discussed below) that will reduce water consumption with the least adverse impact on the residents and businesses of the Planning Region.
- Non-climate related emergencies (contamination of water source, equipment failure) may result in the need to restrict water use until water service is restored.

9.1.2 Regulations and Enforcement Mechanisms for Water Conservation

Each of the local jurisdictions party to this WSP (Counties of Lancaster, Northumberland, Richmond and Westmoreland, and incorporated towns of Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, and White Stone) adopted a local ordinance supporting the DRCP presented herein (**Appendix K)**. The DRCP is enforceable through these local drought response ordinances, and through the Commonwealth's Water Supply Planning Regulations (Section 9 VAC 25-780-120).

Furthermore, the Code of Virginia (Code), Section 15.2-923, allows localities to restrict nonessential use of ground water during times of water shortages or water emergencies. Finally, Section 15.2-924 of the Code gives localities the power to restrict water use for the prevention of or the duration of a water supply emergency.

The DRCP is applicable to all community and self-supplied water sources in the Planning Region. As discussed in detail below, a committee of representatives from the Planning Region will monitor conditions for the pending on-set of drought, and implement specific actions addressed in this DCRP.

9.2 Overview of Drought Monitoring and Response

The following discussion presents an overview of the DRCP protocol. **Table 9-1** summarizes the correlation between drought conditions and DRCP-based drought stages (termed Drought Watch, Drought Warning and Drought Emergency). **Table 9-2** summarizes required actions corresponding to each drought stage.

The terms "Local Drought Monitoring Committee", "drought stage", and a discussion on local monitoring will be introduced in more detail after this initial overview.

DRCP implementation will proceed according to the following outline:

- The Local Drought Monitoring Committee (LDMC) will review the VDEQ's ***Drought Monitor***, a web-based resource, in order to identify regional drought stages, which in turn trigger specific actions (see **Table 9-1**).

- Regional retrograde drought conditions are also monitored and communicated in the Planning Region until the LDMC confirms from ***Drought Monitor*** that all areas of the Planning Region may return to normal water use conditions.

Drought response actions are described below and in **Table 9-2**, and enforced through local ordinance and the Code of Virginia.

9.2.1 Introducing the Local Drought Monitoring Committee (LDMC)

The Local Drought Monitoring Committee (LDMC) for the Planning Region is tasked with monthly, and if necessary weekly, monitoring of regional drought conditions using DEQ web-based technologies, and to lead drought response implementation. The members of the LDMC are not identified here, but a general membership target is presented. The LDMC will be comprised of a representative(s) designated from the counties of Lancaster, Northumberland, Richmond and Westmoreland and incorporated towns therein. Also, participation will be offered to representatives from large self-supplied users in the Planning Region, as determined by the local jurisdictions.

The objectives of the LDMC are as follows:

- Monitor monthly or weekly (under Drought Watch, Warning or Emergency) regional drought conditions using DEQ's Drought Monitor website (discussed below);
- Activate notifications to the Planning Region in order to identify drought stage, and request appropriate response to identified drought conditions;
- Provide information to water suppliers and public regarding drought status and response methods;
- Monitor regional drought progress (via DEQ's Drought Monitor; contacts with local suppliers) and implement triggers (prograde or retrograde drought) as appropriate;
- Determine when regional drought conditions have attenuated sufficiently to justify a return to normal water supply conditions.

9.2.2 Introducing Drought Stages

The Governor's Executive Order #39 (issued December 13, 2002) established the Virginia Water Supply Initiative, requiring the Commonwealth's Drought Coordinator to develop a formal drought assessment and response plan. As a result, the Drought Response Technical Advisory Committee was convened in 2003. This committee is chaired by the VDEQ and is supported by the Virginia Drought Monitoring Task Force (DMTF).

The DMTF has responsibility for monitoring drought conditions in the Commonwealth. The DMTF produces the ***Drought Monitor***, an Internet-based service available at the following URL:

http://www.deq.state.va.us/watersupplyplanning/drought.php

The ***Drought Monitor*** uses a multi-index drought classification system, for low-to-high severity categories D0 through D4. **Table 9-1** (below) summarizes the drought classification system used by the ***Drought Monitor***, and correlates to drought stages identified in this DRCP (Watch, Warning, Emergency).

Community water supplies on the NN are derived from ground water. The DMTF drought monitoring program integrates water level data from USGS monitoring wells in the NN region. There are two wells in Lancaster County, one well in Northumberland County, one well in Richmond County, and two wells in Westmoreland County. This system of monitoring wells provides relatively good covereage of the NN Planning Region for drought monitoring. Therefore, the implementation, progression and diminution of drought response under this DRCP will be based upon the DMTF's regional drought designation protocol, which will be monitored by the LDMC via the Internet.

Table 9-1 Drought Categories Determined by VDEQ Drought Monitoring and Corresponding Drought Stages for the DRCP

DEQ Drought Monitor Category	Description	Possible Impacts	DRCP Drought Stages
D0	**Abnormally Dry**	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered	
D1	**Moderate Drought**	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested	**Drought Watch**
D2	**Severe Drought**	Crop or pasture losses likely; water shortages common; water restrictions imposed	**Drought Warning**
D3 and D4	**Extreme Drought**	Major crop/pasture losses; widespread water shortages or restrictions	**Drought Emergency**
	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies	

The DRCP is designed to monitor regional and local drought conditions monthly (increasing to weekly under DO Category "Abnormally Dry" conditions), and respond to three stages of drought conditions (Drought Watch, Drought Warning and Drought Emergency) (**Table 9-1**). Each stage triggers increasingly stringent response measures to be implemented as water supply and/or demand conditions worsen (**Table 9-2**).

The LDMC is responsible for evaluating regional drought conditions via the ***Drought Monitor***, and implementing response actions (**Table 9-2**). The DRCP includes voluntary and mandatory water reduction strategies (**Table 9-2**). Water Supply Regulation 9 VAC 25-780-120 established a goal of 5-10% reduction in water use by voluntary reduction

(Drought Watch, Drought Warning) and 10-15% reduction by mandatory reduction (Drought Emergency).

The DRCP implementation initially functions with the LDMC conducting monthly monitoring for incipient drought using the VDEQ ***Drought Monitor***. When climate conditions lead to D1 Category (Drought Watch) conditions within any of the NN jurisdictions, the LDMC begins weekly monitoring, and initiates notifications to the public, Large Self-supplied sources and Communtiy sources of incipient drought (**Table 9-2**).

Table 9-2 Drought Stages and Corresponding Actions

STAGE	Required Actions
Drought Watch	1) **LDMC** initiate weekly monitoring of ***Drought Monitor*** website. **LDMC** to notify public, community and self-suppliers of Drought Watch via newspaper, public service announcement, notices with water bills. Request voluntary reductions in non-essential water use.
Drought Warning	**Voluntary water use reduction.** **LDMC** will notify public, community and self-supplied sources of Drought Warning. **LDMC** will request voluntary reduction in the following non-essential water use to meet drought stage target of **10% reduction** in water withdrawals **(See Note 1)**:
	(1) Water to wash down streets, sidewalks, walkways, driveways, parking lots, service station aprons, tennis courts, other hard surfaced areas, buildings, and structures, except as required for safety concerns.
	(2) Water to wash automobiles, trucks, trailers, and any other type of mobile equipment, except where required to meet air quality standards.
	(3) Watering of shrubbery, trees, lawns, grass, plants, and other vegetation.
	(4) Water from fire hydrants for construction purposes or any purpose other than fire suppression or other public emergency
	(5) Water to fill or refill swimming pools.
	(6) Storage facilities to be filled during non-peak times for fire flow.
	(7) Customer not served drinking water in restaurant unless requested.
Drought Emergency (includes non-climate emergency impact to water source)	**Mandatory water use reduction**. **LDMC** will notify public, community and self-supplied sources of Drought Emergency. **LDMC** will implement **mandatory** water restrictions to reach drought stage target of **15% reduction** in water withdrawals for water uses listed under Drought Warning (Also see Note 1).
	Penalties (See Note 2): Violating the DRCP Drought Emergency stage may result in penalties (enforced by local ordinance) in accordance with schedule below. First offense Written warning; Second offense $50 fine; Third offense $100 fine; Fourth offense $250 fine and water service suspension.

Notes for Table 9-2:

Note 1: Specific Water Use Reduction Strategies
Urge (or require for Drought Emergency) customers to not use water for outdoor watering with sprinklers or irrigation systems between 10 am and 6 pm, and

* Odd-number addresses - Tuesday, Thursday and Saturday
* Even-number addresses - Wednesday, Friday and Sunday

* During Drought Warning, watering by hand (with cans, wands, hand-held hoses) allowed any day of the week.

Drought Emergency landscape exception: customers may water first-year foundations, trees and shrubs up to two hours a day by a hand-held or soaker hose, and new planting of grass within the first 30 days up to one hour a day by any means. Restrictions do not apply to locations using treated wastewater effluent for irrigation.

Note 2: Violation Penalty Enforcement
Penalties for violating the DRCP Drought Emergency stage required actions are enforceable by local ordinance.

Voluntary water use reductions (Drought Watch and Drought Warning) rely on community goodwill to attempt to comply with the provisions. Mandatory water-use reductions (Drought Emergency) have enforceable limits placed on certain types of water use. This is also supported by the Code of Virginia, Section 15-2-924.

9.3 Exemptions

Upon implementation of a Drought Emergency stage, an appeals board (Board) will be established by the jurisdiction within which the drought emergency occurs (i.e., any or all of the local jurisdictions party to this WSP). The Board will consist of three (3) representatives from each jurisdiction. The jurisdiction's attorney, or legal counsel designated by the jurisdiction, will serve as legal counsel to the Board. The Board shall be empowered to review applications for exemptions from the provisions of the mandatory water use reductions on a case-by-case basis and, if warranted, to make equitable adjustments to such provisions. The Board shall also be empowered to establish regulations governing the granting of temporary exemptions applicable to all or some of the uses of the water supply as set forth. The Board shall, in deciding applications, balance economic and other hardships to the applicant resulting from the imposition of water use restrictions or allocations against the individual and cumulative impacts to the water supply resulting from the granting of exemptions. Individual applications shall be decided by the board within two (2) weeks of receipt of an application in proper form and containing all necessary information.

Water customers who are engaged in activities in which water is essential for public health, such as health care facilities (including but not limited to hospitals, minor emergency centers, health care practices, nursing homes, and convalescent centers), will be exempt from the mandatory water use reductions and increased water rates imposed under the DRCP (**Table 9-2**) provided that they have satisfactorily completed, submitted, and received approval for an exemption from the Board.

Additionally, commercial and industrial customers who require water as a major and essential part of their day-to-day operations will be exempt from mandatory water use reductions under the DRCP (**Table 9-2**) provided that they have satisfactorily completed, submitted, and received approval for an exemption from the Board.

9.4 Declaring Reduction of DRCP Drought Stages

As drought conditions dissipate, and water sources are replenished, weekly drought conditions monitoring (regional conditions via ***Drought Monitor*** by LDMC; Individual supplies) will continue.

The LDMC will communicate regional retrograde drought condition notices in similar fashion as described above for Drought Watch, Drought Warning and Drought Emergency. Ultimately, as meteorological drought conditions dissipate, water suppliers will progress through reduced drought stages (**Table 9-2**) until finally returning to "normal" water use conditions.

Note that the response time for drought impact and recovery for ground water sources is longer than that for surface water reservoirs. This is due to a longer lag time between local climate variation and resulting effects on aquifer recharge, as compared to surface water reservoirs. In general, while the criteria triggering initiation of drought response measures will likely occur sooner with the on-set of drought for surface water sources as compared to ground water, return to normal conditions will take longer for ground water sources.

9.5 Non-Climate Related Water Emergency Response

Non-climate related emergencies (contamination of water source, equipment failure) may result in declaration of a Drought Emergency stage by any individual water supply, or if the impact is on a regional basis, the LDMC. Appropriate response actions will be followed (**Table 9-2**) in order to mandate water use restrictions until water service is restored.

9.6 Periodic Review and Update DRCP

In accordance with Water Supply Planning Regulations, Section 9 VAC 25-780-120, the regional WSP must be reviewed and updated by the participating jurisdictions every five (5) years. The DRCP component of the WSP (herein) will likewise be reviewed and updated for conditions at the current time in the region.

In particular, this review will focus on any required modifications in triggering criteria to reflect changed conditions. Population growth and increasing water demand may increase a water supplier's vulnerability to drought. Major additions of new water sources or improvements to water system facilities may significantly reduce vulnerability.

The update process also helps ensure that the Planning Region jurisdictions are familiar with the plan and encourages "post event" reviews of the plan to identify and correct any problems that may have arisen during an implementation.

9.7 Local Drought Management Ordinances

At the time of preparation of the WSP, the jurisdictions in the Planning Region had no ordinances to address drought contingency and response. The DRCP will serve as an overall drought mitigation plan for the Planning Region. Each jurisdiction party to the WSP passed adopted an ordinance supporting the DRCP (**Appendix K**).

10.0 STATEMENT OF NEED AND ALTERNATIVES (9 VAC 25-780-130)

The following discussion evaluates the adequacy of existing community water sources to meet current and projected community water demands, presents a Statement of Need, and outlines water supply alternatives that may be considered for short-term and long-term options in the Planning Region. This discussion is presented in accordance with Water Supply Regulations 9 VAC 25-780-130.

Data and conclusions for the evaluation of adequacy and Statement of Need were compiled from previous sections of the WSP, including available community supply capacity (**Sections 2, 4, 5**), and projected water demand and demand management (**Sections 7 and 8**). The evaluation of adequacy and Statement of Need are based on all water data available at the time this report was completed.

10.1 Adequacy of Existing Water Sources

Table 10-1 summarizes the analysis of adequacy of existing Community water sources to meet projected water demand in the Planning Region, throughout the Planning period (2007 to 2107). **Table 10-1** is structured to demonstrate the per-decade evaluation of adequacy, summarizing the results of per-capita demand forecasting discussed in **Section 7.0** and **Section 8.0** (see Columns 1 through 5 of **Table 10-1**), and comparison of permit capacity (see Column 6 of **Table 10-1**). The total permitted withdrawal available for community systems in the Planning Region was estimated at **4.74** MGD (**Form 2A, Appendix L**).

Table 10-1 summarizes Community water supply adequacy by comparing the available capacity to projected demand, listing water demand as a percentage of available capacity per decade (see Column 6 of **Table 10-1**). Column 7 of **Table 10-1** specifically notes whether a water demand or surplus is anticipated for each decade of the Planning Period (Community water source surplus is anticipated for the Planning Region throughout the Planning Period).

Additional information is provided in **Table 10-1** (Column 8 through 10), where water conservation from demand management (**Section 8.0**) is assessed as a percentage of water savings per decade.

To summarize the results shown in **Table 10-1**, **the total adjusted water demand for community systems in the Planning Region by year 2107 is 3.57 MGD**. This water demand represents approximately 70% of the total permitted withdrawal for community systems in the Planning Region. Based on the assumptions and estimations for water demand and demand management (**Sections 7.0** and **8.0**), the overall conclusion is that water sources in the Region are adequate to meet current and projected demand(s) through the Planning Period. The adequacy of resources will be re-evaluated in five years after compliance determination, according to 9 VAC 25-780.

Table 10-1 Adequacy of Community Water Sources (listed by decade) for the Planning Period 2007 to 2107

Year	Northern Neck population	Estimated population served by community systems*	Adjusted water demand of community systems (MGD)**	Total permitted capacity of community systems (MGD)+	Adjusted water demand as % of permitted withdrawal	Deficit (-) or surplus (+)	Original estimate of community demand projections (MGD)++	Total savings in community systems due to water management practices (MGD)	Water savings as % of permitted withdrawal
2007	58,421	29,211	2.19	4.74	46%	+	2.19	0.00	0%
2010	59,567	29,784	2.22	4.74	47%	+	2.23	0.01	0.2%
2020	63,166	31,583	2.33	4.74	49%	+	2.37	0.04	1%
2030	66,959	33,479	2.44	4.74	51%	+	2.51	0.07	1.5%
2040	70,714	35,357	2.55	4.74	54%	+	2.65	0.10	2%
2050	74,169	37,085	2.65	4.74	56%	+	2.78	0.13	3%
2060	77,962	38,981	2.76	4.74	58%	+	2.92	0.16	3.4%
2070	81,623	40,811	2.87	4.74	61%	+	3.06	0.19	4%
2080	85,302	42,651	2.98	4.74	63%	+	3.20	0.22	5%
2090	88,954	44,477	3.09	4.74	65%	+	3.34	0.25	5.3%
2100	92,610	46,305	3.19	4.74	67%	+	3.47	0.28	6%
2107	**95,216**	**47,608**	**3.27**	4.74	**69%**	+	**3.57**	**0.30**	**6.3%**

* Approximately 50% of the Planning Region population is served by community systems.

** Results of multiplying the estimated cumulative population change by the adjusted per capita water use factor of **59 g/d/p**. This rate results from using the Virginia Uniform Statewide Building Code (**USBC**) in all **new** homes and businesses = 24 g/d/p savings (see **Table 8-1**) as main water management practice. This rate also includes a **15% contingency factor** for unaccounted losses.

+ The total permitted withdrawal for community systems in the planning region was estimated at **4.74 MGD**. This number represents the sum of VDH Permitted System Capacity of community systems (**Form 2A, Appendix B**) for which information was available.

++ Demand projections in Section 7.0

10.2 Statement of Need

The discussion of adequacy of resources in **Section 10.1** forms the basis for the Statement of Need for Community water supplies. Under the assumptions and estimations for water demand and demand management used in **Sections 7 and 8**, water resources are evaluated to be adequate to meet projected demand in the Planning Region (**Table 10-1).**

The Adequacy Assessment and Statement of Need were made in aggregate for all community systems in the Planning Region. This is based on the particular context of the Planning Region, reliance on ground water and the potential for consolidation of private and Community systems. There are 96 community water systems in the Planning Region, all relying on ground water to supply approximately 50% of the Planning Region population (see **Section 4.0 and Section 5.0**). Individual analysis of each community system was not viable given the limited information at the level of individual systems and the small scale of most community systems (some supplying a service area as little as 3 residences).

The ratio of population served by community systems and private individual wells may change in the future if development, climate and local aquifer conditions lead to a trend toward expansion of community systems to serve existing self-supplied users. This may occur as population growth in the Planning Region leads to consolidation of communities, and the aggregate replacement of individual private wells by Community sources. Consolidation into Community sources may also occur if private water sources are abandoned (i.e., contamination, drought).

The adequacy of existing water sources to meet projected community water demand could change in the future given that all Community systems rely on ground water supplies. Continued or increased extra-regional withdrawals could affect the Planning Region's ground water supplies. Besides unforeseen economic and demographic changes in the neighboring regions, severe drought conditions can affect the ground water sources in the Planning Region (**Section 9.0** addresses **Drought Response and Contingency Planning**).

As noted previously in this WSP, extra-regional water users are impacting ground water levels in the region and may affect the Northern Neck's ground water supply. Common aquifers are used by the Northern Neck, the Middle Peninsula, and Southern Maryland. Negotiations and intra-regional water planning efforts should be considered in order to ensure water sustainability, especially since ground water aquifers do not follow the boundaries of the planning districts.

The evaluation of adequacy and the Statement of Need are based on all water data available at the time this report was completed. In order to achieve the goal of the WSP existing as a "living document", future updates of this WSP should consider the key changing variables that affect water demand in the Northern Neck. The adequacy of

resources will be re-evaluated in five years when the WSP compliance determination occurs, according to 9 VAC 25-780.

Any new water source will have to be assessed on a case-by-case basis to get authorization for surface and ground water withdrawals according to DEQ and VDH permitting processes. Furthermore, any future water use will be considered in the context of the latest update of this Regional Water Supply Plan.

It is critical for the Planning Region that community water supplies maintain the capacity to respond to both domestic demands and economic development potential. The Steering Committee agrees that diversification of water supply is important. A summary listing of short-term and long-term alternative methods are provided in **Section 10.3**, below, for potential scoping and evaluation in the future as the WSP undergoes periodic 5-year review to ensure water sustainability.

10.2.1 Conditions that may change the adequacy of water sources

The evaluation of adequacy is based on all water data available at the time this report was completed. Future updates of this WSP should consider the key changing variables that affect water demand in the Northern Neck.

First, trends toward increased in tourism and establishment of more secondary homes may increase seasonal population fluctuations in the Planning Region, especially during the summer months. Demand projections in this WSP focused on local population growth due to limited data on transient tourist population and no concrete plans for developing a new significant tourist destination. Future iterations of the WSP could include assessments to quantify the influx of tourists during the summer months (i.e. through study of solid waste in the Region).

A second aspect to consider is the changing ratio of the population served by community systems and private wells as ground water resources become scarce or less cost-effective. Integration of domestic, self-suppliers into the community systems is likely to happen to reduce the harvesting and distribution costs of ground water as the quality and quantity of ground water decreases. The possible integration of domestic self-suppliers into community systems could create an additional region-wide potential stress to community systems. If new community sources need to be developed, every new project or the expansion of existing sources should be to evaluate on a case-by-case basis, in the context of this WSP. The approval or extension of community water sources will follow the permitting process of DEQ and VDH. It is noted that a locality’s ability to expand community water may be limited, and requires long-term planning, and consideration of water supplies when proposing / approving new developments.

Third, any new industrial development or expansion of existing industrial suppliers may drastically increase water withdrawals in the Planning Region. Any new industrial water user will have to be assessed on a case-by-case basis to get authorization for surface and ground water withdrawals according to DEQ and VDH permitting processes.

Furthermore, any future water use will be considered in the context of the latest update of this Regional Water Supply Plan.

Fourth, as noted previously in this WSP, extra-regional water users are impacting ground water resources since common aquifers are used by the Northern Neck, the Middle Peninsula, and Southern Maryland. Negotiations and intra-regional water planning efforts should be considered in order to ensure water sustainability, especially since ground water aquifers do not follow the boundaries of the planning districts.

Finally, special consideration should be given to ground water contamination, drought or other conditions that may cause reduction on the wells' yield or closure of the wells. Shallow wells (primary means of serving individual self-supplied residences and businesses) are at the greatest risk for drought, and contamination. Expansion of community systems (ground water or surface water) may be required in the future to replace private sources (i.e., population density shifts, drought impacts, contamination), leading to more stress being placed on community systems to meet demand. The counties in the planning region have paid emphasis to water well protection, quality monitoring, and reservoir alternatives in the latest updates of their Comprehensive Plans.

10.2.1.1 Scenario where part of the self-supplied population integrates into the community systems

The following discussion focuses on a scenario where an increased proportion of domestic self-suppliers (e.g., private residential wells) are abandoned and community water system service areas are expanded. This implies a change in the assumption used in **Section 7.0**, where the ratio of population served by community systems and private wells are approximately equivalent (50% each) throughout the Planning Period. This "what if" scenario does not presume an increased water demand, but highlights how the adequacy of permitted resources changes if the assumed ratio of community systems/ private wells changes over time. Moreover, this scenario can help in regional planning to compare a baseline overview of supplies and their adequacy, and "what if" scenarios where water demand or demand management conditions change in the Planning Region. Future changes in the water demand context of the planning region (i.e. new economic and industrial, housing developments, etc) will require updates of the WSP (demand projections, adjusted demand, adequacy of resources, and Statement of Need).

Table 10-2 shows the water demand scenario where 10% of the self-supplied population in each decade integrates into the community systems. Columns three, four and five show the future increase in population served by community systems at the beginning of each decade (total population served, net population change and cumulative change). Column six shows the progressive increase in population served by community sources, as a percentage of the total population in the Planning Region. Column seven presents the adjusted water demand of community systems after accounting for demand management practices in all new residences. Column eight then re-states this water demand as a percentage of permitted withdrawal capacity in the Region. The same items are presented in columns nine through fourteen for domestic self-suppliers.

In this scenario, **community sources in the planning region will reach 74% of the total permitted withdrawal capacity (4.74 MGD) by year 2050 and 100% of such capacity by year 2080 (column eight).** By year 2100, 100% of the population would be served by community sources (column six).

Short-term and long-term alternatives are suggested in **Section 10.5** to supplement the community supplies under this scenario or other scenarios that could increase water demand.

Table 10-2 Water demand scenario where part of the self-supplied population integrates into community systems

Year	Northern Neck population	Estimated population served by community systems	Change in population (community systems)	Cumulative change in population (community systems)	% of NN population served by community systems*	Water demand of community systems (MGD)**	Water demand of community systems as % or permitted withdrawal+	Estimated population served by private wells	Change in population (private wells)	Cumulative change in population (private wells)	% of NN population served by private wells*	Water demand of residential, small self suppliers (MGD)	Total water demand (community and domestic wells) (MGD)
2007	58,421	29,211			50%	2.19	46.2%	29,211			50%	2.19	4.38
2010	59,567	29,784	573	573	50%	2.22	46.9%	29,784	573		50%	2.22	4.45
2020	63,166	34,742	4,958	5,531	55%	2.52	53.0%	28,425	-1,359	-1,359	45%	2.13	4.65
2030	66,959	40,175	5,434	10,965	60%	2.83	59.7%	26,784	-1,641	-3,000	40%	2.01	4.84
2040	70,714	45,964	5,788	16,753	65%	3.17	66.9%	24,750	-2,034	-5,034	35%	1.86	5.03
2050	74,169	51,919	5,955	22,708	**70%**	3.52	**74.3%**	22,251	-2,499	-7,533	30%	1.67	5.19
2060	77,962	58,472	6,553	29,261	75%	3.91	82.4%	19,491	-2,760	-10,293	25%	1.46	5.37
2070	81,623	65,298	6,827	36,088	80%	4.31	90.8%	16,325	-3,166	-13,459	20%	1.22	5.53
2080	85,302	72,507	7,209	43,296	**85%**	4.73	**99.7%**	12,795	-3,529	-16,988	15%	0.96	5.69
2090	88,954	80,058	7,552	50,848	90%	5.17	109.0%	8,895	-3,900	-20,888	10%	0.67	5.84
2100	92,610	92,610	12,552	63,400	100%	5.91	124.6%	0	-8,895	-29,784	0%	0.00	5.91
2107	95,216	95,216	2,606	66,006	100%	6.06	127.8%	0	0	-29,784	0%	0.00	6.06

* Approximately 50% of the Planning Region population is served by community systems.

** Results of multiplying the estimated cumulative population change by the adjusted per capita water use factor of **59 g/d/p**. This rate results from using the Virginia Uniform Statewide Building Code (**USBC**) in all **new** homes and businesses = 24 gpd/p savings (see **Table 8-1**) as main water management practice. This rate also includes a **15% contingency factor** for unaccounted losses.

+ The total permitted withdrawal for community systems in the planning region was estimated at **4.74 MGD**. This number represents the sum of VDH Permitted System Capacity of community systems (**Form 2A, Appendix B**) for which information was available

10.2.2 Threats of Extra-Regional Withdrawals on Ground Water Supplies

Extra–regional ground water withdrawals can be considered a threat to water supplies in the Northern Neck. In the Planning Region, groundwater resources are impacted by Southern Maryland and the Middle Peninsula of Virginia. Since all community water systems in the Planning Region utilize groundwater, any significant change in well yields could severely impact water supplies. These competing uses can affect aquifer's quantity and quality, and diminish the capacity of the localities in the Planning Region to respond to unforeseen major demographic or economic changes inside the region and in the neighboring regions.

The Northern Neck Regional Water Supply Steering Committee (Committee) is aware of the need to consider extra-regional users while planning for water sustainability in the NN. For the purposes of this WSP, a one hundred year planning period was undertaken (2007 to 2107). The Committee requested a 100-year planning period to better plan for potential groundwater supply deficits due to the impact of extra-regional users. A long-term planning period serves to identify the framework in which the new water supply planning efforts should consider, given stresses placed on groundwater aquifers underlying the Planning Region.

The NN counties are not able to limit groundwater withdrawals under current Virginia Law, since local control is outside the jurisdiction. Nonetheless, safeguarding and monitoring water supply and water quality is recognized as critical by the NN localities, and land use policies that assist this should be continued and strengthened. Planning and land use controls are critical for siting and permitting any future large-volume groundwater withdrawals (e.g., industries, golf course, etc.).

The Comprehensive Plans of Lancaster County and Northumberland County specifically support all efforts by the DEQ to designate the region as a Groundwater Management Area, under the Groundwater Management Act of 1992. The plans also foresee plans for DEQ and USGS for establishing additional water supply and water quality monitoring points in the NN, including drilling additional wells to obtain more complete data on the hydrogeology of the NN.

Lancaster County will actively support efforts to have the Eastern Virginia Groundwater Management Area extended through the Middle Peninsula and the Northern Neck. This will ensure that future entities that wish to withdraw large amounts of water will be required to seek a permit and report to the Virginia Department of Environmental Quality. The County will also encourage conservation efforts on the part of current and future users. Any future golf courses will be required to develop plans that include surface or recycled water sources for their needs rather than being totally dependent on groundwater withdrawals.

King William County, home to the largest industrial groundwater user in the region, is the only Middle Peninsula locality included in a groundwater management area. Groundwater levels there have been affected by local industrial pumping and regional drawdown, and have declined steadily since the 1930s. A cone of depression with a 29-mile radius formed, primarily as a result of industrial withdrawals. The Commonwealth designated King William as a Groundwater Management Area in 1999.

It is important to note that the expansion of the Ground Water Management Area by DEQ will not affect southern Maryland's withdrawals.

10.3 Summary of Potential Water Supply Alternatives

The Statement of Need indicates, according to available data, that water sources are considered adequate to meet current and projected demand(s) of Community systems in the Planning Region throughout the Planning Period. Therefore, a formal water supply alternatives analysis is not required for this WSP.

Nonetheless, the NN Water Supply Steering Committee agrees that diversification of water supply in the Planning Region is important. Moreover, the Committee acknowledges that water quality and quantity need to be monitored in the Northern Neck. To that end, the analysis of future alternatives for water conservation and new water supplies is introduced in this WSP for future consideration, and to benefit water supply sustainability of the Planning Region. A full and detailed alternatives analysis, including technological, economic and permitting analysis, will be required if the Planning Region, or individual Community sources identify a need to replace or upgrade a water source.

10.3.1 Short- term Alternatives

The following alternatives can enhance water supplies in the Planning Region if short term adequacy or water emergencies occur:

a) Water conservation
b) Increased permitted withdrawal capacity

10.3.1.1 Water conservation

As noted before in this WSP, water demand management techniques that are currently in effect, or under consideration by the Planning Region, are already incorporated into a refined water demand projection (**Section 8.0**). The implementation of further water demand management practices is the most efficient strategy to improve water supply sustainability in the Region. Examples of water demand management practices that may be considered by jurisdictions and community sources in the Planning Region are presented in **Section 8.1**.

Localities in the Planning Region may also benefit from applying to the State Revolving Fund Program (SRF), which is administered by the Environmental Protection Agency (EPA). The SRF focuses on better management, water efficiency, water planning with a

watershed approach, full cost pricing, new investment in research, and new strategies for education and knowledge management.

10.3.1.2 Increased permitted withdrawal capacity
This alternative focuses on using the existing well(s) for more withdrawal capacity, as opposed to installing new ground water extraction infrastructure. This alternative may entail well rehabilitation and/or well deepening, which can be carried out taking one well off-line during refurbishment and thus minimizing disruption to the water supply.

10.3.2 Long- term Alternatives

The following alternatives comprise methods for enhancing or replacing water supplies in the Planning Region if long-term adequacy or water emergencies occur:

a) Refurbish or install new ground water wells
b) Less conventional alternatives: Reclaimed water, desalination, rain harvesting, water marketing and transfers
c) Surface water reservoir

This list of alternatives was refined after consideration of a larger listing of methodologies, and deemed to represent relatively reasonable options for the Planning Region.

10.3.2.1 Refurbish or install new ground water wells

Refurbishing existing wells (well work-over, extending a well deeper into the aquifer) is likely the most effective long-term alternative for improving or replacing a Community source (i.e., 100% of Community sources in the Planning Region currently rely on ground water).

10.3.2.2 Unconventional alternatives: Reclaimed water, desalination, water marketing and transfers

Water supply alternatives that are less conventional, including reclaimed water, desalination and water marketing present potential innovative solutions to water supply needs, as compared to the more conventional ground water or surface water source development. As technology improves, and costs decrease, these alternatives may prove beneficial in the future.

Desalination is an evident option given the geographic location of the Planning Region. This alternative could be explored in the future to supply water to residents in the shoreline. Several technologies are currently available to remove salt from ocean or brackish water (i.e. reverse osmosis membrane, solar evaporation array). Given the current high cost of these technologies, it is more likely to consider desalination as a future long-term alternative, when market prices may lower and economic incentives may be available.

10.3.2.3 Surface water reservoir(s)

Developing a regional surface water reservoir, or multiple sub-regional reservoirs, has been considered by the NN planning region as an alternative water supply(ies).

In 1969, the Northern Neck Development Commission (NEDCO) completed a report entitled Engineer's Comprehensive Plan (for) Water and Sewerage Facilities (in) Lancaster, Northumberland and Richmond Counties. In the report, 43 candidate reservoir sites were identified. **Appendix L** shows the preliminary design data from the 1969 NEDCO report for the recommended water supply reservoirs. Data include the specification of each reservoir: flood volume, wildlife volume, water supply volume, drainage area, and sediment volume. Design data in the summary table were derived from analysis of water runoff data for the years 1954-1956. This period represents the worst extended drought for similar streams for which records were available at that time; thus the selected reservoirs were estimated to provide the indicated water storage during periods of extreme drought.

More recently, the four counties comprising the Northern Neck region updated their Comprehensive Plan, and water supply protection factors prominently in the Counties' planning efforts. The potential for developing surface water reservoir(s) for supplemental or primary water supplies in the NN was also incorporated into the updated County Comprehensive Plans. Some of the reservoirs identified in the NEDCO report are included in the Comprehensive Plans; mainly the ones close to population centers. The following provides a summary overview of water sustainability issues and surface water reservoirs identified by each county in their Comprehensive Plan.

a) Lancaster County

Chapter 3 of the latest update to the Lancaster County Comprehensive Plan (LCCP, 2007) addresses protection of water supplies in the County. Ground water and surface water supplies located in the County are recognized as some of its most valuable natural resources. Lancaster County's ground water resources supply 100% of its potable water supply.

Surface water in the County supports a broad section of its economy and is critical to future economic development. Chapter 3 of the Plan presents a comprehensive assessment of current conditions and threats to surface waters of the County. Much of the surface water in Lancaster County is tidally influenced and not considered a readily available potential drinking water source. In the upper reaches of the creeks where the water is fresh enough to be used for drinking water, there is not enough stream flow to allow for direct intakes from the water body. However, at the headwaters of these creeks are located a number of millponds. With improved, higher impoundment structures there is the potential to create larger ponds or reservoirs. The existing millponds, or the potential new ponds, could be developed as possible surface drinking water sources in the future, subject to the Joint Permit Application review process for activities in the waters and wetlands of the Commonwealth of Virginia.

According to the Lancaster County Comprehensive Plan, domestic ground water demand in the County ranged from 1.01 MGD in 1990 to 1.08 MGD in 2000. Under County-specific assumptions, domestic ground water demand may increase to 1.44 MGD by 2030. The Comprehensive Plan concludes that current and projected ground water withdrawal within the County's jurisdictional boundaries is relatively low. Therefore, the County considers the more immediate threat to ground water supply surrounds water quality issues. However, the Comprehensive Plan notes that large commercial users that may potentially locate within the County or NN in the future (and by extension current and future extra-regional withdrawals) will present a long-term threat to water supply quantity.

Lancaster County Comprehensive Plan suggests that the County undertake a parcel-specific inventory of all abandoned wells, launch an intensive campaign on well care, and pursue grants for well upgrades. The Plan recommends that the Northern Neck be designated as a Ground water Management Area. Moreover, it recommends ground water level monitoring wells be installed in the county and Northern Neck area.

Lancaster County reservoir sites mentioned in Comprehensive Plan from the NEDCO study include the following sites:

LBB1 - Balls Branch
LCM1 - Camps Millpond
LLB1 - Little Branch, Corrotoman River
LLB2 - Little Branch, Corrotoman River
LMS1 - McMahon Swamp
LMS2 - McMahon Swamp
LCR1 - Upper West Branch Corrotoman River
LOC1 - Quarter Cove

b) Northumberland County

The Northumberland County Comprehensive Plan (NCCP, 2006) was most recently updated in 2006. Ground water supplies 100% of the potable water supply for Northumberland County. Continued withdrawal of artesian water at current rates, causing water level declines of >1 to 3 feet/year, are ultimately not sustainable. Currently, declining water levels in the artesian aquifers of Northumberland County are caused predominantly by ground water withdrawals by large extra-regional water users in Southern Maryland and the West Point (King William County) region. In the future, increasing economic and residential development in Northumberland County will place additional stress on the ability of the artesian aquifers and accelerate water level decline.

Future needs over the next 20 years and beyond for potable water are a significant planning issue for Northumberland County. Eventually, the regional artesian aquifers will cease to supply an adequate quantity of potable water and alternative supplies will be required. If large-scale development of the type that is developing in many communities along the Mid-Atlantic States comes to Northumberland County, or to nearby

communities using the same aquifers (as is already happening in Maryland to the detriment of artesian aquifers) water supply will become a more immediate problem.

Such development, however, may be regulated and required to provide its own water system in scale with need. It would be prudent on the County's part, however to have an alternative source of potable water supply. This is particularly true because of the County's proximity to sea water. Major withdrawals even in the upper reaches of the lower aquifers combined with pressure from sea water would modify adversely the quality of water available in the aquifers.

The Comprehensive Plan links sustainable water supply that includes surface water reservoirs to economic development in the County. This economic development is planned around major village centers with commercial hubs, historic tours and commercial development, and residential growth.

The basic water-supply policy is to stress a diversity of public and private water sources including the surficial aquifer, the artesian aquifer and reservoirs. The major planning issue regarding potable water supply are to provide for sustainable supplies of water and to protect the ground water sources from contamination. The Comprehensive Plan recommends that the Northern Neck be designated as a Ground water Management Area and that surface water reservoirs be developed for supplemental potable water.

Nine (9) potential reservoir sites were identified in Northumberland County in previous studies. The sites of greatest potential include:

Site	Serving	Acres	Million gallons/day
Lodge Creek	Callao	118	1.05
Mill Creek	Wicomico Church	163	0.35
Sydnor's Mill	Burgess and points east	328	0.48
Crabbe Mill	Heathsville	310	0.56

If developed and permitted in the future, these four reservoirs could provide 2.4 million gallons/day of water, enough to serve 24,000 people assuming typical water usage of 100 gallons/day/person. These four reservoirs could be used to provide water for the foreseeable future, recognizing that some citizens not easily served by a public supply will remain on either artesian or shallow wells. Because most of the population of the county is in the northeast, and that is where growth is likely to be highest, it will ultimately be necessary to connect the reservoirs. It would be advantageous to Lancaster County to utilize Mill Creek reservoir and the two adjacent counties should coordinate planning.

The key points in the Comprehensive plan regarding water sustainability and surface water reservoirs include:

- Artesian aquifer ground water is a finite resource. Because a water shortage may occur in the near future the County should plan for reservoirs as one of the sources of potable water.
- Reservoirs are one of the important potential sustainable sources of water and a desirable source of water for centers of population and for industry when the aquifer becomes impaired.
- Reservoirs would be economic engines today even if not used immediately for water supply. Shorelines of reservoirs would increase in value significantly and provide jobs and economic opportunities for recreation facilities and fishing, restaurants, and inns.
- Current recommended sites should be protected from potential sources of contamination and development (Chapter 3 of Comprehensive Plan).
- The County should update the existing engineering study and develop a detailed economic and financial plan and schedule to bring at least one of the five proposed reservoirs on line in the 2010 – 2015 time period. This will provide the ability to expand the system of reservoirs as the supply from the current deep aquifer is depleted or becomes too saline.
- Development will continue and the choice of reservoir sites will become more limited and more difficult to sequester or reserve with the passage of time. Land prices will continue to increase and the cost of land acquisition for reservoir sites will become increasingly expensive with the passage of time.
- Current recommended sites should be protected from potential sources of contamination and development. From a point of view of land use planning the County should limit and control development by establishing a Reservoir Overlay District at the proposed reservoir footprints so that the option of constructing surface impoundments remains open.
- Shallow wells will continue to provide another sustainable source for citizens not within economic distance of a reservoir.
- Other sources such as rainwater harvesting should be considered and promoted as the available technology exists to make this a sanitary source of drinking water. Desalinization systems may be necessary for many citizens with waterfront property not near reservoirs and unable to utilize shallow wells.

c) Richmond County

The Richmond County Comprehensive Plan (RCCP, 2001) lists protection of ground water and surface water supplies as a goal of current and future planning efforts. Objectives and recommendations for protecting water supplies include various resource assessment and mapping activities, working with other agencies on resource management, developing proposed zoning and planning tools to steer responsible future land use activities.

The comprehensive plan does not specifically mention specific sites in text but does mention that six sites were identified in the 1973 Water Quality Management Plan. The plan suggests that the county should identify and protect one or more of the possible sites. The plan also acknowledges the expense required in building a reservoir.

The following reservoir sites were shown to have either roads or e911 address points within the future reservoir location:

RCP6 - 568 Tallent Town Road
RCP4 - Snyder Road
RMS1 - Rich Neck Road
RTC1 - 2637 Canal Road and 649 Canal Road
RTC3 - Lutterville Lane
No ID - Quinton Oak Lane

d) Westmoreland County

Westmoreland County has no mention of reservoirs in its Comprehensive Plan.

10.3.2.3.1 Specific Consideration for Cat Point Creek Watershed Management

The Cat Point Creek watershed is located within the NN region, with its headwaters in Westmoreland County, flows into Richmond County and discharges to the Rappahannock River. Currently, Cat Point Creek is not being used as a water supply source. However, a time may come when Westmoreland or Richmond County may construct surface water impoundments in order to meet the water supply needs of its citizens. The Cat Point Creek Watershed Management Plan, 2004 notes that the Richmond County Comprehensive Plan includes two proposed water impoundments on tributaries of Cat Point Creek. Specifically, the Richmond County Comprehensive Plan references potential future development of two water impoundments on tributaries to Cat Point Creek.

The Department of Conservation and Recreation (DCR), in cooperation with the Tidewater Resource Conservation and Development Council, initiated a ground water monitoring study in the Cat Point Creek watershed in December, 1995. In 1996, the DCR ranked Cat Point Creek as a high priority watershed for non-point source (NPS) pollution potential and high natural heritage value.

In an effort to protect and improve the watershed, the Tidewater Resource Conservation and Development Council (RC&D) acquired an EPA 319 grant to initiate agricultural research, forest planning and educational programs. It also facilitated the formation of a citizens committee to oversee and direct conservation efforts specific to the watershed.

The Cat Point Creek Citizens Committee is comprised of a core group of watershed residents from Richmond and Westmoreland counties, local government representation, agency support and staff of the US Fish and Wildlife Service (USFWS) with newly acquired holdings adjacent to the creek. The property was named the Tayloe Unit of the Rappahannock River Valley National Wildlife Refuge which became a demonstration site for certain aspects of the initial watershed project.

In 2003, the Citizens Committee was approached by local agencies to participate in the development of a comprehensive watershed management plan for Cat Point Creek as part of the effort to meet one of the C2K goals to develop plans for two-thirds of the Chesapeake Bay watershed by 2010. In 2004, the NNPDC prepared the Cat Point Creek Watershed Management Plan (NNDPC, 2004). This Plan provides an overall assessment of the watershed, and addresses the need for regional water supply planning and establishment of additional ground water monitoring wells in the NN.

The on-going work within the Cat Point Creek Watershed, as described in the Plan (NNPDC, 2004) represents a valuable assessment and planning tool to be integrated with water supply planning for the NN. In 2009, given available funding sources, the Cat Point Creek Watershed Management Plan is scheduled for review and revision to account for then-current watershed conditions.

11.0 CONCLUSIONS

This document presents the Regional Water Supply Plan for the Counties of Lancaster, Northumberland, Richmond and Westmoreland, and incorporated towns of Colonial Beach, Irvington, Kilmarnock, Montross, Warsaw, and White Stone (i.e., the Planning Region). The WSP was prepared in accordance with Local and Regional Water Supply Planning Regulations (9 VAC 25-780), which were adopted in response to the 2003 amended Code of Virginia that requires the development of a comprehensive statewide water supply planning process.

In 2006, the NNPDC notified DEQ of the intent for the Northern Neck (NN) localities to participate in a Regional Plan. The NNPD received an Interagency Grant from the Virginia Department of Environmental Quality (DEQ) [Purchase Order #12968, dated July 30, 2006] to support preparation of the initial phase of this regional WSP. DEQ Grant support was extended for fiscal year 2008-2009 to complete Phase II of this WSP.

The first phase of this WSP focused on the collection of water source and water use information, and identification of environmental conditions affecting the development and use of water supplies. The second Phase of the WSP addressed projection of future water demands, water demand management, drought contingency and response planning, and adequacy of water resources to meet current and projected demands. A statement of need and recommendations were prepared to protect and enhance water sustainability in the Region.

The WSP is heavily weighted to consideration of ground water issues. Ninety-six (96) of the 102 sources identified in this WSP are ground water suppliers and 100% of the community water supplies on the NN are derived from ground water. Ground water sources provide drinking water for all residents and visitors in the WSP Region.

Moreover, it is noted that the WSP is primarily focused on water use, water demand projection, statement of need and alternatives for Community water systems. The main reasons for this approach are the scope of served population and the more readily available water data as compared to private well systems. A total of 96 community suppliers were identified for the NN in the DEQ and VDH databases, all using ground water sources. Approximately 50% of the Planning Region population is served by community water sources (see **Section 4.0 and Section 5.0**). At the time this WSP was developed, no data were readily available to evaluate disaggregated water use in each community system or county (see **Sections 4.1 and 5.1**). However, due to the rural nature of the Planning Region, the small footprint of the community sources, and their scattered distribution, it seems community sources primarily serve residential users. It is assumed that the residents not served by community water systems obtain water from private, individual wells. Thus, approximately 50% of the population is self-supplied.

Small, commercial self-suppliers and large self-suppliers did not provide sufficient data (i.e., data and information were not readily available) to support detailed analyses via this WSP. Current water use was estimated for agricultural and non-agricultural users. Only three of the six large self-suppliers identified in the Planning Region responded the survey. DEQ and VDH records were used to estimate water use for the remaining suppliers

This WSP includes water data available at the time of report preparation. **Section 3** provides a detailed discussion of data collection efforts, their limitations and results.

A water demand forecast was prepared for Community systems, which considered water demand management in the Planning Region. Projected population increase in the Planning Region through 2107 will increase community-system water demand by 1.08 MGD, from 2.19 MGD to 3.27 MGD (see **Table 8-4**). Such water use scenario represents approximately 70% of the total permitted withdrawal capacity for community systems in the Planning Region (see **Table 8-4**).

11.1 Summary of Water Supply Planning Results

Estimates of current and projected water demands in the Planning Region are summarized in **Table 11-1**. The water demand projections for community systems and residential self-suppliers account for water use savings induced by application of current demand management practices in the Region (e.g. adoption and enforcement of the USBC). No data were readily available at the time of plan preparation to evaluate disaggregated water demand for community or self-supplied water systems in the Region (see **Sections 4.1 and 5.1**). The Adequacy Assessment and Statement of Need were made in aggregate for all community systems in the Planning Region. This is based on the particular context of the Region, reliance on ground water and the potential for consolidation of private and Community systems (see **Section 10.2**). Therefore, aggregate community water demand, and small self-supplied demand were presented in this WSP.

Insufficient data were provided by large (>300,000 gal/mo) self-supplied users in the water supply planning effort to perform a systematic demand projection. Rough baseline estimates were calculated for large agricultural and non-agricultural self-suppliers, using the limited data available. Agricultural and non-agricultural activities were assumed to remain constant in the Region throughout the Planning Period in order to contribute to an overall estimate of water demand in the Region.

No current or projected water supply deficits were identified for community sources in the Planning Region. Therefore, a formal water supply alternatives analysis is not required for this WSP. The projected water demand for community systems in year 2007 is estimated at 3.27 MGD (**Table 11-1**), which represents 70% of the 4.74 MGD permitted withdrawal capacity for community systems in the Region.

Table 11-1 Summary of estimated, current and projected demands in the Region

	NN WSP Region	2007	2107
Community systems	Total Population of Planning Area (2006)[1] :	58,421	95,216
	Population Served by Community Sources[2]:	29,211	47,608
	Community Source Demand (based on 58.65 gpd/p) (mgd)[3]:	2.19	3.27
	Water demand of community systems as % of permitted withdrawal[4]	46%	69%
Small self-suppliers	Estimated Self-supplied Population (<300,000 gpm)[2]:	29,211	47,608
	Estimated Domestic, Self-supplied Demand (based on 58.65 gpd/p) (mgd)[3]:	2.19	3.27
	Estimated number of businesses self-supplied by individual wells[5]:	80	80
	Estimated Domestic, Self-supplied Demand (mgd)[5]:	N/A*	N/A*
Agricultural, large self-suppliers[+]	Reported Self-supplied Agricultural Sources (>300,000 gpm)[6]:	1	1
	Reported Self-supplied Agricultural Demand (mgd)[6]:	0.033	0.033
	Percent Agricultural Demand Met by Surface Water Withdrawals:	0.00	0.00
Non-agricultural, large self-suppliers[+]	Reported Self-supplied Non-Agricultural Sources (>300,000 gpm)[7]:	6	6
	Reported Self-supplied Non-Agricultural Demand (mgd)[7]:	2.21	2.21
	Percent Non-Agricultural Demand Met by Surface Water Withdrawals:	80.75	80.75
	Estimated Unaccounted Losses (15% of water use total) (mgd):	0.99	1.32
	Total Water Demand (mgd):	**7.61**	**10.10**

NOTES:

[1] Population data and projections from **Section 7.0**. Population of incorporated Towns was included in County data.
[2] Approximately 50% of the Planning Region population is served by community systems, the rest of the population is assumed to be served by private wells (**Section 7.3**).
[3] Adjusted per capita water use factor after accounting for demand management practices and a 15% contingency factor for unaccounted losses. (**Section 8.2**).
[4] The total permitted withdrawal capacity for community systems in the planning region was estimated at **4.74 MGD**. This number resulted from adding up the VDH Permitted System Capacity of community systems (**Form 2A, Appendix B**) for which information was available (**Section 8.2**).
[5] See **Section 4.6.2** and **Forms 2-I** and **3-J**, **Appendix B**.
[6] **See Section 4.5** and **Forms 2-H** and **3-I**, **Appendix B**.
[7] See **Sections 4.2.1** and **4.2.2**, and **Forms 2-E** and **3-H**, **Appendix B**.
* N/A = no data reported.
[+] A baseline estimate was calculated using data from self-suppliers that provided information to EEE. Agricultural and non-agricultural activities were assumed constant in the Region throughout the Planning Period.

NOTE: Data on decadal planning for community systems and small self-suppliers are provided in **Tables 7-11 and 7-12**. **Tables 8-4, 8-5 and 8-6** show the revised water demand for community sources and domestic self-suppliers after accounting for demand

management practices. In the case of large self supplied nonagricultural and agricultural users, their water demand was assumed constant throughout the planning period due to limited information provided in the survey data collection and also due to economic instability at the time of the development of this WSP.

Under the assumptions and estimations for water demand and demand management used in **Sections 7 and 8**, Community water resources appear to be adequate to meet projected Community demand in the Planning Region (**Table 10-1).**

The adequacy of existing water sources to meet projected community water demand could change in the future given that all Community systems rely on ground water supplies. The evaluation of adequacy and the Statement of Need are based on available data collected at the time this report was completed. Future updates of this WSP should calibrate key variables that affect water demand in the Northern Neck. The adequacy of resources will be re-evaluated in five years when the WSP compliance determination occurs, according to 9 VAC 25-780.

Some conditions that may change the adequacy of water resources include (see **Section 10.2** for more details):

- extreme prolonged drought coupled with an increase in seasonal population fluctuations (due to tourism and secondary homes)
- changes in the ratio of the population served by community systems and private wells (**Section 10.2.1.1** presents a scenario where part of the self-supplied population integrates into the community systems)
- new industrial development or expansion of existing industrial suppliers may drastically increase water withdrawals in the Region
- extra-regional withdrawals could affect the Planning Region's ground water supplies
- ground water contamination, drought or other conditions that may cause reduction on the well's yield or closure of wells

It is critical for the Planning Region that community water supplies maintain the capacity to respond to both domestic demands and economic development potential. The Steering Committee agrees that diversification of the regional water supplies is important. A summary listing of short-term and long-term alternatives for water supplies are provided below (see **Section 10.3**) for potential scoping and evaluation in the future as the WSP undergoes periodic 5-year review to ensure water sustainability.

Potential alternatives to diversify and improve water supplies in the Planning Region:

- short-term alternatives
    - water conservation
    - increase withdrawal permit limit
- long-term alternatives
    - Refurbish or install new ground water wells

- Less conventional alternatives: Reclaimed water, desalination, rain harvesting, water marketing and transfers
- Surface water reservoir (s)

A full and detailed alternatives analysis, including technological, economic and permitting analysis, will be required if the Planning Region, or individual Community sources identify a need to replace or upgrade a water source.

Any new water source will be assessed on a case-by-case basis to get authorization for surface or ground water withdrawals according to DEQ and VDH permitting processes. Furthermore, any future water use will be considered in the context of the latest update of this Regional Water Supply Plan.

11.2 General recommendations for continuous improvement of water supply planning and water sustainability in the Region

In order to achieve a primary goal that the WSP exists as a "living document", future updates of this WSP should include readily available data (at that time) on water resources, water use, demand management practices, and the best available studies of aquifers' capacity and ground water quality. The following general recommendations are aimed towards the continuous improvement of water supply planning and water sustainability in the Region:

- Quantify population fluctuations (due to tourism and part-time residents) on a regular basis and use this information to update water demand projections. One way to estimate this transient population is through the collection of solid waste disposal data from convenience centers throughout the NN, and from the Westmoreland County Solid Waste Transfer Station (only transfer station in the NN), which will provide a semi-quantitative assessment of seasonal population flux in the NN, based upon solid waste disposal volumes per month.
- Fill out data gaps regarding water permits, water permits, average and seasonal withdrawals, disaggregated uses, and demand management practices in the community systems and private wells in the NN. Use this data to update the ratio of the population served by community systems and private wells.
- Fill out gaps regarding water permits, water permits, average and seasonal withdrawals, disaggregated uses, and demand management practices of large self-suppliers in the Region.
- Include latest assessments of aquifers' capacity and ground water quality in future updates of the WSP's adequacy of resources and statement of need.
- Consider performing a water balance for the NN entire Region.
- Conduct negotiations and intra-regional water planning efforts to reduce the impact of extra-regional water uses on the Northern Neck's ground water supply. As noted previously in this WSP, extra-regional water users are impacting ground water levels in the region and may affect the Northern Neck's ground water supply. Ground water aquifers do not follow the boundaries of the planning

districts and common aquifers are used by the Northern Neck, the Middle Peninsula, and Southern Maryland.

- Future development and 5-year reviews of the WSP should take into consideration the case of a designation of the Planning Area as a Ground Water Management Area. The NN is not located within a Ground Water Management Area (as designated by DEQ), and therefore data derived from ground water withdrawal permits is not available, which reduced available data for analysis of small self-suppliers. Impacts of such designation would have pros and cons (see **Section 4.0** and **Section 6.11.1**).
- Improve water conservation practices across all users in the NN and document practices used and their effect in water demands. Include this data in future forecasts of water demand.
- Consider options to diversify water supplies in the Region (see **Section 10.3**). Some long-term alternatives include:
    - Refurbishing or installation of new ground water wells
    - Use of less conventional alternatives: Reclaimed water, desalination, rain harvesting, water marketing and transfers
    - Development of surface water reservoir. If this option is selected, an update of the NEDCO reservoir study (see **Section 10.3.2.3**) is suggested to better reflect the current conditions of the NN.
- Improve ground water quality monitoring of shallow wells in the Region. Shallow wells (primary means of serving individual self-supplied residences and businesses) are at the greatest risk for drought, and contamination.
- Develop Wellhead Protection Programs for all counties and towns in the NN. Currently only the Town of Warsaw has developed a Wellhead Protection Program (see **Section 4-7**). The other NN jurisdictions have not prepared specific Source Water Assessment Plans, or Wellhead Protection Plans.
- Implement, monitor and update the DRCP included in this WSP. Include feedback of local authorities and residents..
- Other general recommendations to protect ground water quality:
    - Well abandonment programs
    - Household hazardous waste collection
    - Drilling test monitoring wells
    - Inventory of septic tanks
    - Treatment technologies for de-nitrification of conventional septic tanks systems

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APPENDIX A

Digital Electronic Data on Compact Disk

COMPACT DISK FOLDER

APPENDIX B

VDEQ Water Supply Data Forms 2A through 3J

Virginia Department of Environmental Quality Division of Water Resources Office of Water Supply Planning **REGIONAL WATER SUPPLY PLAN** **NORTHERN NECK PDC** Calendar Year 2008	Completed By: William Newcomb, P.G., EEE Consulting Inc. Signature: Lead Agency: Northern Neck PDC (#17) Date: Pending May 2007 Local Plan ☐ Regional Plan ☒

SECTION 1: GENERAL INFORMATION

1. Political Locality(s):	Counties: Richmond County, Lancaster County, Northumberland County, and Westmoreland County Towns: Irvington, Kilmarnock, White Stone, Warsaw, Colonial Beach, Montross
2. River Basin(s):	Lower Chesapeake, Potomac
3. River Sub-Basin(s):	Lower Rappahannock (HUC: 02080104); Lower Potomac (HUC: 02070011); Great Wicomico-Plankatank (HUC: 02080102)
4. Population (Plan Total):	51,163 (2006 Provisional; January 2007 Weldon Cooper Center Report)
5. Contact Name:	Mr. Jerry Davis, AICP
6. Title:	Executive Director, Northern Neck Planning District Commission
7. Mailing Address:	P.O. Box 1600
8. City:	Warsaw
9. State:	Virginia, 22572
10. Phone:	(804) 333-1900
11. Fax:	(804) 333-5274
12. E-Mail:	jdavis@nnpdc17.state.va.us
13. Locality FIPS Code(s):	Richmond County (159), Lancaster County (103), Northumberland County (133), and Westmoreland County (193) Irvington (391), Kilmarnock (398), White Stone (484), Warsaw (479), Colonial Beach (345), Montross (414)

SECTION 2-A: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS USING GROUNDWATER (9 VAC 25-780-70B)

1. Community Water System Name	2. Well ID Number	3. Well Depth (ft)	4. Casing Depth (ft)	5. Screen Depth (ft) or Water Zones		6. Well Diameter (in)	7. Design Capacity for Withdrawal		8. VDH Permitted System Capacity [2] (gal/day)	9. Groundwater Withdrawal Permit Amount (GWWP) [3]		Data Source Key [1]
				a. Top	b. Bottom		a. Average Daily	b. Maximum Daily		a. Annual	b. Monthly	
Heritage Point	1A	595	4.5" to 395' 2" to 555'	555	595	2"	57,600	90,720	66,000	-	-	1
	2	646	4" to 293' 2" to 625'	625	635	2"	36,000	50,400				
White Sands Harbour	1-A	760	760	733	753	4.5"	60,400	60,400	48,960	-	-	1
	2	777	777	730	770	4.5"	40,300	40,300	46,080	-	-	1
Sandy Point Subdivision	1	581	-	-	-	6"	60,400	60,400	33,600	-	-	1
	2	280	280	250	270	4.5"	43,000	43,000	24,000	-	-	1
Waverly Subdivision	1-A	620	620	596	616	4.5"	27,360	27,360	15,200	-	-	1
Vineyard Grove	1	703	703	666	696	4.5"	41,760	41,760	9,600	-	-	1
Pine Harbor	1	682	682	655	675	4.5"	48,000	48,000	27,200	-	-	1
Springfield Beach	1	285	285	Unknown	Unknown	4"	30,200	30,200	16,800	-	-	1
Lewisetta	1	659	659	340 640	550 650	4"	72,000	72,000	23,000	-	-	1
	1-A	658	658	643	658	4"	40,000	40,000	31,000	-	-	1
Highbank	1	630	630	605	625	4.5"	31,600	31,600	33,120	-	-	1
General Parker Shores	2	275	275	260	270	4.5"	19,200	19,200	19,200	-	-	1
Western Branch Subdivision	1	760	760	733	753	4.5"	47,500	47,500	47,500	-	-	1
Sloop Point	1	285	285	245	285	4.5"	46,000	46,000	12,960	-	-	1
Horner's Beach	1-A	476	476	451	471	4"	33,600	33,600	33,600	-	-	1
	2	275	275	255	275	4"	37,000	37,000	-	-	-	1
Chesapeake Cove	1	727	727	700	720	4.5"	43,920	43,920	43,920	-	-	1
Bells Cove	1-A	376	376	360	370	4.5"	46,830	46,830	22,800	-	-	1
	2	389	389	375	389	4"	3,100	3,100		-	-	1
Ditchley Water Works, Inc.	2	640	8" 94 ft; 4" 205 ft; 2" 320 ft	320 - 340 ft	-	2"	-	-	-	-	-	1
Forest Hills Subdivision	1	-	-	-	-	-	-	-	-	-	-	1
COLONIAL BEACH, TOWN OF	ROBIN GROVE WELL #1	441	-	-	-	8	187,200	-	1,282,400	-	-	2
	WILKERSON FARM WELL	960	18" : 0 -120' 10" : 0 - 920; 950 - 960	920	950	10"	612,000	-		-	-	
	4TH STREET WELL #3	865	10": 2' - 525' 10: 540' - 672' 10": 682' - 700' 6": 700' - 800'	525 672 718 783	540 682 723 798	-	900,000	-		-	-	
	POINT WELL (CASTLEWOOD PARK)#2	565	-	-	-	8	374,400	-		-	-	
KILMARNOCK	RGH WELL #3	782	18" 100ft 8" 350ft 6" 782	616 636 666 738	626 646 676 768	6"	525,600	-	816,800	-	-	1
	RADIO STATION WELL (Well #4)	825	18" 100ft 8" 500ft 6" 825ft	652 690 754	662 730 784	6"	614,880	-		-	-	1
	CHURCH STREET WELL #2	740	10" 440ft, 8" 700, 6" 740	676 700	686 730	8"	329,760	-		-	-	1
WARSAW	WELL #1	653	8" 622 ft	622 628	628 640	6"	303,840	-	55,000	-	-	2
	WELL #4	-	-	-	-	-	-	-		-	-	2
	WELL #2	682	16" 73ft 8" 300ft 6" 682ft	622 660	632 674	6"	724,320	-		-	-	2
	WELL #3	674	18" 57 ft 8" 674	587 639	612 664	8"	576,000	-		-	-	2
IRVINGTON	WEST WELL #2	675	10" 355ft 6" 638ft	555 612	570 638	6"	288,000	-	385 ERCs (154,000 gpd)	-	-	2
	EAST WELL #1	700	8" 538 ft	536 557 613 674	552 567 639 695	6"	244,800	-		-	-	2

SECTION 2-A: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS USING GROUNDWATER (9 VAC 25-780-70B)

1. Community Water System Name	2. Well ID Number	3. Well Depth (ft)	4. Casing Depth (ft)	5. Screen Depth (ft) or Water Zones		6. Well Diameter (in)	7. Design Capacity for Withdrawal		8. VDH Permitted System Capacity [2] (gal/day)	9. Groundwater Withdrawal Permit Amount (GWWP) [3]		Data Source Key [1]
				a. Top	b. Bottom		a. Average Daily	b. Maximum Daily		a. Annual	b. Monthly	
MONTROSS	WELL #2	654	8" 300ft 6" 654 ft	549 611	554 631	6"	191,520	216,000	200,000	-	-	1
	WELL #3	570	8" 350 ft 6" 570ft	438 458 472 488 520 536 550	453 468 482 500 530 542 560	6"	504,000	-		-	-	1
POTOMAC/WESTMORELAND SHORES	WESTMORELAND WELL #1A	219	4" 209ft	209	219	4"	43,200	-	566 ERCs (226,400 gpd)	-	-	2
	POTOMAC WELL #1A	399	9.75" - 369' 6.75" - 399'	369	389	4"	129,600	-		-	-	2
	WESTMORELAND WELL #2A	399	4" 369 ft 2" 399 ft	369 379	379 389	2"	129,600	-		-	-	2
	POTOMAC WELL #2A	430	9.75" - 400 6.75" - 430	400	420	4"	110,880	-		-	-	2
PLACID BAY ESTATES	WELL #1	407	6" 199 ft 3" 405 ft 2.5" 407 ft	385	405	2>5"	288,000	-	409 ERCs (163,600 gpd)	-	-	1
	WELL #2	300	6.5" 211ft 4.5" 400 ft	240	260	4.5"	79,200	-		-	-	1
	WELL #3 (On-line Nov 2006)	-	-	-	-	6"	-	-		-	-	1
WHITE STONE	WELL #2	740	6" 309ft 5.5" 548 ft 4" 717 ft	593 651 692	603 656 712	4"	158,400	-	366 ERCs (146,400 gpd)	-	-	2
	WELL #1	661	8" 590ft	590	616	8"	105,120	-		-	-	2
WEEMS	SOUTH WELL	636	6" 130 3" 636 ft	616	636	3"	224,640	-	278 connections (111,200 gpd)	-	-	2
	NORTH WELL #2	640	16" 105ft 8" 380 ft 6" 640 ft	557 624	592 634	6"	576,000	-		-	-	2
STRATFORD HARBOR	WELL #12B	627	6" 313 ft 3" 627 ft	591 611	611 621	3"	142,560	-	130,000	-	-	2
	WELL #12 CLUB	603	6" 306 ft 3" 568 ft 2.5" 603 ft	568 578	578 588	2.5"	174,240	-		-	-	2
	WELL #13 GROVE	653	6" 311 ft 3" 589 ft 2.5" 653 ft	589 599	599 609	2.5"	184,320	-		-	-	2
RAPPA WESTMINSTER-CANTEBURY	WELL #2	745	6" 256 ft 4" 730 ft	633 696	638 726	4"	144,000	-	77, 600	-	-	2
	WELL #1	745	6" 250 ft 4" 734 ft	637 700	642 730	4"	216,000	-		-	-	2
CABIN POINT (Cabin Point & Glebe Harbour)	CABIN POINT WELL #16	780	10" 340 ft 8" 420 ft	340 420 522 570 698	360 440 538 582 718	8"	797,760	-	425 ERCs (170,000 gpd)	-	-	2
	Gleber Harbour WELL #18	468	6" 205 ft 3" 468 ft	391 432	411 442	3"	155,520	-		-	-	2
	Gleber Harbour WELL #17	389	6" 190 ft 4.5" 365 ft	190 365	220 389	4.5"	216,000	-		-	-	2
BERKELEY BEACH-EBB TIDE BEACH	Berkley Beach Well #8	224	4" 205 ft	206	216	4"	50,400	-	244 ERCs (97,600)	-	-	2
	Ebb Tide Beach Well 1A	399	4" 373 ft 2" 399 ft	373	394	2"	138,240	-		-	-	2
	Ebb Tide Beach Well 2A	475	6" 212 ft 4" 444 ft	212 412	222 422	4"	96,480	-		-	-	2
CALLAO	WELL #2	360	6" 334 ft	No screens	-	6"	187,200	-	185 ERCs (74,000 gpd)	-	-	2
	WELL #1	348	8" - 348	No screens	-	8"	120,960	-		-	-	2
REEDVILLE	YORK WELL #1	685	3" - 640 to 685	640?	685?	3"	72,000	-	160 ERCs (64,000)	-	-	2
	YORK WELL #2	780	6" 210 ft 3" 780 ft	755	775	3'	100,800	-		-	-	2

SECTION 2-A: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS USING GROUNDWATER (9 VAC 25-780-70B)

1. Community Water System Name	2. Well ID Number	3. Well Depth (ft)	4. Casing Depth (ft)	5. Screen Depth (ft) or Water Zones		6. Well Diameter (in)	7. Design Capacity for Withdrawal		8. VDH Permitted System Capacity [2] (gal/day)	9. Groundwater Withdrawal Permit Amount (GWWP) [3]		Data Source Key [1]
				a. Top	b. Bottom		a. Average Daily	b. Maximum Daily		a. Annual	b. Monthly	
	TANK WELL #2	725	4" 680 ft 2.5" 720 ft	680	720	2.5"	100,800	-		-	-	2
LIVELY	WELL #2	700	6" 400 ft 4" 620 ft	564 602	584 612	4"	144,000	-	212 ERCs (84,800 gpd)	-	-	2
	WELL #1	365	8" 344 ft 6" 365 ft	344	354	6"	77,760	-		-	-	2
Monroe Bay Estates and Trailer park (Curley Packing)	WELL #1	839	6" 200 ft 3" 838.5 ft	814	834	3"	144,000	-	44,000			1
	Well #2 (no data regional VDH files)	-	-	-	-	-	-	-		-	-	1
	WELL #3 (not listed in DEQ database; data from VDH file review)	466	4" 231 ft 2" 466 ft	430	461	2"	84,960	-		-	-	1
BAY QUARTER SHORES	WELL #20 CAMP	628	6" 628	585	615	6"	188,640	-	64,000	-	-	2
	WELL #19 STORAGE TANK	-	-	-	-	-	-	-		-	-	2
SHERWOOD FOREST SHORES	WELL #22 STORAGE TANK	804	6" 304 ft 3" 804 ft	670 693 754	680 703 764	3"	79,200	-	82,400	-	-	2
	WELL #23	792	6" 208 ft 3" 792 ft	671 695 740	681 705 750	3"	69,120	-		-	-	2
FOXWELLS	WELL 1	668	4" 130 ft 2" 648 ft	648	668	2"	46,080	-	75 ERCs (30,000 gpd)	-	-	2
HERITAGE POINT WATER SYSTEM	WELL #2	Could not find VDH records	-	-	-	-	-	-	-	-	-	-
	WELL #1	Could not find VDH records	-	-	-	-	-	-	-	-	-	-
CORROTOMAN BY THE BAY	WELL #25 CLUB	689	6" 303 ft 3" 659 ft	659	670	3"	237,600	-	179 ERCs (71,600 gpd)	-	-	2
	WELL #24 STORAGE TANK	737	6" 256 ft 3" 695 ft 2" 737 ft	695 705	705 725	2;	46,080	-		-	-	2
INDIAN CREEK	WELL #2	647	4" 126 ft 2" 647 ft	630	645	2"	57,600	-	105 ERCs (42,000)	-	-	2
	WELL #1	631	4" 231 ft 2" 631 ft	604	625	2"	86,400	-		-	-	2
LANCASTER COURT HOUSE	WELL	554	6" 60 ft 3" 523 ft	523 530.17 542	528.67 540.67 552.5	3"	64,800	-	42 ERCs (16,800 gpd)	-	-	2
KINGSLAND	KINGSLAND WELL #1	640	8" 82 ft 4" 640 ft	563 594 624	573 614 634	4"	155,520	-	49 ERCs (19,600 gpd)	-	-	2
Va. DOC - Haynesville Correctional Center	Well #1	713	693	693	713	4"	-	-	199,200	-	-	1
	Well #2	727	700	680	700	6"	-	-		-	-	1
	Well #3	726	705	680	700	15"	-	-		-	-	1
Northumberland Shores	Well	320	290	290	320	3	-	-	60 ERCs (24,000)	-	-	1
Tides Lodge inc., Golder Eagle HOA (The Greens Compex Well)	WELL #1 (The Greens Compex Well)	675	8" 306 ft 4" 655 ft	655	675	4"	360,000	-	49 ERCs (19,600 gpd)	-	-	2
Ball Point	Well 1A	-	-	-	-	-	-	-	-	-	-	4
Black Stump	Well 1	-	-	-	-	-	-	-	-	-	-	4
Churchfields	Well 1	-	-	-	-	-	-	-	-	-	-	4
Corbin Lewis	Well 1	-	-	-	-	-	-	-	-	-	-	4
Cove Colony	Well 1	-	-	-	-	-	-	-	-	-	-	4
Lancaster Courthouse	Well 1	-	-	-	-	-	-	-	-	-	-	4
Lancaster Courthouse	Well 1A	-	-	-	-	-	-	-	-	-	-	4
Lancaster Shores	Well 1	-	-	-	-	-	-	-	-	-	-	4
Whitestone	Well 1	-	-	-	-	-	-	-	-	-	-	4
Whitestone	Well 2	-	-	-	-	-	-	-	-	-	-	4
Bon Harbor	Well 1	-	-	-	-	-	-	-	-	-	-	4
Brown's Store	Well 1	-	-	-	-	-	-	-	-	-	-	4
Burgess	Well 1	-	-	-	-	-	-	-	-	-	-	4

SECTION 2-A: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS USING GROUNDWATER (9 VAC 25-780-70B)

1. Community Water System Name	2. Well ID Number	3. Well Depth (ft)	4. Casing Depth (ft)	5. Screen Depth (ft) or Water Zones		6. Well Diameter (in)	7. Design Capacity for Withdrawal		8. VDH Permitted System Capacity [2] (gal/day)	9. Groundwater Withdrawal Permit Amount (GWWP) [3]		Data Source Key [1]
				a. Top	b. Bottom		a. Average Daily	b. Maximum Daily		a. Annual	b. Monthly	
Burgess	Well 1A	-	-	-	-	-	-	-	-	-	-	4
Callao	Well 1	-	-	-	-	-	-	-	-	-	-	4
Callao	Well 2	-	-	-	-	-	-	-	-	-	-	4
Chesapeake Bay Estates	Well 1A	-	-	-	-	-	-	-	-	-	-	4
Glebe Point	Well 1	-	-	-	-	-	-	-	-	-	-	4
Heathsville	Well 1	-	-	-	-	-	-	-	-	-	-	4
Heathsville	Well 2	-	-	-	-	-	-	-	-	-	-	4
Heathsville	Station 3	-	-	-	-	-	-	-	-	-	-	4
Lottsburg	Well 2	-	-	-	-	-	-	-	-	-	-	4
Lottsburg	Well 3	-	-	-	-	-	-	-	-	-	-	4
Mallard Bay	Well 1	-	-	-	-	-	-	-	-	-	-	4
Mallard Bay	Well 2	-	-	-	-	-	-	-	-	-	-	4
Rivers Bend Estates	Well 1	-	-	-	-	-	-	-	-	-	-	4
Wicomico Church	Well 1	-	-	-	-	-	-	-	-	-	-	4
Wicomico Ridge	Well 1	-	-	-	-	-	-	-	-	-	-	4
Bell Acres	Well 1	-	-	-	-	-	-	-	-	-	-	4
Bunker Hill	Well 1	-	-	-	-	-	-	-	-	-	-	4
Luttreville	Well 1	-	-	-	-	-	-	-	-	-	-	4
Pleasant View Estates	Well 1	-	-	-	-	-	-	-	-	-	-	4
School House Meadows	Well 1	-	-	-	-	-	-	-	-	-	-	4
Bushfield	Well 1	-	-	-	-	-	-	-	-	-	-	4
Kinsale	Well 1	-	-	-	-	-	-	-	-	-	-	4
Nomini Bay	Well 1	-	-	-	-	-	-	-	-	-	-	4
Nomini Bay	Well 1A (new)	-	-	-	-	-	-	-	-	-	-	4
		-	-	-	-	-	-	-	-	-	-	

Notes:

- Not reported or data not available

[1] Key to Data Sourcces:

1 Aggregate data from survey responses received 2006 - 2007, DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ), and VDH file review

2 VDH Regional Office file review conducted February 12, 2007

3 DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ)

4. 2006 data reported by Aqua Virginia to DEQ

[2] VDH files listed ERCs = Equiavalent Residential Connection. VDH conversion = 1 ERC = 4 persons = 400 gallons/day (Virginia Waterworks Regulations)

[3] Not applicable as the Northern Neck is not included in a DEQ Groundwater Management Zone

FORM 2-B: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS USING SURFACE WATER RESERVOIRS (9 VAC 25-780-70C)									
1. Reservoir Name	2. Sub-Basin(s)	3. Drainage Area	4. On-Stream Storage Available for Water Supply	5. Design Capacity for Withdrawal		6. Safe Yield	7. Water Treatment Capacity	8. VDH Permitted System Capacity	9. Limtations on Withdrawal Established by Permit
				a. Average Daily	b. Maximum Daily				
None Identified									

FORM 2-C: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS USING STREAM INTAKES (9 VAC 25-780-70 D)										
1. Stream or River Name	2. Drainage Area of Intake	3. Sub-Basin in Which Intake is Located	4. Design Capacity for Withdrawal		5. Safe Yield	6. Lowest Daily Flow of Record	7. Design Capacity of Pump Station	8. Design Capacity of the Water Treatment Plant	9. Capacity of the System Permitted by the VDH	10. Limitations on the Withdrawal Established by Permit
			a. Average Daily	b. Maximum Daily						
None Identified										

FORM 2-D: EXISTING WATER SOURCE INFORMATION - SELF SUPPLIED USERS OF MORE THAN 300,000 GAL/MO FROM SURFACE WATERS FOR NON-AGRICUTURAL USES (9 VAC 25-780-70 E)

1. User Name	2. Name of Water Body Utilized	3. Design Capacity for Withdrawal		4. Limitations Established by Permit	Data Source [1]
		a. Average Daily Withdrawal (MGD)	b. Maximum Daily Withdrawal (MGD)		
Tides Golf Lodge Inc. and Golden Eagle Golf Course	Lake Irvington	-	-	-	3
	Constructed Ponds	-	-	-	3
Zapata Protein USA, Inc.	Cockrell Creek (unconfirmed by survey)	1.5	47	-	1

Notes:
Zapata Protein, Tides Golf Course operate both groundwater and surface water withdrawal systems
- Not reported or data not available

[1] Key to Data Sourcces:
1 NNPDC water supply planning survey response (total surface water withdrawal provided, values estimated above are inferred)
2 VDH Regional Office file review conducted February 12, 2007
3 DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ)

FORM 2-E: EXISTING WATER SOURCE INFORMATION - SELF-SUPPLIED USERS OF MORE THAN 300,000 GAL/MO OF GROUNDWATER FOR NON-AGRICULTURAL USES (9 VAC 25-780-70 F)

1. Well Name	2. Well Number	3. Well Depth (ft)	4. Casing Depth (ft)	5. Screen Depth or Water Zones (ft below ground)		6. Well Diameter (in)	7. Design Capacity for Withdrawal Capacity (gallons / day)		8. Limitations Established by Permit (gallons / day)	Data Source [1]
				a. Top	b. Bottom		a. Average Daily	b. Maximum Daily		
Bevans Oyster	Well #1	-	-	-	-	-	-	-	-	3
	Well #2	-	-	-	-	-	-	-	-	3
	Well #3	-	-	-	-	-	-	-	-	3
Lake Packing Co.	2nd Factory Well #3	660	600	600	660	6"	20,000	144,000	n/a	1
	Factory Well #9	330	300	300	330	6"	35,000	144,000	n/a	1
	1st PVC Factory #5	330	300	300	330	6"	5,000	20,000	n/a	1
	WELL #2-A 4 IN 330 1ST STRATA	-	-	-	-	-	-	-	-	3
	WELL #3-A FACTORY 660'	-	-	-	-	-	-	-	-	3
	WELL #9 FACTORY - WAREHOUSE	-	-	-	-	-	-	-	-	3
NN Coca Cola	Well #1	-	-	-	-	-	-	-	-	3
Zapata Protein USA, Inc.	Well #1	210	-	-	-	3"	-	-	-	1
	Well #2	785	685	-	-	6"	-	724,320	26,800	1
	Well #3	-	-	-	-	-	-	-	-	1
Tides Golf Lodge Inc. and Golden Eagle Golf Course	WELL 151-089	-	-	-	-	-	-	-	-	2
	Wells for Lodge and Pond	-	-	-	-	-	-	-	-	2
Westmoreland State Park	Well #2	456	456	435	445	3"	1,013	-	-	1
	Well #4	565	565	-	-	10"	6,924	-	28,800	1
	Well #5	370	370	-	-	2"	3,565	-	6,400	1

Notes:
- Not reported or data not available

[1] Key to Data Sourcces:
1 NNPDC water supply planning survey response
2 VDH Regional Office file review conducted February 12, 2007
3 Well identified in DEQ withdrawal database

FORM 2-F: EXISTING WATER SOURCE INFORMATION - GROUND OR SURFACE WATER PURCHASED FROM WATER SUPPLY SYSTEMS OUTSIDE THE GEOGRAPHIC BOUNDARIES OF THE PLANNING AREA (9 VAC 25-780-70 G)

1.	2.		3.	4.		5.				
Community Water System	Ground Water Source		Surface Water Source (Water Body Utilized)	Amount to be Purchased		Contractual Limitations on Ground or Surface Water Permits				
	a. Well Name	b. Well ID Number		a. Maximum Daily	b. Average Annual	a. Contract or Agreement Term	b. Recipient(s) or Areas Served	c. Name(s) or Areas Served	d. Limitations on Purchase	e. Other
None Identified										

FORM 2-G: EXISTING WATER SOURCE INFORMATION - GROUND OR SURFACE WATER PURCHASED FROM WATER SUPPLY SYSTEMS OUTSIDE THE GEOGRAPHIC BOUNDARIES OF THE PLANNING AREA (WITH THE CAPCITY TO WITHDRAW MORE THAN 300,000 GAL/MO FROM ANY SOURCE) (9 VAC 25-780-70 H)

1.	2.		3.	4.		5.				
Community Water System	Ground Water Source		Surface Water Source (Water Body Utilized)	Amount to be Purchased		Contractual Limitations on Ground or Surface Water Permits				
	a. Well Name	b. Well ID Number		a. Maximum Daily	b. Average Annual	a. Contract or Agreement Term	b. Recipient(s) or Areas Served	c. Name(s) or Areas Served	d. Limitations on Purchase	e. Other
None Identified										

FORM 2-H: EXISTING WATER SOURCE INFORMATION - SOURCE AND USE INFORMATION FOR ALL AGRICULTURAL USERS WHO UTILIZE MORE THAN 300,000 GAL.MO OF GROUND OR SURFACE WATER (9 VAC 25-780-70 I)

1. User	2. Agricultural Usage by Source [1]							
	Groundwater			Surface Water		Purpose		
	a. Well Name	b. Well ID Number	c. Total Estimated Use in 2006 (gals)	d. Water Body Utilized	e. Total Estimated Use (gals)	f. Irrigation	g. Non-Irrigation	Data Source [2]
Lake Packing Co.	Barn Well	#7	9,875,000	n/a	n/a	X		4
	Upper Place Well	#4		n/a	n/a	X		4
	Upper Place Well	#6		n/a	n/a	X		4
	Upper Place Well	#8		n/a	n/a	X		4
	2nd Factory Well	#3		n/a	n/a		X	4
	WELL #9 FACTORY - WAREHOUSE	#9		n/a	n/a		X	4
	1st PVC Factory	#5		n/a	n/a		X	4
	Upper Place Well	#1	0	n/a	n/a	Not reported		1
	Upper Place Well	#2	0	n/a	n/a	Not reported		1
	WELL #2-A 4 IN 330 1ST STRATA	#2A	0	n/a	n/a	Not reported		1
	WELL #3-A FACTORY 660'	#3A	1,520,000	n/a	n/a	Not reported		1
	FACTORY WELL #9 330'	#9	600,000	n/a	n/a	Not reported		1
	Mt. Zion	n/a	n/a	Lodge Creek	0	X		4
	Blackwells	n/a	n/a	Pond	0	X		4
	Bryants	n/a	n/a	Pond	0	X		4
	Georgetown-Hinton	n/a	n/a	Pond	Not reported	Not reported		1
	Mr. Jenkins Farm Pond	n/a	n/a	Pond	Not reported	Not reported		1
	Mr. Airey Farm Pond	n/a	n/a	Pond	Not reported	Not reported		1
	Scates Pond	n/a	n/a	Pond	Not reported	Not reported		1

Notes:

- Not reported or data not available

[1] Reported as withdrawal; no water use data available from source

[2] Key to Data Sourcces:

1 Aggregate data from survey responses received 2006 - 2007, DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ), and VDH file review

2 VDH Regional Office file review conducted February 12, 2007

3 DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ)

4 Specifically reported on EEE survey returned by Lake Packing (data for other listed wells were derived from the VDEQ database)

FORM 2-I: EXISTING WATER SOURCE INFORMATION - ESTIMATE OF THE NUMBER OF RESIDENCES AND BUSINESSES THAT ARE SELF-SUPPLIED BY INDIVIDUAL WELLS WITHDRAWING LESS THAN 300,000 GAL/MO (9 VAC 25-780-70 J)

2-I. List individual well use information. Include an estimate of the number of residences and businesses that are self-supplied by individual wells withdrawing less than 300,000 gallons per month, and an estimate of the population served by individual wells. Mark and label areas served by individual wells on the map containing plan elements.

2-I.1 Number of residences that are self supplied by individual wells withdrawing les than 300,000 gallons per month:	17,666 [1]
2.I-2. Number of busineses that are self-supplied by individual wells withdrawing less than 300,000 gallons per month:	80 [1]
2.I.3 Estimate of the population served by individual wells:	25,413 [1]

SECTION 2-J: EXISTING WATER SOURCE INFORMATION - SUMMARY OF THE FINDINGS AND RECOMMENDATIONS FROM APPLICABLE SOURCE WATER ASSESSMENT PLANS OR WELLHEAD PROTECTION PROGRAMS

FORM 2-J. Provide a summary of findings and recommendations from applicable source water assesment plans or welhead protection programs:

None of the four Northern Neck counties have completed a Source Water Assessment Plan, nor a Wellhead Protection Plan. See WSP narrative for discussion of VDH-sponsored source water susceptability survey. The WSP narrative summarizes information on water supply protection and planning contained in the NNPDC Groundwater Quality Protection Plan, and the Northern Neck Counties' comprehensive plan elements for water supply protection.

[1] See WSP narrative for methodology employed to estimate this value.

FORM 3-A: EXISTING WATER SOURCE INFORMATION - COMMUNITY WATER SYSTEMS (9 VAC 25-780-80 B1-4)

1. Community System	2. Population Served (within the planning area)	3. Number of Connections	4. Withdrawal Amount		5. Water Usage gallons		
			a. Average Daily (gals / day)	b. Maximum Daily (gals / day)	a. Annual Average (gals / yr)	b. Monthly Average (gals / mo)	Data Source Key [1]
Heritage Point	-	84	8,000 - 24,000	33,600	8,760,000	33,600	4
White Sands Harbour	174	58	6,301	-	2,300,000	-	4
Waverly Subdivision	84	28	3,014	-	-	-	4
Vineyard Grove	57	19	1,370	2,590	-	-	4
Pine Harbor	51	17	1,644	2,590	-	-	4
Springfield Beach	33	11	1,507	2,600	-	-	4
Sandy Point Subdivision	150	50	8,219	18,840	-	-	4
Lewisetta	36	12	3,836	9,440	-	-	4
General Parker Shores	60	20	1,671	2,860	-	-	4
Western Branch Subdivision	9	3	New system	New system	New system	New system	4
Sloop Point	30	10	New system	New system	New system	New system	4
Horner's Beach	183	61	3,562	5,200	-	-	4
Chesapeake Cove	48	16	1,452	3,315	-	-	4
Bells Cove	300	100	9,315	11,485	3,400,000	290,000	4
Town of Kilmarnock	1550	1034	-	-	85,605,200	6,775,600	4
Town of Montross	315	-	61,151	83,667	22,300,000	1,860,000	4
Rappahannock, Westmoreland, Canterbury, Inc	451	220	27,619	-	10,080,000	840,000	4
Highbank	36	12	New system	New system	New system	New system	4
Forest Hills Subdivision	-	-	-	-	-	-	4
Monroe Bay Ests / Trailer Park	508	36	5,479	4,333	3,366,395	-	4
Ditchley Water Works, Inc.	-	25	8000 - 15000	-	-	-	4
COLONIAL BEACH, TOWN OF (2005 Survey Report)	3200	2200	-	-	147,959,320	-	2
WARSAW (2006 Survey Report)	1375	575	-	-	73,813,220	-	2
IRVINGTON	1050	350	-	-	29,828,298	2,485,692	2, 5
BAY QUARTER SHORES (2006 Survey Report)	450	226	-	-	5,406,745	-	2
BERKELEY BEACH-EBB TIDE BEACH (2005 Survey Report)	460	230	-	-	10,176,930	-	2
CALLAO	456	141	-	-	7,605,500	633,792	2, 5
CORROTOMAN BY THE BAY (2005 Survey Report)	248	124	-	-	4,431,100	-	2
FOXWELLS	240	80	-	-	6,473,600	539,483	2, 5
INDIAN CREEK	294	105	-	-	4,358,350	363,196	2, 5
KINGSLAND	100	33	-	-	3,108,500	259,042	2, 5
LANCASTER COURT HOUSE	89	40	-	-	4,392,100	366,008	2, 5
LIVELY	477	159	-	-	7,491,200	624,267	2, 5
PLACID BAY ESTATES (2005 Survey Report)	800	409	5,664	85,100	-	-	1
REEDVILLE (1999 Survey Report)	500	160	-	-	9,319,910	-	2
SHERWOOD FOREST SHORES (2006 Survey Report)	486	164	-	-	5,123,140	-	2
STRATFORD HARBOR (2005 Survey Report)	662	331	-	-	12,177,495	-	2
WEEMS	684	228	-	-	12,212,820	1,017,735	2, 5
Va. DOC - Haynesville Correctional Center	1500	15	119,392	133,340	-	-	1
Northumberland Shores	28 (permanent as of 1990)	49	-	-	3850 (1990)	8367 (1990)	4
Tides Lodge inc., Golder Eagle GC (The Greens Compox Well) [2]	-	30	282,485	-	5,692,300	474,358	1, 5
Ball Point	50	17	-	-	1,022,690	85,224	5
Bell Acres	75	25	-	-	1,795,910	149,659	5
Black Stump	80	24	-	-	988,200	82,350	5
Bon Harbor	108	36	-	-	1,451,259	120,938	5
Brown's Store	42	14	-	-	568,690	47,391	5
Bunker Hill	-	-	-	-	335,430	27,953	5
Burgess	158	63	-	-	3,935,171	327,931	5
Bushfield	81	27	-	-	675,570	56,298	5
Chesapeake Bay Estates	393	131	-	-	2,655,300	221,275	5
Churchfields	36	12	-	-	506,440	42,203	5
Corbin Lewis	90	30	-	-	1,789,300	149,108	5
Cove Colony	99	33	-	-	1,117,730	93,144	5
Glebe Point	96	37	-	-	4,351,380	362,615	5
Heathsville	299	107	-	-	4,798,100	399,842	5
Kinsale	190	76	-	-	2,907,900	242,325	5
Lancaster Courthouse	140	41	-	-	4,392,100	366,008	5
Lancaster Shores	75	25	-	-	877,480	73,123	5
Lottsburg	204	68	-	-	3,499,900	291,658	5
Luttreville	210	70	-	-	3,151,789	262,649	5
Mallard Bay	166	58	-	-	26,436,990	2,203,083	5
Nomini Bay	150	50	-	-	2,235,600	186,300	5
Pleasant View Estates	33	11	-	-	543,910	45,326	5
Rivers Bend Estates	102	37	-	-	1,141,300	95,108	5
School House Meadows	51	17	-	-	837,050	69,754	5
Whitestone	870	290	-	-	16,451,699	1,370,975	5
Wicomico Church	84	28	-	-	1,191,460	99,288	5
Wicomico Ridge	30	11	-	-	831,020	69,252	5

Notes:

- Not reported or data not available

[1] Key to Data Sources:

1 Aggregate data from survey responses received 2006 - 2007, DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ), and VDH file review

2 VDH Regional Office file review conducted February 12, 2007

3 DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ)

4 Reported by direct survey responses received 2006 - 2007

5 Reported by Aqua Virginia in 2006 DEQ withdrawal reporting (**Reported as water useage**)

[2] Given the volume of withdrawal listed in DEQ database, this well may provide operations water to the golf course, along with domestic water to community (Need survey response to elucidate).

FORM 3-B EXISTING WATER USE INFORMATION - COMMUNITY WATER SYSTEMS, PEAK DAY WATER USE BY MONTH (9VAC25-180-80-B5) [1]

Data Source Key
[2]

Heritage Point

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	6,000	May	15,000	Sep	12,000	1
Feb	5,000	June	16,000	Oct	9,000	
Mar	6,000	July	16,000	Nov	8,000	
Apr	12,000	August	20,000	Dec	9,000	

White Sands Harbour

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	8,050	May	6,440	Sep	8,430	1
Feb	3,610	June	6,830	Oct	6,400	
Mar	4,640	July	11,670	Nov	1,930	
Apr	4,080	August	6,500	Dec	6,840	

Waverly Subidivision

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	3,200	May	3,750	Sep	3,670	1
Feb	2,860	June	4,330	Oct	4,030	
Mar	2,830	July	6,050	Nov	3,450	
Apr	4,400	August	3,760	Dec	3,240	

Pine Harbor

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	1,400	May	1,800	Sep	1,620	1
Feb	1,410	June	1,900	Oct	1,700	
Mar	1,170	July	2,590	Nov	1,610	
Apr	2,060	August	1,720	Dec	1,680	

Springfield Beach

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	780	May	1,560	Sep	2,600	1
Feb	710	June	2,290	Oct	1,860	
Mar	9,300	July	2,500	Nov	1,680	
Apr	1,100	August	1,710	Dec	530	

Lewisetta

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	4,160	May	3,630	Sep	3,260	1
Feb	2,880	June	4,730	Oct	5,140	
Mar	2,580	July	5,390	Nov	9,440	
Apr	3,430	August	3,566	Dec	2,720	

General Parker Shores

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	1,210	May	1,390	Sep	2,610	1
Feb	1,140	June	2,460	Oct	1,730	
Mar	1,030	July	2,860	Nov	1,320	
Apr	1,580	August	1,930	Dec	1,040	

Horner's Branch

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	2,600	May	3,530	Sep	5,130	1
Feb	1,940	June	4,690	Oct	6,400	
Mar	1,910	July	5,200	Nov	3,480	
Apr	2,770	August	4,210	Dec	2,560	

FORM 3-B EXISTING WATER USE INFORMATION - COMMUNITY WATER SYSTEMS, PEAK DAY WATER USE BY MONTH (9VAC25-180-80-B5) [1]

Data Source Key
[2]

Chesapeake Cove

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	580	May	1,430	Sep	3,315	1
Feb	770	June	2,000	Oct		
Mar	1,170	July	1,770	Nov		
Apr	1,110	August	2,250	Dec		

Bells Cove

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	7,365	May	8,725	Sep	9,920	1
Feb	8,921	June	10,149	Oct	11,280	
Mar	6,447	July	11,485	Nov	9,825	
Apr	9,381	August	10,611	Dec	9,990	

Town of Kilmarnock

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	231,700	May	272,193	Sep	213,102	1
Feb	231,897	June	299,326	Oct	218,566	
Mar	235,870	July	236,312	Nov	214,266	
Apr	245,466	August	243,000	Dec	208,273	

Town of Montross

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	65,858	May	77,210	Sep	63,230	1
Feb	60,025	June	72,357	Oct	62,771	
Mar	68,695	July	62,032	Nov	62,340	
Apr	59,503	August	81,203	Dec	60,593	

Rappahannock Westminster - Canterbury, Inc

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	22,467	May	33,700	Sep	26,973	1
Feb	22,100	June	36,673	Oct	26,648	
Mar	23,500	July	33,693	Nov	29,600	
Apr	28,400	August	34,835	Dec	23,632	

Va. DOC - Haynesville C. C.

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	4,317	May	4,490	Sep	7,273	1
Feb	4,727	June	4,497	Oct	4,883	
Mar	4,437	July	7,140	Nov	3,913	
Apr	4,490	August	6,747	Dec	4,153	

PLACID BAY ESTATES

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	-	May	-	Sep	-	1
Feb	-	June	-	Oct	-	
Mar	-	July	-	Nov	-	
Apr	-	August	-	Dec	-	

Ditchley Water Works, Inc.

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	-	May	-	Sep	-	1
Feb	-	June	-	Oct	-	
Mar	-	July	-	Nov	-	
Apr	-	August	-	Dec	-	

Northumberland Shores

	Peak Day Use		Peak Day Use		Peak Day Use	
Jan	-	May	-	Sep	-	1
Feb	-	June	-	Oct	-	
Mar	-	Jul (1990)	8,350	Nov	-	
Apr	-	August	-	Dec	-	

Notes:
- Data not reported or not available

[1] Data provided as Withdrawal amount, not Useage amount

[2] Key to Data Sourcces:

1 Reported by direct survey responses received 2006 - 2007

FORM 3-C: EXISTING WATER USE INFORMATION – COMMUNITY WATER SYSTEMS, ESTIMATED AVERAGE ANNUAL SURFACE AND GROUND WATER USE BY SELF-SUPPLIED, NON-AGRICULTURAL USERS OF MORE THAN 300,000 GAL/MO (WITHIN THE SERVICE AREA) (9 VAC 25-780-80 B6)

Community Water System	Estimated Average Annual Surface Water Usage Million gallons	Estimated Average Annual Ground Water Usage Million gallons	Data Source Key [1]
None - Assumed that all Self-Supplied users are not located within a Community service area. Will verify through mapping as Water Supply Plan is Completed			

FORM 3-D: EXISTING WATER USE INFORMATION – COMMUNITY WATER SYSTEMS, ESTIMATED AVERAGE ANNUAL SURFACE AND GROUND WATER USE BY SELF-SUPPLIED, AGRICULTURAL USERS OF MORE THAN 300,000 GAL/MO (WITHIN THE SERVICE AREA) (9 VAC 25-780-80 B7)

Community Water System	Estimated Average Annual Surface Water Usage	Estimated Average Annual Ground Water Usage
None - Assumed that all Self-Supplied agricutural users are not located within a Community service area. Will verify through mapping as Water Supply Plan is Completed		

FORM 3-E: EXISTING WATER USE INFORMATION – COMMUNITY WATER SYSTEMS, ESTIMATED GROUND WATER USE BY SELF-SUPPLIED USERS OF LESS THAN 300,000 GAL/MO (WITHIN THE SERVICE AREA) (9 VAC 25-780-80 B8)			
Community Water Systems	**Number of Self-Supplied Users**	**Total Amount of Groundwater Usage (Average Annual)**	**Data Source Key [1]**
Heritage Point	0 identified	0 gallons identified	4
White Sands Harbour	0 identified	0 gallons identified	4
Waverly Subdivision	0 identified	0 gallons identified	4
Sandy Point Subdivision	0 identified	0 gallons identified	4
Town of Kilmarnock	0 identified	0 gallons identified	4
Town of Montross	0 identified	0 gallons identified	4
Rappahannock,Westmoreland,Cant	0 identified	0 gallons identified	4
Vineyard Grove	0 identified	0 gallons identified	4
Pine Harbor	0 identified	0 gallons identified	4
Springfield Beach	0 identified	0 gallons identified	4
Lewisetta	0 identified	0 gallons identified	4
Highbank	0 identified	0 gallons identified	4
General Parker Shores	0 identified	0 gallons identified	4
Western Branch Subdivision	0 identified	0 gallons identified	4
Sloop Point	0 identified	0 gallons identified	4
Horner's Beach	2 Users Identified	0 gallons identified	4
Chesapeake Cove	0 identified	0 gallons identified	4
Bells Cove	0 identified	0 gallons identified	4
Forest Hills Subdivision	0 identified	0 gallons identified	4
Ditchley Water Works, Inc.	18 Users	-	4

Notes:

- Data not reported or not available (Only sources that reported at least one aspect of this data element are represented)

[1] Key to Data Sourcces:

1 Aggregate data from survey responses received 2006 - 2007, DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ), and VDH file review

2 VDH Regional Office file review conducted February 12, 2007

3 DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ)

4 Specifically reported on EEE survey returned by Community supplier (Data for other listed wells was derived from the VDEQ database)

FORM 3-F: EXISTING WATER USE INFORMATION – COMMUNITY WATER SYSTEMS, DISAGGREGATED WATER USE AMOUNTS (ANNUAL AVERAGE) (9 VAC 25-780-80 B9)

1. Community Water Systems	2a. Residential Connections	2b. Residential Use (gallons per Year)	3. Commercial, Institutional, and Light Industrial (CIL) Use	4. Heavy Industrial Use	5. Military Water Use	6. Water Used in Water Production Processes	7. Unaccounted Water Loss	8. Sale to Other Community Water Systems		9. Other Use	10. Other Use	11. Subtotal	Data Source Key [1]
								Name	Amount (gal/mo)				
Heritage Point	84	9,490,000	0 gallons reported	0 gallons reported	0 gallons reported	0 gallons reported	0 gallons reported	0 gallons reported	0 gallons reported	0 gallons reported	0 gallons reported	9,490,000	1
White Sands Harbour [3]	58	2,300,000	-	-	-	-	-	-	-	-	-	2,300,000	1
Waverly Subdivision [3]	25 (3 connections)	1,100,000	3 Connections (No use reported)	-	-	-	-	-	-	-	-	1,100,000	1
Sandy Point Subdivision [3]	60	3,350,000	-	-	-	-	-	-	-	-	-	3,350,000	1
Town of Kilmarnock [3]	1033	85,905,200	-	-	-	-	-	-	-	-	-	85,905,200	1
Town of Montross [3]	-	22,300,000	-	-	-	-	-	-	-	-	-	22,300,000	1
Rappahannock, Westmoreland,Cant [3]	220	33,207	-	-	-	-	-	-	-	-	-	33,207	1
Vineyard Grove [3]	19	500,000	-	-	-	-	-	-	-	-	-	500,000	1
Pine Harbor [3]	17	600,000	-	-	-	-	-	-	-	-	-	600,000	1
Springfield Beach [3]	11	550,000	-	-	-	-	-	-	-	-	-	550,000	1
Lewisetta [2]	50	1,400,000	-	-	-	-	-	-	-	-	-	1,400,000	1
Highbank [2]	12 (new system)	0	-	-	-	-	-	-	-	-	-	0	1
General Parker Shores [2]	20	610,000	-	-	-	-	-	-	-	-	-	610,000	1
Western Branch Subdivision [2]	3 (new system)	0	-	-	-	-	-	-	-	-	-	0	1
Monroe Bay Ests [2]	36	2,000,000	-	-	-	-	-	-	-	-	-	2,000,000	1
Sloop Point [2]	10 (new system)	0	-	-	-	-	-	-	-	-	-	0	1
Horner's Beach [2]	61	1,300,000	-	-	-	-	-	-	-	-	-	1,300,000	1
Chesapeake Cove [2]	16	530,000	-	-	-	-	-	-	-	-	-	530,000	1
Bells Cove [2]	53	3,400,000	-	-	-	-	-	-	-	-	-	3,400,000	1
Ditchley Water Works, Inc. [2]	25	5,475,000	-	-	-	-	-	-	-	-	-	5,475,000	1
PLACID BAY ESTATES [2]	409	14,407,000	-	-	-	-	-	-	-	-	-	14,407,000	1
Forest Hills Subdivision [2]	-	-	-	-	-	-	-	-	-	-	-	-	1
Va. DOC - Haynesville C. C. [2]	5	43,578,300	-	-	-	-	-	-	-	-	-	43,578,300	1
Ball Point	17	1,022,690	-	-	-	-	-	-	-	-	-	1,022,690	5
Bell Acres	25	1,795,910	-	-	-	-	-	-	-	-	-	1,795,910	5
Black Stump	24	988,200	-	-	-	-	-	-	-	-	-	988,200	5
Bon Harbor	36	1,451,259	-	-	-	-	-	-	-	-	-	1,451,259	5
Brown's Store	14	568,690	-	-	-	-	-	-	-	-	-	568,690	5
Bunker Hill	-	335,430	-	-	-	-	-	-	-	-	-	335,430	5
Burgess	63	3,935,171	-	-	-	-	-	-	-	-	-	3,935,171	5
Bushfield	27	675,570	-	-	-	-	-	-	-	-	-	675,570	5
Chesapeake Bay Estates	131	2,655,300	-	-	-	-	-	-	-	-	-	2,655,300	5
Churchfields	12	506,440	-	-	-	-	-	-	-	-	-	506,440	5
Corbin Lewis	30	1,789,300	-	-	-	-	-	-	-	-	-	1,789,300	5
Cove Colony	33	1,117,730	-	-	-	-	-	-	-	-	-	1,117,730	5
Glebe Point	37	4,351,380	-	-	-	-	-	-	-	-	-	4,351,380	5
Heathsville	107	4,798,100	-	-	-	-	-	-	-	-	-	4,798,100	5
Kinsale	76	2,907,900	-	-	-	-	-	-	-	-	-	2,907,900	5
Lancaster Courthouse	41	4,392,100	-	-	-	-	-	-	-	-	-	4,392,100	5
Lancaster Shores	25	877,480	-	-	-	-	-	-	-	-	-	877,480	5
Lottsburg	68	3,499,900	-	-	-	-	-	-	-	-	-	3,499,900	5
Luttreville	70	3,151,789	-	-	-	-	-	-	-	-	-	3,151,789	5
Mallard Bay	58	26,436,990	-	-	-	-	-	-	-	-	-	26,436,990	5
Nomini Bay	50	2,235,600	-	-	-	-	-	-	-	-	-	2,235,600	5
Pleasant View Estates	11	543,910	-	-	-	-	-	-	-	-	-	543,910	5
Rivers Bend Estates	37	1,141,300	-	-	-	-	-	-	-	-	-	1,141,300	5
School House Meadows	17	837,050	-	-	-	-	-	-	-	-	-	837,050	5
Whitestone	290	16,451,699	-	-	-	-	-	-	-	-	-	16,451,699	5
Wicomico Church	28	1,191,460	-	-	-	-	-	-	-	-	-	1,191,460	5
Wicomico Ridge	11	831,020	-	-	-	-	-	-	-	-	-	831,020	5
			-	-	-	-	-	-	-	-	-	-	

Notes:

- Data not reported or not available

Assume no data reported for disaggregated use by Source indicates all water use is for residential purposes

[1] Key to Data Sources:

1 Reported by direct survey responses received 2006 - 2007

2 Reported by Aqua Virginia in 2006 DEQ withdrawal reporting **(Reported as water useage)**

[2] Reported by source as water withdrawal, not water use. Assume the Supplier only meters water withdrawal at the well(s) head, not at or by connnections.

FORM 3-G: EXISTING WATER USE INFORMATION – COMMUNITY WATER SYSTEMS USING STREAM INTAKES (9 VAC 25-780-80 B10

1. Community Water System	2. Name of Stream or River	3. Drainage Areas of Intake	4. Sub-Basin in Which Intake is Located	5. Within the Planning Area, Existing In-Stream Beneficial Uses That May Be Affected by Withdrawal	6. Outside the Planning Area, Existing In-Stream Beneficial Uses That May Be Affected by
None					

FORM 3-H: EXISTING WATER USE INFORMATION – ESTIMATED AVERAGE ANNUAL SURFACE AND GROUND WATER USE BY SELF-SUPPLIED, NON-AGRICULTURAL USERS OF MORE THAN 300,000 GAL/MO (OUTSIDE THE SERVICE AREA OF COMMUNITY WATER SYSTEMS) (9 VAC 25-780-80C)

1. Water Systems	2. Estimated Average Annual Surface Water *Usage* (gallons) **[1]**	3. Estimated Average Annual Ground Water *Usage* (gals) **[1]**	Data Source Key **[2]**
Westmoreland State Park	No surface water source reported	1,400,000	1
Bevans Oyster	No surface water source reported	17,354,000	3
NN Coca Cola	No surface water source reported	1,600,000 (2002 data)	3
Zapata Protein USA, Inc.	562,653,200 (Reported as 2006 water use)	31,903,900	1
Tides Golf Lodge Inc.	No surface water source reported	103,000,000	3
Tides Golf Lodge Inc. and Golden Eagle Golf Course	88,500,000	No non-community groundwater source reported	3

Notes:

- Data not reported or not available

[1] Reported as groundwater withdrawal; no water use data reported for source

[2] Key to Data Sourcces:

1 Aggregate data from survey responses received 2006 - 2007, DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ), and VDH file review

2 VDH Regional Office file review conducted February 12, 2007

3 DEQ withdrawal permit database (2004 or 2005 data depending upon whether source reported 2005 data to DEQ)

FORM 3-I: EXISTING WATER USE INFORMATION – ESTIMATED AVERAGE ANNUAL SURFACE AND GROUND WATER USE BY SELF-SUPPLIED, AGRICULTURAL USERS OF MORE THAN 300,000 GAL/MO (OUTSIDE THE SERVICE AREA OF COMMUNITY WATER SYSTEMS) (9 VAC 25-780-80D			
1. Water System	2. Estimated Average Annual Surface Water *Usage* in 2006 [1]	3. Estimated Average Annual Ground Water *Usage* in 2006	Data Source Key [2]
Lake Packing Company	0 gallons (19,792,760 gals in 1999)	11,995,000	1

Notes:

- Data not reported or not available

[1] Reported as 0 gallons withdrawal, and by extension 0 gallons water used.

[2] Key to Data Sourcces:

1 NNPDC water supply planning survey response

FORM 3-J: EXISTING WATER USE INFORMATION –ESTIMATED GROUND WATER USE BY SELF-SUPPLIED USERS OF LESS THAN 300,000 GAL/MO (OUTSIDE THE SERVICE AREA OF COMMUNITY WATER SYSTEMS) (9 VAC 25-780-80 E)

1. Community Water System	2. Number of Self-Supplied Users	3. Total Amount of Ground Water Usage (Average Annual)	Data Source Key [1]
See Form 2-I for summary of overall self-supplied users withdrawing <300,000 gallons / month.			

APPENDIX C

Soil Types of the NN Counties &Water Quality: Virginia's Northern Neck

Map Unit Legend Summary

Northumberland and Lancaster Counties, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BeA	Beltsville very fine sandy loam, nearly level	1,508.3	0.6
BeB	Beltsville very fine sandy loam, gently sloping	77.1	0.0
BeB2	Beltsville very fine sandy loam, gently sloping, eroded	990.6	0.4
Br	Bertie silt loam	5,663.6	2.1
Bt	Bladen silt loam	189.1	0.1
CaC3	Caroline clay loam, sloping, severely eroded	136.8	0.1
CaD3	Caroline clay loam, strongly sloping, severely eroded	186.3	0.1
CfB2	Caroline very fine sandy loam, gently sloping, eroded	404.9	0.1
CfC2	Caroline very fine sandy loam, sloping, eroded	345.4	0.1
Co	Coastal beach	805.9	0.3
CrD3	Craven clay loam, strongly sloping, severely eroded	306.4	0.1
CsA	Craven silt loam, nearly level	617.3	0.2
CsB2	Craven silt loam, gently sloping, eroded	470.9	0.2
CsC2	Craven silt loam, sloping, eroded	151.0	0.1
Dr	Dragston fine sandy loam	5,025.3	1.8
Ek	Elkton silt loam	203.7	0.1
Fa	Fallsington fine sandy loam	3,431.0	1.3
KeA	Kempsville fine sandy loam, nearly level	4,307.4	1.6
KeB	Kempsville fine sandy loam, gently sloping	3,759.6	1.4
KeB2	Kempsville fine sandy loam, gently sloping, eroded	870.6	0.3
KeC2	Kempsville fine sandy loam, sloping, eroded	286.7	0.1
KeC3	Kempsville fine sandy loam, sloping, severely eroded	139.7	0.1

Northumberland and Lancaster Counties, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
LaB	Lakeland loamy fine sand, gently sloping	699.0	0.3
Le	Lenoir silt loam	238.9	0.1
Lo	Local alluvial land	282.9	0.1
MaA	Matapeake silt loam, nearly level	7,849.4	2.9
MaB	Matapeake silt loam, gently sloping	26.5	0.0
MaB2	Matapeake silt loam, gently sloping, eroded	948.0	0.3
MaC2	Matapeake silt loam, sloping eroded	204.9	0.1
MaD2	Matapeake silt loam, strongly sloping, eroded	133.9	0.0
Mt	Mattapex silt loam	8,351.3	3.1
Mx	Mixed alluvial land	7,681.7	2.8
Ot	Othello silt loam	9,243.6	3.4
RtB	Rumford loamy sand, thick surface, gently sloping	158.9	0.1
RuB	Rumford loamy sand, gently sloping	690.8	0.3
RuC2	Rumford loamy sand, sloping, eroded	281.1	0.1
SaA	Sassafras fine sandy loam, nearly level	16,560.0	6.1
SaB	Sassafras fine sandy loam, gently sloping	36,337.3	13.4
SaB2	Sassafras fine sandy loam, gently sloping, eroded	2,263.6	0.8
SaC2	Sassafras fine sandy loam, sloping, eroded	3,744.9	1.4
SaC3	Sassafras fine sandy loam, sloping, severely eroded	1,550.7	0.6
SaD2	Sassafras fine sandy loam, strongly sloping, eroded	496.5	0.2
SaD3	Sassafras fine sandy loam, strongly sloping, severely eroded	358.2	0.1
SfA	Sassafras loamy fine sand, thick surface, nearly level	5,889.1	2.2
SfB	Sassafras loamy fine sand, thick surface, gently sloping	3,947.0	1.5

Northumberland and Lancaster Counties, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
SsD	Sloping sandy land	15,101.3	5.6
StE	Steep sandy land	41,770.7	15.4
Th	Tidal marsh, high	191.3	0.1
To	Tidal marsh, low	3,539.6	1.3
W	Water	63,816.9	23.5
Wo	Woodstown fine sandy loam	9,825.6	3.6

Map Unit Legend Summary

Richmond County, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Atlee silt loam	467.5	0.3
2	Bibb and Levy soils	7,368.1	5.3
3B	Catpoint loamy sand, 0 to 6 percent slopes	695.7	0.5
4B	Dogue fine sandy loam, 2 to 6 percent slopes	860.3	0.6
5B	Emporia loam, 2 to 6 percent slopes	8,709.5	6.3
6B	Kempsville sandy loam, 2 to 6 percent slopes	3,018.3	2.2
7	Kempsville loam	2,214.4	1.6
8	Leaf silt loam	1,641.6	1.2
9	Lumbee loam	631.2	0.5
10	Nansemond fine sandy loam	2,190.1	1.6
11	Pamunkey loam, wet substratum	342.1	0.2
12	Pits, sand and gravel	106.0	0.1
13	Rappahannock muck	4,565.5	3.3
14B	Rumford loamy sand, 0 to 6 percent slopes	3,118.1	2.3
15E	Rumford soils, 15 to 50 percent slopes	35,532.8	25.7
16D	Rumford and Tetotum soils, 6 to 15 percent slopes	7,867.4	5.7
17A	Savannah fine sandy loam, 0 to 2 percent slopes	1,173.1	0.8
17B	Savannah fine sandy loam, 2 to 6 percent slopes	3,501.0	2.5
18A	State fine sandy loam, 0 to 2 percent slopes	880.7	0.6
18B	State fine sandy loam, 2 to 6 percent slopes	732.7	0.5
19A	Suffolk sandy loam, 0 to 2 percent slopes	8,633.4	6.2
19B	Suffolk sandy loam, 2 to 6 percent slopes	15,655.6	11.3
20A	Tetotum fine sandy loam, 0 to 2 percent slopes	4,894.9	3.5

Richmond County, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
20B	Tetotum fine sandy loam, 2 to 6 percent slopes	1,682.8	1.2
21	Tomotley fine sandy loam	3,864.3	2.8
22	Wahee fine sandy loam	807.9	0.6
23	Yemassee fine sandy loam	1,107.1	0.8
W	Water	16,169.4	11.7

Map Unit Legend Summary

Westmoreland County, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1A	Ackwater silt loam, 0 to 2 percent slopes	451.6	0.3
1B	Ackwater silt loam, 2 to 6 percent slopes	354.4	0.2
2	Bibb and Levy soils	7,410.0	4.6
3	Bohicket silty clay loam	2,029.6	1.3
4	Bojac loamy sand	1,373.0	0.8
5B	Catpoint loamy sand, 0 to 6 percent slopes	916.6	0.6
6B	Emporia loam, 2 to 6 percent slopes	5,778.7	3.6
7A	Kempsville loam, 0 to 2 percent slopes	5,987.3	3.7
7B	Kempsville loam, 2 to 6 percent slopes	11,769.1	7.3
8	Leaf silt loam	6,652.7	4.1
9	Lenoir silt loam	2,471.9	1.5
10	Lumbee loam	9,039.8	5.6
11A	Montross silt loam, 0 to 2 percent slopes	3,352.3	2.1
11B	Montross silt loam, 2 to 6 percent slopes	1,532.2	0.9
12	Nansemond fine sandy loam	5,079.4	3.1
13	Pamunkey fine sandy loam, wet substratum	988.3	0.6
14	Pits, sand and gravel	292.4	0.2
15	Rappahannock muck	733.7	0.5
16B	Rumford fine sandy loam, 0 to 6 percent slopes	4,158.3	2.6
17E	Rumford soils, 15 to 50 percent slopes	33,743.0	20.8
18D	Rumford and Tetotum soils, 6 to 15 percent slopes	9,404.9	5.8
19A	Savannah loam, 0 to 2 percent slopes	810.0	0.5
19B	Savannah loam, 2 to 6 percent slopes	1,215.0	0.8

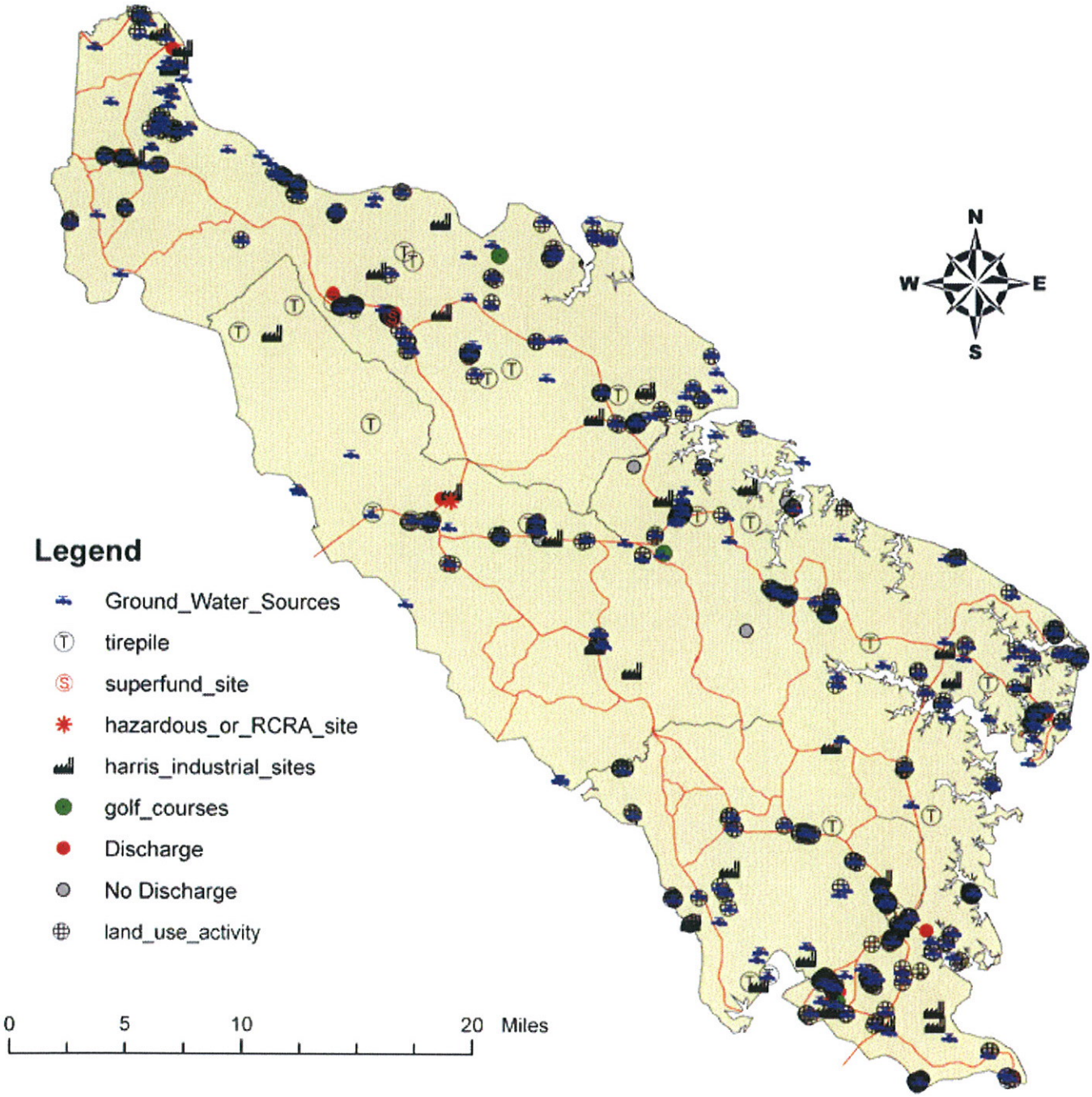
Westmoreland County, Virginia

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
20A	State fine sandy loam, 0 to 2 percent slopes	3,304.5	2.0
20B	State fine sandy loam, 2 to 6 percent slopes	1,520.2	0.9
21A	Suffolk sandy loam, 0 to 2 percent slopes	4,650.2	2.9
21B	Suffolk sandy loam, 2 to 6 percent slopes	11,811.1	7.3
22A	Tetotum loam, 0 to 2 percent slopes	6,310.3	3.9
22B	Tetotum loam, 2 to 6 percent slopes	1,897.6	1.2
23A	Turbeville loam, 0 to 2 percent slopes	214.8	0.1
23B	Turbeville loam, 2 to 6 percent slopes	1,241.7	0.8
23C	Turbeville loam, 6 to 10 percent slopes	319.6	0.2
W	Water	15,176.5	9.4

APPENDIX D

SWAP Susceptibility Results, Northern Neck Counties

Virginia Department of Health
Source Water Assessment Program (SWAP)
GIS Data within 1500 feet of a Public Water Source



Funding Provided by:

Data Sources: Virginia Department of Health: Source Water Assessment Program (SWAP) Data, 2001.

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
6099315	KING GEORGE	VU DELI	WELL		2/11/2003	WL	NC
6099590	KING GEORGE	WALNUT GROVE TRAILER PARK	DRILLED WELL	High	9/27/2002	WL	C
4101400	KING WILLIAM	A & H COUNTRY KITCHEN	WELL	High	1/24/2003	WL	NC
4101010	KING WILLIAM	ACQUINTON/HAMILTON HOLMES	DRILLED WELL # 2	Low	1/29/2002	WL	NTNC
4101020	KING WILLIAM	AYLETT DRIVE-IN	DRILLED WELL	Low	12/30/2002	WL	NC
4101030	KING WILLIAM	BLACK CREEK SUBDIVISION	DRILLED WELL	Low	12/30/2002	WL	C
4101060	KING WILLIAM	BRAXTONS LANDING	DRILLED WELL #1	High	1/29/2002	WL	C
4101110	KING WILLIAM	CENTRAL GARAGE WATER SYSTEM	WELL #1	Low	1/24/2003	WL	C
4101160	KING WILLIAM	FAS MART #33	WELL	Low	12/30/2002	WL	NC
4101670	KING WILLIAM	FONTAINBLEAU INDUSTRIAL PARK	WELL NO. 1	High	8/20/2002	WL	NTNC
4101150	KING WILLIAM	GUARDIAN ANGELS DAY CARE	DRILLED WELL	Low	3/23/2005	WL	NTNC
4101307	KING WILLIAM	KING WILLIAM COUNTY PARK	CONCESSION STAND WELL	Low	12/30/2002	WL	NC
4101650	KING WILLIAM	M & M PIZZA	WELL		12/30/2002	WL	NC
4101500	KING WILLIAM	MARLE HILL SUBDIVISION	DRILLED WELL	Low	1/29/2002	WL	C
4101550	KING WILLIAM	MT. OLIVE CHURCH COMM. WELL CO	DRILLED WELL	Low	1/29/2002	WL	C
4101600	KING WILLIAM	OAK SPRINGS	DRILLED WELL #1	Low	8/21/2002	WL	C
4101600	KING WILLIAM	OAK SPRINGS	DRILLED WELL #2	Low	8/21/2002	WL	C
4101310	KING WILLIAM	OLD KING WILLIAM COURTHOUSE	DRILLED WELL	Low	1/29/2002	WL	NTNC
4101086	KING WILLIAM	PAMUNKEY RIDGE CAMP (EQUESTRIAN	EQUESTRIAN-WELL	High	12/30/2002	WL	NC
4101085	KING WILLIAM	PAMUNKEY RIDGE CAMP (MAIN WELL)	MAIN CAMP WELL	Low	12/30/2002	WL	NC
4101715	KING WILLIAM	SHARON ROAD SHOPPING CENTER	DRILLED WELL	Low	3/23/2005	WL	NC
4101092	KING WILLIAM	SONJA'S RESTAURANT	DRILLED WELL	Low		WL	NC
4101800	KING WILLIAM	VENTER HEIGHTS SUBDIVISION	DRILLED WELL #1	Low	8/21/2002	WL	C
4101800	KING WILLIAM	VENTER HEIGHTS SUBDIVISION	DRILLED WELL #2	Low	8/21/2002	WL	C
4101900	KING WILLIAM	WEST POINT, TOWN OF	DRILLED WELL #1	High	8/1/2002	WL	C
4101900	KING WILLIAM	WEST POINT, TOWN OF	DRILLED WELL #2	Low	8/1/2002	WL	C
4101900	KING WILLIAM	WEST POINT, TOWN OF	DRILLED WELL #3	Low	8/1/2002	WL	C
4101950	KING WILLIAM	WOODRUFF SUBDIVISION	WELL # 1	Low	8/20/2002	WL	C
4101950	KING WILLIAM	WOODRUFF SUBDIVISION	WELL # 2		8/20/2002	WL	C
4103050	LANCASTER	ALEXANDRIA POLICE BOYS CAMP	WELL NO. 1A		10/31/2002	WL	NC
4103100	LANCASTER	BALL POINT	WELL 1A	Low	9/11/2001	WL	C
4103120	LANCASTER	BELLE ISLE STATE PARK	WELL NO. 1	Low	9/11/2001	WL	NC
4103130	LANCASTER	BLACK STUMP	DRILLED WELL # 1	Low	9/11/2001	WL	C
4103150	LANCASTER	BRIGHTWATERS	DRILLED WELL	Low	9/11/2001	WL	NC
4103200	LANCASTER	CHURCHFIELDS	DRILLED WELL	High	9/10/2001	WL	C
4103225	LANCASTER	CORBIN-LEWIS ESTATES	DRILLED WELL	Low	9/11/2001	WL	C

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
4103230	LANCASTER	CORROTOMAN BY THE BAY	DRILLED WELL #1	Low	9/11/2001	WL	C
4103230	LANCASTER	CORROTOMAN BY THE BAY	DRILLED WELL #2	Low	9/11/2001	WL	C
4103975	LANCASTER	CORROTOMAN PLAZA	WELL NO. 1	Low	10/30/2002	WL	NC
4103245	LANCASTER	COTTAGES AT THE GOLDEN EAGLE	WELL NO. 1A	Low	9/11/2001	WL	C
4103250	LANCASTER	COVE COLONY	WELL 1A	Low	9/14/2001	WL	C
4103336	LANCASTER	FLOWERING FIELDS	WELL	High	5/6/2003	WL	C
4103338	LANCASTER	FOREST HILLS SUBD	DRILLED WELL	High	3/14/2002	WL	C
4103340	LANCASTER	FOUND FOR HIST CHRIST CH INC	WELL	Low	10/28/2002	WL	NC
4103350	LANCASTER	FOXWELLS	DRILLED WELL	Low	9/5/2001	WL	C
4103365	LANCASTER	GOLDEN EAGLE COUNTRY CLUB	DRILLED WELL	Low	10/25/2002	WL	NC
4103375	LANCASTER	GRANVILLE BAY SUBDIVISION	DRILLED WELL	Low	9/5/2001	WL	C
4103400	LANCASTER	GREEN, THE	WELL NO. 1	High	7/25/2001	WL	C
4103500	LANCASTER	HERITAGE POINT	WELL 1A		9/5/2001	WL	C
4103500	LANCASTER	HERITAGE POINT	WELL 2	Low	9/5/2001	WL	C
4103550	LANCASTER	IRVINGTON COMMUNITY OF	DRILLED WELL #1	High	8/23/2001	WL	C
4103550	LANCASTER	IRVINGTON COMMUNITY OF	DRILLED WELL #2	Low	8/23/2001	WL	C
4103600	LANCASTER	KILMARNOCK, TOWN OF	DRILLED WELL #3	Low	9/5/2001	WL	C
4103600	LANCASTER	KILMARNOCK, TOWN OF	DRILLED WELL #4	Low	9/5/2001	WL	C
4103630	LANCASTER	KINGSLAND	DRILLED WELL #1A	Low	9/5/2001	WL	C
4103680	LANCASTER	LANCASTER COURTHOUSE	WELL NO. 1A		9/5/2001	WL	C
4103684	LANCASTER	LANCASTER HEALTH DEPT	DRILLED WELL	Low	9/5/2001	WL	NTNC
4103687	LANCASTER	LANCASTER HIGH SCHOOL	DRILLED WELL	Low	9/5/2001	WL	NTNC
4103695	LANCASTER	LANCASTER PRIMARY SCHOOL	DRILLED WELL	Low	9/5/2001	WL	NTNC
4103710	LANCASTER	LANCASTER SHORES	DRILLED WELL #1A	Low	9/5/2001	WL	C
4103750	LANCASTER	LAUREL POINT	DRILLED WELL1	Low	9/5/2001	WL	C
4103750	LANCASTER	LAUREL POINT	DRILLED WELL2	Low	9/5/2001	WL	C
4103780	LANCASTER	LITTLE BAY ASSOCIATES	DRILLED WELL	High	9/5/2001	WL	C
4103800	LANCASTER	LIVELY, COMMUNITY OF	DRILLED WELL1	High	9/5/2001	WL	C
4103800	LANCASTER	LIVELY, COMMUNITY OF	DRILLED WELL2	Low	9/5/2001	WL	C
4103820	LANCASTER	MOSQUITO POINT	DRILLED WELL NO. 1	Low	9/5/2001	WL	C
4103870	LANCASTER	RAPPAHANNOCK WESTMINSTER	WELL NO. 1	Low	9/5/2001	WL	C
4103870	LANCASTER	RAPPAHANNOCK WESTMINSTER	WELL NO. 2	Low	9/5/2001	WL	C
4103898	LANCASTER	TIDES LODGE	DRILLED WELL	Low	1/29/2003	WL	NC
4103950	LANCASTER	WAVERLY SUBDIVISION	WELL NO. 1	Low	9/5/2001	WL	C
4103950	LANCASTER	WAVERLY SUBDIVISION	WELL NO. 1A		9/5/2001	WL	C
4103830	LANCASTER	WEEMS	WELL2 @ NTH WEEMS	Low	9/5/2001	WL	C

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
4103830	LANCASTER	WEEMS	WELL3 @ STH WEEMS	Low	9/5/2001	WL	C
4103955	LANCASTER	WESTERN BRANCH PRESERVE	WELL NO. 1			WL	C
4103977	LANCASTER	WHISPERING PINES MOTEL	WELL (WITH PITLESS ADAPTER)	High	10/30/2002	WL	NC
4103980	LANCASTER	WHITE STONE-WHITE STONE BEACH	DRILLED WELL 1	High	9/5/2001	WL	C
4103980	LANCASTER	WHITE STONE-WHITE STONE BEACH	DRILLED WELL 2	Low	9/5/2001	WL	C
4103985	LANCASTER	WINDMILL POINT MARINE RESORT	WELL NO. 1	High	1/30/2003	WL	NTNC
4103985	LANCASTER	WINDMILL POINT MARINE RESORT	WELL NO. 2		1/30/2003	WL	NTNC
4103993	LANCASTER	YANKEE PT SAILBOAT MARINA	DRILLED WELL	High	10/28/2002	WL	NC
1105050	LEE	APPALACHIA SERVICE PROJECT	WELL			WL	NC
1105075	LEE	CAVE SPRINGS	WELL #1	High	3/22/2002	WL	NC
1105860	LEE	HARVEST BAPTIST CHILDCARE MINISTRIES	WELL #1	High	10/8/2002	WL	C
1105200	LEE	JONESVILLE, TOWN OF	WYNN SPRING #1		6/3/2002	SP	C
1105400	LEE	LEE COUNTY WATER	BLUE SPRING			SP	C
1105500	LEE	PENNINGTON GAP, TOWN OF	POWELL RIVER INTAKE FACILITY	High	3/22/2002	IN	C
1105850	LEE	STICKLEYVILLE ELEMENTARY SCHOOL	WELL	High	3/22/2002	WL	NTNC
6107175	LOUDOUN	ADESA WASHINGTON DC (FORMER ABC	WELL	High	3/26/2003	WL	NTNC
6107011	LOUDOUN	ALDIE ELEMENTARY SCHOOL	WELL#1	High	8/29/2002	WL	NTNC
6107010	LOUDOUN	ALDIE WATER COMPANY	WELL #1	High	1/13/2002	WL	C
6107010	LOUDOUN	ALDIE WATER COMPANY	WELL #2	High	1/13/2002	WL	C
6107018	LOUDOUN	ALGONKIAN REG. PARK - COMFORT STATION	WELL NO 1	High	3/7/2003	WL	NC
6107015	LOUDOUN	ALGONKIAN REG. PARK - CONFERENCE	WELL 1	High	3/7/2003	WL	NC
6107017	LOUDOUN	ALGONKIAN REG. PARK - COTTAGES	WELL	High	3/7/2003	WL	NC
6107019	LOUDOUN	ALGONKIAN REG. PARK - MAINTENANCE	WELL 1		4/15/2003	WL	NC
6107016	LOUDOUN	ALGONKIAN REGIONAL PARK - POOL	WELL 1	High	3/7/2003	WL	NC
6107025	LOUDOUN	ARCOLA COMMUNITY CENTER	WELL	High	3/26/2003	WL	NTNC
6107024	LOUDOUN	ARCOLA ELEMENTARY SCHOOL	WELL#1	High	8/29/2002	WL	NTNC
6107026	LOUDOUN	ARCOLA UNITED METHODIST CHURCH	WELL			WL	NTNC
6107033	LOUDOUN	BANNEKER ELEMENTARY SCHOOL	WELL 2 (NEW FOR 99)	High	8/29/2002	WL	NTNC
6107045	LOUDOUN	BANSHEE REEKS PARK	BANSHEE PARK		4/30/2003	WL	NC
6107037	LOUDOUN	BEACON HILL-LCSA	WELL C			WL	C
6107037	LOUDOUN	BEACON HILL-LCSA	WELL HA			WL	C
6107240	LOUDOUN	BEAUTIFUL SOUTH, THE	WELL		3/26/2003	WL	NC
6107038	LOUDOUN	BLUEMONT COMMUNITY CENTER	WELL	High	3/26/2003	WL	NTNC
6107034	LOUDOUN	BRAMBLETON GOLF COURSE	WELL	High	3/26/2003	WL	NC
6107052	LOUDOUN	CAMP HIGHROAD	WELL	High	3/26/2003	WL	NC
6107120	LOUDOUN	CAMP POTOMAC WOODS-RIDGE AND	MOUNTFORD WELL	High	3/7/2003	WL	NC

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
3131040	NORTHAMPTON	SUNSET BEACH RESORT	WL003		4/16/2003	WL	NC
3131854	NORTHAMPTON	SUNSET BEACH RESORT RV PARK	WELL	High	4/4/2003	WL	NC
3131371	NORTHAMPTON	THOMAS B. LONG JR. MLC	WELL001	High	7/3/2003	WL	NC
4133038	NORTHUMBERL	BAY MOTEL	DEEP WELL	High	10/29/2002	WL	NC
4133040	NORTHUMBERL	BAY QUARTER SHORES	WELL 1A @ STAT 20	High	10/4/2001	WL	C
4133040	NORTHUMBERL	BAY QUARTER SHORES	WELL 2 @ STAT 19	High	10/4/2001	WL	C
4133080	NORTHUMBERL	BELLS COVE SUBD	WELL NO. 1A	Low	4/9/2002	WL	C
4133080	NORTHUMBERL	BELLS COVE SUBD	WELL NO. 2	Low	4/9/2002	WL	C
4133100	NORTHUMBERL	BON HARBOURS	DRILLED WELL NO. 1A	High	10/4/2001	WL	C
4133110	NORTHUMBERL	BROWNS STORE	DRILLED WELL	Low	10/5/2001	WL	C
4133120	NORTHUMBERL	BURGESS	WELL NO. 2	Low	10/4/2001	WL	C
4133120	NORTHUMBERL	BURGESS	WELL NO. 2A		10/4/2001	WL	C
4133160	NORTHUMBERL	CALLAO	DRILLED WELL NO. 1	High	3/14/2002	WL	C
4133160	NORTHUMBERL	CALLAO	DRILLED WELL NO. 2	Low	3/14/2002	WL	C
4133170	NORTHUMBERL	CALLAO SHOPS AND APARTMENTS	WELL NO. 1	High	10/29/2002	WL	C
4133175	NORTHUMBERL	CAMP KITTAMAQUND GIRL SCOUTS	DRILLED WELL	High	10/28/2002	WL	NC
4133200	NORTHUMBERL	CHESAPEAKE BAY ESTATES	DRILLED WELL NO. 2	Low	10/11/2001	WL	C
4133825	NORTHUMBERL	CHESAPEAKE BAY SMITH ISLAND KOA	ARTESIAN WELL	High	10/25/2002	WL	NC
4133203	NORTHUMBERL	CHESAPEAKE COVE	WELL NO. 1			WL	C
4133205	NORTHUMBERL	COAN RIVER MARINA	WELL	High	10/28/2002	WL	NC
4133207	NORTHUMBERL	COCKRELL'S MARINE RAILWAY	WELL NO. 1			WL	NC
4133215	NORTHUMBERL	COWART SEAFOOD CORP	WELL NO. 1			WL	NC
4133215	NORTHUMBERL	COWART SEAFOOD CORP	WELL NO. 2			WL	NC
4133240	NORTHUMBERL	DITCHLEY	DRILLED WELL	Low	10/12/2001	WL	C
4133275	NORTHUMBERL	FAIRPORT MARINA	WELL	High	10/28/2002	WL	NC
4133280	NORTHUMBERL	FLEETON	WELL NO. 1A	High	10/4/2001	WL	C
4133445	NORTHUMBERL	GAPS MARINA	WELL	High	10/28/2002	WL	NC
4133320	NORTHUMBERL	GLEBE POINT	DRILLED WELL	High	10/9/2001	WL	C
4133330	NORTHUMBERL	GREAT WICOMICO CAMPGROUND AND	DRILLED WELL	High	10/28/2002	WL	NC
4133195	NORTHUMBERL	HAROLD EUBANK	WELL	High	1/28/2003	WL	NC
4133360	NORTHUMBERL	HEATHSVILLE	WELL NO. 1	High	10/3/2001	WL	C
4133360	NORTHUMBERL	HEATHSVILLE	WELL NO. 2	Low	10/3/2001	WL	C
4133400	NORTHUMBERL	INDIAN CREEK ESTATES	WELL NO. 2	High	7/3/2002	WL	C
4133400	NORTHUMBERL	INDIAN CREEK ESTATES	WELL NO. 3	Low	7/3/2002	WL	C
4133405	NORTHUMBERL	INDIAN CREEK YACHT AND COUNTRY CLUB	WELL NO. 1	Low	4/3/2003	WL	NTNC
4133415	NORTHUMBERL	JETTYS REACH	DRILLED WELL	Low	10/9/2001	WL	C

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
4133440	NORTHUMBERL	LEE DALE SHORES	DRILLED WELL #1A	Low	10/29/2001	WL	C
4133480	NORTHUMBERL	LEWISETTA	DRILLED WELL #1	High	10/15/2001	WL	C
4133480	NORTHUMBERL	LEWISETTA	DRILLED WELL #1A	High	10/15/2001	WL	C
4133500	NORTHUMBERL	LIGHTHOUSE CHRISTIAN ACADEMY	DEEP WELL	High	10/5/2001	WL	NTNC
4133510	NORTHUMBERL	LITTLE RIVER CAMPGROUND	WELL NO. 1			WL	NC
4133515	NORTHUMBERL	LITTLE RIVER SEAFOOD	DRILLED WELL			WL	NC
4133520	NORTHUMBERL	LOCKSLEY HALL ESTATES	DRILLED WELL # 1	Low	10/5/2001	WL	C
4133520	NORTHUMBERL	LOCKSLEY HALL ESTATES	DRILLED WELL #2	Low	10/5/2001	WL	C
4133560	NORTHUMBERL	LOTTSBURG	WELL NO. 2	High	4/9/2002	WL	C
4133560	NORTHUMBERL	LOTTSBURG	WELL NO. 3	High	4/9/2002	WL	C
4133580	NORTHUMBERL	LOTTSBURG CAFE'	WELL NO. 1		4/28/2004	WL	NC
4133600	NORTHUMBERL	LUCOM POINT SUBD	WELL NO. 1A	Low	10/12/2001	WL	C
4133620	NORTHUMBERL	MALLARD BAY SUBDIVISION	WELL NO. 1	Low	7/3/2002	WL	C
4133620	NORTHUMBERL	MALLARD BAY SUBDIVISION	WELL NO. 2	Low	7/3/2002	WL	C
4133621	NORTHUMBERL	NORTHUMBERLAND COUNTY COMMUNITY	WELL NO. 1			WL	NC
4133622	NORTHUMBERL	NORTHUMBERLAND ELEMENTARY SCHOOL	DRILLED WELL	High	10/17/2001	WL	NTNC
4133625	NORTHUMBERL	NORTHUMBERLAND HIGH SCHOOL	DRILLED WELL	Low	10/17/2001	WL	NTNC
4133640	NORTHUMBERL	NORTHUMBERLAND PLANTATION	DRILLED WELL #1	High	10/10/2002	WL	C
4133680	NORTHUMBERL	NORTHUMBERLAND SHORES	DRILLED WELL	High	10/15/2001	WL	C
4133695	NORTHUMBERL	OLVERSON'S MARINA	DRILLED WELL	High	10/28/2002	WL	NC
4133980	NORTHUMBERL	OMEGA PROTEIN, INCORPORATED	DRILLED WELL NO. 2	High	3/14/2002	WL	NTNC
4133696	NORTHUMBERL	PINE HARBOR	WELL NO. 1			WL	C
4133697	NORTHUMBERL	QUINTON OAKS GOLF CLUB	WELL	High	10/17/2002	WL	NC
4133740	NORTHUMBERL	REEDVILLE MANOR	REEDVILLLE MANOR WELL	Low	4/9/2002	WL	C
4133720	NORTHUMBERL	REEDVILLE-TOWN OF	TOWER WELL-WELL #2A	Low	10/15/2001	WL	C
4133720	NORTHUMBERL	REEDVILLE-TOWN OF	YORK PROPERTY-WELL #3A	Low	10/15/2001	WL	C
4133760	NORTHUMBERL	RIVERBEND ESTATES	DRILLED WELL	Low	10/11/2001	WL	C
4133800	NORTHUMBERL	SHERWOOD FOREST SHORES	DRILLED WELL #1	Low	10/4/2001	WL	C
4133800	NORTHUMBERL	SHERWOOD FOREST SHORES	DRILLED WELL #2	Low	10/4/2001	WL	C
4133820	NORTHUMBERL	SMITH POINT MARINA	DRILLED WELL	High	10/25/2002	WL	NC
4133845	NORTHUMBERL	TIDES ON THE CHESAPEAKE ASSOC	DRILLED WELL	Low	10/15/2001	WL	NC
4133850	NORTHUMBERL	TOWLES LANDING	DRILLED WELL	High	10/16/2001	WL	C
4133865	NORTHUMBERL	UPPER BAY VIEW ESTATES	WELL NO. 1			WL	C
4133877	NORTHUMBERL	VILLAGE GREEN	WELL	High	10/17/2002	WL	NC
4133888	NORTHUMBERL	WESTBAY	WELL NO. 1	Low	4/8/2003	WL	C
4133886	NORTHUMBERL	WESTSIDE HALL	DRILLED WELL	Low	10/17/2002	WL	NC

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
4133890	NORTHUMBERL	WHITE SAND HARBOUR	WELL NO 1A	Low	4/3/2003	WL	C
4133890	NORTHUMBERL	WHITE SAND HARBOUR	WELL NO 2	Low	4/3/2003	WL	C
4133900	NORTHUMBERL	WICOMICO CHURCH	DRILLED WELL	High	3/14/2002	WL	C
4133920	NORTHUMBERL	WICOMICO RIDGE	DRILLED WELL	High	3/14/2002	WL	C
1720076	NORTON	NORTON, CITY OF	BENGES BRANCH	High	3/20/2002	IN	C
1720076	NORTON	NORTON, CITY OF	UNNAMED TRIBUTARY TO BENGES	High	3/20/2002	IN	C
5135390	NOTTOWAY	AMELIA-NOTTOWAY VOCATIONAL CEN	WELL NO.1	High	12/6/2002	WL	NTNC
5135100	NOTTOWAY	BLACKSTONE, TOWN OF	NOTTOWAY RESERVOIR	High	6/13/2002	IN	C
5135110	NOTTOWAY	BURKEVILLE, TOWN OF	WELL NO. 1	High	4/15/2003	WL	C
5135110	NOTTOWAY	BURKEVILLE, TOWN OF	WELL NO. 2	High	4/15/2003	WL	C
5135110	NOTTOWAY	BURKEVILLE, TOWN OF	WELL NO. 3	High	4/15/2003	WL	C
5135110	NOTTOWAY	BURKEVILLE, TOWN OF	WELL NO. 4	High	4/15/2003	WL	C
5135110	NOTTOWAY	BURKEVILLE, TOWN OF	WELL NO. 5	High	4/15/2003	WL	C
5135110	NOTTOWAY	BURKEVILLE, TOWN OF	WELL NO. 7	High	4/15/2003	WL	C
5135120	NOTTOWAY	COUNTRY INN	WELL	High	8/18/2005	WL	NC
5135160	NOTTOWAY	CREWE, TOWN OF	CRYSTAL LAKE	High	6/13/2002	IN	C
5135260	NOTTOWAY	HICKORY HILL	WELL NO.1		9/21/2005	WL	C
5135550	NOTTOWAY	SLAW'S RESTAURANT	BORED WELL	High	12/6/2002	WL	NC
5135295	NOTTOWAY	TYSON FOODS INC	WELL NO. 12	High	9/30/2002	WL	NTNC
5135295	NOTTOWAY	TYSON FOODS INC	WELL NO. 5	High	9/30/2002	WL	NTNC
5135295	NOTTOWAY	TYSON FOODS INC	WELL NO. 9	High	9/30/2002	WL	NTNC
6137001	ORANGE	AEROJET CORPORATION	WELL 4	High	3/6/2003	WL	NTNC
6137020	ORANGE	BATTLEFIELD FARMS	WELL 1	High	3/6/2003	WL	NTNC
6137210	ORANGE	LIGHTFOOT ELEM SCHOOL	WELL	High	10/28/2002	WL	NTNC
6137212	ORANGE	LOCUST GROVE ELEMENTARY/MIDDLE	WELL	High	10/28/2002	WL	NTNC
6137003	ORANGE	LOCUST GROVE TOWN CENTER	WELL		3/6/2003	WL	NTNC
6137167	ORANGE	MEADOWS FARMS GOLF COURSE	DRILLED WELL		3/6/2003	WL	NC
6137228	ORANGE	MONTPELIER MANSION (KITCHEN)	DRILLED WELL	Moderate	3/6/2003	WL	NC
6137229	ORANGE	MONTPELIER VISITOR'S CENTER	WELL	High	3/6/2003	WL	NC
6137500	ORANGE	ORANGE, TOWN OF	RAPIDAN RIVER	High	5/24/2002	IN	C
6137325	ORANGE	PALLADIO RESTAURANT	WELL	High	3/6/2003	WL	NC
6137120	ORANGE	RSA ROUTE 20	DRILLED WELL	High	10/28/2002	WL	C
6137321	ORANGE	SOMERSET GOLF CLUB LLC	WELL	High	3/6/2003	WL	NC
6137370	ORANGE	UNIONVILLE ELEMENTARY SCHOOL	WELL	High	10/28/2002	WL	NTNC
6137999	ORANGE	WILDERNESS WTP	RAPIDAN RIVER INTAKE	High	5/24/2002	IN	C
6137515	ORANGE	WILLOW GROVE INN AND RESTAURANT	WELL 1	High	3/6/2003	WL	NC

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
1750100	RADFORD	RADFORD, CITY OF	INTAKE ON NEW RIVER	High	7/18/2002	IN	C
6157388	RAPPAHANNOC	CHILD CARE & LEARNING CENTER	WELL	High	9/20/2002	WL	NTNC
6157386	RAPPAHANNOC	FLINT HILL PUBLIC HOUSE	DRILLED WELL	High	3/3/2003	WL	NC
6157225	RAPPAHANNOC	FOUR & TWENTY BLACKBIRDS	DRILLED WELL	High	3/3/2003	WL	NC
6157280	RAPPAHANNOC	HEARTHSTONE SCHOOL	WELL	High	11/19/2002	WL	NTNC
6157203	RAPPAHANNOC	MOUNTAIN CAFE	WELL		3/3/2003	WL	NC
6157385	RAPPAHANNOC	RAPPAHANNOCK ELEM SCHOOL	WELL	High	9/20/2002	WL	NTNC
6157380	RAPPAHANNOC	RAPPAHANNOCK HIGH SCHOOL	WELL 1	High	9/20/2002	WL	NTNC
6157205	RAPPAHANNOC	THE BLUE ROCK INN	WELL 1	High	3/3/2003	WL	NC
6157500	RAPPAHANNOC	WAKEFIELD COUNTRY DAY SCHOOL	DRILLED WELL	High	9/20/2002	WL	NTNC
6157400	RAPPAHANNOC	WASHINGTON, TOWN OF	WELL 1	High	9/20/2002	WL	C
6157400	RAPPAHANNOC	WASHINGTON, TOWN OF	WELL 3	High	9/20/2002	WL	C
4760100	RICHMOND CITY	RICHMOND, CITY OF	RAW WATER INTAKE	High	2/12/2002	IN	C
4159020	RICHMOND	ACCOPATOUGH BEACH CAMPGROUND	DRILLED WELL	High	10/30/2002	WL	NC
4159100	RICHMOND	BELL ACRES	WELL NO. 1	High	3/14/2002	WL	C
4159235	RICHMOND	FARNHAM MANOR	WELL 1	High	3/14/2002	WL	C
4159235	RICHMOND	FARNHAM MANOR	WELL 2	High	3/14/2002	WL	C
4159200	RICHMOND	HAYNESVILLE CORRECTIONAL CENTER	WELL NO. 1	High	3/14/2002	WL	C
4159200	RICHMOND	HAYNESVILLE CORRECTIONAL CENTER	WELL NO. 2	Low	3/14/2002	WL	C
4159200	RICHMOND	HAYNESVILLE CORRECTIONAL CENTER	WELL NO. 3	Low	3/14/2002	WL	C
4159150	RICHMOND	HERITAGE PARK RESORT INC	WELL	High	10/28/2002	WL	NC
4159420	RICHMOND	LITTLE FLORIDA	WELL NO. 1			WL	NC
4159500	RICHMOND	LUTTRELLVILLE	DRILLED WELL NO. 1A	Low	3/14/2002	WL	C
4159550	RICHMOND	MAI-LAN	WELL	High	10/30/2002	WL	NC
4159610	RICHMOND	NAYLORS BEACH CAMPGROUND	WELL #1	High	10/28/2002	WL	NC
4159600	RICHMOND	NAYLORS BEACH-RAPPA POINT	DRILLED WELL	High	3/14/2002	WL	NC
4159630	RICHMOND	NORTHERN NECK SEAFOOD	WELL	High	1/27/2003	WL	NC
4159700	RICHMOND	PLEASANT VIEW ESTATES	WELL NO. 1	High	4/5/2002	WL	C
4159750	RICHMOND	RICHMOND CO INTERMED. SCHOOL	DRILLED WELL	High	4/8/2002	WL	NTNC
4159350	RICHMOND	RICHMOND COUNTY COMMUNITY CENTER	DRILLED WELL	High	10/28/2002	WL	NC
4159800	RICHMOND	SCHOOLHOUSE MEADOWS	DRILLED WELL	Low	4/5/2002	WL	C
4159900	RICHMOND	WARSAW, TOWN OF	WELL NO. 1	High	4/8/2002	WL	C
4159900	RICHMOND	WARSAW, TOWN OF	WELL NO. 2	Low	4/8/2002	WL	C
4159900	RICHMOND	WARSAW, TOWN OF	WELL NO. 3	Low	4/8/2002	WL	C
4159900	RICHMOND	WARSAW, TOWN OF	WELL NO. 4	Low	4/8/2002	WL	C
4159925	RICHMOND	WHELAN MARINA NO. 1	DRILLED WELL #1	High	10/28/2002	WL	NC

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
4159927	RICHMOND	WHELAN MARINA NO. 2	DRILLED WELL #2		10/28/2002	WL	NC
4159926	RICHMOND	WHELAN MARINA NO. 3	DRILLED WELL #3		10/28/2002	WL	NC
2770650	ROANOKE CITY	CARVINS COVE WTP	CARVINS COVE	High	6/7/2001	IN	C
2770650	ROANOKE CITY	CARVINS COVE WTP	MUSE WELL	High	6/7/2001	WL	C
2770650	ROANOKE CITY	CARVINS COVE WTP	WELL 1	High	6/7/2001	WL	C
2770650	ROANOKE CITY	CARVINS COVE WTP	WELL 2	High	6/7/2001	WL	C
2770650	ROANOKE CITY	CARVINS COVE WTP	WELL NO. 4 (LABELLEVUE NO.2)		6/7/2001	WL	C
2770650	ROANOKE CITY	CARVINS COVE WTP	WELL NO. 6 (LABELLEVUE NO. 7)		6/7/2001	WL	C
2770650	ROANOKE CITY	CARVINS COVE WTP	WELL NO. 8 (BOTETOURT EAST NO 2)		6/7/2001	WL	C
2770650	ROANOKE CITY	CARVINS COVE WTP	WELL NO. 9 (BOTETOURT EAST NO 3)		6/7/2001	WL	C
2770750	ROANOKE CITY	CRYSTAL SPRING	HAMPDEN HILLS WELL NO. 1		6/7/2001	WL	C
2770750	ROANOKE CITY	CRYSTAL SPRING	SPRING	High	6/7/2001	SP	C
2770800	ROANOKE CITY	FALLING CREEK WTP	FALLING CREEK	High	6/7/2001	IN	C
2770425	ROANOKE CITY	SKATE CENTER OF ROANOKE VALLEY	DRILLED WELL	High	9/25/2002	WL	NC
2161283	ROANOKE	9607 BENT MTN. RD.	WELL		9/25/2002	WL	NC
2161023	ROANOKE	BACK CREEK ELEMENTARY SCHOOL	WELL	High	7/24/2002	WL	NTNC
2161042	ROANOKE	BENT MOUNTAIN ELEM SCHOOL	WELL		7/24/2002	WL	NTNC
2161103	ROANOKE	CAMP ROANOKE	DRILLED WELL		9/25/2002	WL	NC
2161110	ROANOKE	CAROLINA VILLAGE	CAROLINA VILLAGE WELL		6/5/2002	WL	C
2161150	ROANOKE	CATAWBA HOSPITAL	SPRING - CATAWBA HOSPITAL	High	9/3/2002	SP	C
2161150	ROANOKE	CATAWBA HOSPITAL	WELL - CATAWBA HOSPITAL	High	9/3/2002	WL	C
2161150	ROANOKE	CATAWBA HOSPITAL	WELL 9 - CATAWBA HOSPITAL	High	9/3/2002	WL	C
2161155	ROANOKE	CAVE SPRING MIDDLE SCHOOL	WELL	High	7/24/2002	WL	NTNC
2161244	ROANOKE	DARK HOLLOW - LOWER	DRILLED WELL (LOWER)	High	11/13/2002	WL	NC
2161243	ROANOKE	DARK HOLLOW - UPPER	DRILLED WELL (UPPER)	High	9/25/2002	WL	NC
2161250	ROANOKE	DELANEY COURT	WELL	High	7/24/2002	WL	C
2161286	ROANOKE	EXPLORE PARK	WELL NO. 1 (MCKEE'S FORD WELL)	High	1/28/2003	WL	NC
2161290	ROANOKE	FALLING CREEK ESTATES	WELL 1 (TWIN MOUNTAIN)	High	4/22/2002	WL	C
2161290	ROANOKE	FALLING CREEK ESTATES	WELL 3 (FALLING CREEK A)	High	4/22/2002	WL	C
2161290	ROANOKE	FALLING CREEK ESTATES	WELL 4 (TODDSBURY)	High	4/22/2002	WL	C
2161290	ROANOKE	FALLING CREEK ESTATES	WELL 5 (FALLING CREEK B)	High	4/22/2002	WL	C
2161315	ROANOKE	GARDEN CITY	WELL 1 (NEW WELL) - GARDEN CITY/WEBB		9/18/2002	WL	C
2161315	ROANOKE	GARDEN CITY	WELL 2 (OLD WELL) - GARDEN CITY/WEBB		9/18/2002	WL	C
2161335	ROANOKE	GLENVAR ELEM. & HIGH SCHOOL	WELL	High	7/24/2002	WL	NTNC
2161348	ROANOKE	GREEN HILL PARK	WELL	High	11/13/2002	WL	NC
2161364	ROANOKE	GREEN VALLEY ELEMENTARY SCHOOL	WELL	High	7/24/2002	WL	NTNC

PWSID	CNYCTY	NAME	SourceName	Susceptibility	SWADate	TYPE_CODE	D_PWS_FED_TYPE_CD
4193993	WESTMORELAN	PORT KINSALE INN	WELL NO.3	High	7/11/2003	WL	NC
4193995	WESTMORELAN	PORT KINSALE MARINA	WELL NO. 1	High	7/11/2003	WL	NC
4193995	WESTMORELAN	PORT KINSALE MARINA	WELL NO. 2	Low	7/11/2003	WL	NC
4193750	WESTMORELAN	POTOMAC SUPPLY CORPORATION	DRILLED WELL (DOMESTIC)	High	7/3/2002	WL	NTNC
4193750	WESTMORELAN	POTOMAC SUPPLY CORPORATION	DRILLED WELL (FIRE PROTECTION)	Low	7/3/2002	WL	NTNC
4193760	WESTMORELAN	POTOMAC WESTMORELAND SHORES	WELL PTMAC5	High	7/3/2002	WL	C
4193760	WESTMORELAN	POTOMAC WESTMORELAND SHORES	WELL WMLAND2	High	7/3/2002	WL	C
4193760	WESTMORELAN	POTOMAC WESTMORELAND SHORES	WELL WMLAND3	High	7/3/2002	WL	C
4193760	WESTMORELAN	POTOMAC WESTMORELAND SHORES	WELL1A PTMAC4	High	7/3/2002	WL	C
4193835	WESTMORELAN	SANDY POINT MARINA	ARTESIAN WELL NO. 2	High	10/23/2002	WL	NC
4193840	WESTMORELAN	SANDY POINT SUBDIVISION	WELL NO. 1	High	7/3/2002	WL	C
4193840	WESTMORELAN	SANDY POINT SUBDIVISION	WELL NO. 2		7/3/2002	WL	C
4193875	WESTMORELAN	SHO-NUFF BAR.B.Q.	WELL	High	10/18/2002	WL	NC
4193880	WESTMORELAN	SPRINGFIELD BEACH	WELL NO. 1	High	7/3/2002	WL	C
4193925	WESTMORELAN	STANLEY'S DAIRY FREEZE	ARTESIAN WELL	High	10/30/2002	WL	NC
4193910	WESTMORELAN	STRATFORD HALL PLANTATION	DRILLED WELL #1	High	4/5/2002	WL	NC
4193910	WESTMORELAN	STRATFORD HALL PLANTATION	WELL NO. 2A	Low	4/5/2002	WL	NC
4193920	WESTMORELAN	STRATFORD HARBOUR	DRILLED WELL #12	High	7/3/2002	WL	C
4193920	WESTMORELAN	STRATFORD HARBOUR	DRILLED WELL #12B	High	7/3/2002	WL	C
4193920	WESTMORELAN	STRATFORD HARBOUR	DRILLED WELL #13	High	7/3/2002	WL	C
4193955	WESTMORELAN	VETS INN RESTAURANT	DRILLED WELL	High	10/31/2002	WL	NC
4193950	WESTMORELAN	WASHINGTON & LEE HOME FOR THE	WELL	High	7/3/2002	WL	C
4193960	WESTMORELAN	WASHINGTON DISTRICT ELEMENTARY	WELL NO. 1	Low	7/3/2002	WL	NTNC
4193975	WESTMORELAN	WESTMORELAND BERRY FARM	WELL	High	10/18/2002	WL	NC
4193080	WESTMORELAN	WESTMORELAND COUNTY INDUSTRIAL	WELL 2 (A. T. JOHNSON BUILDING)	High	4/5/2002	WL	C
4193080	WESTMORELAN	WESTMORELAND COUNTY INDUSTRIAL	WELL 3 (MONTROSS MIDDLE SCHOOL)	High	4/5/2002	WL	C
4193980	WESTMORELAN	WESTMORELAND STATE PARK	DRILLED WELL	Low	4/5/2002	WL	NC
4193981	WESTMORELAN	WESTMORELAND STATE PARK CAMP	DRILLED WELL	High	4/5/2002	WL	NC
4193979	WESTMORELAN	WESTMORELAND STATE PARK-DAY USE	DRILLED WELL	Low	4/5/2002	WL	NC
4193985	WESTMORELAN	WHITE POINT MARINA	WELL NO. 2		10/31/2002	WL	NC
4193985	WESTMORELAN	WHITE POINT MARINA	WELL NO.1		10/31/2002	WL	NC
4193982	WESTMORELAN	WILKERSONS RESTAURANT	WELL	High	10/17/2002	WL	NC
4193982	WESTMORELAN	WILKERSONS RESTAURANT	WELL 2	High	10/17/2002	WL	NC
4193299	WESTMORELAN	WILLEY'S	WELL	High	10/30/2002	WL	NC
4193990	WESTMORELAN	WOODLAND ACADEMY	DRILLED WELL	Low	7/3/2002	WL	NTNC
3830850	WILLIAMSBURG	WILLIAMSBURG, CITY OF	RAWWATER N-N	High	10/28/2002	IN	C

VIRGINIA DEPARTMENT OF HEALTH – DIVISION OF DRINKING WATER

Potential Sources of Contamination in Zone 1 and 2 (Form D)

Subject: RICHMOND COUNTY **Water:** WARSAW, TOWN OF **PWSID#:** 4159900 **Source Name:** WELL NO. 1

Compiled by: PAL **Date:** 03/14/02 **Reviewed by:** Source Water Supervisor **Date:** 03/14/02

Map ID #	Unique ID	Description of Contaminant Source	Property Owner	Mailing Address (Street or POB, Town)
P-1	159003	Tire Piles	Carr's Tire Service	4040 Early Rd. Harrisonburg VA 22801

VIRGINIA DEPARTMENT OF HEALTH -- DIVISION OF DRINKING WATER

Potential Conduits to Groundwater Inventory Form (Form F)

Subject: RICHMOND COUNTY **Water:** WARSAW, TOWN OF **PWSID#:** 4159900 **Source Name:** WELL NO. 1

Compiled by: Winston Marshall **Date:** 06/19/00 **Reviewed by:** Mohsen Shahramfar **Date:**

Map ID #	Type of Conduit	Estimated Distance from Well (feet)	Comments
C-1	Ponds, streams	233	drainage pond

VIRGINIA DEPARTMENT OF HEALTH -- DIVISION OF DRINKING WATER

Potential Sources of Contamination in Zone 1 and 2 (Form D)

Subject: RICHMOND COUNTY **Water:** WARSAW, TOWN OF **PWSID#:** 4159900 **Source Name:** WELL NO. 2

Compiled by: PAL **Date:** 03/14/02 **Reviewed by:** Source Water Supervisor **Date:** 03/14/02

Map ID #	Unique ID	Description of Contaminant Source	Property Owner	Mailing Address (Street or POB, Town
P-1	159003	Tire Piles	Carr's Tire Service	4040 Early Rd. Harrisonburg VA 22801

VIRGINIA DEPARTMENT OF HEALTH – OFFICE OF WATER PROGRAMS

11/3/00

Source Water Susceptibility Determination (Form A)

Subject: Richmond	**Water: Town of Warsaw**	**PWSID No.: 4159900**	**Source Name: Well No. 3**
Evaluated by: Winston Marshall	Date: November 13, 2001	Reviewed by: Mohsen Shahramfar	Date:

Step		CIRCLE ANSWER	
		YES	NO
1	Has a nitrate concentration > 5 mg/L been detected in the past 5 years? Has a nitrite concentration > 0.5 mg/L been detected in the past 5 years? Have any SOC/VOC contaminants(excluding TTHM's) been detected in the past 5 years? Has a combined Radium 226 and Radium 228 concentration > 5 pCi/L in 2 or more samples been detected in past 5 years? Has detection of any IOC contaminant exceeded the PMCL in 2 or more samples in the past 5 years?	(If any are) Go to step 11	(If all are) Go to step 2
2	Is source water type a surface water or GUDIS?	Circle step 12	Go to step 3
3	Identify the groundwater area where the source is located using the Groundwater Map of Virginia prepared by the Virginia Water Control Board. Is the source located in the Mountainous Terrain Ground Water Area, or the Miocene, Paleocene-Eocene or Cretaceous Aquifers of the Coastal Plain Ground Water Area?	Go to step 5	Go to step 4
4	Is the source located in a confined or nonsensitive aquifer as determined by the U.S. Geological Survey Aquifer Susceptibility Study? If unknown, answer 'no'.	Go to step 5	Circle step 12
5	Has OWP determined that disinfection is required for the source water, or, is the geometric mean > 3 TC/100 ml in 20 or more source(raw) water samples collected in the last 5 years or have fecal coliform been detected in 2 or more source samples collected in the past 5 years?	(If either is) Go to step 11	(If both are) Go to step 6
6	Is the source a Class IIB(or better) well constructed in accordance with the Waterworks Regulations?	Go to step 7	Circle step 12
7	Does a driller's log or the U.S. Geological Survey study clearly indicate that an aquitard is present?	Go to step 8	Circle step 12
8	Does evidence exist to suggest the aquitard does not extend over the entire assessment area?	Circle step 12	Go to step 9
9	Do any identified Potential Conduits to groundwater(table 3) penetrate the aquitard? If unknown, answer 'Yes'.(Home wells not included.)	Go to step 12	Go to step 10
10	Does the most recent sanitary survey confirm that the source construction conforms to the construction standards of the Waterworks Regulations?	Circle step 13	Circle step 12
11	List detected contaminant(s) and sample dates on Form B List of Known Contamination Documentation Form.	Circle step 12	
12	Source ***IS*** Sensitive.	Go to step 14	
13	Source ***IS NOT*** Sensitive.	Go to step 14	
14	Does a Land Use Activity or PSC exist in the Zone 1 assessment area or, for groundwater sources: does a potential conduit to groundwater exist in Zone 1 or; does a potential source of contamination exist in Zone 2?	Go to step 15	Go to step 15

15 CIRCLE THE SUSCEPTIBILITY OF THE SOURCE IN THE APPROPRIATE ROW ON THE CHART BELOW

Source Water Type	Sensitive Source	LUA, PSC or PC Present in Assessment Area	Susceptibility
Groundwater	No	No	Very Low
Groundwater	No	Yes	Low
Groundwater	Yes	No	Moderate
Groundwater	Yes	Yes	High

VIRGINIA DEPARTMENT OF HEALTH – DIVISION OF DRINKING WATER

Potential Conduits to Groundwater Inventory Form (Form F)

Subject: RICHMOND COUNTY **Water:** WARSAW, TOWN OF **PWSID#:** 4159900 **Source Name:** WELL NO. 3

Compiled by: Winston Marshall **Date:** 06/19/00 **Reviewed by:** Mohsen Shahramfar **Date:**

Map ID #	Type of Conduit	Estimated Distance from Well (feet)	Comments
C-1	Other Wells in Use	948	

VIRGINIA DEPARTMENT OF HEALTH – DIVISION OF DRINKING WATER

Potential Sources of Contamination in Zone 1 (Form D)

Subject: RICHMOND COUNTY **Water:** WARSAW, TOWN OF **PWSID#:** 4159900 **Source Name:** WELL NO. 3

Compiled by: PAL **Date:** 03/14/02 **Reviewed by:** Source Water Supervisor **Date:** 03/14/02

Map ID #	Unique ID	Description of Contaminant Source	Property Owner	Mailing Address (Street or POB, Town)
P-1	159003	Tire Piles	Carr's Tire Service	4040 Early Rd. Harrisonburg VA 22801

VIRGINIA DEPARTMENT OF HEALTH – OFFICE OF WATER PROGRAMS

11/3/00

Source Water Susceptibility Determination (Form A)

Subject: Richmond	**Water: Town of Warsaw**	**PWSID No.: 4159900**	**Source Name: Well No. 4**
Evaluated by: Winston Marshall	Date: November 13, 2001 / Reviewed by: Mohsen Shahramfar	**Date:**	

Step		CIRCLE ANSWER: YES	CIRCLE ANSWER: NO
1	Has a nitrate concentration > 5 mg/L been detected in the past 5 years? Has a nitrite concentration > 0.5 mg/L been detected in the past 5 years? Have any SOC/VOC contaminants(excluding TTHM's) been detected in the past 5 years? Has a combined Radium 226 and Radium 228 concentration > 5 pCi/L in 2 or more samples been detected in past 5 years? Has detection of any IOC contaminant exceeded the PMCL in 2 or more samples in the past 5 years?	(If any are) Go to step 11	(If all are) Go to step 2
2	Is source water type a surface water or GUDIS?	Circle step 12	Go to step 3
3	Identify the groundwater area where the source is located using the Groundwater Map of Virginia prepared by the Virginia Water Control Board. Is the source located in the Mountainous Terrain Ground Water Area, or the Miocene, Paleocene-Eocene or Cretaceous Aquifers of the Coastal Plain Ground Water Area?	Go to step 5	Go to step 4
4	Is the source located in a confined or nonsensitive aquifer as determined by the U.S. Geological Survey Aquifer Susceptibility Study? If unknown, answer 'no'.	Go to step 5	Circle step 12
5	Has OWP determined that disinfection is required for the source water, or, is the geometric mean > 3 TC/100 ml in 20 or more source(raw) water samples collected in the last 5 years or have fecal coliform been detected in 2 or more source samples collected in the past 5 years?	(If either is) Go to step 11	(If both are) Go to step 6
6	Is the source a Class IIB(or better) well constructed in accordance with the Waterworks Regulations?	Go to step 7	Circle step 12
7	Does a driller's log or the U.S. Geological Survey study clearly indicate that an aquitard is present?	Go to step 8	Circle step 12
8	Does evidence exist to suggest the aquitard does not extend over the entire assessment area?	Circle step 12	Go to step 9
9	Do any identified Potential Conduits to groundwater(table 3) penetrate the aquitard? If unknown, answer 'Yes'.(Home wells not included.)	Go to step 12	Go to step 10
10	Does the most recent sanitary survey confirm that the source construction conforms to the construction standards of the Waterworks Regulations?	Circle step 13	Circle step 12
11	List detected contaminant(s) and sample dates on Form B List of Known Contamination Documentation Form.	Circle step 12	
12	Source *IS* Sensitive.	Go to step 14	
13	Source ***IS NOT*** Sensitive.	Go to step 14	
14	Does a Land Use Activity or PSC exist in the Zone 1 assessment area or, for groundwater sources: does a potential conduit to groundwater exist in Zone 1 or; does a potential source of contamination exist in Zone 2?	Go to step 15	Go to step 15
15	CIRCLE THE SUSCEPTIBILITY OF THE SOURCE IN THE APPROPRIATE ROW ON THE CHART BELOW		

Source Water Type	Sensitive Source	LUA, PSC or PC Present in Assessment Area	Susceptibility
Groundwater	No	No	Very Low
Groundwater	No	Yes	Low
Groundwater	Yes	No	Moderate
Groundwater	Yes	Yes	High

VIRGINIA DEPARTMENT OF HEALTH–DIVISION OF DRINKING WATER

Area Features Documentation Form (Form E2)

Subject: RICHMOND COUNTY

Water: WARSAW, TOWN OF

PWSID#: 4159900

Source Name: WELL NO. 4

Evaluated by: Source Water Supervisor

Date: 03/14/2002

Reviewed By:

Date:

Map ID #	Unique ID #	Classification of Contaminant Source	Property Owner	Mailing Address (Street or POB, Town)
L-2	985	On-site sewage system	Brooks Lucille G	PO Box 142, Warsaw, VA 22572
L-2	985	On-site sewage system	Barber Virgil Sr	12839 Historyland Hwy, Warsaw, VA 22572
L-2	985	On-site sewage system	Tate-Allison Donna S	781 Scott Town Rd, Warsaw, VA 22572
L-2	985	On-site sewage system	Gaines Major	606 Scott Town Rd, Warsaw, VA 22572
L-2	985	On-site sewage system	Scott William Henry	570 Scott Town Rd, Warsaw, VA 22572
L-2	985	On-site sewage system	Gaines Milford	606 Scott Town Rd, Warsaw, VA 22572

PWSID: 4159900
FACILITY: WELL NO. 1
WATERWORKS: WARSAW, TOWN OF

SWAP Zone 1 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY

Source location and accuracy was not verified for all PSCs and BMPs shown. Data was collected from various federal, state, and private sources, which used a variety of collection methods.

Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

N
200 0 200 400 Feet

Potential Sources of Contamination (P-#)

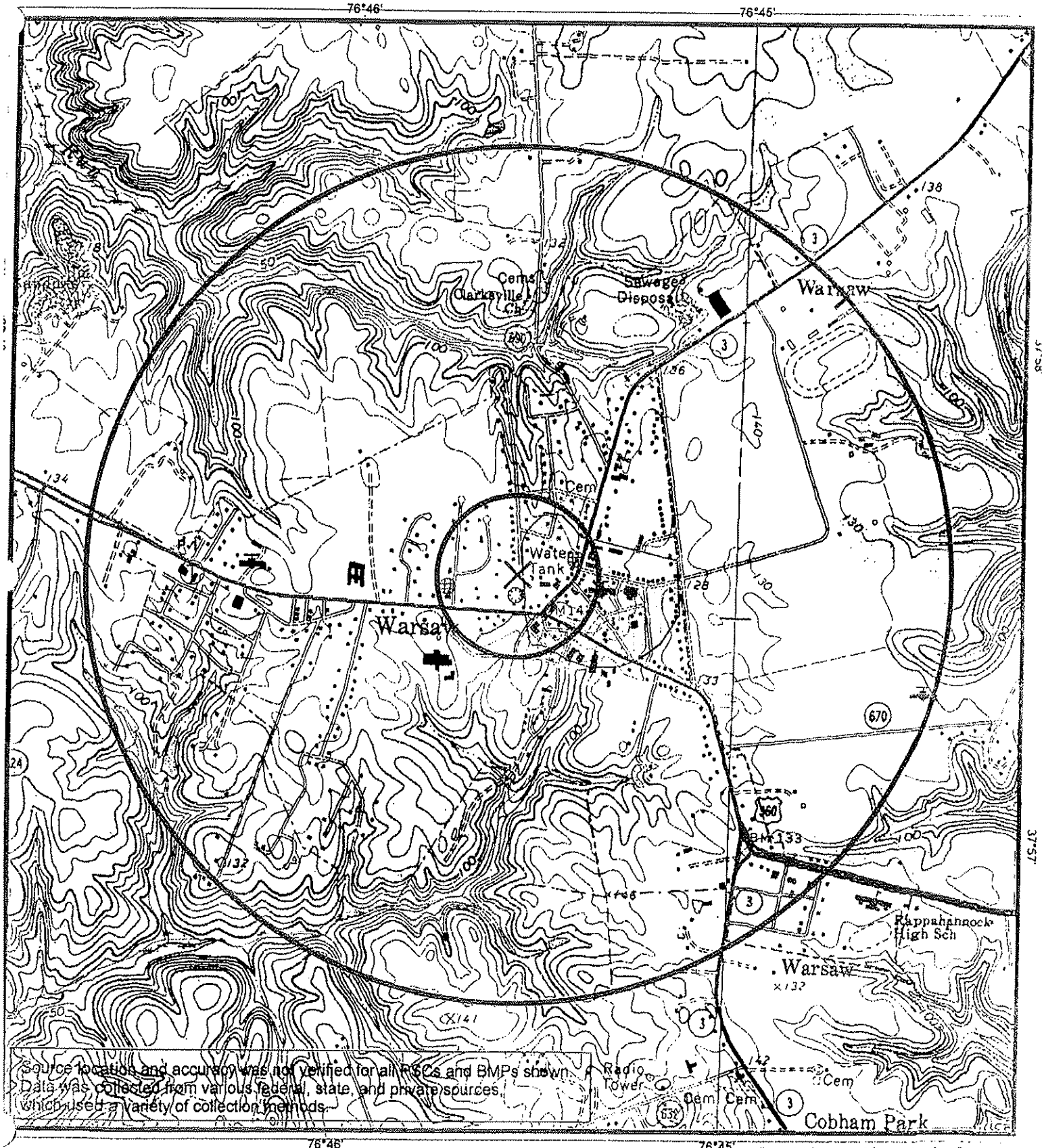
Landfills
Discharge -- No Discharge Facilities
Discharge
No Discharge
DEQSWRO -- Storage Tank Releases
Active
Closed

Actions
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Dumpsites
Tire Piles

PWSID:4159900
FACILITY:WELL NO. 1
WATERWORKS:WARSAW, TOWN OF

SWAP Zone 2 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

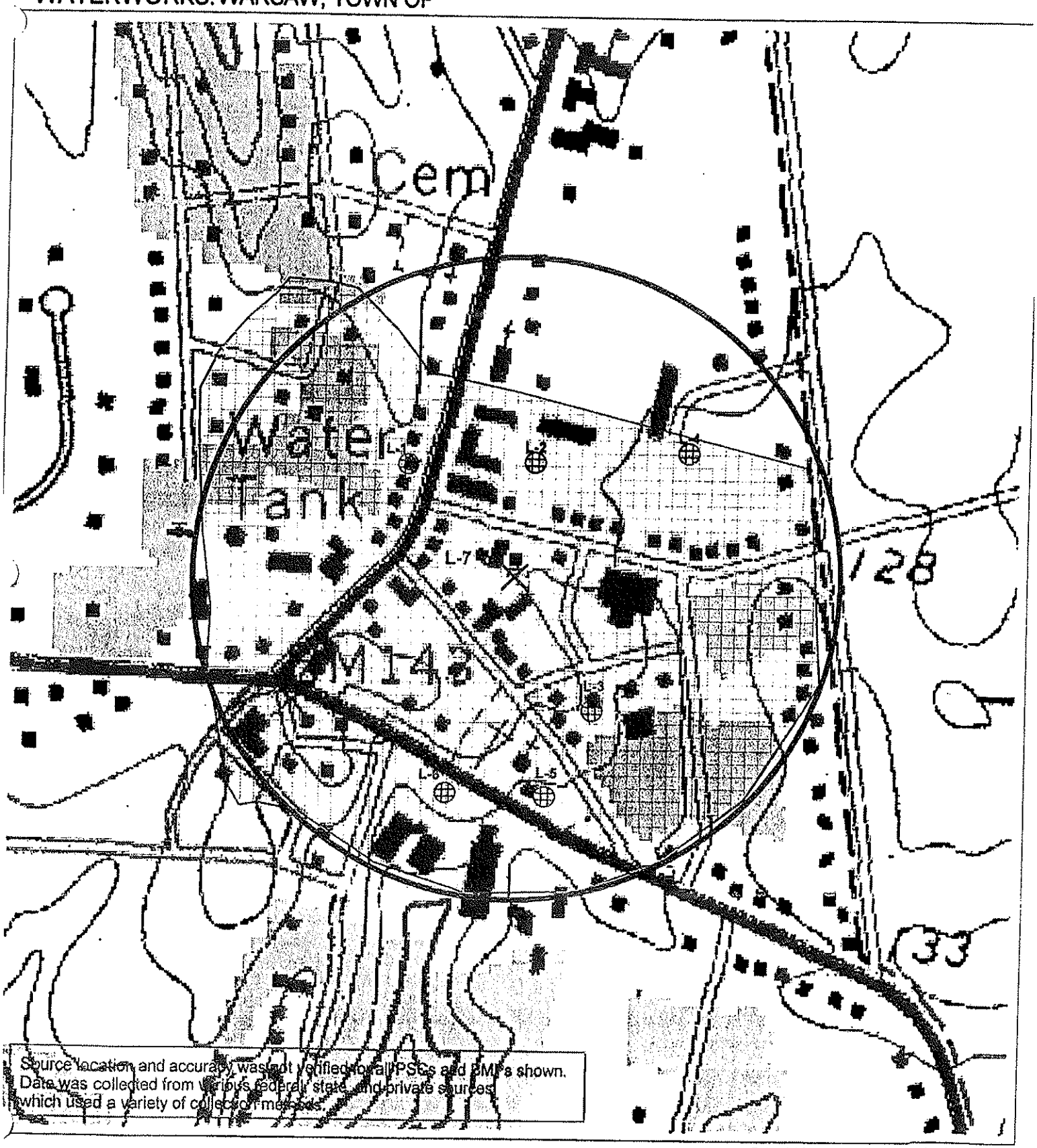
N
800 0 800 1600 Feet

Potential Sources of Contamination (P-#)
Landfills
Discharge – No Discharge Facilities
Discharge
No Discharge
DEQSWRO – Storage Tank Releases
Active
Closed
Airports
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Hospitals
Tire Piles

PWSID: 4159900
FACILITY: WELL NO. 2
WATERWORKS: WARSAW, TOWN OF

SWAP Zone 1 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Source location and accuracy was not verified for all PSCs and BMPs shown. Data was collected from various federal, state, and private sources which used a variety of collection methods.

Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

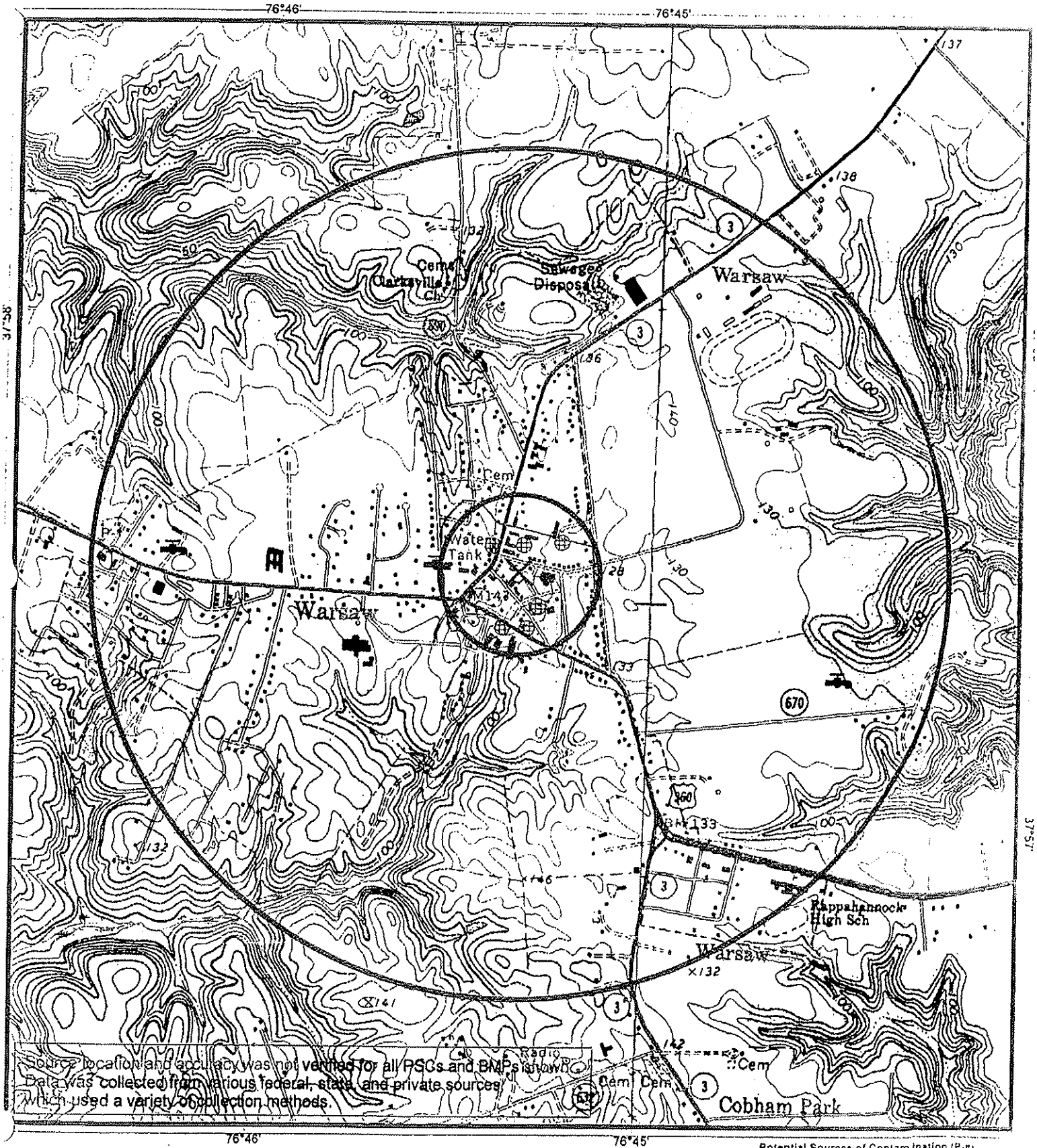
N
200 0 200 400 Feet

Potential Sources of Contamination (P-#)
Landfills
Discharge – No Discharge Facilities
Discharge
No Discharge
DEQSWRO – Storage Tank Releases
Active
Closed
Airports
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Hospitals

PWSID: 4159900
FACILITY: WELL NO. 2
WATERWORKS: WARSAW, TOWN OF

SWAP Zone 2 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Source location and accuracy was not verified for all PSCs and BMPs shown. Data was collected from various federal, state, and private sources which used a variety of collection methods.

Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

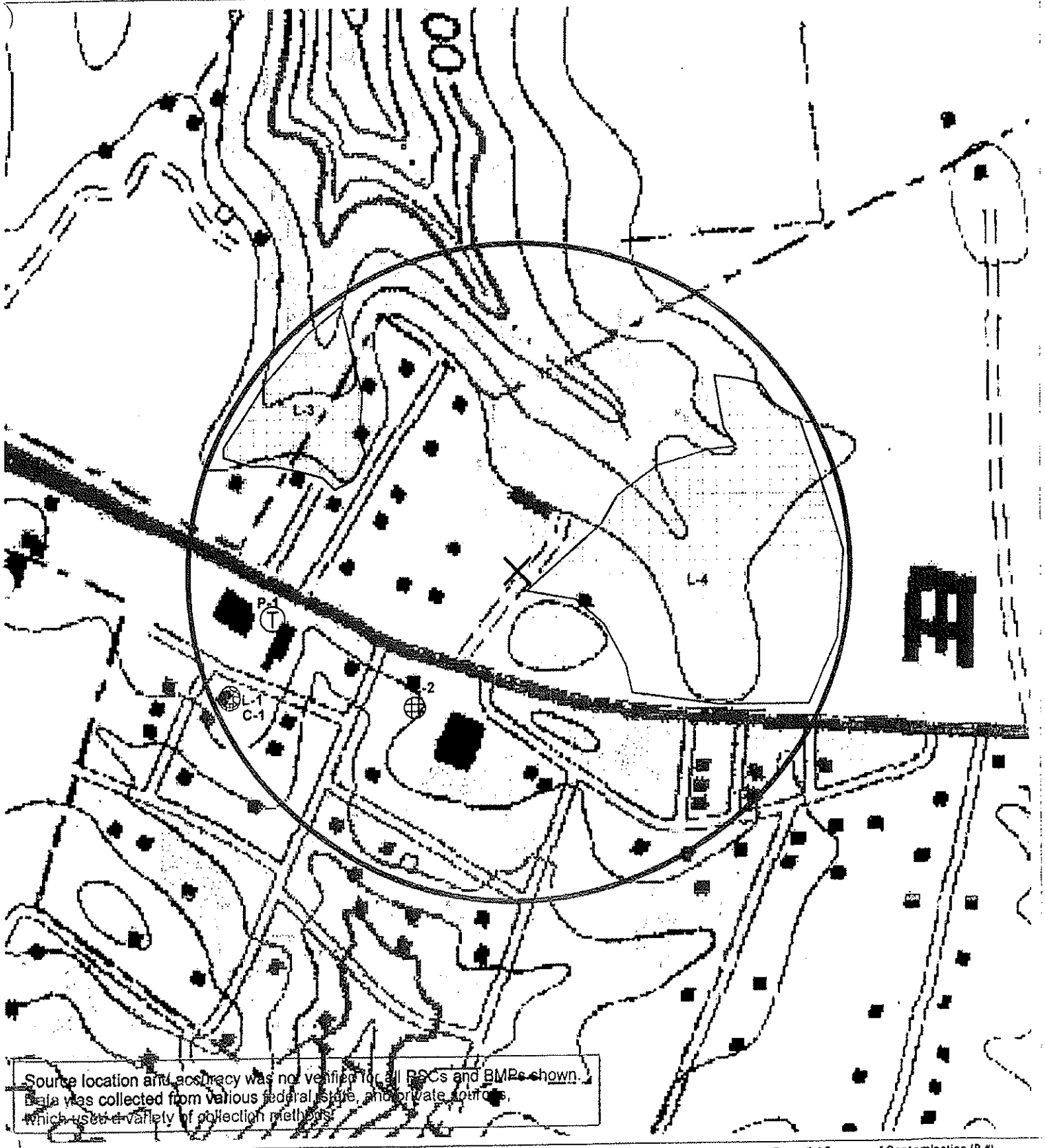
N
800 0 800 1600 Feet
Print Date: March 2002

Potential Sources of Contamination (P-#)
Landfills
Discharge -- No Discharge Facilities
Discharge
No Discharge
DEQSWRO -- Storage Tank Releases
Active
Closed
Junkyards
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Incinerators
Turf Farms

SWAP Zone 1 Map

PWSID: 4159900
FACILITY: WELL NO. 3
WATERWORKS: WARSAW, TOWN OF

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Source location and accuracy was not verified for all PSCs and BMPs shown. Data was collected from various federal, state, and private sources, which used a variety of collection methods.

Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

N
200 0 200 400 Feet

Print Date: March 2002

Potential Sources of Contamination (P-#)

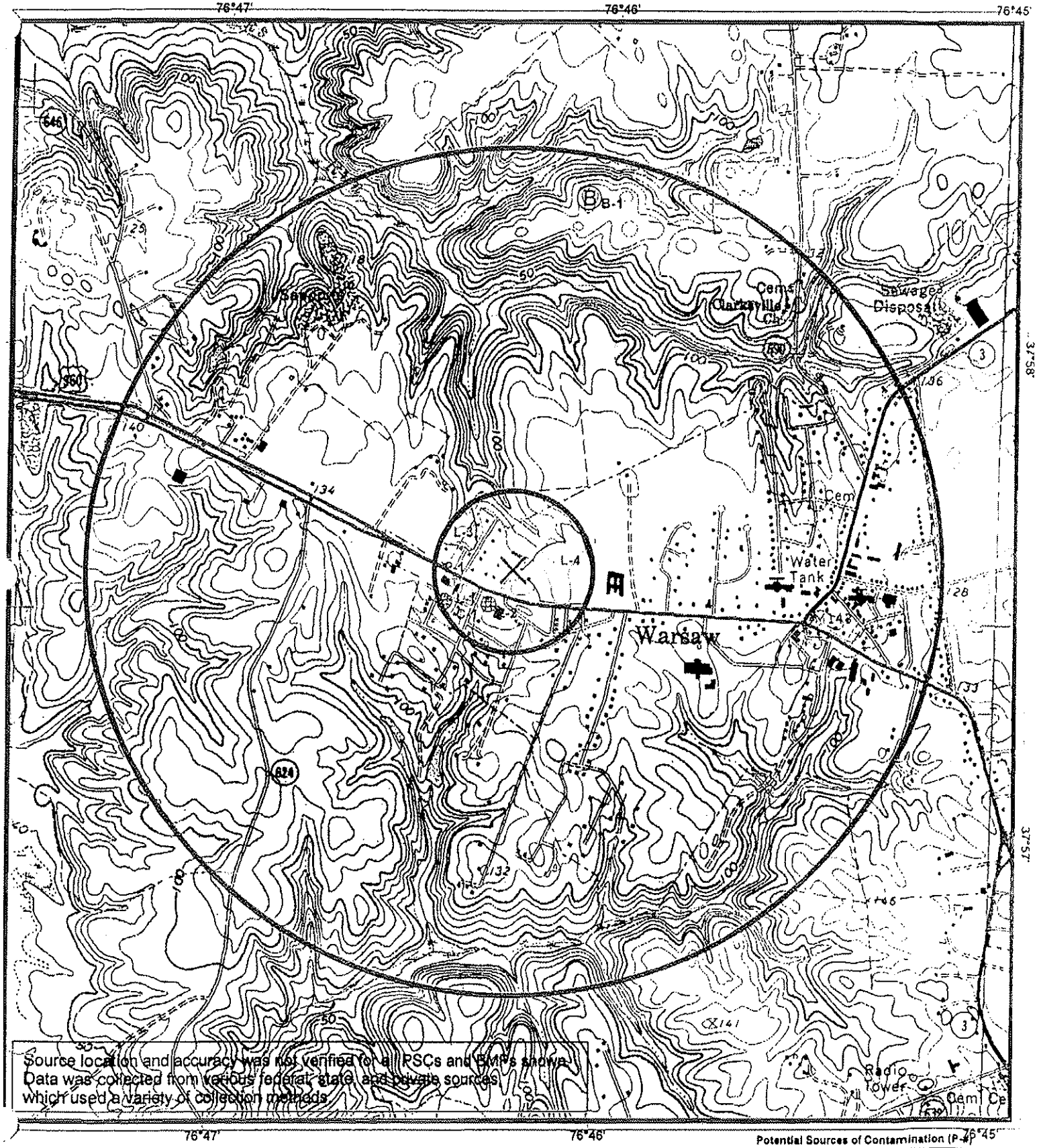
Landfills
Discharge – No Discharge Facilities
Discharge
No Discharge
DEQSWRO – Storage Tank Releases
Active
Closed

Airports
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Hospitals
Tire Piles

PWSID: 4159900
FACILITY: WELL NO. 3
WATERWORKS: WARSAW, TOWN OF

SWAP Zone 2 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Potential Sources of Contamination (P-#)

Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

N
800 0 800 1600 Feet

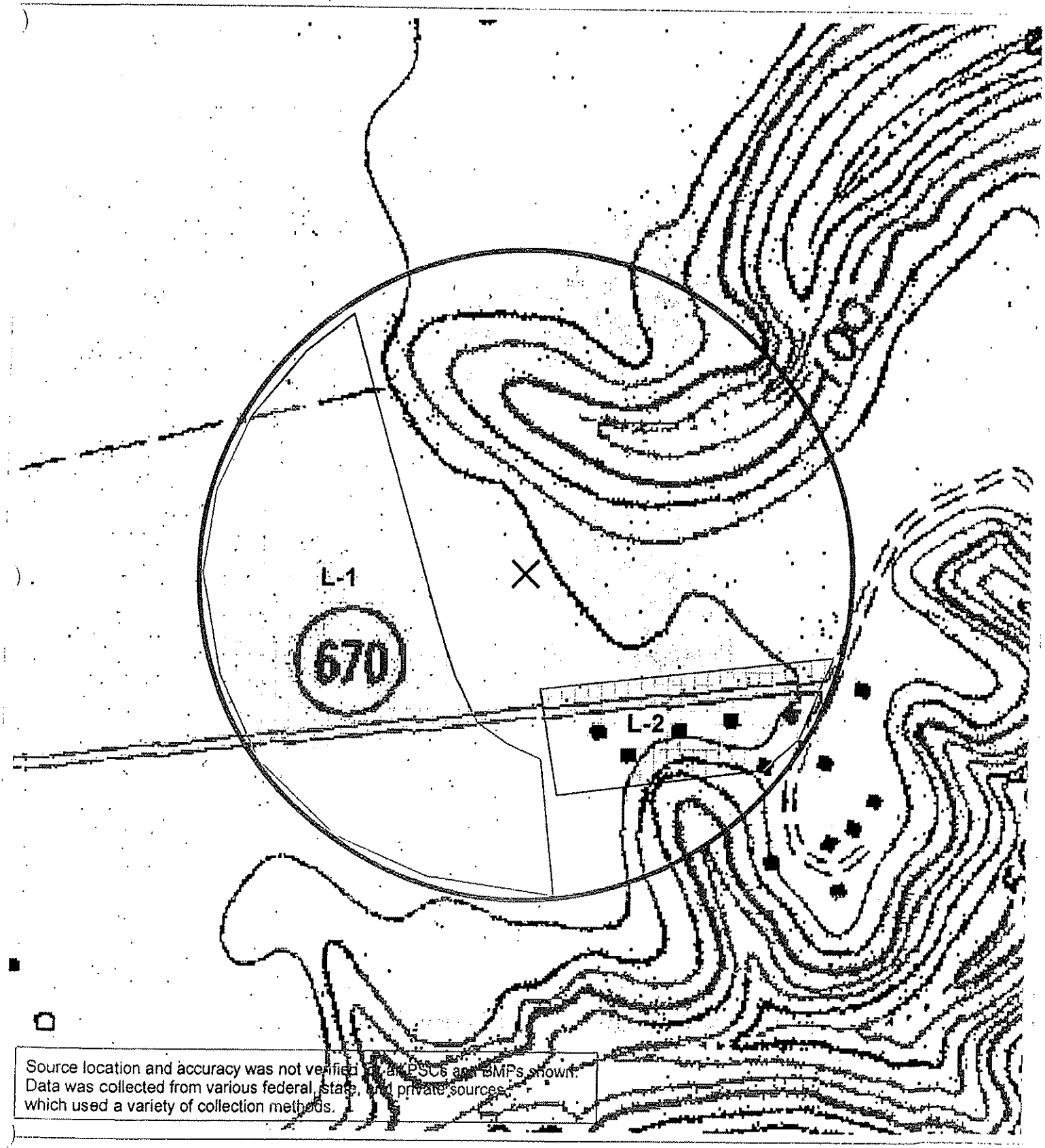
Landfills
Discharge – No Discharge Facilities
Discharge
No Discharge
DEQSWRO – Storage Tank Releases
Active
Closed

Airports
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Hospitals

PWSID: 4159900
FACILITY: WELL NO. 4
WATERWORKS: WARSAW, TOWN OF

SWAP Zone 1 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Source location and accuracy was not verified for all PSCs and BMPs shown. Data was collected from various federal, state, and private sources which used a variety of collection methods.

Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Division of Drinking Water

N
200 0 200 400 Feet

Print Date: March 2002

Potential Sources of Contamination (P-#)

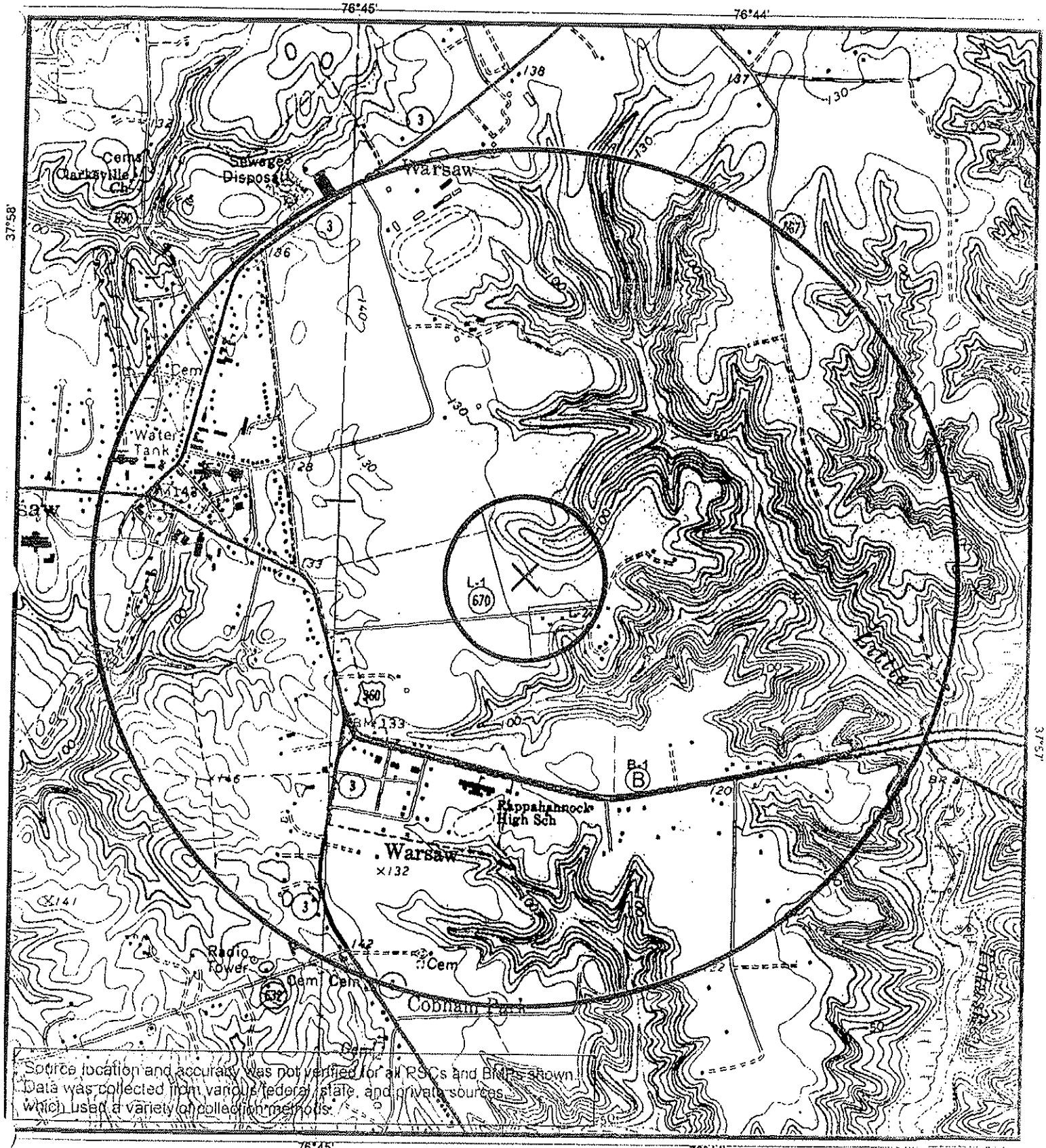
Landfills
Discharge -- No Discharge Facilities
Discharge
No Discharge
DEQSWRO -- Storage Tank Releases
Active
Closed

Airports
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Hospitals
TRI Sites

PWSID: 4159900
FACILITY: WELL NO. 4
WATERWORKS: WARSAW, TOWN OF

SWAP Zone 2 Map

DISTRICT 17
COUNTY/CITY: RICHMOND COUNTY



Ground Water Sources
Selected Water Source
LUA Polygons
PC Polygons
Land Use Activities (L-#)
Potential Conduits (C-#)
Best Management Practices (B-#)

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment
Division of Drinking Water

N
800 0 800 1600 Feet

Potential Sources of Contamination (P-#)

Landfills
Discharge – No Discharge Facilities
Discharge
No Discharge
DEQSWRO – Storage Tank Releases
Active
Closed

Airports
Industrial Sites
Superfund Sites
Golf Courses
Underground Injection Wells
Hazardous and RCRA Sites
Hotspots

APPENDIX E

Threatened and Endangered Species in the NN

Natural Heritage Resources by County

Your Search Criteria:
Lancaster, Northumberland, Richmond, Westmoreland County(ies)
Search run: 04-16-2007

See Map

On the map page, set page orientation to landscape to print map.
Click highlighted scientific names below to go to NatureServe report.

Search Menu

Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Last Year Observed
Lancaster						
BIRDS						
Falco peregrinus	Peregrine Falcon	G4	S1B,S2N		LT	1994
Haliaeetus leucocephalus	Bald Eagle	G5	S2S3B,S3N	LT,PDL	LT	2002
COLEOPTERA (BEETLES)						
Cicindela dorsalis dorsalis	Northeastern Beach Tiger Beetle	G4T2	S2	LT	LT	2006
COMMUNITIES						
Natural Community	Coastal Plain / Piedmont Acidic Seepage Swamp	GNR	SNR			2002
Natural Community	Coastal Plain/Piedmont Basic Seepage Swamp	GNR	SNR			2002
Natural Community	Maritime Dune Grassland	GNR	SNR			1995
Natural Community	Maritime Dune Woodland	GNR	SNR			1995
VASCULAR PLANTS						
Cyperus diandrus	Umbrella Flatsedge	G5	S1			1953
Cypripedium kentuckiense	Kentucky Lady's Slipper	G3	S1			2006
Matelea decipiens	Old-field Milkvine	G5	S1			1973
Polygonum glaucum	Sea-beach Knotweed	G3	S1S2			1951
Stewartia ovata	Mountain Camellia	G4	S2			1960
Tetragonotheca helianthoides	Pineland Squarehead	G5	S1			1940
Trillium pusillum var. virginianum	Virginia Least Trillium	G3T2	S2	SOC		2005

Northumberland

Natural Community	Tidal Freshwater Marsh	GNR	SNR			2001
CRUSTACEA (AMPHIPODS, ISOPODS & DECAPODS)						
Stygobromus sp. 21	Rappahannock Spring Amphipod	G1G2	S1S2	SOC		2000
VASCULAR PLANTS						
Aeschynomene virginica	Sensitive Joint-vetch	G2	S2	LT	LT	2001
Carex lacustris	Lake-bank Sedge	G5	S1			1969
Eriocaulon parkeri	Parker's Pipewort	G3	S2			2001
Eupatorium glaucescens	Wedge-leaf Thoroughwort	G5	S1			1912
Potamogeton spirillus	Spiral Pondweed	G5	S1			1979
Ranunculus hederaceus	Long-stalked Crowfoot	G5	SH			1984

Note: On-line queries provide basic information from DCR's databases at the time of the request. They are NOT to be substituted for a project review or for on-site surveys required for environmental assessments of specific project areas.

Need Additional Information? For more detailed information on locations of Natural Heritage Resources submit an information request.

Want to Contribute? If you have information on locations of natural heritage resources, please fill out and submit a rare species sighting form

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Return to the Online Information page

APPENDIX F

Virginia Landmark Register, Registered Historic Places in the NN

APPENDIX G

List of Current and Potential Conservation Easements in the NN

Lancaster County

8 Records Found with a Total Acreage of: **2,154.38 Acres**

SOURCE LINK	TOTAL ACRES	NAME	LAND TYPE	AGENCY
Belle Isle State Park	739.37	Belle Isle	State Park	VA Dept. of Conservation and Recreation
Hickory Hollow State Natural Area Preserve	254.02	Hickory Hollow	State Natural Area Preserve	Northern Neck Audubon Society
Chilton Woods State Forest	397	Chilton Woods	State Forest	VA Dept. of Forestry
VOF	24	LAN-VOF-882	VOF Easement	VOF
VOF	30	LAN-VOF-925	VOF Easement	VOF
VOF	304.94	LAN-VOF-1551	VOF Easement	VOF
VOF	222.79	VOF Easement	VOF Easement	VOF
VOF	182.26	VOF Easement	VOF Easement	VOF

Northumberland County

22 Records Found with a Total Acreage of: **1,592.56 Acres**

SOURCE LINK	TOTAL ACRES	NAME	LAND TYPE	AGENCY
Dameron Marsh State Natural Area Preserve	316	Dameron Marsh	State Natural Area Preserve	VA Dept. of Conservation and Recreation
Bush Mill Stream State Natural Area Preserve	102.7	Bush Mill Stream	State Natural Area Preserve	VA Dept. of Conservation and Recreation
Hughlett Point State Natural Area Preserve	204	Hughlett Point	State Natural Area Preserve	VA Dept. of Conservation and Recreation

Gardys Millpond Public Fishing Lake	0	Gardys Millpond	State Public Fishing Lake	VA Dept. of Game and Inland Fisheries
Northumberland Co, Property Next To Dameron Marsh	17.5	Northumberland Co, Property Next To Dameron Mar	Local Park	Northumberland County
VOF	2.9	NUM-VOF-931	VOF Easement	VOF
VOF	74.29	VOF Easement	VOF Easement	VOF
VOF	4.57	VOF Easement	VOF Easement	VOF
VOF	74	NUM-VOF-1325	VOF Easement	VOF
VOF	7	NUM-VOF-1426	VOF Easement	VOF
VOF	31.35	NUM-VOF-1427	VOF Easement	VOF
VOF	211	NUM-VOF-1928	VOF Easement	VOF
VOF	46.29	NUM-VOF-1542	VOF Easement	VOF
VOF	52.28	NUM-VOF-1541	VOF Easement	VOF
VOF	71	NUM-VOF-1916	VOF Easement	VOF
VOF	93	NUM-VOF-1963	VOF Easement	VOF
VOF	8.47	NUM-VOF-36	VOF Easement	VOF
VOF	3.2	NUM-VOF-598	VOF Easement	VOF
VOF	32.48	NUM-VOF-35	VOF Easement	VOF
VOF	26.36	VOF Easement	VOF Easement	VOF
VOF	182.26	VOF Easement	VOF Easement	VOF

VOF	31.91	VOF Easement	VOF Easement	VOF

Richmond County

16 Records Found with a Total Acreage of: **9,843.45 Acres**

SOURCE LINK	TOTAL ACRES	NAME	LAND TYPE	AGENCY
Rappahannock River Valley National Wildlife Refuge	6288.94	Rappahannock River	National Wildlife Refuge	U.S. Fish and Wildlife Service
CBF Easement 2	42	CBF Easement	Non-Profit Conservation Easement	Chesapeake Bay Foundation
VOF	234.76	RMD-VOF-406	VOF Easement	VOF
VOF	75.3	RMD-VOF-348	VOF Easement	VOF
VOF	75	RMD-VOF-349	VOF Easement	VOF
VOF	300	RMD-VOF-347	VOF Easement	VOF
VOF	15	RMD-VOF-101	VOF Easement	VOF
VOF	96.4	RMD-VOF-292	VOF Easement	VOF
VOF	372	RMD-VOF-59	VOF Easement	VOF
VOF	714.31	RMD-VOF-683	VOF Easement	VOF
VOF	516	RMD-VOF-684	VOF Easement	VOF
VOF	470.9	RMD-VOF-685	VOF Easement	VOF
VOF	83.08	RMD-VOF-967	VOF Easement	VOF
VOF	135.7	RMD-VOF-1991	VOF Easement	VOF
VOF	46.11	RMD-VOF-1616	VOF Easement	VOF
VOF	377.95	VOF Easement	VOF Easement	VOF

Westmoreland County

24 Records Found with a Total Acreage of: **9,835.19 Acres**

SOURCE LINK	TOTAL ACRES	NAME	LAND TYPE	AGENCY
Westmoreland State Park	1388	Westmoreland	State Park	VA Dept. of Conservation and Recreation
Stratford Hall	1461.21	Stratford Hall	Museum Estate	Robert E. Lee Mem. Association
George Washington Birthplace National Park	1012.73	George Washington Birthplace	National Park	National Park Service
Gardys Millpond Public Fishing Lake	0	Gardys Millpond	State Public Fishing Lake	VA Dept. of Game and Inland Fisheries
Chandlers Millpond Public Fishing Lake	0	Chandlers Millpond	State Public Fishing Lake	VA Dept. of Game and Inland Fisheries
Voorhees Preserve	728.84	Voorhees	TNC Preserve	The Nature Conservancy
VOF	412.36	WES-VOF-682	VOF Easement	VOF

APPENDIX H

Impaired (VDEQ 303(d) Report) Waters of the NN

Water Name	Category	Miles	Comment	Assessed Date	Location
Mattox Creek	5A	31.6	pH, Fecal Coliform, Dissolved Oxygen	2/7/2006	Mainstem and tributaries above the limit of tide.
Monroe Creek	5C	9.4	pH, Dissolved Oxygen	2/7/2006	Monroe Creek watershed above the tidal limit.
Pine Hill Creek Watershed	4C	11.5	pH, Dissolved Oxygen	2/7/2006	Pine Hill Creek and tributaries from rivermile 8.36 to its mouth at Rosier Creek. Segment altered in 2006 due to Natural Conditions Assessment reports.
Popes Creek	5C	14.7	pH, Dissolved Oxygen	2/6/2006	Watershed above tidal limit.
Thompson Branch	5C	1.6	pH, Dissolved Oxygen	2/7/2006	Headwaters to tidal limit.
Mill Creek	5A	3.9	pH, Fecal Coliform	2/7/2006	From its headwaters to Courtney Millpond.
Coan Mill Stream	5A	1.1	Fecal Coliform	2/8/2006	From the confluence with the unnamed trib at rivermile 1.53 to the Coan River.
Little Wicomico River	5C	2.3	pH	2/8/2006	Headwaters to tidal limit
Bush Mill Stream	5A	5.9	Fecal Coliform	3/3/2006	Bush Mill Stream upstream of the tributary at river mile 2.43.
Black Swamp	5C	4.2	pH	2/14/2006	Black Swamp from its headwaters downstream to Chandlers Millpond
Cat Point Creek	5A	5.0	pH, Fecal Coliform	2/14/2006	Cat Point Creek from Ruin Branch (river mile 14.1) downstream to Canal Swamp (river mile 10.54.)
Cat Point Creek	4C	1.1	pH	2/14/2006	Cat Point Creek from The Big Swamp to Ruin Branch.
Cat Point Creek tributaries	4C	50.1	pH	2/14/2006	Cat Point Creek tributaries, excluding Black Swamp and The Big Swamp
The Big Swamp	5C	6.6	pH, Dissolved Oxygen	2/14/2006	Headwaters to mouth at Cat Point Creek
Bookers Mill Stream	5A	6.2	Fecal Coliform	2/15/2006	Bookers Mill Stream in its entirety.
Totuskey Creek	5A	8.0	10107	2/15/2006	The nontidal portion of Totuskey Creek
UT to Western Branch Corrotoman River	5C	3.1	VAP-E26R-01	2/15/2006	Headwaters to mouth at Western Branch Corrotoman River

Water Name	Category	Square Miles	AU_COMMENT
			15000 (PCBs), 10061 (SAV), 01766 (DO) VAP-C01E-28, VAP-C01E-17, VAP-A34E-27 VDH-DSS Shellfish Condemnation Notice 017-188, 7/13/2004
Antipoison Creek	5A	0.45	7-ANT001.50 (A) Old stations: 7-ANT002.50 (SS) 7-ANT001.00 (TE) 7-ANT000.00 (SS) The Chesapeake Bay
Ball Creek	5A	0.09	{\rtf1\ansi\deff0\deftab720{\fonttbl{\f0\fswiss MS Sans Serif;}{\f11\roman\fcharset2 Symbol;}} {\colortbl\red0\green0\blue0;} \deflang1033\pard\plain\f0\fs17 15000 (PCBs), 10061 (SAV), 00948 (SF), 01766 (DO) \par \par VAP-C01E-17, VAP-A34E-27, VAP-C
Ball Creek	5A	0.14	15000 (PCBs), 10061 (SAV), 01766 (DO) VAP-C01E-17, VAP-A34E-27 Assessment info from VAP-C01E_BAL01A02 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 meal
Balls Creek	5A	0.18	15000 (PCBs), 10061 (SAV), 15014 (SF) VAP-C01E-17, VAP-A34E-27, VAP-C01E-02 Old: 7-BLS000.73 in BLS02A04 (deleted) 7-BLS000.73 (SS, PFCO, TE) 01775 (DO), 10051 (SAV)
Barnes Creek	5A	0.06	VAP-A31E-02 1ABAN000.16 (old SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle.
Barrett Creek	5A	0.10	15000 (PCBs), 10061 (SAV), 15003 (SF), 01766 (DO) VAP-C01E-17, VAP-A34E-27, VAP-C01E-04 VDH-DSS Condemnation Notice 013-089D, 4/16/2004. The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Adviso
Beach Creek	5A	0.11	01776 (DO), 10071 (SAV), 01067 (SF) 303(d) segment: VAP-E25E-14, VAP-E22E-01 VDH shellfish condemnation 116A, 12/27/2004 3-XDV000.77 (1995 SS)
Bells Creek	5A	0.06	01069 (SF), 01074 (DO) 303(d) segment: VAP-E26E-15, VAP-E26E-25 VDH shellfish condemnation 021-058B, 4/21/2004 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The mesohaline Corrotoman failed the open wate
Belwood Swamp	5A	0.01	01097 (FC), 01074 (DO), 01076 (SF) 303(d) segments: VAP-E26E-25, VAP-E26E-09, VAP-E26E-27 (see 2004 fact sheet VAP-E26R-01) 3-BLD000.58 (A) Portion of VDH shellfish condemnation 021-132A, 3/27/2002
Bells Mill Creek	5A	0.08	15000 (PCBs), 10061 (SAV), 00949 (SF), 01766 (DO) VAP-C01E-17, VAP-A34E-27, VAP-C01E-33 VDH-DSS Shellfish Condemnation Number 013-089I, 4/16/2004. The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumptio
Beaverdam Creek	5A	0.06	10051 (SAV), 01775 (DO), 00930 (SF) VAP-A34E-25, VAP-A31E-02 VDH Shellfish Condemnation 008-214F, 12/29/2003 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the
Bonum Creek	5A	0.21	01775 (DO), 10051 (SAV), 00019 (SF) VAP-A33E-03, VAP-A31E-02 VDH-DSS Condemnation Notice 159, 7/2/2002 1ABOM000.46 (A)
Branson Cove	5A	0.02	01775 (DO), 10051 (SAV), 00009 (SF) VAP-A32E-09, VAP-A31E-02 VDH-DSS Condemnation Notice 83C, 12/18/2002 1ABNC000.23 (old SS)
Bridge Creek	5A	0.11	10061 (SAV), 10063 (SF), 01766 (DO) VAP-A34E-17, VAP-A34E-27 (DO/SAV) VDH-DSS Condemnation Notice 010-105C, 9/15/2004 The segment was delisted in 2004 because the area was reopened for harvest, but was closed in the 9/15/2004 condemnation, so
Bridge Creek	5D	0.09	10061 (SAV), 01766 (DO), 10062 (SF) VAP-A34E-18, VAP-A34E-27 (DO/SAV) VDH-DSS Condemnation Notice 010-105D, 9/15/2004 The segment was delisted in 2004 because the area was reopened for harvest, but was closed in the 9/15/2004 condemnation, so

Water Name	Category	Square Miles	AU_Cause(s)
Acquasco Creek	5A	0.4687[illegible]0924	15000 (PCBs) 10051 (SAV) 01766 (DO) VAP-C01E -28, VAP-C01E -17, VAP-A34E -21 VDH-DSS Shellfish Conservation Notice 013-169, 7/13/2004 7-ANT001.90 (A) OM stations 7-ANT002.90 (SS) 7-ANT001.00 (TC) 7-ANT000.00 (SS)
Bell Creek	5A	0.0[illegible]1551	The Chesapeake Bay [illegible] MS Sum Sal [illegible] Symbol]) [illegible] [illegible] 15000 (PCBs) 10051 (SAV) 00016 (SF) 01766 (DO) New New VAP-C01E -17, VAP-A34E -21, VAP-C
Bird Creek	5A	0.1[illegible]9336	15000 (PCBs) 10051 (SAV) 01766 (DO) VAP-C01E -17, VAP-A34E -27 Assessment info from VAP-C01E _BAL01A03 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 meal
Back Creek	5A	0.2[illegible]2867	15000 (PCBs) 10051 (SAV) 15014 (SF) VAP-C01E -17, VAP-A34E -27, VAP-C01E -02 OSI 7-BIL000.73 in BL 507464 (aquatics) 7-BIL000.73 (SS, PH CG, HL) VDH-DSS Conservation Notice 013-151, 4/16/2004 This area is revisited during the 2006 cycle. Alternate
Herring Creek	5A	0.0[illegible]0073	01775 (DO) 10051 (SAV) VAP-A34E -02 1ABHA000.10 (old 5B) The monitoring portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle
Burnt Creek	5A	0.0[illegible]3195	15000 (PCBs) 10051 (SAV) 15003 (SF) 01766 (DO) VAP-C01E -17, VAP-A34E -27, VAP-C01E -02 VDH-DSS Conservation Notice 013-150, 4/16/2004 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advis
Broad Creek	5A	0.1[illegible]0024	01776 (DO) 10051 (SAV) 01007 (SF) 303(d) segment VAP-E20E -16, VAP-E20E -01 VDH shellfish conservation 016A 12/27/2004 3-XDV000.77 (1505 SS) The monitoring portion of the Potomac failed the open water summer dissolved oxygen criteria a
Back Creek	5A	0.0[illegible]7185	01069 (SF) 01074 (DO) 303(d) segment VAP-E20E -15, VAP-E20E -01 VDH shellfish conservation 021-0501, 6/21/2004 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The monitoring Consortium failed the open wate
Elizabeth Swamp	5A	0.0[illegible]7795	01007 (FC) 01074 (DO) 01079 (SF) 303(d) segments VAP-E20E -25, VAP-E20E -03, VAP-E20E -21 (see 2004 list) short VAP-E20E-01 3-EIL000.58 (A) Portion of VDH shellfish condemnation 021-152A, 3/27/2002 The segment was initially assessed in 1998 a
Burle Mill Creek	5A	0.0[illegible]1283	15000 (PCBs) 10051 (SAV) 00940 (SF) 01766 (DO) VAP-C01E -17, VAP-A34E -27, VAP-C01E -03 VDH-DSS Shellfish Conservation Notice 013-155, 4/16/2004 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption
Deep Creek	5A	0.0[illegible]552	10051 (SAV) 01775 (DO) 00030 (SF) VAP-A34E -21, VAP-A34E -02 VDH Shellfish Condemnation 028-21EF, 12/20/2003 The monitoring portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standard during the
Broad Creek	5A	0.2[illegible]0003	01775 (DO) 10051 (SAV) 00019 (SF) VAP-A34E -03, VAP-A34E -02 VDH-DSS Conservation Notice 152, 7/22/2003 1ABDA000.46 (A) The monitoring portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards d
Branson Cove	5A	0.0[illegible]538	01775 (DO) 10051 (SAV) 00009 (SF) VAP-A34E -03, VAP-A34E -02 VDH-DSS Conservation Notice 830, 12/18/2002 1ABNC000.23 (old 5A) The monitoring portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage st
Bridge Creek	5A	0.1[illegible]045	10051 (SAV) 10003 (SF) 01766 (DO) VAP-A34E -17, VAP-A34E -27 (DO&SAV) VDH-DSS Conservation Notice 010-1002, 8/11/2001 The segment was delisted in 2004 because the area was reopened for harvest, but was closed in the 5/15/2004 condemnation ad
Bridge Creek	5D	0.0[illegible]730	10051 (SAV) 01766 (DO) 10002 (SF) VAP-A34E -18, VAP-A34E -27 (DO-SAV) VDH-DSS Conservation Notice 010-1002, 8/11/2001 The segment was delisted in 2004 because the area was reopened for harvest, but was closed in the 5/15/2004 condemnation ad
Bridgeman Creek	5A	0.0[illegible]266	10051 (SAV) 01775 (DO) 00031 (SF) VAP-A34E -10, VAP-A34E -02 VDH-DSS Conservation Notice 002-147A, 12/22/2001 The monitoring portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during th
Bridge Creek	5A	0.1[illegible]721	00665 (FC) 01775 (PO4 and DO) 10051 (PO4 and SAV) VAP-A34E -11 (FC) VAP-A34E -02 (DO & SAV) 0165665 (old 5D SS) No new monitoring in 2006 cycle, as previous impairment of pollutants is carried over 2006 PO4 and SAV TMDL DW 300 TMDL

Water Name	Category	Square Miles	AU_COMMENT
Hunting Creek	5A	0.003540697	01775 (DO) 10051 (SAV) 00910 (SF) VAP-A31E-05, VAP-A31E-02 VDH Condemnation 0520, 12/1/04 Assessment info from VAP-A31E_B(B)02A03 The mesohaline portion of the Potomac fails the open water summer dissolved oxygen criteria and the SAV acreage
Dutchmen Creek	5A	0.201231409	01775 (DO) 10051 (SAV) VAP-A31E-02 1A(B)A001.02 (Cycle 2000 Listing) - VDH, screening level 2A The mesohaline portion of the Potomac fails the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Gilbert Run Creek	5A	0.195287429	01775 (DO) 10051 (SAV) VAP-A31E-02 Non-production per VDH Condemnation Notice 165. 4/27/1982 no longer required (as noted in previous VDH Listings) The mesohaline portion of the Potomac fails the open water summer dissolved oxygen criteria and th
Carter Cove	5A	0.015584617	01976 (SF) 10071 (SAV) 01776 (DO) 303(d) segment VAP-E20C-09, VAP-L22E-01 VDH shellfish condemnation 020 0410C, 12/17/2004 Assessment info from C1R01A00, C1R03A00 Was threatened in 1998 b/c it was part of the seasonal condemnation. Was downg
Carter Creek	5A	0.201743107	10071 (SAV) 01776 (DO) 303(d) segment VAP-L22E-01 VDH Condemnation 0410, 12/17/2004 (was delisted because the area is prohibited because of outfalls) 3-C1R001.09 (A) Assessment info from 3-C1R000.10 at mouth of Carter Creek in C1R03A00 The C
Carter Creek	5A	0.055133547	01977 (SF) 10071 (SAV) 01776 (DO) 303(d) segment VAP-E20C-09, VAP-L22E-01 VDH condemnation 0410, 12/17/2004 Assessment info from C1R01A00 and 3-C1R000.10 at mouth The C1 standards were exceeded during the 2000 cycle. Was delisted
Carter Creek, Lagoon Branch, Carter Creek	5A	0.074002354	10071 (SAV) 01776 (DO) 303(d) segment VAP-L22E-01 VDH shellfish condemnation 020 0410B, 12/17/2004 is seasonally conditional. Reason: the segment is fully supporting with conditions (DO) 3-C1R000.10 (C) Assessment info from VAP-L22E_C1R01A
Gut Point Creek	5A	1.270957356	10071 (SAV) 01776 (DO) VAP-L22E-01 3-CAT000.56 3-CAT000.73 (C2) - scenario 5 - unexplained effects for instream calculation probably not due to chemical contamination) 3CAT-C24 ALL (E-coli) 3CAT-C25 ALL (E-coli) Shellfish: the removed site prohi
CHESAPEAKE BAY - Northern portion of CB7 Segment CB7PH	5A	127.1595816	The assessment uses a combination of the Chesapeake Bay Program segment CB7PH, located in the mainstem of the Virginia Inlet Bay between James and Rappahannock Rivers. Water Quality standards class II (Total Waters in the Chesapeake Bay) a
CHESAPEAKE BAY - VA portion of CB7 Segment CB7MH	5A	187.6002780	The assessment uses the Virginia portion of Chesapeake Bay Program segment CB7MH, located in the mainstem of the Virginia Inlet Bay from the mouth of the Rappahannock River and northward. Water Quality standards class II (Total Waters in th
Chesapeake Bay, VA	5A	0.016757316	15000 (PCBs) 10051 (SAV) 00975 (SF) 01766 (DO) VAP-C04E-17, VAP-A31E-01, VAP-C04E-01 VDH 165 condemnation notice 011-190, 2/18/2004 The Chesapeake Bay and its total tributaries are included under the 12/15/2004 VDH Fish Consumption Advisory
Chickahominy Creek	5A	0.021150512	15000 (PCBs) 10051 (SAV) 00950 (SF) 01766 (DO) VAP-C04E-17, VAP-A31E-01, VAP-C04E-10 VDH 165 Shellfish Condemnation Notice 014-174A, 8/15/01 The Chesapeake Bay and its total tributaries are included under the 12/15/2004 VDH Fish Consumption A
Chickahominy Creek	5A	0.004101161	15000 (PCBs) 10051 (SAV) 01766 (DO) VAP-C04E-17, VAP-A31E-01 The Chesapeake Bay and its total tributaries are included under the 12/15/2004 VDH Fish Consumption Advisory for PCBs. No more than 2 meals/month are recommended of shad or eels (cook)
Coan River	5A	0.055742003	10051 (SAV) 01775 (DO) 10068 (PCBs) VAP-A31E-02, VAP-A31E-15, VAP-A31E-09 VDH Fish Consumption Advisory (12/15/2004) for PCBs in gizzard shad, white perch, and channel catfish Assessment info from VAP-A31E_COA02A02 Top Coan River shad
Coan River	5A	0.055195704	10051 (SAV) 01775 (DO) 10057 (PCBs) 00909 (SF) VAP-A31E-05, VAP-A31E-02, VAP-A31E-15 1ACOA-COANE-A01 (brown) 1ACOA004.24 (SS) Heavy Cove, Mill Creek and a portion of the Coan River were assessed as a portion of the Shellfish Use in 1998 b
Coan River	5A	2.719772477	10051 (SAV) 01775 (DO) 10057 (PCBs) VAP-A31E-02, VAP-A31E-15 VDH Fish Consumption Advisory (12/15/2004) for PCBs in gizzard shad, white perch, and channel catfish 1ACOA003.44 (A) 1ACOA002.08 (SS) 1ACOA002.41 (SS) 1ACOA-COANE2-A01 (brown)
Coan River	5A	0.078439206	10051 (SAV) 01775 (DO) 10057 (PCBs) 00909 (SF) VAP-A31E-05, VAP-A31E-02, VAP-A31E-15 Assessment info from 1ACOA-COANE-A01 (brown) and 1ACOA004.24 (SS) - VAP-A31E_COA03A03 Heavy Cove, Mill Creek and a portion of the Coan River were assess
Coan River, VA	5A	0.014276541	10051 (SAV) 01775 (DO) 00975 (SF) VAP-A31E-04, VAP-A31E-02 VDH 1998 Condemnation notice # 2140, 12/05/2003 VAP_2000-02 (1998 SS) The mesohaline portion of the Potomac fails the open water summer dissolved oxygen criteria and the SAV acreage

Water Name	Category	Square Miles	AU_COMMENT
Cockrell Creek	5A	0.611434687	15000 (PCBs) 10001 (SAV) 00951 (SF) 10700 (DO) VAP-C01E-17 VAP-A34E-27, VAP-C01E-08 7-COC001 61 (A, PF, 1) VDH-OSS Shellfish Condemnation Notice 612-0091, 11/15/2001 Assessment information from COC02A08 was merged into the segment in 2006
Cockrell Creek	5A	0.035737402	VDH-OSS Shellfish Condemnation Notice, 612-0070, 11/15/2001 Prohibited area covers 51F outfall Assessment information from COC01A08, COC02A08 15000 (PCBs) 10001 (SAV) 01766 (DO) VAP-C01E-17, VAP-A34E-27 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH-OSS Consumption Advisories for PCBs
Cockrell Creek	5A	0.429730654	15000 (PCBs) 10001 (SAV) 00951 (SF) 01700 (DO) VAP-C01E-17, VAP-A34E-27 VAP-C01E-08 7-COC000 40 (F,S) 7-COC000 53 (C2) 7-COC000 73 (1005 SS, 06) VDH-OSS Shellfish Condemnation Notice 612-0070A 11/15/2001 Area delisted in 2006 cycle A160
Cockrell Creek	5A	0.185264701	15000 (PCBs) 10001 (SAV) 01700 (DO) VAP-C01E-17, VAP-A34E-27 7-COC000 06 (C2) Assessment information from VAP-C01, COC01A08 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH-OSS Consumption Advisories for PCBs
Coal Creek	5A	0.034059375	10001 (SAV) 01775 (DO) 00177 (SF) VAP-A34E-08 VAP-A31E-02 VDH-OSS Condemnation Notice 141B 12/22/2001 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 20 00177 (SF) 10001 (SAV) 01775 (DO) VAP-A34E-02 1ACO0000 42 (A) VDH-OSS Condemnation Notice 609-141A 12/22/2001 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during
Coal Creek, Tributary Wicomico	EU	0.070031407	10001 (SAV) 00177 (SF) 01700 (DO) VAP-A34E-27 (DO/SAV) VAP-A34E-15 Coal Creek was delisted as impaired during the 1998 cycle because of VDH-OSS Shellfish Condemnation 105N 6/16/1997 In the 2004 cycle the segment was delisted by 0.5 sq. mi
Coal Harbor Bay	5A	0.029927691	01775 (DO) 10001 (SAV) 00951 (SF) VAP-A32E-01 VAP-A32E-02 Delisted in VDH-OSS Shellfish Condemnation 184A, 6/23/03 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards
Coal Harbor Creek	5A	0.042625555	01775 (DO) 10001 (SAV) Delisted in condemnation 004-184M1, 6/23/2003 Seasonally condemned, as fully supporting with reduced effects VAP-A31E-02 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria
Cottonwood River	5A	4.243053559	01074 (DO) VAP-C02E-01 3-CRR000 38 (A, 1) 3-CRR001 38 (C1) 3-CRR001 08 (C2) WQS Category 2, Category 2A 3-CRR000 58 (C2) WQS Category 5A - cause of habitat alterations suspected to be water quality TMDL complete CRS/WQ is modified
Crane Creek	5A	0.000171015	15000 (PCBs) 10001 (SAV) 01700 (DO) VAP-C01E-17 VAP-A34E-27 VDH-OSS Shellfish Condemnation Notice 613-0030A, 4/16/2003 (seasonal) The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH-OSS Consumption Advisories
Crane Creek	5A	0.014301404	15000 (PCBs) 10001 (SAV) 01766 (DO) VAP-C01E-17, VAP-A31E-27 VDH-OSS Shellfish Condemnation Notice 613-0030A4, 4/16/2003 (seasonal) The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH-OSS Consumption Advisories
Cubit Creek	5A	0.320931455	00951 (SF) 00935 (FC) 10001 (SAV) 01775 (DO) VAP-A34E-15 VAP-A31E-02 1ACU0000 58 (A) VDH-OSS Condemnation Notice 165, 4/27/1999 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acre
Curtis Bay	5A	0.792513361	01775 (DO) 10001 (SAV) VAP-A31E-02 1ACU0000 73 (Cove W 2000) - WQS - a Cat. NI scenario 5 - Sediments contained dredged effects 1ACU0000 10 (WB 6G) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen crite

Water Name	Category	Square Miles	AU_COMMENT
Cameron Creek	5A	0.051403655	01775 (DO) 10051 (SAV) 00612 (PC) VAP-A37E-02 VAP-A31E-02 VDH-DSS Shellfish Condemnation 184 6/18/2002 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the
Dawkins Creek	5A	0.070532504	15000 (PCBs) 10061 (SAV) 00954 (SF) 01766 (DO) VAP-C01E-17, VAP-C01E-34 VAP-A34E-27 VDH Shellfish Condemnation 1603, 7/13/2001 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for
Dave Creek	5A	0.016304041	01074 (DO) 01079 (SF) 303(d) segment VAP-E20E-05 VAP-E20E-06 VDH-DSS Shellfish Condemnation 091 1300, 3/22/2002 The new Chesapeake Bay water quality standards were implemented during the 2000 cycle. The mesohaline Coliform failed the open
Deep Creek	5A	0.219501208	10071 (SAV) 01776 (DO) 01055 (SF) 303(d) segment VAP-E25E-03 VAP-A22E-01 VDH condemnation 023-1718, 9/23/2004 The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standards du
Dividing Creek	5A	0.215151242	15000 (PCBs) 10061 (SAV) 00955 (SF) 01766 (DO) VAP-C01E-17, VAP-A34E-27, VAP-C01E-15 7-XOR0000 08 (A) 7-DIV0002 39 (old TL-CH_b) 7-DIV0001 75 (old TL) 7-NE0000 14 (old TL) VDH-DSS Shellfish Condemnation 82 (ce 011-22A 4/25/2003) The Lag
Dividing Creek	5A	0.976570223	15000 (PCBs) 10061 (SAV) 01766 (DO) VAP-C01E-17, VAP-A34E-27 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 mile segments are recommended for condemnation [xxxx]
Drum Cove	5A	0.037357803	10051 (SAV) 01775 (DO) 10054 (SF) VAP-A31E-02 VAP-A32E-06 VDH-DSS Shellfish Condemnation 007-0280, 7/21/2004 1MA1A001 00 (1995 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acr
Dundee Cove	5A	0.00411661	01775 (DO) 10054 (SAV) 00950 (SF) VAP-A32E-11, VAP-A32E-42 VDH-DSS Shellfish Condemnation 007-0280, 7/21/2004 Assessment info from VAP-A32E, 03/02/2000 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria
Dundee Cove	5A	0.041209781	10051 (SAV) 01775 (DO) VAP-A31E-02 1MA1A000 15 (1995 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Dyson Creek	5A	0.243938116	15000 (PCBs) 10061 (SAV) 00955 (SF) 01766 (DO) VAP-C01E-17 VAP-A34E-27 VAP-C01E-24 7-DYM0001 79 (A) VDH-DSS Shellfish Condemnation Notice 010-02A, 1/5/2004 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 V
Dyson Creek	5A	0.755477705	15000 (PCBs) 10061 (SAV) 01766 (DO) VAP-C01E-17, VAP-A34E-27 7-DYM0000 62 (old TL) 7-DYM0001 34 (old TL) Assessment information from VAP-C01E, DYM01A05 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Ad
Dyson Creek	5A	0.075415149	15000 (PCBs) 10061 (SAV) 01766 (DO) VAP-C01E-17 VAP-A34E-27 7-DYM0000 60 (C) Assessment information from VAP-C01E, DYM01A05 7-DYM0000 67 (old TL) 7-DYM0001 24 (old TL) The Chesapeake Bay and its tidal tributaries are included under the 12/1
Eastern Branch Carter Creek	5A	0.258181207	10071 (SAV) 01776 (DO) 01077 (PC) 01073 (SF) 303(d) segment VAP-E26E-15 VAP-E22E-01 VDH shellfish condemnation 020-611A 12/13/2004 3-CE 0001 02 (A) Assessment info from VAP-E22E_CE1103A00 The CB algorithms were implemented during the 2000
Eastern Branch Corrotoman River	5A	0.075143218	01073 (SF) 01074 (DO) 303(d) segment VAP-E26E-16 VAP-E20E-05 VDH shellfish condemnation 091-654A 4/21/2004 3CEA0135-A11 (old origin station) Chesapeake Bay random bottom study CB0000 is incorrect
Eastern Branch Corrotoman River			The new Chesapeake Bay water quality standards were implemented during the 2000 cycle.
Elfgren Creek	5A	0.010553778	10001 (SAV) 10065 (SF) 01766 (DO) VAP-A35E-23 (DO-SAV) VAP-A35E-20 VDH-DSS condemnation 010-456A 8/15/2004 Assessment info from VAP-A35E_LIS02A00 and LIS02A05 During the 2000 cycle, the revised Chesapeake Bay water quality standards we
Evans Point	5A	0.010503753	01079 (SF) 01074 (DO) 303(d) segment VAP-E20E-05 VAP-E20E-25 VDH shellfish condemnation 1870, 5/27/2002 The new Chesapeake Bay water quality standards were implemented during the 2000 cycle. The mesohaline Coliform failed the open water sta

Water Name	Category	Square Miles	ALL COMMENTS
Fairlawn Creek	5A	0.42055750	10071 (SAV); 01770 (DO); 01007 (Chl); 01057 (SF); 01956 (FC) DO(dissolved): VAP-A32E-01, VAP-A32E-01 VDH condemnation 074-010, 10/17/2000 3 FAA002 (2 (A) The mesohaline portion of the Elizabeth failed the open water summer dissolved oxygen
Fisher Bay	5A	5.207190217	15002 (PCBs); 10001 (SAV); 01766 (DO) VAP-C01E-17, VAP-A32E-27, (2002 VAP-C01E-18) The Chesapeake Bay and its total tributaries are included under the 12/13/2004 VDH Fish Consumption Advisory for PCBs. No information is available at this time.
Fountain Cove	5A	0.030347279	10061 (SAV); 01775 (DO); 10050 (SF) VAP-A31E-02; VAP-A31E-06 VDH DSS consumption 099-1421, 12/22/2004 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 c
Gardner Creek	5A	0.103431708	01775 (DO); 10061 (SAV); 00021 (SF) VAP-A32E-01; VAP-A31E-02 VDH DSS Condemnation Number 163, 7/2002 Assessment info from VAP-A32E_GA0002A50 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV
Gaines Creek	5A	0.027403519	01775 (DO); 10061 (SAV) VAP-A31E-02 1AGA0000 (1 (A) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Georgian Cove	5A	0.03356395	15000 (PCBs); 10061 (SAV); 00050 (SF); 01766 (DO) VAP-C01E-17; VAP-A34E-27; VAP-C01E-25 Assessment information 1XVA01608 VDH DSS Shellfish Condemnation Notice 016-740C, 1/6/2004 The Chesapeake Bay and its total tributaries are included under t
Great and Little Creeks	5A	0.235356608	01775 (DO); 10061 (SAV) VAP-A31E-02 1AGL0000 (3 (Dissolved)) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Gresham Creek	5A	0.03361869	01775 (DO); 10061 (SAV); 10052 (SF) VAP-A31E-02; VAP-A31E-02 VDH DSS Shellfish Condemnation 0588, 6/23/04 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria during the 2000 cycle The mesohaline
Gwynn Creek	5A	0.035453702	15000 (PCBs); 10061 (SAV); 01766 (DO); 15004 (SF) VAP-C01E-17, VAP-A34E-27, VAP-C01E-02 VDH DSS Shellfish Condemnation Number 013-0616, 4/16/2004 The Chesapeake Bay and its total tributaries are included under the 12/13/2004 VDH Fish Consump

Water Name	Category	Square Miles	ALL COMMENT
Great Wicomico River	5A	0.542665281	15000 (PCBs) 10061 (SAV) 00920 (ST) 01720 (DO) VAP-C01E-17, VAP-A34E-27, VAP-C01E-01 7-GWR005.80 (A FF) 7GWR-G01-A01 7-GWR006.00 (old FS) VDH-DSS Condemnation Number 013-003A 4/16/2004 The Chesapeake Bay and its total tributaries are included
Great Wicomico River	5A	2.017631683	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27 7-GWR004.65 (A) 7-GWR007.91 (C) The Chesapeake Bay and its total tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 meals/month
Great Wicomico River	5A	0.016031636	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27 VDH-DSS Shellfish Condemnation No. 013-003A1 (revised) dated 4/16/2004 Assessment information from VAP-C01E, GWR002A0 The Chesapeake Bay and its total tributaries are included on
Great Wicomico River	5A	5.709108302	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27 7-NNN001.03 (C2) 7-NNN001.15 (C2) The Chesapeake Bay and its total tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 meals/month
Great Wicomico River at Cedar Creek	5A	0.007782943	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27 VDH-DSS Shellfish Condemnation No. 013-003A2 (revised) dated 4/16/2004 Assessment information from VAP-C01E, GWR002A0 The Chesapeake Bay and its total tributaries are included on
Greenwich Creek	5A	0.084264274	10071 (SAV) 01770 (DO) 01058 (ST) VAP-A22E-01, VAP-A24E-15 VDH-DSS condemnation 054A, 2/5/2003 7-GEF 000.77 (C2) - WQE locations 2, C1 2A The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and f
Greenwich Creek	5A	0.011420972	10071 (SAV) 01770 (DO) NONE segment VAP-A22E-01 VDH-DSS condemnation 054B 2/5/2003 Seasonally condemned, the other fully supporting with observed effects The mesohaline portion of the Rappahannock failed the open water summer dissolved ox
HOG Creek	5A	0.01070203	10051 (SAV) 01775 (DO) VAP-A31E-02 1-MUC 000.56 (A) VDH-DSS condemnation 101, 6/27/1989 Designated as non-productive shellfish growing area by VDH-DSS (previous condemnation) to be removed The mesohaline portion of the Potomac failed th
Hungerford Branch, Jenkins Branch	5A	0.434637609	01775 (DO) 10051 (SAV) 00922 (ST) VAP-A31E-02, VAP-A32E-01 & 2004 has listed VAP-A32E-08 (00924) 1-MUM000.50 (SS 1 samples) VDH-DSS Shellfish Condemnation Number 28C, 7/11/2002 During the 2004 cycle, the Hungerford Branch condemnation was
Hoskins Cove	5A	0.009771181	10051 (SAV) 01775 (DO) 00922 (ST) VAP-A34E-05, VAP-A31E-02 Hoskins Cove, like Creek, was a portion of the Deep Rivers were discussed or inspected at the Shellfish Use in 1993 because of VDH ST C 145(a and b) 2/27/1997. During the 2004 cycle, the
Hungar Creek	5A	0.02833474	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27 7-NNT 000.42 (old TE) The Chesapeake Bay and its total tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 meals/month are recommen
Hicks Creek	5A	0.003508701	01051 (ST) 01007 (DO) 0000(a) segment VAP-C02E-14, VAP-E20E-05 VDH shellfish condemnation 021-050A, 4/21/2004 The new Chesapeake Bay water quality standards were implemented during the 2000 cycle. The mesohaline Coliform failed the open wat
Herring Gutter	5A	0.008676907	15000 (PCBs), 10061 (SAV) 00960(ST) 01760 (DO) VAP-C01E-17, VAP-A34E-27, VAP-C01E-01 VDH-DSS Shellfish Condemnation Notice 013-005A1 4/16/2003 Area expanded in the 2000 cycle The Chesapeake Bay and its total tributaries are included under t
Hull Creek	5A	0.345616546	10051 (SAV) 01775 (DO) 00939 (ST) VAP-A32E-12, VAP-A31E-02 VDH-DSS Condemnation Notice 007-142C 12/22/2004 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2
Hunts Cove	5A	0.005601273	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27 Assessment information 07/A07A5A VDH-DSS Shellfish Condemnation Notice 24C, 5/27/1996 (the area is depicted). The 7/11/2000 condemnation shows the area open for harvest. The segment
Indian Creek	5A	0.015407555	Area around STP outfall. Shellfish Use removed due to a prohibition issued by VDH-DSS VDH-DSS Shellfish Condemnation Notice 57B, 11/09/2000 01760 (DO) VAP-A34E-27 Assessment information VAP-C01E, IND001A5A During the 2000 cycle, the IBV160
Indian Creek	5A	0.016667757	15000 (PCBs) 10061 (SAV) 01760 (DO) VAP-C01E-17, VAP-A34E-27, 2004 VAP-C01E-09 The Chesapeake Bay and its total tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 meals/month are recommended

Water Name	Category	Begin Miles	AU_COMMENT
Indian Creek	5A	0.014200970	15000 (PCBs) 10051 (SAV) 01765 (DO) VAP-C01E-17, VAP-A34E-27, (2001 VAP-C01E-29) VDH-DSS (Beaverdam) Shellfish Contamination No. 016-M174, 4/13/1995 Assessment information in VAP-C01E_IR0304A00 Based on the VDH SFC, this segment was assessed a
Indian Creek, Unnam Conv	5A	0.012212378	15000 (PCBs) 10051 (SAV), 00601 (SF) 15000 (Fecal coliform) 01765 (DO) VAP-C01E-17 VAP-A34E-27, VAP-C01E-27 VAP-C01E-29 7-IND002.98 (A, 3) 7-IND001.69 (C) 7-IND000.01 (1E 1F) - 02 7-IND1000.50 (1A 1E 1F)(DN_4) VDH-DSS Shellfish Contamination
Jackson Creek	5A	0.141459246	01775 (DO) 10051 (SAV) 00923 (SF) VAP-A34E-02 VAP-A34E-02 1A0104A00-00 (A) VDH-DSS Contamination Notice 144, 7/2/2007 The mainstem portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standard.
Jones Creek	5A	0.0038 2007	15000 (PCBs) 10051 (SAV) 00903 (SF) 01765 (DO) VAP-C01E-17 VAP-A34E-27 VAP-C01E-29 VDH-DSS contamination 015-027P, 4/13/2003 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for
Johnson Creek	5A	0.012000573	15000 (PCBs) 10051 (SAV) 15001 (SF) 01765 (DO) VAP-C01E-17 VAP-C01E-29, VAP-A34E-27 Assessment information from VAP-C01E_IR0101A00 VDH-DSS Shellfish Contamination Notice 010-240 10/5/2004 The Chesapeake Bay and its tidal tributaries.
Kettrick Creek	5D	0.018027004	10051 (SAV) 01775 (DO) 00173 (SF) VAP-A34E-02 VAP-A34E-02 VDH-DSS contamination 6-214B, 12/20/2002 The mainstem portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standard during the 2000 cycle
Kettrick Creek	5A	0.014200551	10051 (SAV) 01775 (DO) 10058 (SF) VAP-A34E-02 VAP-A34E-02 VDH Shellfish Contamination 6-214A 12/20/2002 The mainstem portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standard during the 2000
Kingsville Creek	5A	0.000340552	10051 (SAV) 01775 (DO) VAP-A34E-02 Assessment info from VAP-A34E_XIN01A00 VDH-DSS contamination 6-213W/V 12/20/2002 Reasonably conservative: the data considered fully supporting with observed effects 1A0104A00-38 (1005 SS) The mainstem po

Water Name	Category	Square Miles	AU_COMMENT
Kingsville Creek	5A	0.009294047	10051 (SAV), 01775 (DO), 10069 (SF) VAP-A31E-09, VAP-A31E-21 VDH DSS condemnation 035-213A 12/29/2003 Assessment info from VAP-A31E_KIN01600 1AKIN000 38 (1995 SS) The middle/lower portion of the Potomac failed the open water summer dissolved oxygen criteria
Kingsville Creek	5A	0.292667445	10051 (SAV), 01775 (DO) VAP-A31E-09 1AKIN-CCANS-ALL (CCANS) 1AKIN000 38 (1995 SS) The middle/lower portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle
Kingsville Creek	5A	0.007205745	10051 (SAV), 01775 (DO) VAP-A31E-09 Assessment info from VAP-A31E_KIN01600 VDH DSS condemnation 8-213M1 12/29/2003 Seasonally condemned, therefore considered fully supporting with observed effects 1AKIN000 38 (1995 SS) The middle/lower po
Lewisetta Creek	5A	0.022032593	10071 (SAV), 01770 (DO), 01055 (SF), 01060 (FC), 01033 (Cl) 303(d) segment VAP-E25E-11, VAP-E25E-16, VAP-E25E-01 VDH shellfish condemnation 026-120B, 02/3/2004 reduced in 2006 3-LAN001.03 (A) 3-LAN007.01 (A) 3-LIN is an outlet of 3-LAN001
Lewisetta Creek	5A	1.075673161	10071 (SAV), 01770 (DO), 01033 (chloride) VAP-E25E-16, VAP-E25E-01 Assessment information from LAN01A58 3-LIN is an outlet of station 004110 3-LAN000.03 (Ind) The middle/lower portion of the Rappahannock failed the open water summer dissolved o
Lewisetta Creek	5A	0.003010669	10071 (SAV), 01770 (DO), 01033 (chloride) VAP-E25E-16, VAP-E25E-01 Assessment information from LAN00A67 VDH SFC condemnation 003-120M1, 5/23/2004 Seasonally condemned, therefore fully supporting with observed effects The middle/lower portion o
Lowland Cove	5A	0.087165909	15000 (PCBs), 10051 (SAV), 00058 (SF), 01760 (DO) VAP-C01E-17, VAP-A31E-21, VAP-C01E-15 VDH DSS Shellfish Condemnation Notice 045-92B, 6/25/2003 The segment was separated from DEV01A55 in 2003 due to a reduction in the size of the shellfish
Lost Cove	5A	0.01642003	15000 (PCBs), 10051 (SAV), 00504 (SF), 01760 (DO) VAP-C01E-17, VAP-A31E-27, VAP-C01E-20 Assessment information DEV01A58 VDH DSS condemnation 010-024B 1/6/2004 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH
Little Bay	5A	1.034211654	15000 (PCBs), 10051 (SAV), 01760 (DO) VAP-C01E-17, VAP-A31E-21 24 16000 72 (CT) 24 16000 06 (EC, 64) The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisories for PCBs. No more than 2 miles
Little Branch	5A	0.152316231	01070 (SF), 01074 (DO), 10084 (Pathogens) 303(d) segment VAP-E30L-05, VAP-E30L-21, VAP-E30L-20 Portion of VDH shellfish condemnation 031-13M, 3/21/2007 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle.
Little Carter Creek, Jugs Creek	5A	0.015245853	10071 (SAV), 01770 (DO), 01033 (Cl) 303(d) segment VAP-E20E-09, VAP-E20E-01 VDH DSS SFC 036B, 3/9/2007 remains closed but is now incorporated into SFC 036A, 3/26/2004 The middle/lower portion of the Rappahannock failed the open water summer dissol
Little Tankernative Creek	5A	0.013764707	15000 (PCBs), 10051 (SAV), 00505 (SF), 01760 (DO) VAP-C01E-17, VAP-A31E-27, VAP-C01E-11 In 2002, Little Tankernative Creek was not supporting for shellfish based on VDH DSS Shellfish Condemnation Notice 11-10B, 4/9/1999. During the 2006 cycle this
Little Wicomico River	5A	0.158845031	00158 (SF), 10051 (SAV), 10097 (enterococci), 01760 (DO) VAP-A31E-10, VAP-A31E-27 (DO/SAV), VAP-A31E-31 1AL16004.00 (A) A segment of the Little Wicomico River was assessed as impaired in 1998 based on VDH SF C105B 6/10/1997. During the 2004 cycl
Little Wicomico River	5A	0.166745627	10051 (SAV), 10069 (SF), 01760 (DO) VAP-A31E-27 (DO/SAV), VAP-A31E-30 (SF) VDH Shellfish condemnation 010-105B, 8/15/2001 was expanded during the 2006 cycle. The Affected Acres for the 2006 reference the MPA is due to 2006 Assessment info fro
Little Wicomico River	5A	0.206152236	00158 (SF), 10051 (SAV), 10097 (enterococci), 01760 (DO) VAP-A31E-10, VAP-A31E-27 (DO/SAV), VAP-A31E-31 Assessment info from VAP-A31E_LIS01A02 A segment of the Little Wicomico River was assessed as impaired in 1998 based on VDH SF C105B 6/10/1997
Little Wicomico River	5A	0.066592061	10051 (SAV), 01760 (DO) VAP-A31E-27 (DO/SAV) Assessment info from LIS03A08 During the 2006 cycle, the revised Chesapeake Bay water quality standards were adopted. Segment C105 middle/lower segment failed the Shallow Water Use SAV acreage criteria

Water Name	Category	Square Miles	AU_COMMENT
Little Wicomico River	SA	0.016512770	10061 (SAV), 01766 (DO) VAP-A34E-97 (DO-SAV) 1AL15002-00 (A) Segment removed from 1996 (Section 303(d)) list in 2002 based on use of assessment methodology During the 2000 cycle, the revised Chesapeake Bay water quality standards were adopted
Little Wicomico River	SA	0.010922504	10061 (SAV), 01766 (DO) Assessment info from VAP-A34E_LISG2A00 and LISG2A58 VAP-A34E-97 (DO-SAV) During the 2000 cycle, the revised Chesapeake Bay water quality standards were adopted. Virginia's EPIS assessment approach does the Sandy Water
Little Wicomico River, Slough Creek	SA	0.037131735	10061 (SAV), 10004 (SF), 01766 (DO) VAP-A34E-97 (DO-SAV), VAP-A34E-98 Assessment info from VAP-A34E_LISG2A58 VDH-DSS Condemnation Notice 010-105M1, 01/15/2004 During the 2000 cycle, the revised Chesapeake Bay water quality standards were adopted
Little Wicomico River, Slough Creek	SA	0.026031612	10061 (SAV), 01766 (DO) VAP-A34E-97 (DO-SAV) VDH-DSS condemned 010-105M1, 01/15/2004 Solidarity condemned, Invasive fully supporting with observed effects Assessment info from VAP-A34E_LISG2A00 and LISG2A58 During the 2000 cycle, the revised
Ledge Creek	SA	0.030456746	10061 (SAV), 01775 (DO), 10053 (Chlora) VAP-A33E-02, VAP-A33E-04 Shellfishing Line removed around 5 MP (mile) VDH-DSS Condemnation Notice 2001, 1/21/2001 Assessment info from VAP-A33E_LISG2A58 1AL002561-01 (ALS) Fecal coliform no data
Ledge Creek	SA	0.020113369	10061 (SAV), 01775 (DO), 10053 (Chlora), 00925 (SF) VAP-A33E-10, VAP-A33E-04, VAP-A33E-07 1AL000120 (A) VDH-DSS Shellfish Condemnation 2001, 1/21/2001 The freshwater portion of the Potomac failed the open water summer dissolved oxygen criteria
Lower Machodoc Creek	SA	0.030960139	01775 (DO), 10061 (SAV), 00914 (SF) VAP-A33E-03, VAP-A33E-07 1AL0W001.77 (A) 1AL0W001.73 (FFCO) 1AL0W017.00 The freshwater portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the
Lower Machodoc Creek	SA	0.018326682	01775 (DO), 10061 (SAV) VAP-A33E-02 1AL0W001.05 (SS) 1AL0W001.77 (CT) - WQI: Iceland 5 - Bacteria contribute dissolved effects 1AL0W009.71 (old SS) 1AL0W002.05 (old SS) The freshwater portion of the Potomac failed the open water summer d
Lower Machodoc Creek	SA	0.030160410	01775 (DO), 10061 (SAV) VAP-A33E-07 Assessment info from VAP-A33E_LGW02A00 The freshwater portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle. (Ni station, Pasture)

Water Name	Category	Square Miles	303 COMMENT
Mattox Creek	5A	0.010260736	00AM (Bacteria) 10051 (SAV) 01775 (DO) VAP-A31E-06 VAP-A31E-02 Assessment info from VAP-A31E _MACOTA58 Shellfish has removed due to VDH Protection 007-0011 , 11/14/2004 The mesohaline portion of the Potomac failed the open water summer DO
Mattox Creek	5A	0.033411071	00208 (Bacteria) 00678 (SF) 01775 (DO) 10051 (SAV) VAP-A31E-08 VAP-A31E-02 VDH/DSS Shellfish Condemnation 0010, 11/15/01 1AMA0001 02 (TN) Assessment info from VAP-A31E _MACOZA00 1AMA0001 02 (old TN) An exceedance of the NOAA LEL w
Mattox Creek	5A	0.555717505	10051 (SAV) 01775 (DO) VAP-A31E-03 1AMA0000 42 1AMA0000 15 (old) Chlorophyll A observed effect The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standard during the 2002 cycl
Mill Creek	5A	0.168750035	10051 (SAV) 01775 (DO) 00930 (SF) VAP-A33E-09, VAP-A31E-03 VDH DSS Shellfish Condemnation Notice 28E 7/21/2004 1AMA0001 00 (100 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the S
Mill Creek	5A	0.158811591	10051 (SAV) 01775 (DO) VAP-A31E-02 1AMA0001 02 (100 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2002 cycle
Mill Creek	5A	0.009503171	10051 (SAV) 01775 (DO) 00005 (SF) VAP-A31E-05, VAP-A31E-02 Nearly Close, Mill Creek and a portion of the Clean River were assessed as impaired of the Shellfish Uses in 1998 because of VDH SFC 1454 and 1453, 2/21/1997. During the 2004 cycle, due to
Mill Creek	5A	0.424415206	15000 (PCBs) 10051 (SAV) 00569 (SF) 01766 (DO) VAP-C01E-12, VAP-A31E-07, VAP-C01E-19 1AMC0004 00 (A) VDH DSS Shellfish Condemnation Notice 010-12M, 8/4/2004 The condemnation was expanded in the 2002 cycle The Chesapeake Bay and its
Mill Creek	5A	1.17255916	15000 (PCBs) 10051 (SAV) 01775 (DO) VAP-C01E-17, VAP-A31E-27 1AMC0007 27 (C2) The Chesapeake Bay and its tidal tributaries are included under the 10/13/2004 VDH Fish Consumption Advisory for PCBs. No more than 2 meals/month are recommended
Mineboro Pining	5A	0.041117657	01024 (DO) 01053 (SF) 5(b)(3) segment VAP-E20E-07 VAP-E20E-01 VDH Shellfish condemnation 1821, 3/27/2002 No non Chesapeake Bay water quality standards were implemented during the 2002 cycle. The mesohaline Connecticut failed the open water su
Monroe Bay	5A	0.112174569	01775 (DO) 10051 (SAV) 00584 (PCBs) VAP-A31E-05, VAP-A31E-10 VAP-A31E-02 VDH DSS Shellfish Condemnation 001845, 11/15/2004 (Seasonal - fully supporting with dissolved PCB) Assessment info from VAP-A31E _MON The mesohaline portion of th
Monroe Bay	5A	0.357855555	01775 (DO) 10051 (SAV) 00584 (PCBs) VAP-A31E-10, VAP-A31E-02 Assessment info from VAP-A31E _MON The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2002 cycle
Monroe Creek	5A	0.172355318	00584 (PCBs) 01775 (DO) 10051 (SAV) VAP-A31E-10 (PCBs not met) - Impaired 1AMC0002 49 (C) VDH DSS Condemnation Notice 002-0310 11/15/2004 Shellfish Use removed because of data Assessment info from VAP-A31E _MON Mercury in fish tissue 00584 (PCBs) 01775 (DO) 10051 (SAV) 00530 (SF)
Monroe Creek	5A	0.436097076	VAP-A31E-04, VAP-A31E-10, VAP-A32E-02 1AMC0002 01 1AMC0000 (S) 1AMC0100 02 VDH DSS Condemnation Notice 001A 11/15/01 Assessment info from VAP-A31E _MON Chlorophyll a observed effect The
Morris Creek	5A	0.001833251	10051 (SAV) 01775 (DO) 00584 (PCBs) VAP-A31E-10, VAP-A31E-02 Shellfish Use removed due to VDH Protection 001C 11/15/01 Assessment info from VAP-A31E _MON The mesohaline portion of the Potomac failed the open water summer dissolved oxygen
Mountain Creek	5A	0.335316084	10071 (SAV) 01775 (DO) 01065 (N) 01067 (SF) 5(b)(3) segment VAP-E22E-12, VAP-E22E-10, VAP-E22E-01 3MF1000 01 (A) VDH Shellfish condemnation 1204, 6/23/2004 Assessment information Sent MT02/03 The mesohaline portion of the Potomac
Mosquito Creek	5A	0.078855602	10071 (SAV) 01775 (DO) 01065 (N) VAP-E20E-04, VAP-E22E-01 VDH DSS Shellfish Condemnation 203 11/6/2003 The CB standards were implemented during the 2000 cycle. The mesohaline portion of the Rappahannock failed the open water summer dissolved

Water Name	Category	Square Miles	AU_COMMENT
Mulberry Creek	5A	0.192760041	10071 (SAV) 01770 (DO) 01506 (FC) 01003 (SF) 10075 (chloride) 303(d) segment VAP-E20 -13, VAP-E20E-01, VAP-E20E-03 VDH Shellfish condemnation 023-12-A, 5/20/2004 - Site not cited in 2006 cycle Attainments: 50 from 3 AU's (1000 -55 in VAP-E20E -01/03)
Mulberry Creek	5A	0.229187037	10071 (SAV) 01770 (DO) 10075 (chloride) 303(d) segment VAP-E20E-05 VAP-E20E-07 3 AU's (1200 -60 (A) 01501 (FC) 01611 (impervious) The impervious portion of the Kingsmill stock is not the open water consider dissolved oxygen criteria and the SAV
Myer Creek	5A	0.051130593	01000 (SF) 01074 (DO) 303(d) segment VAP-E20E-05 VAP-E20E-25 VDH Shellfish Condemnation 21-10(M) 11/6/2003 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The impervious Condemnation is not the open water
Myer Creek	5A	0.045540041	01074 (DO) 01068 (SF) 303(d) segment VAP-E20E-25 VAP-E20E-30 VDH Shellfish Condemnation 21-10(M) 11/6/2003 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The impervious Condemnation is not the open water
Myer Creek	5A	0.016155623	01074 (DO) 303(d) segment VAP-E20E-25 VDH DSS Condemnation 21-10(M) 11/6/2003 Bacteriologically condemned, therefore fully supporting with observed effects The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. This no
Myer Creek UT	5A	0.040662126	01067 (SF) 01074 (DO) 303(d) segment VAP-E20E-32, VAP-E20E-31 VDH DSS Shellfish Condemnation 21-10(M) 11/6/2003 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The impervious Condemnation is not the open w
Nansemond Creek	5A	2.355630005	01775 (DO) 10051 (SAV) 00515 (SF) VAP-A32E-02, VAP-A31E-02 VDH Condemnation 004-087A 7/14/2004 1ANONM005.56 (N2) WQE scenario 5 benthics considered observed effects 1NONM005.09 (A) 1ANONM005.37 (A) 1ANONM-1-ALL (old stream) The new 10051 (SAV) 01775 (DO) VAP-A31E-02 1ANONM001.60 delisted in 2001 1ANONM004.53 (C2) - WQE scenario 5 benthics considered observed effects 1ANONM-2-ALL (Green) Old stations 1ANONM004.84 1ANONM005.66 1ANONM005.09, 1ANONM002.51, 1ANONM004.10.
Nansemond Creek	5A	2.068767108	01775 (DO) 10051 (SAV) VAP-A31E-02 and 2004 list shows VAP-A32E-07 1ANONM000.50 (1996 SS) This segment was initially delisted as the segment of the Aquatic life use support goal in 2002 because of a delisted oxygen violation rate of 20% at 16

Water Name	Category	Source Map	All Comment
North Prong Buckner Creek	5A	0 [illegible]	01775 (DO); 10051 (SAV); 00917 (BF) VAP-A31E-00, VAP-A31E-07 VDH Condemnation Notice 004-0520, 7/11/2004 The mainstem portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000's
NW Yeocomico (White Point Creek/Sharpe Branch)	5A	0 [illegible]	10051 (SAV); 01775 (DO) VAP-A31E-02 VDH-DSS Condemnation 007-0280, 01/21/2004 Segment is tidally confined, therefore it is considered fully supporting with observed effects The mainstem portion of the Potomac failed the open water su
Cedar Point	5A	0 [illegible]	10000 (PCBs); 10051 (SAV); 00967 (BF); 01700 (DO) VAP-C01E-17, VAP-A31E-27, VAP-C01E-10 VDH-DSS Shellfish Condemnation Notice 192, 10/1/1997 FOW-P000-00 (CP) The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Ch
Poplar Creek	5A	0 [illegible]	01776 (DO); 10071 (SAV) 303(d) segment VAP-L22E-01 VDH-DSS Shellfish Condemnation 112 (Has removed b/c non-productive) The mainstem portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standar
Pepper Creek	5A	0 [illegible]	00997 (BF); 00905 (Bacteria); 01775 (DO); 10057 (SAV) VAP-A31E-07, VAP-A31E-03 TMDL-P000-38 (A) TMDL-P000-001-AEL (CP/GN) 01660/01750 (old US/GS) 01660/01760 (old US/GS) VDH-DSS Shellfish Condemnation 166, 4/27/1999 Impaired or Stressed Shellfish 10000 (PCBs); 10051 (SAV); 00968 (BF); 01700 (DO)
Hopewell Creek	5A	0 [illegible]	VAP-C01E-17, VAP-A31E-27, VAP-C01E-10 VDH-DSS Shellfish Condemnation Notice 010-0220, 6/26/2000 Assessment information PN160A07 The Chesapeake Bay and its tidal tributaries are included under th
Hunting Creek	5A	0 [illegible]	10000 (PCBs); 10051 (SAV); 01700 (DO) VAP-C01E-17, VAP-A31E-27 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Shellfish Condemnation Advisory for PCBs. No more than 2 meals/month are recommended of any hunting fowl
Hunting Creek	5A	0 [illegible]	10000 (PCBs); 10051 (SAV); 00923 (BF); 01700 (DO) VAP-C01E-17, VAP-A31E-27, VAP-C01E-02 VDH-DSS Shellfish Condemnation Notice 015-0221, 4/21/2003 Assessment information PN102A07 The Chesapeake Bay and its tidal tributaries are included under t
Hurley Creek	5A	0 [illegible]	00941 (BF); 10051 (SAV); 01775 (DO) VAP-A31E-00, VAP-A31E-02 TMDL-P000-38 (A) TMDL-P000-001-AEL (CP) - WQS scenario 2 - fully supporting VDH-DSS Condemnation Notice 140, 4/27/1999 The mainstem portion of the Potomac failed the open water s
Hoggard Point Bay	5A	0 [illegible]	10051 (SAV); 01775 (DO) VAP-A31E-02 VDH-DSS Condemnation 030-0208, 01/13/1999 Shellfish condemned. Therefore fully supporting with observed effects The mainstem portion of the Potomac failed the open water summer dissolved oxygen criteria
Rappahannock River	5A	0 [illegible]	10070 (PCBs); 01028 (cu); 01776 (DO); 10071 (SAV); 10120 (B-IBI) 303(d) segments VAP-L22E-08, VAN-E20E-03, VAP-C02E-01, VAP-L22E-02 5-RPP-000-42 (C) CB B-IBI segment RPP0000 is impaired - listed for DO but of bypass at mouth Cows Bay random bm
Rappahannock River	5A	0 [illegible]	10070 (PCBs); 01776 (DO); 10071 (SAV); 10120 (B-IBI) 303(d) segments VAN-E20E-00, VAP-L22E-01, VAP-L22E-02 5-RPP-025-02 (A, 1) 5-RPP-017-72 (A, 1) 5-RPP-010-00 (A, 1) 5-RPP-008-42 5-RPP-000-00 5-RPP-003-10 (CP) - WQS scenario 2 - category 3A
Rappahannock River	5A	0 [illegible]	10070 (PCBs); 01028 (cu); 01776 (DO); 10071 (SAV); 10120 (B-IBI) 303(d) segments VAP-L22E-08, VAN-E20E-03, VAP-E22E-01, VAP-E22E-02 CB B-IBI segment RPP0000 is impaired - listed for DO b/c of bypass at mouth Assessment information from VAP-L22E
Rappahannock River	5A	0 [illegible]	01028 (chlorine); 10009 (SAV); 10070 (PCBs) VAP-L22E-08, VAP-L20E-03, VAP-L20E-03 5-RPP-064-00 (A) station at 71.2 Zn (CB) VDH Shellfish Condemnation 068 - Remediation Chesapeake Bay random benthic stations 07/02, 07/03, 11/03 RPP0000 - Impairment data for dissolved Assessment info from 30-RPP-01/02
Rappahannock River	5A	0 [illegible]	01028 (chlorine); 10070 (PCBs) 303(d) segments VAP-L22E-08, VAN-E20E-03 5-RPP-051-01 (A) 5-RPP-050-04 (old SS) CB-IBI station 11/03 RPP0000 - impairment Chlorine is mentioned at river mile 50.01 in 1990 in relation to an observed effect Tmy

Water Name	Category	Impairment	AU_COMMENT
Rappahannock River	5A	0 9107370647	01078 (ci) 10070 (PCBs) 30X(d) segment VAFH-22E-68, VAFH-22E-03 Assessment info from VAFH-22E, RIPN-M02 RIPO Data verification VDH Sheffish Consumption (Non-production) Fish consumption fully supporting with designated uses based on criteria
Rappahannock River	5A	0 1511102704	10070 (PCBs) 01078 (ci) 01776 (DO) 10071 (SAV) 10120 (Hg) 30X(d) segment VAFH-22E-68, VAFH-22E-03, VAFH-22E-01, VAFH-22E-02 Hg fish segment RIPN data impacted Hg fish stations 30125, 10071, 10072, 11020, 11020, 30124, 10023, 10023 Hg issue
Rappahannock River	5A	0 1511102704	10070 (PCBs) 01078 (ci) 01776 (DO) 10071 (SAV) 01011 (SF) 10120 (Hg) 30X(d) segment VAFH-22E-01, VAFH-22E-68, VAFH-22E-03, VAFH-22E-01, VAFH-22E-02 VDH Sheffish Consumption 6/8/2004 CB Hg fish segment RIPN data impacted - rated
Rappahannock River	5A	14 4555 1027	10070 (PCBs) 01078 (ci) 01776 (DO) 10071 (SAV) 01012 (Hg) 30X(d) segment VAFH-22E-68, VAFH-22E-03, VAFH-22E-01, VAFH-22E-02 CB Hg fish segment RIPN data impacted - rated for DO b/c of hypoxia at mouth 5 (RP-050-A1 (crown) 5 (RP-031-57 (A)
Rappahannock River	5A	0 1506612303	10070 (PCBs) 01078 (ci) 01776 (DO) 10071 (SAV) 01012 (Hg) 30X(d) segment VAFH-22E-68, VAFH-22E-03, VAFH-22E-01, VAFH-22E-02 Portion of VDH DSS SI C 06-071A 12/22/2004 CB Hg fish segment RIPN data impacted - rated for DO
Rappahannock River	5A	0 1304432003	10070 (PCBs) 01776 (DO) 10071 (SAV) 01011 (SF) 10120 (Hg) 30X(d) segment VAFH-22E-03, VAFH-22E-01, VAFH-22E-68, VAFH-22E-02 VDH DSS Sheffish Consumption 05/06, 04/04/1993 Hg fish segment RIPN data impacted - rated for DO due to hypoxia
Richardson Creek	5A	0 1003312335	01019 (SF) 10071 (SAV) 01776 (DO) VAFH-22E-06, VAFH-22E-01 Portion of VDH Sheffish Consumption 07/06, 12/22/2004 The non-tidal portion of the Rappahannock fails the open water summer dissolved oxygen criteria and the SAV acreage standards d
Rupes Creek	5A	0 6204402202	10051 (SAV) 01775 (DO) 00912 (SF) VAFP-A34C-15, VAFP-A31E-02 VDH DSS Consumption Notice 009-1420 12/22/2004 The non-tidal portion of the Potomac fails the open water summer dissolved oxygen criteria and the SAV acreage standards during the 9
Rocky Creek	5A	0 2003120653	00900 (SF) 01775 (DO) 10051 (SAV) VAFP-A31E-01, VAFP-A31E-02 VDH DSS Sheffish Consumption 06/06, 9/22/2004 MRO0001 05 - discontinued in 2002 The non-tidal portion of the Potomac fails the open water summer dissolved oxygen criteria and t

Water Name	Category	Square Miles	AU_COMMENT
Beaver Creek	5A	0.309766694	01775 (DO) 10051 (SAV) VAP-A31E-02 Assessment info from VAP-A31E_ROS01A58 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Broad Creek	5A	0.002641435	01074 (DO) 01092 (SF) 303(d) segment: VAP-E20E-08, VAP-E20E-25 VDH shellfish condemnation 021-1208, 3/21/2002 The new Chesapeake Bay water quality standards were implemented during the 2000 cycle. The mesohaline Chesapeake failed the open water
Shannon Branch	5A	0.123132037	10051 (SAV) 01775 (DO) 10051 (SF) VAP-A31E-02, VAP-A31E-12 VDH DSS Condemnation Notice 097-026A 07/21/2004 1ASHA000.58 (1995 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV a
Shannon Branch	5A	0.133379066	10051 (SAV) 01775 (DO) VAP-A31E-02 1ASHA000.58 (1995 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Shannon Branch	5A	0.034975061	10051 (SAV) 01775 (DO) VAP-A31E-02 VDH DSS Shellfish condemnation 097-026A01 7/21/2004 Restored condemnation breaks in a condemned fully supporting with observed effects 1ASHA000.58 (1995 SS) The mesohaline portion of the Potomac
South Fork Occoquan River	5A	0.761192757	10051 (SAV) 01775 (DO) VAP-A31E-02 1ASOV000.66 (N WQ) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
South Fork Occoquan River	5A	0.105083808	10051 (SAV) 01775 (DO) VAP-A31E-02 VDH DSS condemnation 097-026A01, 7/21/2004 Seasonally condemned, therefore considered fully supporting with observed effects Assessment info from VAP-A31E_SR2V01A02 The mesohaline portion of the Potomac fa
Spring Creek	5A	0.000346876	00913 (FC) 10051 (SAV) 01775 (DO) 00937 (SF) VAP-A31E-24, VAP-A31E-02, VAP-A31E-19 1ASP000.08 (A) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycl
Stevens Point	5D	0.037375691	10051 (SAV) 01775 (DO) 00171 (SF) VAP-A34L-03, VAP-A31E-02 VDH DSS Condemnation Notice A-2140, 10/22/2003 1ASI000.27 (1995 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage
Tabbs Creek	5A	0.027454555	15000 (PCBs) 10051 (SAV) 00971 (SF) 01760 (DO) VAP-C01E-17, VAP-C01E-27, VAP-A31E-27 2-TIS001.05 (A) VDH DSS Shellfish Condemnation Notice 133, 10/8/2002 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish
Tabbs Creek	5A	0.037645007	15000 (PCBs) 10051 (SAV) 01760 (DO) VAP-C01E-17, VAP-A31E-27 Assessment information from NBS01A58 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2004 VDH Fish Consumption Advisory for PCBs. No more than 2 meals/week
Taylor Creek	5A	0.002431042	01074 (SF) 01074 (DO) 303(d) segment: VAP-E20E-25, VAP-E20E-03 VDH shellfish condemnation 201 was rescinded in 2000 cycle and then reopened on 3/27/2002 The new Chesapeake Bay water quality standards were implemented during the 2000 cycle. The
Tho Gibbs	5A	0.058722008	10051 (SAV) 01775 (DO) 00937 (SF) VAP-A31E-01, VAP-A31E-02 Assessment info from VAP-A31E_GI01A58 A portion of Gibbs Creek was initially assessed as impaired of the Shellfish Use due to VDH DSS Condemnation Notice 1450, 3/21/1997. In the 2
The Gibbs	5D	0.137420312	10051 (SAV) 01775 (DO) 00937 (SF) VAP-A31E-01, VAP-A31E-02 1AGL000.76 (SS) 1AGL000-GOANS-ALL (Gross) 1AGL000.76 (1995 SS) A portion of Gibbs Creek was initially assessed as impaired of the Shellfish Use due to VDH DSS Condemnation Notice 1
The Gibbs	5A	0.206070605	10051 (SAV) 01775 (DO) 10000 (SF) VAP-A31E-26, VAP-A31E-02 1AGL000.50 (SS) 1AGL000-GOANS-ALL (Gross) The Gibbs shellfish condemnation was extended in 2000, as demonstrated in VDH DSS condemnation 058-213B 12/20/2003. The TMDL for the expand
The Gibbs	5A	0.120676045	10051 (SAV) 01775 (DO) VAP-A31E-02 1AGL000-GOANS-ALL (Gross) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle.
The Gibbs	5A	0.047575478	10051 (SAV) 01775 (DO) 00938 (SF) VAP-A31E-26, VAP-A31E-02 The segment was condemned prior to 2000 because of VDH DSS Shellfish Condemnation 145A 11/27/2001. During the 2000 cycle, the Gibbs Creek condemnation was extended and the segment a

Water Body	Category	Source Mess	TMDL Comment
Tyler Creek	5A	0.136120457	10000 (PCBs) 10001 (SAV) 00972 (SF) 01760 (DO) VAP-C01E -17 VAP-A34E-27, VAP-C01E -18 VDH DSS Shellfish Condemnation Notice 015-09C 4/15/2001 Area expanded in the 2006 cycle The Chesapeake Bay and its tidal tributaries are included under t
Tidewater Creek	5A	0.356335528	10071 (SAV) 01770 (DO) 01050 (Cl) 01051 (FC) 10074 (Chl-a) VAP-L22E-01, VAP-L24E-02 VDH Shellfish condemnation 076-071B, 12/22/2004 - Uses removed due to pollution 9-101007 B1 (C2) - WQS scenario 1A - Category 5A - strong evidence for tox
Tidewater Creek	5A	0.674551144	10071 (SAV) 01770 (DO) 01050 (Cl) 01051 (FC) 10074 (Chl-a) 01055 (NH3) 303(d) registered VAP-L24E-01, VAP-L24E-02, VAP-L22E-01 Portion of VDH condemnation 076-071A 12/22/2005 Chesapeake Bay monitoring station: 10119 B-101 registered BPJ-16
Water Creek	5A	0.018715186	10000 (PCBs) 10001 (SAV) 01760 (DO) VAP-C01E-17 VAP-A34E-27 VDH DSS Shellfish Condemnation Number 012-12/2/1, 8/3/2005 (permanent) The Chesapeake Bay and its tidal tributaries are included under the 12/13/2001 VDH Fish Consumption Advisories
Town Creek	5A	0.016767735	01074 (Chl) 01095 (SF) 303(d) registered VAP-L26E-02, VAP-L26E-05 VDH shellfish condemnation 183A 3/24/2003 Chesapeake Bay monitoring station 10107 - CB3.3C is impacted The new Chesapeake Bay water quality standards were approved d
Unnamed Cove of Elizabeth Creek	5A	0.011507116	10000 (PCBs) 10001 (SAV) 00910 (SF) 01760 (DO) VAP-C01E-17 VAP-A34E-27, VAP-C01E-18 VDH DSS Shellfish Condemnation Notice 015-09C 4/15/2001 Assessment info from VAP-C01E DEQ03A60 The Chesapeake Bay and its tidal tributaries are included i
Unnamed tributary in A32	5A	0.003918688	01775 (DO) 10001 (SAV) VAP-A32E-02 The mainstem portion of the Pocomoke failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle
Unnamed tributary in A32	5A	0.003693005	01775 (DO) 10001 (SAV) VAP-A32E-02 The mainstem portion of the Pocomoke failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle

Water Name	Category	Square Miles	AU_COMMENT
Unassigned estuarine in A33	5A	0.001203445	10051 (SAV); 01775 (DO) VAP-A31E-02 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Unassigned estuarine in A34	5A	0.056178544	10051 (SAV); 01775 (DO) VAP-A31E-02 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Unassigned estuarine in C01	5A	1.076666298	Unassigned portion of the C01E watershed 15000 (PCBs); 10051 (SAV); 01775 (DO) VAP-C01E-12, VAP-A34E-02 The Chesapeake Bay and its tidal tributaries are included under the 12/13/2001 VDH Fish Consumption Advisory for PCBs. See more back info
Unassigned estuarine in E22	5A	0.785462257	10059 (SAV) VAN-E20E-02 VDH Shellfish Condemnation 06A 3/20/2001 Chesapeake Bay stations The tidal Delaware Rappahannock River failed the SAV acreage requirements for the Shallow Water use during the 2000 cycle
Unassigned estuarine in E32	5A	0.010015015	01775 (DO); 10071 (SAV) VAP-E32E-01 The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Unassigned estuarine in E33	5A	0.003922706	10071 (SAV); 01775 (DO) VAP-E32E-01 The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Unassigned estuarine in F23	5A	0.059853563	10071 (SAV); 01775 (DO); 01051 (SFC) VAP-E20E-01, VAP-E32E-01 Portion of VDH DSS condemnation 06AA 3/20/2001 The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standards during
Unassigned estuarine in F25	5A	0.243407059	10071 (SAV); 01775 (DO) 303(d) segment VAP-E32E-01 The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle
Unassigned estuarine in F26	5A	1.002478284	01775 (DO); 10071 (SAV) 303(d) segment VAP-E32E-01 The CB standards were implemented during the 2000 cycle. The mesohaline portion of the Rappahannock failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the
Unassigned estuarine in G26	5A	1.741282511	01074 (DO) 303(d) segment VAP-L20E-01 The new Chesapeake Bay water quality standards were implemented during the 2000 cycle. The mesohaline Corrotoman failed the open water summer dissolved oxygen criteria
Westmoreland Creek	5A	0.026376106	15000 (PCBs); 10051 (SAV); 00974 (SF); 01775 (DO) VAP-C01E-12, VAP-A34E-02, VAP-C01E-00 VDH DSS Shellfish Condemnation Notice 013-0503 4/18/2001. Also reported for the 2000 cycle The Chesapeake Bay and its tidal tributaries are included under
Westmoreland Creek	5A	0.000145609	01775 (DO); 10051 (SAV) VAP-A31E-02 VAN-E-A900-12 (ref 55) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2000 cycle

Water Name	Category	Square Miles	AU_COMMENT
Wentworth Creek	5A	0.046043124	01775 (DO) 10051 (SAV), 00918 (SF) VAP-A32(*-10, VAP-A31(*-02 1AWE A000 17 (old SS) VDH-DSS Condemnation 0330, 12/10/02 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards due
West Yeocomico River	5A	0.020115775	10051 (SAV), 01775 (DO) VAP-A31(*-02 VDH-DSS Condemnation 007-02MD, 07/01/2006 Seasonally condemned, so fully supporting was observed effects 1AWE,5000 61 (A) The mesohaline portion of the Potomac failed the open water summer dissolved o
West Yeocomico River	5A	0.327760456	10051 (SAV), 01775 (DO) VAP-A31(*-02 1AWE 5001 001 1 (single event) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle
Wicomico Branch Condemnation River	5A	0.456431323	01016 (SF), 01074 (DO) 303(d) segment VAP-T-2(C-09, VAP-T-2(C-25 VDH shellfish condemnation 021-10TA 3/27/2002 Chesapeake Bay nutrient toxics study stream 6550.0 Segment CHBWQ is insufficient The new Chesapeake Bay water quality standards we 01074 (DO) 303(d) segment VAP-T-2(C-25 Original 2006 listing 34CH0000 65 - WQS scenario 2, Category 2A CHBWQ is insufficient The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The mesohaline
Wigg's Creek	5A	0.140422814	16000 (PCBs), 10051 (SAV), 00923 (SF) VAP-C01(-12, VAP-A31(*-02, VAP-C01(-05 2WWH000 38 (C2) CM station 2WWH000 72 (1999 TE, CHE_3) VDH DSS Shellfish Condemnation Notice 013-0004 4/16/2002 Area expanded for the 2006 cycle No Change
White Point Creek	5A	0.074556107	10051 (SAV), 01775 (DO), 00922 (SF) VAP-A31(*-05, VAP-A31(-02 1AWH0000 54 (1999 SS) VDH DSS Condemnation Notice 007-02MD, 07/01/2006 The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acre
White Point Creek	5A	0.03306932	10051 (SAV), 01775 (DO) VAP-A31(-02 1AWH0001 54 (1999 SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle
Whitehouse Creek	5A	0.050035157	01074 (DO), 01016 (SF) 303(d) segment VAP-T-2(C-09, VAP-T-2(C-25 VDH shellfish condemnation 18-01, 5/22/2002 The new Chesapeake Bay water quality standards were implemented during the 2006 cycle. The mesohaline Condemnation failed the open water su
Wicomico Point Yacht Haven	5A	0.010105659	01110 (DO), 10051 (SAV) 303(d) segment VAP-T-2(C-01 VDH DSS Shellfish Condemnation 018-01MD (6/10/1993 (use cold-spot removal b/c protection ground marina) The mesohaline portion of the Rappahannock failed the open water summer dissolved oxy
Wright Cove	5A	0.033[illegible]	10051 (SAV), 01775 (DO), 00914 (SF) VAP-A3((-02, VAP-A3(L-01 1AGLE 4CORN5 AC1 (closed) Wright Cove was closed or impaired in 2004 because of VDH DSS Shellfish Condemnation 14-01, 11/27/2002. During the 2006 cycle, the Global Cove Impairment wa
Yeocomico River (W) Tributaries	5A	0.144[illegible]	10051 (SAV), 01775 (DO) VAP-A31(-02 1AYE C000 01 (SS) 1AYE C001 15 (03 TE) 1YE C000 001 (SS) The mesohaline portion of the Potomac failed the open water summer dissolved oxygen criteria and the SAV acreage standards during the 2006 cycle

APPENDIX I

Focus on Surficial Aquifers of the Northern Neck

APPENDIX I

Focus on a Water Supply Source
The Surficial Aquifers of the Northern Neck

Amount Available

The potential water supply in the surficial aquifer (water table aquifer) is enormous. In Northumberland County, for example, there are approximately 77 million gallons of water available and continually being renewed by rain and snow melt.

In one acre, assuming 12 inches of our average rainfall of 42 inches per year recharges, our surficial aquifer receives approximately 326,000 gallons of recharge each year or 892 gallons per day.

Water Quality

Studies conducted by SAIF Water Wells, Inc. in Lancaster and Northumberland Counties utilizing hundreds of laboratory analyses indicate that the surficial aquifer has, for the most part, good quality water.

Factors Effecting Potability

The potability of this water supply is primarily affected by inadequate design, construction, and care of wells and water distribution systems.

Efforts are underway to develop technology which would enable the "shallow", large-bore well to be constructed, as Health Department regulations require, in a manner which leaves them sealed. Current construction methods simply stack cement curbs on top of each other with no attempt at sealing. Plumbing lines are often installed without sealing. And concrete well caps have no provision for adequate sealing.

The primary concern is for an effective means of preventing or controlling bacteria.

Potentially a Cost-Effective Alternative

With improved technology, and treatment systems where needed for specific issues, we have the potential of a water supply that will be particularly valuable in the many outlying areas where pipelines from central water supplies would be costly.

SAIF Water Wells, Inc. P.O. Box 839, Burgess, VA 22432
804 580-2079 www.saifwater.org saif@crosslink.net

APPENDIX J

Community Profile Brochures

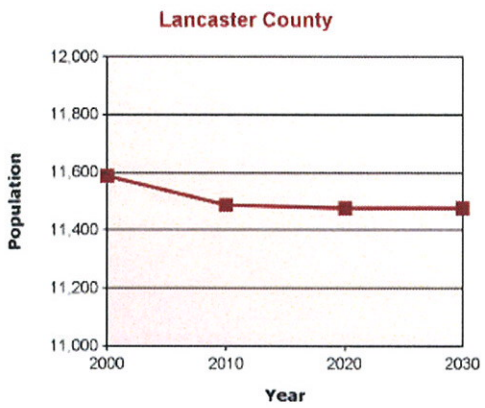
Northern Neck Planning Region

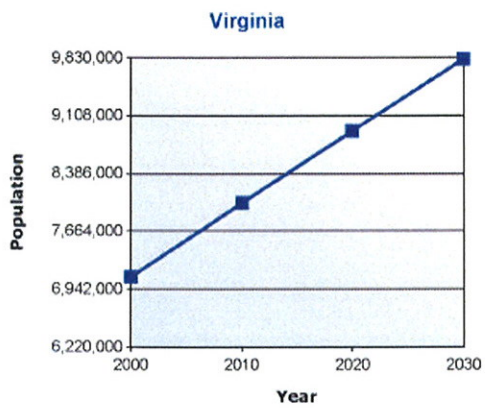
Appendix J

Community profile brochures for the Northern Neck counties of Lancaster, Northumberland, Richmond and Westmoreland

1) LANCASTER COUNTY

Population Change



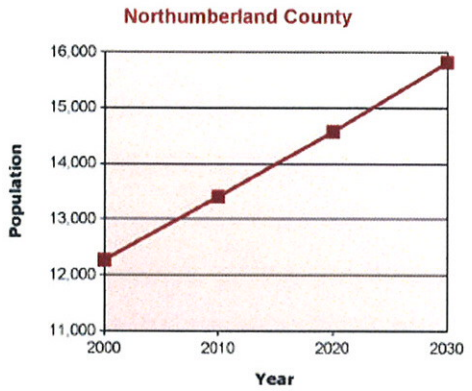


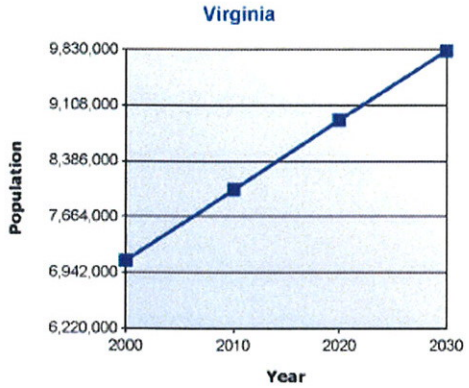
	Lancaster County	(% change)	Virginia	(% change)
1990	10,925		6,216,884	
2000	11,589	6.08 %	7,104,078	14.27 %
2010	11,485	-0.90 %	8,010,340	12.76 %
2020	11,477	-0.07 %	8,917,569	11.33 %
2030	11,478	0.01 %	9,825,288	10.18 %

Source: U.S. Census Bureau, Virginia Employment Commission.

2) NORTHUMBERLAND COUNTY

Population Change



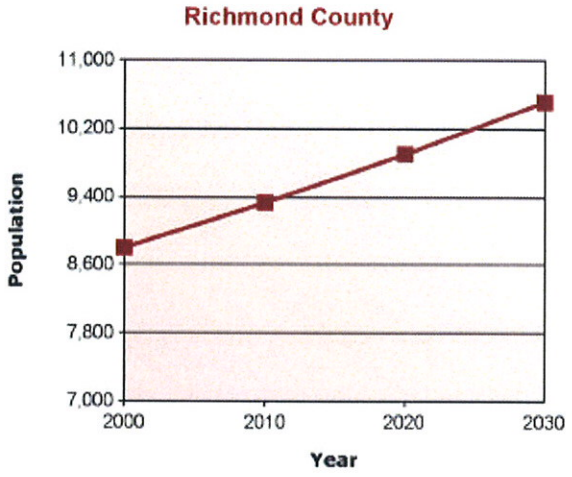


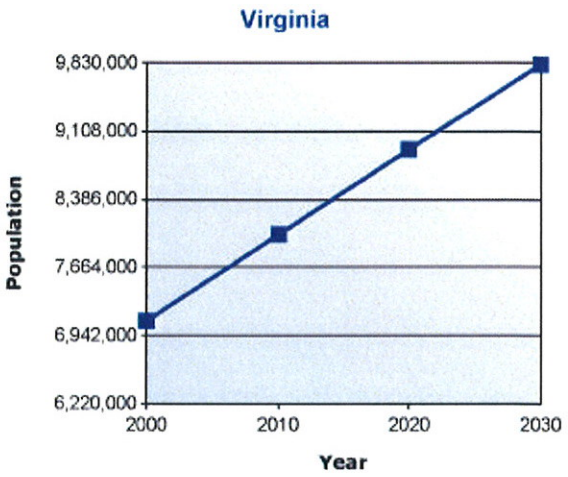
	Northumberland County	(% change)	Virginia	(% change)
1990	10,550		6,216,884	
2000	12,282	16.42 %	7,104,078	14.27 %
2010	13,420	9.27 %	8,010,340	12.76 %
2020	14,587	8.70 %	8,917,569	11.33 %
2030	15,821	8.46 %	9,825,288	10.18 %

Source: U.S. Census Bureau, Virginia Employment Commission.

3) RICHMOND COUNTY

Population Change



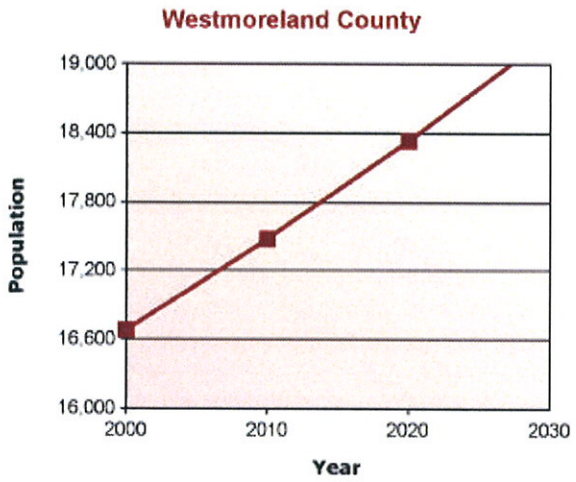


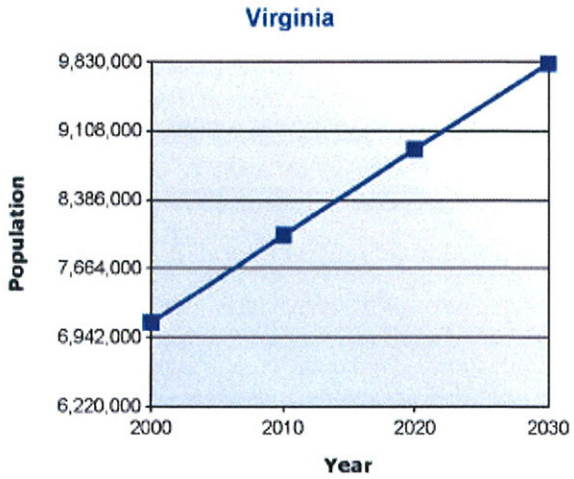
	Richmond County	(% change)	Virginia	(% change)
1990	7,279		6,216,884	
2000	8,794	20.81 %	7,104,078	14.27 %
2010	9,333	6.13 %	8,010,340	12.76 %
2020	9,900	6.08 %	8,917,569	11.33 %
2030	10,512	6.18 %	9,825,288	10.18 %

Source: U.S. Census Bureau, Virginia Employment Commission.

4) WESTMORELAND COUNTY

Population Change





	Westmoreland County	(% change)	Virginia	(% change)
1990	15,577		6,216,884	
2000	16,686	7.12 %	7,104,078	14.27 %
2010	17,483	4.78 %	8,010,340	12.76 %
2020	18,336	4.88 %	8,917,569	11.33 %
2030	19,261	5.04 %	9,825,288	10.18 %

Source: U.S. Census Bureau, Virginia Employment Commission.

APPENDIX K

Local ordinances adopted by the jurisdictions that are party to the regional WSP support implementation and enforcement of the DRCP

Example Local Government Ordinance for Drought Response and Contingency Plan

Northern Neck Regional Water Supply Plan

TEMPLATE DROUGHT RESPONSE ORDINANCE
[Local Jurisdiction]
ARTICLE X. DROUGHT MANAGEMENT
Sec. XX-01. Short title.
This Article shall be known and may be cited as the Drought Management Ordinance.
(Ord. No. XXXX-XXXX, DATE)
Sec. XX-02. Authority to declare a potential shortage of water and to impose water conservation measures. The [County Administrator, Town Manager] is authorized to take special measures of prudent management to prevent a critical water shortage when a potential shortage and/or emergency condition exists in the water system(s), and to declare Drought Watch, Drought Warning or Drought Emergency conditions within the jurisdiction. Drought Emergency conditions may also be declared by the jurisdiction in the event of equipment failure, contamination or other non-drought related event that prevents short-term provision of adequate water supplies.

Sec. XX-03. Authority granted to local jurisdictions by the Code of Virginia.
Section 15.2-924 of the Code of Virginia states that localities have the power to declare water supply emergency, and to restrict citizens' water use for the prevention of or the duration of a water supply emergency. When such restrictions are put into place, any local water supply system may apply to the State Water Control Board for assistance if they are able to provide evidence that they have exhausted their available means. Water can be bought from one water supplier for the benefit of another to alleviate local water shortages; in such cases, water will be paid for at the established rate of the supplier.

Sec. XX-04. Conditions for the declaration of potential shortage of water.
The Drought Contingency and Response Plan, included in the Northern Neck Regional Water Supply Plan (WSP), provides guidance for evaluating the potential for, or existence of, drought conditions and implementation of response and contingency activities.

Upon a determination by the [County Administrator, Town Manager] of the existence of the following conditions, the [County Administrator, Town Manager] shall take the following actions:

(a) Drought Watch.
Drought Watch stage targets increased monitoring of drought conditions and increased public awareness of incipient drought conditions. Required actions under the Drought Watch include notifying the public of incipient drought via newspaper, public service announcement, notices with water bills, and to request voluntary reduction in non-essential water use.
(b) Drought Warning.
Drought Warning target is to increase public awareness, and reduce water withdrawals by 10% through voluntary water conservation. Required actions include notifying public of the Drought Warning, and requesting voluntary reduction in the following non-essential water use:
(1) Water to wash down streets, sidewalks, walkways, driveways, parking lots, service station aprons, tennis courts, other hard surfaced areas, buildings, and structures, except as required for safety concerns;
(2) Water to wash automobiles, trucks, trailers, and any other types of mobile equipment, except where required to meet air quality standards;
(3) Watering of shrubbery, trees, lawns, grass, plants, and other vegetation;
(4) Water from fire hydrants for construction purposes or any purpose other than fire suppression or other public emergency;
(5) Water to fill or refill swimming pools;
(6) Customer not served drinking water in restaurant unless requested.
(7) Urge customers to refrain from outdoor watering with sprinklers or irrigation systems between 10 am and 6 pm;
(8) Implement alternate-day use schedules based on last digit of residential or commercial address: odd-number addresses - Tuesday, Thursday and Saturday; even-number addresses - Wednesday, Friday and Sunday; watering by hand (with cans, wands, hand-held hoses) is allowed any day of the week.

(9) The Drought Warning stage implements higher water rates for excess use. Normal water rates apply for consumption up to 12,000 gallons per billing cycle. Rates are increased by 15% for consumption above 12,000 gallons per billing cycle.

(c) Drought Emergency.

Drought Emergency target is to increase public awareness and reduce water withdrawals by 15%. Required actions include notifying public of the Drought Emergency, and implementing mandatory reduction in the following non-essential water uses:

(1) Water to wash down streets, sidewalks, walkways, driveways, parking lots, service station aprons, tennis courts, other hard surfaced areas, buildings, and structures, except as required for safety concerns;

(2) Water to wash automobiles, trucks, trailers, and any other type of mobile equipment, except where required to meet air quality standards;

(3) Watering of shrubbery, trees, lawns, grass, plants, and other vegetation (exception: customers may water first-year foundations, trees and shrubs up to two hours a day by a hand-held or soaker hose, and new planting of grass within the first 30 days up to one hour a day by any means; restrictions do not apply to locations using treated wastewater effluent for irrigation);

(4) Water from fire hydrants for construction purposes or any purpose other than fire suppression or other public emergency;

(5) Water to fill or refill swimming pools;

(6) Customer not served drinking water in restaurant unless requested.

(7) Require customers to refrain from outdoor watering with sprinklers or irrigation systems between 10 am and 6 pm;

(8) Implement alternate-day use schedules based on last digit of residential or commercial address: odd-number addresses - Tuesday, Thursday and Saturday; even-number addresses - Wednesday, Friday and Sunday; watering by hand (with cans, wands, hand-held hoses) is allowed any day of the week.

(9) The Drought Emergency stage implements higher water rates for excess use. Normal rates are increased by 15% for consumption up to 12,000 gallons per billing cycle. Normal rates are increased by 30% for consumption above 12,000 gallons per billing cycle.

Section XX-05. Penalties

Violations of this ordinance when a Drought Emergency stage is declared may result in penalties being assessed to the customer:

(1) First offense Written warning;

(2) Second offense $50 fine;

(3) Third offense $100 fine;

(4) Fourth offense $250 fine and water service suspension.

Section XX-06. Appeals and Exceptions

Upon implementation of a Drought Emergency stage (above), the [County Administrator, Town Manager] shall appoint an appeals board consisting of three (3) representatives from the jurisdiction under which the Drought Emergency is declared. The jurisdiction attorney or designee shall serve as legal counsel to the appeals board.

The appeals board shall be empowered to review customer applications for exemptions from the provisions of the mandatory conservation on a case-by-case basis and, if warranted, to make equitable adjustments to such provisions. The board shall also be empowered to establish regulations governing the granting of temporary exemptions applicable to all or some of the uses of the water supply as set forth. The board shall, in deciding applications, balance economic and other hardships to the applicant resulting from the imposition of water use restrictions or allocations against the individual and cumulative impacts to the water supply resulting from the granting of exemptions. Individual applications shall be decided by the board within two (2) weeks of receipt of an application in proper form and containing all necessary information.

(a) *Rescinding orders.* Nothing in this section shall be construed to prohibit the [County Administrator, Town Manager] from rescinding any orders issued hereunder when the conditions creating the need for such orders have abated.

(Ord. of XX-XX-XX)

Example Local Government Ordinance for Drought Response and Contingency Plan

Northern Neck Regional Water Supply Plan

TEMPLATE DROUGHT RESPONSE ORDINANCE
[Local Jurisdiction]
ARTICLE X. DROUGHT MANAGEMENT

Sec. XX-01. Short title.

This Article shall be known and may be cited as the Drought Management Ordinance. (Ord. No. XXXX-XXXX, DATE)

Sec. XX-02. <u>Authority to declare a potential shortage of water and to impose water conservation measures</u>. The [County Administrator, Town Manager] is authorized to take special measures of prudent management to prevent a critical water shortage when a potential shortage and/or emergency condition exists in the water system(s), and to declare Drought Watch, Drought Warning or Drought Emergency conditions within the jurisdiction. Drought Emergency conditions may also be declared by the jurisdiction in the event of equipment failure, contamination or other non-drought related event that prevents short-term provision of adequate water supplies.

Sec. XX-03. <u>Authority granted to local jurisdictions by the Code of Virginia.</u>

Section 15.2-924 of the Code of Virginia states that localities have the power to declare water supply emergency, and to restrict citizens' water use for the prevention of or the duration of a water supply emergency. When such restrictions are put into place, any local water supply system may apply to the State Water Control Board for assistance if they are able to provide evidence that they have exhausted their available means. Water can be bought from one water supplier for the benefit of another to alleviate local water shortages; in such cases, water will be paid for at the established rate of the supplier.

Sec. XX-04. <u>Conditions for the declaration of potential shortage of water.</u>

The Drought Contingency and Response Plan, included in the Northern Neck Regional Water Supply Plan (WSP), provides guidance for evaluating the potential for, or existence of, drought conditions and implementation of response and contingency activities.

Upon a determination by the [County Administrator, Town Manager] of the existence of the following conditions, the [County Administrator, Town Manager] shall take the following actions:

<u>(a) Drought Watch.</u>

Drought Watch stage targets increased monitoring of drought conditions and increased public awareness of incipient drought conditions. Required actions under the Drought Watch include notifying the public of incipient drought via newspaper, public service announcement, notices with water bills, and to request voluntary reduction in non-essential water use.

(b) Drought Warning.

Drought Warning target is to increase public awareness, and reduce water withdrawals by 10% through voluntary water conservation. Required actions include notifying public of the Drought Warning, and requesting voluntary reduction in the following non-essential water use:

(1) Water to wash down streets, sidewalks, walkways, driveways, parking lots, service station aprons, tennis courts, other hard surfaced areas, buildings, and structures, except as required for safety concerns;

(2) Water to wash automobiles, trucks, trailers, and any other types of mobile equipment, except where required to meet air quality standards;

(3) Watering of shrubbery, trees, lawns, grass, plants, and other vegetation;

(4) Water from fire hydrants for construction purposes or any purpose other than fire suppression or other public emergency;

(5) Water to fill or refill swimming pools;

(6) Customer not served drinking water in restaurant unless requested.

(7) Urge customers to refrain from outdoor watering with sprinklers or irrigation systems between 10 am and 6 pm;

(8) Implement alternate-day use schedules based on last digit of residential or commercial address: odd-number addresses - Tuesday, Thursday and Saturday; even-number addresses - Wednesday, Friday and Sunday; watering by hand (with cans, wands, hand-held hoses) is allowed any day of the week.

(9) The Drought Warning stage implements higher water rates for excess use. Normal water rates apply for consumption up to 12,000 gallons per billing cycle. Rates are increased by 15% for consumption above 12,000 gallons per billing cycle.

(c) Drought Emergency.

Drought Emergency target is to increase public awareness and reduce water withdrawals by 15%. Required actions include notifying public of the Drought Emergency, and implementing mandatory reduction in the following non-essential water uses:

(1) Water to wash down streets, sidewalks, walkways, driveways, parking lots, service station aprons, tennis courts, other hard surfaced areas, buildings, and structures, except as required for safety concerns;

(2) Water to wash automobiles, trucks, trailers, and any other type of mobile equipment, except where required to meet air quality standards;

(3) Watering of shrubbery, trees, lawns, grass, plants, and other vegetation (exception: customers may water first-year foundations, trees and shrubs up to two hours a day by a hand-held or soaker hose, and new planting of grass within the first 30 days up to one hour a day by any means; restrictions do not apply to locations using treated wastewater effluent for irrigation);

(4) Water from fire hydrants for construction purposes or any purpose other than fire suppression or other public emergency;

(5) Water to fill or refill swimming pools;

(6) Customer not served drinking water in restaurant unless requested.

(7) Require customers to refrain from outdoor watering with sprinklers or irrigation systems between 10 am and 6 pm;

(8) Implement alternate-day use schedules based on last digit of residential or commercial address: odd-number addresses - Tuesday, Thursday and Saturday; even-number addresses - Wednesday, Friday and Sunday; watering by hand (with cans, wands, hand-held hoses) is allowed any day of the week.
(9) The Drought Emergency stage implements higher water rates for excess use. Normal rates are increased by 15% for consumption up to 12,000 gallons per billing cycle. Normal rates are increased by 30% for consumption above 12,000 gallons per billing cycle.

Section XX-05. Penalties

Violations of this ordinance when a Drought Emergency stage is declared may result in penalties being assessed to the customer:
(1) First offense Written warning;
(2) Second offense $50 fine;
(3) Third offense $100 fine;
(4) Fourth offense $250 fine and water service suspension.

Section XX-06. Appeals and Exceptions

Upon implementation of a Drought Emergency stage (above), the [County Administrator, Town Manager] shall appoint an appeals board consisting of three (3) representatives from the jurisdiction under which the Drought Emergency is declared. The jurisdiction attorney or designee shall serve as legal counsel to the appeals board.
The appeals board shall be empowered to review customer applications for exemptions from the provisions of the mandatory conservation on a case-by-case basis and, if warranted, to make equitable adjustments to such provisions. The board shall also be empowered to establish regulations governing the granting of temporary exemptions applicable to all or some of the uses of the water supply as set forth. The board shall, in deciding applications, balance economic and other hardships to the applicant resulting from the imposition of water use restrictions or allocations against the individual and cumulative impacts to the water supply resulting from the granting of exemptions. Individual applications shall be decided by the board within two (2) weeks of receipt of an application in proper form and containing all necessary information.
(a) *Rescinding orders.* Nothing in this section shall be construed to prohibit the [County Administrator, Town Manager] from rescinding any orders issued hereunder when the conditions creating the need for such orders have abated.
(Ord. of XX-XX-XX)

Virginia Drought Assessment and Response Plan

Submitted by the Drought Response Technical Advisory Committee

March 28, 2003

Introduction

During the summer of 2002 Virginia experienced significant drought impacts due to precipitation deficits that dated to 1999 in most areas of the Commonwealth. While this drought did not reach the level of severity of the drought of record (1930-1932), increases in water demands when compared to the 1930's resulted in significant impacts to all sectors of Virginia's economy and society.

The intensity of these drought impacts peaked in late August 2002. Wildfire indices were at levels previously unrecorded in Virginia, the vast majority of Virginia agricultural counties had applied for Federal drought disaster designation, streamflows reached period of record lows, and thousands of individual private wells failed. During the third week of August several public water supply systems across the Commonwealth were on the brink of failure. Several large municipal systems, such as Charlottesville and Portsmouth, had less than sixty days of water supply capacity remaining in reservoirs. Several smaller rural systems that rely primarily on withdrawals from free-flowing streams, such as the towns of Farmville and Orange, had at most a few days of water supply available and were forced to severely curtail usage.

On August 30, 2002 Governor Warner took the unprecedented action of declaring a drought emergency in the majority of the Commonwealth by issuance of Executive Order #33. This executive order required the elimination of some non-essential water uses in large areas of the Commonwealth. In addition, this executive order named the Deputy Secretary of Natural Resources as the Commonwealth Drought Coordinator and charged him with the implementation of the water use restrictions. While these emergency actions were necessary in light of the drought impacts within the Commonwealth, they resulted in significant confusion and consternation among water users who were impacted.

On December 13, 2002 Governor Warner issued Executive Order #39, the Virginia Water Supply Initiative. This executive order requires the Commonwealth's Drought Coordinator to develop a formal drought assessment and response plan. In January 2003, the Deputy Secretary of Natural Resources invited a broad coalition of stakeholders to participate in a Drought Response Technical Advisory Committee chaired by the Virginia Department of Environmental Quality. This technical advisory committee was supported by the existing Virginia Drought Monitoring Task Force. Groups and agencies invited to participate or represented on the Drought Monitoring Task Force are listed below.

Mid-Atlantic Car Wash Association
National Spa and Pool Institute
Virginia Rural Water Association
Virginia Agribusiness Council
Virginia Green Industry Council
Virginia Golf Course Superintendent's Association
Virginia Association of Counties
Virginia Section of the American Water Works Association
Virginia Municipal League
Virginia Sports Turf Manager's Association
Virginia Hospitality and Travel Association
Virginia Water Well Association

Virginia Manufacturer's Association
Virginia Farm Bureau
Southern Environmental Law Center
Roanoke River Landowner's Association
Virginia Irrigation Association
City of Portsmouth
Henrico County
Town of Orange
U.S. Navy
U.S. Army Corp of Engineers
Virginia Department of Environmental Quality
Virginia Department of Emergency Management
Virginia Department of Health
Virginia Cooperative Extension Service
Virginia Department of Game and Inland Fisheries
Virginia Department of Agriculture and Consumer Services
Virginia State Climatology Office
Virginia Department of Forestry
U.S. Geological Survey
U.S. Department of Agriculture, Farm Services Agency
National Oceanic and Atmospheric Administration, National Weather Service

The Drought Response Technical Advisory Group met three times in February and March and developed the following drought assessment and response plan for the consideration of the Commonwealth Drought Coordinator. There are several key concepts that must be kept in mind as this proposal is reviewed.

The development of droughts and the development of associated impacts is very complex. The coverage of monitoring points for most drought indicators (precipitation deficits, streamflows, ground water levels, and reservoir storage) is sparse. These two facts work together to preclude the development of a truly automated, objective drought monitoring system. This proposal includes a monitoring framework that relies heavily on the professional judgment of the Virginia Drought Monitoring Task Force in the determination of drought stages in the Commonwealth.

Due to the complexity of drought impacts on differing segments of society, the responses that are proposed at each drought stage are actions that should be considered. The Commonwealth Drought Coordinator will need to evaluate reported drought conditions and the impacts associated with those conditions and decide what actions are necessary. As an example, there will likely be circumstances in the future when actions currently proposed at the drought warning stage should be initiated somewhat earlier.

From a water supply standpoint, the impacts on a particular water supply may be as dependent on the reliability of that supply as it is on the severity of drought conditions at any point in time. As an example, water supply systems that rely on small order free-flowing streams and do not have storage may experience large impacts from relatively small drought events. This variability in reliability exists in all categories of water supplies; public waterworks, large self-supplied industrial and commercial supplies, and individual residential water supplies. Nothing that is proposed in this plan should be

viewed as limiting local government or public waterworks from taking more stringent action at any time to respond to local conditions.

Drought Monitoring

The responsibility for monitoring drought conditions in the Commonwealth rests with the Virginia Drought Monitoring Task Force (DMTF), an interagency group of technical representatives from state and federal agencies responsible for monitoring natural resource conditions and the effects of drought on various segments of society. During periods of normal moisture conditions, the Virginia Department of Environmental Quality will monitor the NOAA U.S. Drought Monitor, and will produce information from this report specific to Virginia on a monthly basis. The Virginia drought map will be produced concurrent with the release of NOAA monthly and seasonal outlooks, which usually are released on the Thursday closest to the middle of the month. The DMTF will be activated with the first occurrence of *moderate drought* conditions (D1) in the Commonwealth or the occurrence of smaller scale moisture deficits that may fall beneath the level of resolution of the U.S. Drought Monitor. The DMTF will monitor the advance of drought conditions in the Commonwealth using the drought indicators listed on page 4 as other indicators such as the Standardized Precipitation Index, Palmer Drought Severity Index, Crop Moisture Index, Keetch-Byrum Drought Index, and NOAA monthly and seasonal precipitation outlooks. In addition, the DMTF will monitor the effect of advancing drought conditions on various sectors of society including agriculture, forestry, and recreation. The DMTF will produce a monthly report of current drought conditions and their effects, and will generally remain active until the NOAA U.S. Drought Monitor indicates that all drought impacts in the Commonwealth have subsided to an *unusually dry* level (D0). The DMTF may remain active after all drought impacts have subsided to an *unusually dry* level when small areas beneath the resolution of the U.S. Drought Monitor continue to experience drought impacts. The primary purpose of the drought monitoring system described below is to provide a framework for the DMTF to operate within when preparing recommendations for the declaration of various drought stages. Due to the complex nature of drought development, professional expertise must be applied to the wide range of drought monitoring data in order to develop defensible recommendations.

Drought Evaluation Regions

For the purpose of implementation of this drought response plan the Commonwealth has been divided into thirteen drought evaluation regions. The regions were established based on a consideration of river basins, climatic divisions, physiographic provinces, major geomorphologic features, and service areas of major water supplies. Regional boundaries were chosen to correspond with local government boundaries to simplify the implementation of this plan. While the regional boundaries are somewhat arbitrary, they generally correspond to regions of the Commonwealth that possess similar climatic, ground water, streamflow and water supply conditions. Drought evaluation regions for the Commonwealth are listed below and displayed in Appendix A. Towns and independent cities are only listed when they are on the boundary of a drought evaluation region. Drought evaluation regions included all towns and independent cities located within the region.

Big Sandy Drought Evaluation Region: Lee, Wise, Buchanan, Dickenson, Scott, Russell, Tazewell, Washington and Smyth Counties.

New River Drought Evaluation Region: Grayson, Wythe, Bland, Carroll, Floyd, Pulaski, Giles, and Montgomery Counties.

Roanoke River Drought Evaluation Region: Patrick, Franklin, Roanoke, Henry, Bedford, Pittsylvania, Campbell, Halifax, Charlotte, and Mecklenburg Counties.

Upper James Drought Evaluation Region: Craig, Alleghany, Bath, Highland, Botetourt, and Rockbridge Counties.

Middle James Drought Evaluation Region: Amherst, Lynchburg, Nelson, Albemarle, Appomattox, Buckingham, Fluvanna, Prince Edward, Cumberland, Goochland, Amelia, Powhatan, Chesterfield, Petersburg, Hopewell, Colonial Heights, Henrico, and Hanover Counties.

Shenandoah Drought Evaluation Region: Augusta, Rockingham, Shenandoah, Frederick, Page, Warren, and Clarke Counties.

Northern Virginia Drought Evaluation Region: Fauquier, Loudoun, Prince William, Arlington, and Fairfax Counties.

Northern Piedmont Drought Evaluation Region: Greene, Madison, Rappahannock, Orange, Culpeper, Louisa, Spotsylvania, and Stafford Counties.

Chowan Drought Evaluation Region: Lunenburg, Nottoway, Brunswick, Dinwiddie, Greensville, Sussex, Prince George, Southampton and Surry Counties.

Northern Coastal Plain Drought Evaluation Region: Caroline, King George, King William, King and Queen, Essex, Richmond, Westmoreland, Gloucester, Mathews, Middlesex, Lancaster, and Northumberland Counties.

York-James Drought Evaluation Region: Hampton, Newport News, James City, York, Charles City, and New Kent Counties.

Southeast Virginia Drought Evaluation Region: Suffolk, Isle of Wight, Chesapeake, Virginia Beach, Portsmouth, and Norfolk.

Eastern Shore Drought Evaluation Region: Northampton and Accomack Counties.

Drought Indicators

In order to monitor potential drought conditions in a uniform manner across the Commonwealth, Virginia will use four indicators to evaluate drought severity. The indicators are based on the amount of precipitation and the effect of the precipitation (or lack of precipitation) on the hydrologic system. These indicators include:

- Precipitation Deficits
- Streamflows
- Ground water levels
- Reservoir storage

Indicators will be evaluated by comparing current conditions to long term average conditions. This evaluation will be used to determine if current conditions are within a range of conditions commonly experienced or if significant drought conditions exist.

Precipitation Deficits

Precipitation deficits will be monitored by comparing current precipitation amounts with historical precipitation values as a percent of normal long-term average values. Comparisons will be made for each drought evaluation region using data compiled by the Office of the State Climatologist. Normal long-term average precipitation is defined as the mean precipitation for a thirty-year period of record for the area and time period being evaluated.

Precipitation amounts will be evaluated based on the water year (beginning October 1). Water years are a natural dividing point for water supply drought, as precipitation that falls in the first six months of a water year is analogous to putting money in the bank. Precipitation that occurs during this six month period has the potential to recharge ground water, which will sustain stream flows and support withdrawals from wells during the following six month period when moisture deficits naturally develop as evaporation and plant transpiration generally exceed precipitation. If a precipitation deficit outside of the normal range exists at the end of a water year, the precipitation records will carry forward until a normal condition is reached (i.e. if a precipitation deficit exists on October 1, precipitation records for the previous twelve months will be evaluated until the twelve month deficit is eliminated).

Because the significance of a precipitation deficit changes as the water year progresses, drought response stages will trigger at different percentages of normal depending upon the date of evaluation.

Months Analyzed	**Normal (% of Normal Precipitation)**	**Watch (% of Normal Precipitation)**	**Warning (% of Normal Precipitation)**	**Emergency (% of Normal Precipitation)**
October-December	>75.0	<75.0	<65.0	<55.0
October-January	>80.0	<80.0	<70.0	<60.0
October-February	>80.0	<80.0	<70.0	<60.0
October-March	>80.0	<80.0	<70.0	<60.0
October-April	>81.5	<81.5	<71.5	<61.5
October-May	>82.5	<82.5	<72.5	<62.5
October-June	>83.5	<83.5	<73.5	<63.5
October-July	>85.0	<85.0	<75.0	<65.0
October-August	>85.0	<85.0	<75.0	<65.0
October – September (and previous 12 months)	>85.0	<85.0	<75.0	<65.0

Streamflow

Streamflow gages representing drought evaluation regions will be used to monitor streamflow responses to drought conditions. Representative daily flow values will be compared with historic flow statistics for the period of record. Representative daily streamflows above the 25th percentile for return flow frequency will be defined as normal conditions. Representative daily streamflows between the 10th and 25th percentile for return flow frequencies will be defined as drought watch conditions. Representative daily streamflows between the 5th and 10th percentile for return flow frequencies will be defined as drought warning conditions. Representative daily streamflows below the 5th percentile for return flow frequencies will be defined as drought emergency conditions. (A streamflow that represents the 25th percentile of return flow frequencies indicates that, for the period of record, 75% of streamflows have exceeded the current flow.) Gages were selected on the basis of the availability of real-time data, period of record, and relative location within the drought evaluation region. Typically, gages were selected that monitor moderately large drainage areas on streams without significant regulation. In drought evaluation areas where no appropriate stream gages exist, this indicator will not be utilized. Gages selected to monitor drought severity in each evaluation region are listed below and displayed in Appendix B.

Big Sandy Drought Evaluation Region: Clinch River at Cleveland, USGS Station 03524000

New River Drought Evaluation Region: Reed Creek at Graham Forge, USGS Station 03167000

Roanoke River Drought Evaluation Region: Goose Creek near Huddleston, USGS Station 02059500

Upper James Drought Evaluation Region: Cowpasture River near Clifton Forge, USGS Station 02016000

Middle James Drought Evaluation Region: Appomattox River at Farmville, USGS Station 02039500

Shenandoah Drought Evaluation Region: North Fork Shenandoah near Strasburg, USGS Station 01634000

Northern Virginia Drought Evaluation Region: Accotink Creek near Annandale, USGS Station 01654000

Northern Piedmont Drought Evaluation Region: Rapidan River near Culpeper, USGS Station 01667500

Chowan Drought Evaluation Region: Meherrin River near Lawrenceville, USGS Station 02051500

Northern Coastal Plain Drought Evaluation Region: Mattaponi River near Beulahville, USGS Station 01674500

York-James Drought Evaluation Region: Chickahominy River near Providence Forge, USGS Station 02042500

Southeast Virginia Drought Evaluation Region: No stream gages available to monitor.

Eastern Shore Drought Evaluation Region: No stream gages available to monitor.

Ground Water Levels

Water table ground water monitoring wells representing drought evaluation regions will be used to monitor shallow ground water responses to drought conditions. In areas west of Route 95 it was assumed that wells completed in shallow fractured rock formations are indicative of water table conditions. Measured ground water levels will be compared with historic level statistics for the period of record. Measured ground water levels above the 25th percentile for all historic levels will be defined as normal conditions. Measured ground water levels between the10th and 25th percentiles for all historic levels will be defined as drought watch conditions. Measured ground water levels between the 5th and 10th percentile for all historic levels will be defined as drought warning conditions. Measured ground water levels below the 5th percentile for all historic levels will be defined as drought emergency conditions. Monitoring wells were selected on the basis of period of record and relative location within the drought evaluation region. Monitoring wells selected to monitor drought severity in each evaluation region are listed below and displayed in Appendix C. In drought evaluation regions where no appropriate monitoring wells exist, the ground water indicator will not be used.

Big Sandy Drought Evaluation Region: No water table monitoring wells available to monitor.

New River Drought Evaluation Region: Christiansburg Observation Well, USGS Local Number 27F 2 SOW 019

Roanoke River Drought Evaluation Region: Roanoke-Nelson Observation Well, USGS Local Number 31G 1 SOW 008

Upper James Drought Evaluation Region: Glasgow Observation Well, USGS local Number 35K 1 SOW 063

Middle James Drought Evaluation Region: Buckingham Observation Well, USGS Local Number 41H 3; Virginia Maples Observation Well, USGS Local Number 53K 19 SOW 080

Shenandoah Drought Evaluation Region: McGaheysville Observation Well, USGS Local Number 41Q 1; Blandy Farm Observation Well, USGS Local Number 46W 175

:

Northern Virginia Drought Evaluation Region: Harper's Ferry Observation Well, USGS Local Number 49Y 1 SOW 022; Arlington Cemetery Observation Well, USGS Local Number 54V 3

Northern Piedmont Drought Evaluation Region: Gordonsville Observation Well, USGS Local Number 45P 1 SOW 030

Chowan Drought Evaluation Region: Slade Farm Observation Well, USGS Local Number 57E 13 SOW 094C

Northern Coastal Plain Drought Evaluation Region: George Washington Birthplace Observation Well, USGS Local Number 55P 9

York-James Drought Evaluation Region: Toano Observation Well, USGS Local Number 56H 31 SOW 135B

Southeast Virginia Drought Evaluation Region: Brinkley Observation Well, USGS Local Number 58B 13; Pungo Observation Well, USGS Local Number 62B 1 SOW 098A

Eastern Shore Drought Evaluation Region: P. C. Kellam Observation Well, USGS Local Number 63H 6 SOW 103A; Withams Observation Well, USGS Local Number 66M 19 SOW 110S

Reservoir Storage

Storage in major reservoirs will be used as a fourth drought indicator. Major reservoirs in Virginia support a wide variety of uses that include water supply storage, electric power generation, and flow augmentation to protect water quality. Water supply reservoirs will be evaluated based on the estimated days of available usable storage. Storage of greater than 120 days will represent normal conditions, storage of 90 to 120 days will represent watch conditions, storage of 60 to 90 days will represent warning conditions, and storage of less than 60 days will represent emergency conditions. Useable storage will be calculated as that storage above the level where advanced water treatment will be required.

Several large multi-purpose reservoirs will be evaluated as drought indicators. The criteria for consideration of drought stages are listed below for these reservoirs. Pool elevations of these reservoirs will be compared to benchmark elevations in relation to mean sea level (msl) or U.S. Army Corp of Engineers operating guide curves as indicated in the following table.

	NORMAL	DROUGHT WATCH	DROUGHT WARNING	DROUGHT EMERGENCY
Smith Mountain Lake	>793 feet msl	793 to 791.5 feet msl	791.5 to 790 feet msl	< 790 feet msl
Lake Moomaw	>1565 feet msl	1565 to 1562.5 feet msl	1562.5 to 1560 feet msl	< 1560 feet msl
Lake Anna	> 248 feet msl	248 to 246 feet msl	246 to 244 feet msl	< 244 feet msl
Kerr Reservoir	< 3 feet below the guide curve	3 to 6 feet below the guide curve	> 6 feet below the guide curve	< 288 feet msl

Reservoirs that will be used to monitor drought conditions are listed below. In drought evaluation regions where no appropriate reservoirs exist, this indicator will not be used.

Big Sandy Drought Evaluation Region: Big Cherry Water Supply Reservoir

New River Drought Evaluation Region: No reservoirs will be monitored.

Roanoke River Drought Evaluation Region: Smith Mountain Lake, Kerr Reservoir

Upper James Drought Evaluation Region: Lake Moomaw

Middle James Drought Evaluation Region: Lake Moomaw, Charlottesville Water Supply Reservoir System

Shenandoah Drought Evaluation Region: Switzer Water Supply Reservoir

Northern Virginia Drought Evaluation Region: Occoquan Water Supply Reservoir, Lake Manassas Water Supply Reservoir

Northern Piedmont Drought Evaluation Region: Lake Anna, Spotsylvania Water Supply Reservoir System

Chowan Drought Evaluation Region: Emporia Water Supply Reservoir

Northern Coastal Plain Drought Evaluation Region: Gloucester Water Supply Reservoir

York-James Drought Evaluation Region: Newport News Water Supply Reservoir System

Southeastern Virginia Drought Evaluation Region: Kerr Reservoir, Portsmouth Water Supply Reservoir System

Eastern Shore Drought Evaluation Region: No reservoirs will be monitored.

Other Indicators

The DMTF will evaluate all other available drought information during deliberations related to the development of drought stage recommendations. Other drought indicators that will be considered include the Standardized Precipitation Index, Palmer Drought Severity Index, Crop Moisture Index, and NOAA monthly and seasonal precipitation outlooks.

When streamflows or ground water levels at the selected monitoring sites previously listed indicate drought conditions, the DMTF will monitor other stream gages and ground water monitoring wells that are available.

The DMTF will evaluate the Cumulative Severity Index developed by the Virginia Department of Forestry (VDOF) and the Keech-Byrum Drought Index to determine the potential impact of drought on forests and the potential for wildfire starts. In addition, the DMTF will consider the number of wildfire starts and the number of acres of forest burned as supplied by the VDOF as indicators of drought impacts on forestry.
The DMTF will evaluate information compiled by the Virginia Agricultural Statistics Service to assess the impacts of drought on agricultural interests in the state. The DMTF will also rely on the input of local agricultural extension agents through the Virginia Cooperative Extension Service to document actual drought impacts through the Commonwealth. In addition, the DMTF will evaluate the number of requests for federal

drought disaster designation as reported by the Virginia Department of Agriculture and Consumer Services.

The DMTF will consider operating conditions at public waterworks in the determination of drought recommendations. The Virginia Department of Health (VDH) monitors the conditions of many public waterworks in the Commonwealth on a monthly basis. At a minimum, individual public waterworks typically contact the VDH when they experience water supply problems that are due to drought. VDH will continue to provide support to these waterworks and will continue monthly reporting of water supply problems. These monthly reports will be used as an additional indicator of drought severity in the Commonwealth. In addition, the DMTF will consider the number of private well replacement permits issued by the VDH as an indication of drought impacts to persons served by this type of system.

Declaration of Drought Stages

The DMTF will use the four drought indicators; precipitation deficits, streamflows, ground water levels, and reservoir levels; as the initial indicators to be considered when making a recommendation concerning the declaration of a particular drought stage. When two indicators exceed the threshold for stage determination, the DMTF will evaluate all other drought information and provide a recommendation to the Virginia Drought Coordinator. This recommendation may be to declare a specific drought stage or the recommendation may include an explanation of why the particular drought stage should not be declared at that time. Conversely, the DMTF may recommend the declaration of a particular drought stage prior to the exceedance of threshold levels for two of the four indicators. Recommendations for declaration of specific drought stages will generally be based on the drought evaluation regions previously described. It is likely that conditions may exist where the DMTF may recommend the declaration of a specific drought stage for a portion of a drought evaluation region. Recommendations for declaration of a portion of a drought evaluation region may be based on differing climatic conditions within the area or differences in the ability of specific waterworks to reliably provide water during drought conditions.

As an example, when two of the four drought indicators indicate drought warning conditions, the DMTF will evaluate all other drought information available and, if the majority of information warrants declaration, recommend the declaration of a drought warning in the drought evaluation region where these conditions exist. In all cases, the final decision regarding the declaration of a particular drought stage will be at the discretion of the Virginia Drought Coordinator. Any local government may declare local drought emergencies, adopt emergency ordinances to address those local emergencies and implement those ordinances prior to the declaration of a Drought Emergency by the Governor of Virginia.

The DMTF will use the following general descriptions of four drought stages when making recommendations to the Virginia Drought Coordinator concerning drought declarations in the Commonwealth. These descriptions should not be viewed as absolute requirements for drought designation, but as a mechanism to be used by the DMTF to reach consensus on the appropriate drought recommendations.

Normal Conditions

No more than one indicator outside of the normal range:

- Precipitation exceeds the percent of normal precipitation for the time period in precipitation table
- Streamflows are above the 25th percentile
- Ground water levels are above the 25th percentile for all historic levels
- Water Supply Reservoirs exceed 120 days of useable storage or appropriate criteria for non-water supply reservoirs

Drought Watch

At least 2 indicators meet the following conditions:

- Precipitation levels are at or below the percent of normal precipitation for the time period in precipitation table
- Streamflows fall between the 10th and 25th percentile
- Ground water levels fall between the 10th and 25th percentile for all historic levels
- Water Supply Reservoirs contain between 90 and 120 days of useable storage or appropriate criteria for non-water supply reservoirs

Drought Warning

At least 2 indicators meet the following conditions:

- Precipitation levels are at or below the percent of normal precipitation for the time period in precipitation table
- Streamflows fall between the 5th and 10th percentile
- Measured ground water levels fall between the 5th and 10th percentile for all historic levels
- Reservoirs contain between 60 and 90 days of useable storage or appropriate criteria for non-water supply reservoirs

Drought Emergency

At least 2 indicators meet the following conditions:

- Precipitation levels are at or below the percent of normal precipitation for the time period in precipitation table
- Streamflows are at or below the 5th percentile
- Measured ground water levels fall are at or below the 5th percentile for all historic levels
- Reservoirs contain 60 days or less of useable storage or appropriate criteria for non-water supply reservoirs

Responses to Drought in Virginia

The impacts of drought on society are broad reaching and complex. In addition, the nature of a particular drought event is dependent on the time of year, the long-term duration of precipitation deficits, the immediate impacts of short-term precipitation deficits within a period of general precipitation deficits, and many other interrelated factors. In short, every significant drought has a particular signature and the impacts of no two droughts will be identical. Due to the complex nature of droughts, responses to individual drought events must be tailored to the impacts that are being propagated. The specific response activities that are delineated below for the three drought stages should

be viewed as activities that will generally be initiated and not as required activities that are "written in stone".

Drought watch responses are generally responses that are intended to increase awareness, in the public and private sector, to climatic conditions that are likely to precede the occurrence of a significant drought event. During this drought stage the primary activities that are suggested are to prepare for the onset of a drought event. It is unlikely that significant water use reductions will occur at this stage although it is possible that the increased public awareness of water conservation activities may reduce water use up to 5%.

Drought warning responses are generally responses that are required when the onset of a significant drought event is imminent. Water conservation and contingency plans that have been prepared during a drought watch stage would begin to be implemented. From the perspective of the Commonwealth, water conservation activities at this stage would generally be voluntary. Voluntary water conservation activities generally result in reductions in water use of 5-10%.

Drought emergency responses are generally responses that are required during the height of a significant drought event. During these times, it is likely that some water supplies will not supply the amount of water needed by all users and non-essential uses of water should be eliminated. Mandatory water conservation requirements contained in water conservation and contingency plans should be initiated at this stage. Mandatory water conservation activities generally result in water use reductions of 10-15%.

While actions on the State level are important for the purpose of alerting localities and citizens of the advance of drought impacts, actions by local governments, individual water suppliers, and individual citizens are much more important and effective in actually addressing the impacts of drought. Water sources used by public waterworks and self-supplied water users vary considerably across the Commonwealth. Water conservation requirements for water users whose only source of water supply is a free-flowing stream with no significant storage will likely be different than requirements for a water user who relies entirely on a reservoir system for water supply. The development of a drought water conservation and contingency plan that takes into account the nature of a particular water source and the nature of the end use of water withdrawn is necessary to assure that proper water conservation activities are instituted at the proper times. In general, water supplies that rely on sources with significant storage (reservoir and ground water based systems) will realize greater benefits of water conservation activities initiated early in a drought cycle when compared to supplies that rely solely on free-flowing streams. It is likely that individual private well users, especially those who rely on shallow water table wells, will receive the largest benefit from their early individual initiation of water conservation activities.

The following responses will generally be made upon declaration of individual drought stages.

Drought Watch

- The Virginia Drought Coordinator will declare a statewide or regional Drought Watch and will issue a press release indicating the reasons for the declaration.
- The Virginia Drought Coordinator will notify all local governments within the drought watch area of drought watch status.

- The Virginia Drought Coordinator will report the drought watch declaration to the Governor's Cabinet and request the assistance of all state agencies in the implementation of the drought response plan.
- The VDH will inform all public waterworks within the drought watch area of drought watch status.
- The Virginia Cooperative Extension Service will cooperate with all state agencies owning or controlling impoundments and/or river access to identify sources that may be used by livestock producers for emergency livestock watering during declared drought emergencies. VCE will inform livestock producers of these opportunities and will provide contact information necessary to access these sources.
- The DMTF will continue to monitor statewide moisture conditions and provide monthly reports of drought conditions to the Virginia Drought Coordinator who will update the Governor's Cabinet.
- The DMTF will make monthly reports of drought conditions available to media outlets within the drought watch area.
- The Virginia Drought Coordinator will encourage all public waterworks and self-supplied water users who withdraw more than 10,000 gallons per day to develop or review existing drought water conservation and contingency plans.
- All DMTF agencies will include water conservation information on their websites and will distribute water conservation information as broadly as possible.
- All executive branch agencies and institutions will review existing drought water conservation and contingency plans or develop new plans with the goal of reducing water usage by 15% during declared drought emergencies.
- VDH will continue monitoring problems incurred by public waterworks on a monthly basis.
- VDH will encourage all public waterworks to aggressively pursue leak detection and repair programs.
- Local governments and public waterworks may impose water use restrictions consistent with local water supply conditions at any time.

Drought Warning

- The Virginia Drought Coordinator will declare a statewide or regional Drought Warning and will issue a press release indicating the reasons for the declaration.
- The Virginia Drought Coordinator will notify all local governments within the drought warning area of drought warning status.
- The Virginia Drought Coordinator will advise the Governor and his Cabinet regarding the necessity of authorizing the Departments of State Police, Transportation and Motor Vehicles to grant temporary overweight/overwidth/registration/license exemptions to carriers transporting essential emergency relief supplies into and through the Commonwealth in order to support disaster response and recovery.
- The VDH will inform all public waterworks within the drought warning area of drought warning status.
- The Virginia Department of Agriculture and Consumer Services will cooperate with the Virginia Association of Counties, the Virginia Municipal League, Virginia Cooperative Extension, the Virginia Farm Bureau Federation and the Virginia Agribusiness Council in notifying agricultural communities, agriculture

interest groups and local governments within the drought warning area of the potential for federal agricultural drought disaster designation. VDACS will also work with VACO, VML, VCE, VFBF and VAC in communicating the appropriate procedure for local governments to use in applying to the Governor for federal disaster designation.

- The DMTF will continue to monitor statewide moisture conditions and provide monthly reports of drought conditions to the Virginia Drought Coordinator. Significant changes in drought conditions will be reported biweekly.
- The Virginia Drought Coordinator will update the Governor's Cabinet concerning drought conditions on a biweekly basis.
- The Governor's Press Office will encourage media outlets within the drought warning area to publicize updates of drought conditions by developing biweekly press releases.
- All local governments will be encouraged to review existing local ordinances requiring mandatory non-essential water use restrictions or adopt such ordinances consistent with the mandatory non-essential water use restrictions listed below.
- All public waterworks and self-supplied water users who withdraw more than 10,000 gallons per day will initiate voluntary water conservation requirements contained in drought water conservation and contingency plans.
- All public waterworks and self-supplied water users who withdraw more than 10,000 gallons per day that have not developed drought water conservation and contingency plans will be encouraged to voluntarily reduce or eliminate non-essential uses of water including the elimination of non-essential flushing of water lines.
- All persons who utilize any source of water for outdoor irrigation will assure that the minimum amount of water is utilized in the most efficient manner practical.
- All self-supplied users who withdraw less than 10,000 gallons per day, including private well users, will be encouraged to voluntarily reduce or eliminate non-essential uses of water.
- All executive branch agencies and institutions will initiate the reduction or elimination of non-essential uses of water with the goal of reducing total water usage by 5-10%.
- VDH will continue monitoring problems incurred by public waterworks on a monthly basis.
- Local governments and public waterworks may impose water use restrictions consistent with local water supply conditions at any time.

Drought Emergency

- The Governor will declare a statewide or regional Drought Emergency by executive order and will issue a press release indicating the reasons for the declaration.
- The Virginia Drought Coordinator will notify all local governments within the drought emergency area of drought emergency status.
- The VDH will inform all public waterworks within the drought emergency area of drought emergency status.
- The DMTF will continue to monitor statewide moisture conditions and provide monthly reports of drought conditions to the Virginia Drought Coordinator. Significant changes in drought conditions will be reported weekly.

- The Virginia Drought Coordinator will update the Governor's Cabinet concerning drought conditions on a weekly basis.
- The Governor's Press Office will encourage media outlets within the drought emergency area to publicize updates of drought conditions by developing weekly press releases.
- All public waterworks and self-supplied water users who withdraw more than 10,000 gallons per day will initiate mandatory water conservation requirements contained in drought water conservation and contingency plans that include the mandatory non-essential water use restrictions listed on page 16.
- All public waterworks and self-supplied water users who withdraw more than 10,000 gallons per day that have not developed drought water conservation and contingency plans initiate the mandatory non-essential water use restrictions listed below including the elimination of non-essential flushing of water lines.
- All self-supplied users, who withdraw less than 10,000 gallons per day, including private well users, will initiate the mandatory non-essential water use restrictions listed below.
- All executive branch agencies and institutions will implement drought water conservation and contingency plans with the goal of reducing water usage by 15% that include the mandatory non-essential water use restrictions listed on page 16.
- Local governments and public waterworks may impose water use restrictions more stringent than the mandatory non-essential water use restrictions listed below consistent with local water supply conditions at any time.
- For the duration of the declared drought emergency the Director of the Department of Environmental Quality shall be authorized to allocate ground water and surface water resources and to restrict any withdrawals based upon the adequacy of the resource to meet the necessary beneficial uses as set forth in §62.1-44.36 of the Code of Virginia. Such allocations may apply to any withdrawer and shall over-ride any existing authorizations to use or withdraw surface water or ground water.
- For the duration of the declared drought emergency the State Forester shall be authorized to declare open burning bans in wild fire susceptible areas of the Commonwealth.
- For the duration of the declared drought emergency the Departments of State Police, Transportation and Motor Vehicles shall be authorized to grant temporary overweight/overwidth/registration/license exemptions to carriers transporting essential emergency relief supplies into and through the Commonwealth in order to support the disaster response and recovery.
- Volume I, Virginia Emergency Operations Plan (COVEOP) Basic Plan, July 1997 as amended shall be implemented by agencies of the state and local government along with other appropriate state agency plans.
- The Virginia Emergency Operations Center (VEOC) and State Emergency Response Team (SERT) will be activated to coordinate state operations in support of affected localities and the Commonwealth, to include issuing mission assignments to agencies designated in the COVEOP and others that may be identified by the State Coordinator of Emergency Management, in consultation with the Secretary of Public Safety, which are needed to provide for the preservation of life, protection of property and implementation of recovery activities.

- Local governments of the Commonwealth will be authorized to adopt local ordinances to enforce the mandatory non-essential water use restrictions listed below and to establish, collect, and retain fines for violations of these restrictions. Nothing contained in this drought response plan should be construed to limit the powers of local government to adopt and enforce local emergency ordinances as necessary to protect the public welfare, safety and health.

Mandatory Non-essential Water Use Restrictions

The following non-essential water uses will be prohibited during periods of declared drought emergencies. Please note the exceptions that follow each prohibited use. These prohibitions and exceptions will apply to uses from all sources of water and will only be effective when the Governor of Virginia declares a Drought Emergency through the issuance of an executive order. Water use restrictions shall not apply to the agricultural production of food or fiber, the maintenance of livestock including poultry, nor the commercial production of plant materials so long as best management practices are applied to assure the minimum amount of water is utilized.

Unrestricted irrigation of lawns is prohibited.

- Newly sodded and seeded areas may be irrigated to establish cover on bare ground at the minimum rate necessary for no more than a period of 60 days. . Irrigation rates may not exceed one inch of applied water in any 7 day period.
- Gardens, bedding plants, trees, shrubs and other landscape materials may be watered with hand held containers, hand held hoses equipped with an automatic shutoff device, sprinklers or other automated watering devices at the minimum rate necessary but in no case more frequently than twice per week. Irrigation should not occur during the heat of the day.
- All allowed lawn irrigation must be applied in a manner to assure that no runoff, puddling or excessive watering occurs.
- Irrigation systems may be tested after installation, routine maintenance or repair for no more than ten minutes per zone.

Unrestricted irrigation of golf courses is prohibited.

- Tees and greens may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary.
- Localized dry areas may be irrigated with a hand held container or hand held hose equipped with an automatic shutoff device at the minimum rate necessary.
- Greens may be cooled by syringing or by the application of water with a hand held hose equipped with an automatic shutoff device at the minimum rate necessary.
- Fairways may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary not to exceed one inch of applied water in any ten-day period.
- Fairways, tees and greens may be irrigated during necessary overseeding or resodding operations in September and October at the minimum rate necessary. Irrigation rates during this restoration period may not exceed one inch of applied water in any seven-day period.

- Newly constructed fairways, tees and greens and areas that are re-established by sprigging or sodding may be irrigated at the minimum rate necessary not to exceed one inch of applied water in any seven-day period for a total period that does not exceed 60 days.
- Fairways, tees and greens may be irrigated without regard to the restrictions listed above so long as:
  - The only water sources utilized are water features whose primary purpose is stormwater management,
  - Any water features utilized do not impound permanent streams,
  - During declared Drought Emergencies these water features receive no recharge from other water sources such as ground water wells, surface water intakes, or sources of public water supply, and,
  - All irrigation occurs between 9:00 p.m. and 10:00 a.m.
- All allowed golf course irrigation must be applied in a manner to assure that no runoff, puddling or excessive watering occurs.
- Rough areas may not be irrigated.

Unrestricted irrigation of athletic fields is prohibited.

- Athletic fields may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. at a rate not to exceed one inch per application or more than a total of one inch in multiple applications during any ten-day period. All irrigation water must fall on playing surfaces with no outlying areas receiving irrigation water directly from irrigation heads.
- Localized dry areas that show signs of drought stress and wilt (curled leaves, foot-printing, purpling) may be syringed by the application of water for a cumulative time not to exceed fifteen minutes during any twenty four hour period. Syringing may be accomplished with an automated irrigation system or with a hand held hose equipped with an automatic shutoff device at the minimum rate necessary.
- Athletic fields may be irrigated between the hours of 9:00 p.m. and 10:00 a.m. during necessary overseeding, sprigging or resodding operations at the minimum rate necessary for a period that does not exceed 60 days. Irrigation rates during this restoration period may not exceed one inch of applied water in any seven-day period. Syringing is permitted during signs of drought stress and wilt (curled leaves, foot-printing, purpling).
- All allowed athletic field irrigation must be applied in a manner to assure that no runoff, puddling or excessive watering occurs.
- Irrigation is prohibited on athletic fields that are not scheduled for use within the next 120-day period.
- Water may be used for the daily maintenance of pitching mounds, home plate areas and base areas with the use of hand held containers or hand held hoses equipped with an automatic shutoff device at the minimum rate necessary.
- Skinned infield areas may utilize water to control dust and improve playing surface conditions utilizing hand held containers or hand held hoses equipped with an automatic shutoff device at the minimum rate necessary no earlier than two hours prior to official game time.

Washing paved surfaces such as streets, roads, sidewalks, driveways, garages, parking areas, tennis courts, and patios is prohibited.

- Driveways and roadways may be pre-washed in preparation for recoating and sealing.
- Tennis courts composed of clay or similar materials may be wetted by means of a hand-held hose equipped with an automatic shutoff device at the minimum rate necessary for maintenance. Automatic wetting systems may be used between the hours of 9:00 p.m. and 10:00 a.m. at the minimum rate necessary.
- Public eating and drinking areas may be washed using the minimum amount of water required to assure sanitation and public health.
- Water may be used at the minimum rate necessary to maintain effective dust control during the construction of highways and roads.

Use of water for washing or cleaning of mobile equipment including automobiles, trucks, trailers and boats is prohibited.

- Mobile equipment may be washed using hand held containers or hand held hoses equipped with automatic shutoff devices provided that no mobile equipment is washed more than once per calendar month and the minimum amount of water is utilized.
- Construction, emergency or public transportation vehicles may be washed as necessary to preserve the proper functioning and safe operation of the vehicle.
- Mobile equipment may be washed at car washes that utilize reclaimed water as part of the wash process or reduce water consumption by at least 10% when compared to a similar period when water use restrictions were not in effect.
- Automobile dealers may wash cars that are in inventory no more than once per week utilizing hand held containers and hoses equipped with automatic shutoff devices, automated equipment that utilizes reclaimed water as part of the wash process, or automated equipment where water consumption is reduced by at least 10% when compared to a similar period when water use restrictions were not in effect.
- Automobile rental agencies may wash cars no more than once per week utilizing hand held containers and hoses equipped with automatic shutoff devices, automated equipment that utilizes reclaimed water as part of the wash process, or automated equipment where water consumption is reduced by at least 10% when compared to a similar period when water use restrictions were not in effect.
- Marine engines may be flushed with water for a period that does not exceed 5 minutes after each use.

Use of water for the operation of ornamental fountains, artificial waterfalls, misting machines, and reflecting pools is prohibited.

- Fountains and other means of aeration necessary to support aquatic life are permitted.

Use of water to fill and top off outdoor swimming pools is prohibited.

- Newly built or repaired pools may be filled to protect their structural integrity.
- Outdoor pools operated by commercial ventures, community associations, recreation associations, and similar institutions open to the public may be refilled as long as:
  - Levels are maintained at mid-skimmer depth or lower,
  - Any visible leaks are immediately repaired,
  - Backwashing occurs only when necessary to assure proper filter operation,

    - Deck areas are washed no more than once per calendar month (except where chemical spills or other health hazards occur),
    - All water features (other than slides) that increase losses due to evaporation are eliminated, and
    - Slides are turned off when the pool is not in operation.
- Swimming pools operated by health care facilities used in relation to patient care and rehabilitation may be filled or topped off.
- Indoor pools may be filled or topped off.
- Residential swimming pools may be filled only to protect structural integrity, public welfare, safety and health and may not be filled to allow the continued operation of such pools.

Water may be served in restaurants, clubs, or eating-places only at the request of customers.

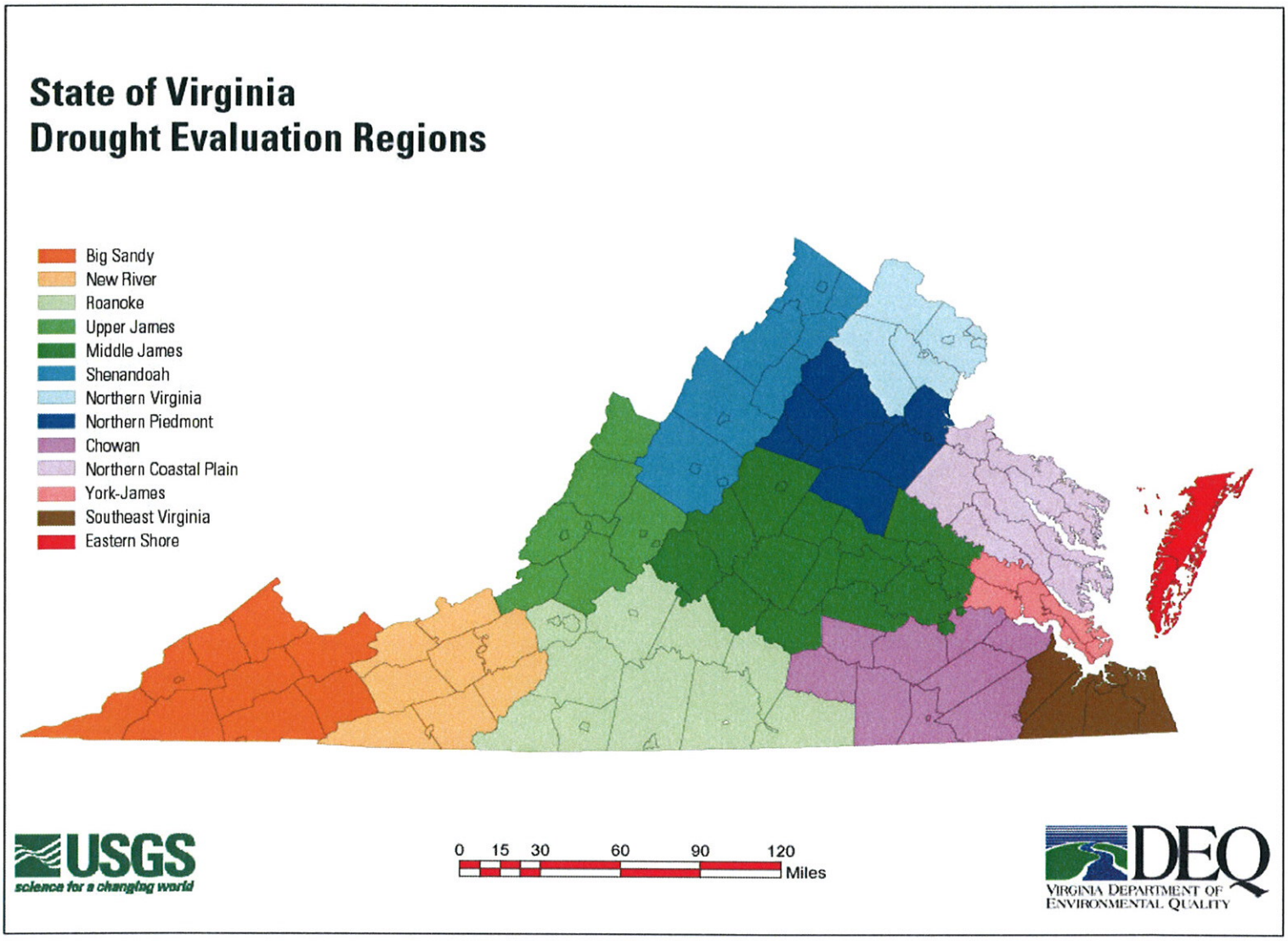
All residential, business and industrial water users; whether supplied by public water supplies, self-supplied sources, or private water wells; who do not normally utilize water for any of the listed prohibited uses are requested to voluntarily reduce water consumption by at least 10%. This reduction may be the result of elimination of other non-essential water uses, application of water conservation practices, or reduction in essential water uses.

Water Rationing

In some cases, the mandatory non-essential water use restrictions may not be sufficient to protect the supplies of an individual public waterworks. When an individual waterworks' sources are so depleted as to threaten public health and safety, it may become necessary to ration water within that system in order to assure that water is available to support essential uses. Rationing water is a more severe measure than merely banning nonessential uses of water. Under rationing, each customer is allotted a given amount of water, based on a method of allotment developed by the waterworks or local government. Generally it will be based on a percentage of previous usage or on a specific daily quantity per household. Rationing is more likely to have some effect on welfare than mandatory non-essential use restrictions, because industrial and commercial water uses may be curtailed or eliminated to assure an adequate supply is available for human consumptive uses.

The decision to ration water will typically be made by the local government or waterworks operator. The Virginia Drought Coordinator will work closely with any entity where water rationing is required to assure that all available State resources are effectively used to support these highly stressed water supply systems. The Virginia Department of Emergency Management (VDEM) is the first point of contact for waterworks or local governments who decide to ration water. VDEM will coordinate the Commonwealth's response and assistance to such entities.

Appendix A


State of Virginia
Drought Evaluation Regions
Big Sandy
New River
Roanoke
Upper James
Middle James
Shenandoah
Northern Virginia
Northern Piedmont
Chowan
Northern Coastal Plain
York-James
Southeast Virginia
Eastern Shore
USGS
science for a changing world
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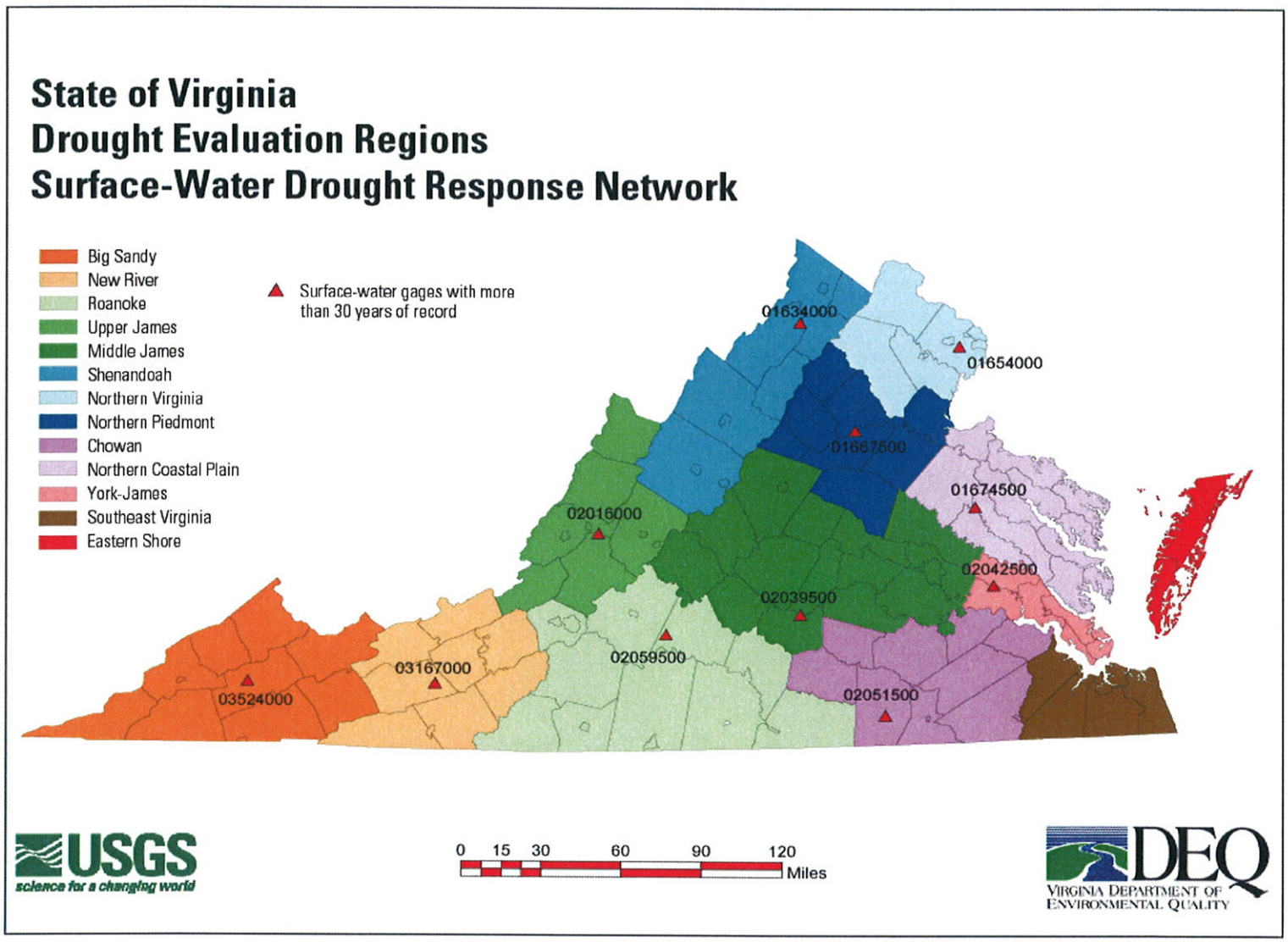
Miles
DEQ
Virginia Department of
Environmental Quality

Appendix B


State of Virginia
Drought Evaluation Regions
Surface-Water Drought Response Network
Big Sandy
New River
Roanoke
Upper James
Middle James
Shenandoah
Northern Virginia
Northern Piedmont
Chowan
Northern Coastal Plain
York-James
Southeast Virginia
Eastern Shore
Surface-water gages with more than 30 years of record
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01667500
01674500
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02039500
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USGS
science for a changing world
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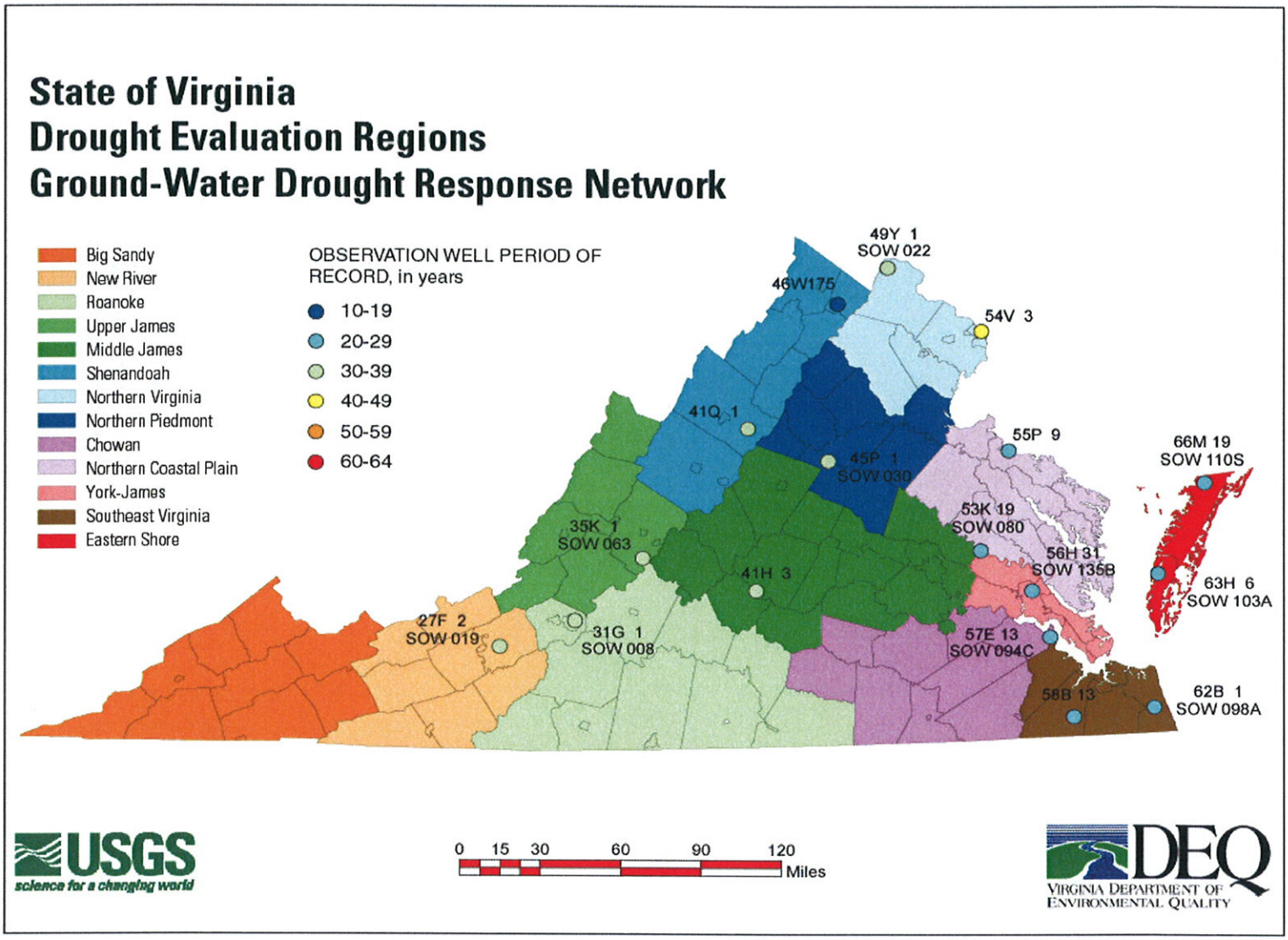
Miles
DEQ
Virginia Department of Environmental Quality

Appendix C


State of Virginia
Drought Evaluation Regions
Ground-Water Drought Response Network
Big Sandy
New River
Roanoke
Upper James
Middle James
Shenandoah
Northern Virginia
Northern Piedmont
Chowan
Northern Coastal Plain
York-James
Southeast Virginia
Eastern Shore
OBSERVATION WELL PERIOD OF RECORD, in years
10-19
20-29
30-39
40-49
50-59
60-64
49Y 1 SOW 022
46W175
54V 3
41Q 1
55P 9
66M 19 SOW 110S
45P 1 SOW 030
53K 19 SOW 080
35K 1 SOW 063
56H 31 SOW 135B
41H 3
63H 6 SOW 103A
27F 2 SOW 019
31G 1 SOW 008
57E 13 SOW 094C
58B 13
62B 1 SOW 098A
USGS
science for a changing world
0 15 30 60 90 120 Miles
DEQ
Virginia Department of Environmental Quality

APPENDIX L

Summary table of the Reservoirs study for the Northern Neck Development Commission, Volume II.
Prepared By Martin, Clifford & Associates, Engineers and Consultants,
January, 1969

TABLE VIII-4

PRELIMINARY DESIGN DATA-WATER SUPPLY RESERVOIRS

NORTHERN NECK AREA

Key	Stream	Drainage Area Acres	Drainage Area Sq.Mi.	Sediment Volume Acre Ft.	Flood Storage Volume Acre Ft.	Flood & Sediment Volume Acre Ft.	Water Supply Volume Min. AcreFt.	Water Supply Volume Max. AcreFt.
WCP1	Cat Point Creek	5553	8.68	231	1851	2082	594	2422
WCP2	Cat Point Creek	4365	6.82	182	1455	1637	467	1904
WCP3	Cat Point Creek	2748	4.29	115	916	1031	294	1199
RCP4	Cat Point Creek	2159	3.73	90	720	810	231	942
RCP5	Cat Point Creek	1107	1.73	46	369	415	118	483
RCP6	Cat Point Creek	2446	3.82	102	815	917	262	1067
RCP7	Cat Point Creek	2117	3.31	88	706	794	226	923
RCP8	Cat Point Creek	1496	2.34	62	499	561	160	653
WN1	Nomini Creek	1965	3.07	82	655	737	210	857
WN2	Nomini Creek	1845	2.88	77	615	692	197	805
WN3	Nomini Creek	7038	11.00	293	1994	2287	752	3069
WN4	Nomini Creek	6678	10.43	278	421	699	714	2910
WM1	Mattox Creek	8773	13.70	366	2924	3290	938	3287
WP1	Popes Creek	4654	7.27	194	657	851	498	2028
WPD1	Peedee Creek	1020	1.59	43	340	383	109	445
WPD2	Peedee Creek	1579	2.47	66	526	592	169	689
WHH1	Hampton Hall Creek	4321	6.75	180	1440	1620	462	1885
RWL1	Wilna Creek	2062	3.22	86	687	773	220	899
RWL2	Wilna Creek	960	1.50	40	320	360	103	419
NHH2	Hampton Hall Creek	2709	4.23	113	---	113	290	959
NMC1	Mill Creek	2633	4.11	110	878	987	281	1148
NBM1	Bush Mill Stream-Wic.R.	2045	3.20	85	682	767	219	892
NBM2	Bush Mill Stream-Wic.R.	2602	4.07	108	867	976	278	1135
NBM3	Bush Mill Stream-Wic.R.	4127	6.45	172	1376	1548	441	1800
NHR1	Head River Br.-Wic.R.	2490	3.89	104	830	934	266	1086
NSM1	Sydnor's Mill Creek	3586	5.60	149	1195	1345	383	1564
LMS1	McMahon Swamp-Cor. R.	3390	5.30	141	1130	1271	363	1479
LMS2	McMahon Swamp-Cor. R.	2657	4.15	111	886	996	284	1159
LCR1	McMahon Swamp-Cor. R.	5495	8.59	229	1093	1322	588	2397
IBB1	Balls Br.-Lancaster Cr.	1287	2.01	54	429	483	138	561
LLB1	Little Branch - Cor.R.	2694	4.21	112	450	562	288	1174
LLB2	Little Branch - Cor.R.	1178	1.84	49	393	442	126	792
LBC1	Browns Creek	1985	3.10	83	662	745	212	866
LCM1	Camps Millpond	3944	6.16	164	---	164	422	685
LQC1	Quarter Cove	1794	2.80	75	598	673	192	783
NL1	Lodge Creek	7843	12.25	327	---	327	839	1868
RTC1	Totuskey Creek	7117	11.12	297	2172	2469	761	3105
RTC3	Totuskey Creek	3846	6.01	160	1282	1442	411	1678
RBMS1	Bookers Mill Stream	5050	7.89	210	1683	1894	540	2203
RTC4	Totuskey Creek	7842	12.25	327	---	327	839	1976
RMS1	Marshy Swamp	4820	7.53	201	1607	1808	515	2103
RMS2	Marshy Swamp	2433	3.80	101	811	913	260	1062
NWR1	Wicomico River	4164	6.51	174	1388	1562	445	1817

Wic. R. = Wicomico River
Cor. R. = Corrotoman River

TABLE VIII-4 (Cont'd.)

PRELIMINARY DESIGN DATA-WATER SUPPLY RESERVOIRS

NORTHERN NECK AREA

Water Supply Draft Max. M.G.D.	Water Supply Draft Safe M.G.D.	Fish & Wildlife Volume Acre.Ft.	Excess Storage Available Acre Ft.	Total Normal Pool Volume Acre.Ft.	Normal Pool Maximum Elev.	Normal Pool Maximum Area Acres	Flood Pool Maximum Elev.	Flood Pool Maximum Area Acres	Dam Top Elev.	Dam Ht. Ft.	Total Maximum Storage Acre.Ft.
2.51	0.75	703	5427	8783	96	470	100	536	106	66	10634
1.97	0.59	522	6479	9087	99	570	100	585	106	52	10542
1.24	0.37	220	----	1534	78	190	80	205	86	32	2450
0.97	0.29	273	1756	3061	77	180	80	210	86	30	3781
0.50	0.15	140	2706	3375	78	160	80	170	86	61	3744
1.10	0.33	310	945	2424	38	190	40	205	46	41	3239
0.96	0.28	268	1378	2657	76	147	80	180	86	61	3363
0.68	0.20	189	3508	4412	98	222	100	245	106	61	4911
0.89	0.26	96	----	1035	37	92	40	105	46	30	1690
0.83	0.25	233	2095	3210	57	168	60	192	66	56	3825
3.18	0.95	---	----	3362	36	265	40	312	46	41	5356
3.02	0.90	---	----	3188	39	250	40	265	46	46	3609
3.96	1.18	1110	1413	6176	36	405	40	570	46	41	9100
2.10	0.63	---	----	2222	35	185	40	230	46	31	2879
0.46	0.14	129	3579	4196	98	190	100	210	106	66	4536
0.71	0.21	200	2193	3228	76	155	80	182	86	61	3754
1.95	0.58	547	5255	7867	57	460	60	522	66	56	9307
0.93	0.28	261	4789	6035	57	250	60	275	66	66	6722
0.43	0.13	121	2645	3225	77	140	80	155	86	66	3545
1.22	0.36	---	----	1072	40	85	40	85	46	32	1072
1.19	0.35	175	----	1432	38	150	40	163	46	36	2310
0.92	0.27	178	----	1155	13	116	20	183	26	26	1837
1.18	0.35	329	3749	5322	57	300	60	350	66	66	6189
1.86	0.55	522	1355	3849	58	340	60	390	66	36	5225
1.12	0.33	315	1122	2627	37	195	40	214	46	41	3457
1.62	0.48	454	1784	3952	37	300	40	328	46	36	5147
1.53	0.46	429	1514	3563	37	250	40	275	46	46	4693
1.20	0.36	210	----	1479	56	130	60	150	66	36	2365
2.48	0.74	---	----	2397	38	270	40	340	46	42	3719
0.58	0.17	167	----	783	58	74	60	90	66	31	1212
1.22	0.36	---	----	1286	39	140	40	155	46	40	1736
0.53	0.16	116	----	957	39	80	40	105	46	43	1350
0.90	0.27	251	911	2111	38	170	40	185	46	36	2773
1.78	0.53	---	----	849	20	170	20	170	26	16	849
0.81	0.24	227	62	1147	37	110	40	122	46	36	1745
3.54	1.05	---	----	2195	40	118	40	118	46	44	2195
3.21	0.96	---	----	3402	36	350	40	395	46	29	5574
1.74	0.52	487	3689	6014	37	520	40	640	46	29	7296
2.28	0.68	639	3784	6837	79	480	80	730	86	41	8520
3.54	1.05	---	----	2303	40	162	40	162	46	29	2303
2.18	0.65	364	----	2668	56	235	60	290	66	49	4275
1.10	0.33	308	1032	2504	76	190	80	315	86	31	3315
1.88	0.56	527	1005	3523	37	270	40	310	46	46	4911