Dissolved Oxygen (DO) Assessment For Virginia Beach

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1. INTRODUCTION

1.1 Background

The Clean Water Act (CWA) that became law in 1972 requires that all U.S. streams, rivers, and lakes meet certain water quality standards. The CWA also requires that states conduct monitoring to identify waters that are polluted or do not otherwise meet standards. Through this required program, the state of Virginia has found that many stream segments do not meet state water quality standards for protection of the six beneficial uses: recreation/swimming, aquatic life, wildlife, fish consumption, shellfish consumption, and public water supply (drinking).

When streams fail to meet standards, Section 303(d) of the CWA and the U.S. Environmental Protection Agency's (EPA) Water Quality Management and Planning Regulation (40 CFR Part 130) both require that states develop a Total Maximum Daily Load (TMDL) for each pollutant. A TMDL is a "pollution budget" for a stream; that is, it sets limits on the amount of pollution that a stream can tolerate and still maintain water quality standards. In order to develop a TMDL, background concentrations, point source loadings, and nonpoint source loadings are considered. A TMDL accounts for seasonal variations and must include a margin of safety (MOS).

Once a TMDL is developed and approved by EPA, measures must be taken to reduce pollution levels in the stream. Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) states in section 62.1-44.19:7 that the *"Board shall develop and implement a plan to achieve fully supporting status for impaired waters"*. The TMDL Implementation Plan (IP) describes control measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), which should be implemented in a staged process. Through the TMDL process, states establish water-quality based controls to reduce pollution and meet water quality standards.

The study area for this project is in the Virginia Beach and Chesapeake areas. The impaired segments include Albemarle Canal, North Landing River, West Neck Creek, Milldam Creek and Nawney Creek (Figure 1.1). The Virginia Department of

Environmental Quality (VADEQ) has identified all of these segments as impaired with regard to fecal bacteria. For the purposes of this report, this watershed shall be referred to as the Virginia Beach study area.

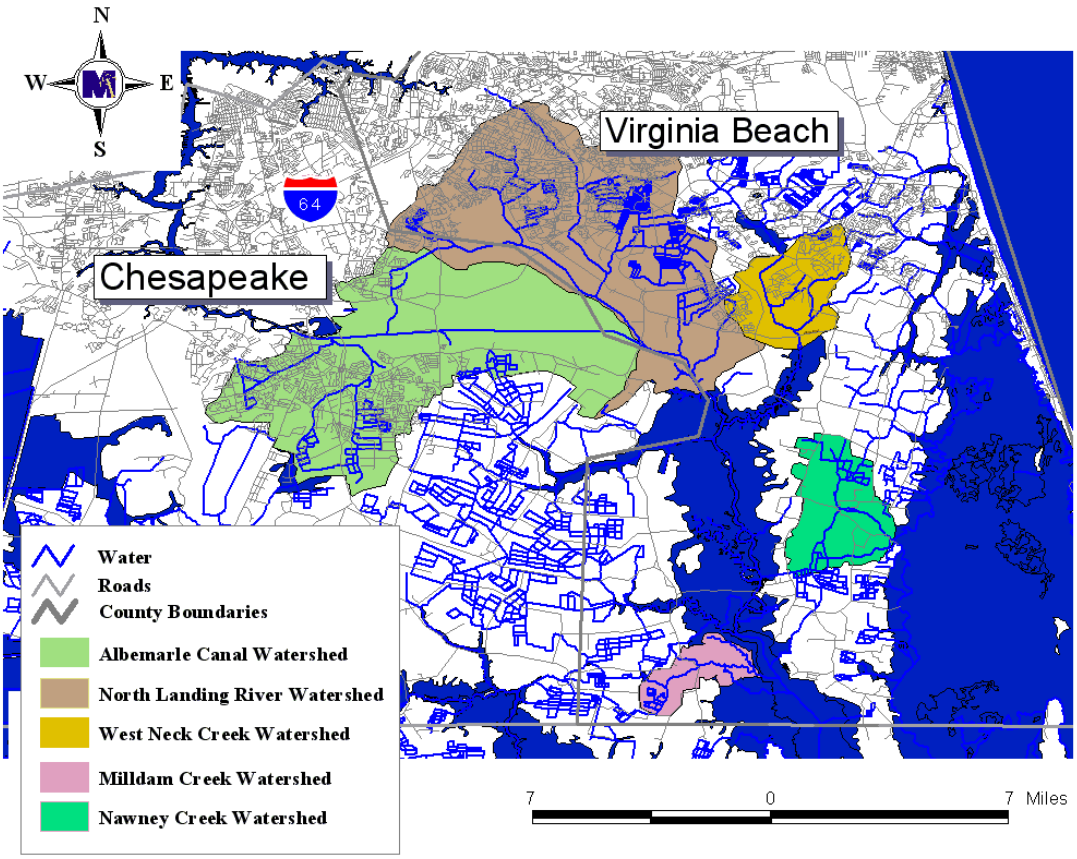

Figure 1.1 Location of the Virginia Beach study area watersheds.

Table 1.1 lists, for each impairment, the VADEQ water quality monitoring station used for impaired waters assessment, the initial year that the segment was listed in the Section 303(d) list and current miles affected in the 2008 listing. Figure 1.2 shows the current impaired segments.

Albemarle Canal (VAT-K41R_AAC01A06), North Landing River (VAT-K41R_NLR02A06) and Milldam Creek (VAT-K41R_MLD02A06) were initially listed on the 2002 list for violations of the minimum dissolved oxygen (DO) water quality standard. West Neck Creek (VAT-K41R_WNC01A00) and Nawney Creek (VAT-

K42E_NWN01A00) were initially listed in 1998 and 2004 respectively for violations of the minimum dissolved oxygen water quality standard.

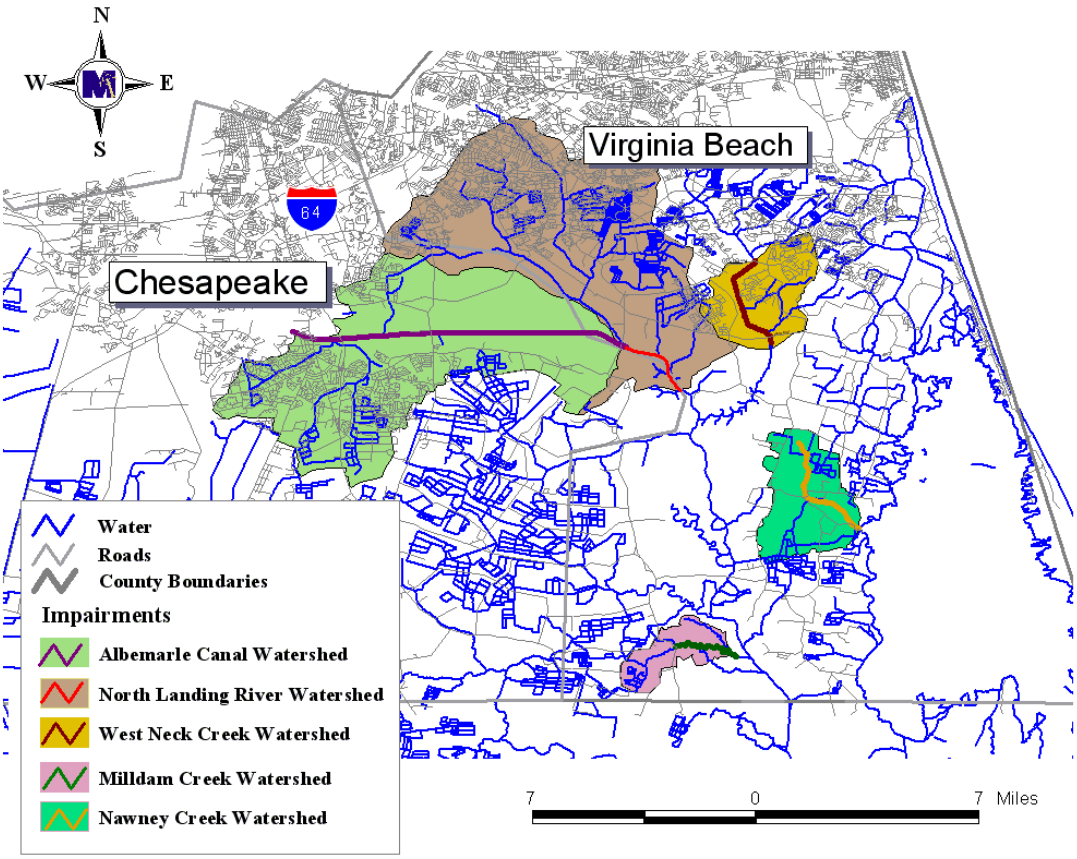

Figure 1.2 Impaired stream segments in the Virginia Beach study area.

Table 1.1 Dissolved oxygen impairments on the *2008 Section 305(b)/303(d) Water Quality Integrated Report* within the Virginia Beach area.

Stream Name HUP	Listing Station ID(s)	Initial Listing Year	River Length Affected (miles)	2008 303(d) List Dissolved Oxygen Violations/ Total Samples	Location
Albemarle Canal VAT-K41R_AAC01A06	5BAAC001.31 5BAAC000.49	2002	8.8	NA	Great locks bridge to North Landing River confluence
North Landing River-middle VAT-K41R_NLR02A06	5BNLR013.61 5BNLR012.19	2002	2.23	NA	Intercoastal waterway (RM 13.65) to instream island (RM 12.01) near West Neck Creek confluence
West Neck Creek-middle VAT-K41R_WNC01A00	5BWNC003.65	1998	3.59	NA	Princess Anne road crossing to just downstream of Indian River Road crossing
Milldam Creek-lower VAT-K41R_MLD02A06	5BMLD001.92	2002	2.5	NA	Blackwater Road crossing to North Landing River confluence
Nawney Creek-upper VAT-K42E_NWN01A00	5BNWN001.84	1996	0.02 sq mi	16/62	Above Nawney Creek Road Bridge to just below Nawney Creek Road Bridge
Nawney Creek-lower VAT-K42E_NWN02A00	5BNWN000.00	2008	0.02 sq mi	8/71	From Nawney Creek bridge downstream to Back Bay confluence

NA – segments were not sampled during the 2008 303(d) listing cycle.

1.2 *Virginia Beach Area Watershed Characteristics*

The Virginia Beach study area watershed is entirely located within the level III Middle Atantic Coastal Plain ecoregion. The level IV subset for all of the stream in the study area with the exception of Milldam Creek is the Chesapeake-Pamlico Lowlands and Tidal Marshes ecoregion. This level IV ecoregion is "universally low in elevation and is characterized by nearly flat terrain, terraces, tidal marshes, ponds, and swampy streams." Brackish wetlands are common and serve as habitat for fish, shellfish, and wildfowl. Elevations range from 0 to 50 feet (0-15 m) and relief is less than 35 feet (11 m); surrounding ecoregions are both higher and better drained. This ecoregion is underlain by unconsolidated lower terrace sediments of Quaternary age. Alluvial sand and silt, estuarine sand and silt, saline marsh deposits, and marine sand, silt, and clay are common; swamp deposits occur. Ultisols and Histosols have commonly developed from residuum. They support a potential natural vegetation of Oak-Hickory-Pine Forest (dominants: hickory, longleaf pine, shortleaf pine, loblolly pine, white oak and post oak), Northern Cordgrass Prairie, and Southern Floodplain Forest.

Streams are usually low in gradient, sluggish, tidally influenced, poorly incised, and lack a defined channel; they are fed by shallow groundwater aquifers and become brackish as they begin to mix with the Chesapeake Bay. Wide riparian wetlands occur and channelization is common. Stream water is often high in both natural acidity and dissolved organic carbon and is often stained.

Extensive tidal marshes and salt estuarine bay marshes are found on the poorly drained soils of the silty low terraces of this ecoregion. The tidal marshes are most extensive on the lower Eastern Shore of the Chesapeake Bay; here, the terrain is low and tidal marshes extend farther inland than in other coastal areas. Dominant brackish marsh plant species are: a) big cordgrass along margins of tidal creeks and ponds; b) hightide bush along the higher periphery of marshes; c) saltmeadow cordgrass in marsh meadows; d) saltmarsh cordgrass - saltmeadow cordgrass on well-drained tidal flats; e) olney three-square in extensive, poorly drained, shallow depressions normally covered with surface water; and f) saltgrass. Salt estuarine bay marshes are found in lower Chesapeake Bay waters where salinity is relatively high and tidal fluctuations are narrow.

Today, forests and agriculture including corn and soybean farming are found where natural or artificial drainage is sufficient. Urban and industrial areas are found near large harbors and poultry operations are locally common.

The ecoregions boundary sometimes follows the scarp dividing low terraces from interior uplands and typically includes areas that have a high concentration of tidal marshes. The border between this ecoregion and the Dismal Swamp was based primarily on the swamp deposit polygon (qsp); qsp is exclusively limited to the Dismal Swamp. The boundary between this ecoregion and the Rolling Coastal Plain was defined on the basis of topography, surficial deposits, and soils. The border of this ecoregion and the Delmarva Uplands roughly follows the inner limit of the STATSGO MD005 polygon (silty Othello, Elkton, and Mattapex soils) and is near the aeb polygon (alluvial and estuarine sand and silt). The boundary of this ecoregion with the higher, hillier, Chesapeake Rolling Coastal Plain is near the line surrounding STATSGO polygon MD005 (silty Othello, Elkton, and Mattapex soils) and the alluvial and estuarine sand and silt polygon. (http://www.eoearth.org/article/Ecoregions_of_Delaware%2C_Maryland%2C_Pennsylvania%2C_Virginia%2C_and_West_Virginia_(EPA).

Milldam Creek lies with in the Level IV subset Virginia Barrier Islands and Coastal Marshes. This Level IV ecoregion is "composed of beaches, dunes, low terraces, beach ridges, and barrier islands that are fringed by lagoons, bays, tidal salt marshes, mudflats, anastomosing tidal channels, or ocean. An extensive barrier – back barrier system parallels much of the Atlantic shore. Elevations range from only 35 feet (11 m) to sea level.

The Barrier Islands - Coastal Marshes ecoregion is more exposed to the open ocean than other nearby regions and, resultantly, its landforms are more dynamic. Significant wave and wind action occurs and has affected both landforms and the position of the shoreline itself. In the last 10,000 years, the overall trend for the sandy coastline has been westward retreat; from the mid-1950s or mid-1960s to the early-1980s, net erosion averaged five feet (1.5 m) per year. The barrier islands, in particular, have been heavily affected by hurricanes while protecting the mainland from erosion.

The Barrier Islands - Coastal Marshes ecoregion is underlain by Quaternary unconsolidated sand, silt, and clay that were laid down as beach, dune, barrier beach, saline marsh, terrace, and nearshore marine deposits. Soils are mostly Entisols, Ultisols, and Inceptisols.

The potential natural vegetation of the ecoregion is mapped as mostly Northern Cordgrass Prairie and contrasts with the natural hardwood vegetation of the Delmarva Uplands. The dunes and strand support only a few species of xerophilous herbaceous plants and are characteristically unwooded. Oak-Hickory-Pine Forest occurs in better drained, higher areas; dominants are hickory (Carya spp.), shortleaf pine (Pinus echinata), loblolly pine (Pinus taeda), white oak (Quercus alba), and post oak (Quercus stella).

This ecoregion and, particularly, its barrier islands contain many unique habitats for wildlife; large areas have been set aside as state parks, wildlife refuges, and national seashore. Several of Virginia's rarest birds, including the piping plover, Wilson's plover, and the gull billed tern nest in the sand of the Barrier Islands - Coastal Marshes. In addition, loggerhead turtles use its barrier island beaches as nest sites.

The Barrier Islands - Coastal Marshes is found adjacent to the ocean and includes beaches, dunes, low terraces, beach ridges, and barrier islands. Its western boundary with the Delmarva Uplands generally follows a long, often poorly defined, east-facing scarp that parallels the present shoreline at about 20 feet (6 m) above sea level. As such it includes upper Pleistocene and younger deposits (Mixon and others, 1989)." (http://www.eoearth.org/article/Ecoregions_of_Delaware%2C_Maryland%2C_Pennsylvania%2C_Virginia%2C_and_West_Virginia_(EPA).

As for the climatic conditions in the Virginia Beach study area watersheds, during the period from 1946 to 2008 Norfolk WSO Airport, Virginia (NCDC station# 446139) received an average annual precipitation of approximately 46.6 inches, with 58% of the precipitation occurring during the May through October growing season (SERCC, 2009). Average annual snowfall is 7.1 inches, with the highest snowfall occurring during February (SERCC, 2009). The highest average daily temperature of 87.5 ºF occurs in

July, while the lowest average daily temperature of 34.3 ºF occurs in January (SERCC, 2009).

2. WATER QUALITY ASSESSMENT APPLICABLE WATER QUALITY STANDARDS

According to 9 VAC 25-260-5 of Virginia's State Water Control Board *Water Quality Standards,* the term "water quality standards" means "…provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law and the federal Clean Water Act."

As stated in Virginia state law 9 VAC 25-260-10 (Designation of uses),

> *A. All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.*
>
> ♦
>
> *D. At a minimum, uses are deemed attainable if they can be achieved by the imposition of effluent limits required under §§301(b) and 306 of the Clean Water Act and cost-effective and reasonable best management practices for nonpoint source control.*

Virginia's current water quality standards, with the 2008 amendments, require the following for dissolved oxygen concentrations. See Table 2.1.

Table 2.1 VAC 25-260-50. Numerical criteria for dissolved oxygen, pH, and maximum temperature

CLASS	DESCRIPTION OF WATERS	Dissolved Oxygen (mg/L) Min	Daily Avg	pH	Maximum Temperature (^oC)
I	Open Ocean	5.0	--	6.0-9.0	--
II	Tidal Waters in the Chowan Basin and the Atlantic Ocean	4.0	5.0	6.0-9.0	--
II	Tidal waters in the Chesapeake Bay and its tidal tributaries	see VAC 25-260-185		6.0-9.0	
III	Nontidal Waters Coastal and Piedmont Zones	4.0	5.0	6.0-9.0	32
IV	Mountainous Zones Waters	4.0	5.0	6.0-9.0	31
V	Stockable Trout Waters	5.0	6.0	6.0-9.0	21
VI	Natural Trout Waters	6.0	7.0	6.0-9.0	20
VII	Swamp Waters	*	*	4.3-9.0*	**

*This classification recognizes that the natural quality of these waters may fall outside of the ranges for D.O. and pH set forth above as water quality criteria; therefore, on a case-by-case basis, criteria for specific Class VII waters can be developed which reflect the natural quality of the waterbody. Virginia Pollutant Discharge Elimination System limitations in Class VII waters shall meet pH of 6.0 - 9.0.
** Maximum temperature will be same for Classes I through VI waters as appropriate.

The dissolved oxygen criteria used in developing the dissolved oxygen TMDL(s) in this study is outlined in Class II (Tidal waters in the Chowan Basin and Atlantic Ocean) in the table above.

2.1 Discussion of In-Stream Water Quality

This section provides an inventory and analysis of available observed in-stream monitoring data in the Virginia Beach study area watersheds. An examination of data from water quality stations used in the 303(d) assessment was. Sources of data and pertinent results are discussed.

2.1.1 Inventory of Water Quality Monitoring Data

The primary sources of available water quality information are:

- DO, pH, temperature, oxygen demand indicators, orgnic solids and nutrient samples from seven VADEQ in-stream monitoring stations,

2.1.1.1 VADEQ Water Quality Monitoring for TMDL Assessment

Data from in-stream water samples, collected at VADEQ monitoring stations from January 1998 through August 2009 (Figure 2.1) were analyzed for dissolved oxygen, pH, conductivity, biochemical oxygen demand (BOD_5), total organic solids, temperature, nitrate-nitrogen (NO3-N), total nitrogen (TN) and total phosphorus (TP) (Tables 2.2 – 2.10). Dissolved oxygen, temperature and pH measurements were made for the express purpose of determining compliance with the state water quality standards. There are currently no water quality standards for nutrients, total organic solids, conductivity and BOD_5. Tables 2.2 – 2.10 summarize the dissolved oxygen, pH, temperature, nitrate nitrogen, total nitrogen, total phosphorus, BOD_5 and conductivity results from the in-stream monitoring stations. The tables are arranged in alphabetical order by stream name then from downstream to upstream station location. A discussion of pertinent water quality parameters will follow. See Figure 2.1.

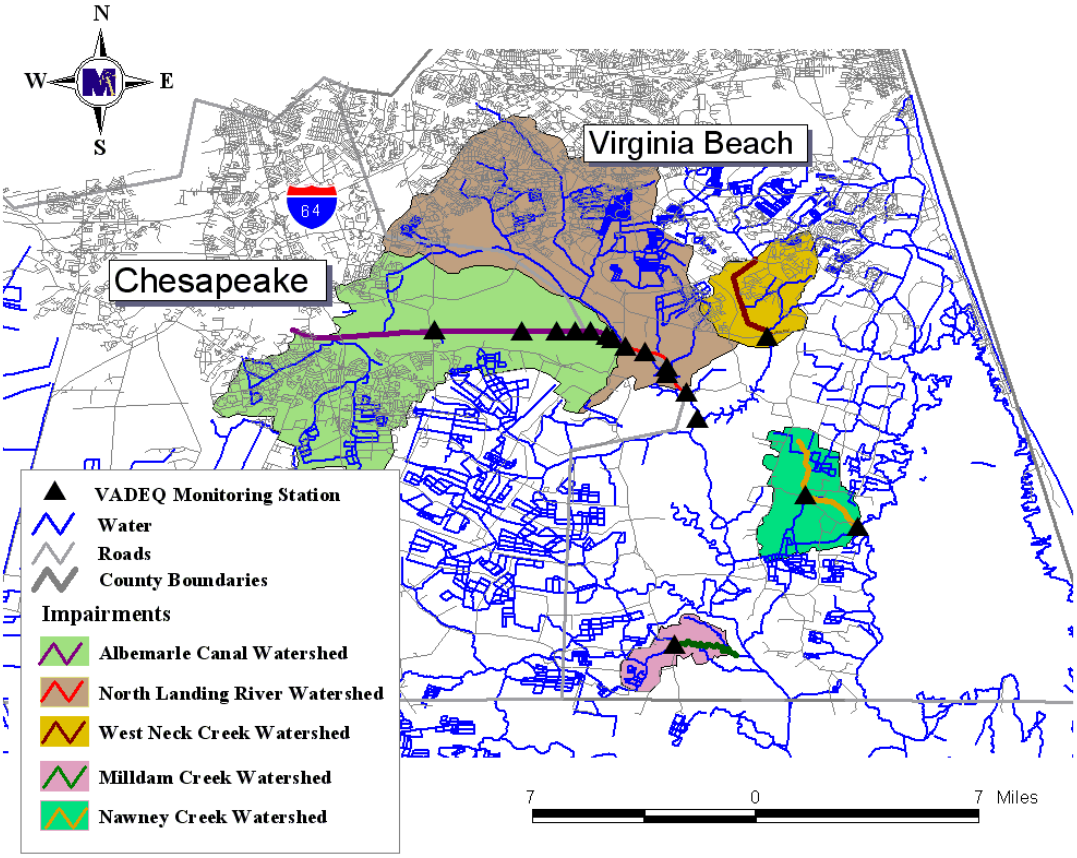

Figure 2.1 Location of VADEQ water quality monitoring stations in the Virginia Beach study area.

Table 2.2 Summary of DO (mg/L) data collected by VADEQ from January 1998 - August 2009.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %
Albemarle Canal	5BAAC000.30	8/09	1	2.50	2.50	2.50	NA	NA	100%
Albemarle Canal	5BAAC000.49	8/06	1	6.70	6.70	6.70	NA	NA	0.00%
Albemarle Canal	5BAAC000.93	8/09	1	3.60	3.60	3.60	NA	NA	100%
Albemarle Canal	5BAAC001.31	8/04	1	1.52	1.52	1.52	NA	NA	100%
Albemarle Canal	5BAAC001.79	8/09	1	2.90	2.90	2.90	NA	NA	100%
Albemarle Canal	5BAAC002.62	8/09	1	2.90	2.90	2.90	NA	NA	100%
Albemarle Canal	5BAAC004.83	8/09	1	4.20	4.20	4.20	NA	NA	0.00%
Milldam Creek	5BMLD001.92	1/98 - 8/09	91	1.20	12.30	5.77	5.51	2.53	29.67%
Nawney Creek	5BNWN000.00	1/98 - 5/09	78	2.36	13.21	7.62	7.44	2.62	10.26%
Nawney Creek	5BNWN001.84	1/98 - 5/09	80	0.39	13.44	6.01	5.25	3.12	27.50%
North Landing River	5BNLR010.49	8/09	1	5.40	5.40	5.40	NA	NA	0.00%
North Landing River	5BNLR011.44	8/09	1	3.70	3.70	3.70	NA	NA	100%
North Landing River	5BNLR012.19	'7/03	1	2.89	2.89	2.89	NA	NA	100%
North Landing River	5BNLR012.39	8/09	1	4.20	4.20	4.20	NA	NA	0.00%
North Landing River	5BNLR013.07	8/09	1	4.90	4.90	4.90	NA	NA	0.00%
North Landing River	5BNLR013.61	1/98 - 4/09	88	0.85	14.41	6.50	6.31	3.06	21.59%
West Neck Creek	5BWNC003.65	1/98 - 5/09	86	0.14	14.70	6.62	6.30	2.91	18.60%

Table 2.3 Summary of pH (std units) data collected by VADEQ from January 1998 - August 2009.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %
Albemarle Canal	5BAAC000.30	8/09	1	6.90	6.90	6.90	NA	NA	0.00%
Albemarle Canal	5BAAC000.49	8/06	1	7.00	7.00	7.00	NA	NA	0.00%
Albemarle Canal	5BAAC000.93	8/09	1	6.80	6.80	6.80	NA	NA	0.00%
Albemarle Canal	5BAAC001.31	8/04	1	6.94	6.94	6.94	NA	NA	0.00%
Albemarle Canal	5BAAC001.79	8/09	1	6.90	6.90	6.90	NA	NA	0.00%
Albemarle Canal	5BAAC002.62	8/09	1	6.90	6.90	6.90	NA	NA	0.00%
Albemarle Canal	5BAAC004.83	8/09	1	6.90	6.90	6.90	NA	NA	0.00%
Milldam Creek	5BMLD001.92	1/98 - 5/09	91	6.09	11.40	6.72	6.65	0.57	0.00%
North Landing River	5BNLR010.49	8/09	1	7.40	7.40	7.40	NA	NA	0.00%
North Landing River	5BNLR011.44	8/09	1	7.20	7.20	7.20	NA	NA	0.00%
North Landing River	5BNLR012.19	7/03	2	6.89	6.89	6.89	NA	NA	0.00%
North Landing River	5BNLR012.39	8/09	1	6.90	6.90	6.90	NA	NA	0.00%
North Landing River	5BNLR013.07	8/09	1	7.00	7.00	7.00	NA	NA	0.00%
North Landing River	5BNLR013.61	1/98 - 4/09	89	6.21	7.74	6.82	6.80	0.24	0.00%
Nawney Creek	5BNWN000.00	1/98 - 5/09	77	6.01	10.10	7.02	6.93	0.62	0.00%
Nawney Creek	5BNWN001.84	1/98 - 5/09	79	5.94	8.30	6.81	6.75	0.46	1.27%
West Neck Creek	5BWNC003.65	1/98 - 5/09	85	6.02	8.39	6.99	7.00	0.42	0.00%

Table 2.4 Summary of temperature (^{o}celsius) data collected by VADEQ from January 1998 - August 2009.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Albemarle Canal	5BAAC000.30	8/09	1	27.80	27.80	27.80	NA	NA	NA
Albemarle Canal	5BAAC000.49	8/06	1	27.70	27.70	27.70	NA	NA	NA
Albemarle Canal	5BAAC000.93	8/09	1	28.00	28.00	28.00	NA	NA	NA
Albemarle Canal	5BAAC001.31	8/04	1	27.70	27.70	27.70	NA	NA	NA
Albemarle Canal	5BAAC001.79	8/09	1	28.50	28.50	28.50	NA	NA	NA
Albemarle Canal	5BAAC002.62	8/09	1	29.00	29.00	29.00	NA	NA	NA
Albemarle Canal	5BAAC004.83	8/09	1	29.00	29.00	29.00	NA	NA	NA
Milldam Creek	5BMLD001.92	1/98 - 5/09	91	1.39	29.10	16.47	16.10	7.80	NA
North Landing River	5BNLR010.49	8/09	1	28.80	28.80	28.80	NA	NA	NA
North Landing River	5BNLR011.44	8/09	1	28.90	28.90	28.90	NA	NA	NA
North Landing River	5BNLR012.19	7/03	1	29.67	29.67	29.67	NA	NA	NA
North Landing River	5BNLR012.39	8/09	1	29.10	29.10	29.10	NA	NA	NA
North Landing River	5BNLR013.07	8/09	1	27.90	27.90	27.90	NA	NA	NA
North Landing River	5BNLR013.61	1/98 - 4/09	89	1.49	29.50	17.59	17.78	8.51	NA
Nawney Creek	5BNWN000.00	1/98 - 5/09	79	0.00	29.40	16.79	15.00	8.25	NA
Nawney Creek	5BNWN001.84	1/98 - 5/09	81	0.50	28.46	16.16	14.56	7.97	NA
West Neck Creek	5BWNC003.65	1/98 - 5/09	87	0.20	28.50	15.99	15.33	8.04	NA

[1] There is no maximum temperature standard for Class II waters.

Table 2.5 Summary of NO3-N (mg/L) data collected by VADEQ from January 1998 - August 2006.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Albemarle Canal	5BAAC000.49	8/06	1	0.07	0.07	0.07	NA	NA	NA
Albemarle Canal	5BAAC001.31	8/04	1	0.12	0.12	0.12	NA	NA	NA
Milldam Creek	5BMLD001.92	1/98 - 5/09	54	0.02	1.50	0.16	0.04	0.27	NA
North Landing River	5BNLR012.19	7/03	1	0.18	0.18	0.18	NA	NA	NA
North Landing River	5BNLR013.61	1/98 - 5/03	53	0.04	0.33	0.13	0.13	0.07	NA
Nawney Creek	5BNWN000.00	1/98 - 5/03	48	0.04	2.90	0.48	0.13	0.74	NA
Nawney Creek	5BNWN001.84	1/98 - 5/03	48	0.04	1.93	0.53	0.40	0.56	NA
West Neck Creek	5BWNC003.65	1/98 - 5/03	49	0.04	0.31	0.11	0.09	0.08	NA

[1] there is no water quality standard for NO_3-N.

Table 2.6 Summary of TN (mg/L) data collected by VADEQ from January 1998 - May 2009.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Milldam Creek	5BMLD001.92	1/98 - 3/09	89	0.76	5.54	1.63	1.43	0.69	NA
North Landing River	5BNLR013.61	1/98 - 4/09	88	0.55	3.32	1.40	1.24	0.53	NA
Nawney Creek	5BNWN000.00	1/98 - 5/09	83	0.88	6.35	2.14	1.87	0.99	NA
Nawney Creek	5BNWN001.84	1/98 - 5/09	84	0.51	4.38	2.16	2.02	0.86	NA
West Neck Creek	5BWNC003.65	1/98 - 5/09	84	0.46	2.46	1.11	0.98	0.45	NA

[1] there is no water quality standard for TN.

Table 2.7 Summary of TP (mg/L) data collected by VADEQ from January 1998 - May 2009.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Milldam Creek	5BMLD001.92	1/98 - 3/09	89	0.01	0.68	0.21	0.19	0.11	NA
North Landing River	5BNLR013.61	1/98 - 4/09	89	0.01	0.38	0.15	0.13	0.07	NA
Nawney Creek	5BNWN000.00	1/98 - 5/09	84	0.01	0.44	0.12	0.10	0.07	NA
Nawney Creek	5BNWN001.84	1/98 - 5/09	86	0.01	2.68	0.24	0.20	0.30	NA
West Neck Creek	5BWNC003.65	1/98 - 5/09	86	0.01	0.30	0.13	0.12	0.07	NA

[1] there is no water quality standard for TP.

Table 2.8 Summary of BOD_5 (mg/L) data collected by VADEQ from January 1998 - July 2001.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Milldam Creek	5BMLD001.92	1/98 - 6/01	42	2.00	7.00	3.17	3.00	1.29	NA
North Landing River	5BNLR013.61	1/98 - 6/01	40	2.00	6.00	2.40	2.00	0.96	NA
Nawney Creek	5BNWN000.00	1/98 - 7/01	37	2.00	6.00	3.22	3.00	1.08	NA
Nawney Creek	5BNWN001.84	1/98 - 7/01	38	2.00	20.00	3.97	3.00	3.29	NA
West Neck Creek	5BWNC003.65	1/98 - 7/01	38	2.00	5.00	2.82	3.00	0.87	NA

[1] there is no water quality standard for BOD_5.

Table 2.9 Summary of conductivity (μmhos/cm) data collected by VADEQ from January 1998 – May 2009.

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Milldam Creek	5BMLD001.92	1-98 - 5/03	42	137	4,930	1,236	799	1,172	NA
North Landing Creek	5BNLR013.61	1-98 - 5/03	42	441	13,800	4,455	3,512	3,420	NA
Nawney Creek	5BNWN000.00	1-98 - 5/03	37	160	5,930	2,418	2280	1,682	NA
Nawney Creek	5BNWN001.84	1-98 - 5/03	37	202	4,973	1,325	739	1,259	NA
West Neck Creek	5BWNC003.65	1-98 - 5/03	37	213	10,140	2,510	1370	2,767	NA

[1] there is no water quality standard for conductivity.

Table 2.10 Summary of total organic solids (mg/L) data collected by VADEQ from January 1998 - May 2003

Stream	Station	Date	Count	Minimum	Maximum	Mean	Median	Standard Deviation	Violation %[1]
Milldam Creek	5BMLD001.92	1/98 - 5/03	54	41	632	156	102	128	NA
North Landing River	5BNLR013.61	1/98 - 5/03	54	62	1,740	434	296	373	NA
Nawney Creek	5BNWN000.00	1/98 - 5/03	47	55	780	253	204	178	NA
Nawney Creek	5BNWN001.84	1/98 - 5/03	47	47	604	162	91	129	NA
West Neck Creek	5BWNC003.65	1/98 - 5/03	48	53	9,470	483	152	1,372	NA

[1] there is no water quality standard for total organic solids.

3. ASSESSMENT OF NATURAL CONDITIONS

This chapter utilizes the approach for determining the level to which DO and pH impaired streams are impacted by natural conditions, and the resulting justification for proceeding with TMDL development or choosing an alternative path (*e.g.*, revision of the water quality standard) (MapTech, 2003). The procedure developed by MapTech requires four specific criteria be applied to an impaired stream to determine whether the impairment is naturally occurring or the result of anthropogenic acitivities. The four criteria are described below:

1. Are wetlands present in the impaired segment? Natural conditions associated with low dissolved oxygen (DO) and low pH involve slow moving streams with little slope that have high dissolved organic matter and have a brownish-yellow color. The breakdown of organic matter can deplete oxygen concentrations, and the organic acids that are produced lower the pH.

2. Are there excessive nutrients in the stream? High nutrient concentrations can cause reductions in dissolved oxygen concentrations by accelerating the rate of organic matter decomposition in streams. USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L. Streams with average concentrations of nutrients greater than the national background concentrations are considered to have impacts from anthropogenic sources.

3. Does DO vary seasonally (i.e., oxygen deficit in the summer)? Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. A weak

seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

4. Is there evidence of human impact that warrants the development of a TMDL? Point sources should be identified and analyzed to determine if there is any impact on the stream DO or pH concentrations. Violations of other water quality standards (e.g., benthic, *E. coli*) for a stream segment could indicate that anthropogenic sources are affecting the DO and/or pH levels. Land use analysis can also be a valuable tool for identifying potential human impacts.

Following the application of the four criteria listed above, four outcomes are possible and are noted below:

1. If one or more of the four analyses indicate the presence of an anthropogenic source, and the indicators of natural causes are NOT present, then natural conditions are NOT likely, and TMDL development should be pursued.

2. If one or more of the four analyses indicate the presence of an anthropogenic source, but the indicators of natural causes are present, then natural conditions are likely being compounded by anthropogenic sources, and TMDL development should be pursued.

3. If none of the four analyses indicate the presence of an anthropogenic source, but the indicators of natural causes are NOT present, then natural conditions are NOT likely, and TMDL development should be pursued.

4. If none of the four analyses indicate the presence of an anthropogenic source, and the indicators of natural causes are present, then natural conditions are likely, and a change in the water quality standard should be pursued.

3.1 Albemarle Canal /North Landing River

The Albemarle Canal and North Landing River were assessed as not supporting the Aquatic Life Use designation on Virginia's 2002 303(d) list based on violations of VADEQ's water quality standard for minimum dissolved oxygen concentrations. DO water quality standard violations were recorded at five monitoring stations on the Albemarle Canal and three on the North Landing River between January 1998 and August 2009. Figures 3.1 shows VADEQ monitoring station 5BNLR013.61 (the only station with enough data to graph).

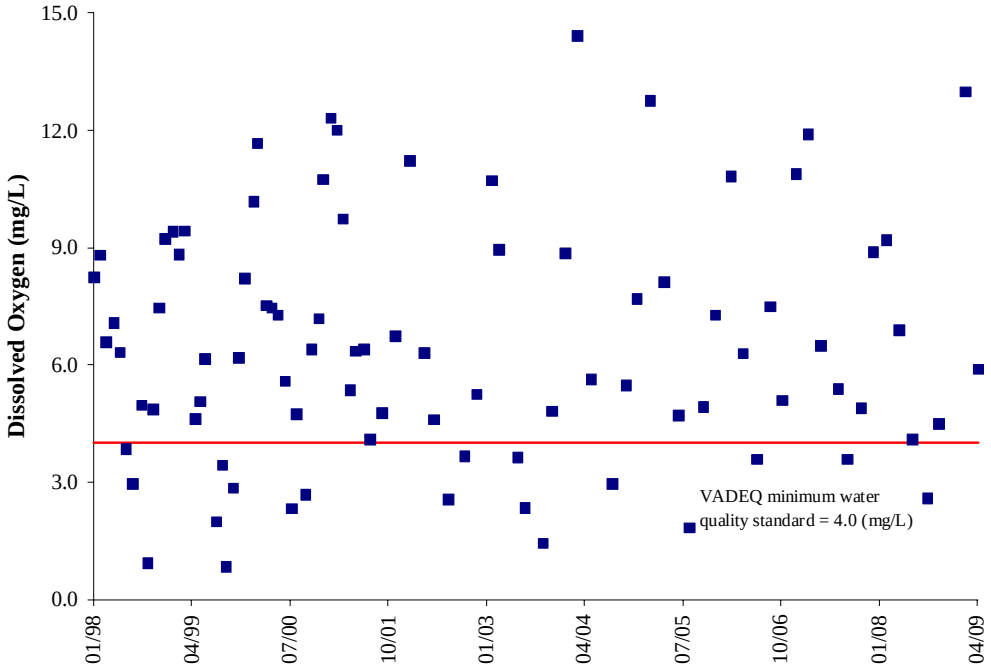

Figure 3.1 DO concentrations at VADEQ monitoring station 5BNLR013.61.

It is clear from the figure above that low dissolved oxygen is a chronic problem in the Albemarle Canal/North Landing River. From the methodology developed by MapTech (MapTech, 2003) four decisions are to be made in assessing anthropogenic impacts on the low DO concentrations in the Albemarle Canal/North Landing River.

3.1.1 Question 1. Are wetlands present in the impaired segment of the stream?

A site visit to both Albemarle Canal and North Landing River on October 22, 2009 revealed very swampy conditions in the watershed but both streams had well defined channels (Figures 3.2, 3.3 and 3.4). The stream had highly colored water indicating a high level of dissolved organics in the water. Water sample were collected at two VADEQ monitoring sites and analyzed by use of Fluorometric analysis to determine the presence of dissolved organics. The color of swamp water results from the decomposition of plant material that produces compounds such as fulvic and humic acids. One way to confirm the presence of fulvic and humic acids is through the use of fluorometry. Fluorescence has been used for purposes ranging from detecting detergent whiteners to determining the origin of petroleum spills in harbors. Fluorescence is a luminescence usually in the ultra violet or blue region of the spectrum. It does not occur in all compounds and requires that a fluorophore be present in a substance. A fluorophore absorbs energy of a specific wavelength and re-emits energy at a different and specific wavelength. The amount and wavelength of the emitted energy depend on both the fluorophore and the chemical environment of the fluorophore. Therefore, fluorescent substances have distinct specific wavelengths and can be identified with the proper equipment and techniques. The results of the analysis can be used to generate 3-dimensional images referred to as an excitation-emission matrixes or EEMs.

Standard Fulvic Acid is a fluorescent substance used in studies where the dissolved organic matter in a stream originates from soil or swamp/wetland vegetation. That is, Standard Fulvic Acid is a fingerprint for dissolved organic matter of that origin. The "reagent grade" standard, referred to as "Standard Suwannee River Fulvic Acid" (SRFA), is obtained from the International Humic Substance Society. MapTech performed a Fluorometric analysis of water samples from a location on the North Landing River and Albemarle Canal. The EEMs are shown in Figures 3.5 and 3.6. The results indicate a

very strong fulvic acid presence (blue and dark blue half moon near a wavelength of 500 nm on the x-axis) that confirmed that the swamp water characteristics of both impaired streams.

Figure 3.2 Albemarle Canal upstream from of Rt. 165 bridge at VADEQ monitoring station 5BAAC001.31.

Figure 3.3 North Landing River upstream from of west landing at VADEQ monitoring station 5BNLR012.91.

Figure 3.4 North Landing River near the Rt. 165 bridge at VADEQ monitoring station 5BNLR013.61.

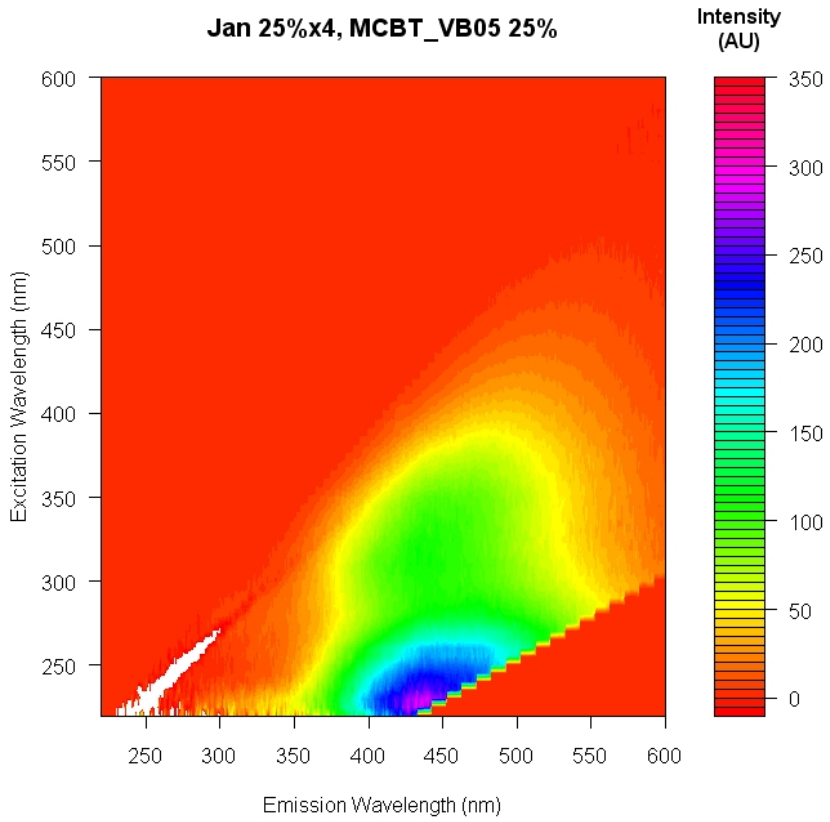

Figure 3.5 EEM for the Albemarle Canal upstream from of Rt. 165 bridge at VADEQ monitoring station 5BAAC001.31.

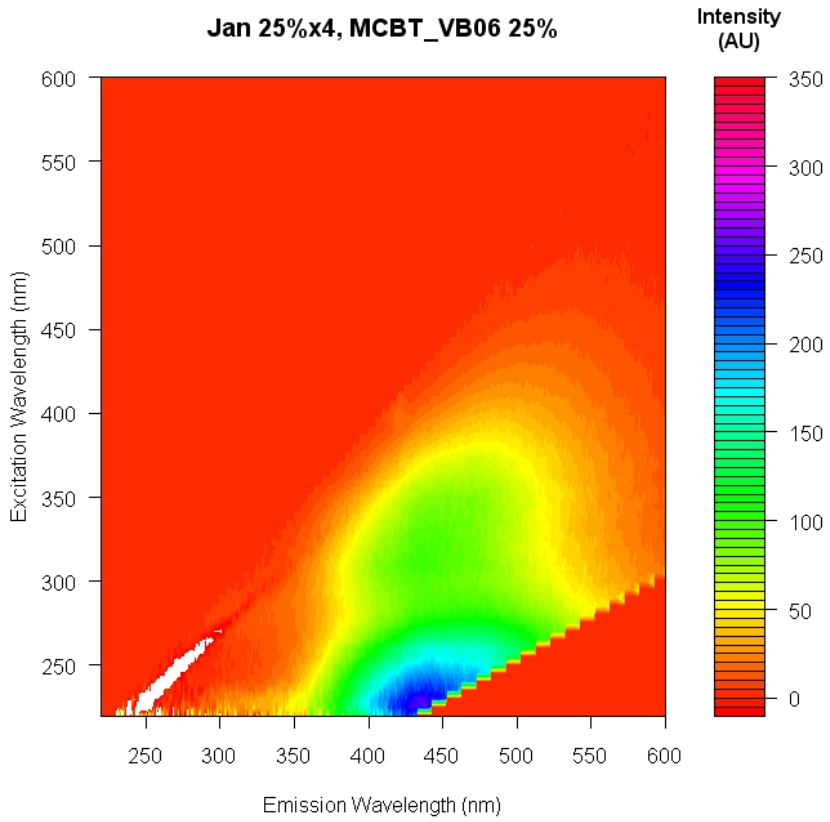

Figure 3.6 EEM for the North Landing River near the Rt. 165 bridge at VADEQ monitoring station 5BNLR013.61.

Land use within the Albemarle Canal/North Landing River drainage area is approximately 25% forest, 30% agricultural and 14% wetlands. Estimation of the hydrologic slope of the stream is <0.1%. Wetlands are present within the impaired segments of both streams.

3.1.2 Question 2. Are there excessive nutrients in the stream?

Nitrate-nitrogen (NO3-N), total nitrogen (TN) and total phosphorus (TP) were monitored at least once at VADEQ monitoring station 5BNLR013.61 from January 1988 to April 2009 (Tables 2.5, 2.6 and 2.7). Mean concentrations of NO3-N, TN, and TP are shown in Table 3.1. The nitrate-nitrogen average was well below national criteria. Average TN and TP concentrations exceeded the average background concentrations estimated by the

USGS (1999). Nutrients in the Albemarle Canal/North Landing River exceed screening levels.

Table 3.1 Average NO3-N, TN and TP concentrations collected by the VADEQ at station 5BNLR013.61.

	NO3-N	TN	TP
Station	**Criteria 0.60 (mg/L)**	**Criteria 1.0 (mg/L)**	**Criteria 0.10 (mg/L)**
5BNLR013.61	**0.13**	**1.4**	**0.15**

Bold values exceed national criteria.

3.1.3 Question 3. Does DO vary seasonally (*i.e.,* oxygen deficit in the summer)?

A seasonal analysis of dissolved oxygen data from station 5BNLR013.61 was conducted using a Moods median test. This test was used to compare median values of DO in each month. Differences in mean monthly DO concentrations are indicated in Table 3.2. DO in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, May and June are in median group "B" and are not significantly different from each other. The results indicate that DO levels in the spring-summer months tend to be lower than DO in the winter months and are therefore not significantly impacted by anthropogenic impacts.

Table 3.2 Summary of Moods median tests on mean monthly DO concentrations at station 5BNLR013.61.

Month	Mean (mg/L)	Min (mg/L)	Max (mg/L)	Median Groups[1]			
January	10.1	8.24	12.31			C	D
February	11.0	8.81	13			C	D
March	9.0	6.31	14.41			C	
April	6.5	4.62	8.12		B	C	
May	5.6	3.64	7.28		B		
June	5.0	3.6	6.41		B		
July	2.7	2	4.09	A			
August	4.0	1.84	7.5	A	B		
September	2.4	0.85	4.77	A	B		
October	4.9	2.86	6.4		B		
November	6.3	4.82	7.46		B	C	
December	9.0	7.29	10.9			C	

[1] DO concentrations in months with the same median group letter are not significantly different from each other at the 95% level of significance.

3.1.4 Question 4. Is there evidence of human impact that warrants the development of a TMDL?

Tables 3.3 and 3.4 show the VADEQ permitted discharges in the Albemarle Canal and North Landing River watersheds respectively. The majority of these permits are very small and not expected to contribute significantly to the nutrient loads in each stream. The five-day biochemical oxygen demand (BOD_5) averaged 2.4 (mg/L). BOD_5 indicates excess organic matter the stream and these concentrations are not considered excessive compared to a local reference stream. Total organic solids concentrations show extreme spikes indicating there are times when the stream is impacted by excess organic matter (maximum 1,740 mg/L). Based on the high nutrient concentrations and spikes in total organic solids it is likely that anthropogenic sources are exacerbating the naturally low DO conditions in the stream.

Table 3.3 Summary of VADEQ permits in the Albemarle Canal watershed.

Permit Type	Discharger Type	Permit_number	Facility_name	Receiving or Adjacent Stream
Domestic	Sanitary Wastewater	VAG403059	Bedford Street Plumbing and Cabinet Making	Dry ditch to Albemarle Chesapeake canal
Domestic	Sanitary Wastewater	VAG403053	True Way Evangelistic Church	Ditch to Albemarle Chesapeake canal
VPA	Land application of domestic wastewater from a military facility.	VPA01003	NA	NA
VPA	Land application of Industrial Wastewater from milk processing plant.	VPA01072	NA	NA
MS4	Municipal Storm Water	VA0088625	City of Chesapeake	Waters within the vicinity of Chesapeake

Table 3.4 Summary of VADEQ permits in the North Landing River watershed.

Permit Type	Discharger Type	Permit_number	Facility_name	Receiving or Adjacent Stream
VPDES	Oil & Grease*	VA0087548	NuStar Terminals Operations Prtnrshp LP - VA	North Landing River
Domestic	Sanitary Wastewater	VAG403065	Battlefield Golf Club at Centerville	Unnamed Trib to North Landing River
Domestic	Sanitary Wastewater	VAG403048	Ross Charles K Residence	North Landing River
CAFO	Agriculture	VPG100167	Salmons Farm - David S. Salmons	North Landing River
MS4	Municipal Storm Water	VA0088676	City of Virginia Beach	Waters within the vicinity of Virginia Beach

* Facility not expected to discharge total phosphorus.

Conclusion: Based nutrient concentrations exceeding screening levels, a nutrient TMDL will be necessary for the Albemarle Canal and North Landing River watersheds. A local reference stream with little or no anthropogenic impacts will be used a reference station for both impaired streams. The stream is the feeder ditch canal from Lake Drummond, and the data were collected at VADEQ monitoring station 5BXCK000.00. Table 3.5 shows a comparison of nutrient averages for the reference station and the impaired monitoring station (5BNLR013.61). Based on the higher the total phosphorus concentrations in the impaired stream, the nutrient TMDL will be based on total phosphorus. The minimum dissolved oxygen standard for both streams should be revised to reflect natural low dissolved oxygen conditions.

Table 3.5 Nutrient averages at VADEQ monitoring stations 5BXCK000.00 and 5BNLR013.61.

VADEQ Monitoring Station	NO_3-N	TN	TP
5BXCK000.00	0.29	2.62	0.06
5BNLR013.61	0.13	1.4	0.15

3.2 Milldam Creek

Milldam Creek was assessed as not supporting the Aquatic Life Use designation on Virginia's 2008 303(d) list based on water quality monitoring performed at VADEQ monitoring station 5BMDL001.92. Minimum DO water quality standard violations were recorded at 5BMDL001.92 during the 2008 assessment period. Figure 3.7 shows the DO concentrations at VADEQ monitoring station 5BMLD001.92.

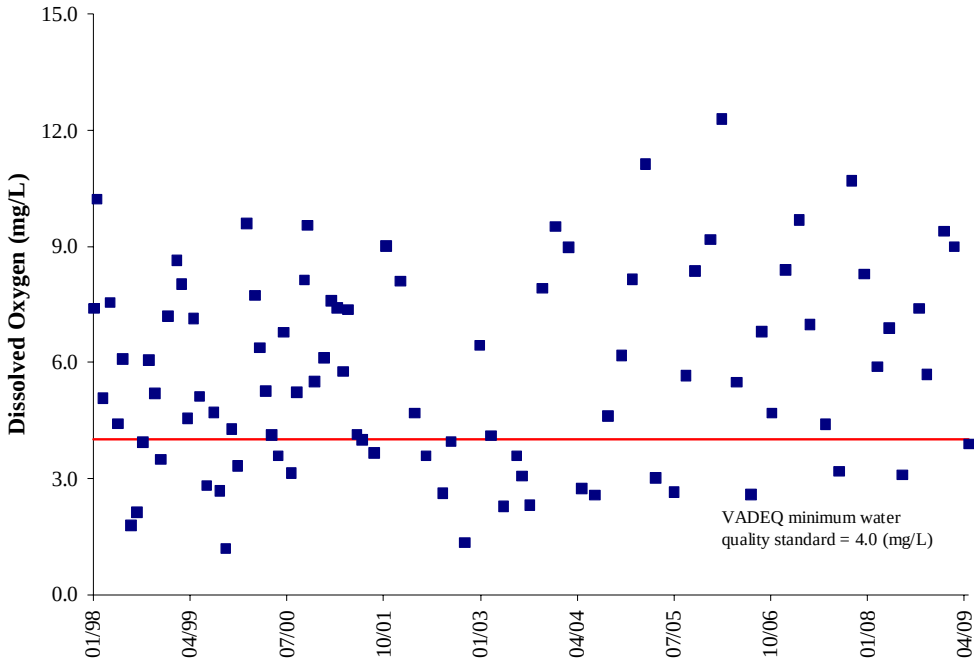

Figure 3.7 DO concentrations at VADEQ monitoring station 5BMLD001.92.

It is clear from the figure above that low dissolved oxygen is a chronic problem in Milldam Creek. From the methodology developed by MapTech (MapTech, 2003), four decisions are to be made in assessing anthropogenic impacts on low DO concentrations in Mill Swamp.

3.2.1 Question 1. Are wetlands present in the impaired segment of the stream?

A site visit to Milldam Creek on October 22, 2009 revealed very swampy conditions in the watershed but a clearly defined stream channel. (Figure 3.8). The highly colored water indicated a high level of dissolved organics in the water. A water sample was

collected at the DEQ monitoring site (5BMLD001.92) and analyzed by use of Fluorometric analysis to determine the presence of dissolved organics. The results of the analysis indicate a strong signal for fulvic and humic acids, which are the products of wetland area plant decomposition (Figure 3.9).

Figure 3.8 Milldam Creek at the Blackwater Road bridge at VADEQ monitoring station 5BMLD001.92.

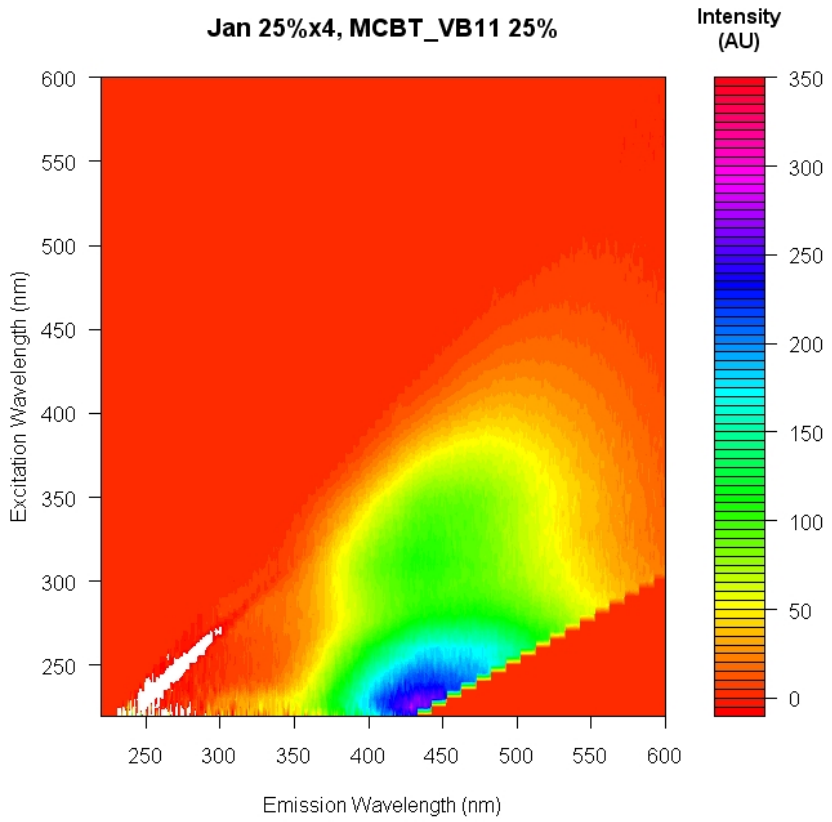

Figure 3.9 EEM for Milldam Creek at the Blackwater Road bridge, VADEQ monitoring station 5BMLD001.92.

Land use within the Milldam Creek drainage area is approximately 12% forest, 42% agricultural and 45% wetlands. Estimation of the hydrologic slope of the stream is <0.1%. Wetlands are definitely present within the impaired segment drainage area of this stream.

3.2.2 Question 2. Are there excessive nutrients in the stream?

Nitrate-nitrogen (NO3-N), total nitrogen (TN) and total phosphorus (TP) were monitored at VADEQ monitoring station 5BMLD001.92 (Tables 2.5, 2.6 and 2.7). Mean concentrations of NO3-N, TN, and TP are shown in Table 3.6. The average concentrations for NO3-N were below the average background concentration estimated by USGS (1999). However, TN and TP average concentrations exceeded the national

background concentrations. Therefore, nutrients in Milldam Creek exceed the screening values.

Table 3.6 Average NO3-N, TN and TP concentrations collected by the VADEQ in Milldam Creek.

Station	NO3-N Critieria 0.60 (mg/L)	TN Critieria 1.0 (mg/L)	TP Critieria 0.10 (mg/L)
5BMLD001.92	0.16	1.63	0.21

3.2.3 Question 3. Does DO vary seasonally (*i.e.,* oxygen deficit in the summer)?

A seasonal analysis of dissolved oxygen data from station 5BMLD001.92 was conducted using a Moods median test. This test was used to compare median values of DO in each month. Differences in mean monthly DO concentrations are indicated in Table 3.7. DO in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, January and February are in median group "B" and are not significantly different from each other. The results indicate that DO levels in the spring-summer months tend to be lower than DO in the winter months and are therefore not significantly impacted by anthropogenic impacts.

Table 3.7 Summary of Moods median tests on mean monthly DO concentrations at station 5BMLD001.92.

Month	Mean (mg/L)	Min (mg/L)	Max (mg/L)	Median Groups[1]		
January	8.2	6.12	9.6			C
February	8.6	7.61	10.23			C
March	7.7	4.11	12.3		B	C
April	5.8	4.56	7.56		B	
May	4.8	2.3	7.38	A	B	
June	4.7	3.6	6.1	A	B	
July	3.4	1.8	6.78	A		
August	3.3	2.14	4.72		B	
September	4.5	2.33	7.4	A	B	
October	5.3	1.2	8.14	A	B	C
November	6.7	1.35	10.7	B	C	
December	4.1	3.34	5.51	A	B	

[1] DO concentrations in months with the same median group letter are not significantly different from each other at the 95% level of significance.

3.2.4 Question 4. Is there evidence of human impact that warrants the development of a TMDL?

There are no point source discharges located in the Milldam Creek drainage area. This watershed is impaired for fecal bacteria, and a TMDL has been developed and was approved by the USEPA on 9/27/2005. An implementation plan has also been developed for this watershed. The average five-day biochemical oxygen demand (BOD_5) was 3.2 (mg/L). BOD_5 can indicate excess organic matter the stream and these concentrations and 3.2 mg/L is not considered excessive. The average total organic solids concentration was 156 (mg/L) with a maximum concentration of 632 (mg/L). The numbers are higher than what can be expected for a stream with minimal anthropogenic impacts. Therefore, it is likely that anthropogenic sources are exacerbating the naturally low DO conditions in the stream.

Conclusion: The approved bacteria TMDL for the Milldam Creek watershed can be expected to significantly reduce the excess organic matter and nutrients reaching the watershed. The TMDL allocations for the watershed require the following reductions in bacterial inputs to the stream: direct livestock 100%, runoff from pasture and cropland 99%, runoff from residential areas 99% and failing septic tanks 100%. An implementation plan has been developed for the Milldam Creek watershed, and the recommended BMPs will improve the overall water quality in the watershed, not just bacteria concentrations. This approach is similar to those approved by the USEPA in other watersheds in Virginia. The minimum dissolved oxygen standard for Milldam Creek should be revised to reflect natural low dissolved oxygen conditions.

3.3 West Neck Creek (Middle Portion)

West Neck Creek was assessed as not supporting the Aquatic Life Use designation on Virginia's 2008 303(d) list based on water quality monitoring performed at VADEQ monitoring station 5BWNC003.65. Minimum DO water quality standard violations were recorded at 5BWNC003.65 during the 2008 assessment period. Figure 3.10 shows DO concentration measurements at VADEQ monitoring station 5BWNC003.65.

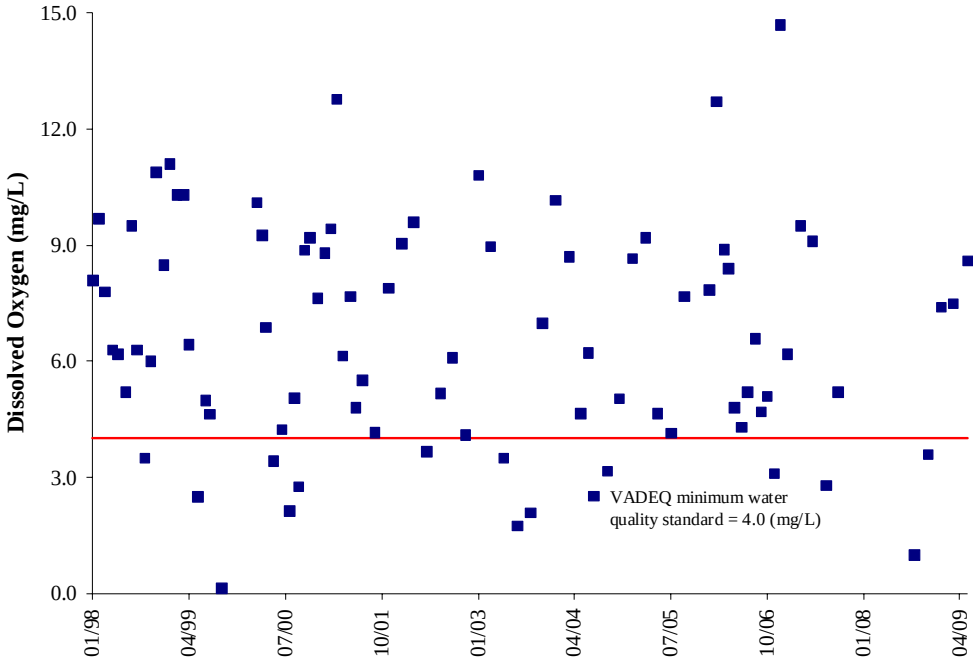

Figure 3.10 DO concentrations at VADEQ monitoring station 5BWNC003.65.

It is clear from the figure above that low dissolved oxygen is a chronic problem in West Neck Creek. From the methodology developed by MapTech (MapTech, 2003), four decisions are to be made in assessing anthropogenic impacts on low DO concentrations in West Neck Creek.

3.3.1 Question 1. Are wetlands present in the impaired segment of the stream?

A site visit to West Neck Creek on October 22, 2009 revealed very swampy conditions in the watershed with clearly defined stream channel (Figure 3.11). The highly colored water indicated a high level of dissolved organics in the water. A water sample was collected at the DEQ monitoring site (5BWNC003.65) and analyzed by use of Fluorometric analysis to determine the presence of dissolved organics. The results of the analysis indicate a strong signal for fulvic and humic acids, which are the products of wetland area plant decomposition (Figure 3.12).

Figure 3.11 West Neck Creek at the Rt. 672 bridge at VADEQ monitoring station 5BWNC003.65.

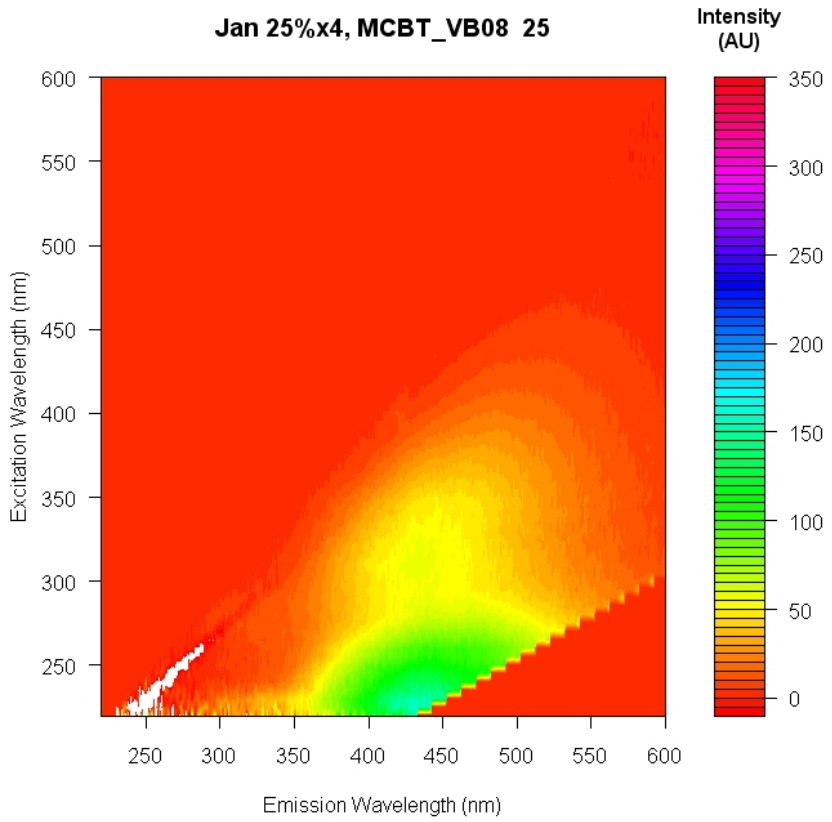

Figure 3.12 West Neck Creek at the Rt 672 bridge at VADEQ monitoring station 5BWNC003.65.

Land use within the West Neck Creek drainage area is approximately 26% forest, 44% agricultural and 12% wetlands. Estimation of the hydrologic slope of the stream is <0.1%. Wetlands are definitely present within the impaired segment drainage area of this stream.

3.3.2 Question 2. Are there excessive nutrients in the stream?

Nitrate-nitrogen (NO3-N), total nitrogen (TN) and total phosphorus (TP) were monitored at VADEQ monitoring station 5BWNC003.65 (Tables 2.5, 2.6 and 2.7). Mean concentrations of NO3-N, TN, and TP are shown in Table 3.8. The average concentrations for TN and TP exceeded the average background concentrations estimated by USGS (1999). Therefore, nutrients in West Neck Creek are considered excessive.

Table 3.8 Average NO3-N, TN and TP concentrations collected by the VADEQ in West Neck Creek.

Station	NO3-N Critieria 0.60 (mg/L)	TN Critieria 1.0 (mg/L)	TP Critieria 0.10 (mg/L)
5BWNC003.65	0.11	**1.11**	**0.13**

Bold values exceed a screening value.

3.3.3 Question 3. Does DO vary seasonally (*i.e.,* oxygen deficit in the summer)?

A seasonal analysis of dissolved oxygen data from station 5BWNC003.65 was conducted using a Moods median test. This test was used to compare median values of DO in each month. Differences in mean monthly DO concentrations are indicated in Table 3.9. DO in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, February and March are in median group "D" and are not significantly different from each other. The results indicate that DO levels in the spring-summer months tend to be lower than DO in the winter months and are therefore not significantly impacted by anthropogenic impacts.

Table 3.9 Summary of Moods median tests on mean monthly DO concentrations at station 5BWNC003.65.

Month	Mean (mg/L)	Min (mg/L)	Max (mg/L)	Median Groups[1]			
January	8.8	6.2	11.1			C	D
February	10.5	9.43	12.72				D
March	9.3	7.5	12.78				D
April	6.8	6.14	8.4		B	C	
May	5.3	2.5	9.1	A	B	C	
June	5.0	4.23	6.22	A	B		
July	4.3	1.76	9.5	A			
August	6.0	5.06	6.6	A	B		
September	3.7	0.14	7.68	A			
October	6.7	5.1	8.88		B	C	D
November	6.4	3.1	10.9	A	B	C	D
December	10.3	7.63	14.7			C	D

[1] DO concentrations in months with the same median group letter are not significantly different from each other at the 95% level of significance.

3.3.4 Question 4. Is there evidence of human impact that warrants the development of a TMDL?

There are no VPDES discharges to the middle portion of the West Neck Creek watershed. This watershed is impaired for fecal bacteria, and a TMDL has been developed and was approved by the USEPA on 9/27/2005. An implementation plan has also been developed for this watershed. The average five-day biochemical oxygen demand (BOD_5) was 2.82 (mg/L), which is not excessive. Total organic solids concentrations average 483 mg/L with a maximum concentration of 9,470 mg/L. The high nutrient and total organic solids concentrations indicate that anthropogenic sources are exacerbating the naturally low DO conditions in the stream.

Conclusion: The approved bacteria TMDL for the middle portion of the West Neck Creek watershed can be expected to significantly reduce the excess nutrients and organic matter from reaching the stream. The TMDL allocations for the watershed require the following reductions in bacterial inputs to the stream: direct livestock 100%, runoff from pasture and cropland 88%, runoff from residential areas 88% and failing septic tanks 100%. An implementation plan has been developed for the West Neck Creek watershed, and the recommended BMPs will improve the overall water quality in the watershed, not just bacteria concentrations. This approach is similar to those approved by the USEPA in other watersheds in Virginia. The minimum dissolved oxygen standard for West Neck Creek should be revised to reflect natural low dissolved oxygen conditions.

3.4 Nawney Creek

Nawney Creek was assessed as not supporting the Aquatic Life Use desgination on Virginia's 2008 303(d) list based on water quality monitoring performed at VADEQ monitoring stations 5BNWN000.00 and 5BNWN001.84. Minimum DO water quality standard violations were recorded at both monitoring stations during the 2008 assessment period. Figures 3.13 and 3.14 show DO concentrations measurements at VADEQ monitoring stations 5BNWN000.00 and 5BNWN001.84.

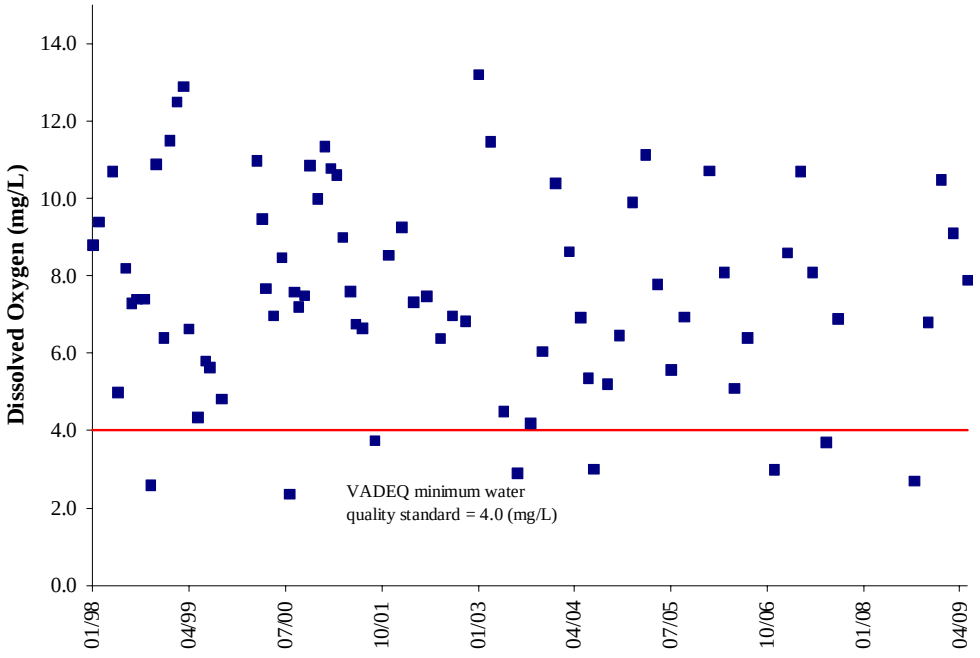

Figure 3.13 DO concentrations at VADEQ monitoring station 5BNWN000.00.

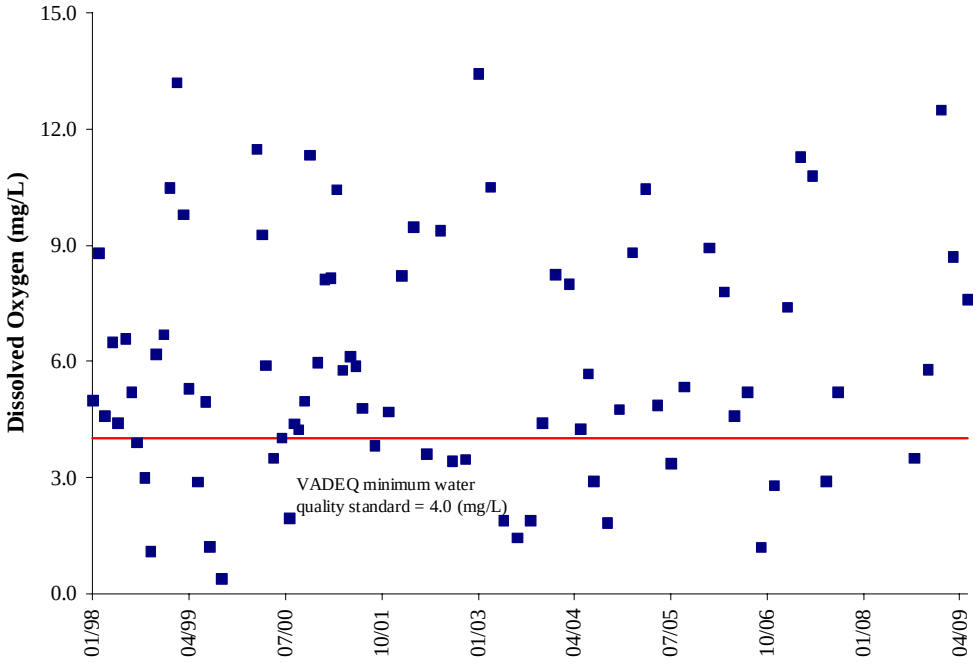

Figure 3.14 DO concentrations at VADEQ monitoring station 5BNWN001.84.

It is clear from the figure above, that low dissolved oxygen is a chronic problem in Nawney Creek. From the methodology developed by MapTech (MapTech, 2003), four decisions are to be made in assessing anthropogenic impacts on low DO concentrations in Nawney Creek.

3.4.1 Question 1. Are wetlands present in the impaired segment of the stream?

A site visit to Nawney Creek on October 22, 2009 revealed very swampy conditions in the watershed with a clearly defined stream channel (Figures 3.15 and 3.16). The highly colored water indicated a high level of dissolved organics in the water. Water samples were collected at the DEQ monitoring sites (5BNWN001.81 and 5BNWN000.00) and analyzed by use of Fluorometric analysis to determine the presence of dissolved organics. The results of the analysis indicate a strong signal for fulvic and humic acids, which are the products of wetland area plant decomposition (Figures 3.17 and 3.18).

Figure 3.15 Nawney Creek at the mouth of Back Bay at VADEQ monitoring station 5BNWN000.00.

Figure 3.16 Nawney Creek at nawney creek road bridge at VADEQ monitoring station 5BNWN001.84.

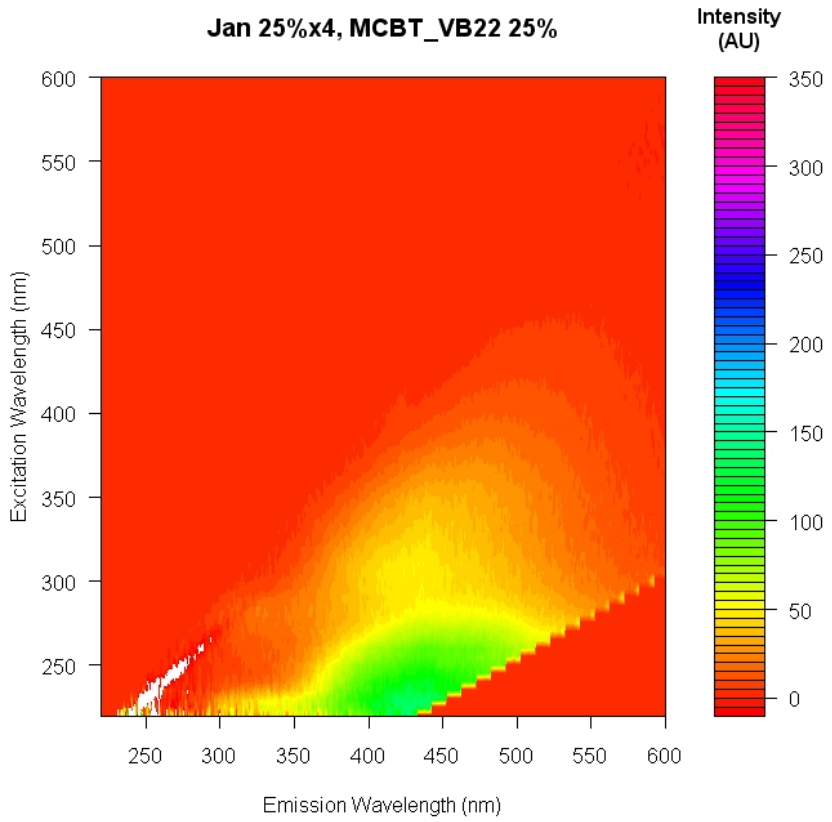

Figure 3.17 EEM for Nawney Creek at the mouth of Back Bay, VADEQ monitoring station 5BNWN000.00.

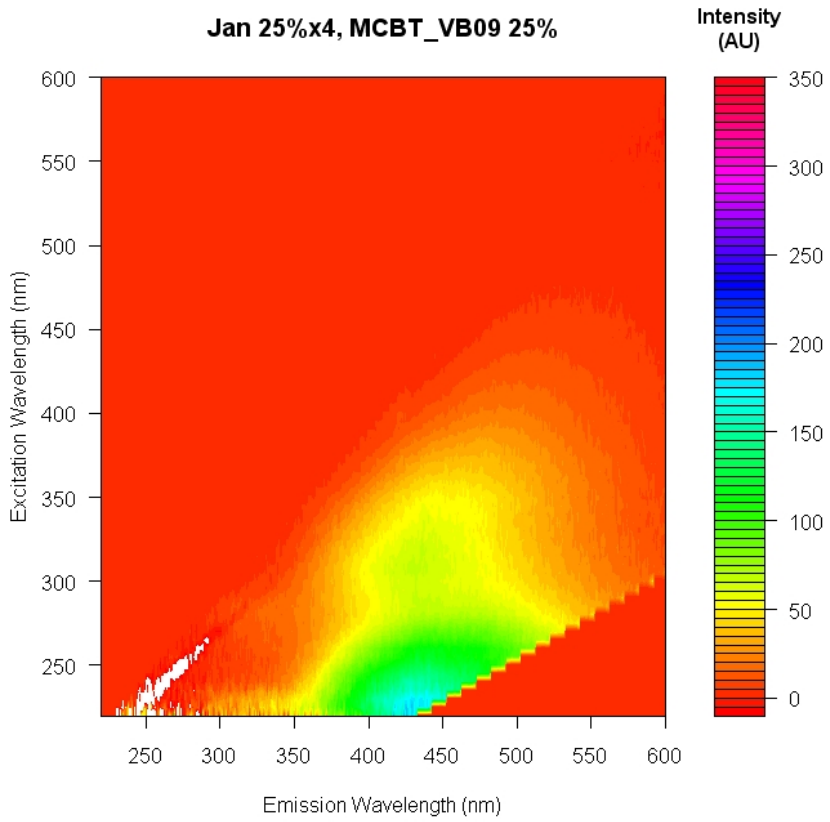

Figure 3.18 EEM for Nawney Creek at nawney creek road bridge, VADEQ monitoring station 5BNWN001.84.

Land use within the Nawney Creek drainage area is approximately 13% forest, 77% agricultural and 9% wetlands. Estimation of the hydrologic slope of the stream is <0.1%. Wetlands are definitely present within the impaired segment drainage area of this stream.

3.4.2 Question 2. Are there excessive nutrients in the stream?

Nitrate-nitrogen (NO3-N), total nitrogen (TN) and total phosphorus (TP) were monitored at VADEQ monitoring stations 5BNWN000.00 and 5BNWN001.84 (Tables 2.5, 2.6 and 2.7). Mean concentrations of NO3-N, TN, and TP are shown in Table 3.10. The average concentrations for TN and TP exceeded the average background concentrations estimated by USGS (1999). Therefore, nutrients in Nawney Creek are considered to be excessive.

Table 3.10 Average NO3-N, TN and TP concentrations collected by the VADEQ in Nawney Creek.

Station	NO3-N Critieria 0.60 (mg/L)	TN Critieria 1.0 (mg/L)	TP Critieria 0.10 (mg/L)
5BNWN000.00	0.48	**2.14**	**0.12**
5BNWN001.84	0.53	**2.16**	**0.24**

Bold values exceed a screening value.

3.4.3 Question 3. Does DO vary seasonally (*i.e.,* oxygen deficit in the summer)?

A seasonal analysis of dissolved oxygen data from stations 5BNWN000.00 and 5BNWN001.84 was conducted using a Moods median test. This test was used to compare median values of DO in each month for each stations data. Differences in mean monthly DO concentrations are indicated in Tables 3.11 and 3.12. DO in months with the same median group letter are not significantly different from each other at the 95% significance level. For example, May and June (station 5BNWN000.00) are in median group "AB" and are not significantly different from each other. The results indicate that DO levels in the spring-summer months tend to be lower than DO in the winter months and are therefore not significantly impacted by anthropogenic impacts.

Table 3.11 Summary of Moods median tests on mean monthly DO concentrations at station 5BNWN000.00.

Month	Mean (mg/L)	Min (mg/L)	Max (mg/L)	Median Groups[1]		
January	10.4	8.6	13.21		B	C
February	10.9	9.4	12.5		B	C
March	9.9	7.32	12.9		B	C
April	8.5	6.63	10.7		B	C
May	6.5	4.35	8.1	A	B	
June	6.9	5.37	8.48	A	B	
July	5.0	2.36	7.3	A		
August	7.5	7.4	7.58		B	
September	5.6	2.7	7.4	A		
October	5.1	2.6	7.5	A	B	
November	7.4	3	10.9	A	B	
December	8.2	6.4	10	A	B	

[1] DO concentrations in months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 3.12 Summary of Moods median tests on mean monthly DO concentrations at station 5BNWN001.84.

Month	Mean (mg/L)	Min (mg/L)	Max (mg/L)	Median Groups[1]			
January	9.1	5	13.44			C	D
February	10.4	8.16	13.2			C	D
March	9.1	4.6	11.3			C	
April	5.9	5.3	6.5		B	C	
May	5.0	1.89	10.8	A	B		
June	5.4	4.02	6.6		B	C	
July	3.8	1.22	9.39	A	B		
August	4.1	3.9	4.39		B		
September	3.1	0.39	5.34	A			
October	3.0	1.1	4.98	A	B		
November	5.4	2.8	11.33	A	B		
December	6.3	5.97	6.7			C	

[1] DO concentrations in months with the same median group letter are not significantly different from each other at the 95% level of significance.

3.4.4 Question 4. Is there evidence of human impact that warrants the development of a TMDL?

There are no VPDES point sources located in the Nawney Creek drainage area. This watershed is impaired for fecal bacteria, and a TMDL has been developed and was approved by the USEPA on 9/27/2005. An implementation plan has also been developed for the watershed. The average five-day biochemical oxygen demand (BOD_5) was 3.22 and 3.97 (mg/L) at VADEQ monitoring stations 5BNWN000.00 and 5BNWN001.84 respectively and these concentrations are not considered elevated. The average total organic solids concentrations are 253 (mg/L) and 162 (mg/L) from 5BNWN000.00 and 5BNWN001.84 respectively. Maximum total organic solids concentrations were 780 (mg/L) and 604 (mg/L) from 5BNWN000.00 and 5BNWN001.84 respectively. The high nutrient and organic matter concentrations indicate that anthropogenic sources are exacerbating the naturally low DO conditions in the stream.

Conclusion: The approved bacteria TMDL for the Nawney Creek watershed can be expected to significantly reduce the excess nutrients reaching the stream. The TMDL allocations for the watershed require the following reductions in bacterial inputs to the stream, direct livestock 100%, runoff from pasture and cropland 85%, runoff from

residential areas 85% and failing septic tanks 100%. An implementation plan has been developed for the Nawney Creek watershed, and the recommended BMPs will improve the overall water quality in the watershed, not just bacteria concentrations. This approach is similar to those approved by the USEPA in other watersheds in Virginia. The minimum dissolved oxygen standard for Nawney Creek should be revised to reflect natural low dissolved oxygen conditions.

4. PUBLIC PARTICIPATION

Public participation during TMDL development for the Virginia Beach area streams was encouraged; a summary of the meetings is presented in Table 4.1. The first public meetings was held at the VADEQ Tidewater Regional Office (TRO) on July 28, 2010 in Virginia Beach, Virginia. Ten people attended the first meeting. A technical advisory committee meeting was held on February 4, 2010 in the VADEQ TRO office. The final public meeting was held at the VADEQ TRO office in Virginia Beach, Virginia on February 22, 2010.

Table 4.1 Public participation during TMDL development for the Meherrin River and Tributaries study area.

Date	Location	Attendance[1]	Type
7/28/2010	VADEQ TRO office Virginia Beach, VA	10	First Public
2/04/2010	VADEQ TRO office Virginia Beach, VA	6	Technical Advisory
02/22/2010	VADEQ TRO office Virginia Beach, VA	13	Final public

[1]The number of attendants is estimated from sign up sheets provided at each meeting. These numbers are known to underestimate the actual attendance.

REFERENCES

Encyclopedia of Earth, ((http://www.eoearth.org/article/Ecoregions_of_Delaware%2C_Maryland%2C_Pennsylvania%2C_Virginia%2C_and_West_Virginia_(EPA) (accessed 12/11/2009).

EPA. 1999. Guidance for Water Quality-Based Decisions: The TMDL Process. http://www.epa.gov/OWOW/tmdl/decisions/dec1c.html

MapTech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments, 2003.

U.S. Geological Survey, *The Quality of Our Nation's Waters – Nutrients and Pesticides:* U.S. Geological Survey Circular 1225, 82 p, (1999).

SERCC. 2009. Southeast Regional Climate Center. http://water.dnr.state.sc.us/climate/sercc/

VADEQ and VADCR. 1998. Section 303(d) Total Maximum Daily Load Priority List and Report.

VADEQ. 2002. Section 303(d) Report on Impaired Waters.

VADEQ. 2004. Section 303(d) Water Quality Assessment Integrated Report.

VADEQ. 2006. 305(b)/303(d) Integrated Report.

VADEQ. 2008. 305(b)/303(d) Integrated Report.