Natural Conditions Assessment for Low pH and Low Dissolved Oxygen, Nottoway River Tributaries in Dinwiddie, Prince George, and Sussex Counties, Virginia

Submitted by

Virginia Department of Environmental Quality

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Executive Summary

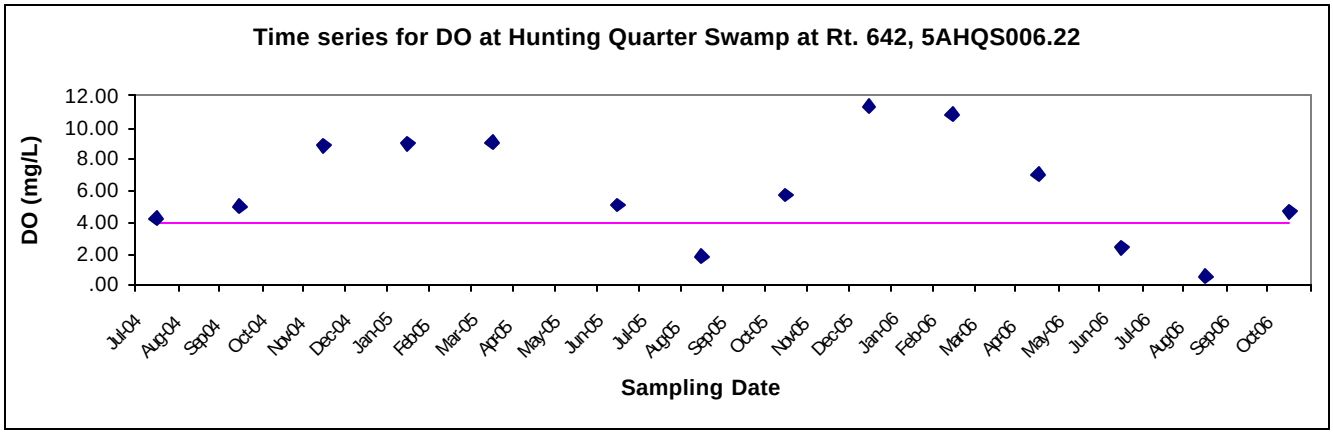
This report presents the assessment of whether low pH and dissolved oxygen (DO) in 16 tributaries to the Nottoway River are due to natural conditions or whether a Total Maximum Daily Load (TMDL) must be performed because of anthropogenic impacts. The Nottoway River tributaries are located in Dinwiddie, Sussex and Prince George Counties in the Chowan River Basin (USGS Hydrologic Unit Code 03010201). The waterbodies identification codes (WBID, Virginia Hydrologic Unit) for the non-tidal Nottoway River tributaries are VAP-K19R, VAP-K21R, VAP-K23R, VAP-K24R. There are 733.8 total stream miles in this Nottoway River tributaries watershed (National Hydrography Dataset (NHD). A total of 217.9 miles of these tributaries were listed as impaired due to violations in water quality standards for pH or dissolved oxygen. This report addresses both the pH and dissolved oxygen impairments.

The drainage area of the Nottoway River and its tributaries is approximately 529.0 square miles. The average annual rainfall is 45.21 inches. The watershed is approximately 338,570.10 acres in size and is predominately forested (66.1 percent). Agriculture encompasses 21.0 percent of the watershed, with 13.4 percent cropland and 7.6 percent pasture/hayland. Residential and industrial areas compose approximately 1.0 percent of the land base. The remaining 11.9 percent of the watershed is comprised of 2.2 percent of transitional areas and grasses, and 9.7 percent wetlands and open water.

These Nottoway River tributaries were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report, 2004 and 2006 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2004 & 2006) due to violations of the State's water quality standard for DO and pH. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

At Hunting Quarter Swamp, the most downstream tributary in this report, a total of 14 DO and pH data points have been taken by DEQ at station 5AHQS006.22, the most downstream bridge, from July 2004 through October 2006 (Figure E1). The DO standard violation rate was 3/14 (21.4%), and pH violations were 7/14 (50%). Similar time series data are presented for multiple stations on the 16 Nottoway River tributaries evaluated in this report.

Figure E1. Time series of DO concentrations (station 5AHQS006.22), July 2004 through October 2006.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, the Nottoway River tributaries must support all designated uses and meet all applicable criteria. If the waterbody violates the instantaneous DO water quality standard of 4.0 mg/l or pH values are less than 6.0 or greater than 9.0 in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

In 2003 VADEQ proposed a methodology for determining whether low DO or pH originates from natural or anthropogenic sources, adapted from "Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia." (MapTech 2003)

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. Conditions in a free-flowing stream that would typically be associated with naturally low DO include slow-moving, ripple-less waters where the bacterial decay of organic matter depletes DO at a faster rate than it can be replenished. Indicators of these conditions include low slope, the presence of wetlands, and often low pH due to organic acids (tannins, humic and fulvic substances) produced in the decay process.

These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in free-flowing streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposed to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Before implementing this procedure, all DO and pH data should be screened for flows less than the 7Q10. DO and pH data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly.

Step 1. Determine slope and appearance (presence of wetlands).
Step 2. Determine nutrient levels and compare with USGS background concentrations.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts from permitted dischargers and land use.

There were no low DO or pH exceedances removed from the dataset as no flows during the sampling period in 2006 were below 7Q10. Many low DO or pH data were removed from the longterm historical data between 1990 and 2005.

The extent of the swampwater segments were determined for each of the 16 tributaries discussed in this report. The low slope for these streams ranged from 0.12% to 0.35%. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand and lower DO as they decay. These are not considered anthropogenic impacts.

The monitoring stations for the Nottoway River tributaries exhibit low nutrient concentrations below national background levels in streams from undeveloped areas (USGS 1999), which are not indicative of human impact. Total nitrogen (TN) at Anderson Branch (TN = 1.02 mg/L), and at Cabin Point Branch (TN = 1.03 mg/L) were slightly above the 1.0 mg/l USGS TN threshold. However, land use does not indicate an anthropogenic impact to the watersheds. There are no permitted facilities in the Cabin Point Swamp watershed. The Sussex County High School (VA0090786) discharges to Anderson Branch, approximately 1.6 rivermiles upstream of station 5AAND000.10. However, the facility Discharge Monitoring Reports (DMRs) for 2006 indicated discharges were well below permitted limits for pH, DO, TKN and CBOD5. The facility does not appear to be a significant contributing factor to the total nitrogen of Anderson Branch. It is believed that the minor TN levels above 1.0 mg/l in these watersheds remain a natural occurrence.

The Nottoway River tributaries exhibit natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are 17 permitted (6 VPDES; 2 VAG; 8 VAR; 1 VAP) Point Source facilities in the Nottoway River tributaries watersheds (K19R, K21R, K23R, and K24R). Six VPDES permittees have design flows and BOD5 or TKN permit limits which could affect instream nutrients. None of the facilities violated their permit limits for DO or pH during the time period of this study. The remaining VPDES permittee has a design flow but no BOD5, TKN or DO limits. One VPA permittee has no design flow. These are not expected to significantly impact DO or pH. TKN (mg/L) concentration maximum permitted limits for the Sussex County High School were set at 4.5 mg/L, and the maximum DMR concentration was 3.3 mg/L. This was modeled to be protective of the water quality of the receiving stream Anderson Branch.

Residential and high use industrial areas comprise approximately 1.0 percent of the land base, not a significant portion of the watershed. The watershed is predominately forested (66.1 percent), with 9.7 percent wetlands and open water. The land use is not considered to have significantly impacted the swampwater conditions of these Nottoway River tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than TMDLs, are indicated for the Nottoway River tributaries located in waterbodies identification codes (WBID, Virginia Hydrologic Unit) K19R, K21R, K23R and K24R, for a total of 257.0 rivermiles. The specific waterbodies are listed below in Table E1. If there is a 305(b)/303(d) assessment prior to the reclassification, these Nottoway River tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

Table E1. Class VII Swampwater designations for the Nottoway River Tributaries.

Stream	Miles	Upstream Class VII Boundary	Downstream Class VII Boundary
Black Branch Sw	6.56	Headwaters	Confluence with Nottoway River
Cabin Point Sw and tributaries	11.63	Headwaters	Confluence with Nottoway River
Gravelly Run and tributaries	18.79	200' at RM 8.56	Confluence with Rowanty Creek
Gosee Swamp and tributaries	12.42	130' at RM 6.88	Confluence with Nottoway River
Hunting Quarter Sw and tributaries	52.81	Headwaters	Confluence with Nottoway River
Hatcher Run and tributaries*	74.33	250' at RM 19.27	Confluence with Rowanty Creek
Harris Swamp and tributaries	27.32	160' at RM 8.72	Confluence with Nottoway River
Moores / Jones Hole Swamps and tributaries	47.21	Headwaters	Confluence with Nottoway River
Southwest Sw and tributaries	12.49	150' at RM 8.55	Confluence with Stony Creek

* excluding Picture Branch.

DEQ performed the assessment of the Nottoway River tributaries low pH and DO natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Nottoway River tributaries including Anderson Branch, Arthur Swamp, Black Branch Swamp, Cabin Point Swamp, Gravelly Run, Hunting Quarter Swamp, Hatcher Run, Harris Swamp, Jones Hole Swamp, Lees Branch, Picture Branch, Reedy Branch, Rocky Branch, Southwest Swamp, and Thweatt Branch, located within Dinwiddie, Prince George and Sussex Counties, Virginia, are minor tributaries to the Chowan River. These tributaries encompass approximately 733.8 rivermiles. They flow southeast from the headwaters of Hatcher Run at Rt. 460 near Poole Siding, VA to the confluence of Hunting Quarter Swamp and the Nottoway River near Lumberton, VA . The watersheds total approximately 529.0 square miles. There is a continuous flow gaging station on Stony Creek near Dinwiddie, VA (USGS: 02046000), which has a drainage area of 112 mi^2 and the adjacent Nottoway River tributary west of the subject Nottoway River tributaries. This gaging station is approximately 6 miles south of the headwaters of Hatcher Run and approximately 27 miles northwest of the mouth of Hunting Quarter Swamp at the Nottoway River.

The Nottoway River tributaries (Hatcher Run, Gosee Swamp, Gravelly Run, Arthur Swamp and Picture Branch, and Hunting Quarter Swamp) were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report, and 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for pH and DO. Harris Swamp was listed as impaired on Virginia's 2006 Water Quality Assessment 305(b)/ 303(d) Integrated Report due to violations of the State's water quality standard for pH. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

2. Physical Settings

2.1. Listed Water Bodies

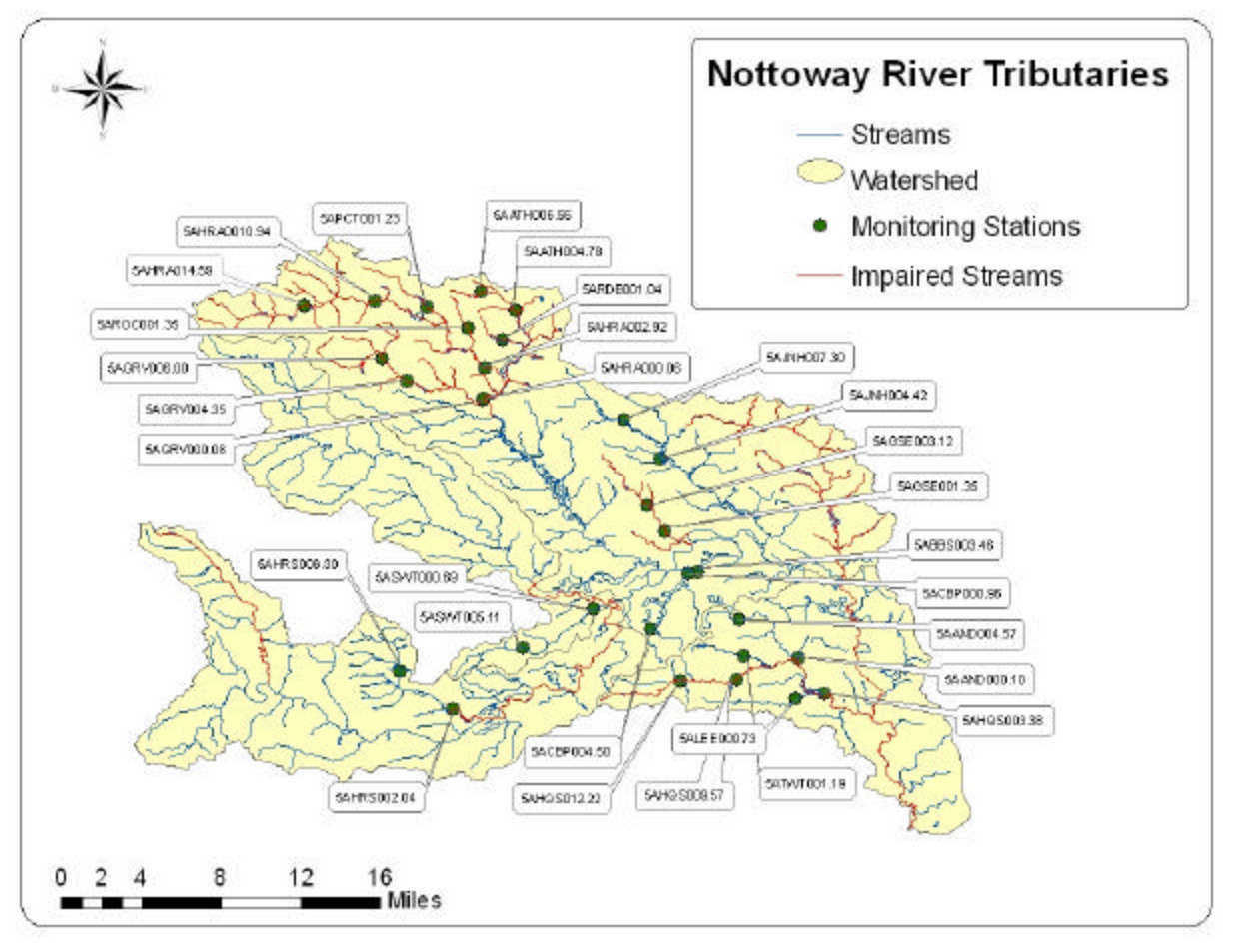
The subject Nottoway River tributaries include Anderson Branch, Arthur Swamp, Black Branch Swamp, Cabin Point Swamp, Gravelly Run, Hunting Quarter Swamp, Hatcher Run, Harris Swamp, Jones Hole Swamp, Lees Branch, Picture Branch, Reedy Branch, Rocky Branch, Southwest Swamp, and Thweatt Branch, located within Dinwiddie, Prince George and Sussex Counties, Virginia. These are minor tributaries to the Chowan River (USGS Hydrologic Unit Code 03010201). The waterbodies identification codes (WBID, Virginia Hydrologic Unit) for the non-tidal Nottoway River tributaries are VAP-K19R, VAP-K21R, VAP-K23R, and VAP-K24R. There are 733.8 total rivermiles in these Nottoway River tributaries (National Hydrography Dataset (NHD). A total of 217.9 rivermiles of the Nottoway River tributaries were listed as impaired due to violations in water quality standards for pH or dissolved oxygen. This report addresses both the pH and dissolved oxygen impairments.

2.2. Watershed

2.2.1. General Description

The Nottoway River and its tributaries, located in Prince George, Dinwiddie and Sussex Counties, Virginia, are major tributaries of the Chowan River Basin. The river and its tributaries are approximately 733.8 miles long and flow southeast from the headwaters of Hatcher Run at Rt. 460 near Poole Siding, VA, to the confluence of Hunting Quarter Swamp with the Nottoway River near Lumberton, VA. The watershed has an area of approximately 529.0 square miles There is a continuous flow gaging station on Stony Creek near Dinwiddie, VA (USGS: 02046000), which has a drainage area of 112 mi^2 and the adjacent Nottoway River tributary west of the subject Nottoway River tributaries. This gaging station is approximately 6 miles south of the headwaters of Hatcher Run and approximately 27 miles northwest of the mouth of Hunting Quarter Swamp at the Nottoway River.

Figure 1. The Nottoway River Tributaries watershed map and associated monitoring stations.



2.2.2. Geology, Climate, Land Use

Geology and Soils

The impaired segment of the Nottoway River and tributaries are predominately within the Atlantic Coastal Plain physiographic region, though the headwaters of some tributaries are located within the lower Piedmont physiographic province. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.geology.state.va.us/DOCS/Geol/coast.html).

Soils for the Nottoway River watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Six general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi). Figure 2 shows the location of these general soil types in the watershed.

Soils of the **Emporia-Johnston-Kenansville-Remlik-Rumford-Slage-Suffolk-Tomotley series (VA027)** are very deep, very poorly to somewhat excessively drained, with moderately rapid to slow permeability. They are composed of muck, loam and fine sand, with slopes ranging from 0 to 65 percent.

Soils of the **Appling-Wedowee-Ashlar-Louisburg-Vance-Worsham series (VA030)** are moderate to very deep that formed in residuum from weathered igneous, metamorphic, and crystalline rock of the Piedmont Plateau. Soils range from excessively to poorly drained, with moderately rapid to slow permeability.

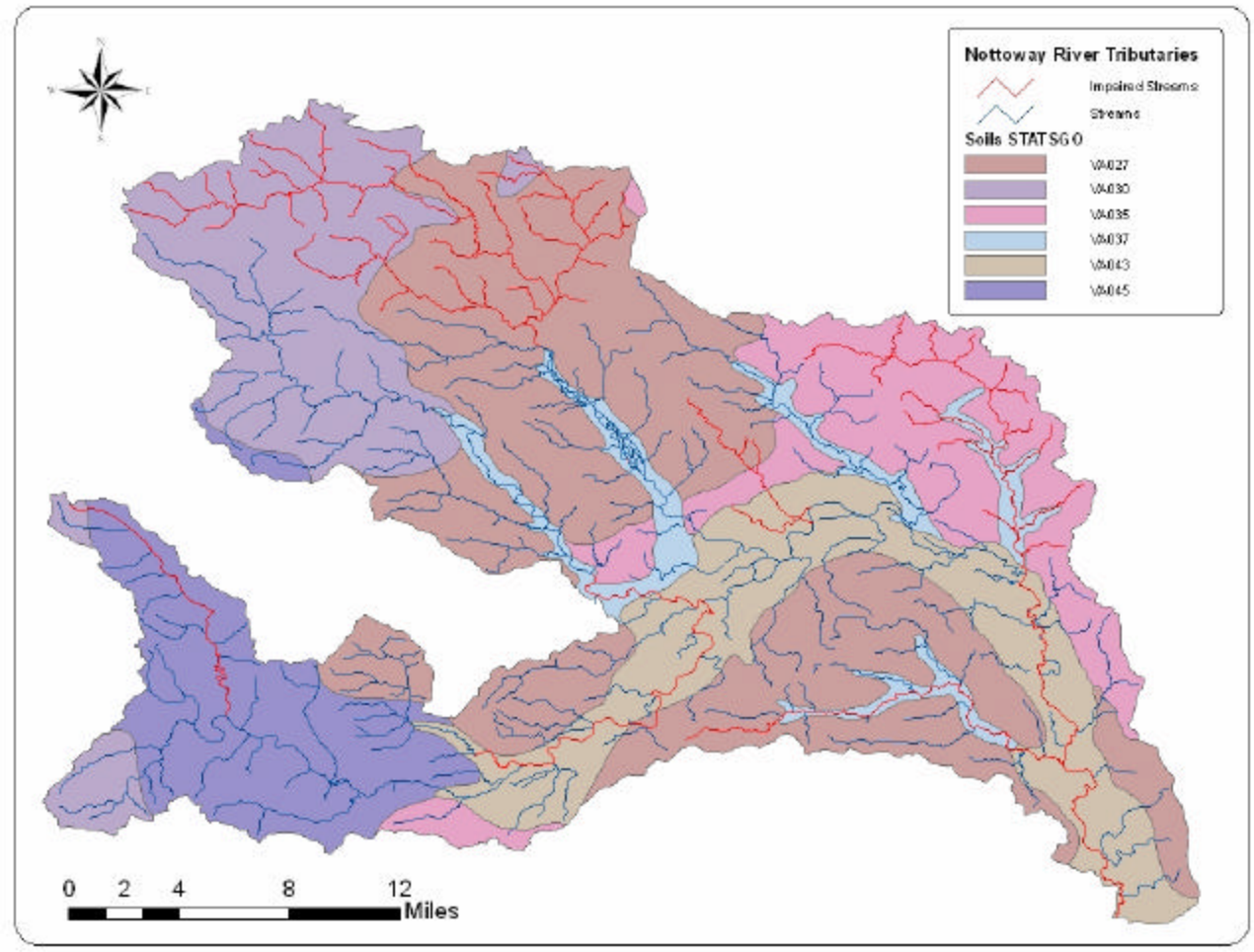
Soils of the **Craven-Mattaponi-Lenoir-Coxville Series (VA035)** are very deep and range from well drained to poorly drained. Permeability ranges from moderately slow to slow. This soil series was formed in clayey, sandy to silty loam. Slopes range from 0 to 25 percent.

The **Portsmouth-Roanoke-Rains-Eunola-Levy-Kalmia Series** (**VA037**) are very deep, very poorly to moderately well drained soils. These soils are located on low stream or marine terraces and in marshes of the Atlantic Coastal Plain. These series are formed from fluvial and marine sediments. Permeability of these soil types ranges from very slow to rapid, depending on soil composition.

Soils of the **Slagle- Kenansville-Lakeland-Roanoke Series (VA043)** very deep, and range from very poor to excessively drained. They are located on uplands and low stream or marine terraces from the upper to lower Coastal Plain. The Roanoke soils formed from Piedmont clayey fluvial sediments, while the other soils formed from marine fluvial sediments and are predominantly silt loam or loamy sand. Permeability range from very slow to very rapid.

Soils of the **Georgeville-Nason-Iredell-Lignum-Orange-Goldston** (**VA045**): are deep, and range from poorly to moderately to well drained. These soils are slow to moderately permeable with slow to medium to high runoff. They were formed from upland materials of weathered fine-grained metamorphic rock.

Figure 2. Soil Characteristics of the Nottoway River Tributaries Watershed.



Climate

The climate summary for the Nottoway River comes from a weather station located in Stony Creek 3 ESE, VA with a period of record from 8/1/1948 to 12/31/2005. The average annual maximum and minimum temperature (°F) at the weather station is 70.3 and 45.6 and the annual rainfall (inches) is 45.21 (Table 1) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 1. Climate summary for Stony Creek 3 ESE, Virginia (448129).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	47.9	52.1	60.6	72.2	79.3	86.9	90.2	87.7	82.1	71.5	62.0	51.0	70.3
Average Min. Temperature (F)	26.5	29.3	35.3	44.0	52.9	62.0	66.2	64.4	57.4	44.8	36.3	28.6	45.6
Average Total Precipitation (in.)	3.64	3.22	4.29	3.08	4.29	4.02	4.90	4.74	3.97	2.95	2.84	3.28	45.21

Land Use

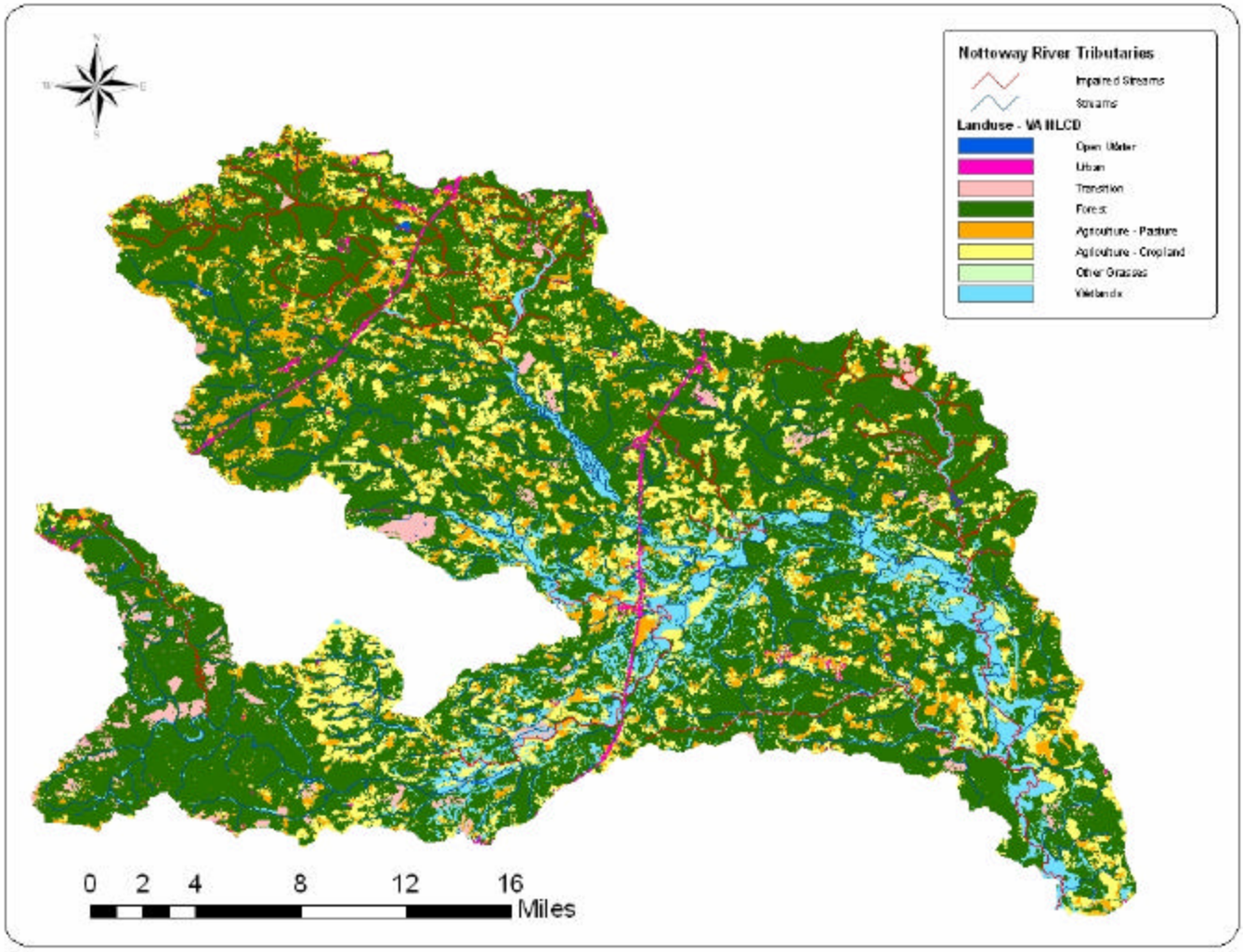
The Nottoway River tributaries watershed extends approximately 48 miles upstream from the confluence of Hunting Quarter Swamp and the Nottoway River to its headwaters at Rt. 460 near Poole Siding, VA, and is 10 - 15 miles wide. The watershed is approximately 338,570.10 acres (529 mi^2) in size and is predominately forested (66.1 percent). Agriculture encompasses 21.0 percent of the watershed, with 13.4 percent cropland and 7.6 percent pasture/hayland. Residential and industrial areas compose approximately 1.0 percent of the land base. The remaining 11.9 percent of the watershed is comprised of 2.2 percent of transitional areas and grasses, and 9.7 percent wetlands and open water. Land use is described in Table 2.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land use is concentrated near the headwaters, and wetlands / water land use is concentrated along the mainstem in the center and downstream portions to the mouth.

Table 2. Land Use in the Nottoway River Tributaries Watershed

Landuse	Acres	Sq Miles	Percent of Total
Open Water	2,553.09	3.99	0.75%
Low Intensity Residential	975.81	1.52	0.29%
High Intensity Residential	5.18	0.01	0.00%
High Intensity Commercial/Industrial/Transportation	2,412.41	3.77	0.71%
Transitional	7,497.66	11.72	2.21%
Deciduous Forest	99,292.42	155.14	29.33%
Evergreen Forest	46,571.56	72.77	13.76%
Mixed Forest	78,040.66	121.94	23.05%
Pasture/Hay	25,581.13	39.97	7.56%
Row Crops	45,500.31	71.09	13.44%
Other Grasses (Urban/recreational; e.g. parks)	7.43	0.01	0.00%
Woody Wetlands	28,731.87	44.89	8.49%
Emergent Herbaceous Wetlands	1400.58	2.19	0.41%
Total:	338,570.10	529.02	100.00

Figure 3. Land Use in the Nottoway River Tributaries Watershed



3. Description of Water Quality Problem/Impairment

The Nottoway River tributaries were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report, 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998 & 2004) due to violations of the State's water quality standard for pH and DO. This report evaluates both the DO and pH impairments by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

DEQ sampled and monitored 30 stations from 16 tributaries to the Nottoway River (Figure 1) from June 12, 2001 through August 21, 2006. Of the 269 total pH data points recorded, 139 violated water quality standards for pH (51.7%), and 87of 270 DO data points violated the water quality standards for DO concentration (32.2%). The DO minimum and maximum values ranged from 0.20 to 13.12 mg/L, and pH values ranged from 3.87 to 7.47. The results are summarized in Table 3.

Table 3. DO and pH data collected by DEQ from 30 stations along 16 tributaries to the Nottoway River.

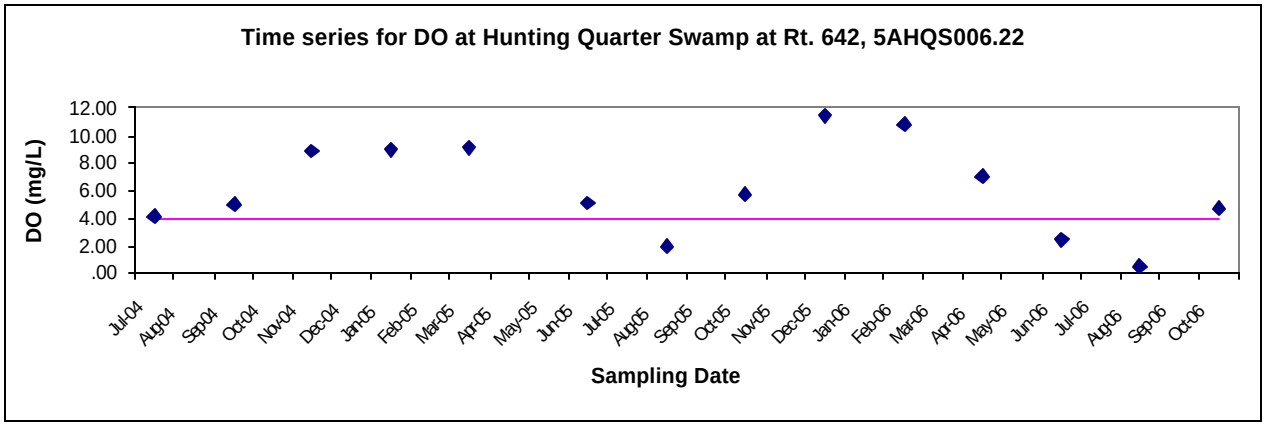
			mg/L		SU		Number of Violations	
Station	**Sample Period**	**Number of Samples**	**Average DO**	**Min-Max DO**	**Average pH**	**Min-Max pH**	**DO**	**pH**
5AAND000.10	1/18/2006 to 8/21/2006	8	4.55	.40 – 8.96	6.13	5.9 – 6.6	3	2
5AAND004.57	1/18/2006 to 8/21/2006	8	6.45	2.4 -9.78	4.08	3.87 – 4.26	2	8
5AATH004.78	1/23/2006 to 8/21/2006	8	6.54	1.5 – 10.10	5.7	5.3 – 6.6	2	7
5AATH006.56	1/23/2006 to 8/21/2006	8	6.11	1.10 – 10.07	5.59	5.2 – 6.1	3	6
5ABBS003.46	1/18/2006 to 8/21/2006	8	4.71	1.30 – 8.21	4.33	4.0 – 4.8	4	8
5ACBP000.96	1/18/2006 to 8/21/2006	8	5.00	.30 – 9.47	4.73	4.28 – 5.50	4	8
5ACBP004.50	1/18/2006 to 8/21/2006	8	4.28	1.10 – 7.45	4.30	3.90 – 4.80	4	8
5AGRV000.08	1/23/2006 to 8/21/2006	8	7.65	3.60 – 11.60	6.48	6.20 – 7.10	1	0
5AGRV004.35	1/23/2006 to 8/21/2006	9	4.91	.50 – 10.76	6.33	5.90 – 7.20	4	1
5AGRV006.00	1/23/2006 to 8/21/2006	9	5.71	.40 – 11.16	6.29	6.0 – 6.8	3	0
5AGSE001.35	1/18/2006 to 8/21/2006	8	4.83	.60 – 10.03	5.48	5.03 – 5.90	5	8
5AGSE003.12	2/06/2006 to 8/21/2006	7	4.39	.30 – 8.52	5.67	5.18 – 6.80	3	6
5AHQS003.38	7/18/2006 to 8/21/2006	2	3.25	1.80 - 04.7	5.9	5.3 – 6.3	1	1
5AHQS009.57	1/18/2006 to 8/21/2006	8	5.73	.50 – 9.82	4.95	4.50 – 5.60	2	8
5AHQS012.22	1/18/2006 to 8/21/2006	8	6.59	.20 – 10.95	4.62	4.26 – 5.30	2	8
5AHRA000.06	1/23/2006 to 8/21/2006	8	6.23	2.20 – 11.40	6.25	5.94 – 6.60	3	1
5AHRA002.92	1/23/2006 – 8/21/2006	8	7.52	3.50 – 10.69	6.52	6.19 – 6.80	1	0
5AHRA010.94	6/12/2001 to 8/21/2006	21/20	6.83	1.90 – 12.59	6.32	5.47 – 6.90	5	4
5AHRA014.59	1/23/2006 to 8/21/2006	8	5.05	.30 – 10.47	6.02	5.90 – 6.60	4	6
5AHRS002.04	6/20/2001 to 8/21/2006	31	8.48	3.20 – 13.12	6.51	5.82 – 7.47	2	3
5AHRS006.30	1/18/2006 to 8/21/2006	8	4.56	.30 – 9.84	6.18	5.90 – 6.5	4	2

Table 3. Continued:

			mg/L		SU		Number of Violations	
Station	**Sample Period**	**Number of Samples**	**Average DO**	**Min-Max DO**	**Average pH**	**Min-Max pH**	**DO**	**pH**
5AJNH004.42	1/23/2006 to 8/21/2006	8	5.78	1.00 – 12.02	6.17	5.97 – 6.50	4	1
5AJNH007.30	1/23/2006 to 8/21/2006	8	4.58	.30 – 10.32	6.06	5.82 – 6.70	4	4
5ALEE000.73	1/18/2006 to 8/21/2006	8	5.39	.80 – 9.54	5.96	5.65 – 6.30	3	5
5APCT001.23	1/23/2006 to 8/21/2006	8	6.77	3.94 – 11.01	6.27	6.02 – 6.70	0	0
5ARDB001.04	1/23/2006 to 8/21/2006	8	5.80	.40 – 9.66	5.83	5.33 – 6.40	2	5
5AROC001.35	1/23/2006 to 8/21/2006	7	6.99	4.30 – 9.56	5.31	4.95 – 5.60	0	7
5ASWT000.69	1/18/2006 to 8/21/2006	8	5.29	.70 – 9.03	5.06	4.40 – 6.10	3	7
5ASWT005.11	1/18/2006 to 8/21/2006	8	4.75	.90 – 9.27	4.71	4.00 – 5.60	5	8
5ATWT001.19	1/18/2006 to 8/21/2006	8	5.57	.70 – 9.72	5.79	5.35 – 6.40	4	7

A time series graphs of all data collected at the original listing station, Hunting Quarter Swamp at Rt. 642, 5AHQS006.22, shows the DO concentrations ranging from 0.50 mg/l to 11.39 mg/l (Figure 4). The horizontal line at the DO = 4.0 mark represents the minimum water quality standard. The data points below the DO = 4.0 line illustrate violations of the water quality standard.

Figure 4. Time series of DO at Hunting Quarter Swamp at Rt. 642, (station 5AHQS006.22).



3.1 Associated DO of Nottoway River Tributaries

DEQ also monitored and collected data at 30 stations from 16 tributaries to the Nottoway for the assessment of low DO and pH due to the natural conditions for the development of a TMDL. Associated stations with DO and pH data are presented in Figures 5-58 below.

Figure 5. DO at Anderson Branch at Rt. 634, 5AAND000.10.

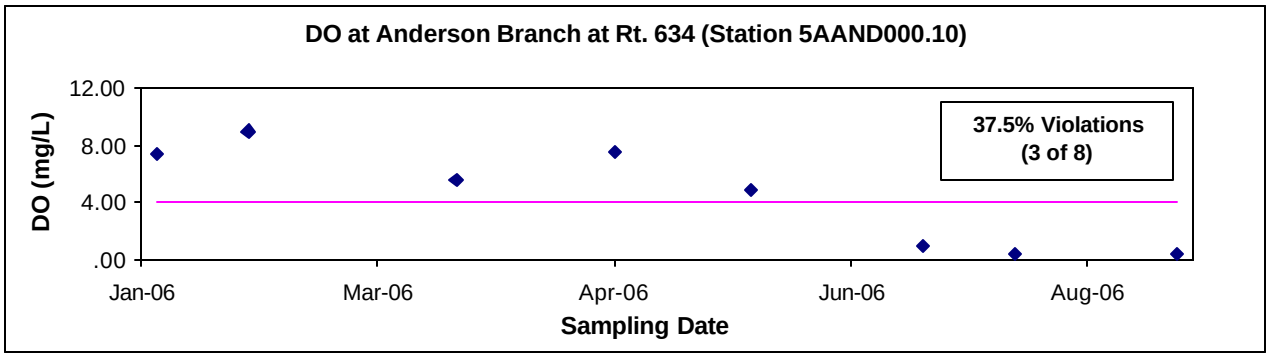


Figure 6. DO Concentrations at Anderson Branch at Rt. 637, 5AAND004.57.

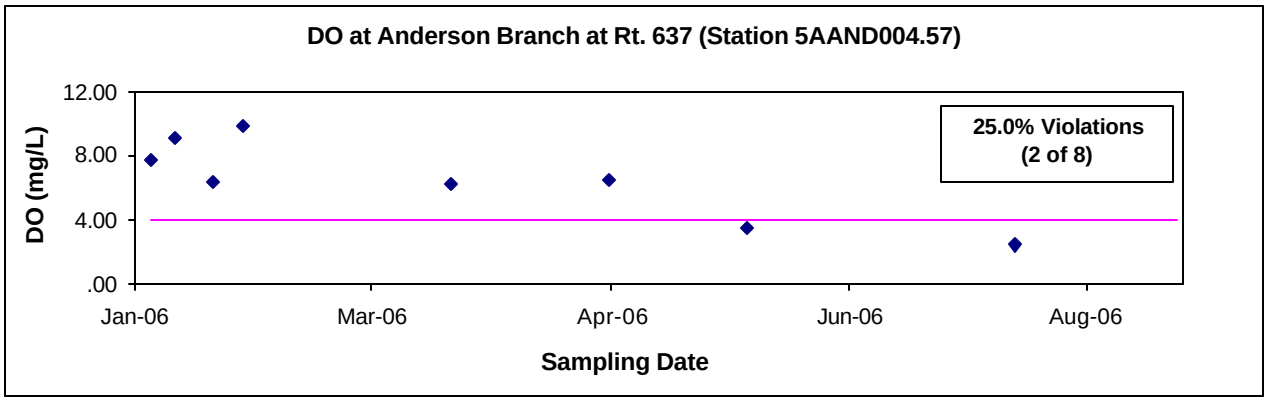


Figure 7. DO Concentrations at Arthur Swamp at Rt. 613, 5AATH004.78.

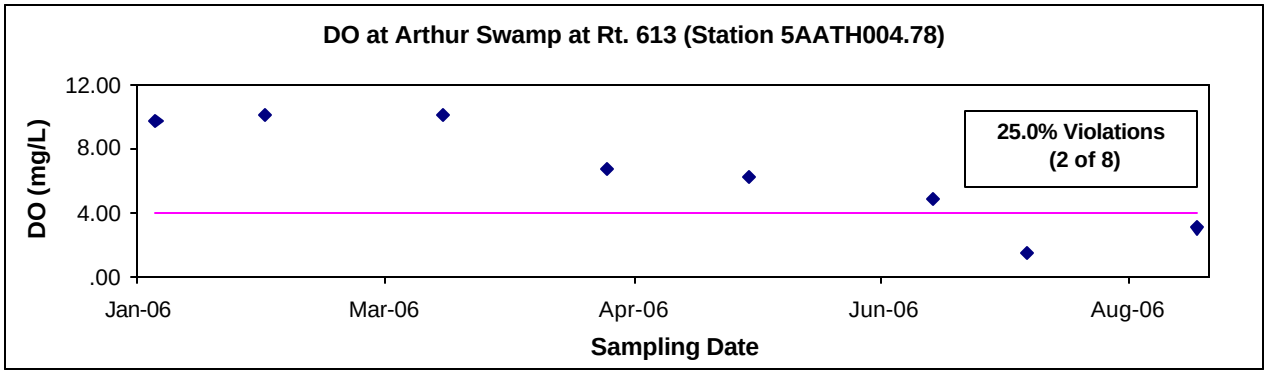


Figure 8. DO Concentrations at Arthur Swamp at Rt. 670, 5AATH006.56.

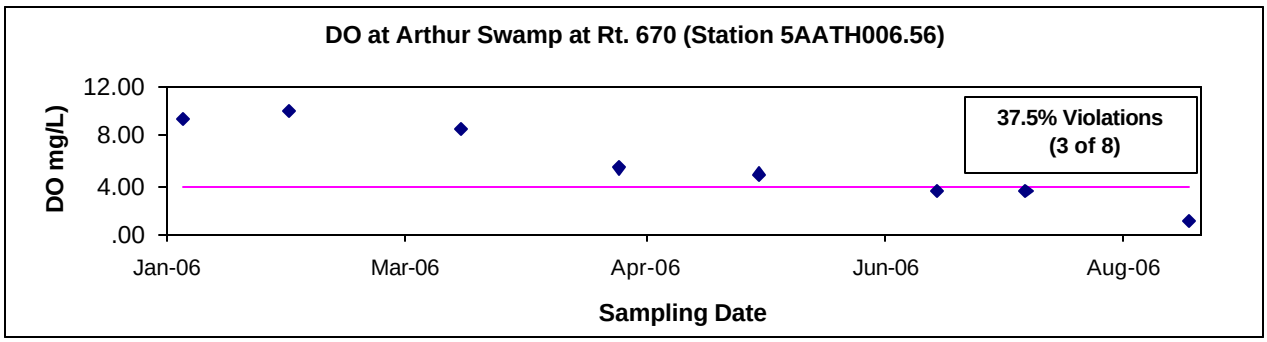


Figure 9. DO Concentrations at Black Branch Swamp at Rt. 640, 5ABBS003.46.

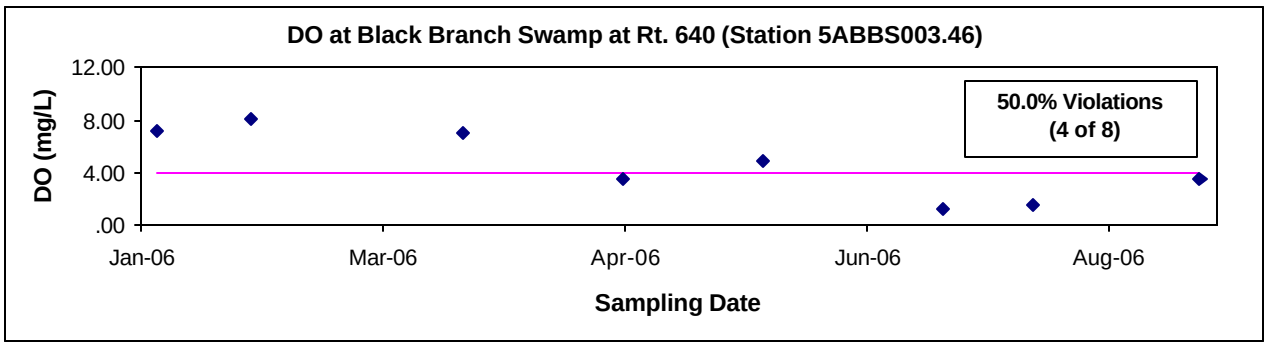


Figure 10. DO Concentrations at Cabin Point Swamp at Rt. 640, 5ACBP000.69.

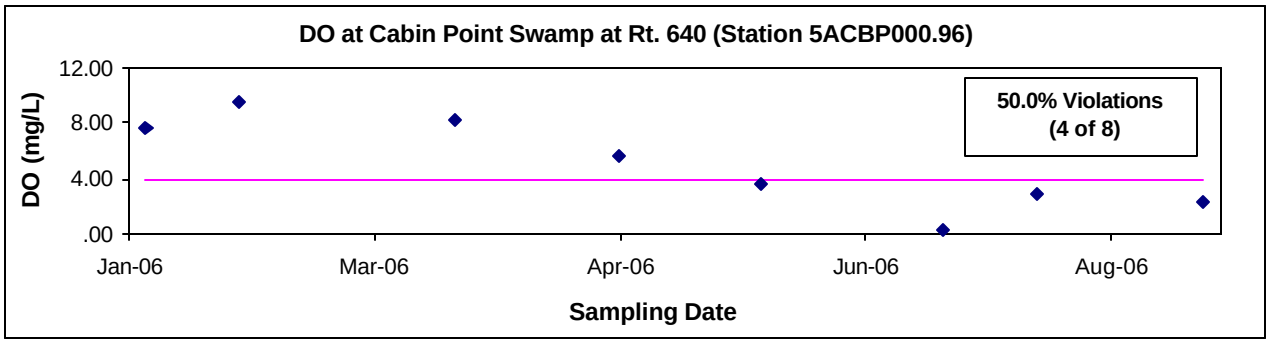


Figure 11. DO Concentrations at Cabin Point Swamp at Rt. 641, 5ACBP004.50.

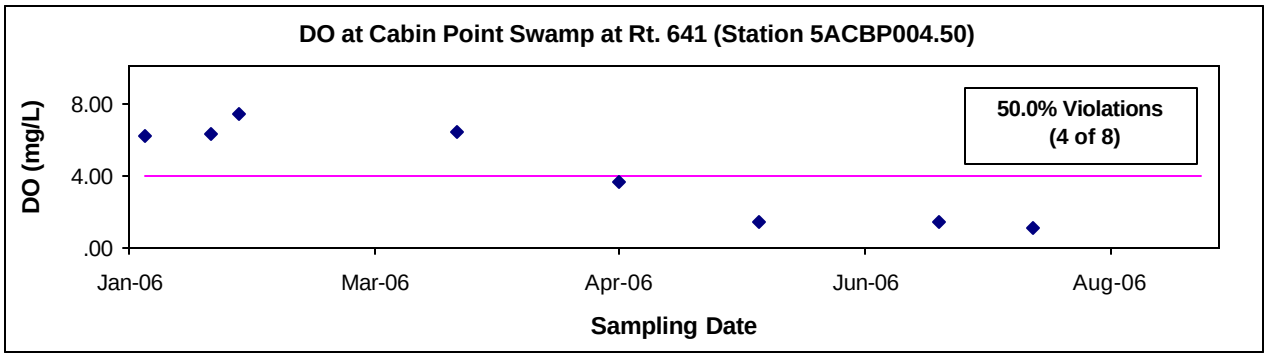


Figure 12. DO Concentrations at Gravelly Run at Rt. 660, 5AGRV004.35.

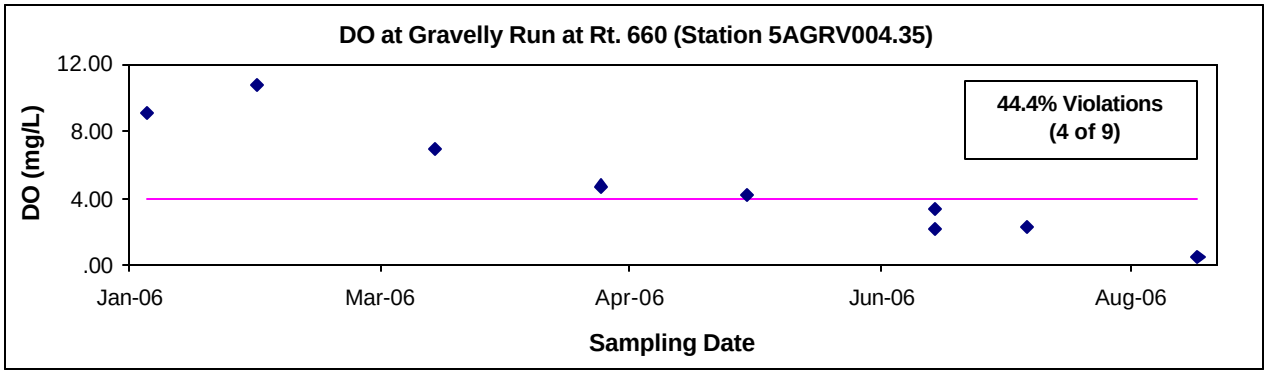


Figure 13. DO Concentrations at Gravelly Run at Rt. 1, 5AGRV006.00.

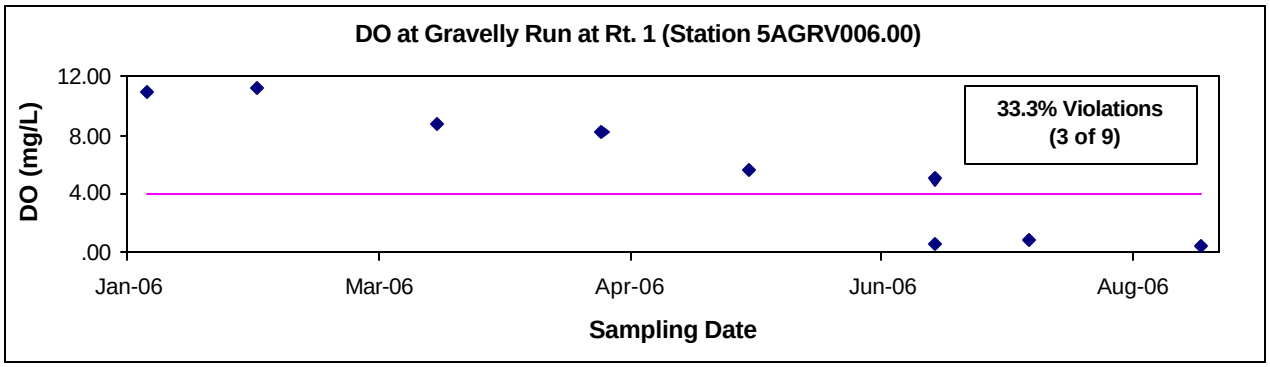


Figure 13a. DO Concentrations at Gravelly Run at Rt. 670, 5AGRV000.08.

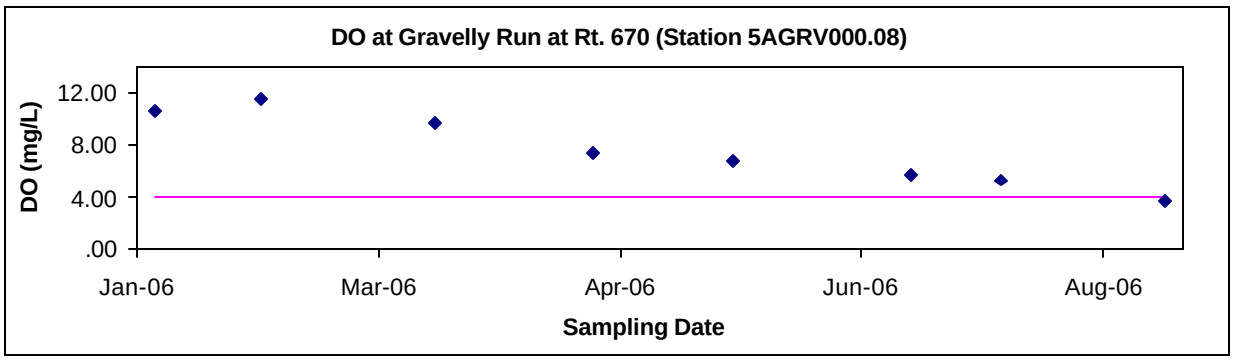


Figure 14. DO Concentrations at Gosee Swamp at Rt. 602, 5AGSE001.35.

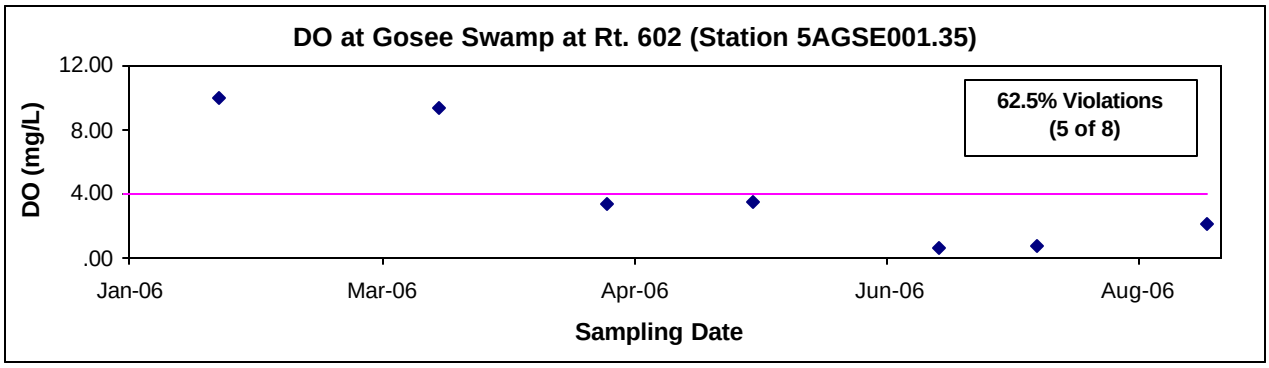


Figure 15. DO Concentrations at Gosee Swamp at Rt. 650, 5AGSE003.12.

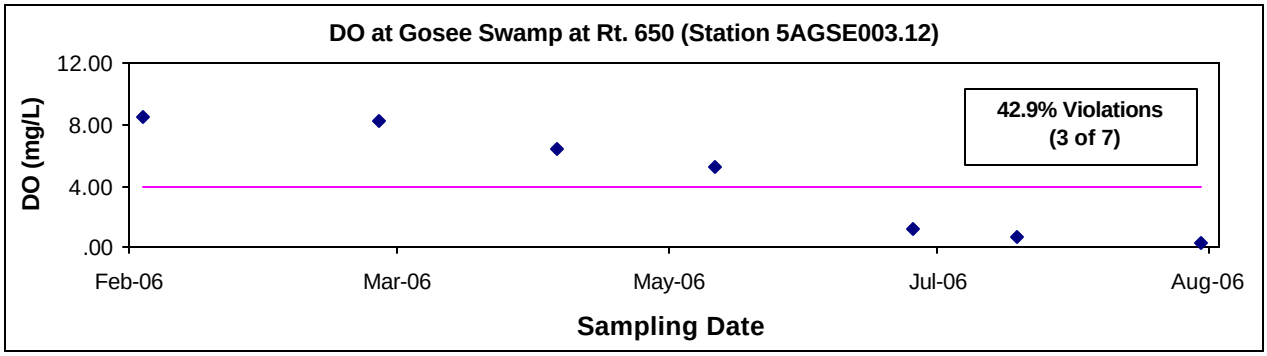


Figure 16. DO Concentrations at Hunting Quarter Swamp at Rt. 735, 5AHQS009.57.

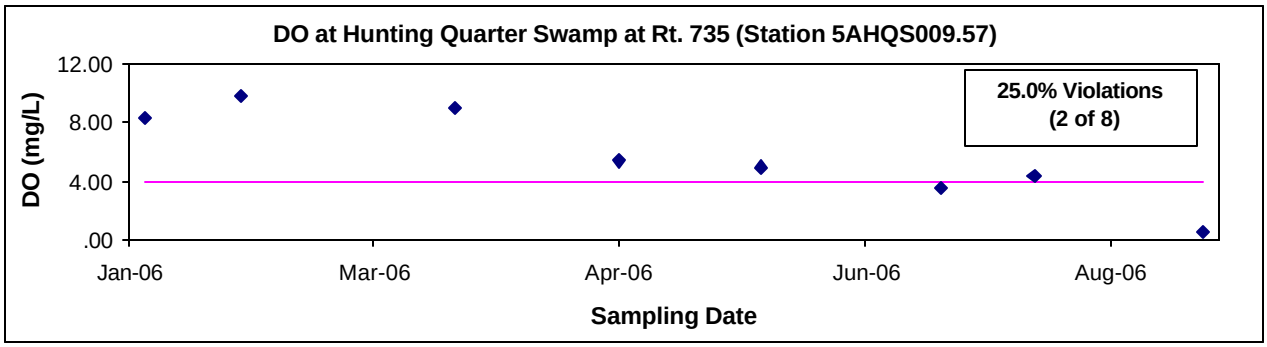


Figure 17. DO Concentrations at Hunting Quarter Swamp at Rt. 641, 5AHQS012.22.

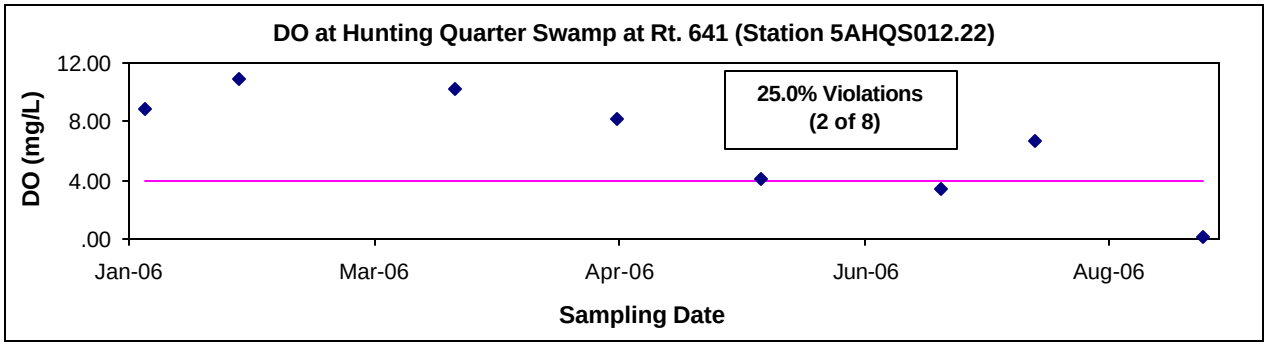


Figure 18. DO Concentrations at Hatcher Run 30m East of Rt. 670, 5AHRA000.06.

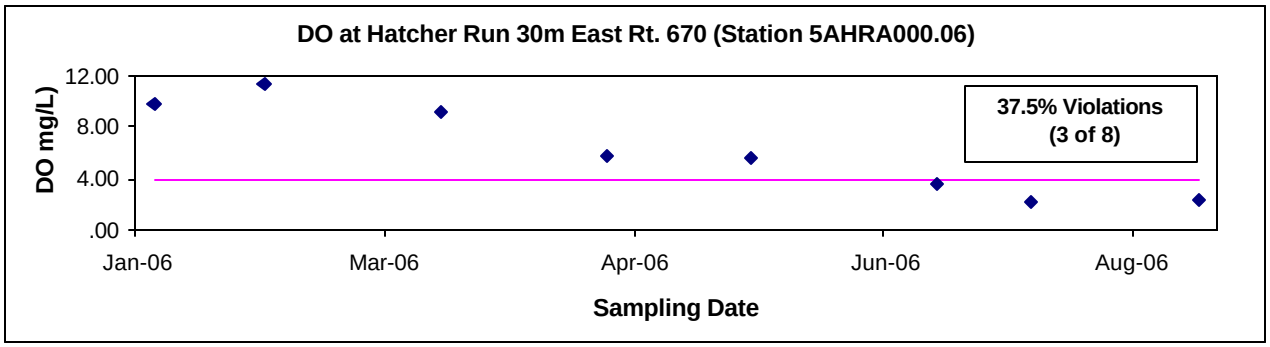


Figure 19. DO Concentrations at Hatcher Run at Rt. 675, 5AHRA002.92.

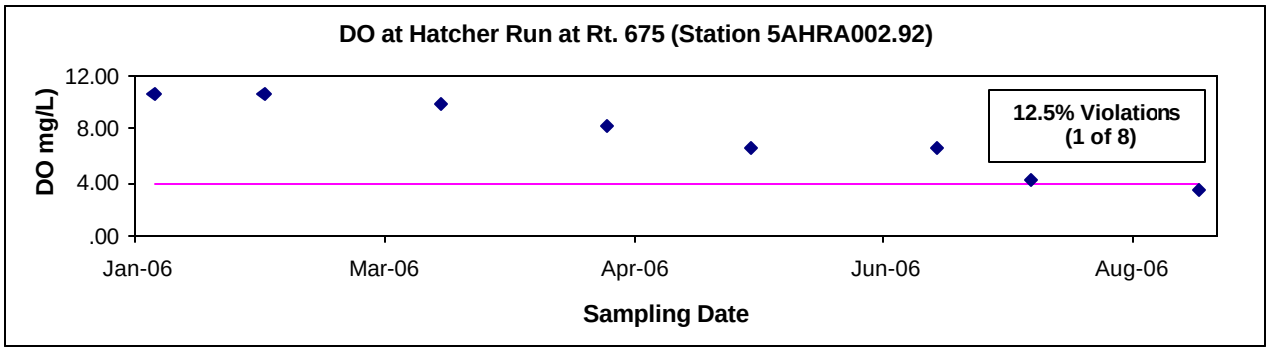


Figure 20. DO Concentrations at Hatcher Run at Rt. 631, 5AHRA010.94.

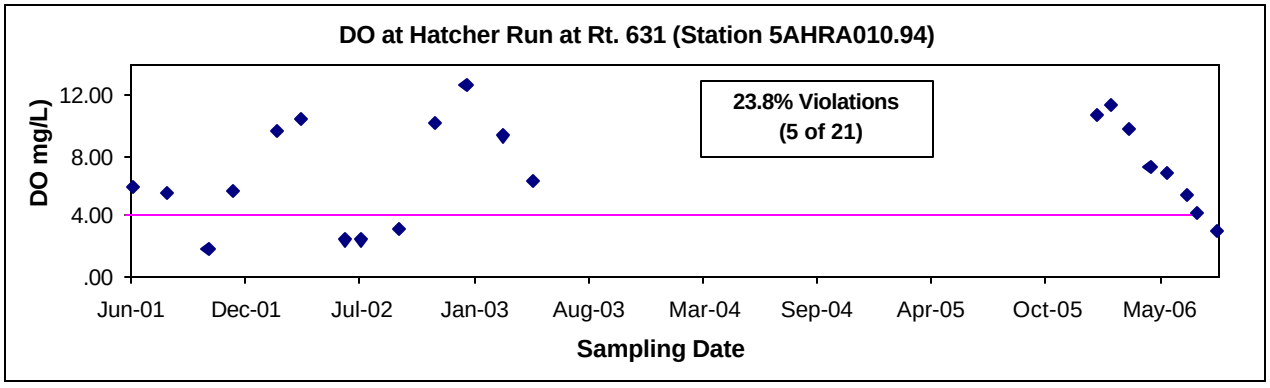


Figure 21. DO Concentrations at Hatcher Run at Rt. 628, 5AHRA014.59.

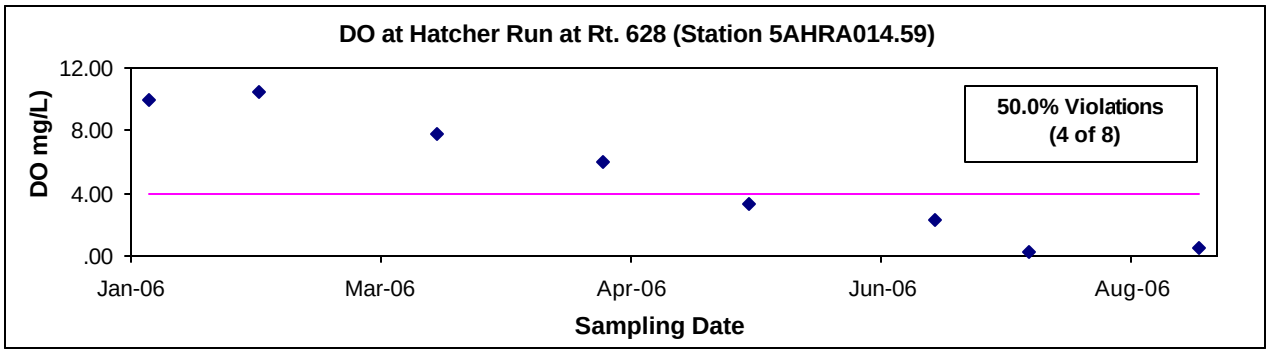


Figure 22. DO Concentrations at Harris Swamp at Rt. 630, 5AHRS002.04.

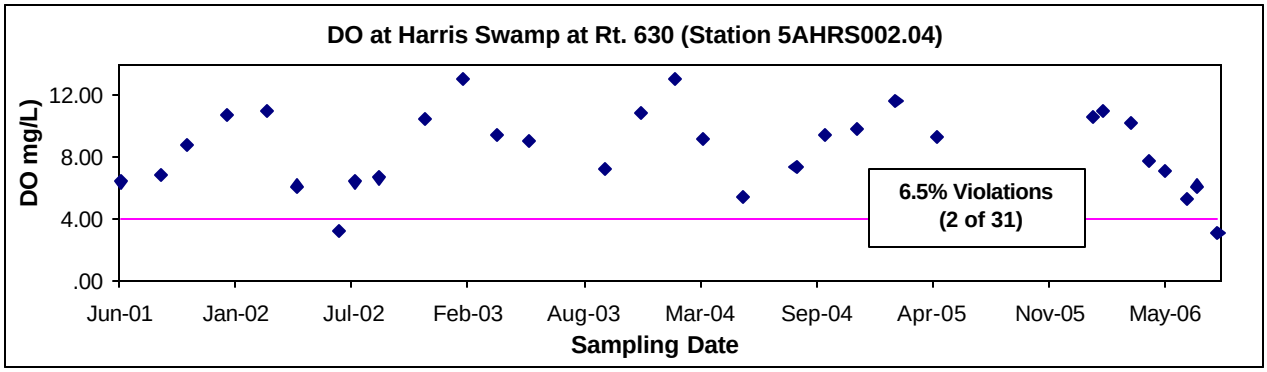


Figure 23. DO Concentrations at Harris Swamp at Rt. 681, 5AHRS006.30.

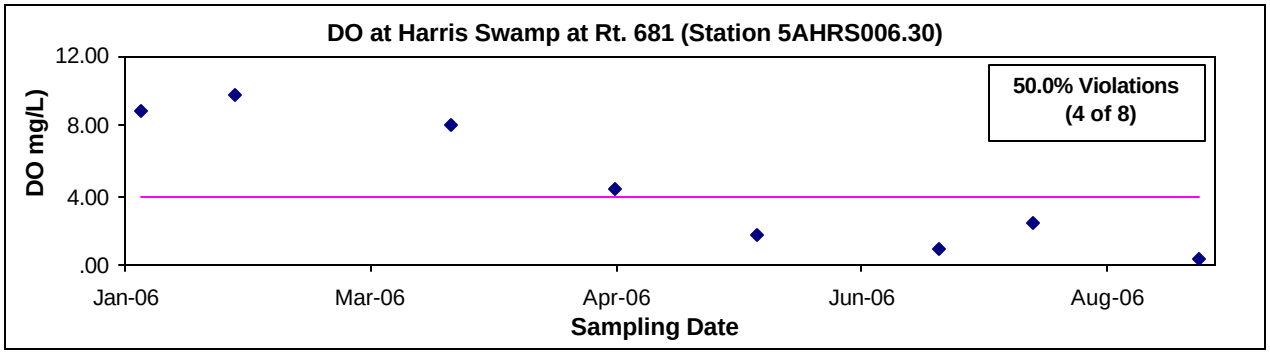


Figure 24. DO Concentrations at Jones Hole Swamp at Rt. 638, 5AJNH004.42.

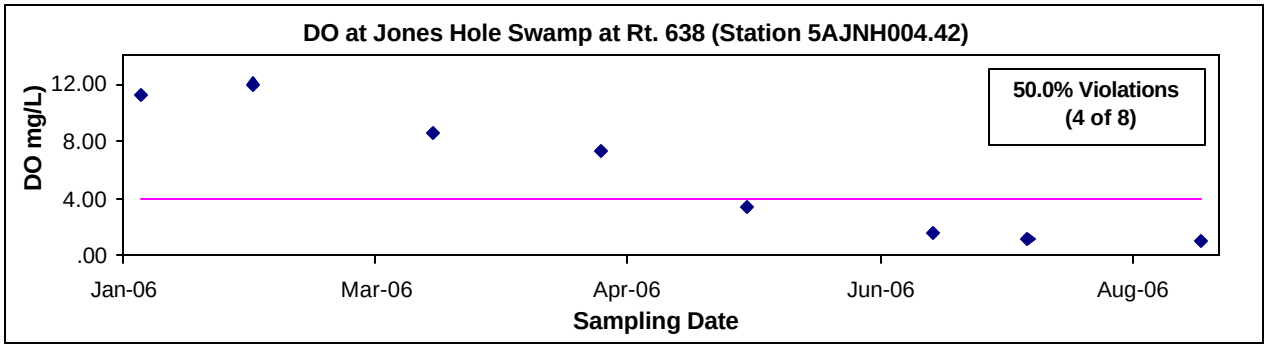


Figure 25. DO Concentrations at Jones Hole Swamp at Rt. 621, 5AJNH007.30.

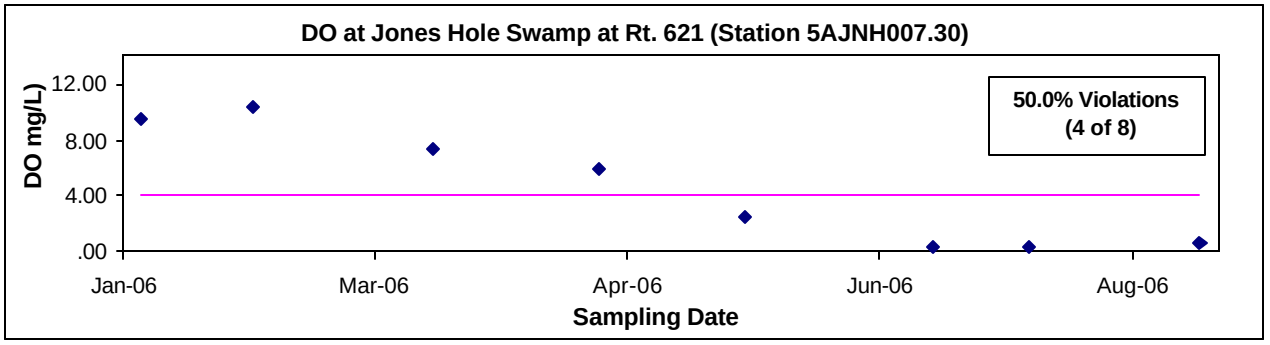


Figure 26. DO Concentrations at Lees Branch at Rt. 608, 5ALEE000.73.

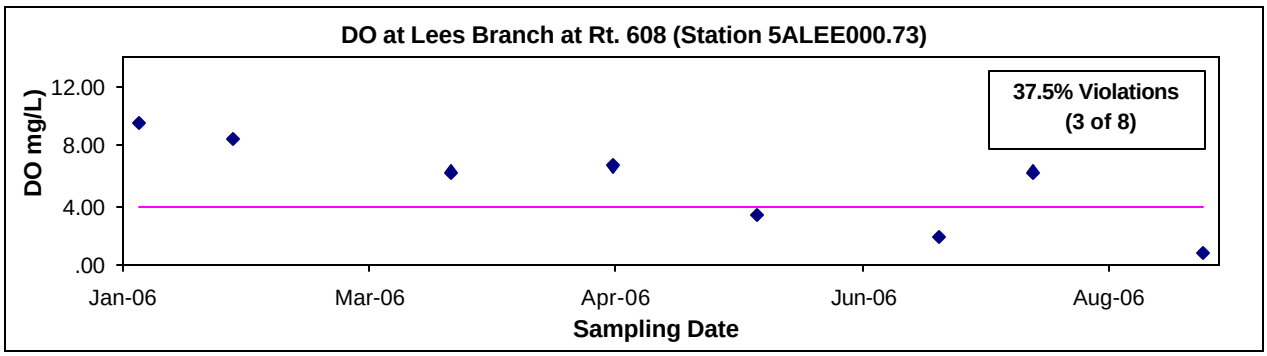


Figure 27. DO Concentrations at Picture Branch at Rt. 1, 5APCT001.23.

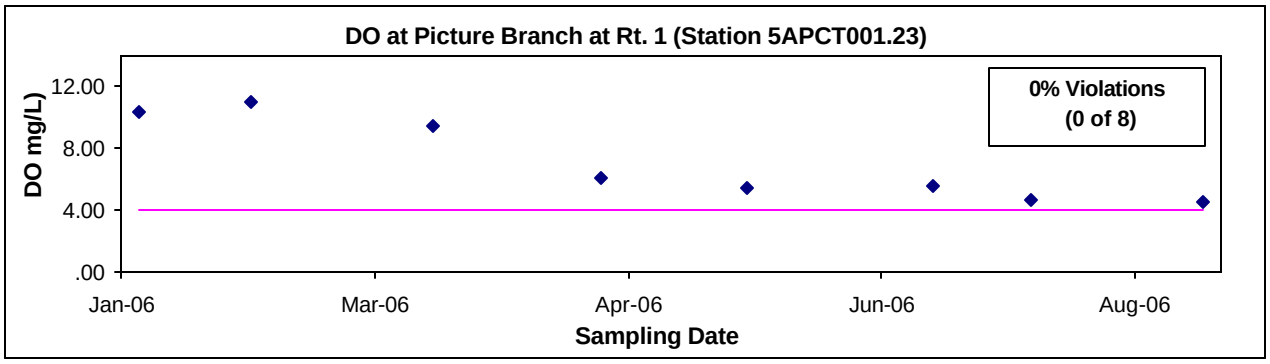


Figure 28. DO Concentrations at Reedy Branch at Rt. 675, 5ARDB001.04.

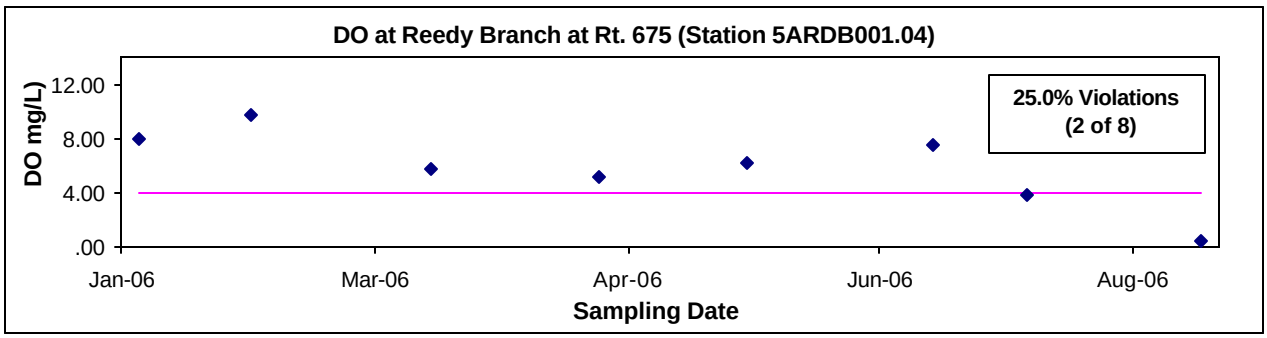


Figure 29. DO Concentrations at Rocky Branch at Rt. 670, 5AROC001.35.

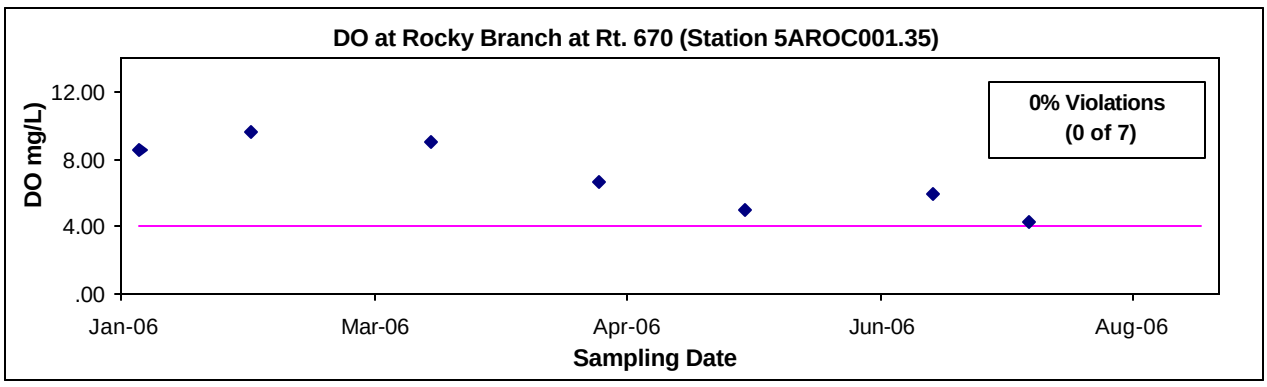


Figure 30. DO Concentrations at Southwest Swamp at Rt. 301, 5ASWT000.69.

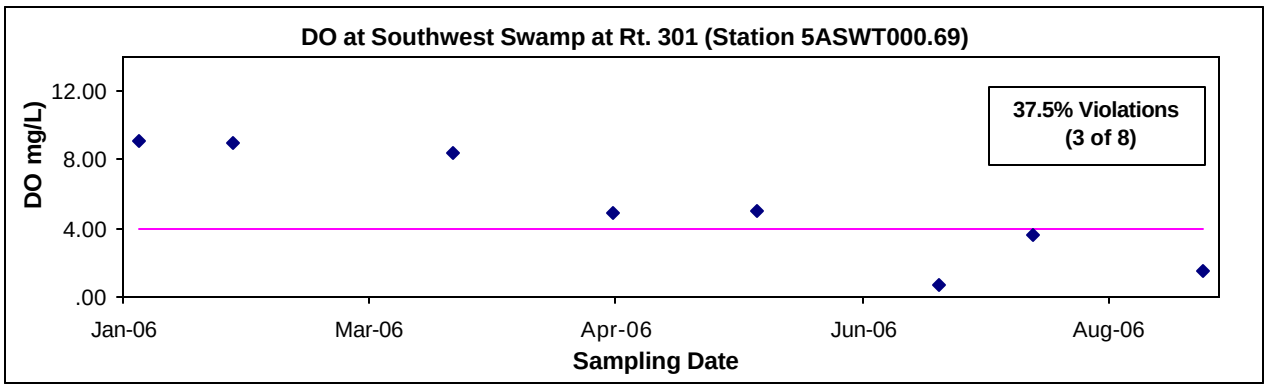


Figure 31. DO Concentrations at Southwest Swamp at Rt. 649, 5ASWT005.11.

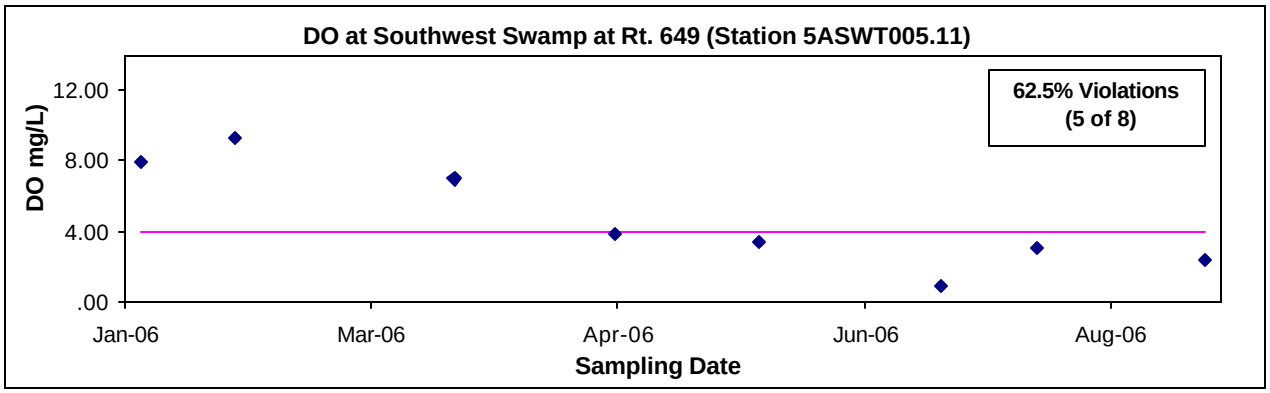
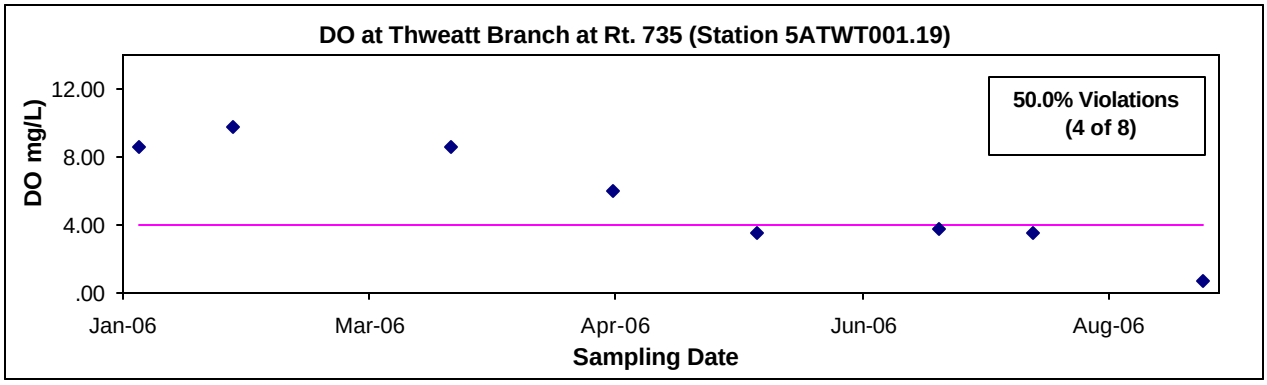


Figure 32 . DO Concentrations at Thweatt Branch at Rt. 735, 5ATWT001.19.



Figures of pH data at the 30 associated stations follow:

Figure 33. pH at Anderson Branch at Rt. 634, 5AAND000.10.

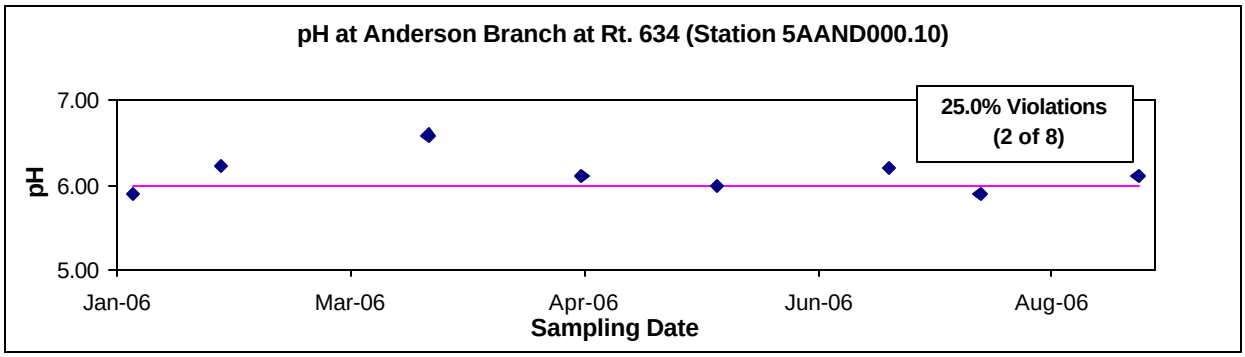


Figure 34. pH at Anderson Branch at Rt. 637, 5AAND004.57.

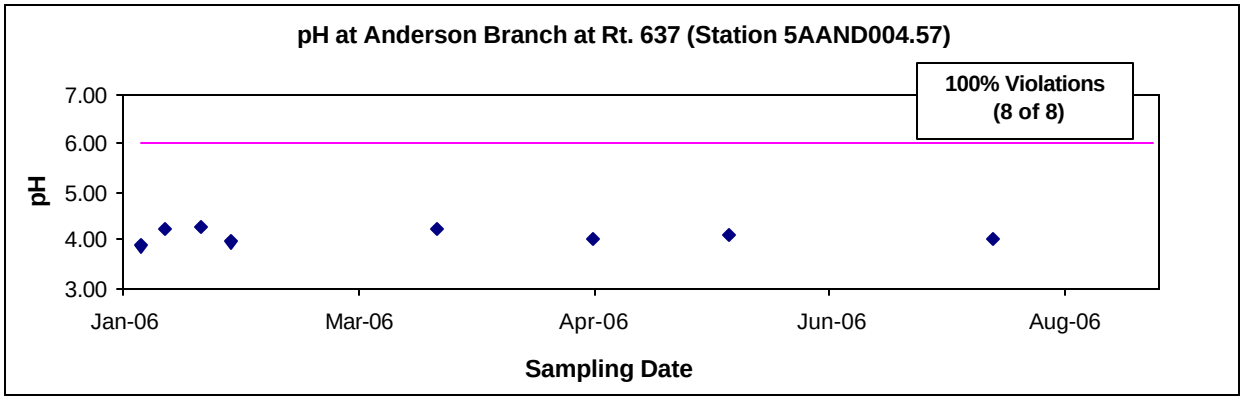


Figure 35. pH at Arthur Swamp at Rt. 613, 5AATH004.78.

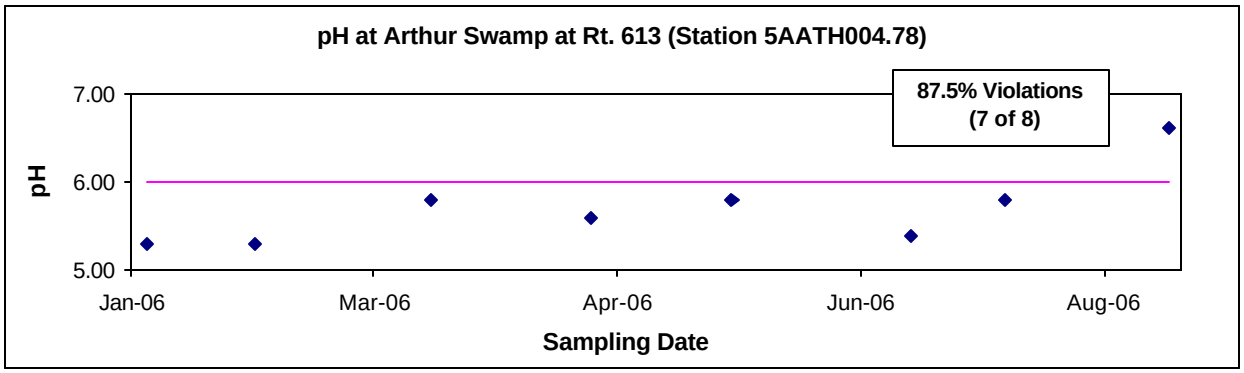


Figure 36. pH at Arthur Swamp at Rt. 670, 5AATH006.56.

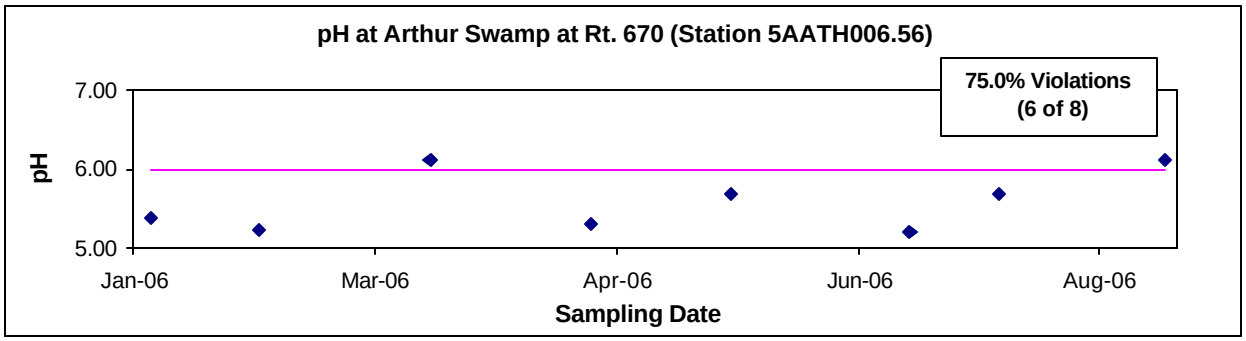


Figure 37. pH at Black Branch Swamp at Rt. 640, 5ABBS003.46.

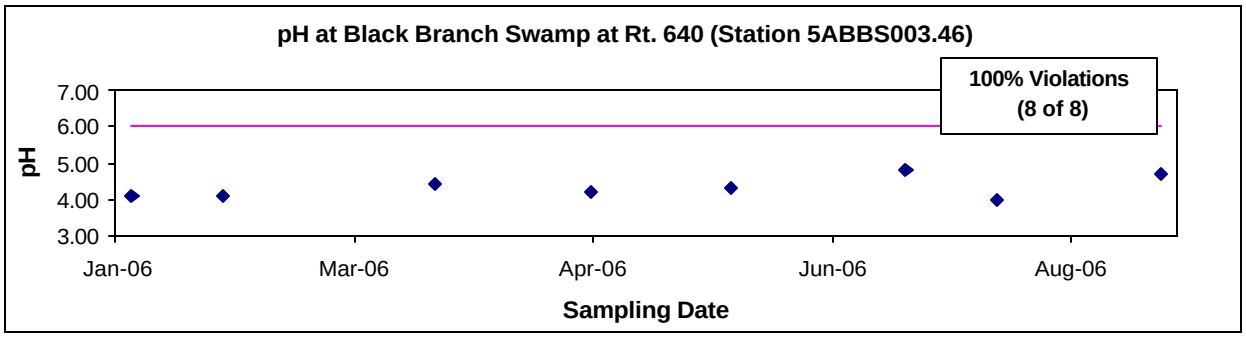


Figure 38. pH at Cabin Point Swamp at Rt. 640, 5ACBP000.96.

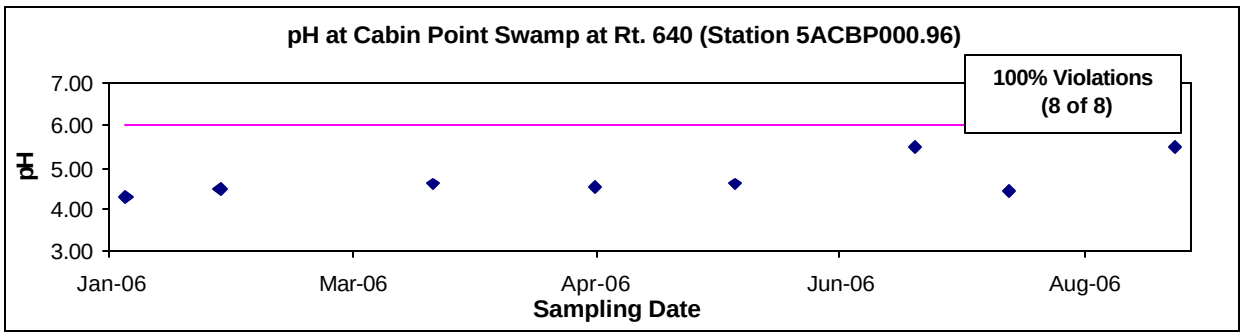


Figure 39. pH at Cabin Point Swamp at Rt. 641, 5ACBP004.50.

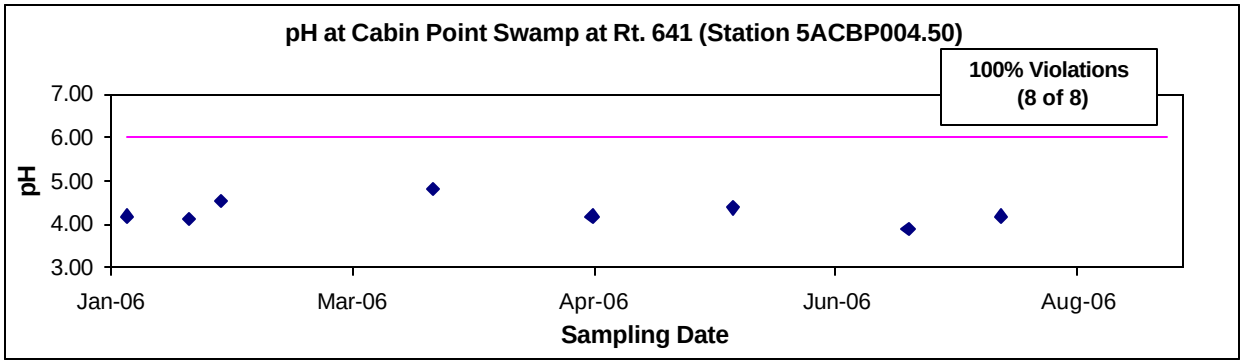


Figure 40. pH at Gravelly Run at Rt. 660, 5AGRV004.35.

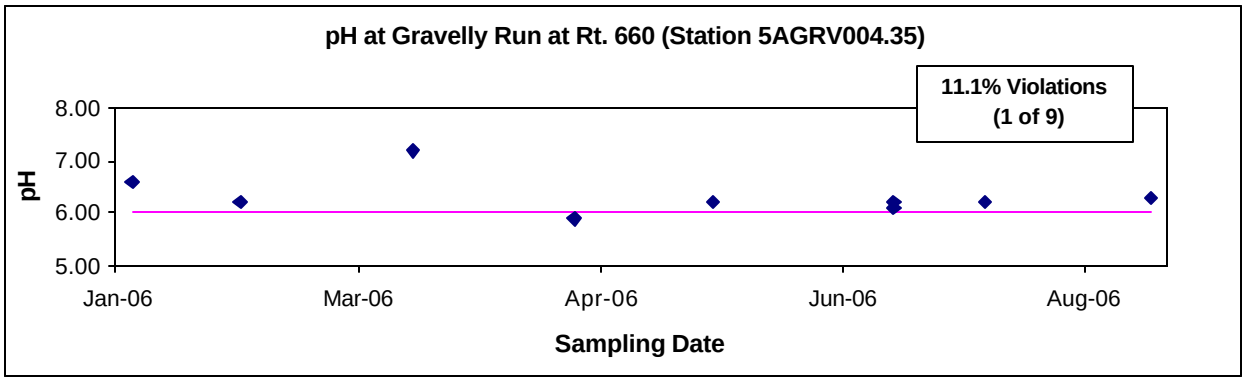


Figure 41. pH at Gosee Swamp at Rt. 602, 5AGSE001.35.

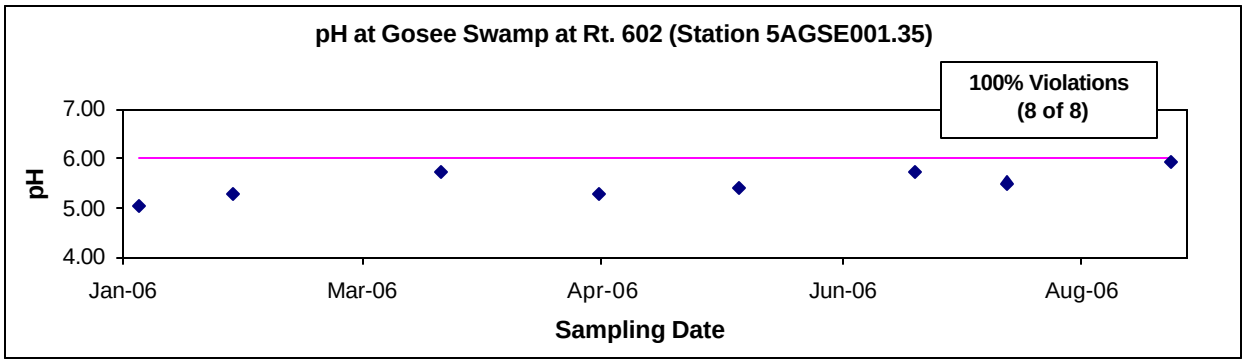


Figure 42. pH at Gosee Swamp at Rt. 650, 5AGSE003.12

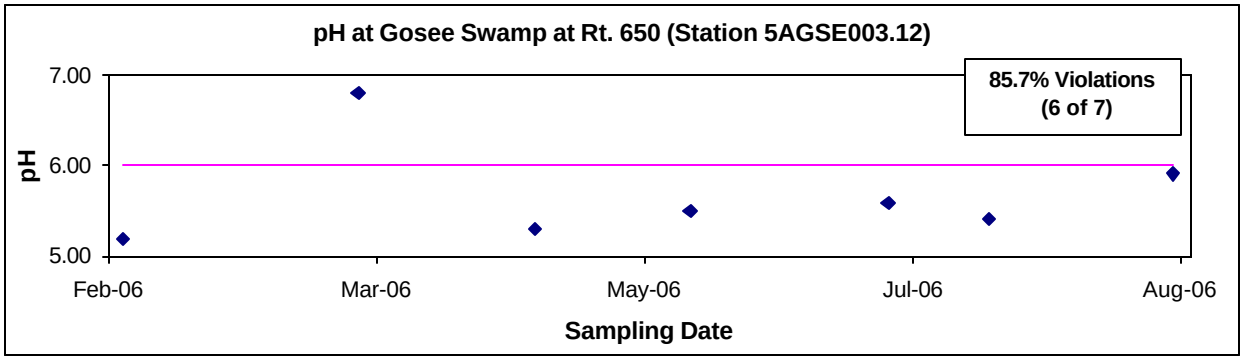


Figure 43. pH at Hunting Quarter Swamp at Rt. 735, 5AHQS009.57.

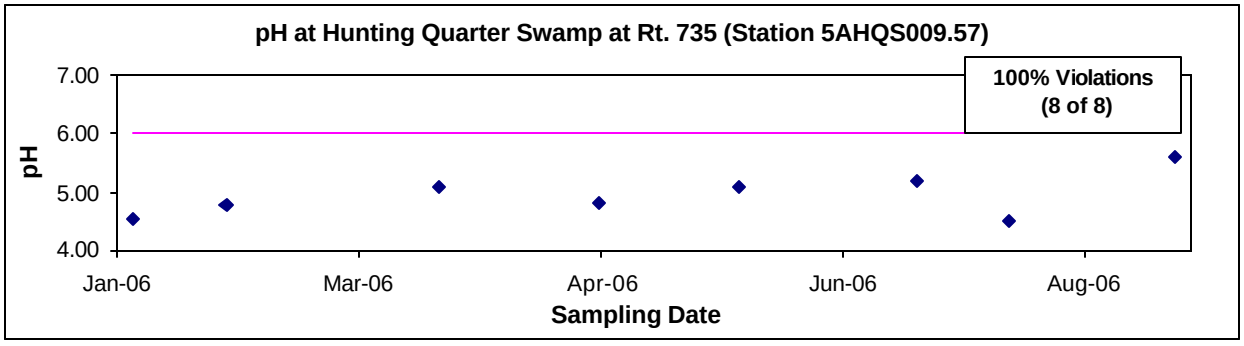


Figure 44. pH at Hunting Quarter Swamp at Rt. 641, 5AHQS012.22.

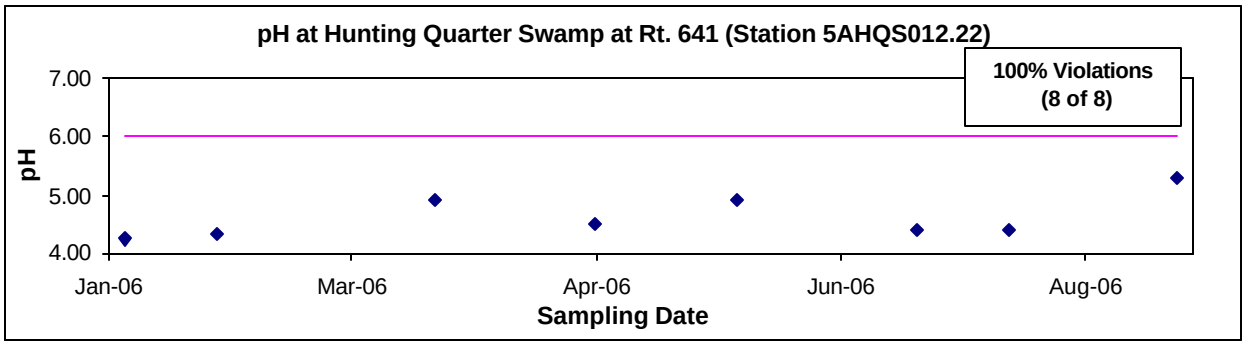


Figure 45. pH at Hatcher Run 30m East of Rt. 670, 5AHRA000.06.

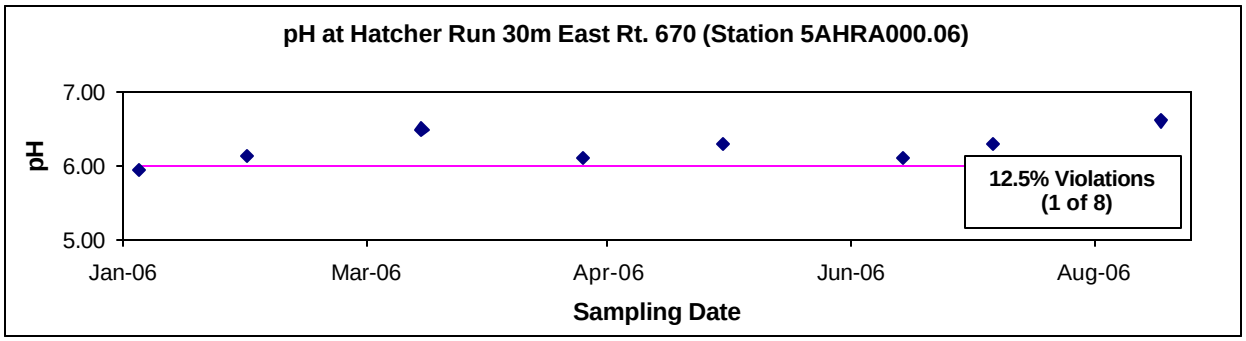


Figure 46. pH at Hatcher Run at Rt. 631, 5AHRA010.94.

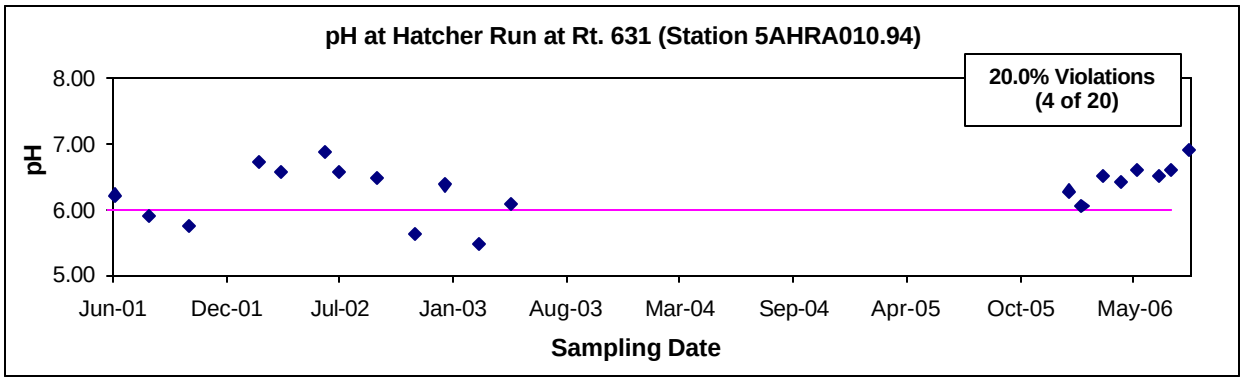


Figure 47. pH at Hatcher Run at Rt. 628, 5AHRA014.59.

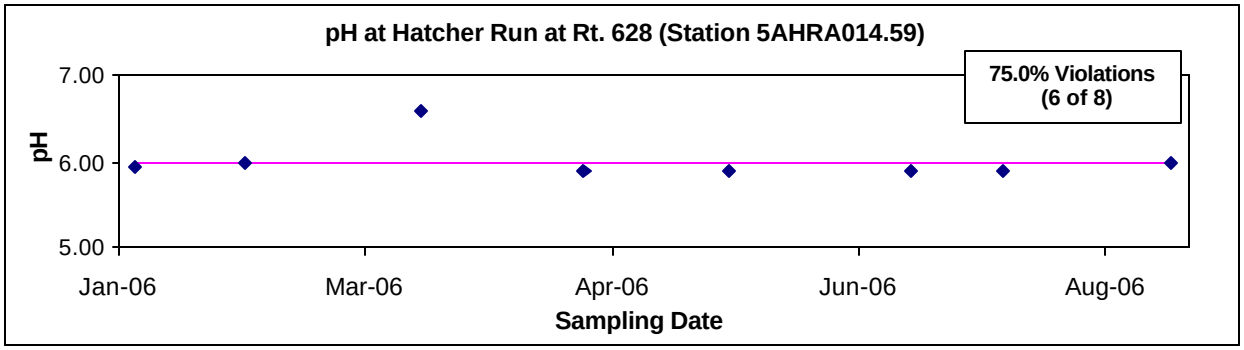


Figure 48. pH at Harris Swamp at Rt. 630, 5AHRS002.04.

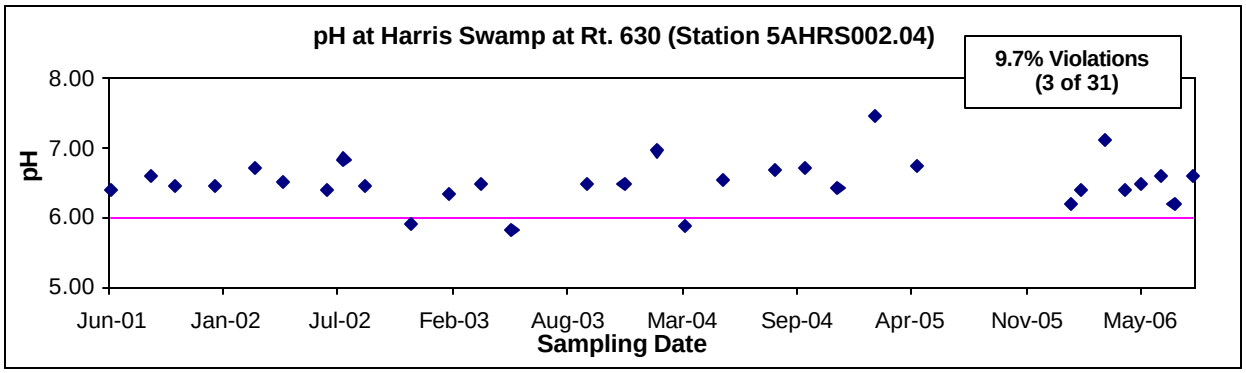


Figure 49. pH at Harris Swamp at Rt. 681, 5AHRS006.30.

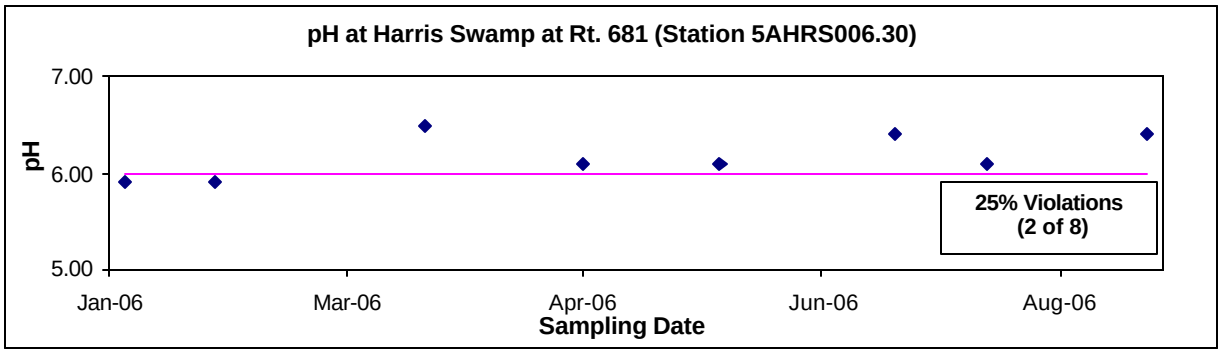


Figure 50. pH at Jones Hole Swamp at Rt. 638, 5AJNH004.42.

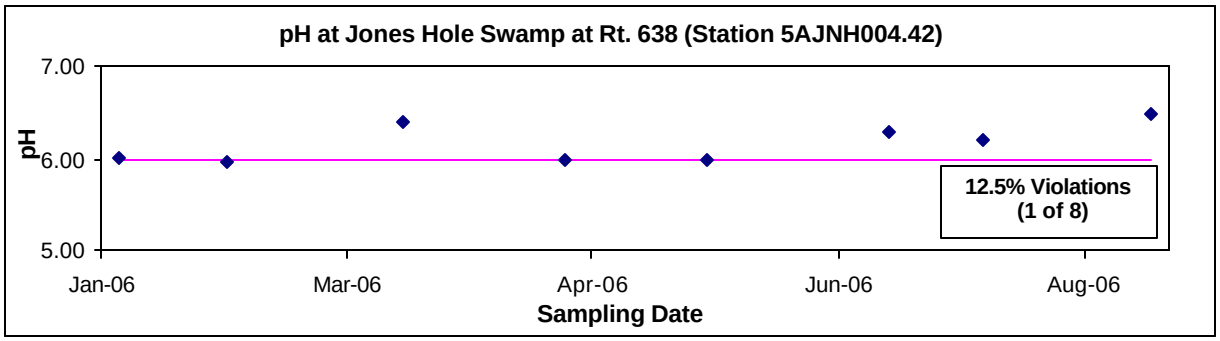


Figure 51. pH at Jones Hole Swamp at Rt. 621, 5AJNH007.30.

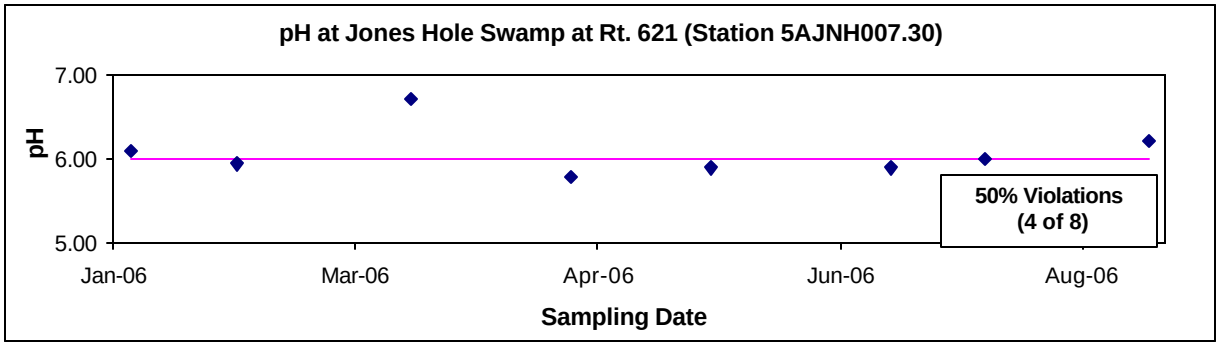


Figure 52. pH at Lees Branch at Rt. 608, 5ALEE000.73.

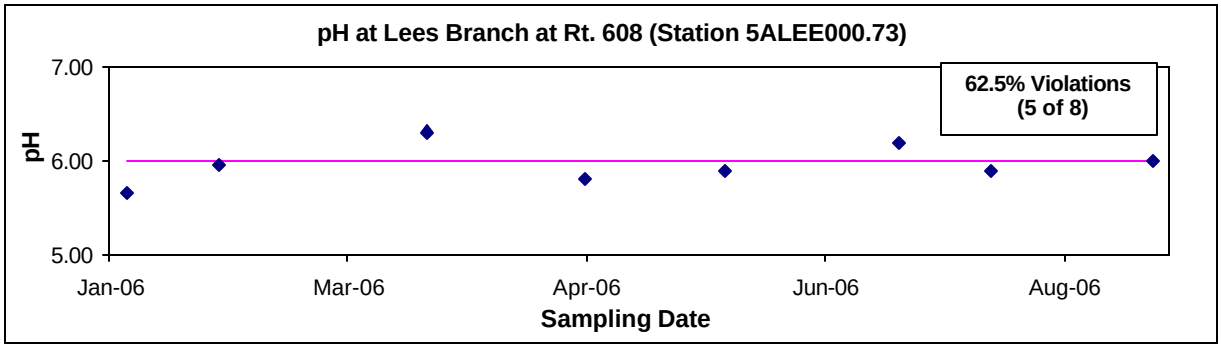


Figure 53. pH at Picture Branch at Rt. 1, 5APCT001.23.

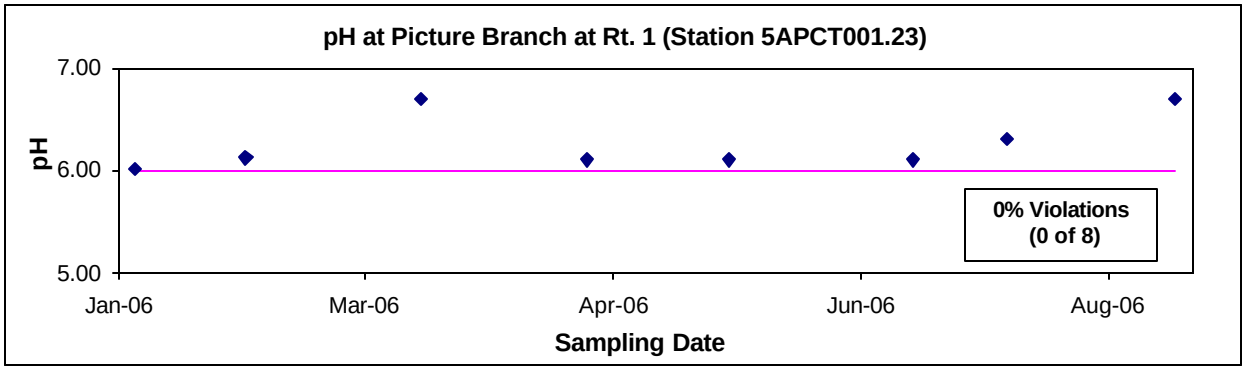


Figure 54. pH at Reedy Branch at Rt. 675, 5ARBD001.04.

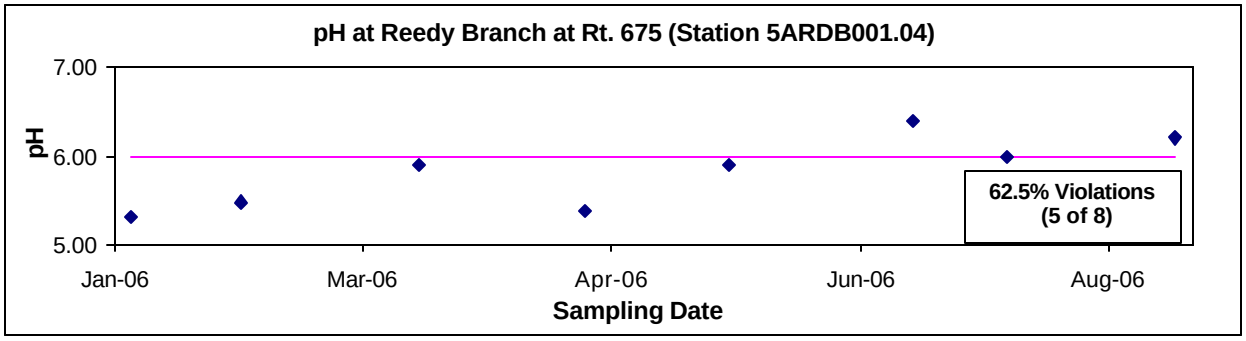


Figure 55. pH at Rocky Branch at Rt. 670, 5AROC001.35.

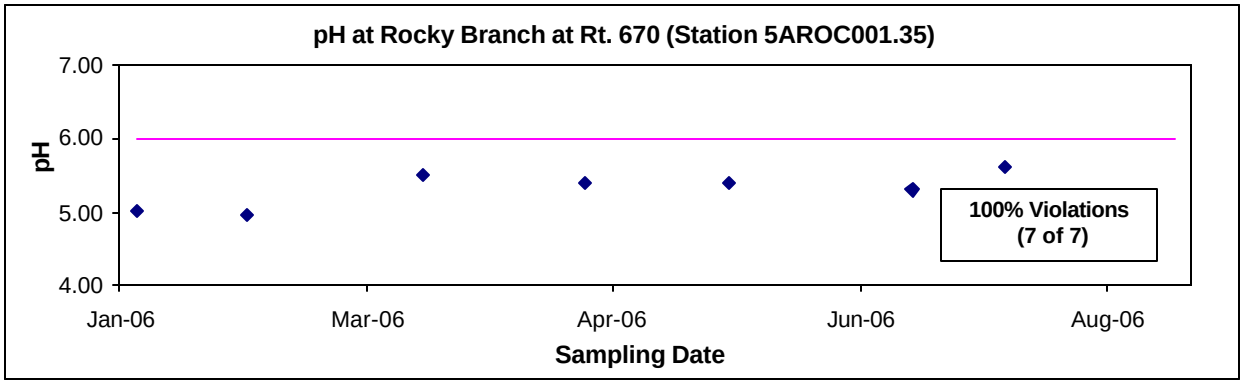


Figure 56. pH at Southwest Swamp at Rt. 301, 5ASWT000.69.

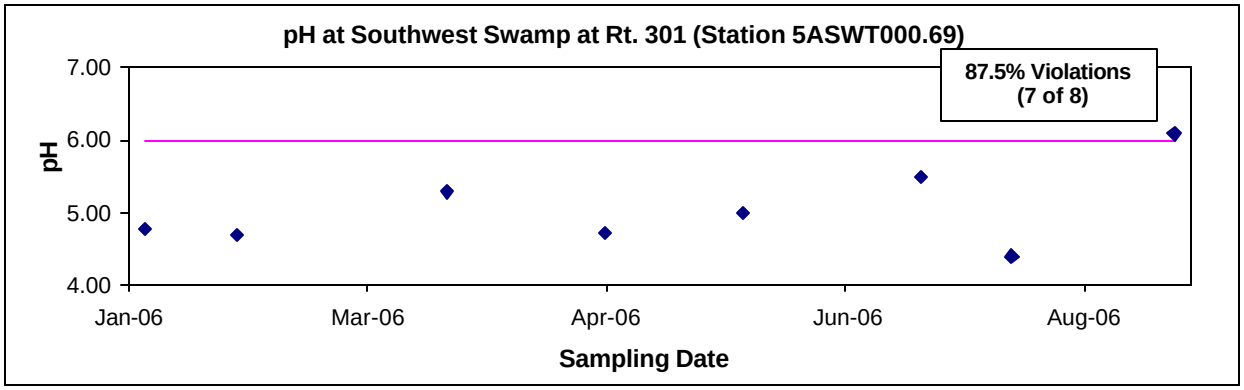


Figure 57. pH at Southwest Swamp at Rt. 649, 5ASWT005.11.

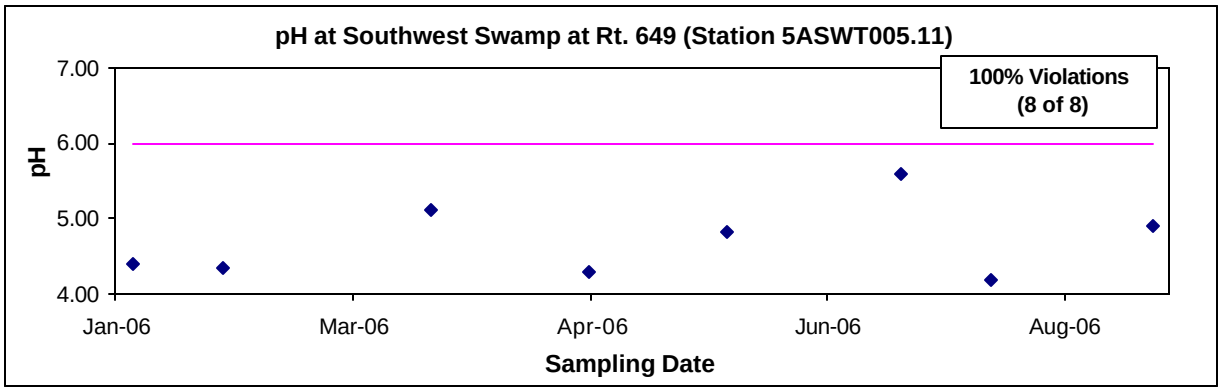
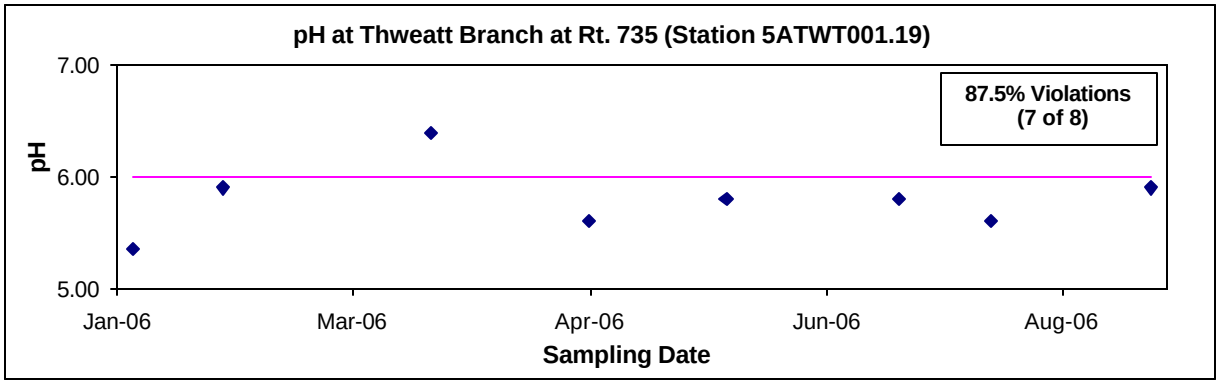


Figure 58. pH at Thweatt Branch at Rt. 735, 5ATWT001.19.



4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Chickahominy River must support all designated uses and meet all applicable criteria.

4.2. Applicable Water Quality Criteria

The applicable water quality criteria for DO in the Chickahominy River watershed is an instantaneous minimum DO of 4.0 mg/l and pH from 6.0 SU to 9.0 SU, as in Table 4.

Table 4. Applicable water quality standards

Parameter	Minimum, mg/l	Maximum, mg/l
DO	4.0	na
pH	6.0	9.0

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and natural conditions must be determined or a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion.

5. Assessment of Natural Conditions Affecting low DO - Process for determining if DO and pH impairments in free-flowing streams are due to natural conditions.

The level of dissolved oxygen in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low DO and pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.

Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen-depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to

determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

Step 1. Determine appearance and flow/slope.

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

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.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Chickahominy Rivers.

7Q10 Data Screen

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

5.1 Preliminary Data Screen for Low Flow 7Q10

The 7Q10 flow of a stream is the lowest streamflow for seven consecutive days that occurs on average once every ten years. The first step for low flow 7Q10 screening is to determine the most accurate 7Q10 available. The 7Q10 flows for the Nottoway River tributaries may be estimated by a drainage area ratio of the 16 watersheds with the 7Q10 flow at the long-term continuous gaging station Stony Creek near Dinwiddie, VA, (#02046000), with a drainage area of 112 mi^2 and a 7Q10 of 0.40 cfs.

The DO Instantaneous Water Quality Standard applies **AT** 7Q10 flow, but **NOT** below 7Q10 flow (9 VAC 25-260-50 ***). Therefore in streams where the 7Q10 > 0.0 cfs, DO less than 4.0 mg/l taken at flows below 7Q10 are not water quality standard violations. However, in streams where the 7Q10 = 0.0 cfs, **ALL** DO data < 4.0 mg/l are standard violations, even if the flow = 0 cfs when the DO was taken.

For the sampling period from June 2001 to August 2006, Stony Creek flow did not fall below the 7Q10 of 0.40 cfs for the low pH and low DO exceedances, therefore by drainage area ratio, flows at the 16 tributaries did not go below 7Q10. Therefore no sampling events were removed from the data set.

5.2 Low slope, Swamps, Wetlands or Large Forested Areas

The extent of the swampwater segments were determined for each of the 16 tributaries of the Nottoway River mentioned in this report. The low slope for these streams ranged from 0.10% to 0.34% (Table 5), which is less than the defined low-slope criteria of 0.50%. Therefore, decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watersheds increase oxygen demand and lower DO as they decay, as well as contribute to the low pH by creation of natural weak organic acids (tannic, humic and fulvic acids) during decomposition of the decaying vegetation. These are not considered anthropogenic impacts.

Table 5. Calculated percent slope for the Nottoway River Tributaries.

Stream	% Slope	Upstream Elevation (Feet) at Rivermile (RM)	Downstream Elevation (Feet) at Rivermile (RM)
Anderson Branch	0.23	120’ at RM 7.03	60’ at RM 2.00
Arthur Swamp	0.16	170’ at RM 8.34	100’ at RM -0.08
Black Branch Swamp	0.12	85’ at RM 5.98	50’ at RM 0.60
Cabin Point Swamp	0.16	100’ at RM 6.35	50’ at RM 0.57
Gravelly Run	0.20	200’ at RM 8.56	100’ at RM 0.22
Gosee / Indian Swamps	0.25	130’ at RM 6.88	50’ at RM 0.89
Hunting Quarter Swamp	0.13	135’ at RM 16.38	25’ at RM 0.19
Hatcher Run	0.15	250’ at RM 19.27	100’ at RM 0.85
Harris Swamp	0.17	160’ at RM 8.72	80’ at RM 0.06
Jones Hole Swamp	0.13	130’ at RM 10.68	60’ at RM 0.58
Lees Branch	0.27	100’ at RM 4.24	50’ at RM 0.73
Reedy Branch	0.35	150’ at RM 2.56	110’ at RM 0.42
Rocky Branch	0.34	180’ at RM 3.38	120’ at RM 0.08
Southwest Swamp	0.20	150’ at RM 8.55	60’ at RM 0.08
Thweatt Branch	0.30	100’ at RM 3.65	70’ at RM 1.73

Visual inspections of the 30 Nottoway River tributaries revealed large swamp areas with heavy tree canopy. Decomposition of vegetative matter from large swampy areas lowers DO and pH as decay occurs. (Figures 59-73).

Figure 59. Anderson Branch at Rt. 634, upstream.

Figure 60. Anderson Branch at Rt. 637, upstream.

Figure 61. Black Branch Swamp at Rt. 640, upstream.

Figure 62. Cabin Point Swamp at Rt. 640, upstream.

Figure 63. Gosee Swamp at Rt. 602, upstream.

Figure 64. Lees Branch at Rt. 608, upstream.

Figure 65. Hunting Quarter Swamp at Rt. 735, downstream.

Figure 66. Hunting Quarter Swamp at Rt. 641, upstream.

Figure 67. Thweatt Branch at Rt. 735, upstream.

Figure 68. Harris Swamp at Rt. 681, upstream.

Figure 69. Arthur Swamp at Rt. 675, upstream.

Figure 70. Reedy Branch at Rt. 613, upstream.

Figure 71. Jones Hole Swamp at Rt. 621, upstream.

Figure 72. Hatcher Run at Rt. 628, upstream.

Figure 73. Gravelly Run at Rt. 660, upstream.

Figure 74. Southwest Swamp at Rt. 649, upstream.

5.3 Instream Nutrients

The VADEQ collected nutrient data from 10 stations located on 9 Nottoway River tributaries (June 2001 to August 2006, Tables 6-15). The average nutrient concentrations are at or below the USGS (1999)

national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

There were two streams (Anderson Branch at Rt. 634, at 1.02 mg/l TN, and Cabin Point Swamp at Rt. 640, at 1.03 mg/l TN) for which the total nitrogen (TN = TKN + NO_3 + NO_2) results were slightly above the USGS background level of 1.0 mg/L. Land use tables and maps are provided for these swamps in Tables 16 and 17 and Figures 75 and 76. Urban land use percentages (0.5% for Anderson Branch and 0.9% for Cabin Point Swamp) do not indicate that urbanization is a significant contributor to TN levels. The agricultural percent land use for these watersheds was 24 percent for Anderson Branch and 15 percent for Cabin Point Swamp, which are not large percentages. Forest and wetlands comprised 75 percent of the Anderson Branch watershed and 83 percent of the Cabin Point Swamp watershed, which are larger than usual percentages, especially for Cabin Point Swamp. Land use does not indicate an anthropogenic impact to the watersheds. There are no permitted facilities in the Cabin Point Swamp watershed. The Sussex County High School (VA0090786) discharges to Anderson Branch at Rt. 40, approximately 1.55 rivermiles upstream of 5AAND000.10. However, the Sussex County High School Discharge Monitoring Reports (DMRs) for 2006 indicated wastewater was within the permitted limits for pH, DO, TKN and CBOD5. The discharge pH ranged from 7 to 8.5 SU, except for 6.5 to 8.0 SU in October. DO ranged from 5.2 mg/l to 7.2 mg/l. CBOD5 ranged from <5.0 mg/l to 14.0 mg/l, with 8 of 12 measurements ≤ 6.0 mg/l. TKN ranged from <0.5 mg/l to 3.3 mg/l, with 8 of 12 values at <0.5 mg/l TKN. Therefore the facility does not appear to be a contributing factor to the total nitrogen of Anderson Branch at Rt. 634. The facility did not discharge effluent that would have lowered pH at 5AAND000.10, and the CBOD5 results were low to below detection during June, July and August when the three low DO violations occurred. It is believed that the minor TN levels above 1.0 mg/l in these watersheds are a natural occurrence. With standard rounding, both average TN are 1.0 mg/l.

Table 6. Instream Nutrients of Anderson Branch at Rt. 634, 5AAND000.10.

Parameter	Average Conc.	Number
Total Phosphorus	**0.061 mg/l**	(n=8)
Orthophosphorus	0.019 mg/l	(n=8)
Total Kjeldahl Nitrogen	0.929 mg/l	(n=7)
Ammonia as N	0.055 mg/l	(n=8)
Nitrate as N	**0.094 mg/l**	(n=8)
Nitrite as N	0.007mg/l	(n=8)
TN (TKN + NO_3 + NO_2)	***1.022* mg/l**	(n=8)

Table 7. Instream Nutrients of Anderson Branch at Rt. 637, 5AAND004.57.

Parameter	Average Conc.	Number
Total Phosphorus	**0.023 mg/l**	(n=7)
Orthophosphorus	0.020 mg/l	(n=7)
Total Kjeldahl Nitrogen	0.643 mg/l	(n=7)
Ammonia as N	0.054 mg/l	(n=7)
Nitrate as N	**0.041 mg/l**	(n=7)
Nitrite as N	0.010 mg/l	(n=7)
TN (TKN + NO_3 + NO_2)	**0.694 mg/l**	(n=7)

Table 8. Instream Nutrients at Black Branch Swamp at Rt. 640, 5ABBS003.46.

Parameter	Average Conc.	Number
Total Phosphorus	**0.060 mg/l**	(n=8)
Orthophosphorus	0.020 mg/l	(n=8)
Total Kjeldahl Nitrogen	0.600 mg/l	(n=6)
Ammonia as N	0.069 mg/l	(n=8)
Nitrate as N	**0.040 mg/l**	(n=8)
Nitrite as N	0.012 mg/l	(n=8)

TN (TKN + NO_3 + NO_2)	**0.652 mg/l**	(n=7)

Table 9. Instream Nutrients at Cabin Point Swamp at Rt. 640, 5ACBP000.96.

Parameter	Average Conc.	Number
Total Phosphorus	**0.054 mg/l**	(n=9)
Orthophosphorus	0.029 mg/l	(n=8)
Total Kjeldahl Nitrogen	1.025 mg/l	(n=8)
Ammonia as N	0.080 mg/l	(n=8)
Nitrate as N	**0.020 mg/l**	(n=8)
Nitrite as N	0.005 mg/l	(n=8)
TN (TKN + NO_3 + NO_2)	***1.030 mg/l***	(n=8)

Table 10. Instream Nutrients at Gravelly Run at Rt. 670, 5AGRV000.08.

Parameter	Average Conc.	Number
Total Phosphorus	**0.059 mg/l**	(n=8)
Orthophosphorus	0.030 mg/l	(n=8)
Total Kjeldahl Nitrogen	0.475 mg/l	(n=8)
Ammonia as N	0.049 mg/l	(n=8)
Nitrate as N	**0.184 mg/l**	(n=8)
Nitrite as N	0.010 mg/l	(n=8)
TN (TKN + NO_3 + NO_2)	**0.669 mg/l**	(n=8)

Table 11. Instream Nutrients at Gosee Swamp at Rt. 602, 5AGSE001.35.

Parameter	Average Conc.	Number
Total Phosphorus	**0.056 mg/l**	(n=8)
Orthophosphorus	0.020 mg/l	(n=8)
Total Kjeldahl Nitrogen	0.927 mg/l	(n=7)
Ammonia as N	0.054 mg/l	(n=8)
Nitrate as N	**0.040 mg/l**	(n=8)
Nitrite as N	0.010 mg/l	(n=8)
TN (TKN + NO_3 + NO_2)	**0.979 mg/l**	(n=8)

Table 12. Instream Nutrients at Hunting Quarter Swamp at Rt. 642, 5AHQS006.22.

Parameter	Average Conc.	Number
Total Phosphorus	**0.051 mg/l**	(n=14)
Orthophosphorus	NA mg/l	(n=0)
Total Kjeldahl Nitrogen	NA mg/l	(n=0)
Ammonia as N	0.071 mg/l	(n=14)
Nitrite + Nitrate as N	**0.147 mg/l**	(n=14)
TN (TKN + NO_3 + NO_2)	**0.842 mg/l**	(n=13)

Table 13. Instream Nutrients at Hatcher Run 30m East of Rt. 670, 5AHRA000.06.

Parameter	Average Conc.	Number
Total Phosphorus	**0.056 mg/l**	(n=8)
Orthophosphorus	0.034 mg/l	(n=8)
Total Kjeldahl Nitrogen	0.562 mg/l	(n=8)
Ammonia as N	0.061 mg/l	(n=8)
Nitrate as N	**0.065 mg/l**	(n=8)
Nitrite as N	0.065 mg/l	(n=8)

TN (TKN + NO_3 + NO_2)	**0.637 mg/l**	(n=8)

Table 14. Instream Nutrients at Harris Swamp at Rt. 630, 5AHRS002.04.

Parameter	Average Conc.	Number
Total Phosphorus	**0.097 mg/l**	(n=19)
Orthophosphorus	0.025 mg/l	(n=19)
Total Kjeldahl Nitrogen	0.700 mg/l	(n=19)
Ammonia as N	0.045 mg/l	(n=19)
Nitrate as N	**0.084 mg/l**	(n=19)
Nitrite as N	0.010 mg/l	(n=19)
TN (TKN + NO_3 + NO_2)	**0.795 mg/l**	(n=19)

Table 15. Instream Nutrients at Southwest Swamp at Rt. 301, 5ASWT000.69.

Parameter	Average Conc.	Number
Total Phosphorus	**0.087 mg/l**	(n=8)
Orthophosphorus	0.052 mg/l	(n=8)
Total Kjeldahl Nitrogen	0.887 mg/l	(n=8)
Ammonia as N	0.042 mg/l	(n=8)
Nitrate as N	**0.040 mg/l**	(n=8)
Nitrite as N	0.010 mg/l	(n=8)
TN (TKN + NO_3 + NO_2)	**0.937 mg/l**	(n=8)

Table 16. Land Use in the Anderson Branch Watershed

Land use	Sq. Miles	Acres	Percent		Sq. Mile	% Total
Open Water	0.007036659	4.503461582	0.1135%			
Low Intensity Residential	0.028850301	18.46419249	0.4653%	Water	0.028850301	0.46%
High Intensity Commercial/Indust	0.004925661	3.152423107	0.0794%	Urban	0.033775962	0.54%
Deciduous Forest	1.289467711	825.2593349	20.7979%	Agriculture	1.507955964	24.24%
Evergreen Forest	1.198694813	767.1646805	19.3338%	Forest	4.269844513	68.63%
Mixed Forest	1.781681988	1140.276473	28.7368%	Wetland	0.381386903	6.13%
Pasture/Hay	0.662853252	424.226081	10.6912%		6.2218	100%
Row Crops	0.845102713	540.865736	13.6307%			
Woody Wetlands	0.353943934	226.5241176	5.7088%			
Emergent Herbaceous Wetlands	0.027442969	17.56350017	0.4426%			
Total	6.2	3968	100.0000%			

Figure 75. Land Use in the Anderson Branch Watershed.

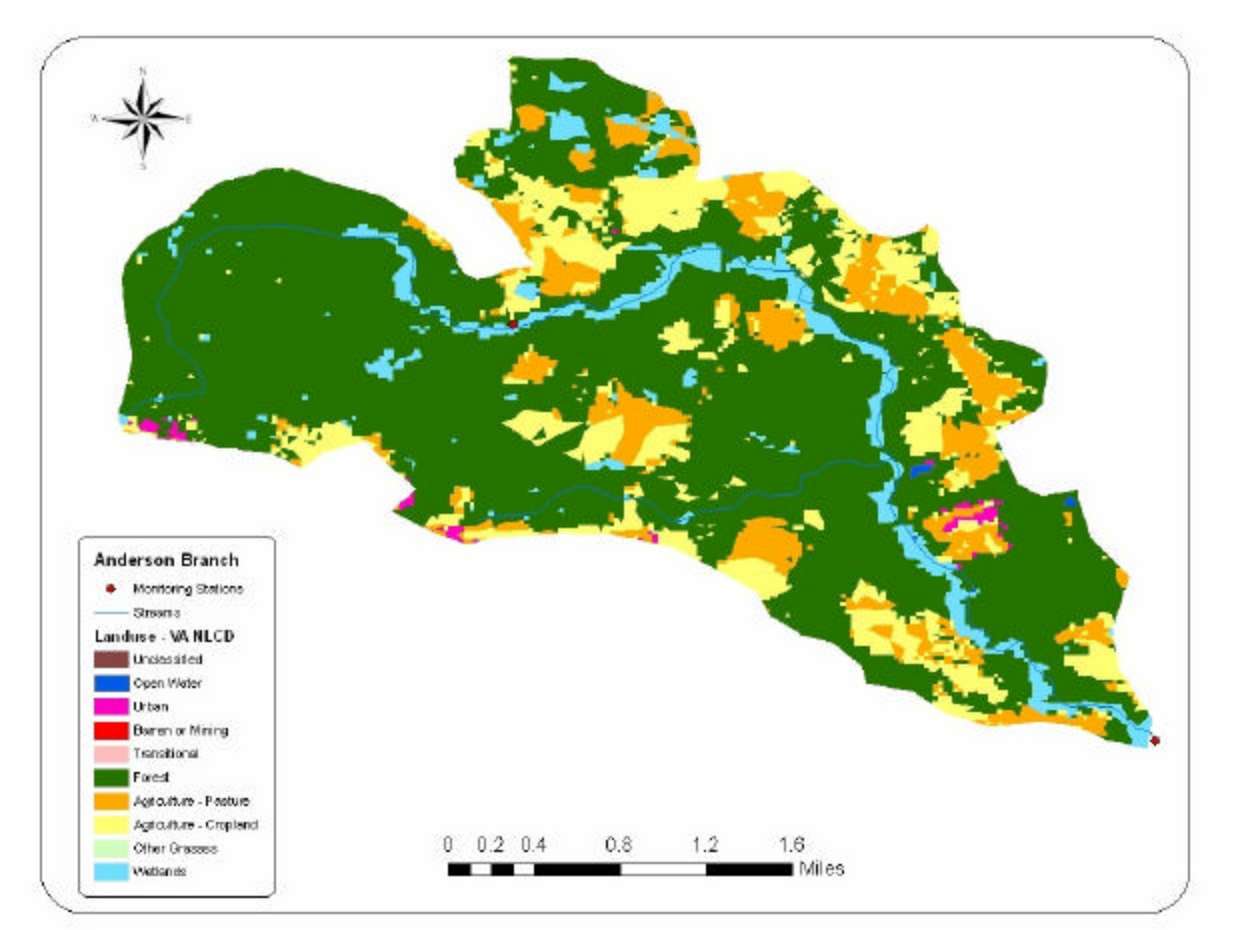
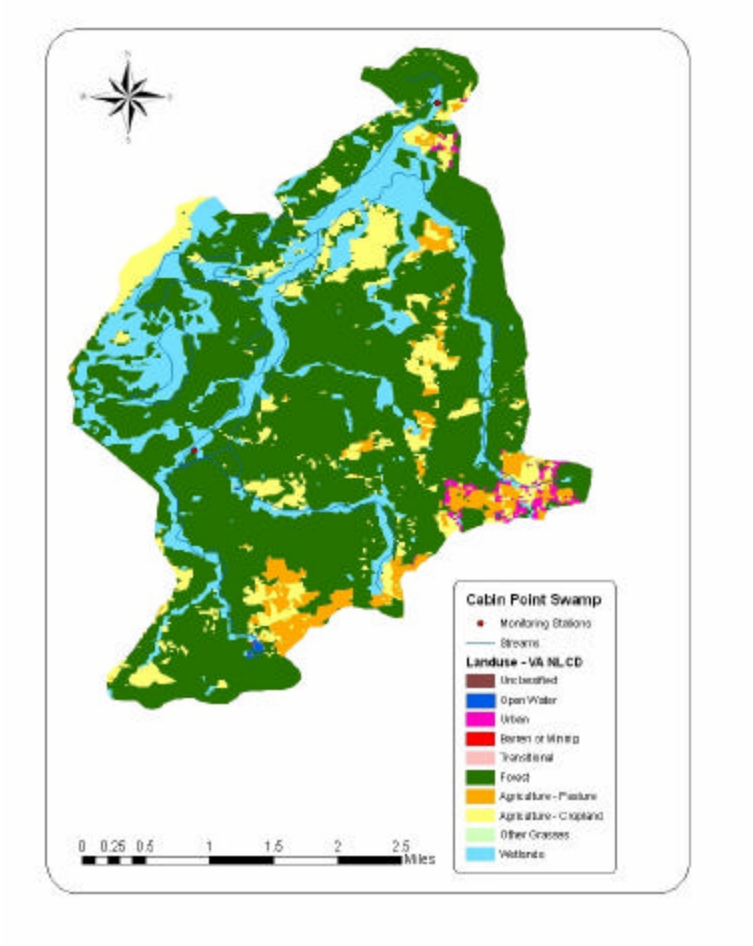


Table 17. Land Use in the Cabin Point Swamp Watershed

	miles sq	acres	percent			
Open Water	0.008782483	5.62078922	0.093%		**Sq Mile**	**% Total**
Low Intensity Residential	0.081501444	52.160924	0.859%	Water	0.0087825	0.093%
High Intensity Commercial/Industrial/Transportation	0.000351299	0.22483157	0.004%	Urban	0.0818527	0.863%
Deciduous Forest	3.428681424	2194.35611	36.129%	Agriculture	1.4589461	15.374%
Evergreen Forest	0.944292589	604.347257	9.950%	Forest	6.2489124	65.847%
Mixed Forest	1.875938402	1200.60058	19.768%	Wetland	1.6915063	17.824%
Pasture/Hay	0.448960539	287.334745	4.731%			
Row Crops	1.009985563	646.39076	10.643%			
Woody Wetlands	1.686236766	1079.19153	17.769%	Total	9.49	100.00%
Emergent Herbaceous Wetlands	0.00526949	3.37247353	0.056%			
Total	9.490	6073.60	100.00%			

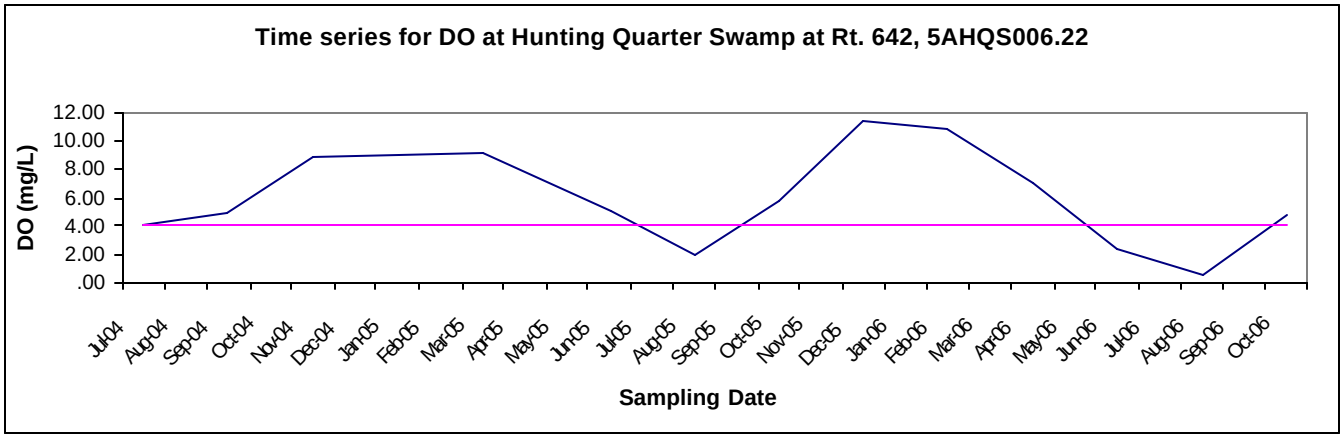
Figure 76. Land Use in the Cabin Point Swamp Watershed



5.4 Natural Seasonal DO Fluctuation

The historical data collected at the Nottoway River tributary Hunting Quarter Swamp was graphed to demonstrate the natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO. DO is high in the winter months while water temperatures are low, and low in the summer months when water temperatures are high. This is depicted in Figure 77.

Figure 77. Seasonal Variation in DO at Hunting Quarter Swamp at Rt. 642, July 2004 – August 2006.



5.5 Impact from Point Source Dischargers and Land Use

There are 17 permitted (6 VPDES; 2 VAG; 8 VAR; 1 VAP) Point Source facilities in the Nottoway River tributaries watersheds (K19R, K21R, K23R, and K24R). Six VPDES permittees have design flows and BOD5 or TKN permit limits which could affect instream nutrients. These are shown in Table 18. None of the facilities violated their permit limits for DO or pH during the time period of this study. The remaining VPDES permittee has a design flow but no BOD5, TKN or DO limits. One VPA permittee has no design flow. These are not expected to significantly impact DO or pH. There were no dischargers located on Cabin Point Swamp, however the Sussex County High School (VA0090786) is located on Anderson Branch at rivermile 1.65, about 1.55 miles upstream of the DEQ monitoring station 5AAND000.10. TKN (mg/L) concentration maximum permitted limits for the Sussex County High School were set at 4.5 mg/L, which was modeled to be conservatively protective of the water quality of the receiving stream Anderson Branch.

Table 18. Permitted dischargers with design flows and permit limits located within the Nottoway River tributaries watersheds.

Facility	Permit	Design Flow (MGD)	pH	DO (mg/L)	BOD (mg/L)	TKN (mg/L)	Receiving Stream
Southside Elementary School	VA0022934	0.0135	6-9	6.0	45 max	N/A	UT Gravelly Run
Picture Lake Campground	VA0070564	0.013	6-9	6.0	45 max	N/A	Picture Branch
Sussex County Courthouse	VA0080390	0.015	6-9	6.5	CBOD5 = 18 max	4.5 max	UT Thweatt Branch
Sussex Schools Complex	VA0090786	0.03	6-9	5.0	N/A	4.5 max	Anderson Branch
Sussex Central HS	VA0090697	0.0007	6-9	N/A	N/A	N/A	UT Anderson Branch
VDOT I-95 Prince George Rest Area	VA0086622	0.04	6-9	5.0	CBOD5 = 15 max	4.5 max	UT of Rowanty Creek

Residential and high use industrial areas compose approximately 1.0 percent of the land base, an insignificant portion of the watershed. Agriculture makes up approximately 21.0 % of the watershed. The watershed is predominately forested (66.1 percent), with 8.9 percent wetlands and 0.75 open water. Land use was not considered to have significantly impacted the swampwater conditions of the Nottoway River tributaries.

6. CONCLUSION

The following decision process is proposed for determining whether low DO values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands or large areas of forested land are present along stream reach AND
If no point sources or point sources with minimal impact on DO AND
If nutrients are < typical background
- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are equal to or less than 0.1 mg/L AND

If nearby streams without wetlands meet DO criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

No low DO or low pH exceedances were removed from the dataset because no samples were collected during periods when flow occurred below 7Q10 of 0.40 cfs at the Stony Creek gaging station near Dinwiddie, VA.

The extent of the swampwater segments were determined for each of the 16 tributaries discussed in this report. The percent slope for these streams ranged from 0.10% to 0.34%, which was considered very low to low slope. Decomposition of the large inputs of decaying vegetation from areas of forested land with swamps and heavy tree canopy throughout the watershed increase oxygen demand, lower DO, result in production of weak organic acids, and lower pH as they decay. These are not considered anthropogenic impacts.

The Nottoway River tributaries exhibit low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact. Sampling stations 5AAND000.10 on Anderson Branch and 5ACBP000.96 on Cabin Point Swamp had total nitrogen levels that were slightly above the USGS background levels. There are no permitted discharges located on Cabin Point Swamp to raise the nitrogen levels. The Sussex County School Complex (VA0090786) is located on Anderson Branch, and there were no violations of permit limits for TKN, pH, CBOD5 or DO there.

The Nottoway River tributaries exhibit natural seasonal DO fluctuation due to the inverse relationship between water temperature and DO.

There are 17 permitted (6 VPDES; 2 VAG; 8 VAR; 1 VAP) Point Source facilities in the Nottoway River tributaries watersheds (K19R, K21R, K23R, and K24R). Six VPDES permittees have design flows and BOD5 or TKN permit limits which could affect instream nutrients. None of the facilities violated their permit limits for DO or pH during the time period of this study. The remaining VPDES permittee has a design flow but no BOD5, TKN or DO limits. One VPA permittee has no design flow. . These are not expected to significantly impact DO or pH. There were no dischargers on Cabin Point Swamp, however the Sussex County High School (VA0090786) is located on Anderson Branch at rivermile 1.65, about 1.55 miles upstream of the DEQ monitoring station 5AAND000.10). TKN (mg/L) concentration maximum permitted limits for the Sussex County High School were set at 4.5 mg/L, which was modeled to be protective of the water quality of the receiving stream Anderson Branch.

Residential and high use industrial areas compose approximately 1.0 percent of the land base, a insignificant portion of the watershed. Agriculture makes up approximately 21.0 % of the watershed. The watershed is predominately forested (66.1 percent), with 8.9 percent wetlands and 0.75 open water. The land use was not considered to have significantly impacted the swampwater conditions of the Nottoway River tributaries.

Based on the above information, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for the Nottoway River tributaries located in waterbodies identification codes (WBID, Virginia Hydrologic Unit) K19R, K21R, K23R and K24R, a total of 257.0 rivermiles. The specific waterbodies are listed below in Table 19. If there is a 305(b)/303(d) assessment prior to the reclassification, Nottoway River tributaries will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

Table 19. Class VII Swampwater designations for the Nottoway River Tributaries.

Stream	Miles	Upstream Class VII Boundary	Downstream Class VII Boundary
Black Branch Sw	6.56	Headwaters	Confluence with Nottoway River
Cabin Point Sw and tributaries	11.63	Headwaters	Confluence with Nottoway River
Gravelly Run and tributaries	18.79	200' at RM 8.56	Confluence with Rowanty Creek
Gosee Swamp and tributaries	12.42	130' at RM 6.88	Confluence with Nottoway River
Hunting Quarter Sw and tributaries	52.81	Headwaters	Confluence with Nottoway River
Hatcher Run and tributaries*	74.33	250' at RM 19.27	Confluence with Rowanty Creek
Harris Swamp and tributaries	27.32	160' at RM 8.72	Confluence with Nottoway River
Moores / Jones Hole Swamps and tributaries	47.21	Headwaters	Confluence with Nottoway River
Southwest Sw and tributaries	12.49	150' at RM 8.55	Confluence with Stony Creek

* excluding Picture Branch.

7. Public Participation

DEQ performed the assessment of the Nottoway River tributaries low DO and low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

8. References

Maptech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia. 2003.

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USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 1998. Virginia. 1998.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 2002. Virginia. 2002.