Virginia Department of Environmental Quality

Benthic Total Maximum Daily Load (TMDL) Phased Development for the Smith River

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Executive Summary

This report addresses the development of the phased benthic TMDL for the Smith River watershed in Virginia. One segment of the Smith River was listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load (TMDL) Priority List and Report due to violations of the state's aquatic life water quality standards, specifically for the general standard. The segment was also included on subsequent 303(d) Reports on Impaired Waters and 305(b)/303(d) Water Quality Assessment Integrated Reports (VA DEQ, 2004, 2006, 2008).\

Description of the Study Area

The Smith River is located in the south central region of Virginia and is a tributary of the Dan River. The Smith River flows through sections of Henry, Patrick, Franklin and Floyd Counties. The impaired benthic segment of the Smith River (VAW-L54R-01) is 13.75 miles in length, extending from the Martinsville Dam at river mile 26.40 (approximately) downstream to the mouth of Turkeypen Branch. The watershed is approximately 336,926 acres (or 526 square miles) in area.

Impairment Description

There is only one segment (TMDL Cause Group Code L54R-01-BEN) of Smith River listed as impaired on Virginia's 305(b)/303(d) Water Quality Integrated Report. *"DEQ's General Standard (VR680-21-01.2) is not met for the protection of aquatic life"* and the segment is not *"supporting of the Clean Water Act's Aquatic Life Use Support Goal for the 2002 305(b) report"* (VADEQ, 2004a, 2006, 2008).

The Smith River was listed on Virginia's 303(d) list for not supporting the aquatic life use (TMDL Cause Group Code L54R-01-BEN) based on biological assessments conducted in 1998 at VA DEQ monitoring stations below the Martinsville Dam. The source of the general standard impairment is a mixture of municipal point source and urban nonpoint source runoff. In addition, the Martinsville Dam (hydroelectric plant) is considered a possible cause of the general standard impairment located immediately downstream of the dam. The operation of the Dam causes scouring due to flow releases and dewatering due to periods of low flow, which affect benthic habitat immediately downstream of the dam. The impaired benthic segment of the Smith River (Cause Group Code L54R-01-BEN) is

13.75 miles in length and extends downstream from the Martinsville Dam to the mouth of Turkeypen Branch.

Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and the water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (VA DEQ, 2007):

> *"'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.)."*

Watershed Characterization and Environmental Monitoring

The Smith River watershed is approximately 336,926 acres or (526 square miles) in area. The land use characterization for the Smith River TMDL watershed was based on the latest available land cover data from the National Land Cover Dataset, also known as NLCD 2001. Dominant land uses in the watershed are forested lands (76%) and agricultural lands (11%).

Environmental monitoring efforts in the Smith River watershed include benthic macroinvertebrate community sampling and analysis and water quality sampling and analysis. VA DEQ has monitored ambient water quality, macroinvertebrate communities, fish tissue, and sediment chemistry at 19 locations in the Smith River watershed. Of the 19 sites, ten are located within the impaired segment. Water quality data collected between 1993 and 2007 were analyzed for the Smith River TMDL study.

There are 13 individual Virginia Pollutant Discharge Elimination System (VPDES) permitted facilities currently active or under application in the Smith River watershed and 42 general permits currently active within the Smith River Watershed that include industrial stormwater and mining permits.

There is one EPA Superfund site (Doyle Wood Treating Plant) and one Resource Conservation and Recovery Act (RCRA) site (DuPont de Nemours & Co) located in the Smith River watershed. Efforts to clean up Doyle Wood Treating Plant were completed in 1996 and are ongoing at DuPont de Nemours & Co.

Stressor Identification

The primary stressor causing the benthic impairment on the Smith River was identified based on evaluations of candidate stressors that potentially could be impacting the stream. Based on the stressor identification analysis, the most probable stressor to the benthic macroinvertebrate community in the Smith River was identified as total Polycyclic Aromatic Hydrocarbons (PAHs) in sediment. Potential sources of total PAHs in the watershed include non-point sources.

Improvement of the benthic invertebrate community in the Smith River is dependent upon reducing nonpoint source total PAH loading to the stream. These measures should serve to improve benthic habitat and subsequently restore macroinvertebrate communities in the stream. Therefore, a Total PAH TMDL was developed for Smith River.

Endpoint Determination

VA DEQ has not yet adopted a numeric standard for Total PAH. Therefore, a total PAH endpoint was determined based on the Threshold Effect Concentration (TEC) for total PAHs. The TEC identifies the contaminant concentrations below which adverse effects to sediment-dwelling organisms are not expected to occur (MacDonald, et al., 2000).

Total PAH Loading Determination

Total PAH sources within the benthic impaired segment of the Smith River watershed include only non-point sources. Total PAH loads were determined for the impaired watershed in order to quantify the reductions necessary to achieve the designated aquatic life use water quality standard in Smith River. A mass balance model was applied to estimate the existing total PAH concentration in sediment in the benthic impaired segment of the Smith River. Accepted literature values for total PAH were used to estimate the total PAH loads' contribution from runoff (Novotny, 2003). A watershed model, the Generalized Watershed Loading Function (GWLF), was applied to estimate sediment loads from all the sources in the Smith River watershed. It was assumed that all PAH runoff load adsorbs to sediment, and thus PAH concentrations in sediment loads are equivalent to PAH concentrations in runoff from the watershed.

TMDL Calculations

Total PAH TMDL allocations for the Smith River impaired watershed were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL = Total Maximum Daily Load
WLA = Waste Load Allocation
LA = Load Allocation
MOS = Margin of Safety

The MOS will be implicitly incorporated into this TMDL. Implicitly incorporating the MOS requires that allocations meet the Threshold Effect Concentration (TEC) of 1.61 mg/kg.

Wasteload allocation (WLA) for total PAH in sediment was applied to 42 general permitted facilities located in the Smith River watershed. There are no MS4 areas located in the Smith River watershed. To account for future growth an expansion factor of 2 was applied to calculate the WLA. The existing, aggregated allocated total PAH load and the required reduction are shown in **Table E-1**. At this phase of the TMDL, the WLA is aggregated, however, depending on new information during the second phase, WLA may be disaggregated and individual WLAs assigned to the individual facilities.

Table E- 1: Aggregated Waste Load Allocation for the Smith River						
Point Source*	**Facility Name***	**Existing Total PAH (kg/day)**	**Expansion for Future Growth (2X of existing facilities' load) (kg/day)**	**Total Load (kg/day)**	**Allowable Load (kg/day)**	**Percent Reduction**
VAG840056	Boxley Materials Company - Horsepasture Plant	0.005	0.010	0.015	0.013	12%
VAG840057	Boxley Materials Company - Fieldale Plant					
VAG842017	Boxley Materials Company - Fieldale Plant					
VAR050001	CPFilms Inc					
VAR050040	Virginia Mirror Co Inc					
VAR050128	Bassett Chair Company					
VAR050129	Bassett Fiberboard Plant					
VAR050136	Bassett Superior Lines					
VAR050137	BFI Bassett					
VAR050164	Stanley Furniture Co Inc - Martinsville					
VAR050165	American Furniture Company Inc - Redd Level					
VAR050197	Henry County Plywood Corporation					
VAR050199	Hooker Furniture Corporation - Panel Plant					
VAR050200	Hooker Furniture Corporation - Martinsville					
VAR050215	Chatham Oil Company					
VAR050216	First Piedmont Corp					
VAR050248	Pine Products Incorporated					
VAR050249	Smurfit Stone - Martinsville					
VAR050254	American Standard Building Systems Inc					
VAR050445	Georgia Pacific Corrugated I LLC					
VAR050455	Ridgeway Furniture					
VAR050501	Gravely Auto Sales & Recycling					
VAR050523	Southern Finishing Company Inc					
VAR050532	Stanley Furniture Co Inc - Stanleytown					
VAR050721	Quikrete - Martinsville					
VAR050746	Martinsville Concrete Products Inc					
VAR050751	Griffith Lumber Co Inc					
VAR050752	DeShazo Oil Co Inc					
VAR050758	W-L Construction and Paving Inc - Fieldale					
VAR051003	W Henry Hardy Inc - Martinsville					
VAR051260	Blue Ridge Solvents and Coatings Incorporated					
VAR051279	Nelson Auto Salvage					
VAR051473	Smart Machine Technologies Inc					
VAR051544	Springs Global US - Martinsville Plant					
VAR051576	Cycle Systems Inc - Martinsville					
VAR051604	MasterBrand Cabinets Incorporated					
VAR051623	Bassett Mirror Company Inc - North Bassett Plant					
VAR051662	DuPont					
VAR051716	Tri State Foam Products					
VAR051728	Adams Construction Co - Horsepasture Drum Plant					
VAR051736	A and B Used Parts					
VAR051747	Swing Transport Incorporated					

* Based upon VA DEQ regional adjusted 2007 permit data (facilities are in general permit review status, currently).

Load allocations for Total PAH in sediment were applied to urban land uses that are not included in the WLA. **Table E-2** shows the existing, allocated load, and required reduction for Total PAH in the Smith River watershed.

Table E- 2: Load Allocation for the Smith River

Source	Existing Total PAH	Allocated Total PAH	Percent Reduction
	kg/day	kg/day	
Urban Land (Low, medium, high intensity, open space)*	0.121	0.107	12%

*Excluding the area from general permitted facilities located in the Smith River watershed

The TMDL load, load allocation, wasteload allocation, and margin of safety for total PAH in sediment for the Smith River are summarized in **Table E-3**.

Table E- 3: Overall Recommended TMDL Allocations for Total PAH in Sediment for the Smith River (kg/day)

TMDL	Wasteload Allocation (Point Source)	Load Allocation	Margin of Safety (MOS)
0.120	0.013	0.107	Implicit

Public Participation

Watershed stakeholders had opportunities to provide input and participate in the development of the TMDL during two public meetings held in the watershed. The first meeting was held at the Henry County Administrative Building in Martinsville, Virginia, on August 8th, 2007, the second also at the Henry County Administrative Building, on March 29th, 2010. There were three technical advisory committees on the Smith River Benthic TMDL. All three were located at the Henry County Administrative Building and occurred on May 30th, 2007, January 29th 2008, and March 29th, 2010.

1.0 Introduction

Total Maximum Daily Load (TMDL) development for biological impairment requires a methodology to identify impairment causes and to determine pollutant reductions that will allow streams to attain their designated uses. The identification of the pollutant(s), or *stressor(s)*, responsible for causing impairment to benthic macroinvertebrate communities is an important first step in developing a TMDL that accurately specifies the pollutant load reductions necessary for the stream to comply with Virginia's water quality standards. This report details the steps used to identify and characterize the stressor(s) responsible for biological impairments in the Smith River, Virginia. The first section of this report presents the regulatory guidance and defines the applicable water quality criteria for biological impairment. Subsequent sections of this report discuss watershed and environmental monitoring data collected on the Smith River. Stressors that may be affecting the river are then analyzed in the stressor identification section. Based on this analysis, candidate stressors impacting benthic macroinvertebrate communities in the river are identified. A TMDL will be developed for the stressor identified as the primary source of biological impairment in the Smith River.

1.1 Regulatory Framework

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop TMDLs for waterbodies that are violating water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and nonpoint sources in order to restore and maintain the quality of their water resources (EPA, 2001).

The lead state regulatory agency for environmental matters in Virginia is the Department of Environmental Quality (VA DEQ). VA DEQ works in coordination with the Virginia

Department of Conservation and Recreation (VA DCR), the Department of Mines, Minerals, and Energy (VDMME), and the Virginia Department of Health (VDH) to develop and implement more effective TMDL processes. VA DEQ is the lead agency for the development of TMDLs statewide and focuses on all aspects of pollution reduction and prevention in state waters. VA DEQ ensures compliance with the Federal Clean Water Act and the Water Quality Planning Regulations, as well as with the Virginia Water Quality Monitoring, Information, and Restoration Act (WQMIRA), passed by the Virginia General Assembly in 1997. It also coordinates public participation throughout the TMDL development process. The role of VA DCR is to initiate nonpoint source pollution control programs statewide through the use of federal grant money. VDMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of contamination (VA DEQ, 2001).

As required by the Clean Water Act and WQMIRA, VA DEQ develops and maintains a listing of all impaired waters in the state. This list details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. It is referred to as the Section 303(d) List of Impaired Waters. In addition to Section 303(d) List development, WQMIRA directs VA DEQ to develop and implement TMDLs for listed waters (VA DEQ, 2001). VA DEQ also solicits participation and comments from watershed stakeholders and from the public throughout the TMDL process. Once TMDLs have been developed and the public comment period has been completed, the TMDLs are submitted to EPA for approval.

1.2 Impairment Listing

One segment of the Smith River was listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report due to violations of the state's aquatic life water quality standards, specifically for the benthic general standard. The segment was also included on subsequent 303(d) Reports on Impaired Waters and 305(b)/303(d) Water Quality Assessment Integrated Reports (VA DEQ, 2004, 2006, 2008). The impaired segment is located in the Dan River Basin in southern Virginia (**Figure 1-1**). The Smith River is located in the south central region of Virginia, and is a tributary of the Dan River. The watershed is located in the hydrologic unit (HUC) 03010103 and is within the counties of Henry, Patrick, Franklin and Floyd.

The Smith River was listed on Virginia's 303(d) (TMDL Cause Group Code L54R-01-BEN) list for not supporting the aquatic life use general standard based on biological assessments conducted in 1998 at VA DEQ monitoring stations below the Martinsville Dam. The source of the general standard impairment is a mixture of municipal point source and urban nonpoint source runoff. In addition, the Martinsville Dam (hydroelectric plant) is considered a possible cause of the general standard impairment located immediately downstream of the dam. The dam operation causes scouring due to flow releases and dewatering due to periods of low flow, which affect benthic habitat immediately downstream of the dam. The impaired benthic segment of the Smith River (Cause Group Code L54R-01-BEN) is 13.75 miles in length and extends downstream from the Martinsville Dam to the mouth of Turkeypen Branch. **Figure 1-1** depicts the benthic impaired segment of the Smith River, as well as the delineated watershed boundary.

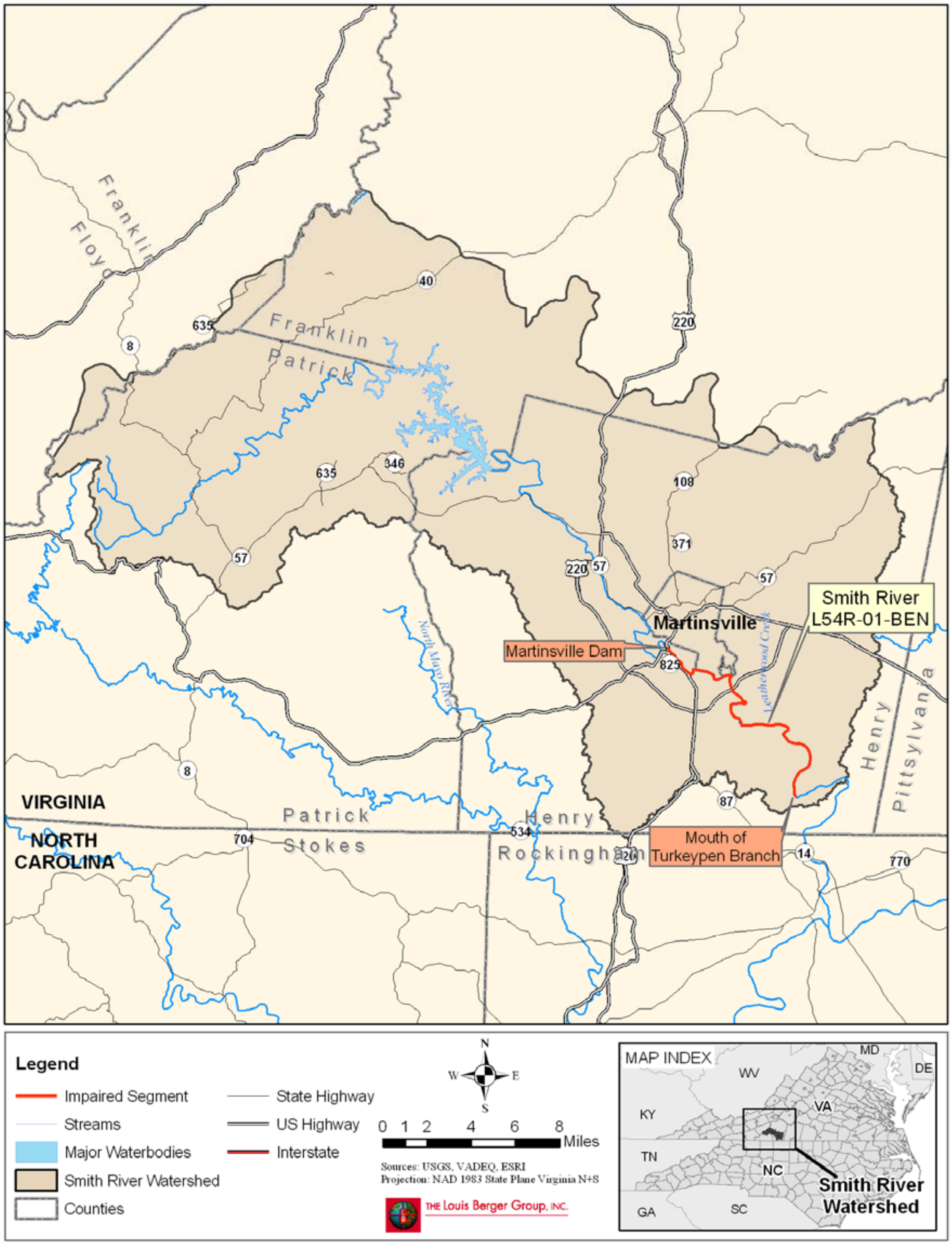

Figure 1-1: Smith River Watershed and Benthic Impaired Segment

1.3 Applicable Water Quality Standard

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

1.3.1 Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10):

> *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

Based on the benthic macroinvertebrate community assessment surveys conducted on the stream, the listed segment defined in Section 1.2 does not support the propagation and growth of a balanced population of aquatic life in the Smith River.

1.3.2 Water Quality Criteria

The General Standard defined in Virginia Water Quality Standards (9 VAC 25-260-20) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The General Standard states:

> *"All state waters, including wetlands, shall be free from substances attributable to sewage, industrial waste, or other waste in concentrations, amounts, or combinations which contravene established standards or*

> *interfere directly or indirectly with designated uses of such water or which are inimical or harmful to human, animal, plant, or aquatic life."*

The benthic macroinvertebrate community assessments conducted on the Smith River indicate that some pollutant(s) are interfering with attainment of the General Standard, as macroinvertebrate communities characteristic of impaired waterbodies have been observed in the listed segment of the River. Although benthic macroinvertebrate assessments are indicative of the impacts from pollution, the specific pollutant(s) and source(s) are not necessarily known based on these assessments alone.

2.0 Watershed Characterization

The physical conditions of the Smith River watershed were characterized using geographic information system (GIS) coverages developed for the watershed. The purpose of the characterization was to provide an overview of the conditions in the watershed related to the benthic impairment present in the listed segment of the stream. Information contained in the watershed GIS was used in the stressor identification analysis, as well as for the subsequent TMDL development. Physical watershed features such as topography, soil types, and land use conditions were characterized. Additionally, the number and location of permitted discharge facilities and DEQ monitoring stations in the watershed were summarized. This chapter serves as an inventory of the existing conditions in the watershed that were taken into consideration at the time of the stressor analysis process. Since the Benthic TMDL on the Smith River is a phased TMDL, efforts will continue to account for current and historical watershed activities that could negatively influence the benthic macroinvertebrate community in the river.

2.1 Physical Characteristics

Important physical characteristics of the Smith River watershed that may be contributing to the benthic impairment were analyzed using GIS coverages developed for the area. GIS coverages for the watershed boundary, stream network, topography, soils, land use, and ecoregion of the watershed were compiled and analyzed.

2.1.1 Watershed Location and Boundary

The Smith River is located in the south central region of Virginia and is a tributary of the Dan River. The Smith River flows through sections of Henry, Patrick, Franklin and Floyd Counties. The impaired benthic segment of the Smith River (VAW-L54R-01) is 13.75 miles in length, extending from the Martinsville Dam at river mile 25.11 downstream to the mouth of Turkeypen Branch (**Figure 2-1**). The watershed is approximately 336,926 acres or (526 square miles) in area.

2.1.2 Stream Network

The stream network for the Smith River watershed was obtained from the USGS National Hydrography Dataset (NHD). The stream network and benthic impairment segment are presented in **Figure 2-1**.

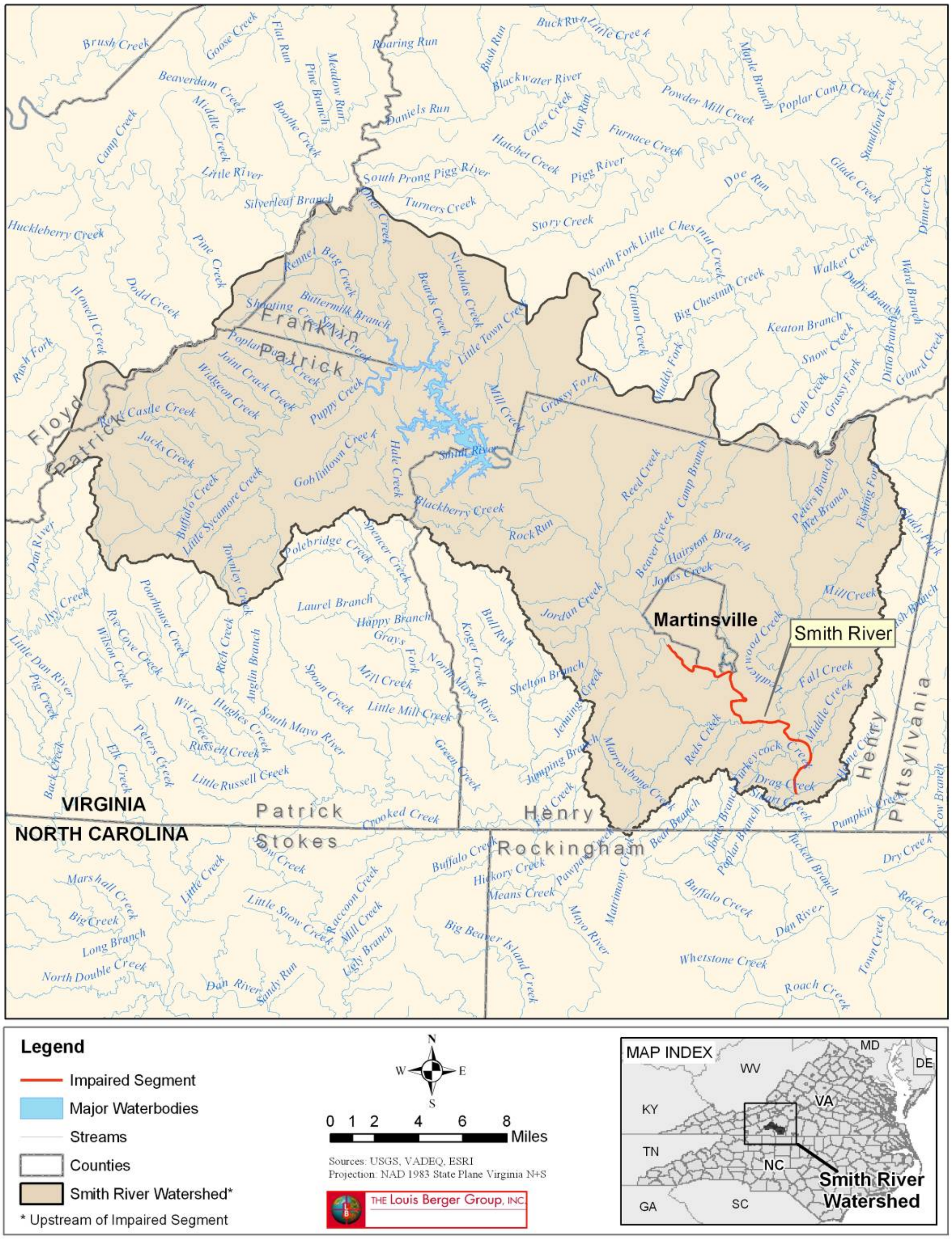

Figure 2- 1: Stream Network for the Smith River Watershed Upstream of the Benthic Impaired Segment

2.1.3 Topography

A digital elevation model (DEM) based on USGS National Elevation Dataset (NED) was used to characterize topography in the watershed. NED data were obtained from the National Map Seamless Data Distribution System maintained by the USGS Eros Data Center. The DEM show that elevation in the watershed ranges from approximately 621 to 3,575 feet above mean sea level, with an average elevation of 1,223 feet above mean sea level.

2.1.4 Soils

The Smith River watershed soil characterization watershed was based on the National Resources Conservation Services (NRCS) and the State Soil Geographic (STATSGO) Database for Virginia. There are seven general soil associations present in the Smith River watershed: Myersville-Catoctin, Hayesville, Nason-Manteo, Madison-Cecil, Rubble land-Porters, Wilkes-Cullen, and Turbeville-State. The majority of soils in the watershed are comprised of the Madison-Cecil soil association. The distribution of soils in the Smith River watershed is provided in **Table 2-1,** along with the hydrologic soil groups of each of the soil associations.

Table 2- 1: Soil Types in the Smith River Watershed

Soil Association	Acres	Percent of Watershed	Hydrologic Soil Group
Myersville-Catoctin	11,199	3%	C
Hayesville	31,784	10%	B
Nason-Manteo	11,806	4%	C
Madison-Cecil	209,405	62%	B
Rubble land-Porters	35,086	10%	A
Wilkes-Cullen	29,849	9%	C
Turbeville-State	7,797	2%	C
Total	**336,926**	**100%**	

Hydrologic soil groups represent the different levels of soil infiltration capacity. Hydrologic soil group “A” designates soils that are well to excessively well drained, whereas hydrologic soil group “D” designates soils that are poorly drained. This means that soils in hydrologic group "A" allow a larger portion of the rainfall to infiltrate and become part of the groundwater system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the groundwater, resulting in more rainfall delivered to surface waters in the form of runoff. Descriptions of the hydrologic soil groups are presented in **Table 2-2**.

Table 2- 2: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover

2.1.5 Land Use

The land use characterization for the Smith River watershed was based on the most recent land cover data from the 2002 USGS National Land Cover Data (NLCD). The distribution of land uses in the Smith River watershed, by land area and percentage, is presented in **Table 2-3**. Forested lands (76%), agricultural lands (11%) and developed lands (8%) represent the dominant land use types in the watershed. Brief descriptions of land use classifications are presented in **Table 2-4**. An overview of the land use distribution is shown in **Figure 2-2**.

Table 2- 3: Land Use within the Smith River Watershed					
General Land Use Category	**Specific Land Use Type**	**Acres**	**Percentage of Watershed (%)**	**Total Acres**	**Total Percent (%)**
Developed	High Intensity Developed	892	<1%	28,284	8%
	Low Intensity Developed	7,160	2%		
	Medium Intensity Developed	2,215	1%		
	Developed Open Space	18,016	5%		
Agriculture	Cultivated Crops	523	<1%	38,356	11%
	Pasture/Hay	37,833	11%		
Forest	Deciduous Forest	216,495	64%	255,501	76%
	Evergreen Forest	39,005	12%		
Water/Wetlands	Woody Wetlands	392	<1%	4,026	1%
	Emergent Herbaceous Wetlands	33	<1%		
	Open Water	3,601	1%		
Grassland/Shrub	Grassland (not used in agriculture)	6,125	2%	10,624	3%
	Scrub/Shrub	4,499	1%		
Barren	Barren Land	138	<1%	138	<1%
Total		336,929	100%		100%
*Differences in percentages are due to rounding					

Table 2- 4: Descriptions of Land Use Types	
Land Use Type	**Description**
Developed, High Intensity	Includes highly developed areas where people reside or work in high numbers. Impervious surfaces account for 80 to 100 percent of the total cover.
Developed, Medium Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50 to 79 percent of the total cover.
Developed, Low Intensity	Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 21 to 49 percent of total cover.
Developed, Open Space	Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover.
Cultivated Crops	Areas used for the production of annual crops. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle and not tilled. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.
Deciduous Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas dominated by trees generally greater than 5 meters tall and greater than 20 percent of total vegetation cover. More than 75 percent of the tree

Table 2- 4: Descriptions of Land Use Types	
Land Use Type	**Description**
	species maintain their leaves all year. Canopy is never without green foliage.
Woody Wetlands	Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
Open Water	All areas of open water, generally with less than 25 percent cover of vegetation or soil.
Grassland	Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
Scrub/Shrub	Areas dominated by shrubs less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Barren Land (Rock/Sand/Clay)	Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earth material. Generally, vegetation accounts for less than 10 percent of total cover.
Source: Coastal NLCD Classification Scheme, NOAA Coastal Services Center	

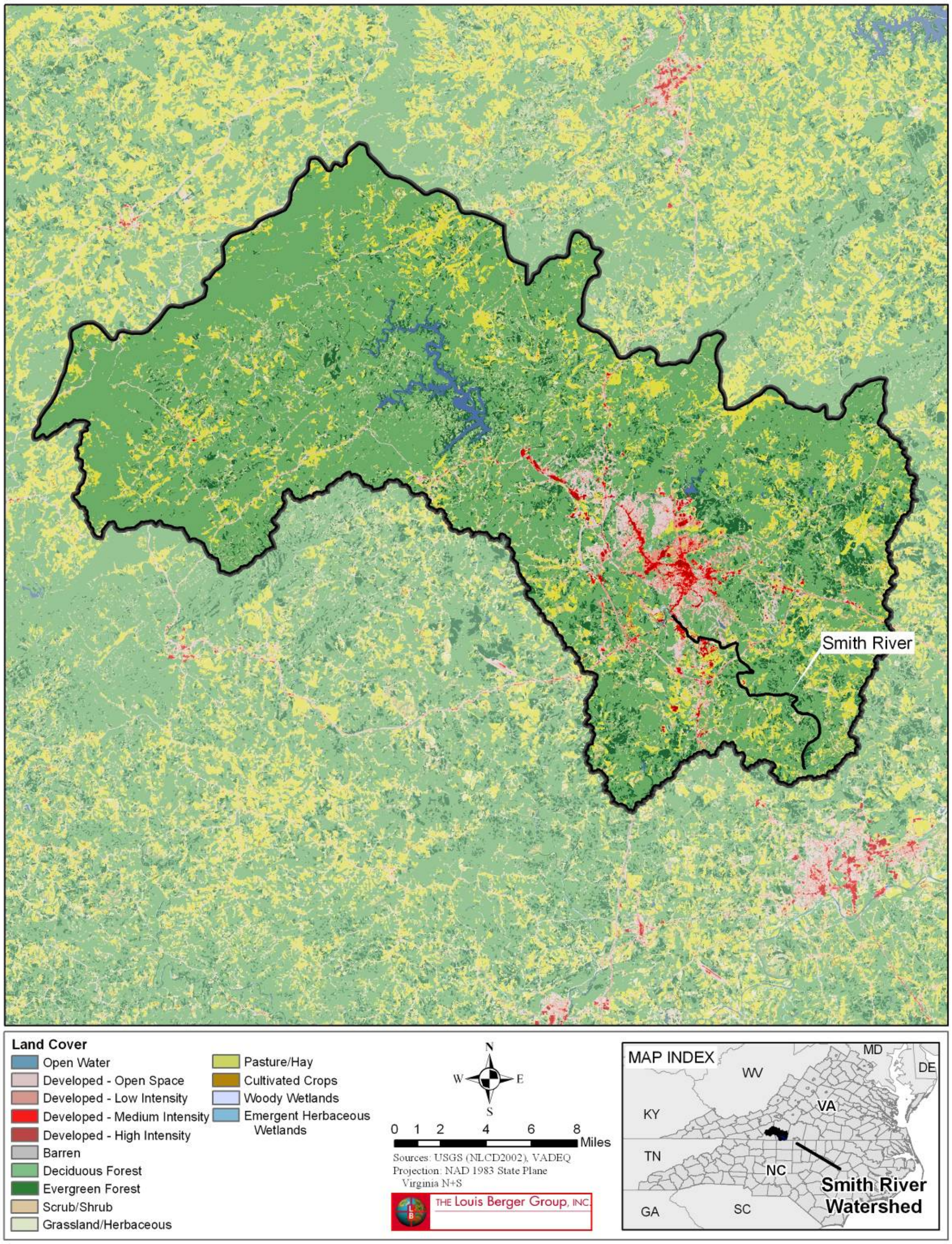

Figure 2- 2: Land Use in the Smith River Watershed

2.1.6 Ecoregion Classification

The Smith River watershed is located in the Piedmont and Blue Ridge ecoregions, USEPA Level III classification numbers 45 and 66, respectively (Woods et al., 1999). The location of the Smith River watershed within these ecoregions is presented in **Figure 2-3.** The majority of the watershed is encompassed by the Piedmont ecoregion.

The Piedmont ecoregion extends from Wayne County, Pennsylvania, southwest through Virginia, and forms a transitional area between the mostly mountainous ecoregions of the Appalachians to the northwest and the flat coastal plain to the southeast. Once largely cultivated, much of this region has reverted to pine and hardwood woodlands. The Piedmont ecoregion is characterized by shallow valleys, irregular plains, and low rounded hills and ridges. The underlying geology of this region consists of deeply weathered, deformed metamorphic rocks with intrusions by igneous material.

The Blue Ridge ecoregion extends from southern Pennsylvania to northern Georgia and comprises a range of narrow ridges, hilly plateaus, and more massive mountainous areas, with high peaks reaching over 2000 meters. The rugged terrain is characterized by mostly forested slopes with high-gradient, cool, and clear streams. The underlying geology of the Blue Ridge ecoregion primarily consists of metamorphic rocks, with minor areas of igneous and sedimentary geology. Annual precipitation of over 78.7401 inches can occur in the wettest areas (Woods *et. al.*, 1996).

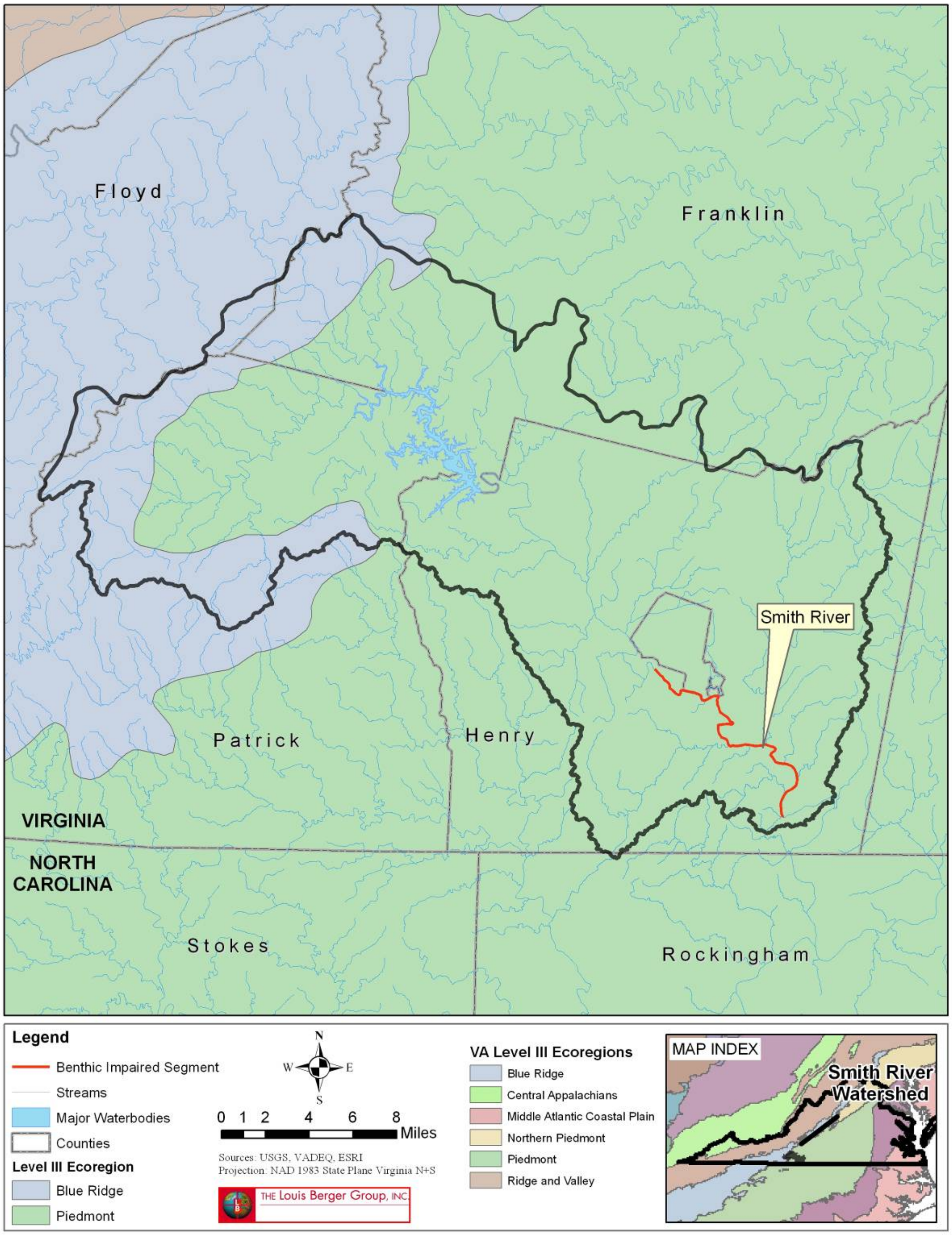

Figure 2- 3: Virginia Level III Ecoregions in the Benthi Impaired Smith River Watershed

2.2 Permitted Discharge Facilities

Data obtained from the VA DEQ's Blue Ridge Regional Office (Roanoke) indicate that there are 13 individual Virginia Pollutant Discharge Elimination System (VPDES) permitted facilities currently active or under application in the Smith River watershed. The permit number, outfall number, permitted flow, and receiving waterbody of the facilities holding individual permits are presented in **Table 2-5**, and their locations are presented in **Figure 2-4**. There are 42 general permits issued in the Smith River Watershed. The permit number, receiving waterbody, and type of permit of the facilities holding general permits are presented in **Table 2-6**, and their locations are presented in **Figure 2-5**. General permits included in **Table 2-6** are based on information available at the time of TMDL development. General permits are reissued every five years and were in the reissuance process in 2010. During the next year of phased TMDL development, VA DEQ's ISWGP database will be revised and **Table 2-6** will be adjusted to reflect the 2010 reissuance. Given the potential inaccuracies of **Table 2-6**, PAH loads from general permits were aggregated for the purpose of this draft of the Phased Benthic TMDL for the Smith River. There are no Municipal Separate Storm Sewer (MS4) permits issued to Cities, Towns, Counties, or other facilities within the Smith River benthic impaired watershed.

Martinsville Speedway is a NASCAR-owned car racing track that has been in operation since 1947. The track had a construction VPDES permit issued in January, 2004, which expired in June, 2004, but does not currently hold any VPDES permits.

Historically, the Martinsville area surrounding the Smith River was known for furniture construction. In the 20th century, there were also many permitted textile mills and knitting plants within the watershed. The waste from these plants was conveyed to wastewater treatment facilities such as Upper Smith Wastewater Treatment Plant (currently inactive), Lower Smith Wastewater Treatment Plant (currently inactive) and Martinsville City Sewage Treatment Plant, or treated onsite. By 1990, many of these facilities had closed. Current industry includes textiles, and a variety of furniture and other manufacturing facilities.

Table 2- 5: Facilities Holding Individual Permits in the Smith River Watershed					
Permit No.	**Facility Name**	**Outfall No.**	**Design Flow (MGD)**	**Facility Type**	**Receiving Waterbody**
VA0086665	Bassett Mirror Company Incorporated	1	0.0035	Industrial	Town Creek
VA0029858	Carver Estates - Sewage Treatment Plant	1	0.06	Municipal	Grassy Creek
VA0072354	CPFilms Inc - Plant 1	1	4.2	Industrial	Smith River
VA0030660	DCR - Fairy Stone State Park	1	0.0005	Industrial	Hale Creek
VA0090174	Green Acres Mobile Home Park	1	0.01	Municipal	Tanyard Branch
VA0001554	Hanesbrands Incorporated	1	0.3881	Industrial	Smith River
VA0069345	Henry County PSA - Lower Smith River STP	1	4.0	Municipal	Smith River
VA0090280	Henry County Public SA - Greenbriar Lagoon STP	1	0.032	Municipal	Grassy Creek
VA0060445	Henry County Public SA - Piedmont Estates Lagoon	1	0.04	Municipal	Mill Creek
VA0025305	Martinsville City Sewage Treatment Plant	1	8.0	Municipal	Smith River
VA0090310	Philpott Dam Hydroelectric Plant	1	0.0638	Industrial	Smith River
VA0058441	Upper Smith River Water Filtration Plant	1	0.096	Industrial	Smith River, UT
VA0021989	Virginia Glass Products Corp	1	0.008	Industrial	Machine Branch, UT

Table 2- 6: Facilities Holding General Permits in the Smith River Watershed			
Permit No	**Facility**	**Receiving Stream**	**Type of Permit**
VAG840056	Boxley Materials Company - Horsepasture Plant	Tanyard Branch	Mining
VAG840057	Boxley Materials Company - Fieldale Plant	Jordan Creek	Mining
VAG842017	Boxley Materials Company - Fieldale Plant	Jordan Creek	Mining
VAR050001	CPFilms Inc	Mill Creek UT	Industrial Stormwater
VAR050040	Virginia Mirror Co Inc	Aarons Branch	Industrial Stormwater
VAR050128	Bassett Chair Company	Smith River	Industrial Stormwater
VAR050129	Bassett Fiberboard Plant	Smith River	Industrial Stormwater
VAR050136	Bassett Superior Lines	Smith River	Industrial Stormwater
VAR050137	BFI Bassett	Smith River	Industrial Stormwater
VAR050164	Stanley Furniture Co Inc - Martinsville	Beaver Creek UT	Industrial Stormwater
VAR050165	American Furniture Company Inc - Redd Level	Smith River	Industrial Stormwater
VAR050197*	Henry County Plywood Corporation	Reed Creek	Industrial Stormwater
VAR050199*	Hooker Furniture Corporation - Panel Plant	Mulberry Creek	Industrial Stormwater
VAR050200*	Hooker Furniture Corporation - Martinsville	Jones Creek	Industrial Stormwater
VAR050215	Chatham Oil Company	Mulberry Creek	Industrial Stormwater
VAR050216	First Piedmont Corp	Mulberry Creek	Industrial Stormwater
VAR050248	Pine Products Incorporated	Titus Creek UT	Industrial Stormwater
VAR050249	Smurfit Stone - Martinsville	Smith River	Industrial Stormwater
VAR050254	American Standard Building Systems Inc	Jones Creek	Industrial Stormwater
VAR050445	Georgia Pacific Corrugated I LLC	Smith River, UT	Industrial Stormwater
VAR050455	Ridgeway Furniture	Reed Creek	Industrial Stormwater
VAR050501	Gravely Auto Sales & Recycling	Cobbs Creek UT DW	Industrial Stormwater
VAR050523	Southern Finishing Company Inc	Jones Creek, UT	Industrial Stormwater
VAR050532	Stanley Furniture Co Inc - Stanleytown	Smith River	Industrial Stormwater
VAR050721	Quikrete - Martinsville	Tanyard Branch	Industrial Stormwater
VAR050746	Martinsville Concrete Products Inc	Smith River UT	Industrial Stormwater
VAR050751	Griffith Lumber Co Inc	Rock Castle Creek	Industrial Stormwater
VAR050752	DeShazo Oil Co Inc	Mulberry Creek UT	Industrial Stormwater
VAR050758	W-L Construction and Paving Inc - Fieldale	Jordan Creek, UT	Industrial Stormwater
VAR051003	W Henry Hardy Inc - Martinsville	Beaver Creek	Industrial Stormwater
VAR051260	Blue Ridge Solvents and Coatings Incorporated	Town Creek	Industrial Stormwater
VAR051279	Nelson Auto Salvage	Reed Creek	Industrial Stormwater
VAR051473*	Smart Machine Technologies Inc	Smith River	Industrial Stormwater
VAR051544	Springs Global US - Martinsville Plant	UT Little Beaver Creek	Industrial Stormwater
VAR051576	Cycle Systems Inc - Martinsville	Beaver Creek	Industrial Stormwater
VAR051604	MasterBrand Cabinets Incorporated	UT Jones Creek	Industrial Stormwater
VAR051623	Bassett Mirror Company Inc - North Bassett Plant	Smith River	Industrial Stormwater
VAR051662*	DuPont	Smith River	Industrial Stormwater
VAR051716	Tri State Foam Products	Smith River	Industrial Stormwater
VAR051728	Adams Construction Co - Horsepasture Drum Plant	UT Tanyard Branch	Industrial Stormwater
VAR051736	A and B Used Parts	UT Grassy Fork	Industrial Stormwater
VAR051747	Swing Transport Incorporated	UT Machine Br.	Industrial Stormwater
*These facilities are not shown on Figure 2-5; Coordinates are not provided with General Permit registration statement.			

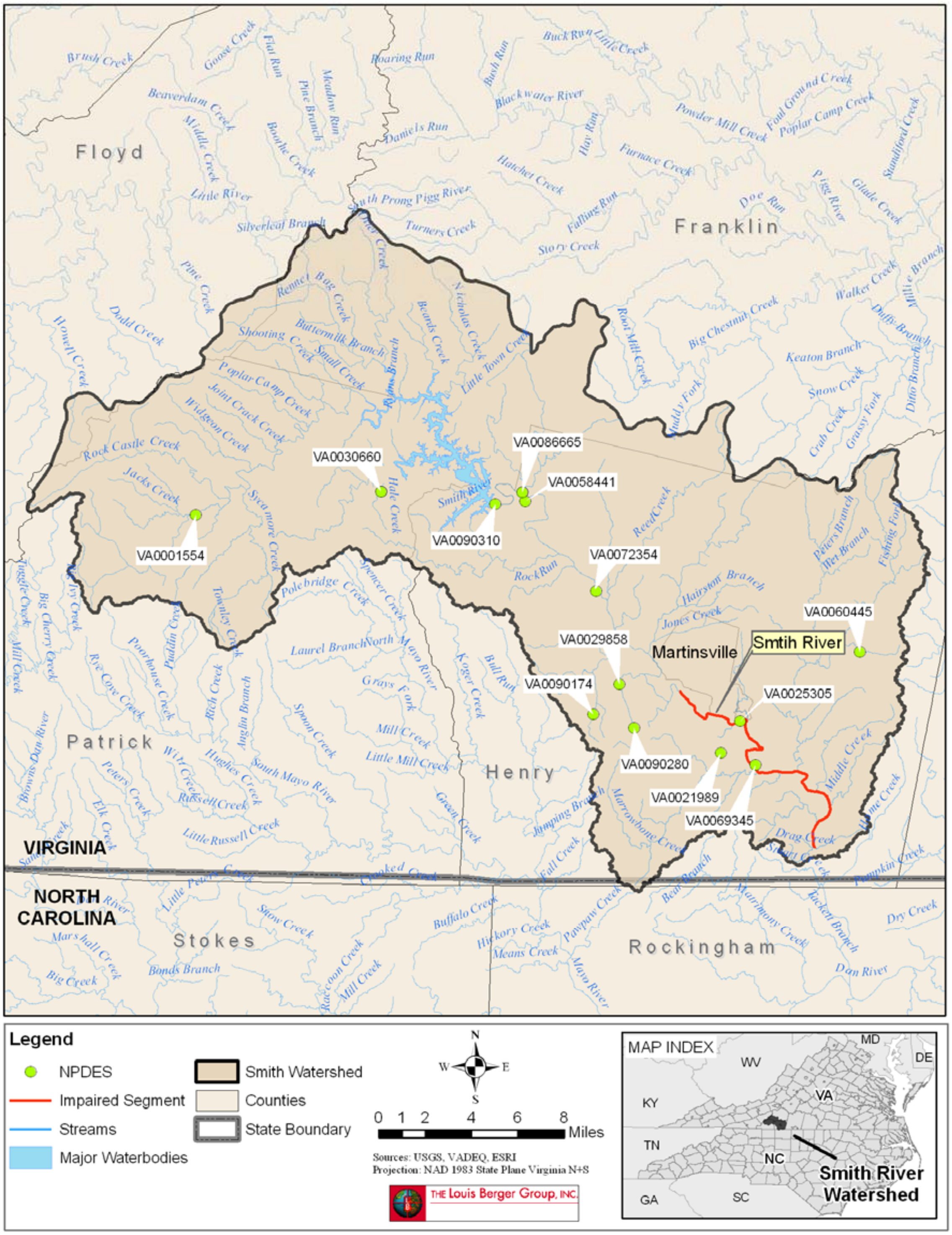

Figure 2- 4: Location of Dischargers with Individual Permits in the Benthic Impaired Smith River Watershed

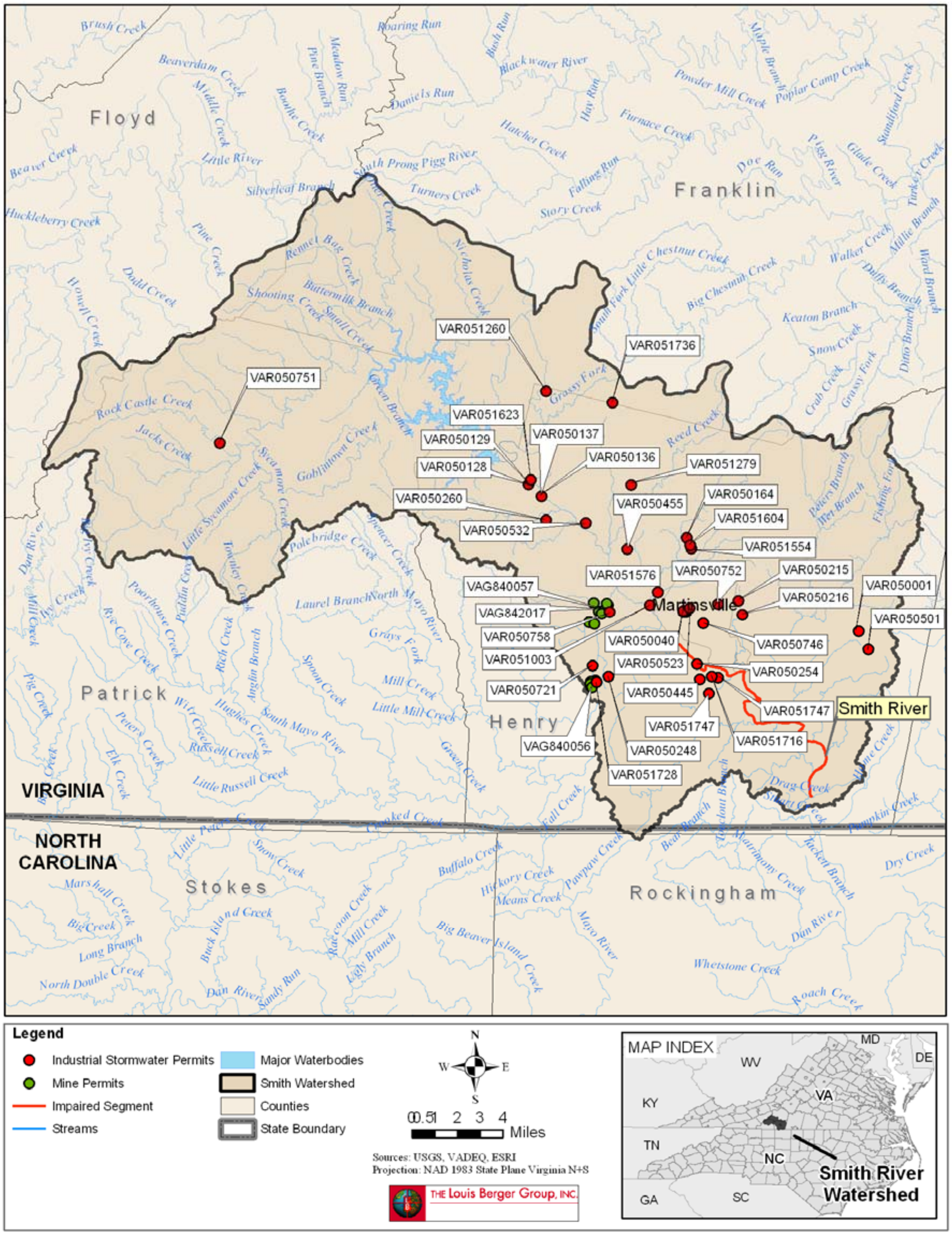

Figure 2- 5: Location of Dischargers with General Permits in the Benthic Impaired Smith River Watershed

2.3 Superfund and RCRA Sites

There is one EPA Superfund site and one Resource Conservation and Recovery Act (RCRA) site located in the Smith River watershed.

Doyle Wood Treating Plant

The Doyle Wood Treating Plant site is a federal registered superfund site (EPA ID # VA0000094490) located within the city of Martinsville. Based on information from EPA's Mid-Atlantic Superfund site (EPA, Dec. 2010), the plant is an abandoned wood treating plant that formerly ran a chromated copper arsenate process. In October of 1993, old storage tanks and drums were discovered on the plant site, which contained hazardeous substances such as chromate copper arsenate (CCA). Removal efforts were carried out from December 16th, 1993 to May 17th 1995, and again from September 12th, 1995 through April 19th, 1996. A preliminary assessment of the site was completed in the month of November, 2004. A further review of the EPA Superfund documentation (EPA, Dec. 2010) revealed that no hazardous substances have been processed or applied except for chromated copper arsenate (CCA).

DuPont de Nemours & Co.

DuPont de Nemours & Co., Inc is a federally registered hazardous site (EPA ID# VAD003114865) that is regulated under the Resource Conservation and Recovery Act (RCRA). The site is located on 550 acres within a stream meander of the Smith River near the Martinsville Dam in Martinsville, VA that is largely wooded and undeveloped. DuPont was one of the world's largest nylon manufacturers and operated from 1941 to 1998. During operation of the plant nylon wastes, finish oil, nitric and formic acids and laboratory chemicals were deposited onsite. Since its closing, the facility has undergone several assessments for contamination in soils, groundwater, and surface waters, and remediation activities. EPA continues to have oversight over the corrective action activities. Included in **Appendix D** is a summary of the assessments and remediation activities that have been and are continuing to be carried out at the DuPont site.

3.0 Environmental Monitoring

Environmental monitoring efforts in the Smith River watershed include benthic community sampling and analysis, habitat condition assessments, ambient water quality sampling, fish tissue and sediment monitoring, probabilistic assessment of hydrophobic organic contaminants, toxicity testing, continuous flow measurements, and Discharge Monitoring Reports (DMR). Monitoring efforts presented in this chapter were conducted by VA DEQ and the U.S. Geological Survey/Columbia Environmental Research Center (USGS/CERC). In addition, the Dan River Basin Association (DRBA) has conducted monitoring efforts.

3.1 DEQ Monitoring Stations

VA DEQ has monitored ambient water quality, macroinvertebrate communities, fish tissue, and sediment chemistry at 20 locations in the Smith River watershed. Of the 20 sites, 10 are located along the impaired segment. A list of the VA DEQ monitoring stations in the Smith River is provided in **Table 3-1,** and the locations of these stations are presented in **Figure 3-1**. Station identification numbers include the abbreviated creek name and the river mile on the creek where the station is located (the river mile number represents the distance from the mouth of the creek).

Table 3-1: Summary of VA DEQ Monitoring Stations in the Smith River Watershed

	Station ID	Station Description	Available Data	Collection Period (Dates)
Smith River	4ASRE055.62	Philpott Reservoir at Buoy 9	Fish tissue	9/7/99
			Sediment	9/8/99
	4ASRE046.90	Philpott Reservoir above dam	Fish tissue	9/8/99, 9/16/02
			Sediment	9/7/99, 9/16/02
	4ASRE033.19	Rt. 701 Bridge	Macroinvertebrates	12/07/94, 07/18/95, 11/21/95, 06/17/96, 09/30/96, 11/03/96, 06/12/97, 11/01/97, 06/06/98, 11/29/98, 05/16/99, 12/05/99, 05/30/00, 11/28/00, 12/03/01, 11/10/03, 06/14/04, 11/13/05, 11/13/06, 10/01/07, 05/29/08, 11/18/08, 04/29/09, 11/03/09
			Fish Tissue and Sediment	8/10/09
			Continuous DO Measurements	11/16-28/07
			Relative Bed Stability	8/17/2008

Table 3-1: Summary of VA DEQ Monitoring Stations in the Smith River Watershed

	Station ID	Station Description	Available Data	Collection Period (Dates)
	4ASRE031.00	Behind Church at Kohler	Macroinvertebrates	11/01/97, 11/29/98, 05/16/99, 12/05/99, 05/30/00, 11/28/00, 11/10/03, 06/14/04, 11/13/05, 11/13/06, 05/29/08, 04/29/09, 11/03/09
			Continuous DO Measurements	05/17-19/06
	4ASRE029.50	*	Sediment	8/14/96
	4ASRE026.77	Above Martinsville Dam	Fish Tissue and Sediment	8/11/09
	4ASRE026.38	At Gage	Macroinvertebrates	11/03/96, 11/01/97, 11/29/98, 05/16/99, 12/05/99, 05/30/00, 12/04/00, 11/16/03, 06/14/04
			Continuous DO Measurements	11/16-28/07
	4ASRE026.27	Below Dam at Powerplant	Instream chemical parameters	8/21/03 - 12/19/06
			Fish tissue	8/18/99
			Sediment	8/18/99
	4ASRE026.06	Downstream of Martinsville Dam, near gage	Fish tissue	6/13/02
			Sediment	6/13/02
	4ASRE024.30	Off Frith Rd. downstream of Railroad Trestle	Macroinvertebrates	11/18/08, 04/29/09, 11/03/09
	4ASRE022.90	Downstream of Machine Br. Mouth	Macroinvertebrates	04/29/09, 11/04/09
	4ASRE022.71	*	Instream chemical parameters	1/26/93 - 6/20/01
	4ASRE022.30	Downstream of Martinsville STP	Macroinvertebrates	11/01/97, 06/06/98, 11/29/98, 05/16/99, 12/05/99, 05/30/00, 12/04/00, 12/03/01, 11/10/03, 06/25/04, 11/13/05, 11/13/06, 10/01/07, 05/29/08, 11/18/08, 04/29/09, 11/04/09
			Fish Tissue and Sediment	8/12/09
			Continuous DO Measurements	11/16-28/07
			Relative Bed Stability	8/17/2008
	4ASRE021.58	Route 58 Bypass Bridge, Henry County	Instream chemical parameters	7/27/98 - 12/14/06
	4ASRE020.75	Off of Rt. 702 downstream of Martinsville STP	Instream chemical parameters	4/28/03 - 6/2/03
			Hydrophobic organics	Spring 2003
	4ASRE019.00	Above Confluence of Marrowbone Creek.	Macroinvertebrates	11/01/97, 07/18/95, 11/21/95, 06/17/96, 11/03/96, 06/12/97, 11/01/97, 06/06/98, 11/29/98, 05/16/99, 12/05/99, 12/03/01, 11/16/03, 06/14/04, 11/13/05, 11/13/06, 10/01/07, 05/29/08, 11/18/08, 04/30/09, 11/04/09
			Instream chemical parameters	8/16/05 - 12/14/06
			Fish tissue	8/18/99
			Fish Tissue** and Sediment	8/18/99, 8/12/09
			Toxicity Testing	5/16/06, 5/17/06, 5/19/06

Table 3-1: Summary of VA DEQ Monitoring Stations in the Smith River Watershed

	Station ID	Station Description	Available Data	Collection Period (Dates)
			Continuous DO Measurements	08/14-16/06
	4ASRE015.43	Rt 636 Bridge	Macroinvertebrates	12/07/94, 07/18/95, 11/21/95, 06/17/96, 06/12/97, 11/01/97, 11/29/98, 05/16/99, 12/05/99, 11/28/00, 12/03/01, 11/16/03, 06/14/04, 11/13/05, 11/13/06, 10/01/07, 05/29/08, 11/18/08, 04/30/09, 11/04/09
			Instream chemical parameters	7/27/98 -12/14/06
			Toxicity Testing	5/16/06, 5/17/06, 5/19/06
			Continuous DO Measurements	05/17-19/06
			Relative Bed Stability	8/17/2008
	4ASRE011.08	*	Sediment	9/18/97
	4ASRE007.90	RT. 622 Bridge, Morgan Ford Bridge	Sediment	9/18/97
Tributary	4AMRR000.02	Route 642 Bridge, Henry County	Instream chemical parameters	2/10/93 - 2/21/07
	4ALWD002.54	Route 650 Bridge, Henry County	Instream chemical parameters	3/30/93 - 12/14/06

*No description available
** Data from 8/12/09 has not been analyzed as of the date of the report

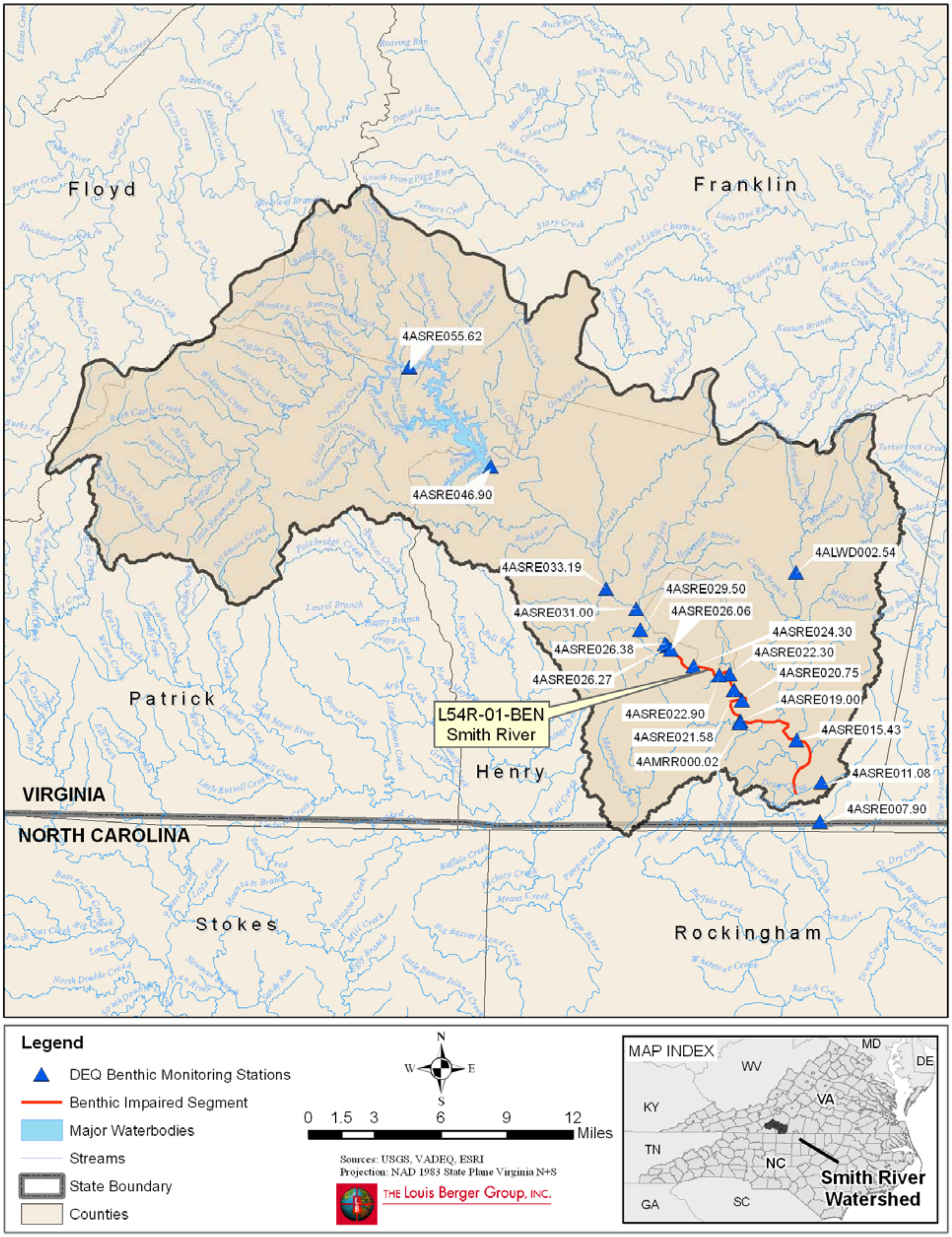

Figure 3-1: Water Quality Monitoring Stations Used in the Benthic TMDL for the Smith River Watershed

3.2 Virginia DEQ Environmental Monitoring Data

The first step in benthic TMDL development is the identification of the pollutant stressor(s) impacting the benthic community. Environmental monitoring data are vital to this initial step. The following sections summarize and present the available monitoring data used to determine the primary stressor impacting the biologically impaired segment of Smith River.

3.2.1 Biological Monitoring Data

Based on biological monitoring data, the Smith River was initially listed on Virginia's 1998 Section 303(d) List, then the 2004 Section 303(d) List, and finally the 2008 Section 303 (d) List of Impaired Waters (VA DEQ, 2008) due to violations of the General Standard (benthic).

In 1994 the VA DEQ West Central Regional Office (WCRO) began several studies of the biological community in the vicinity of dischargers in the Martinsville area (VA DEQ, 2004). Biological monitoring data were collected by VA DEQ from 1994 to the present at eight stations in the Smith River, of which six are located in the impaired segment and two upstream of the impaired segment. The biological monitoring data were evaluated using two indicator scores, the EPA's Rapid Bioassessment Protocol II (RBPII) and the Virginia Stream Condition Index (VSCI), as developed for VA DEQ by Tetra Tech.

Calculation of the RBPII score incorporates eight standard metrics based on the numbers and types of macroinvertebrates present at each station. Points are awarded for indicators of health including high diversity of taxa, and the presence of taxa that are known to be intolerant of stressful conditions. These metrics are taken from stations located in the impaired segment as well as from one paired reference station in a non-impaired, upstream segment that is also located within the watershed. The final RBPII score is based on a comparison of the impaired segment with the reference site. Stations that are very similar to the reference site receive a high score and are generally non-impaired, while stations that are very dissimilar to the healthy reference condition receive a low score.

Calculation of VSCI scores also incorporates eight standard metrics, similar to those used in RBPII scoring. These metrics are evaluated together to produce a unitless score that provides an overall indication of ecological integrity. VSCI scores provide a measure of stream biological integrity on a statewide basis. The VSCI metrics and their expected response to declining stream conditions are presented in **Table 3-4**.

An impairment cutoff score of 60 has been established for assessing results obtained with the VSCI. Streams that score greater than 60 are considered to be non-impaired, whereas streams that score less than 60 are considered impaired (VA DEQ, 2006a).

3.2.1.1. RBPII Scores

RBPII scores were calculated by the VA DEQ at four biomonitoring stations located within the impaired segment. From upstream to downstream these impaired stations are: 4ASRE026.38/27, 4ASRE022.30/20.75, 4ASRE019.00/10, and 4ASRE015.43 (data from samples taken very close together were combined). Station 4ASRE033.19 was used as a reference station for the impaired segment.

The RBPII metrics, as specified in EPA's Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers (Barbour et al., 1999), are presented in **Table 3-2**. The RBPII biomonitoring data collected from the Smith River are discussed in the following section, and the VA DEQ's final RBPII assessment ratings are presented in **Table 3-3**.

Table 3-2: RBPII Metrics Specified in Barbour et al. (2002)

Category	Metric	Definition	Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/ Intolerance	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease

Table 3-2: RBPII Metrics Specified in Barbour et al. (2002)			
Category	**Metric**	**Definition**	**Response to Disturbance**
Measures	% Tolerant Organisms	Percent of the macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures dominance of the most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from water column or sediment	Variable
	% Grazers and Scrapers	Percent of macrobenthos that scrape or graze upon periphyton	Decrease
Other Measures	Hilsenhoff Biotic Index (HBI)	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

a) Reference Station

Station 4ASRE033.19 is the farthest station upstream that was monitored for biological integrity. Although this station was used as a reference for calculating RBP II scores, the RBPII Habitat Method parameters indicate that sediment and embeddedness conditions at this site in the last seven years have slightly declined. Biologist notes described *Ephemerellidae* mayflies dominating in fall surveys, indicating that sediment is a potential stressor. They attributed this decline to recent logging activity in areas surrounding Reed Creek, a major tributary to the Smith River. In addition, a discussion with a US EPA Region III Biologist indicated that Ephemerellidae mayflies also survive well in cold water dominated streams. Therefore, flow regulations and sediment deposition from Philpott Dam were also noted as potential stressors.

b) Impaired Segment

Biological monitoring surveys were conducted by VA DEQ biologists intermittently from 2000 to 2006 along the impaired segment of the Smith River. These surveys indicated that the health of benthic communities downstream from Martinsville Dam (monitoring stations 4ASRE022.30, 4ASRE019.00 and 4ASRE015.43) declined. Based on the RBPII ratings, 14 out of 15 sampling events at these stations found the benthic community to be impaired.[1]

[1] The one non-impaired sample was taken in the fall of 2001 at the downstream station 4ASRE015.43. That same benthic community, however, was found to be impaired four times in the following five years.

Biomonitoring at station 4ASRE026.38, located directly downstream of the dam, indicated benthic impairment in the fall of 2003 and in the spring of 2004. According to DEQ biologists, the Upper Smith River STP and urban NPS pollution may affect this stretch of river. Periodically during monitoring, VA DEQ biologists found that flow releases from Martinsville Dam were very low. This can damage the benthic community by dewatering the substrate, which reduces the amount of available habitat for benthic macroinvertebrates. In addition, discharges from dams lower dissolved oxygen concentrations and contribute to changes in water temperature. Both of these parameters affect the composition of macroinvertebrates found in the stream.

Downstream, the benthic community at monitoring station 4ASRE022.30 was found to be impaired during surveys conducted in 2003 and 2004. VA DEQ biologists noted potential impacts from point source municipal and industrial wastewater dischargers, as well as the nonpoint source of urban runoff. During both sampling events, the benthic community at this station was heavily dominated by *Hydropsychidae* (common netspinners) and *Chironomidae* (midges). *Hydropsychidae* are indicators of organic and nutrient pollution when present in high numbers (Voshell, 2001). *Chironomidae* are moderately pollution-tolerant, and indicate poor stream health when they dominate the benthic community.

Similar macroinvertebrate compositions were observed at station 4ASRE019.00 where, in the fall of 2001, there was a decline in the pollution-intolerant *Ephemeroptera, Plecoptera* and *Trichoptera* (EPT) orders and an increase in tolerant organisms including *Hydropsychidae*. According to the biologist's notes, the two surveys conducted in 2006 had communities dominated by *Hydropsychidae*, which may indicate organic and nutrient pollution. VA DEQ biologist notes also indicated municipal and industrial wastewater point sources as potential impacts to the instream benthic community at this station, which is directly downstream of the Lower Smith River Wastewater Treatment Plant (Henry County PSA). Non-point source urban runoff and sediment from land use conversion throughout the watershed were also noted as possibly affecting the benthic community.

The benthic community farther downstream at biomonitoring station 4ASRE015.43 has been impaired since 2002. Low percentages of intolerant EPT orders and high percentages of *Hydropsychidae* indicate organic and nutrient pollution. Urban runoff and sediment were noted by biologists to be potential stressors at this station. Biologists also noted that the Leatherwood Creek confluence located just upstream of this station may be a substantial source of the sedimentation within the reach.

c) RBPII Final Scoring

For the 2004 303(d) List, the VA DEQ considered the biological monitoring data above, which was collected from 1998 to 2002. In conclusion, the VA DEQ listed the 13.7 mile segment of the Smith River from the Martinsville Dam, downstream to the mouth of Turkeypen Branch as not supporting the aquatic life uses. The VA DEQ's final RBPII assessment ratings for each of the stations in the impaired segment, as well as that of the reference station are presented in **Table 3-3**.

Table 3-3: RBPII Assessment Ratings for Smith River Biomonitoring Surveys

Time Period	Assessment Rating by Station				
	4ASRE033.19*	4ASRE026.38	4ASRE022.3	4ASRE019.00	4ASRE015.43
Spring 1999	-	-	-	-	Slight impairment
Fall 1999	-	-	-	-	-
Spring 2000	-	-	-	-	-
Fall 2000	-	-	-	-	Non-impaired
Spring 2001	-	-	-	-	-
Fall 2001	Non-impaired	-	Impaired	Impaired	Non-impaired
Spring 2003	-	-	-	-	-
Fall 2003	Non-impaired	Impaired	Impaired	Impaired	Impaired
Spring 2004	Non-impaired	Impaired	Impaired	Impaired	Impaired
Fall 2004	-	-	-	-	-
Spring 2005	-	-	-	-	-
Fall 2005	Non-impaired	-	Impaired	Impaired	Impaired
Spring 2006	-	-	-	-	-
Fall 2006	Non-impaired	-	Impaired	Impaired	Impaired

* As this station served as the reference, impairment assessment is based on a VSCI score

3.2.1.2. VSCI Scores

In the Smith River watershed, VSCI scores were calculated by VA DEQ at eight stations, six of which are located on the impaired segment (4ASRE026.38/27, 4ASRE022.30/20.75, 4ASRE019.00/10, 4ASRE015.43, 4ASRE024.30, and 4ASRE022.90; stations at very close locations were considered the same station) (**Figure 3-1**).

The VSCI metrics and their expected response to declining stream conditions are presented in **Table 3-4**. Some of the results found in the metrics are discussed below, and the final VSCI scores are presented at the end of this section.

Table 3-4: Metrics Used to Calculate the Virginia Stream Condition Index (VSCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemeroptera	Decrease	% Ephemeroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index (HBI)
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

a) Taxa Richness and Taxonomic Composition

The metric for taxa richness, which measures the overall variety of the invertebrate assemblage, was generally high at stations upstream of the dam and consistently low downstream of the dam. The percentage of EPT taxa measures the composition of mayfly, stonefly, and caddisfly larvae within the sample (*Ephemeroptera, Plecoptera, Trichoptera*, respectively). Since the majority of these species are highly sensitive to pollution and environmental stress, this metric is used as an indicator of stream health. From upstream to downstream along the benthic impaired segment, the composition of mayflies tends to decrease. As shown in **Figure 3-2**, the percentage of the sample composed of mayflies is highest at the stations upstream of the dam. After the Martinsville Dam, there appears to be recovery occurring downstream, but by station 4ASRE022.30, which is directly after the Martinsville WWTP, mayfly percentages decrease considerably. The lowest mayfly percentages were observed at station 4ASRE019.00.

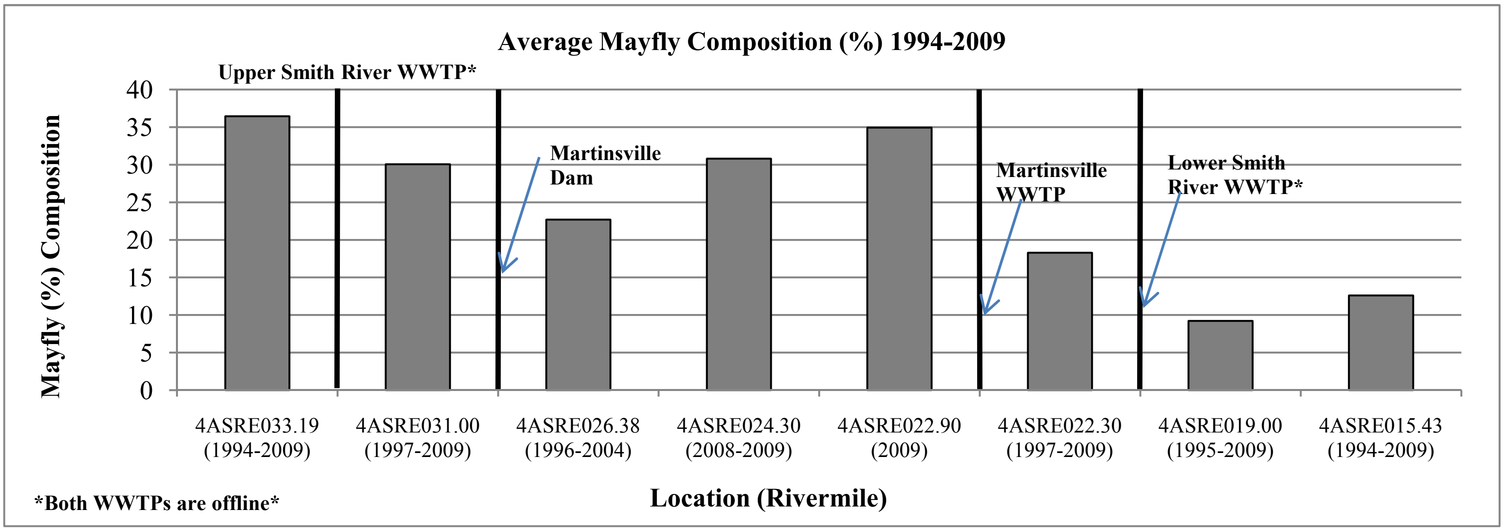

Figure 3-2: Average Mayfly Composition (%) 1994 – 2009

b) Trophic Group

Various species of macroinvertebrates feed by scraping the thin layer of algae off the surface of stream substrate. High levels of sediment, and organic or nutrient pollution causes declines in scraper numbers. As shown in **Figure 3-3**, scrapers increased from upstream to downstream and were most prevalent just before the Martinsville WWTP, at station 4ASRE022.90. Monitoring station 4ASRE019.00 had the lowest amount of scrapers.

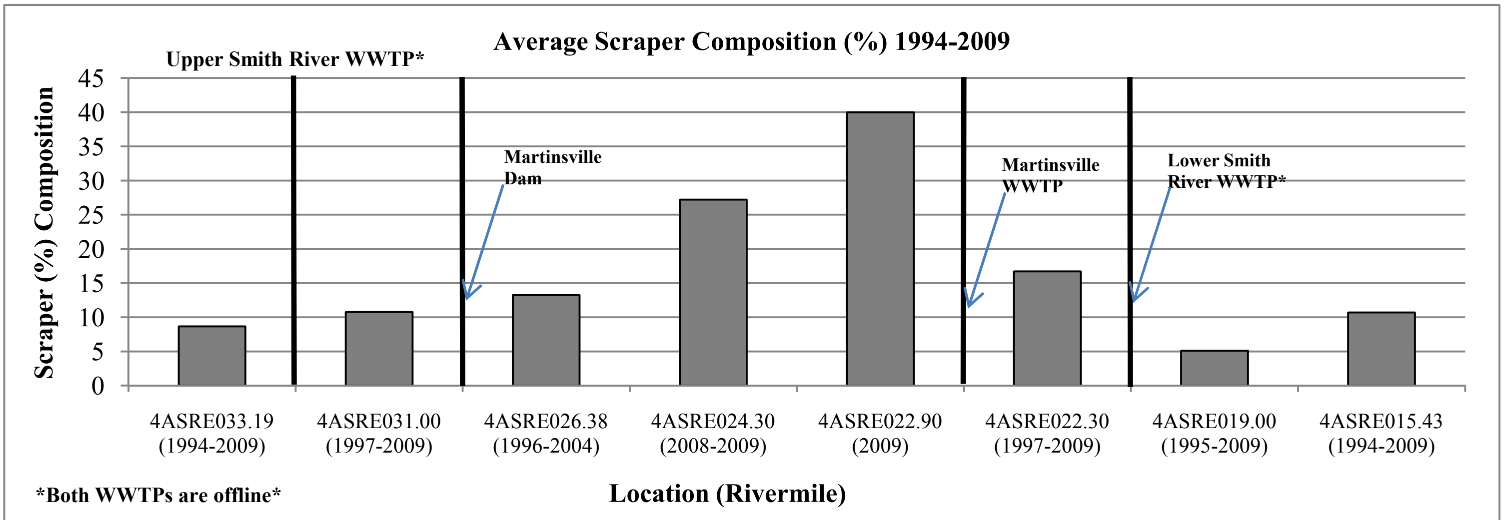

Figure 3-3: Average Scraper Composition (%) 1994 – 2009

c) VSCI Final Scoring

The data discussed in the sections above were used by VA DEQ in calculating VSCI scores for the biomonitoring stations in the Smith River watershed. **Table 3-5** shows the VSCI scoring results for the stations that are discussed in this report.

Table 3-5: Virginia SCI Scores for the Smith River 1994-2009

Collection Period	Other Stations		Stations in Impaired Segment					
	4ASRE033.19	4ASRE031.00	4ASRE026.38	4ASRE024.30	4ASRE022.90	4ASRE022.30	4ASRE019.00	4ASRE015.43
Spring 1994	50.5	-	-			-	-	48.3
Fall 1994	-	-	-			-	-	-
Spring 1995	62.4	-	-			-	47.8	48.6
Fall 1995	63.7	-	-			-	24.1	24.6
Spring 1996	72.7	-	-			-	37.8	40.3
Fall 1996	67.9	-	-			-	31.2	-
Spring 1997	63.2	-	-			-	45.4	42.0
Fall 1997	63.2	51.7	38.9			25.6	31.1	45.9
Spring 1998	56.4	-	-			34.2	44.5	-
Fall 1998	46.1	50.7	49.0			38.02	41.9	53.7
Spring 1999	58.0	48.6	48.3			50.1	39.9	62.4
Fall 1999	64.2	67.4	61.6			43.8	49.9	54.0
Spring 2000	74.7	72.8	54.7			49.3	-	-
Fall 2000	70.8	71.4	52.7			68.3	-	70.4

Table 3-5: Virginia SCI Scores for the Smith River 1994-2009

Collection Period	Other Stations		Stations in Impaired Segment					
	4ASRE033.19	4ASRE031.00	4ASRE026.38	4ASRE024.30	4ASRE022.90	4ASRE022.30	4ASRE019.00	4ASRE015.43
Spring 2001	-	-	-			-	-	-
Fall 2001	65.1	-	-			40.4	38.2	63.0
Spring 2003	-	-	-			-	-	-
Fall 2003	51.0	49.4	50.5			51.9	44.4	45.2
Spring 2004	58.0	40.4	48.0			56.6	35.8	50.3
Fall 2004	-	-	-			-	-	-
Spring 2005	-	-	-			-	-	-
Fall 2005	62.9	58.6	-			46.7	52.6	58.2
Fall 2006	63.5	57.9	-			61	41	43.7
Fall 2007	62.27	-				44.81	39.36	50.66
Spring 2008	52.64	56.81				48.60	56.13	64.50
Fall 2008	62.35	-		66.39		55.10	58.22	54.74
Spring 2009	62.29	69.49		47.92	65.19	66.82	38.07	59.46
Fall 2009	60.98	65.65		66.23	65.84	51.08	62.08	65.44
Average	61.0	58.5	50.5	60.2	65.5	48.9	42.4	52.3
Monitoring station 4ASRE033.19 served as the reference station								

As shown in **Table 3-5**, only two out of six average VSCI scores calculated in the impaired segment were above the impairment cutoff of 60. All other average VSCI scores calculated for biomonitoring stations located in this river segment were well below 60.0 (**Table 3-5**).

VA DEQ assessed VSCI scores between 1994 and 2009 for eight stations in the Smith River. At the reference station, 4ASRE033.19, which includes 24 sampling events, VSCI scores averaged 61.0 and were as high as 74.7. The benthic community just above the dam at station 4ASRE031.00 has fluctuated in past years but most recently have been above the cutoff score of 60.0**.** VSCI scores at station 4ASRE026.38 have averaged 50.5, which is below the 60.0 cutoff. This station lies in the upstream end of the impaired section. Downstream from 4ASRE026.38, VSCI scores at monitoring stations 4ASRE024.30 and 4ASRE022.90 averaged above the cutoff score of 60.0. Downstream of the Martinsville WWTP station 4ASRE022.30 averaged 48.9. It should be noted station 4ASRE022.30 is located within the official mixing zone for the Martinsville WWTP outfall. Farther downstream, towards the end of the impaired segment, the average VSCI at stations 4ASRE019.00 and 4ASRE015.43 were 42.4 and 52.3, respectively. **Figure 3-4** shows the average VSCI scores in Smith River from 1994 to 2009.

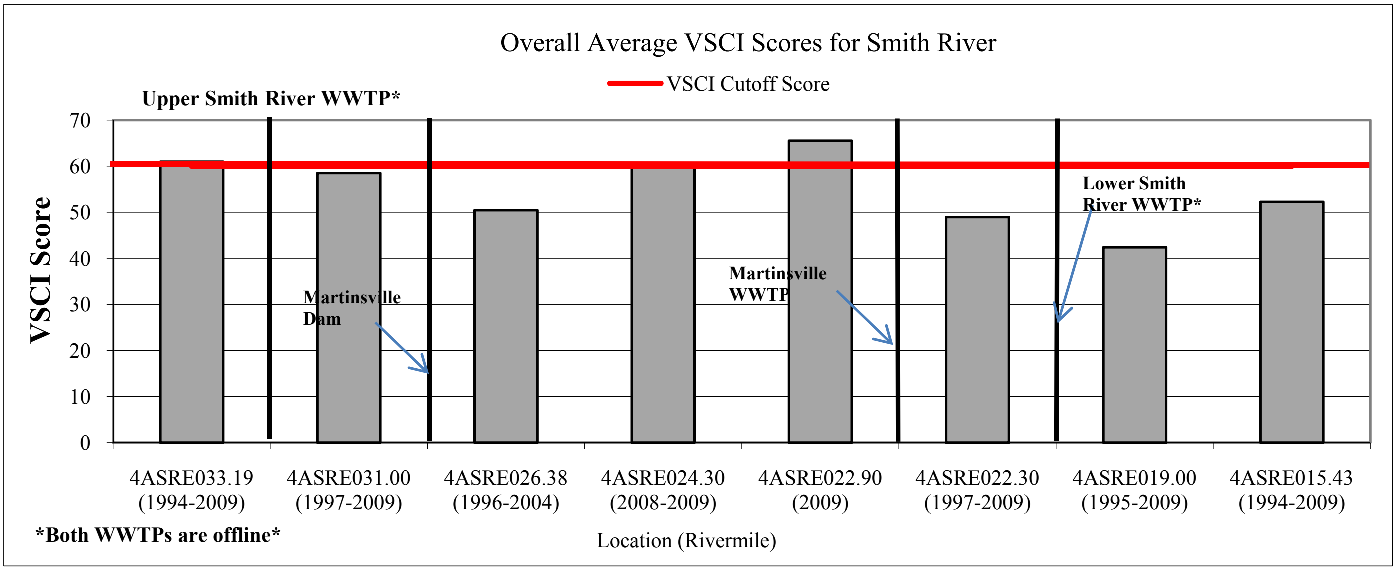

Figure 3-4: Average VSCI Scores 1994 to 2009

Further analysis was completed in order to determine if seasonality affected the VSCI scores. In general, the spring and fall 2009 VSCI scores followed the pattern of the overall VSCI Scores (**Figures 3-5 and 3-6**). The spring 2009 VSCI scores appear to be above the historical average for all but two stations. Generally, the fall 2009 VSCI scores were higher than the spring 2009 VSCI scores. The new station, 4ASRE024.30, had a high number of unidentified oligocheate worms, thereby lowering the score to 48. Also during this season station 4ASRE019.00 continued to have the lowest VSCI score. The fall 2009 data also appeared to have scores well above the historical averages for all but one station (4ASRE022.30). It should be noted that sampling did not occur across the entire river for this station due to above normal flow from power generation by the dam. This low VSCI score may reflect this limited analysis. Additional trend analysis was completed by VA DEQ and is presented in **Appendix A**.

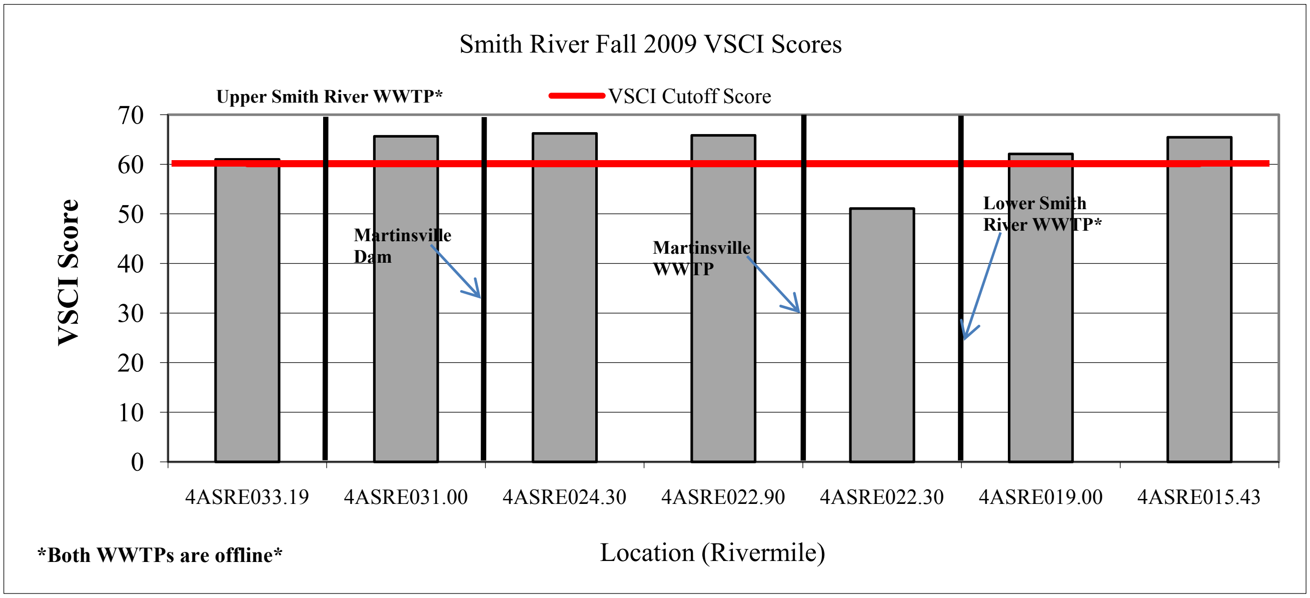

Figure 3-5: Spring 2009 VSCI Scores

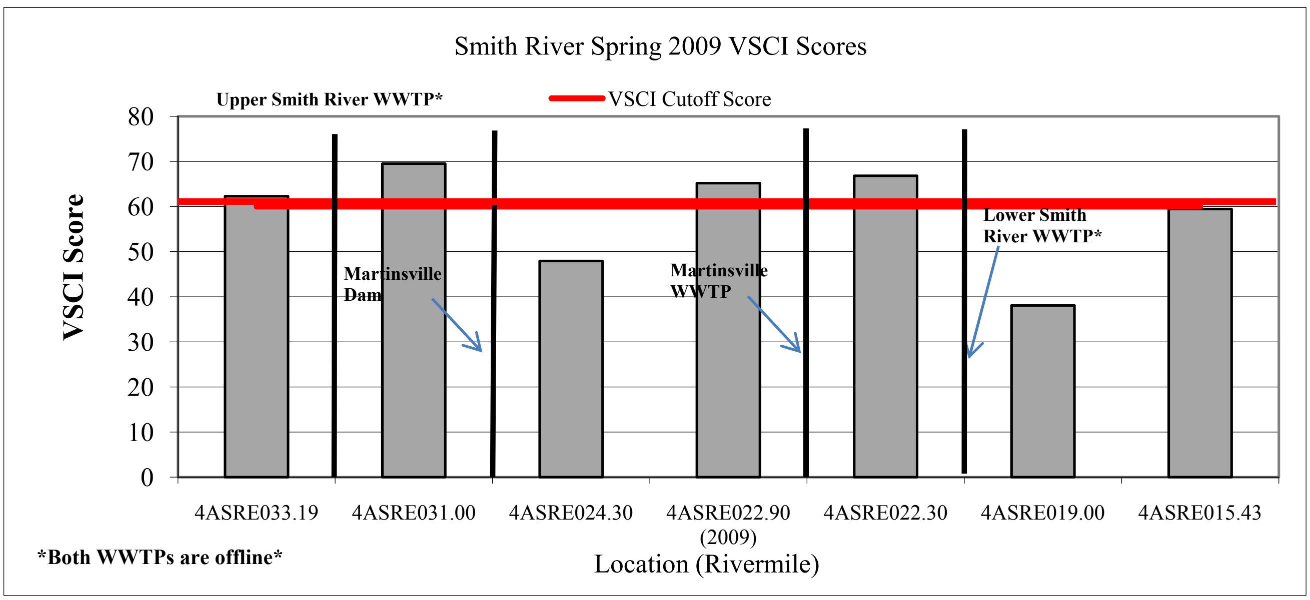

Figure 3-6: Fall 2009 VSCI Scores

3.2.2 Habitat Assessment Scores and Relative Bed Stability

VA DEQ conducted a habitat assessment and a relative bed stability study in the Smith River. The habitat assessment is based on

Habitat Assessment Scores

VA DEQ used EPA's Rapid Bioassessment Protocols (RBP) to evaluate qualitatively method habitat. Habitat parameters examined along the impaired segment include channel alteration, sediment deposition, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. During each sampling event, each parameter was assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. VA DEQ assessed habitat scores between 1997 and 2006 for five stations in the Smith River. The habitat assessment scores for the four Smith River biomonitoring stations and reference station are presented in **Table 3-6** and **Table 3-7**.

Overall, habitat assessment scores were generally higher at the impaired stations than at the reference stations, suggesting that the reference station may need to be assessed for potential habitat impacts. Historically (2000-2006), the habitat showed average sedimentation scores increasing from upstream to downstream; recent RBP scores for sedimentation show increasing sedimentation at the reference site (4ASRE033.19). In the impaired segment, scores for embeddedness, sedimentation, riparian vegetation, riffle frequency, and more recently, bank stabilization and protection were low on average. Sedimentation scores were specifically low beginning in the fall of 2003. Riparian vegetation, grazing, and sedimentation scores in the reference station were considerably low for all years.

Table 3-6: Habitat Scores for Impaired Stations

StationID	Date	Total Habitat Score	Habitat Alteration	Bank Stabilization	Bank Vegetation	Embeddedness	Flow	Riffle Frequency	Riparian Vegetation*	Sedimentation	Velocity	Substrate**
4ASRE026.38	Fall 1997	154	14	16	16	14	18	18	-	13	18	14
	Fall 1998	154	14	15	15	14	18	15	-	14	15	17
	Spring 1999	144	14	18	12	13	13	14	-	12	16	16
	Fall 1999	160	15	15	15	13	18	18	-	16	16	17
	Fall 2000	121	15	10	6	12	18	12	-	9	13	13
	Fall 2003	159	15	15	18	12	16	20	13	13	20	17
	Average (1997-2003)	148	15	15	14	13	17	16	13	13	16	16

Table 3-6: Habitat Scores for Impaired Stations												
StationID	**Date**	**Total Habitat Score**	**Habitat Alteration**	**Bank Stabilization**	**Bank Vegetation**	**Embeddedness**	**Flow**	**Riffle Frequency**	**Riparian Vegetation***	**Sedimentation**	**Velocity**	**Substrate****
4ASRE022.30	**Fall 1997**	157	16	13	16	14	18	15	-	15	18	16
	Spring 1998	153	18	10	8	11	18	18	-	18	18	17
	Fall 1998	165	16	13	16	16	18	17	-	16	17	18
	Spring 1999	140	16	10	10	12	18	16	-	15	15	14
	Fall 1999	158	18	13	12	15	18	16	-	16	16	17
	Fall 2000	142	18	10	6	17	20	13	-	13	13	16
	Fall 2001	184	20	12	15	17	15	20	14	15	20	18
	Fall 2003	149	20	12	14	10	20	20	15	8	16	14
	Fall 2005	152	17	14	14	12	18	17	16	12	18	14
	Fall 2006	161	19	18	18	11	15	18	16	11	18	17
	Fall 2007	130	20	8	8	6	17	15	13	7	19	17
	Spring 2008	147	20	14	16	9	19	15	13	10	18	13
	Fall 2008	148	20	17	17	10	17	9	11	9	19	19
	Spring 2009	148	20	12	14	12	20	13	11	12	19	15
	Fall 2009	147	19	16	17	12	20	12	12	11	15	13
	Average (2003-2009)	148	19	14	15	10	18	15	13	10	18	15
4ASRE019.00	**Spring 1995**	145	18	15	16	8	17	17	-	15	17	10
	Fall 1995	136	18	13	16	8	16	18	-	8	18	10
	Spring 1996	141	17	15	12	10	16	16	-	16	16	13
	Fall 1996	149	18	13	16	8	16	18	-	19	18	11
	Spring 1997	138	18	14	18	7	18	16	-	16	18	7
	Fall 1997	142	18	14	18	8	18	16	-	16	18	8
	Spring 1998	142	18	14	15	11	18	18	-	12	18	9
	Fall 1998	150	7	14	15	13	18	18	-	15	18	16
	Spring 1999	152	20	15	16	11	18	18	-	13	16	13
	Fall 1999	150	16	15	15	12	18	17	-	10	17	15
	Fall 2001	195	20	18	18	12	15	20	18	14	20	20
	Fall 2003	167	20	14	18	12	15	19	20	9	20	20
	Fall 2005	169	19	17	17	14	18	18	17	12	18	19
	Fall 2006	162	19	17	15	14	16	19	16	10	19	17
	Fall 2007	142	20	14	14	6	17	14	16	7	17	17
	Spring 2008	161	18	16	13	17	18	17	13	13	19	17
	Fall 2008	165	20	15	17	13	19	18	12	14	20	17
	Spring 2009	159	20	14	12	15	19	19	14	10	20	16
	Fall 2009	159	19	18	16	13	20	18	16	7	19	13
	Average (2003-2009)	161	19	16	15	13	18	18	16	10	19	17

Table 3-6: Habitat Scores for Impaired Stations

StationID	Date	Total Habitat Score	Habitat Alteration	Bank Stabilization	Bank Vegetation	Embeddedness	Flow	Riffle Frequency	Riparian Vegetation*	Sedimentation	Velocity	Substrate**
4ASRE015.43	Fall 1994	138	15	11	12	13	16	16	-	12	15	14
	Spring 1995	149	15	16	16	14	18	10	-	12	15	16
	Fall 1995	119	13	12	11	10	15	9	-	10	14	12
	Spring1996	113	11	12	11	10	18	11	-	10	10	10
	Spring1997	136	11	14	14	15	18	13	-	13	12	13
	Fall 1997	130	15	10	16	10	18	15	-	5	16	13
	Fall 1998	146	15	13	13	15	18	13	-	14	15	15
	Spring 1999	150	12	17	19	17	19	14	-	13	15	12
	Fall 1999	149	14	15	15	13	18	18	-	15	11	15
	Fall 2000	136	15	11	13	15	14	15	-	12	15	13
	Fall 2001	184	15	18	18	16	19	20	16	17	15	15
	Fall 2003	167	15	16	16	16	20	20	20	10	20	14
	Fall 2005	143	15	13	14	12	16	13	19	11	17	13
	Fall 2006	149	15	17	16	12	17	13	17	10	15	17
	Fall 2007	146	15	16	18	9	17	14	17	10	16	14
	Spring 2008	156	15	12	14	13	19	17	17	13	19	17
	Fall 2008	156	15	16	15	9	19	19	16	9	20	18
	Spring 2009	156	15	12	16	11	20	18	17	11	20	16
	Fall 2009	159	15	13	15	17	20	16	16	13	19	15
	Average (2003-2009)	154	15	14	16	12	19	16	17	11	18	16

*Riparian vegetation scores through the year 2000 were omitted from this study.
** Cover and Substrate scores averaged in samples collected prior to 2003

Table 3-7: Habitat Scores for Reference Station

StationID	Date	Total Habitat Score	Habitat Alteration	Bank Stabilization	Bank Vegetation	Cover	Embeddedness	Flow	Grazing	Riffle Frequency	Riparian Vegetation	Sedimentation	Substrate	Velocity
4ASRE033.19	Fall 1994	136	12	15	15	9	5	16	12	16	5	6	8	17
	Spring 1995	137	14	13	13	11	9	17	9	12	2	12	10	15
	Fall 1995	129	10	13	13	11	11	16	8	13	2	10	12	10
	Spring 1996	137	13	15	10	15	10	16	6	16	1	5	14	16
	Fall 1996	138	13	13	11	12	8	16	7	13	2	9	16	18
	Fall 1996	131	13	13	11	13	9	16	8	13	2	9	16	8
	Fall 1997	135	13	13	13	12	10	18	8	13	2	10	12	11
	Spring 1998	134	5	15	3	15	18	14	2	18	0	15	15	14
	Fall 1998	138	14	11	14	14	10	18	13	13	1	3	14	13
	Spring 1999	143	12	13	16	12	9	18	10	15	2	2	16	18
	Fall 1999	128	13	12	14	11	6	18	9	14	3	2	12	14
	Fall 2000	139	15	16	17	17	15	15	-	10	-	9	-	15
	Fall 2001	145	15	14	13	18	11	18	-	13	11	12	-	20
	Fall 2003	135	15	13	18	-	6	15	-	17	11	6	14	20
	Fall 2005	130	10	14	12	-	9	17	-	13	12	10	15	18
	Fall 2006	142	15	14	15	-	11	18	-	14	12	8	17	18
	Fall 2007	146	16	15	15		9	18		16	12	10	18	17
	Spring 2008	145	15	14	14		10	19		15	12	11	16	19
	Fall 2008	134	15	14	16		10	17		14	7	5	17	19
	Spring 2009	120	15	15	14		3	16		15	10	3	12	17
	Fall 2009	122	15	13	12		6	19		12	11	5	9	20
	Average (2003-2009)	134	15	14	15	-	8	17	-	15	11	7	15	19

Habitat Assessment Scores

Relative Bed Stability (RBS) is a quantitative measure of “stream power” or relative bed particle mobility. A Log Relative Bed Stability (LRBS) near 0 indicates the stream is stable (Kaufmann *et al.*, July 1999, Oct. 2007). Results of 2008 RBS data collection indicates that the Smith River is more stable (closer to 0) at the downstream site (4ASRE015.43) and at the site just downstream of the Martinsville STP outfall; the reference site had the highest RBS indicating that it is more unstable. **Table 3-8** shows the results of the Relative Bed Stability study.

Table 3-8: Relative Bed Stability Results (presented in last column as log Relative Bed Stability).		
Station ID	Station Location	LRBS
4ASRE015.43	Rt. 636/Mitchell Mill Rd. Bridge,	-0.491526024
4ASRE022.30	Downstream of Martinsville STP outfall	-0.68304337
4ASRE033.19	Fieldale, Reference site	-0.884725574

3.2.3 Ambient Water Quality Monitoring

Water quality monitoring stations located along the benthic impaired segment and upstream of the segment were used in the development of this TMDL. This includes stations 4ASRE026.27, 4ASRE022.71, 4ASRE021.58, 4ASRE020.75, 4ASRE019.00, and 4ASRE015.43 within the benthic impaired segment, and 4AMRR000.02 and 4ALWD002.54, located on Marrowbone Creek and Leatherwood Creek, which are tributaries of the Smith River. **Table 3-9** shows the water quality monitoring stations used in the TMDL and the available data range**.**

Table 3-9: Water Quality Monitoring Stations Used for the Benthic TMDL

Station ID[1]	Stream Name	First Sample Date	Last Sample Date
4ASRE026.27	Smith River Impaired Segment	8/21/2003	12/19/2006
4ASRE022.71		1/26/1993	6/20/2001
4ASRE021.58		7/27/1998	12/14/2006
4ASRE020.75		4/28/2003	6/2/2003
4ASRE019.00		8/16/2005	12/14/2006
4ASRE015.43		7/27/1998	12/14/2006
4AMRR000.02	Marrowbone Creek	2/10/1993	2/21/2007
4ALWD002.54	Leatherwood Creek	3/30/1993	12/14/2006

[1]The last 5 digits of the DEQ station number corresponds to stream mile.

VA DEQ collected instream water quality and river sediment samples at these stations. The instream water quality measurements included general parameters (temperature, DO, pH, and spec. conductivity) and chemical parameters (nutrients, solids, metals, and organics) and were generally collected under low and medium flow conditions. The river sediment measurements included heavy metals and organic contaminants. For the analysis, only data collected from 1996-2006 were analyzed and compared to VA DEQ water quality standards.

3.2.3.1. Ambient Water Quality Monitoring Summary

Monitoring Stations along the benthic impaired segment

A summary of selected instream data within the impaired segments is given below (Summary tables of selected instream water quality data collected at all monitoring stations in the impaired segment are provided in **Appendix B**). The summary also includes figures of the selected instream data (For some parameters, BOD_5, TSS, Total NH_3-N, PO_4-P, and TP, the detection limits often create a straight line of low values in the figures).

- Field dissolved oxygen data, presented in **Figure 3-7,** indicated that adequate DO levels are found in the benthic impaired segment of the Smith River (range: 6.9–15.2 mg/L). There were no exceedances for both VA DEQ criteria (minimum and daily average criterion). The upper range (15.2 mg/L on 2/04/2004) is a meter malfunction, since the observed value is greater than the saturation concentration of oxygen in water at the time when minimum or no water plant productivity exists (DO saturation at 4.4 °C: 13.1 mg/L).

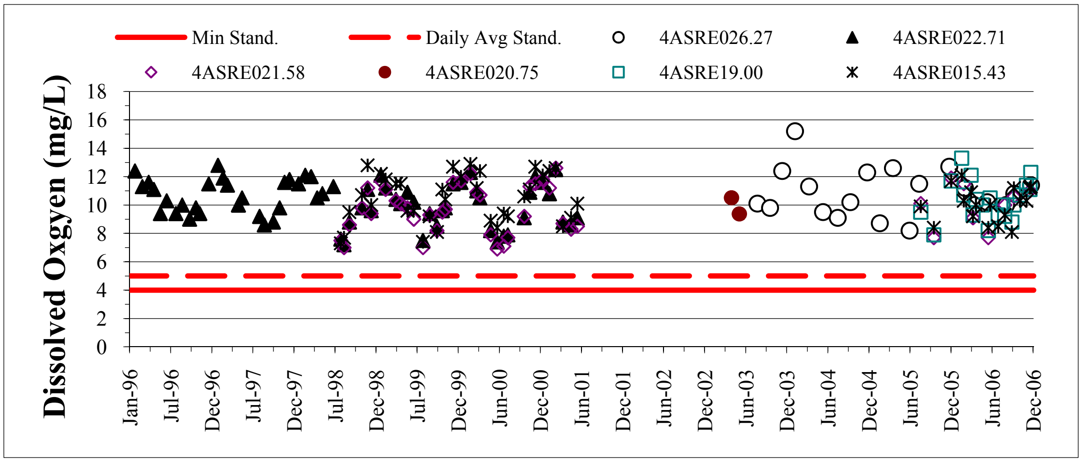

Figure 3-7: Ambient Dissolved Oxygen Measurements in the Benthic Impaired Segment of the Smith River

- All field pH (range: 6.4-8.9) values did not exceed VA DEQ criterion range of 6 to 9 (**Figure 3-8**).

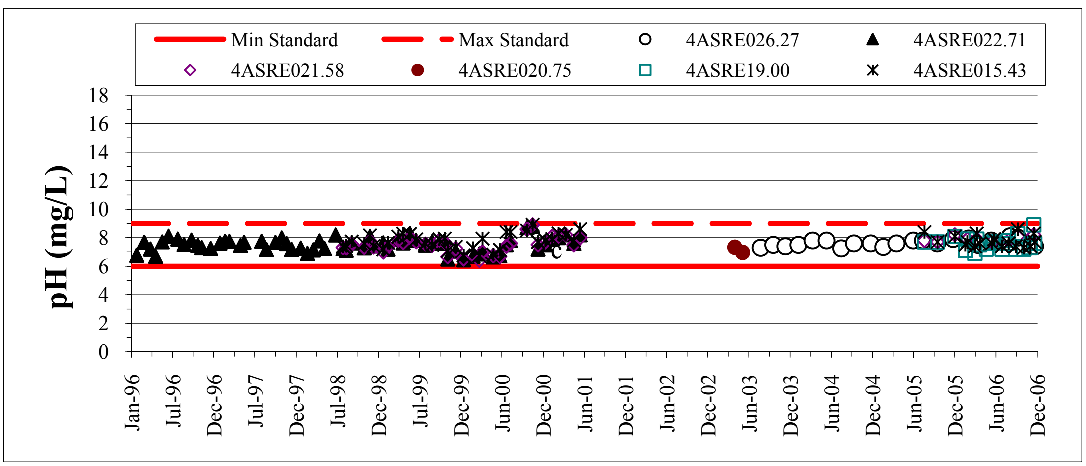

Figure 3-8: Ambient pH Measurements in the Benthic Impaired Segment of the Smith River

- All temperature (range: 3.5-26°C) values did not exceed VA DEQ criterion of a max of 32° Celsius (**Figure 3-9**).

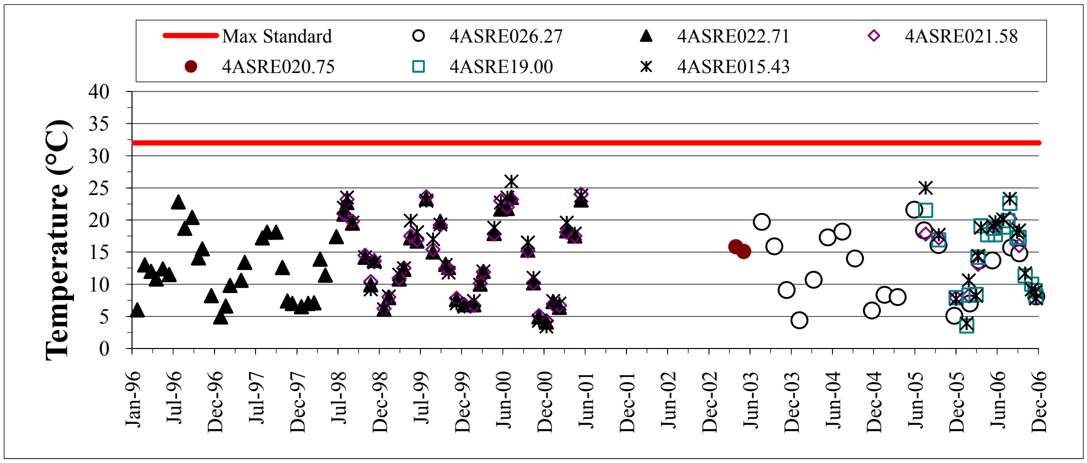

Figure 3-9: Ambient Temperature Measurements in the Benthic Impaired Segment of the Smith River

Temperature from USGS Station 02073000, which is right below the Martinsville Dam, was analyzed from March 2007 to April 2009 and VA DEQ's criterion of 32°C was met for the duration of the monitoring time.

- Specific Conductivity levels were on average approximately 100 µmhos/cm and ranged between 42 and 600 µmhos/cm (**Figure 3-10**). The VA DEQ "reference-filter" value for Specific Conductance in the Piedmont Ecoregion, established at < 250 µmhos/cm (VA DEQ 2006b), was exceeded thirteen times.

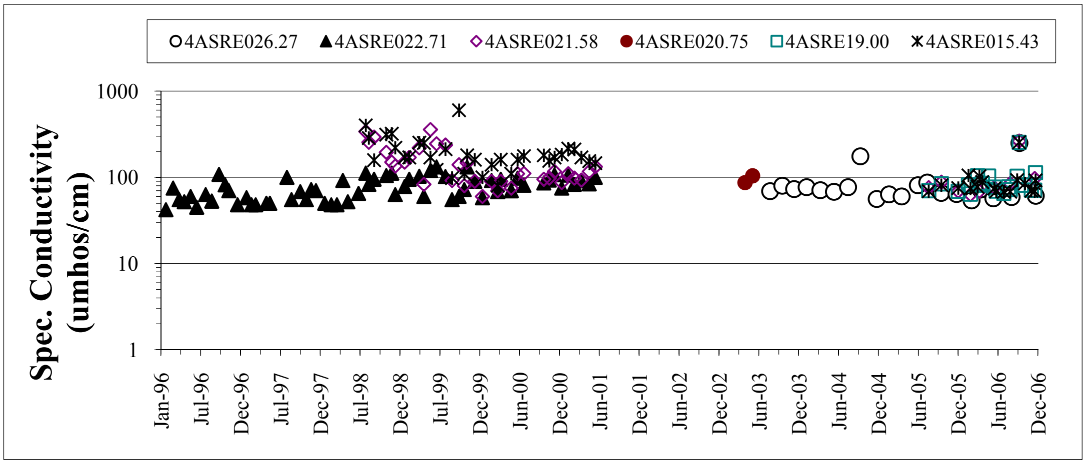

Figure 3-10: Ambient Specific Conductivity Measurements in the Benthic Impaired Segment of the Smith River

- Biochemical oxygen demand (BOD_5) data were only available until 2001. The concentrations ranged between 1 and 4 mg/L, with averages between 1.78 and 2.19 mg/L (**Figure 3-11**). The detection limit for BOD is 1 mg/L. There are no screening values for BOD established by the VA DEQ.

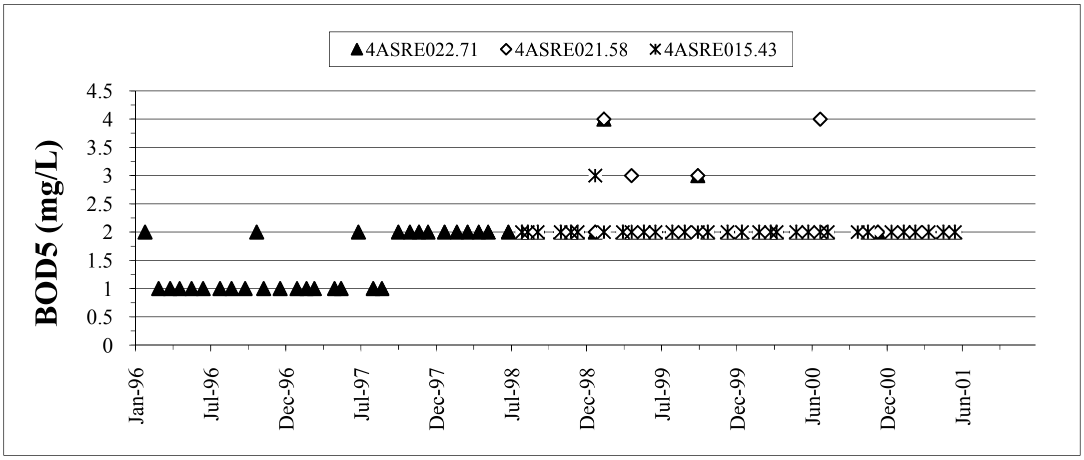

Figure 3-11: Ambient BOD_5 Measurements in the Benthic Impaired Segment of the Smith River

- Total suspended solids (TSS, total non-filterable residue) concentrations ranged between 3 and 316 mg/L (**Figure 3-12**). TSS levels increased at monitoring stations 4ASRE022.71 and 4ASRE021.58 due to several elevated TSS measurements ranging between 3 and 331 mg/L (**Figure 3-13**). The minimum detection limit for TSS is 3 mg/L. Based on reclassification of the measurements between low, medium, and high flow conditions, the elevated TSS occurrences are not related to high flow. There are no VA DEQ screening values for TSS levels.

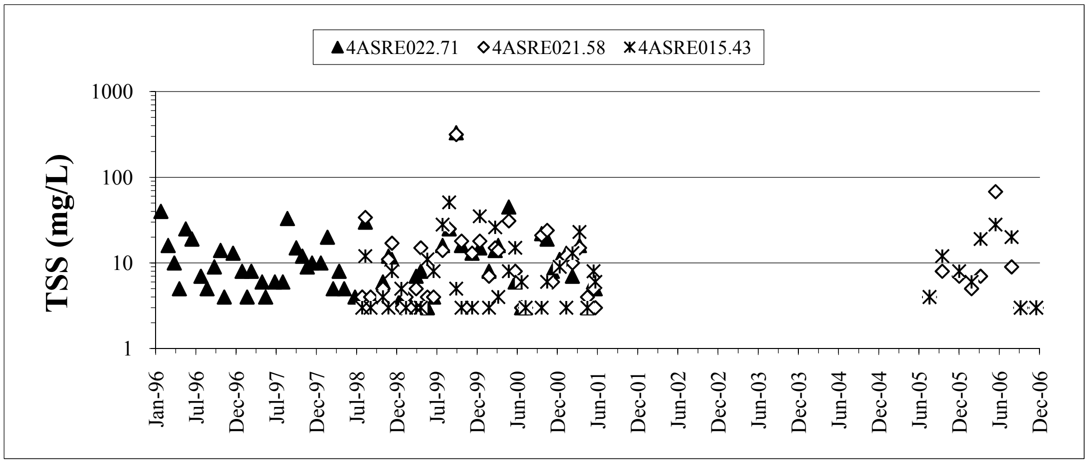

Figure 3-12: Ambient TSS Measurements in the Benthic Impaired Segment of the Smith River

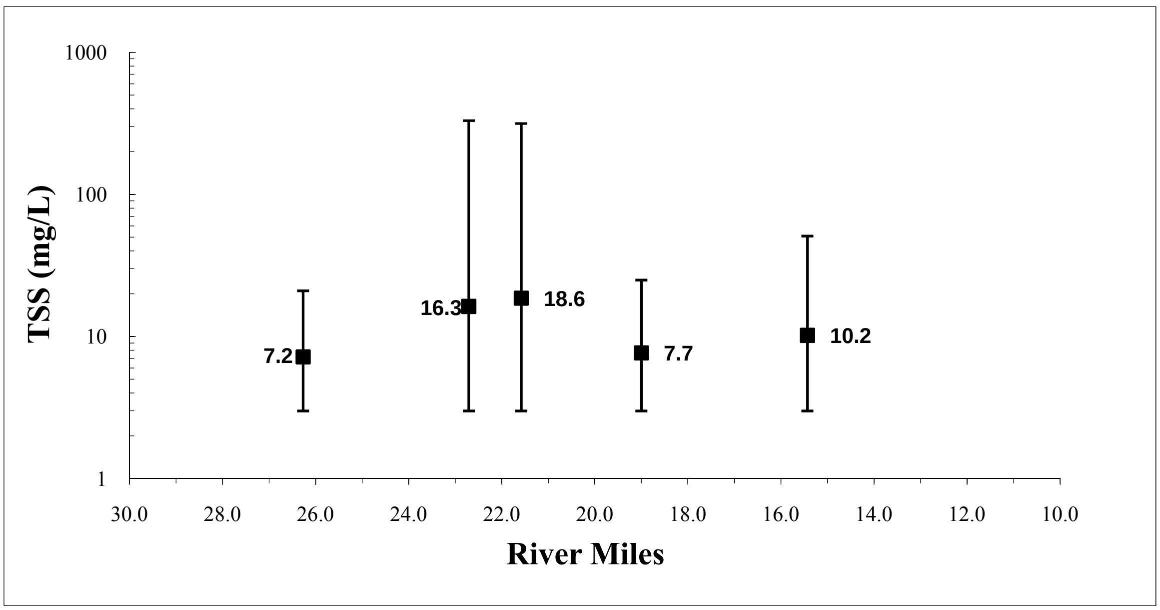

Figure 3-13: Ambient TSS Measurements versus River Miles in the Benthic Impaired Segment of the Smith River

- On average, turbidity levels ranged between 2.56 and 287 EPA Formazin Turbidity Units (FTU) (**Figure 3-14)**. Based on a reclassification of the measurements between low, medium, and high flow conditions, the elevated turbidity measurements were not caused by high flow, since they were not collected during high flow conditions.

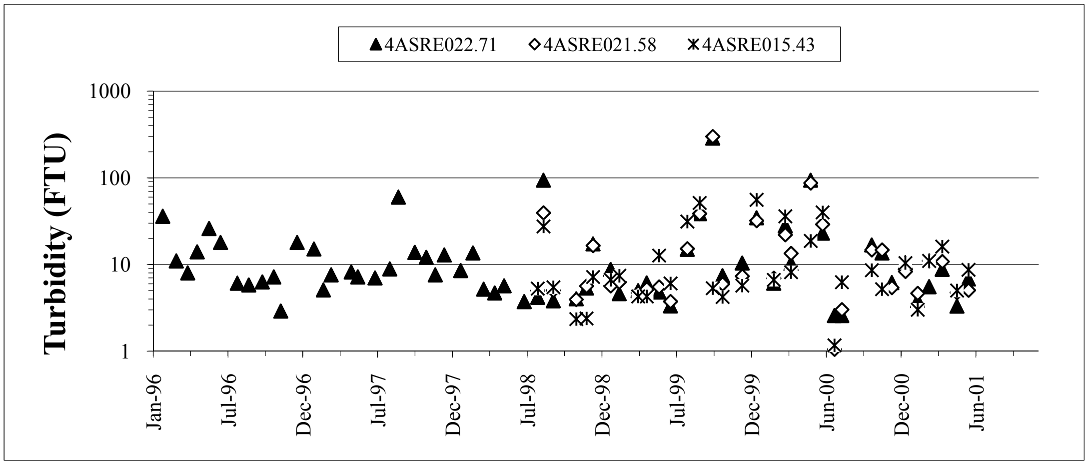

Figure 3-14: Ambient Turbidity Measurements in the Benthic Impaired Segment of the Smith River

- Total ammonia concentrations did not exceed VA DEQ total ammonia criteria for freshwater when trout are absent. VA DEQ ammonia criteria vary with pH and the presence of sensitive fish (trout). They ranged between 0.04 and 0.63 mg/L (**Figure 3-15**). The detection limit for ammonia is 0.04 mg/L.

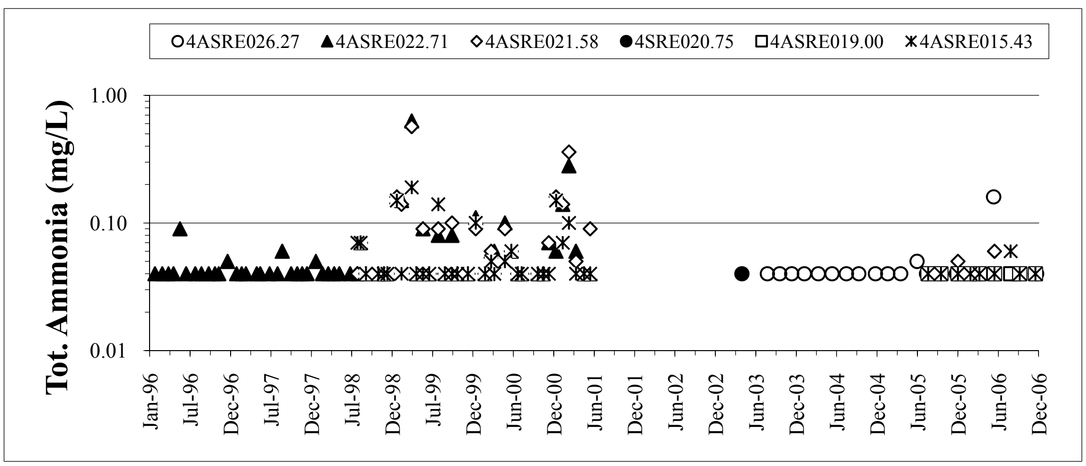

Figure 3-15: Ambient Total Ammonia Measurements in the Benthic Impaired Segment of the Smith River

- NO_3-N (Nitrate) and total nitrogen (TN) concentrations were generally low, ranging between 0.07 and 1.47 mg/L for NO_3-N and 0.27 and 2.52 mg/L for TN (**Figure 3-16 and 3-17**). The VA DEQ "reference-filter" value for TN is 1.5 mg/L (VA DEQ, 2006b). This "reference-filter" value was exceeded ten times.

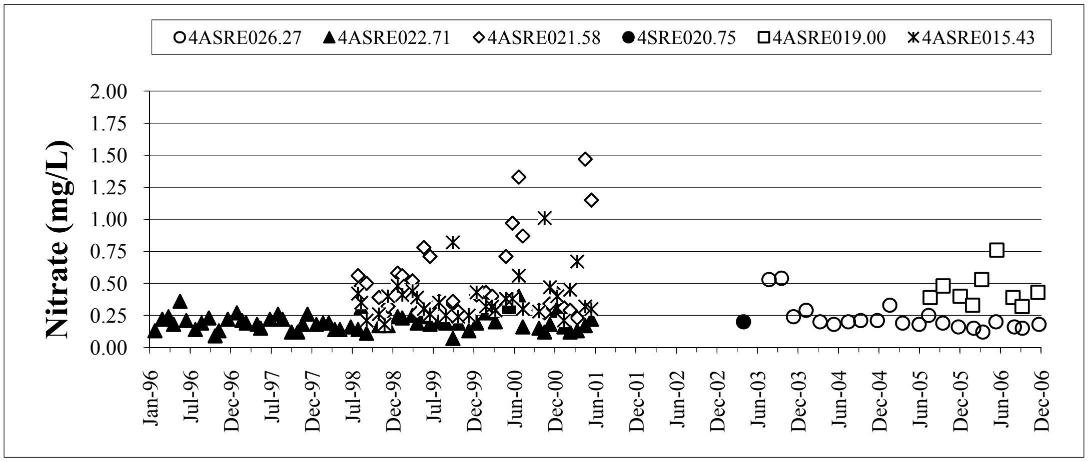

Figure 3-16: Ambient Nitrate Measurements in the Benthic Impaired Segment of the Smith River

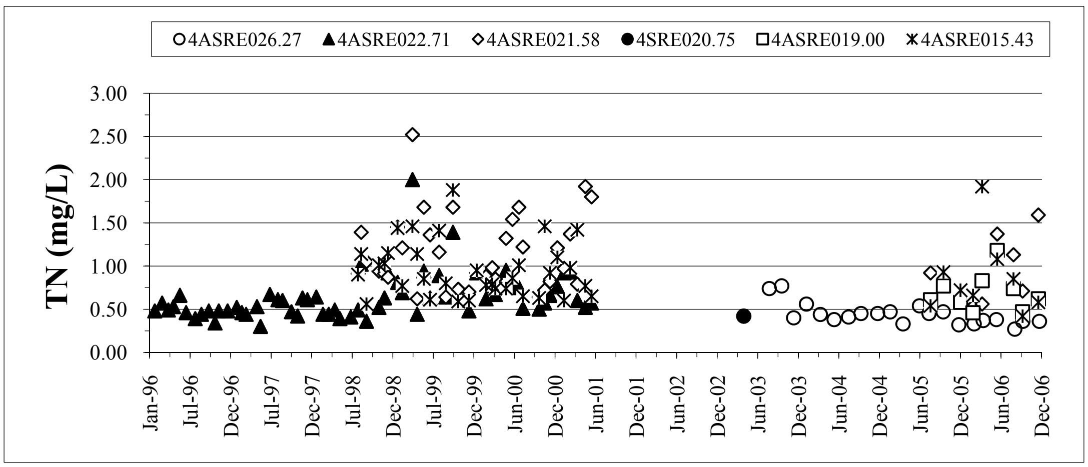

Figure 3-17: Ambient Total Nitrogen Measurements in the Benthic Impaired Segment of the Smith River

- PO_4-P concentrations ranged between 0.01 and 0.24 mg/L (**Figure 3-18**). There are no DEQ screening values for ortho-phosphorous. The minimum detection limit for ortho-phosphorous is 0.01 mg/L.

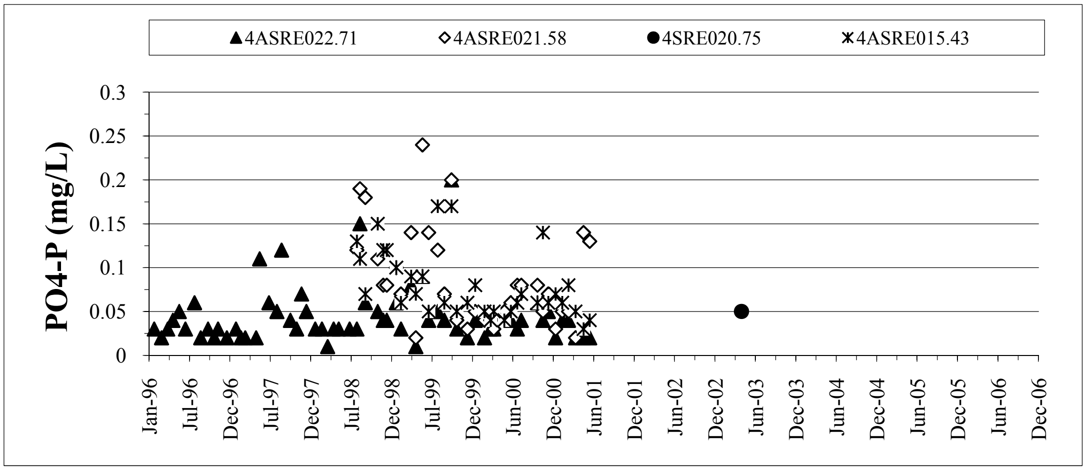

Figure 3-18: Ambient Ortho-Phosphorus Measurements in the Benthic Impaired Segment of the Smith River

- Total phosphorus levels ranged between 0.01 and 1.01 mg/L (**Figure 3-19**). The VA DEQ “reference-filter” value for Total Phosphorous is established at a maximum of 0.05 mg/L. Prior to 1998, monitoring equipment was less sophisticated, and the minimum detection limit from 1996 to 1998 was 0.10 mg/L. From 1998 onward, the minimum detection limit was 0.01 mg/L. Note that total phosphorus levels increased by approximately five times at monitoring station 4ASRE022.71 (**Figure 3-20**), decreased at 4ASRE019.00, and increased slightly again at 4ASRE15.43. The higher levels of phosphorus at station 4ASRE022.71 are most likely attributable to wastewater treatment plants discharging in this section of the river.

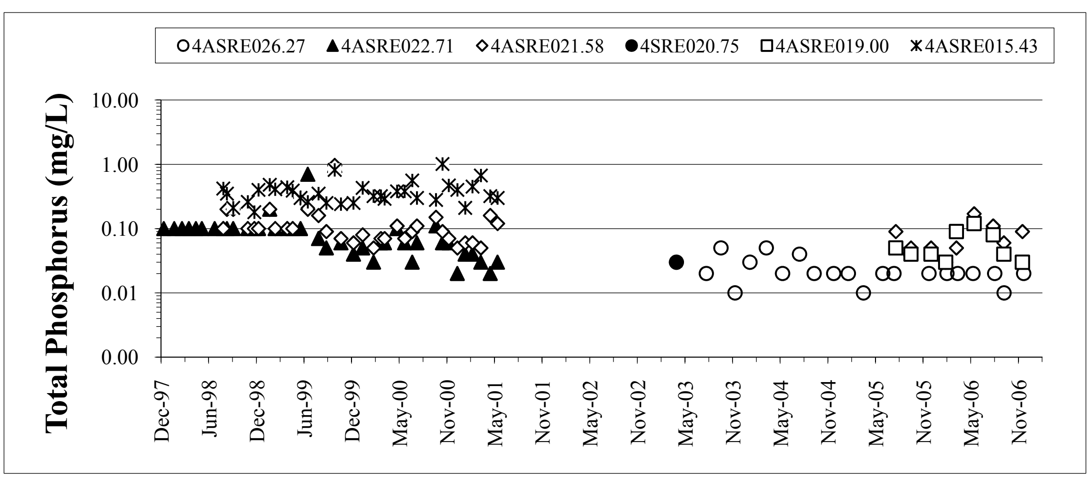

Figure 3-19: Ambient Total Phosphorus Measurements in the Benthic Impaired Segment of the Smith River

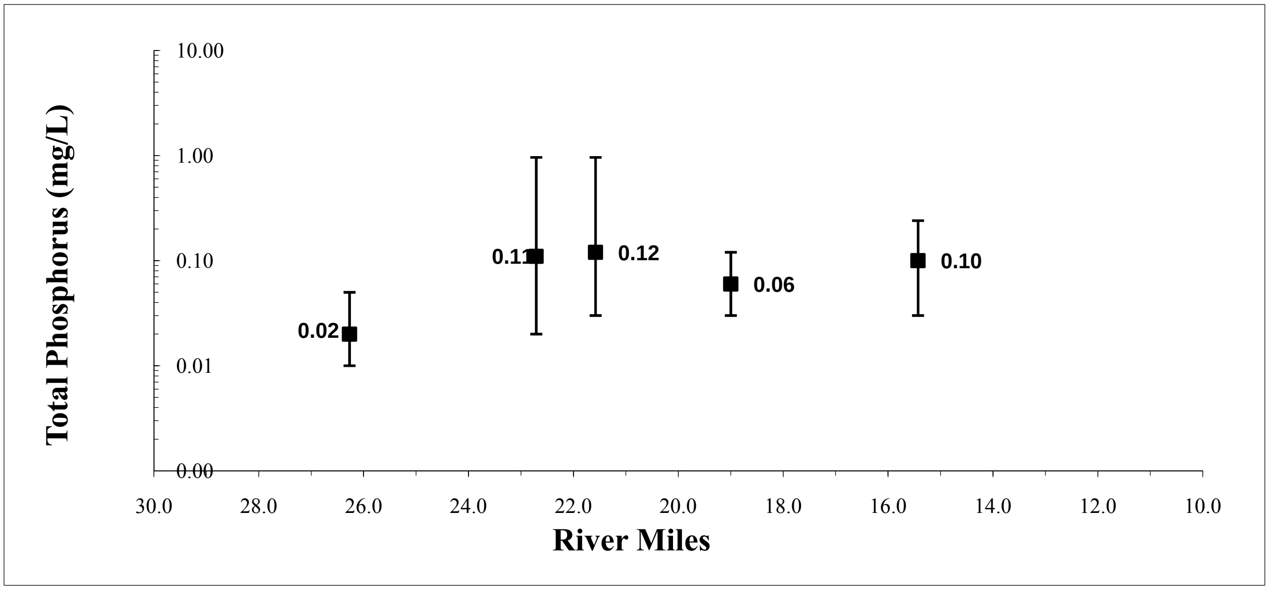

Figure 3-20: Ambient Total Phosphorus Measurements (max, avg, min) versus River Miles in the Benthic Impaired Segment of the Smith River

- Instream chloride levels ranged from 3.70 to 147 mg/L. Although no recent instream chloride measurements were available (after 2001), existing chloride measurements tend to be relatively low (**Figure 3-21**).

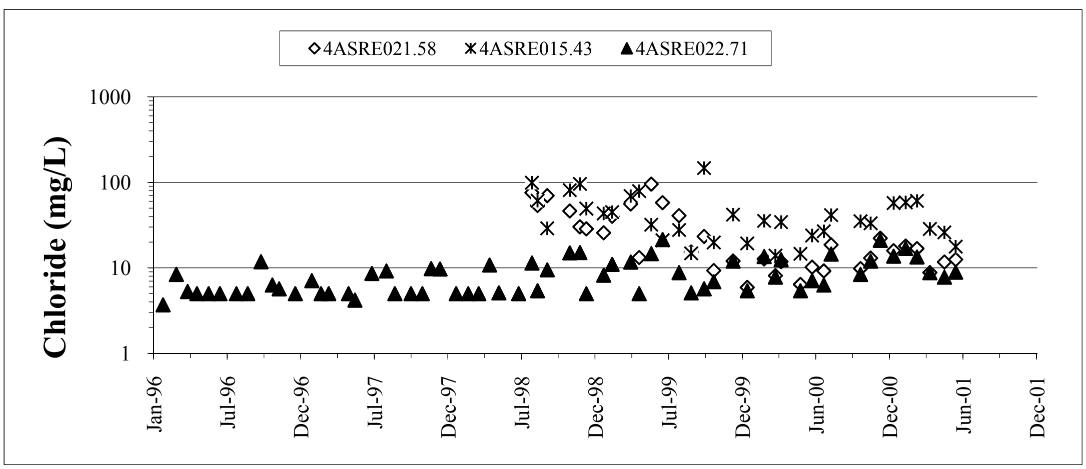

Figure 3-21: Ambient Instream Cloride Measurements in the Benthic Impaired Segment of the Smith River

- Phytoplankton chlorophyll *a* was measured only on one occasion at station 4ASRE020.75 (1.42 µg/L).

Monitoring stations at tributaries

Ambient water quality monitoring data for the two stations located on tributaries (Marrowbone and Leatherwood Creek) that flow into the Smith River within the impaired segments were also analyzed. The water quality data from these stations are depicted in **Table 3-9**. On average, all ambient water quality parameters showed relatively low levels (e.g. TN: 0.44 – 0.62 mg/L, TP: 0.05-0.06 mg/L, and TSS: 11.67-18.50 mg/L). However, several pollutants show elevated maximum concentrations. Based on precipitation data from two weather stations (Woolwine and Philpott) located in the Smith River watershed (NCDC, 2006), the elevated maximum concentrations TSS, turbidity, and total nitrogen, shown in **Table 3-10** and **Figure 3-22,** could be attributed to rain events. Therefore, under rain events, the elevated pollutants from both tributaries may also contribute to the benthic impairment on the Smith River.

Table 3-10: Summary of Instream Water Quality Data Collected at Tributaries at 4AMRR000.02 and 4ALWD002.54 between 1996 and 2007

Station ID		4AMRR000.02				4ALWD002.54			
Parameter	**Units**	**No of Samples**	**Min**	**Max**	**Avg**	**No of Samples**	**Min**	**Max**	**Avg**
Temperature	°C	49	0.60	24.30	13.44	56	1.60	26.00	14.31
DO	mg/L	49	5.76	14.03	10.09	56	6.43	14.10	9.68
Field pH	-	48	6.70	8.59	7.58	56	6.69	8.50	7.51
Spec. Conductance	µmhos/cm	49	33.00	135.80	65.99	55	40.00	257.00	71.98
Chloride	mg/L	20	5.00	17.40	5.78	19	5.00	5.60	5.04
Turbidity	FTU	29	4.90	43.00	15.54	19	3.20	48.00	14.45
Turbidity	NTU	4	11.00	90.00	32.48	21	4.00	173.00	22.65
TSS	mg/L	33	3.00	41.00	11.67	40	3.00	247.00	18.50
VSS	mg/L	32	3.00	7.00	3.59	19	3.00	15.00	3.89
BOD_5	mg/L	20	2.00	2.00	2.00	19	2.00	2.00	2.00
Total NH_3-N	mg/L	33	0.04	1.51	0.10	41	0.04	0.06	0.04
NO_3-N	mg/L	32	0.04	0.47	0.18	20	0.04	0.28	0.13
TN	mg/L	33	0.29	4.10	0.62	41	0.25	0.94	0.44
PO_4-P	mg/L	32	0.01	0.18	0.03	20	0.01	0.05	0.03
TP	mg/L	33	0.02	0.19	0.06	39	0.01	0.13	0.05
Chl*a*	ug/L	9	0.50	1.21	0.84	-	-	-	-

TSS = total suspended solids (= total non-filterable residue)

VSS = volatile suspended solids (= total volatile residue)

Combination of measured and computed. Computed TN values are based on the summation of measured nitrogen forms (TN = TKN + NO_3-N + NO_2-N)

Chl*a* = Phytoplankton

NTU = Nephelometric Turbidity Units
FTU = Formazin Turbidity Unit

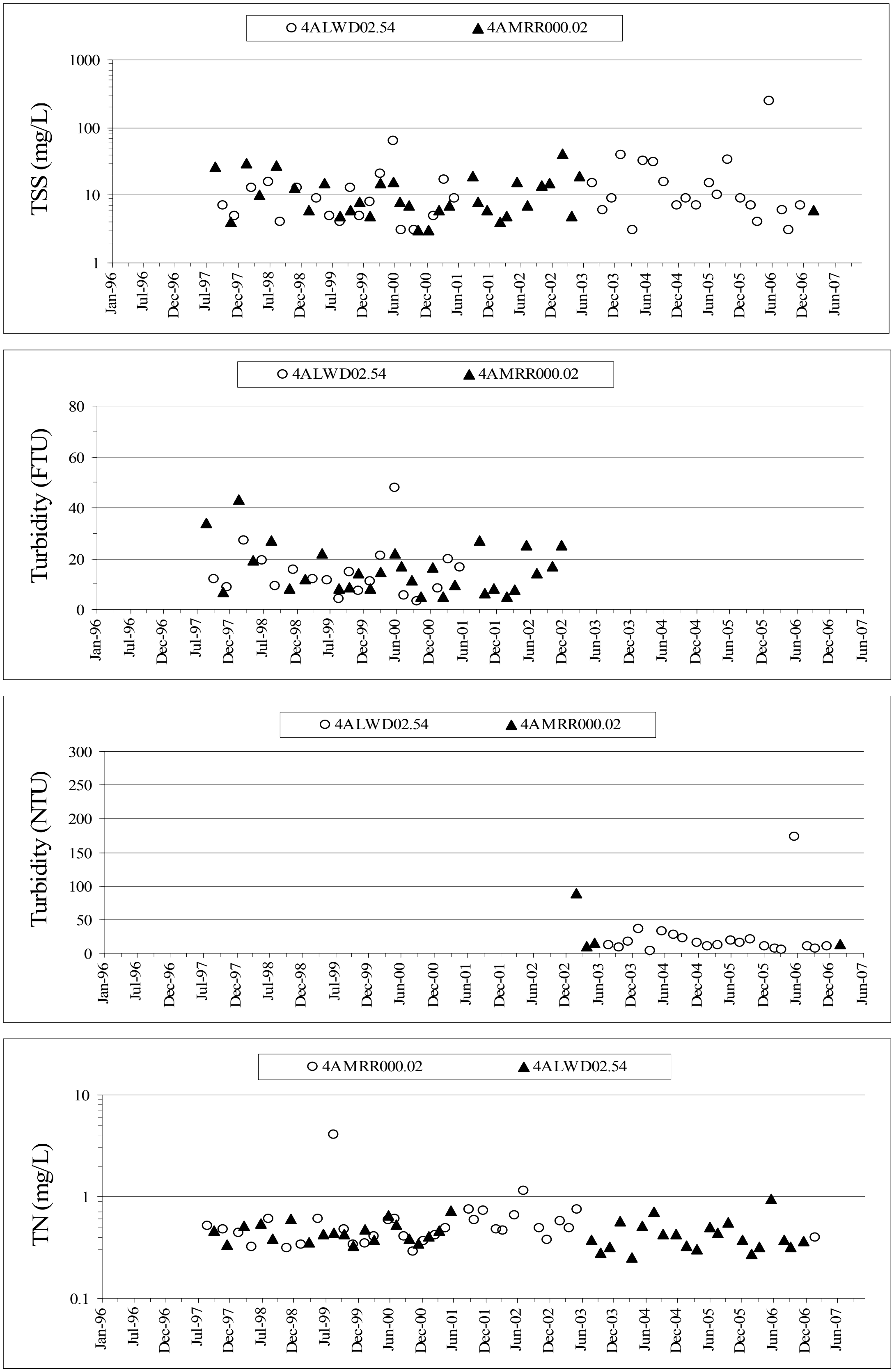

Figure 3-22: Ambient Instream TSS, Turbidity, and TN Measurements at Two Tributaries of the the Smith River

3.2.3.2. Metal Data

Dissolved metal parameters were measured at monitoring stations 4ASRE022.71, 4ASRE021.58, 4ASRE020.75, and 4ASRE015.43. Metals measured included aluminum, barium, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. All available dissolved metal data were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards. No monitored metals parameters exceeded the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards for dissolved metals. In fact, the majority of the metal parameters analyzed were below analytical detection limits.

Additionally, although there are currently no water quality standards established for metals in sediment, the 2007 DEQ assessment guidance memorandum (VA DEQ, 2007a) establishes consensus based Probable Effects Concentrations (PEC) (99^{th} percentile of results throughout Virginia) for use in determining aquatic life use support. Metals in sediment collected at monitoring stations 4ASRE022.71, 4ASRE021.58, 4ASRE020.75, 4ASRE015.43, 4AMRR000.02, and 4ALWD02.54 were analyzed to determine whether they complied with the consensus based screening values. Metals measured included aluminum, antimony, arsen, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc. Though many compounds were noted in sediment testing, none exceeded the thresholds for the PEC.

3.2.3.3. Organic Contaminant Data

There were no instream organic contaminant data available. However, organic contaminant data were collected in sediments at monitoring stations 4ASRE022.71, 4ASRE015.43, 4AMRR000.02, and 4ALWD02.54. Organic contaminants measured included aldrin, dieldrin, chlordane, dicofol, endrin, dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethane (DDD), dichlorodiphenyldichloroethylene (DDE), heptachlor epoxide, heptachlor, and polychlorinated biphenyls (PCBs). Although there are currently no established water quality standards established for organic contaminants in sediments, the 2007 VA DEQ assessment guidance memorandum (VA DEQ, 2007a) establishes consensus based PEC for use in determining aquatic life use support. Based on this assessment guidance, all available data were analyzed to determine whether they complied with the consensus based screening values. Though many compounds were noted in sediment testing, none exceeded the thresholds for the PEC.

3.2.4 Continuous Measurement of Field Parameters Under Dry Weather Conditions

VA DEQ conducted continuous instream measurements for temperature, dissolved oxygen, pH, and specific conductivity three times between May 2006 and November 2007 at several VA DEQ monitoring stations in the Smith River watershed. The majority of the continuous measurements were conducted at monitoring sites located in the impaired segment (**Table 3-11**).

Table 3-11: Monitoring Sites and Period of Measurements for Continuous Measurements in the Smith River Watershed

Monitoring Station	Period of Measurements	Segment
4ASRE033.19	November 16-28, 2007	non-impaired
4ASRE031.00	May 17-19, 2006	
4ASRE026.38	November 16-28, 2007	impaired
4ASRE022.30	November 16-28, 2007	
4ASRE019.00	August 14-16, 2006	
4ASRE015.43	May 17-19, 2006	

Overall, the continuous measurements showed relatively small fluctuations and there were no exceedances of VA DEQ criteria for temperature, dissolved oxygen, and pH. **Table 3-12** and **Figures 3-23** and **3-24** show the results of the continuous measurements conducted during the growing season at stations located within the benthic impaired segment. The remaining results for continuous measurements are shown in **Appendix B**.

Table 3-12: Summary of Instream Continuous Measurements Over Two Days in the Benthic Impaired Segment of the Smith River

	4ASRE019.00[1]					4ASRE015.43[2]				
	Temp	**DO**	**DO**	**pH**	**Spec. Cond**	**Temp**	**DO**	**DO**	**pH**	**Spec. Cond**
	C	**mg/L**	**%**		**µS/cm**	**C**	**mg/L**	**%**		**µS/cm**
COUNT	182	182	182	182	182	161	156	-	161	161
AVE	19.49	9.83	111.20	7.48	69.59	15.91	9.34	-	7.30	97.38
MIN	17.31	8.99	101.63	7.23	60.49	13.98	8.70	-	7.07	92.75
MAX	21.62	11.21	128.80	8.05	93.40	17.77	10.42	-	7.93	101.78
Swing (mg/L)[3]	4.31	2.13	26.99	0.76	32.91	2.16	1.64	-	0.62	7.63

[1]Measurements were conducted between August 14 and 16, 2006

[2]Measurements were conducted between May 17 and 19, 2006

[3]Difference over 24 hours between 6 AM at day 1 and 6 AM at day 2

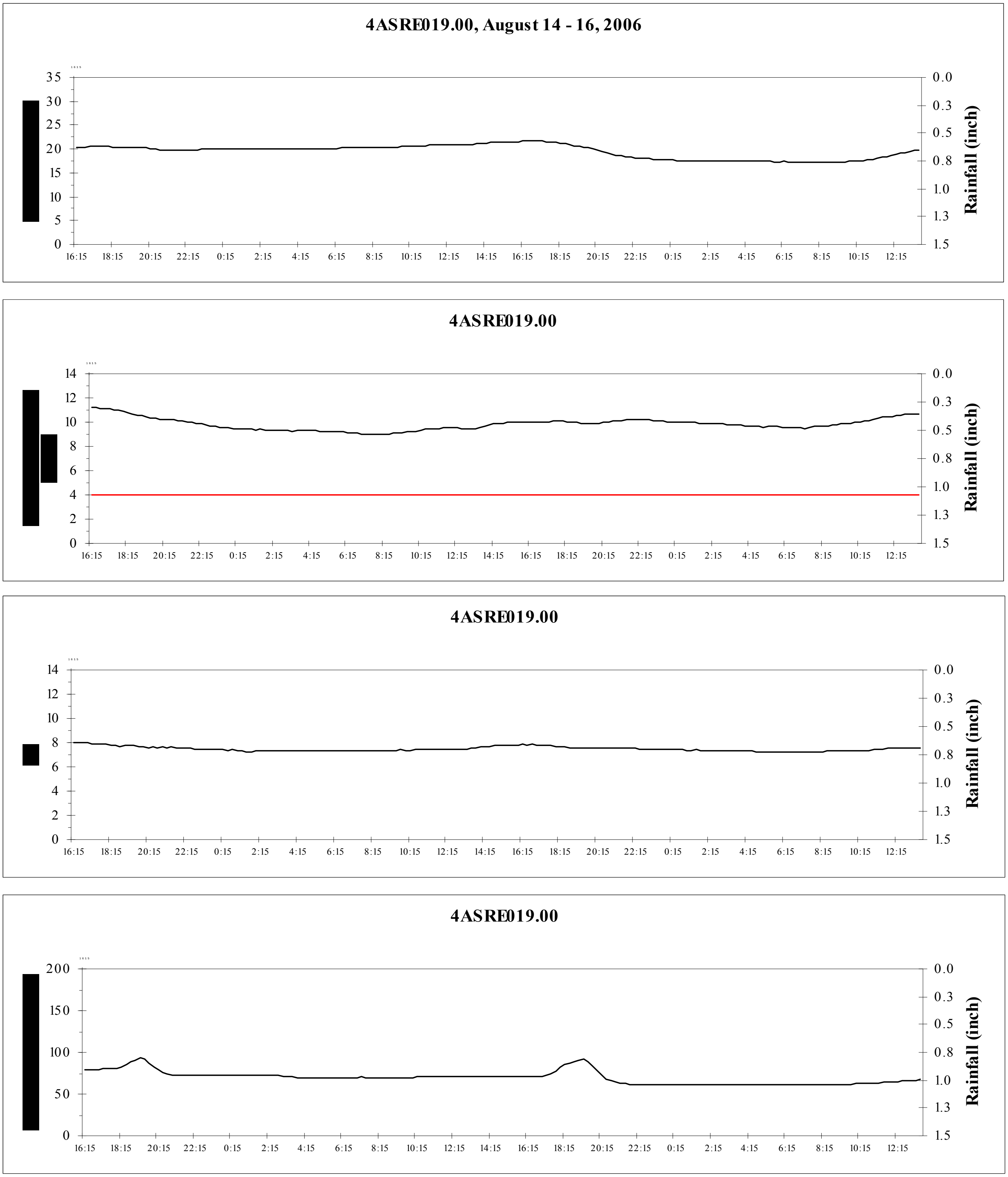

Figure 3-23: Continuous Measurements for Temperature, DO, pH, and Conductivity at Monitoring Station 4ASRE019.00 August 14th - 16th, 2006

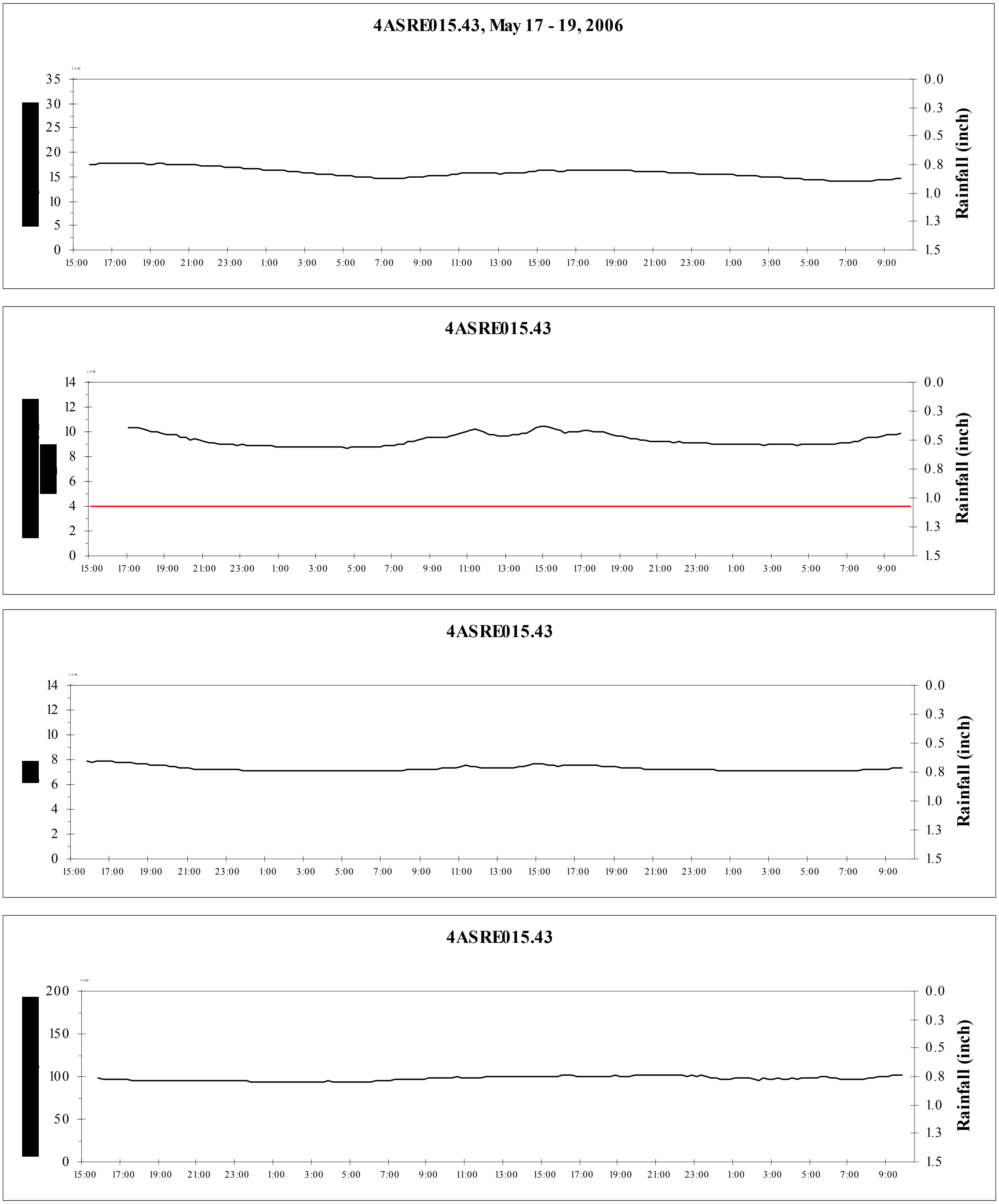

Figure 3-24: Continuous Measurements for Temperature, DO, pH, and Conductivity at Monitoring Station 4ASRE015.43 May 17th – 19th, 2006

3.2.5 Fish Tissue and Sediment Contamination Monitoring Program

VA DEQ collects fish tissue and sediment data in two or three river basins per year. The data are used by VA DEQ to assess the environmental quality of Virginia's waters and by the VDH to determine the need for fish consumption advisories. The probabilistic monitoring program consists of a two-tiered sampling program. Tier I is a screening study which includes a high number of sampling stations in order to recognize areas of streams with contaminated stream sediment and fish tissue. If Tier I shows areas of contamination, a more intense study (Tier II) is conducted to determine the magnitude, geographical extent, and potential source(s) of contamination in the sediments and fish. The collected sediments were analyzed for PAHs (Polycyclic Aromatic Hydrocarbons), PCBs (Polychlorinated Biphenyls), and metals and compared to sediment Threshold Effects Concentration (TEC) and Probable Effects Concentration (PEC) values which were developed by MacDonald et al. 2000.

VA DEQ collected sediment samples at eleven monitoring stations and fish tissue samples at five monitoring stations in the Smith River watershed between 1996 and 2009 (Data is summarized in **Appendix C**). **Table 3-13** shows an inventory of the monitoring stations at which samples for sediment and fish tissue were collected.

The sediment and fish tissue samples were analyzed for PAHs, PCBs, and metals. **Table 3-14** depicts the constituents analyzed by VA DEQ in the sediment and fish tissue samples. Fish tissues were obtained from 13 edible fish species representing top-level predator, mid-level predator, and bottom feeder.

Table 3-13: Inventory of Monitoring Stations with Contaminant Measurements in the Smith River Watershed

Station	Sediments				Fish Tissue			
	Sampling Date	PAHs	PCBs	Metals	Sampling Date	PAHs	PCBs	Metals
4ASRE055.62	9/8/1999	yes	yes	yes	9/7/1999	yes	yes	yes
4ASRE046.90	9/7/1999	yes	yes	yes	9/8/1999	yes	yes	yes
	9/16/2002		yes	yes	9/16/2002	yes	yes	yes
4ASRE033.19	8/10/2009	yes		yes	-	-	-	-
4ASRE029.50	8/14/1996	yes	yes	yes	-	-	-	-
4ASRE026.77	8/11/2009	yes		yes	-	-	-	-
4ASRE026.27	8/18/1999	yes	yes	yes	8/18/1999	yes	yes	yes
4ASRE026.06	6/13/2002	yes	yes	yes	6/13/2002	yes	yes	yes
4ASRE022.30	8/12/2009	yes		yes	-	-	-	-
4ASRE019.00	8/18/1999	yes	yes	yes	8/18/1999	yes	yes	yes
	8/12/2009	yes		yes	-	-	-	-
4ASRE011.08	9/18/1997	yes	yes	yes	-	-	-	-
4ASRE007.90	9/18/1997	yes	yes	yes	-	-	-	-

Stations with grey background are located within the benthic impaired segment

Table 3-14: Constituents Analyzed in Sediment and Fish Tissue Samples

	Constituents in Sediment	Constituents in Fish Tissue*
PAHs	Total PAHs, naphtalene, 2-methyl naphtalene, 1-methyl naphtalene, biphenyl, ace-naphthylene, ace-napthene, dibenzo furan, 2.3.5-trimethyl naphthalene, fluorene,dibenzo thiophene, phenanthrene, anthracene, 1-me phenanthrene, fluoranthene, pyrene, benza anthracene, chrysene, benzo (b) fluoranthene, benzo (k) fluoranthene, benzo(e) pyrene, benzo(a) pyrene, perylene, indeno(1,2,3-cd) pyrene, db(a,h) anthracene, and benzo(ghi) perylene	
PCBs	Total PCBs, total chlordane, total dichlorodiphenyl dichloroethylene (DDE), total dichlorodiphenyl dichloroethane (DDD), total dichlorodiphenyl trichloroethane (DDT), hexachlorobenzene, pentachloroanisole, total polychlorinated terphenyl, ocatchlorodibenzodioxin, tribromoanisole, 1-chloro-2,2-bis-(4'-chlorophenyl)ethane (OCDD), total polybrominated diphenyl ether (BDE)	Total PCBs, total chlordane, total dichlorodiphenyl dichloroethylene (DDE), total dichlorodiphenyl dichloroethane (DDD), total dichlorodiphenyl trichloroethylene, total dichlorodiphenyl trichloroethene (DDT), hexachlorobenzene
Metals	aluminium, silver, arsenic, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, zinc	arsenic, cadmium, chromium, mercury, lead, selenium

* fish tissues from the following species: Bluegill Sunfish, Brown Trout, Bull Chub, Carp, Catfish species, Flathead Catfish, Gizzard Shad, Largemouth Bass, Northern Hogsucker, Roanoke Hogsucker, Redbreast Sunfish, Sucker species, White Sucker

Tables 3-15 through 3-17 depict the exceedances of measured constituents in sediments based on VA DEQ analysis using two different screening values. The screening values include the TEC and PEC, which were developed by MacDonald et al. 2000. The following is a bulleted summary of these exceedances:

- **PAHs (Table 3-15)**
  - The benthic impaired segment shows 14 exceedances (from 2 stations) for PAHs. These exceedances were found only at monitoring stations located downstream of Martinsville Dam.
  - Four exceedances for PAHs were found upstream of the impaired segment at station 4ASRE29.50 and three exceedances for PAHs were found downstream of the impaired segment at station 4ASRE011.08.
- **PCBs, and Pesticides (Table 3-16)**
  - Station 4ASRE029.50 had the most number of exceedances, at 7, for PCBs.
  - One exceedance for total chlorodane was observed within the impaired segment of the Smith River at station 4ASRE26.06.
- **Metals (Table 3-17)**
  - At the Philpott reservoir, located approximately 20 miles upstream from the benthic impaired segment, there were two exceedances each for copper chromium, and arsenic..
  - Station 4ASRE029.50, located approximately 3 miles upstream from the benthic impaired segment had a single exceedance for chromium, mercury, and zinc.
  - One exceedance was found for mercury downstream of the impaired segment (4ASRE011.08).

Based on VA DEQ analysis, one of the organic contaminants and no metal contaminants measured in the fish tissue exceeded VA DEQ screening values. However, Lead was detected in fish tissue samples on four occasions. A bulleted summary of organic contaminants and metals detected in fish tissue in the Smith River is provided below.

- Brown Trout at station 4ASRE026.06 was above VA DEQ's screening value for Total PCB's in 2002.

- Bull Chub and Redbreast Sunfish at station ASRE026.06 was above the Detection Limit for Lead in 2002.
- Bluegill at station ASRE026.27 was above the Detection Limit for Lead in 1999.
- Carp at station ASRE046.90 (Philpott Reservoir) was above the Detection Limit for Lead in 2002.

Table 3-15: Number of PAH Exceedances in Sediment Samples in the Smith River Watershed

Station	Date	TEC[1]		PEC[1]	
		Number of Exceedances	Constituent exceeded	Number of Exceedances	Constituent exceeded
4ASRE055.62	9/8/1999	-	-	-	-
4ASRE046.90	9/7/1999	-	-	-	-
	9/16/2002	-	-	-	-
4ASRE033.19	8/10/2009	-	-	-	-
4ASRE029.50	8/14/1996	**4**	**Total PAH, anthracene (ATH), pyrene, ATH benz(a)**	-	-
4ASRE026.77	8/11/2009	**-**	**-**	-	-
4ASRE026.27	8/18/1999	**-**	**-**	-	-
4ASRE026.06	6/13/2002	**7**	**Total PAH, fluoranthene, pyrene, ATH benz(a), ATH db(a,h), chrysene, benzo(a) pyrene**	-	-
4ASRE022.30	8/12/2009	**-**	**-**		
4ASRE019.00	8/18/1999	**-**	**-**	-	-
	8/12/2009	**7**	**Total PAH, ATH, fluoranthene, pyrene, ATH benz(a), ATH db(a,h), benzo(a) pyrene**		
4ASRE011.08	9/18/1997	**3**	**Total PAH, pyrene, ATH benz (a)**	-	-
4ASRE007.90	9/18/1997	-	-	-	-

Stations with grey background are located within the benthic impaired segment

[1]Screening value for Threshold Effects Concentration and Probable Effects Concentration developed by MacDonald, et al., 2000

Table 3-16: Number of PCB and Pesticide Exceedances in Sediment Samples in the Smith River Watershed

Station	Date	TEC[1]		PEC[1]	
		Number of Exceedances	Constituent exceeded	Number of Exceedances	Constituent exceeded
4ASRE055.62	9/8/1999	-	-	-	-
4ASRE046.90	9/7/1999	-	-	-	-
	9/16/2002	-	-	-	-
4ASRE029.50	8/14/1996	**5**	**Total PCB, Total Chlordane, Sum DDE, Sum DDD, Total DDT**	**2**	**Total Chlordane, Sum DDE**
4ASRE026.27	8/18/1999	-	-	-	-
4ASRE026.06	6/13/2002	**1**	**Total Chlordane**	-	-
4ASRE019.00	8/18/1999	-	-	-	-
4ASRE011.08	9/18/1997	-	-	-	-
4ASRE007.90	9/18/1997	-	-	-	-

Stations with grey background are located within the benthic impaired segment

[1]Screening value for Threshold Effects Concentration and Probable Effects Concentration developed by MacDonald, et al., 2000

Table 3-17: Number of Metal Exceedances in Sediment Samples in the Smith River Watershed

Station	Date	TEC[1]		PEC[1]	
		Number of Exceedances	Constituent exceeded	Number of Exceedances	Constituent exceeded
4ASRE055.62	9/8/1999	**2**	**Cr, Cu**	-	-
4ASRE046.90	9/7/1999	**1**	**Cr**	-	-
	9/16/2002*	**2**	**As, Cu**	**1**	**As**
4ASRE033.19	8/10/2009	-	-	-	-
4ASRE029.50	8/14/1996	**3**	**Cr, Hg, Zn**	-	-
4ASRE026.77	8/11/2009*	-	-	-	-
4ASRE026.27	8/18/1999	-	-	-	-
4ASRE026.06	6/13/2002	-	-	-	-
4ASRE022.30	8/12/2009	-	-	-	-
4ASRE019.00	8/18/1999	-	-	-	-
	8/12/2009	-	-	-	-
4ASRE011.08	9/18/1997	**1**	**Hg**	-	-
4ASRE007.90	9/18/1997	-	-	-	-

Stations with grey background are located within the benthic impaired segment

[1]Screening value for Threshold Effects Concentration and Probable Effects Concentration developed by MacDonald, et al., 2000

*Selenium exceeded the detection limit at this sampling date and station

3.2.6 Probabilistic Assessment of Hydrophobic Organic Contaminants

VA DEQ and USGS/CERC conducted in spring of 2003 an assessment of instream toxic hydrophobic organic contaminants in trace to ultra-trace levels using a Semipermeable Membrane Device (SPMD) (Cranor et al., 2005). The toxic hydrophobic organic contaminants included PAHs, PCBs, organochlorine pesticides (OCPs), and pesticides currently used such as trifluralin, diazinon, dacthal, chloripyrifos, endosulfans, permethrins, and others. Based on probalistic modeling by VA DEQ, 50 sites of free flowing freshwater streams were sampled in Virginia during this assessment. One of these sites, DEQ station 4-ASRE020.75, is located in the benthic impaired segment on the Smith River. The SPMD was deployed in the Smith River at this station for 35 days. The results of the SPMD analysis are summarized below in **Table 3-18** (the concentration of the organic contaminants was compared to VA DEQ water quality standards)**:**

- Mirex, a pesticide, was the only organic contaminant that exceeded VA DEQ water quality standards.
- Several OCPs and PAHs were above the method detection limit (MDL); all PCBs were below MDL.
- Among the OCPs, three currently used pesticides were above the MDL (Trifluralin, Diazinon, and Dacthal) but less than the method quantization limit (MQL).
- Three OCPs were present at quantifiable levels (>MWL). These are pentachoroanisole (PCA), which is a microbial methylation product of the wood-preservative pentachlorophenol and a metabolite of the pentachloronitrobenzene (PCNB; a fungicide with a variety of uses) found in fish tissues, trans-Chlordane, and trans-Nonachlor.
- Among the PAHs, fluoranthene and pyrene had the highest concentration. Both are priority pollutants out of sixteen PAHs listed by EPA. Phenanthrene, which is also a priority pollutant, was found in concentrations between the MDL and MQL limits. These pollutants are originated from pyrogenic sources (incomplete combustion of fossil fuels or wood). Other PAHs with quantifiable

concentrations include benz(a)anthracene, benzo(b)fluoranthene, and benzo(k)fluoranthene.

Table 3-18: Results of SPMD Analysis Conducted by DEQ and USGS/CERC at station 4-ASRE020.75[1]

OCPs and PCBs[2]	Estimated Water Concentrations (pg/L)	PAHs[3]	Estimated Water Concentrations (pg/L)
Trifluralin	**94.78**	Naphthalene	*2921.89*
Hexachlorobenzene	**45.92**	Acenaphthylene	*357.04*
Pentachloroanisole	416.05	Acenaphthene	*1011.98*
a-Benzenehexachloride	*119.43*	Fluorene	*1369.15*
Diazinon	**308.15**	Phenanthrene	**4226.77**
Lindane	*174.25*	Anthracene	**260.34**
B-Benzenehexachloride	*38.90*	Fluoranthene	15349.02
Heptachlor	**19.99**	Pyrene	9853.05
S-Benzenechloride	**5.39**	Benz[a]anthracene	954.6
Dacthal	**29.33**	Chrysene	**4226.77**
Chlorphyrifos	**40.81**	Benzo[b]fluoranthene	1653.95
Oxychlordane	**94.37**	Benzo[k]fluroanthene	781.03
Heptachlor Expoxide	**115.41**	Benzo[a]pyrene	**217.96**
trans-Chlordane	324.10	Indeno[1,2,3-c,d]pyrene	**223.15**
trans-Nonachlor	323.26	Dibenz[a,h]anthracene	*151.47*
o,p,'-DDE	*30.18*	Benzo[g,h,i]perylene	*477.86*
cis-Chlordane	421.08	Benzo[b}thiophene	-
Endosulfan	**N/A**	2-methylnaphthalene	-
p,p,'-DDE	*31.04*	1-methylnaphthalene	-
Dieldrin	**93.09**	Biphenyl	-
o,p,'-DDD	**96.62**	1-enthylnaphthalene	-
Endrin	*44.67*	1,2-dimethylnaphthalene	-
cis-Nanchlor	**89.85**	4-methylbiphenyl	-
o,p,'-DDT	**42.50**	2,3,5-trimethylnaphathalene	-
p,p,'DDD	**96.95**	1-methylfluorene	-
Endosulfan-II	-	Dibenzothiophene	-
p,p,'-DDT	**80.51**	2-methylphenanthrene	-
Endosulfan Sulfate	-	9-methylanthracene	-
Methoxychlor	*2.42*	3,6-dimethylphenanthrene	-
Mirex	*3.00*	2-methylfluoranthene	-
cis-Permethrin	-	Benzo[b]naphtho[2,1-d]thiophene	-
trans-Permethrin	-	Benzo[e]pyrene	-
Total PCBs	*366.88*	Perylene	-
		3-methylchloranthrene	-

[1] Bold values: Values >MDL (method detection limit) and <MQL (method quantitation limit); Italicized values: Values <MDL

[2] OCPs: organochlorine pesticides; PCBs: polychlorinated biphenyls

[3] PAHs: polycyclic aromatic hydrocarbons

Of the chemicals detected, pentachloroanisole (PCA) is of particular concern, since it has many uses and is likely applied in the Smith River watershed. PCA is a microbial methylation product of the wood-preservative pentachlorophenol and a metabolite of PCNB (pentachloronitrobenzene), which is used to prevent the formation of slime in industrial waters. It is also registered as a fungicide that helps prevent or destroy the growth of fungus. It is primarily used to prevent the growth of fungi on grass, lawn flowers, ornamental crops, shrubs and in gardens. It has agricultural uses to protect cotton and grain seeds like barley, oats, rice and wheat from the growth of fungi. On an acute exposure basis, PNCB is highly toxic to freshwater fish and invertebrates. PCNB is toxic on a chronic basis to aquatic and terrestrial animals (EPA, 2006).

3.2.7 Toxicity Testing

Toxicity testing was performed on water samples collected on the Smith River on May 15^{th}, 17^{th}, and 19^{th}, 2006 by VA DEQ at stations 4ASRE019.00 and 4ASRE015.43, located on the mainstem of the impaired segment. The EPA Region 3 laboratory in Wheeling, West Virginia, performed chronic toxicity testing on the samples, using fathead minnows and *Ceriodaphnia dubia* as test organisms. Results indicated *Ceriodaphnia* mortality and reproduction in the Smith River water samples were not statistically different than mortality and reproduction in the control samples, thus indicating that there were no toxic water column effects on *Ceriodaphnia* in the Smith River samples.

Water samples from the Smith River sites had adverse affects on fathead minnow survival and biomass (survival + growth endpoint). Both of the Smith River water samples were statistically different from the control samples. The EPA Region 3 laboratory in Wheeling stated that, in their professional judgment, these results "were biologically significant," and that the observed toxicity testing results should be compared with other water quality data collected at this site to determine the causes of toxicity. In addition, it should be noted that 1.13 inches of precipitation fell on May 14^{th}, 2006, the day preceding the first sample. This rain event may have contributed toxic stormwater to the stream affecting the biomass and survival of the fathead minnows.

3.2.8 Effluent Monitoring

Toxics Management Program (TMP) with whole effluent chronic toxicity testing (WET) was conducted for four dischargers in the Smith River watershed to monitor the effluents toxicity (Oliver, Inc., 2005, VA DEQ, 1999, 2002, 2007b). This monitoring included Lethal Concentration 50 tests (LC50) which ascertains the concentration of an effluent that is lethal to 50% of test organisms, in this case *Ceriodaphnia dubia* and *Pimephales promelas* that are subjected to the effluent for a predetermined time period (48 hours). The results of this testing indicated that the effluent water of three facilities was acutely toxic between 1995 and 2006 (**Table 3-19**). The effluent of Henry County Lower Smith River STP (VA0069345) was under the Toxic Management Program (TMP) by VA DEQ between 1995 and 2005 and showed persistently acute toxic effluents from April 1995 through May 1999 and from March 2001 to June 2004. However, this facility is no longer active. The effluent of Martinsville City Sewage Treatment Plant (VA0025305) has been under the TMP since 1996 and showed acute toxic effluents only in March 1999. The effluent of Bassett Mirror Company (VA0086665) has been under the TMP since 1999 and showed acute toxic effluents from March 2000 to March 2002 and in October 2004.

Table 3-19: Effluent Monitoring Summary								
	Basset Mirror Company VA0086665		Upper Smith River STP VA0061654		Lower Smith River STP VA0069345		Martinsville STP VA0025305	
Year	Passed	Failed	Passed	Failed	Passed	Failed	Passed	Failed
1989			X					
1990			X					
1991			X					
1992			X					
1993			X					
1994			X					
1995			X			X		
1996			X			X		
1997			X			X		
1998			X			X		
1999	X		X			X		X
2000		X					X	
2001		X				X	X	
2002		X				X	X	
2003	X					X	X	
2004		X				X		
2005	X				X		X	
2006	X						X	
Effluent is marked as failing if fails for at least one test organism type. Empty boxes signify no testing took place								

3.3 Supplemental Water Quality Monitoring

The Dan River Basin Association (DRBA) conducted a baseline habitat study on Jordan Creek, a tributary of the Smith River (Davis and Hash, 2007). The study included a habitat assessment, a physical characterization/water quality assessment, and a biological assessment of the benthic macroinvertebrate community. The biological monitoring was conducted in June and July, 2007.

The habitat assessment and physical characterization/water quality assessment were conducted between June 7 and July 13, 2007 at 68 stations covering from the confluence of Jordan Creek and the Smith River, upstream to the crossing of Jordan Creek Road. The results of these assessments found that the habitat of Jordan Creek is largely suboptimal to marginal. The majority of assessment sites had marked bank erosion and sedimentation. The substrate was found to be composed of silt or sand approximately 60 percent of the time. There were also several sites at which livestock had entry access to the stream as well as several noted pipe crossings/outflow.

The biological assessment was conducted over three days at four different stations (**Table 3-20**), using the VA Save our Streams (VA SOS) method of scoring the condition of the macroinvertebrate community. A total of four sites were assessed, all of which were found to have macroinvertebrate communities in 'acceptable' condition.

Table 3-20: Lowest Weekly Average Flow Occurring each Year (1997 - 2006)

Site Number	Location
1	Jordan Creek Park behind ball field upstream of pipe crossing
2	Entrance to Boxley Materials behind parking lot
3	On Boxley property below dam for water pump station
4	On west side of Meadowood Trail about 15 meters up from culvert

3.4 Flow Fluctuation

The benthic impaired segment in the Smith River is impacted by the flow releases from the Philpott Dam and Martinsville Dam. The Philpott Dam is located approximately 15 miles upstream from the benthic impaired segment and was established in 1953 for flood-control purposes, generating electric hydropower, and recreation. The dam has a length of 920 ft, a maximum width (at bases) of 166 ft, and a maximum height of 220 ft. It impounds a surface area of 4,060 acres. Three hydraulic turbines provide electricity year-round. Depending on energy demand and water availability, the flow release varies daily between 45.91 and 1292.52 cfs. The dam is owned and operated by the U. S. Army Corps of Engineers (USACE, 2007).

The Martinsville Dam is located at the upstream boundary of the benthic impaired segment and has been in operation since 1924. It incorporates two turbines for generating electricity. The turbines are only irregularly in operation when high peak demand is required. The dam is 575 ft long and 32 ft high. It is owned and operated by the City of Martinsville (Commonwealth of Virginia, 2007).

This section presents an analysis of streamflow in the benthic impaired segment at USGS Station 2073000, located approximately 0.3 miles downstream from Martinsville Dam. A low-flow analysis at the USGS Station 2073000 on the Smith River is presented to assess the critical low flow conditions in the Smith River, and to identify any release pattern from Martinsville Dam. In particular, this section will evaluate the likelihood that flow regulation is affecting the hydrologic regime in the Smith River. For this evaluation, the USGS Station 2072000, located immediately downstream from Philpott Dam, will also be used. The streamflow data at both USGS stations are based on daily flow measurements and were retrieved from the USGS website (USGS, 2007). **Figure 3-25** shows the location of the two dams and the two USGS flow stations used for analysis.

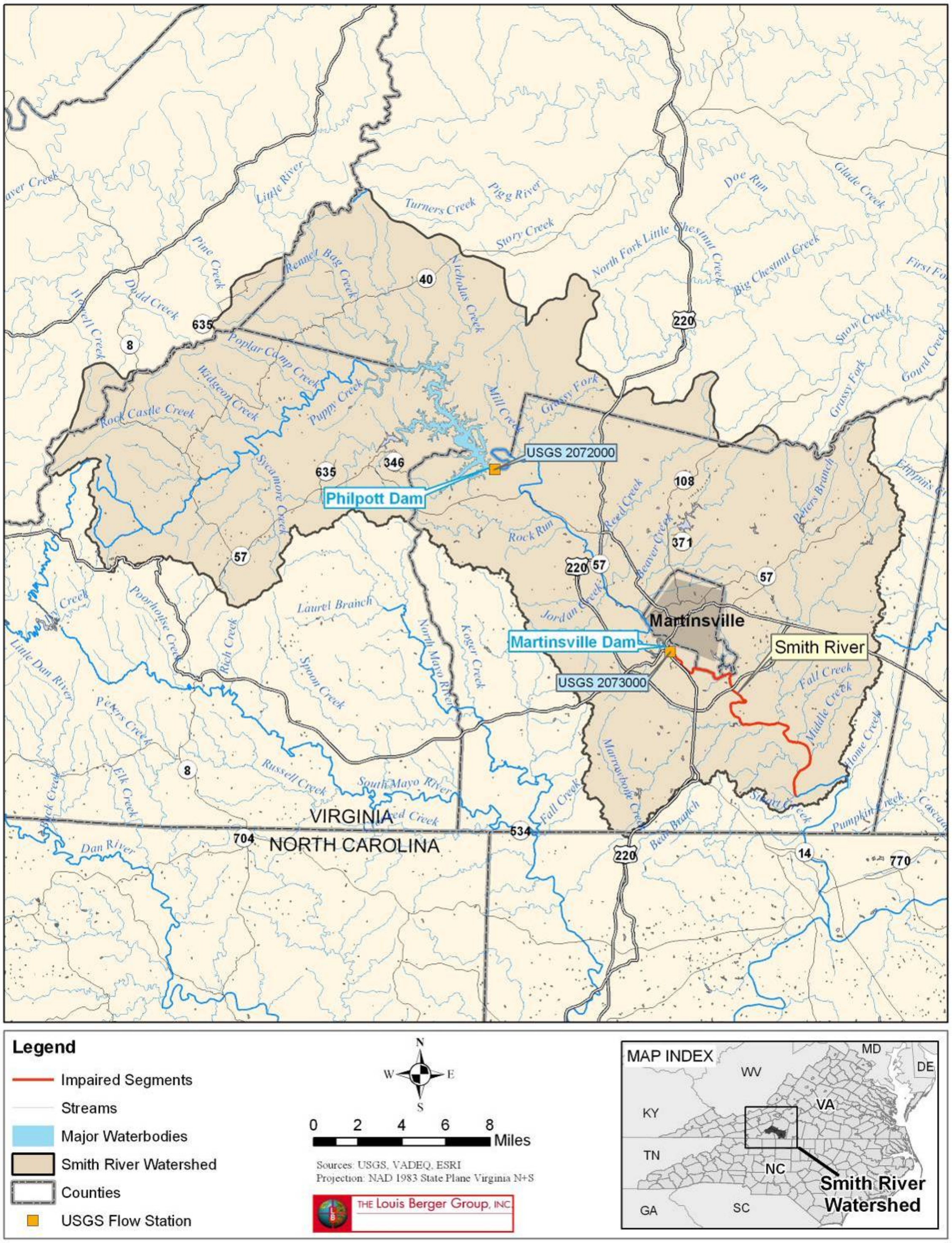

Figure 3-25: Location of Philpott Dam, Martinsville Dam, and USGS Flow Stations 2072000 and 2073000

3.4.1 Low-Flow Analysis in the Benthic Impaired Segment of the Smith River

Streamflow data recorded from the period of 1997 through 2006 at the USGS Station 02073000 (Smith River at Martinsville, VA) were analyzed in order to determine the average flow regime over 10 years. **Figure 3-26** presents the monthly individual minimum (lower bar) and maximum (upper bar), and monthly average (column and bold value) at the USGS Station 0207300 and depicts the overall flow regime in the Smith River located downstream of Martinsville Dam.

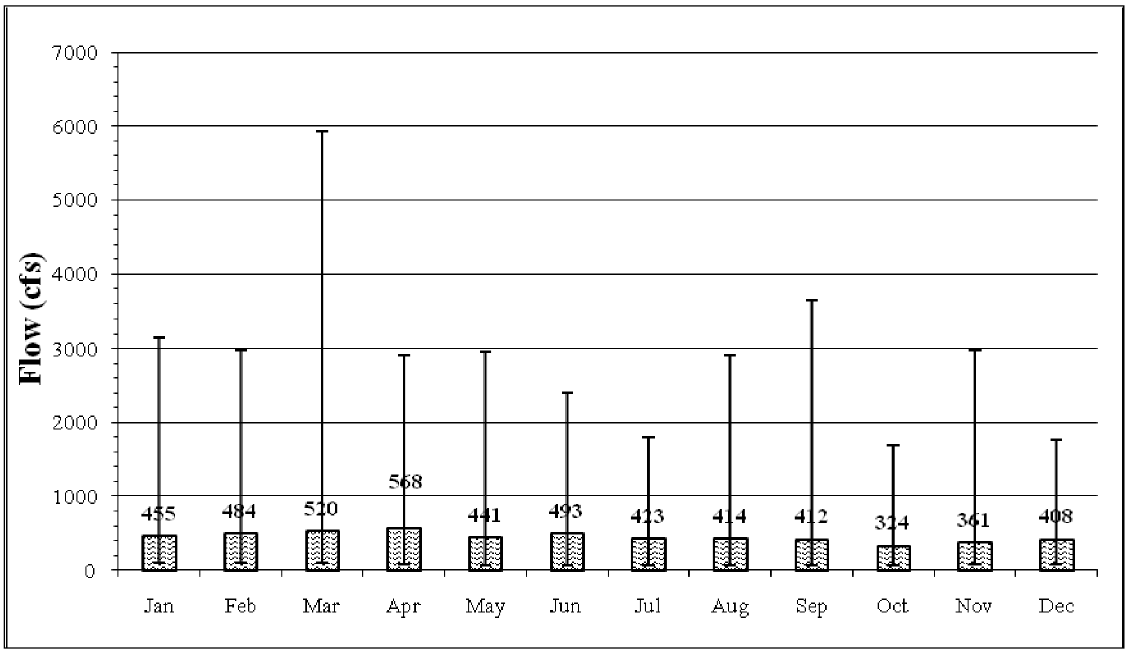

Figure 3-26: 1997-2006 Monthly Individual Minimum and Maximum, and Monthly Average at the USGS Station 02073000

Figure 3-26 shows that there are relatively small fluctuations of the monthly-average flow throughout the year. The majority of the monthly-average flows are approximately 400 cfs. Also, the minimum and maximum monthly flows indicate similar fluctuations throughout the year. Overall, however, a slight seasonal decline in monthly-average flow is visible during late summer and fall, with October showing the lowest monthly-average flow. The relatively small monthly fluctuations are caused by the two dams' operation and the frequent occurrence of heavy rainstorms throughout the year.

Figure 3-27 depicts the yearly average flows and precipitation from 1997 through 2006, at USGS Station 2073000 including the normal flow (513 cfs based on 30 years of flow from 1977 through 2006). The precipitation data are based on two weather stations located in the Smith River watershed (Woolwine and Philpott), and were obtained from the National Climatic Data Center (NCDC, 2006). It should be noted that the yearly average flow from the last ten years indicates a period with extended low flows, with six out of 10 years showing flows less than the 30 year average. The lowest flow occurred in 2002 and ended a four year period of low flow conditions (1999 through 2002). The highest flow year occurred in 2003 and the average flow years (compared to the normal flow) were 1997 and 2005. Each flow condition is also reflected in the precipitation depth.

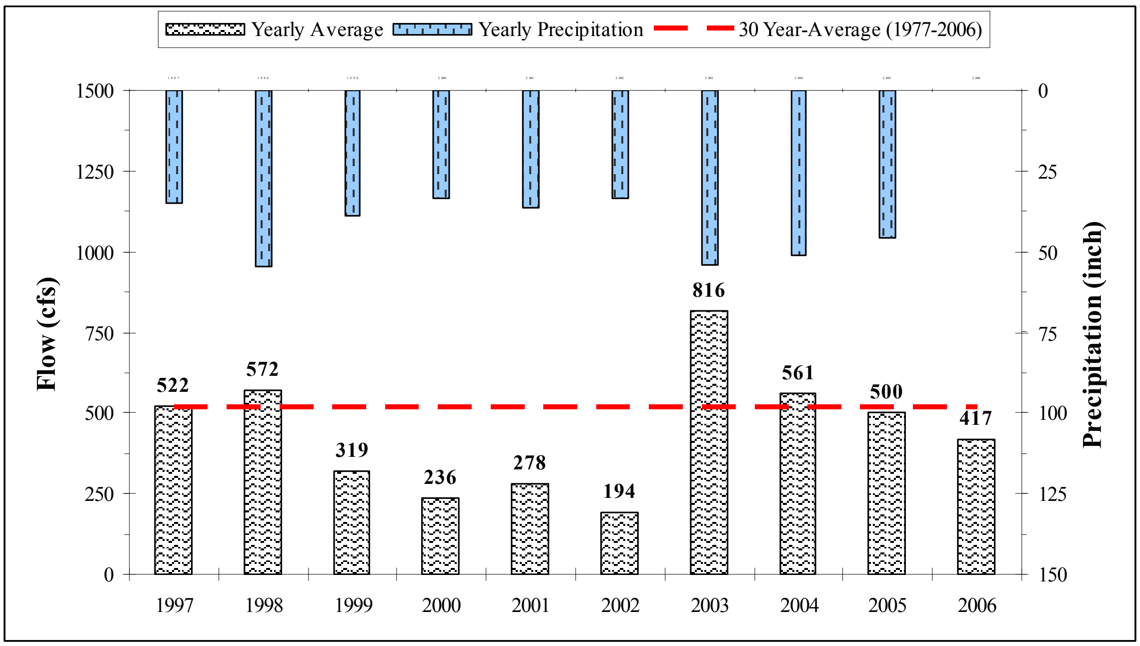

Figure 3-27: Yearly Average Flow by Year at the USGS Station 2073000 and Precipitation from 1997 through 2006 in the Smith River Watershed.

Critical periods in water quality often occur during short periods of one to two weeks. Consequently, weekly low-flow analysis was performed on the stream flow data at the USGS Station 02073000. This analysis consists of identifying the lowest weekly-average flow in the Smith River for each year spanning the period of 1997 through 2006. **Table 3-21** shows the results of the analysis and indicates that most of the time, the lowest weekly-average flow occurs in the month of August, at 82.43 cfs (8/09/02-8/15/02).

Table 3-21: Lowest Weekly Average Flow Occurring each Year (1997 -2006)		
Year	Week	Flow (cfs)
1997	Dec 13 - Dec 19	216.57
1998	Oct 21 - Oct 27	238.86
1999	May 25 - May 31	204.29
2000	Aug 20 – Aug 26	141.14
2001	Aug 31 - Sep 6	144.57
2002	**Aug 9 - Aug 15**	**82.43**
2003	Jan 26 - Feb 1	269.29
2004	Aug 23 - Aug 29	257.14
2005	Sep 30 - Oct 6	210.71
2006	May 13- May 19	155.71

Figure 3-28 shows the flow at USGS Station 2073000 and the precipitation between July and August in 2002, as well as the week in which the lowest weekly average flow occurred in the last 10 years (August 9 through August 15). It should be noticed that the stream responds quickly to rainfall. This is seen in the spikes occurring immediately after rainfall.

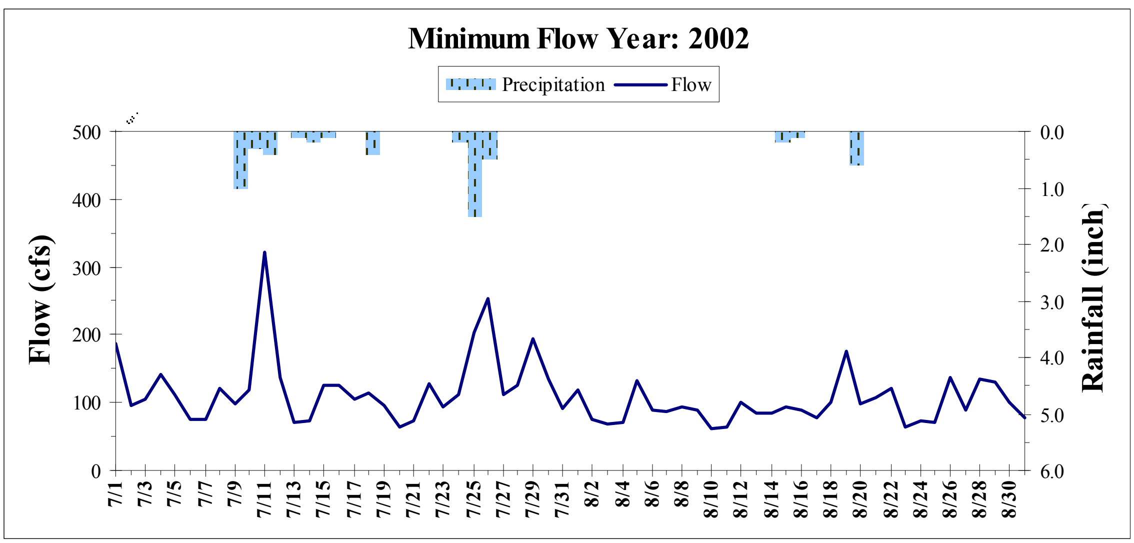

Figure 3-28: Continuous Flow over time at the USGS Station 02073000 and Precipitation from July through August in 2002 (Minimum Flow Year).

The fluctuations (not related to rainfall) seen in **Figure 3-28** are a direct response of flow releases from the Philpott Dam and Martinsville Dam during hydropower operation. Both dams water release is cyclical, and one cycle consists of a period of five days with high flows and is followed by a period of two days with low flows. This is particularly seen in **Figure 3-29** for the maximum, average, and minimum flow years, in which the flow cycles measured immediately downstream of Philpott Dam (USGS Station 2072000) are reflected at Martinsville (USGS Station 2073000). When the flows of both stations are compared to each other, it is noticeable that no flow spikes occurred at the station at Philpott Dam, because any flow triggered by rainstorms is attenuated in Philpott Dam's extended reservoir. In contrast, the flow at the USGS gage station at Martinsville Dam shows flow spikes as a direct response from rainfall events. The reservoir of the Martinsville Dam is considerably smaller than Philpott Dam's reservoir, and therefore the ability to attenuate and store flow from rainstorms is comparably low. Also, extensive areas of impervious land in the city of Martinsville likely leads to increases in urban runoff which accounts for, to a certain extent, the magnitude of the flow spikes. **Figure 3-29** also shows the large differences within one flow cycle. On average, the flow fluctuation within a cycle causes the flow at Martinsville Dam to double. Also, it should be noted that the lag time between both stations is generally less than one day. Overall, Philpott Dam considerably impacts the flow regime of the benthic impaired segment in the Smith River and therefore has considerable impact upon the geomorphologic and the biotic regime in the benthic impaired segment of the Smith River.

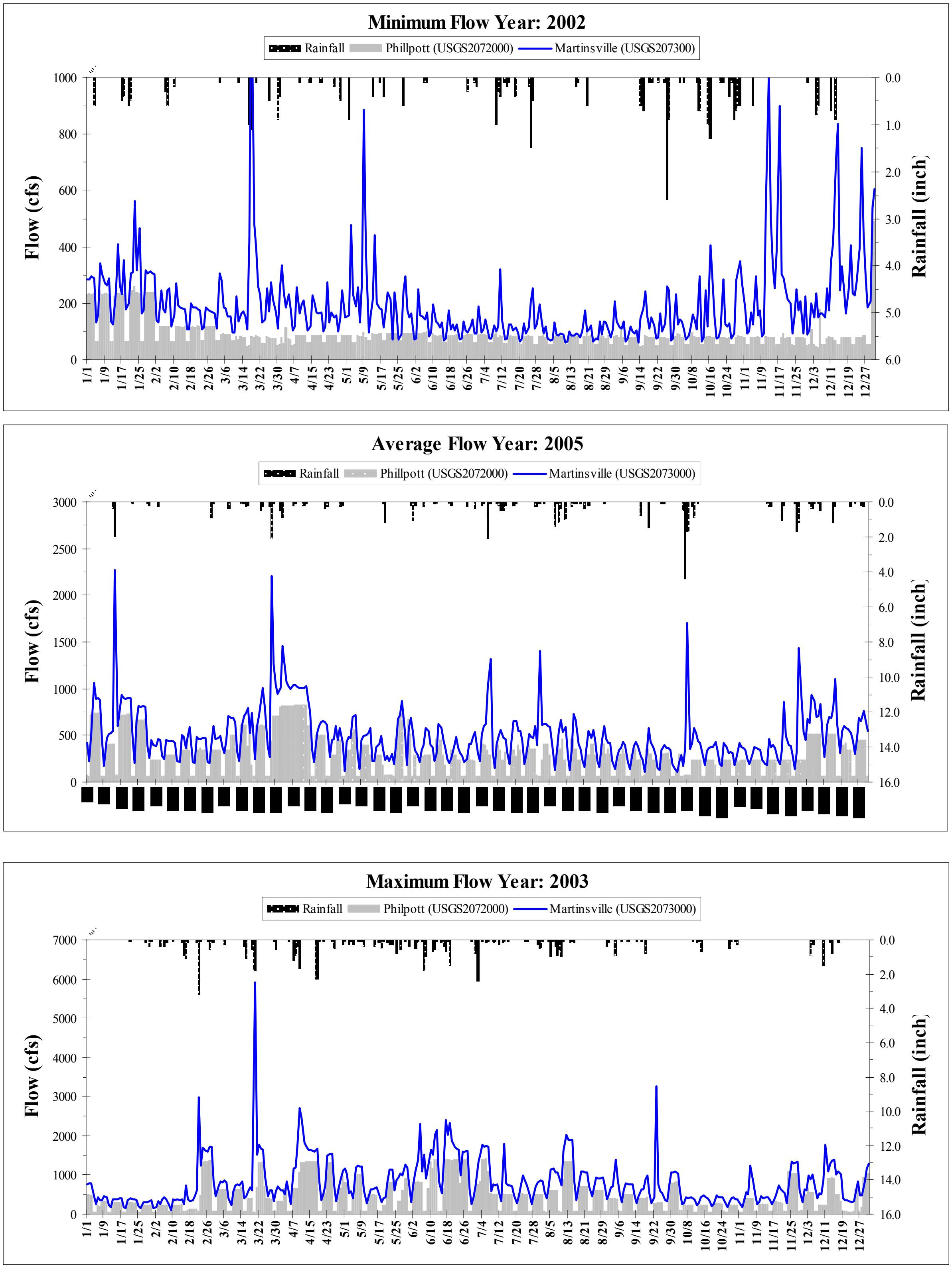

Figure 3-29: Comparison of Flows at USGS stations at Philpott Dam and Martinsville Dam for a Minimum , Average, and Maximum Flow Year (over time)

3.5 Discharge Monitoring Reports

Discharge Monitoring Reports (DMR) for each of the individual permitted facilities discharging into the Smith River watershed were obtained for the period between 2000 and 2009, and analyzed. **Table 3-22** summarizes the exceedances at permitted facilities:

Table 3-22: DMR Summary of Exceedances

Permit No.	Facility Name	Parameter	Quantity Average	Quantity Maximum	Concentration Average	Concentration Maximum
VA0086665	Bassett Mirror Company Inc.	BOD_5	**1**	**2**	**4**	**2**
		TSS	**2**	**1**	**12**	**6**
VA0029858	Carver Estates STP	BOD_5	0	0	**2**	0
		pH	0	0	**1**	0
		TSS	0	0	**1**	0
VA0090174	Green Acres Mobile Home Park	BOD_5	0	**1**	**24**	**12**
		Cl_2, TOTAL	0	0	0	**2**
		TSS	0	0	**7**	**4**
VA0001554	Hanesbrands Incorporated	BOD_5	**1**	0	0	0
VA0090280	Henry County Public SA-Greenbriar Lagoon STP	BOD_5	**10**	**4**	**10**	**4**
		Flow	**8**	0	0	0
		Ammonia (as N Jun-Dec)	0	0	**5**	**5**
		pH	0	0	0	**2**
		TSS	**2**	0	**1**	0
VA0060445	Henry County Public SA-Piedmont Estates Lagoon	BOD_5	**2**	0	**3**	0
		Flow	**9**	0	0	0
		Cl_2 (Inst Res Max)	0	0	**1**	**1**
		pH	0	0	0	**1**
		TSS	**2**	0	**8**	**1**
VA0025305	Martinsville City STP	BOD_5	0	0	**1**	0
		pH	0	0	0	**1**
VA0090301	Philpott Dam	Oil and Grease	0	0	0	**9**
VA0058441	Upper Smith River Water Filtration Plant	Cl_2, TOTAL	0	0	**1**	**1**
VA0021989	Virginia Glass Products Corp	pH	0	0	0	**1**
		TSS	0	0	**2**	**5**

4.0 Stressor Identification Analysis

TMDL development for a benthic impairment requires identification of pollutant stressor(s) affecting the benthic macroinvertebrate community. Stressor identification for the benthic macroinvertebrate community impaired segment of the Smith River was performed using the available environmental monitoring and watershed characterization data discussed in previous sections. The stressor identification follows guidelines outlined in the EPA Stressor Identification Guidance (EPA, 2000).

Stressor identification for the Phased Benthic TMDL on the Smith River was completed using data available as of March 2010. Additional data collected during the next two years will be evaluated and the Stressor identification will be updated as appropriate. The identification of the most probable cause of biological impairment in the Smith River was based on evaluations of candidate stressors that can potentially impact the river. The evaluation includes candidate stressors such as dissolved oxygen, temperature, pH, metals, organic chemicals, nutrient, toxic compounds, flow, and sediments. Each candidate stressor was evaluated based on available monitoring data, field observations, and consideration of potential sources in the watershed. Each stressor was then classified as one of the following:

Non-stressor: Stressor with data indicating normal conditions, without water quality standard exceedances, or without any apparent impact.

Possible stressor: Stressor with data indicating possible links to the benthic impairment, but without conclusive data to show a direct impact on the benthic community.

Most probable stressor: Stressor with conclusive data linking it to the poor health of the benthic community.

Table 4-1 summarizes the results of the stressor analysis for the Smith River.

Table 4-1: Summary of Stressor Identification in the Smith River
Non-Stressors
Instream Dissolved Heavy Metals
DO
pH
Chloride
Possible Stressors
Nutrients
Sedimentation
Flow and Temperature Fluctuation
Most Probable Stressor
Toxicity: Organic Contaminants in Sediment (Total PAHs)

4.1 Non-Stressors

4.1.1 Instream Heavy Metals

All available dissolved metals data (aluminum, beryllium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, and zinc) indicated that their concentrations were below the acute and chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards. In fact, almost all metal parameters analyzed were below analytical detection limits.

Instream heavy metals do not appear to be adversely affecting the benthic macroinvertebrates in the Smith River and are therefore classified as non-stressors.

4.1.2 Dissolved Oxygen

Benthic invertebrates and other aquatic organisms require a suitable range of dissolved oxygen conditions to survive in the benthic sediments of rivers or streams. Decreases in instream oxygen levels can result in oxygen depletion or anoxic sediments, which adversely impact the river's benthic community. Based on grab and continuous measurements for dissolved oxygen, there were no exceedances of VA DEQ standards.

Dissolved oxygen does not appear to be adversely affecting the benthic macroinvertebrates in the Smith River and are therefore classified as non-stressors.

4.1.3 pH

Benthic invertebrates require a suitable range of pH conditions. Although these ranges may vary by invertebrate phylogeny, very high or very low pH values may result in a depauperate invertebrate assemblage comprised predominantly of tolerant organisms. The Virginia Class V water quality standards identify the acceptable pH for the Smith River (6.0 – 9.0). Field measurements indicated adequate pH values in and upstream of the biologically impaired segment.

The pH conditions do not appear to be adversely impacting benthic communities in the Smith River and is therefore classified as a non-stressor.

4.1.4 Chloride

Historically, elevated instream chloride concentrations were detected under low flow conditions downstream at the effluents of two wastewater treatment facilities (Martinsville and Lower Smith River STP). With the closing of several industrial factories, which conveyed their wastewater to the STP, the instream chloride levels were significantly reduced. Based on available VA DEQ water quality monitoring results for chloride collected between 1996 and 2000, chloride concentrations tend to be relatively low.

Chloride does not appear to be adversely impacting benthic communities in the Smith River and is therefore classified as a non-stressor.

4.2 Possible Stressors

4.2.1 Nutrients

Increased nutrients (nitrogen and phosphorus) concentrations can stimulate algal growth that may result in eutrophic conditions, high organic loading, and decreased dissolved oxygen levels in the early morning hours of the growing season. Excessive algal growth can impact the benthic macroinvertebrates present in the stream, causing some trophic groups to decline and others to increase in population. In the Smith River benthic impaired segment, phosphorus concentrations increased abruptly downstream of the Martinsville STP and remained at a similar concentration along the downstream segment. VA DEQ biologists observed periphyton growth each fall at multiple sites during field visits to the impaired segment. However, the periphyton growth noted in the impaired segment was not considered excessive. This is likely due to scouring and low instream temperatures associated with Philpott Dam releases. In addition, the macroinvertebrate community composition found in the impaired segment indicated potential enrichment with high proportions of species tolerant to nutrient pollution.

Based on the analysis above, nutrient enrichment cannot be ruled out as a non-stressor. However, since increased algal growth was not observed throughout the impaired segment and diurnal DO fluctuations were small, it is therefore only considered a possible stressor in the impaired segment of the Smith River.

4.2.2 Sedimentation

The habitat scores for sedimentation were low throughout the impaired segment. In the upper section of the impaired segment, the loss of riparian vegetation, riffle frequency, bank stabilization, and increase of sedimentation are mainly caused by increased runoff associated with increased impervious surfaces and urbanization. In the lower section of the impaired segment, the loss of riparian vegetation, riffle frequency, bank stabilization, and increase of sedimentation are more likely caused by a combination of different land uses. Leatherwood Creek tributary was also noted by biologists as a potential source of sediment. Sedimentation reduces the available habitat for sensitive benthic macroinvertebrates and can cause the community to become impaired. Species sensitive to sedimentation were found in low numbers in the Smith River as compared to the reference conditions. However, the linkage between habitat scores and VSCI scores cannot be established clearly, since for instance the highest habitat score including the highest sedimentation score was found within the reach with the lowest VSCI score. Relative Bed Stability (RBS) scores indicate that the sites that were measured within the impaired segment were more stable than at the site that was measured in the reach upstream of the impaired segment (4ASRE033.19 reference site; historically high VSCI Scores). Additionally, a clear linkage between TSS levels and sedimentation could not be established either, since elevated TSS levels were only observed in isolated peaks.

For these reasons, sedimentation cannot be ruled out as a non-stressor. However, sedimentation is only considered a possible stressor for the following reasons. RBS scores were better in the impaired reach than in the reach upstream of the impairment; elevated TSS levels were not observed throughout the impaired reach; and no clear linkage can be established between poor habitat scores and low VSCI scores.

4.2.3 Flow and Temperature Fluctuation

A flow and temperature analysis was conducted in the Smith River to determine the impact of two dams (Philpott Dam and Martinsville Dam) located upstream of the impaired segment to the benthic community. Flow fluctuations were found to directly respond to releases from the Philpott and Martinsville Dams during hydropower operation. This includes extremely low flow conditions downstream of the Martinsville Dam. Also, temperature fluctuations were found to be directly linked to flow releases from the Martinsville Dam during hydropower operation. An analysis of continuous temperature data (15 minute increments) measured downstream of Martinsville Dam, showed relatively high hourly temperature changes. No direct linkage can be established between the flow modification and the benthic community at this time due to the lack of data; however, it may have indirect impacts on the benthic community.

Therefore, flow and temperature fluctuations in the benthic impaired segment of the Smith River cannot be ruled out as a non-stressor and are considered a possible stressor to the benthic community.

4.3 Most Probable Stressor

4.3.1 Toxicity: Organic Contaminants in Sediment (Total PAHs)

There have been a number of toxicity testing efforts conducted in the Smith River watershed, including instream toxicity testing by EPA, and whole effluent chronic toxicity testing (WET) by several permitted dischargers. In addition, monitoring was conducted by VA DEQ for contaminants in the water column and sediment of the Smith River. Through these efforts, toxic effects and various organic contaminants have been uncovered in the Smith River watershed.

Instream toxicity testing by EPA Region 3 Laboratory from samples collected at two stations within the benthic impaired segment (4ASRE019.00, 4ASRE015.43) found that the water quality samples of both monitoring sites showed adverse effects on fathead minnow survival and biomass (survival + growth endpoint) and were statistically different from that of control samples. In the professional judgment of the EPA Region 3 Laboratory, the results "were biologically significant". They emphasized that the results are qualitative in nature, and should be compared with other water quality data collected at this site to determine the causes of toxicity.

In 2003, at VA DEQ monitoring station 4-ASRE020.75 (located within the impaired segment), VA DEQ and USGS/CERC conducted an assessment of instream organic contaminants, using Semi permeable Membrane Device (SPMD) technology with a deployment period of a few weeks. During the assessment, the presence of several hazardous substances including several OCPs (organochlorine pesticides), and PAHs (polycyclic aromatic hydrocarbons) were detected but did not exceed the VA DEQ water quality standards. However, although no criteria exist for many of the analyzed constituents including Total PAH, it should be noted that the observed Total PAH concentration in the water column was reported as the highest value in Virginia compared to the other sites monitored in 2003.

Historically, VA DEQ collected sediment and fish tissue samples at several monitoring stations in the Smith River to test for PAH, PCB (polychlorinated biphenyls) and heavy metal contamination. Screening values are the consensus based Threshold Effect Concentration (TEC) and Probable Effects Concentration (PEC) levels, developed by MacDonald et al 2000. Within the benthic impaired segment, a total of 15 exceedances were detected for PAHs (14) and pesticides (1) in sediment. Upstream of the impaired segment, 20 exceedances for PAH (4), PCB (1), pesticides (6), and heavy metals (9) were detected. Downstream of the impaired segment, 3 exceedances for PAHs and a single exceedance for mercury were observed. Particularly, total PAH was found to be consistently elevated at monitoring stations throughout the Smith River. PAHs are the most dominant contaminants measured in the sediment and may have the greatest adverse impact on the macroinvertebrate community.

In 2009, VA DEQ collected sediment samples at four stations in the Smith River, two within the impaired segment (4ASRE022.30 and 4ASRE019.00) and two upstream of the impaired segment (4ASRE026.77 and 4ASRE033.19). Hazard quotients (HQs) were calculated based on TEC and PEC screening values and are used to indicate possible toxicity. A hazard quotient is the result of the measured PAH (in µg/kg) divided by the TEC or PEC. HQs for each contaminant are summed to obtain a hazard index (HI). The

HQs are summed because PAHs toxicologically act in an additive manner. Generally, HIs greater than one (HI > 1) indicate possible toxicity. If the calculated HI of a group of compounds is less than the TEC HI of an individual compound (HI < TEC HI), then there would be no expected adverse effects on sediment dwelling organisms. If the calculated HI exceeds the TEC HI of one pollutant (HI > TEC HI) but is below the PEC HI (PEC HI > HI > TEC HI) then there is potential for adverse effects. If the calculated HI is above the PEC HI of one compound (HI > PEC HI) then adverse affects to the sediment dwelling organisms are likely to be observed (MacDonald et al, 2000). **Table 4-2** summarizes the TEC and PEC based HQs and HIs for sediments sampled in August 2009.

Table 4-2: 2009 Sediment PAHs (TEC/PEC based) Hazard Quotients and Hazard Index (Sum of Quotients)

			4ASRE033.19			4ASRE026.77			4ASRE022.30			4ASRE019.00	
Compound	TECs (ug/kg)	PECs (ug/kg)	**ug/kg**	**TEC HQ**	**PEC HQ**	**ug/kg**	**TEC HQ**	**PEC HQ**	**ug/kg**	**TEC HQ**	**PEC HQ**	**ug/kg**	**TEC HQ**
Acenaphthene	NA	NA										8.150	
Acenaphthylene	NA	NA										4.390	
Anthracene	**57.2**	**845**	14.30	**0.250**	**0.017**	47.00	**0.822**	**0.056**	7.280	**0.127**	**0.009**	192.00	**3.357**
Benzo-a-pyrene	**150**	**1,450**	21.70	**0.145**	**0.015**	69.10	**0.461**	**0.048**	6.790	**0.045**	**0.005**	181.00	**1.207**
Benz(a)Anthracene	**108**	**1,050**	31.00	**0.287**	**0.030**	101.00	**0.935**	**0.096**	11.200	**0.104**	**0.011**	169.00	**1.565**
Chrysene	**166**	**1,290**	18.50	**0.111**	**0.014**	60.50	**0.364**	**0.047**	6.790	**0.041**	**0.005**	142.00	**0.855**
Dibenz[a,h]Anthracene	**33**	**NA**	8.32	**0.252**		18.50	**0.561**					40.70	**1.233**
Fluoranthene	**423**	**2230**	46.20	**0.109**	**0.021**	134.00	**0.317**	**0.060**	16.000	**0.038**	**0.007**	387.00	**0.915**
Fluorene	**77.4**	**536**										20.70	**0.267**
Methylnaphthalene, 2-	**NA**	**NA**				4.27						11.90	
Naphthalene	**176**	**561**				4.27	**0.024**	**0.008**				13.20	**0.075**
Phenanthrene	**204**	**1,170**	12.00	**0.059**	**0.010**	39.90	**0.196**	**0.034**	6.310	**0.031**	**0.005**	161.00	**0.789**
Pyrene	**195**	**1,520**	37.00	**0.190**	**0.024**	108.00	**0.554**	**0.071**	12.600	**0.065**	**0.008**	293.00	**1.503**
Hazard Index (Sum Hazard Quotients)				**1.403**	**0.131**		**4.233**	**0.419**		**0.451**	**0.050**		**11.766**

Above the impaired segment (stations 4ASRE033.19 and 4ASRE026.77) the HIs indicate possible toxicity by PAHs. Station 4ASRE022.30 indicates no toxicity and station 4ASRE019.00 indicates PAH toxicity is likely to have adverse affects on the benthic dwelling organisms.

The PAH data discussed here represents only one sampling event at four stations. Additional data collection is needed in order to refine the observations discussed here. Based on a cursory analysis by VA DEQ, it was determined that the PAH assemblages in the Smith River are primarily of pyrogenic origin (combustion of organic matter). Generally, PAHs can be broken down into subclasses, petrogenic and pyrogenic PAHs. Petrogenic PAHs typically originate from fossil fuels (oil, coal, etc.) and pyrogenic PAHs from combustion of organic matter (burning of fossil fuels, manufacturing of iron/steel, carbonization of coal/oil, etc.). Specifically, the PAH isomer ratios of Phenanthrene to anthracene (PH/AN) and fluoranthene to pyrene (FL/PY) can be used to determine if the source is from pyrogenic or petrogenic origin (Neff et al., 2005). For instance, a PH/AN ratio of pyrogenic PAH assemblages is usually less than 5 and the petrogenic ratio is usually greater than 5. Also, a FL/PY ratio of pyrogenic PAH assemblages usually approaches or exceeds 1 and is usually substantially less than 1 in petrogenic PAH assemblages. **Table 4-3** shows the published PH/AN and FL/PY ratios by Neff et al. (2005)

and the calculated ratios using 2009 measured PAH concentrations in sediment at four VA DEQ monitoring stations in the Smith River. As presented in **Table 4-3**, the PH/AN ratios are below 5 and the FL/PY ratios are above 1 and therefore indicate that the PAH assemblages in the Smith River are primarily of pyrogenic origin (mainly combustion of organic matter). Also, from the land use perspective, the PH/AN results indicate that urban areas are most likely the main source of the total PAHs.

Table 4-3: Ratios of PAH Isomers from various sources in the 2010 Smith River Sediments

Source	PH/AN Ratio	FL/PY Ratio
Pyrogenic Sources		
Auto exhaust soot	1.79	0.9
Diesel engine soot	0.06	1.26
Highway Dust	4.7	1.4
Urban Runoff	0.56-1.47	0.23-1.07
Coal Tar	3.11	1.29
Wood burning emissions	6.41	1.26
Petrogenic Sources		
No. 2 Fuel Oil & Diesel Fuel	> 800*	0.38
No. 4 Fuel Oil	11.8	0.16
Road Paving Asphalt	20	<0.11*
Smith River Sediments (Rivermile)		
4ASRE033.19	0.84	1.25
4ASRE026.77	0.85	1.24
4ASRE022.30	0.87	1.27
4ASRE019.00	0.84	1.32

Source Neff et al, 2004, * Anthracene or fluoranthene concentration was below detection limit

Toxicity may originate from urban runoff, however, toxicity caused by organic contaminants in the sediment and the water column may also have potential historic sources. The watershed has historically harbored an abundance of industrial facilities, many related to textile mills and knitting plants. Waste from these industries was conveyed to wastewater treatment facilities such as Martinsville City Sewage Treatment Plant, or treated within the plant such as in DuPont de Nemours & Co., and then discharged to the Smith River (Pratt et al., 1989). DuPont de Nemours & Co., Inc, located within a stream meander of the Smith River, may also be a potential source of contamination, as the plant deposited nylon waste, finish oil, nitric and formic acids, and laboratory chemicals on its site during operation between 1941 and 1998. Soil and groundwater on the property contaminated with PAHs (polycyclic aromatic hydrocarbons) and VOCs (volatile organic compounds) have been monitored and contained (RCRA, 1999, 2007).

Whole effluent chronic toxicity testing (WET) conducted by several permitted dischargers in the Smith River watershed found that between 1995 and 2006, three facilities had effluent water that was acutely toxic. These three include the now inactive Henry County Lower Smith River STP (VA0069345), the active Martinsville City Sewage Treatment Plant (VA0025305), and the Bassett Mirror Company (VA0086665). No WET testing has been conducted recently.

Potential sources from present sites for organic contaminants in the vicinity of the benthic impaired segment include an industrial park, paved roads, and other impervious surfaces.

As illustrated in this section, toxicity has been detected in the past in several sections of the Smith River, particularly in sections downstream of Martinsville Dam (Pratt et al., 1989). Although the closing of several industrial facilities has substantially reduced or eliminated the release of industrial wastes, the toxicity waste from these facilities is likely accumulated in the Smith River bottom sediments. Also, present sources from urban runoff (deposited pyrogenic PAHs onto roadways after combustion of fuel from motors have been found a dominant source of total PAH). As a consequence, toxicity and organic contaminants, specifically total PAHs, in river sediments are considered the most probable stressor to the benthic macroinvertebrates within the impaired segment of the Smith River. Additional data collection is needed to further investigate the PAH stressor.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicate that instream dissolved heavy metals, temperature, DO, pH, and chloride in the biologically impaired segment of Smith River are adequate to support a healthy invertebrate community, and are not stressors contributing to the benthic impairment. Elevated concentrations of nutrients were found at certain monitoring stations, along with high populations of macroinvertebrates tolerant to nutrient enrichment. Nutrients were therefore classified as a possible stressor. Habitat scores and low numbers of intolerant organisms indicated that sedimentation may be affecting the benthic community, and therefore sedimentation was also named as a possible stressor. Flow and temperature fluctuations were also considered as possible stressors both related to flow release schedule of Martinsville Dam, and perhaps Philpott Dam, because of potential indirect impacts to the benthic community.

Toxicity and organic contaminants in sediment and water (specifically total PAHs) were identified as the most probable stressor impacting the benthic community in the Smith River biologically impaired segment. PAHs showed exceedances of TECs (MacDonald et al, 2000) and were found at detectable levels in the sediments of the benthic impaired segment. Therefore, total PAHs in sediments are considered as the most probable stressor in the benthic impaired segment of the Smith River. This conclusion is preliminary as it is based on a small sample size (1 data point at four sampling locations in 2009) and the application of sediment quality guidelines (SQGs) and Hazard Indices. It must be stated that these SQGs and indices are associated with uncertainty when used without incorporating a weight of evidence approach. Further, no known source of PAHs exists in the watershed that matches the phenanthrene to anthracene (PH/AN) and fluoranthene to pyrene (FL/PY) ratios that resulted from the four samples. Finally, a comparison of the observed 2009 PAH concentrations and the 2003-2009 benthic macroinverterbrate community data yield concern that PAHs are the single most probable stressor in the TMDL. The lack of a spatial PAH concentration gradient which agrees with the existing spatial VSCI score gradient may indicate that PAH is not the single most probable stressor throughout the impaired reach and/or that there are multiple stressors.

Only one (4ASRE019.00) of the two stations sampled within the impaired segment indicated potential toxic effects on sediment-dwelling organisms based on the Hazard Indices (see page 4-7). 4ASRE022.30, the second of the two stations sampled within the impaired segment, indicated no potential for toxic effects from PAHs. Station 4ASRE033.19 indicated “possible toxicity” even though it is assessed as unimpaired based on VSCI scores. No individual PAH compounds observed at the four Smith River sites exceeded applicable PECs.

Concentrations above PECs are indicative of negative effects on sediment-dwelling organisms and the predictive ability of this tool ranges between 92% and 100% (see description Section 4.3.1). Anthracene, Benzo-a-pyrene, Benz(a)Anthracene, Dibenz[a,h]Anthracene, and Pyrene exceeded TECs at 4ASRE019.00. Below TECs, “adverse effects on sediment-dwelling organisms are not expected to occur” and the predictive ability of TECs ranges between 71% to 83% (MacDonald et al, 2000). PECs and TECs are considered sediment quality guidelines and using them as a standalone predictor of stress is questionable. A weight of evidence approach incorporating supporting data would provide greater reasonable assurance of an adverse effect on benthic macroinvertebrate communities from PAHs.

The analysis of phenanthrene to anthracene (PH/AN) and fluoranthene to pyrene (FL/PY) ratios used to determine the chemical profile ‘footprint’ yielded no known single source or group of sources of total PAHs observed in recent data. The spatial or temporal distribution of the concentrations does not lead to (a) source(s) of PAHs in the environment.

The spatial distribution of PAH concentrations, although temporally consistent in existing monitoring sites, is limited and appears incongruent with the spatial benthic quality scores and temporal benthic quality trends. **Figure 3-4** provides a spatial representation of the overall average VSCI scores and includes potential sources of stress to the benthic macroinvertebrate community. The 2009 PAH data (**Figure 4-2**) show the lowest concentration at monitoring station 4ASRE022.30 which is below the Martinsville WWTP. This station has the second lowest historical average VSCI score. Based upon the comparison of observed PAH concentrations and the Hazard Indices there is no potential for toxic effects from PAHs. Therefore, it may be concluded that PAHs are not a stressor to the impaired benthic community at this monitoring station.

The next station downstream (4ASRE019.00) and below the Lower Smith River WWTP (offline) has the highest PAH concentrations (2,061ppb, above the TEC) and the lowest average historical VSCI score. The PAH concentrations and the comparison to the Hazard Indices indicate potential toxic effects on sediment-dwelling organisms (see page 4-7). It may be concluded that PAHs are a stressor to the benthic community at this station as the PAH concentrations exceed TECs and the VSCI scores are historically the lowest.

The third highest concentration (258 ppb) was collected at monitoring station 4ASRE033.19. This station is assessed as not impaired, but annually scores only slightly higher than the impairment threshold. The observed PAH concentrations indicated "possible toxicity." No obvious sources of PAHs are present at this station. It may be concluded that PAHs may have an impact to the benthic community at this monitoring station. In summary, it is difficult to establish the relationship between PAH concentrations and stress at two of the three co-located PAH and benthic monitoring stations.

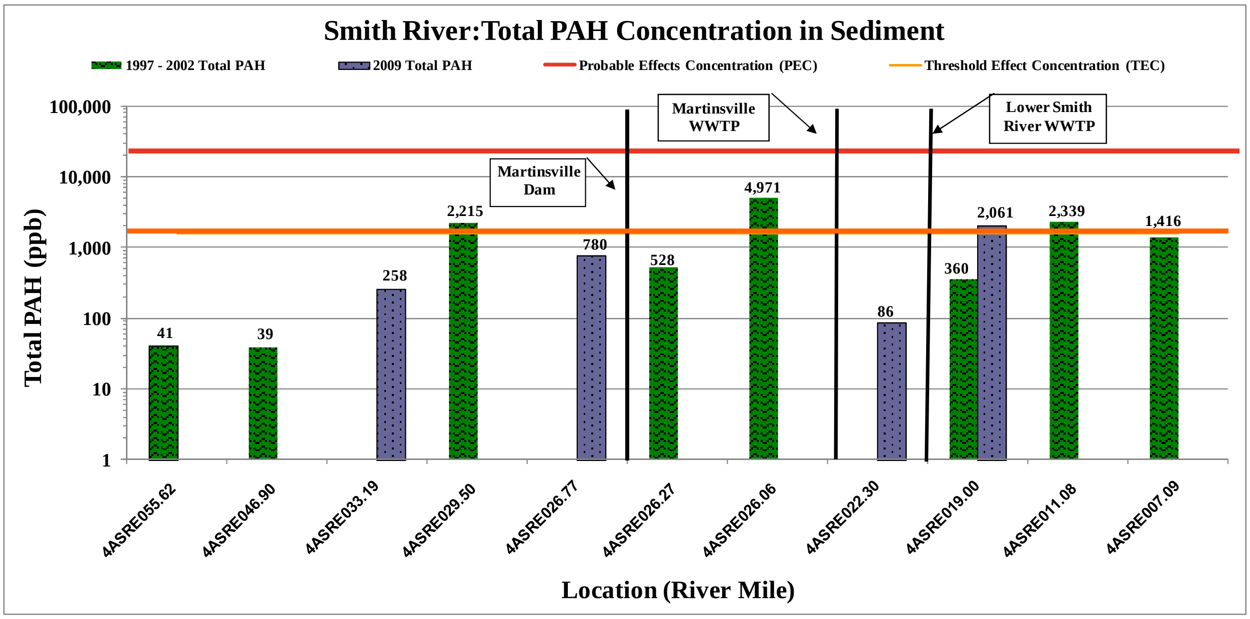

Figure 4- 1: Spatial Representation of Total PAH Concentrations in Sediment

Although evidence points toward a toxicity stressor and PAH is the strongest candidate given the information utilized in the stressor identification, additional data collection is necessary to complete the development of this TMDL. It is the recommendation of this document that the existing report become a phased development TMDL.

A phased TMDL has stringent requirements, including the major requirements of a complete non-phased TMDL. Phased TMDL development requirements also include a reopening commitment date, and a schedule to achieve the data deficiencies. The additional requirements are found in the reasonable assurance section of Chapter 6 of this report.

5.0 Endpoint Identification and Technical Approach

This section describes the endpoint determination and the overall modeling strategy approach used for the development of the Smith River Phased Benthic TMDL.

5.1 Endpoint Identification

The TMDL development process involves the determination of an endpoint, or water quality goal/target, for the impaired waterbody. A TMDL endpoint represents the stream conditions at which a given stream would meet a water quality standard. An endpoint is normally expressed as a numeric water quality criterion for the pollutant causing the impairment. Compliance with the numeric water quality criterion, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have an established numeric water quality criterion. In these cases, alternative approaches may be used to define the TMDL endpoint. As discussed in Section 1.0, Virginia has not yet established a numeric criterion for total PAH in sediment to fully protect impairments of aquatic life. Therefore, an alternate approach for determining the total PAH TMDL endpoint was used to address toxicity and sediment in organic contaminants, specifically total PAH impairments and restore the aquatic life.

The endpoint selected by VA DEQ for the Smith River benthic TMDL is the Threshold Effect Concentration (TEC) for total Polycyclic Aromatic Hydrocarbons (PAHs) in sediment, 1.61 mg/kg. The TEC identifies the contaminant concentrations below which adverse effects to sediment-dwelling organisms are not expected to occur (MacDonald, et al., 2000).

Table 2-2 summarizes the total PAH endpoint in sediment for the Smith River benthic TMDL.

Table 5- 1: Total PAH Endpoint for the Smith River Benthic TMDL

Parameter	**Concentration (**mg/kg)
Total PAH in Sediment	1.61

5.2 Technical TMDL Approach

The existing water quality conditions in the benthic impaired segment are affected by total PAH loads draining from the upstream part of the watershed as well as land-base loads draining from within the impaired segment. A mass balance model was applied to estimate the existing total PAH concentration in sediment in the benthic impaired segment of the Smith River. Accepted literature values for total PAH were used to estimate the total PAH loads' contribution from runoff (Novotny, 2003). A watershed model, the Generalized Watershed Loading Function (GWLF), was applied to estimate sediment loads from all the sources in the Smith River watershed. It was assumed that all total PAH runoff load adsorbs to sediment, and thus total PAH concentrations in sediment loads are equivalent to total PAH concentrations originating from runoff and atmospheric wet and dry deposition within the watershed.

Equation 5-1 presents the mass balance model that estimates the existing total PAH concentration in the Smith River sediment.

$$\frac{\sum L_{PAH}}{\sum L_S} = C_{PAH} \qquad \textbf{(Equation 5-1)}$$

Where

L_{PAH} = Total PAH load in sediment (kg)
L_S = Total Runoff sediment load (kg)
C_{PAH} = Total PAH concentration in sediment

5.2.1 Estimation of Total PAH Runoff Loads in the Smith River Watershed

In order to estimate the total PAH load originating from urban land uses, published annual loads per area were selected (Novotny, 2003). **Table 5-2** depicts the literature total PAH unit loads for urban land uses and **Table 5-3** shows the selected annual total PAH for each urban land use category in the Smith River. Since the land use categories for the published values and the Smith River (based on National Land Cover Data 2001) are different, the published area unit concentrations for each urban land use in the Smith River were combined. For high intensity developed area, it was assumed that the area unit concentration would consist of 20 percent from highway, 40 percent from heavy industrial lands, and 40 percent from commercial. For medium and low intensity developed lands, an average from commercial and residential lands was assigned. For developed open space, an area unit load from residential was selected. The existing stormwater load from the facilities holding general permits was calculated using total runoff area and literature total PAH unit loads for urban areas by Novotny (2003). Since there is little PAH related information on the stormwater runoff area of the industrial stormwater permitted facilities, it was assumed a stormwater runoff area of 13.4 acres for each facility and the stormwater areas consist of 95 percent commercial and 5 percent heavy industrial lands. The area, 13.4 acres, is an estimate based upon a random sampling of facilities with known location and respective stormwater runoff areas. VA DEQ staff will continue work to update the General Permit facility areas and outfall coordinates so that in the future all total areas and locations will be incorporated. To account for future growth an expansion factor of 2 was applied.

Table 5- 2: Published Total PAH Concentration per Area (Novotny, 2003)

Land Use Category	Annual published Total PAH (kg/km^2)
Highway	18.1
Heavy industrial lands	8.4
Commercial	0.59
Residential	0.27

Table 5- 3: Total PAH Concentration per urban land use category Used for the Smith River TMDL

Land Use Category in the Smith River	Acres	Km^2	Annual Total PAH (kg/km^2)	Annual Total PAH (kg) in the Smith river
High Intensity Developed	284*	1.15	7.216	8.29
Medium Intensity Developed	2,215	28.98	0.43	12.46
Low Intensity Developed	7,160	8.96	0.43	3.85
Developed Open Space	18,016	72.91	0.27	19.68
42 permitted Stormwater Facilities	608**	2.46	0.98	5.40
Total	**28,283**	**114.46**	**N/A**	**49.68**

*The total acreage for high intensity developed was reduced by the permitted acreage from industrial stormwater facilities and stormwater for DuPont
** Based upon VA DEQ regional adjusted 2007 permit data (facilities are in general permit review status, currently).

5.2.2 Estimation of Sediment Loads in the Smith River Watershed

The existing water quality conditions in the benthic impaired segment are affected by total PAH loads draining from the upstream part of the watershed as well as land-base loads draining from within the impaired segment. The next stage in the development of this TMDL consists of estimating the total sediment loads draining from the upper watershed as well as the land-based loads within the impaired segment. The sediment load for the Smith River watershed is composed of sediment load from rural runoff, urban runoff, and instream erosion. The sediment load from rural runoff was determined using the Generalized Watershed Loading Functions (GWLF) model. The sediment load from urban runoff was based on published literature sediment unit loads per area (Horner et al., 1994, Shaver et al., 2007) and the instream erosion was computed using a published spatial technique (Evans et al., 2003).

5.2.2.1 GWLF Model Description

For the purpose of TMDL development, annual sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model. GWLF is a time variable model that simulates hydrology and sediment loadings on a watershed basis. Observed daily precipitation data is required in GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is calculated using a lumped parameter for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Erosion and sediment loading is a function of the land source areas present in the watershed. Multiple source areas may be defined based on land use type, the underlying soils type, and the management practices applied to the lands. Sediment loadings from each source area are summed to obtain a watershed total. The Universal Soil Loss Equation (USLE) is used to compute erosion for each source area and a sediment delivery ratio is applied to determine the sediment loadings to the stream (USLE, Wischmeier and Smith, 1978), and is expressed as:

$$A = R\ K\ LS\ C\ P$$

Where:

A =Average annual soil loss in tons per acre per year
R =Rainfall/runoff erosivity
K =Soil erodibility
LS = Field slope length and steepness
C =Cover/management factor
P =Conservation practice factor

The R factor is an expression of the erosivity of rainfall and runoff in the area of interest; the R factor increases as the amount and intensity of rainfall increases. The K factor represents the inherent erodibility of the soils in the area of interest under standard experimental conditions. The K factor is expressed as a function of the particle-size distribution, organic-matter content, structure, and permeability of the soils. The LS factor represents the effect of topography, specifically field slope length and steepness, on rates of soil loss at a particular site. The LS factor increases with field slope length and steepness due to the resulting accumulation and acceleration of surface runoff as it flows down slope. The C factor represents the effects of surface cover and roughness, soil biomass, and soil-disturbing activities on rates of soil loss at the area of interest. The C factor decreases as surface cover and soil biomass increase. The P factor represents the effects of supporting conservation practices, such as contouring, buffer strips, and terracing, on soil loss at the area of interest.

5.2.2.2 Instream Erosion

Instream erosion in the Smith River was calculated using a spatial technique developed by Evans et al. (2003) that estimates streambank erosion based on watershed characteristics. Using this method, a watershed-specific lateral erosion rate (LER) was calculated as follows:

$$LER = aQ^{0.6}$$

Where:

LER = an estimated lateral erosion rate, expressed as meters per month
a = an empirically-derived "erosion potential factor"
Q = monthly stream flow, expressed as cubic meters per second.

The *'a'* factor is computed based on a wide variety of watershed parameters including the fraction of developed area of the watershed, average field slope, mean soil erodibility (K factor), average curve number value, and the mean livestock density for the watershed.

$$a = (0.00147*PD) + (0.000143*AD) + (0.000001*CN) + (0.000425*KF) + (0.000001*MS) - 0.00016$$

Where:
PD = fraction developed land
AD = animal density measured in animal equivalent units/acre
CN = area-weighted runoff curve number value
KF = area-weighted K factor
MS = mean field slope

The fraction of developed land in the Smith Run watershed was obtained from 2001 NLCD data. The mean soil erodibility K factor and mean field slope of the watershed were computed from the STATSGO database. The average watershed curve number was developed based on curve numbers applied in the GWLF model.

LER values were calculated using predicted stream flow from the GWLF model. Monthly sediment loads from streambank erosion (kg/month) were then calculated as the product of the LER (meters/month), total stream length (meters), average streambank height (meters), and average soil bulk density (kg/m^3). The total stream length for the Smith River was obtained from the National Hydrography Dataset (NHD). Mean soil bulk density was obtained from the STATSGO database. Annual sediment loads from streambank erosion were computed as the summation of monthly loads.

5.2.2.3 GWLF Model Setup

GWLF model simulations were performed from April 2004 through March 2008. The five year simulation period accounts for both seasonal and annual variations in hydrology and sediment loading. Model simulations were performed using BasinSim 1.0, which is a windows interface program for GWLF. BasinSim 1.0 facilitates the creation of model input files and the processing of model results.

Weather Data

Daily precipitation and temperature data collected at the Martinsville Filtration Plant in Martinsville, VA for the period of April 2004 through March 2008 were obtained from the National Climatic Data Center (NCDC, 2008). The weather station, located within the Smith River watershed, provided a complete data set for temperature and precipitation.

Model Input Parameters

In addition to weather data, GWLF requires specification of input parameters relating to hydrology, erosion, and sediment yield. In general, Appendix B of the GWLF manual (Haith et al., 1992) served as the primary source of guidance in developing input parameters.

Runoff curve numbers and USLE erosion factors are specified as an average value for a given source area. The land use types present in the watershed (**Table 5-4**) were used to define model source areas (water and wetland areas were not included in the model). As necessary, GIS analyses were employed to obtain area weighted parameter values for each given source area.

Table 5- 4: Land Use within the Smith River Watershed

General Land Use Category	Specific Land Use Type	Acres
Developed	High Intensity Developed	892
	Low Intensity Developed	7,160
	Medium Intensity Developed	2,215
	Developed Open Space	18,016
Agriculture	Cultivated Crops	523
	Pasture/Hay	37,833
Forest	Deciduous Forest	216,495
	Evergreen Forest	39,005
Other	Grassland (not used in agriculture)	6,125
	Scrub/Shrub	4,499
	Barren Land	138
	Total	**332,901***

***Water and Wetland are not included.**

Runoff curve numbers were developed for each model source area in the watershed based on values published in the NRCS Technical Release 55 (NRCS, 1986). STATSGO GIS coverages were analyzed to determine the dominant soil hydrologic groups for each model source area. Evapotranspiration cover coefficients were developed based on values provided in the GWLF manual (Haith et al., 1992) for each model source area. Average watershed monthly evapotranspiration cover coefficients were computed based on an area weighted method. Initialization and groundwater hydrology parameters were set to default values recommended in the GWLF manual.

USLE factors for soil erodibility (K), length-slope (LS), cover and management (C), and supporting practice (P) were derived from multiple sources based on data availability. Average KLSCP values for model source areas were determined based on GIS analysis of soils and topographic coverage and literature review. The rainfall erosivity coefficient was determined from values given in the GWLF manual. The sediment delivery ratio was computed directly in BasinSim.

In BasinSim, developed lands include impervious surfaces that are not subject to soil erosion. Rather, sediment loads from developed lands result from the buildup and washoff of solids deposited on the surface. Therefore, sediment loads from developed lands were not modeled using the USLE. Instead, sediment loads from developed lands were computed based on typical loading rates from developed lands (Horner et al., 1994, Shaver et al., 2007). **Table 5-5** shows the sediment loading rates used in this TMDL.

Table 5- 5: Sediment Loading Rates for Developed Land in the Smith River Watershed

Developed Lands	TSS (lb/ac-yr)*	TSS (kg/ha-yr)
Developed, Low intensity	65	73
Developed, Med Intensity	250	280
Developed, High Intensity	420	471
Developed, Open Space	3	3

*Based on literature values: Fundamentals of Urban Runoff Management (Horner et al., 1994, Shaver et al., 2007)

5.2.2.4 Sediment Load Estimates

The GWLF model was used to estimate land-based average annual sediment loadings from rural land based using a five-year simulation period (2004 through 2008). Sediment loading rates, shown in **Table 5-5**, were used to estimate land based average annual sediment loading from developed land. Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al. (2003), as described in Section 5.2.2.2. The results are presented **Table 5-6.** The total existing sediment load in the Smith River watershed is 27,273,995 kilograms per year.

Table 5- 6: Smith River Average Annual Sediment Loadings (kg/yr)

Source	Average Annual Sediment Loading (kg/year)
Urban Areas (Low, medium, high intensity, open space)[1]	11,449,360
Rural (Pasture, Crop)[2]	15,167,890
Instream Erosion[3]	656,745
Total	**27,273,995**

[1] Based on results from GWLF; no sediment runoff from forest and other land uses.
[2] Based on literature values: Fundamentals of Urban Runoff Management (Horner et al., 1994, Shaver et al., 2007); Table 5-5.
[3] Based on a spatial technique developed by Evans et al. (2003)

5.3 Existing Total PAH Concentration and Load for the Smith River

As discussed in previous sections, the existing total PAH concentration in sediment is calculated using the mass balance model (**Equation 5-1**). An existing total PAH concentration of 1.82 mg/kg was calculated. The identified endpoint of 1.61 mg/kg corresponds to the allowable load of 43.9 kg/year for total PAH in sediment. The required reduction is 12 percent and based on the difference between the existing total PAH load of 50 kg/year (Section 5.2.1) and the allowable total PAH load of 43.9 kg/year.

6.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Total Polycyclic Aromatic Hydrocarbons (PAH) in sediment was identified as the most probable stressor to the benthic community in the Smith River impaired watershed. The endpoint selected by VA DEQ for the Smith River benthic TMDL is the Threshold Effect Concentration (TEC) for total PAH, 1.61 mg/kg. Reduction of Total PAH loading in sediment of the benthic impaired segment to the endpoint estimated for the watershed is expected to restore support of the aquatic life use for the Smith River.

6.1 Basis for TMDL Allocations

TMDL allocations for the benthic impaired Smith River watershed were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:
TMDL= Total Maximum Daily Load
WLA = Wasteload Allocation
LA = Load Allocation
MOS = Margin of Safety

The wasteload allocation represents the total PAH loading in sediment allocated to point sources. The load allocation represents the total PAH loading in sediment allocated to non-point sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

6.1.1 Margin of Safety

The margin of safety (MOS) is a required component of the TMDL, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. According to EPA guidance (EPA, 1991), the MOS can be incorporated into the TMDL using two methods:

- Implicitly incorporating the MOS using conservative model assumptions to develop allocations; or
- Explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS will be implicitly incorporated into this TMDL. Implicitly incorporating the MOS requires that allocations meet the Threshold Effect Concentration (TEC) of 1.61 mg/kg.

6.1.2 Wasteload Allocation

Wasteload allocation (WLA) for total PAH in sediment was applied to the 42 general permitted facilities located in the Smith River watershed. There are no MS4 areas located in the Smith River watershed. The existing stormwater load from the facilities holding general permits was calculated using total runoff area and literature total PAH unit loads for urban areas by Novotny (2003). Since there is little PAH related information on the stormwater runoff area of the industrial stormwater permitted facilities, it was assumed a stormwater runoff area of 13.4 acres for each facility and the stormwater areas consist of 95 percent commercial and 5 percent heavy industrial lands. The area, 13.4 acres, is an estimate based upon a random sampling of facilities with known location and respective stormwater runoff areas. VA DEQ staff will continue work to update the General Permit facility areas and outfall coordinates so that in the future all total areas and locations will be incorporated. To account for future growth an expansion factor of 2 was applied to calculate the WLA. The existing, aggregated allocated total PAH load and the required reduction are shown in **Table 6-1**. At this phase of the TMDL, the WLA is aggregated, however, depending on new information during the second phase, WLA may be disaggregated and individual WLAs assigned to the individual facilities.

Table 6- 1: Aggregated Waste Load Allocation for the Smith River						
Point Source*	**Facility Name***	**Existing Total PAH (kg/day)**	**Expansion for Future Growth** (2X of existing facilities' load) **(kg/day)**	**Total Load (kg/day)**	**Allowable Load (kg/day)**	**Percent Reduction**
VAG840056	Boxley Materials Company - Horsepasture Plant	0.005	0.010	0.015	0.013	12%
VAG840057	Boxley Materials Company - Fieldale Plant					
VAG842017	Boxley Materials Company - Fieldale Plant					
VAR050001	CPFilms Inc					
VAR050040	Virginia Mirror Co Inc					
VAR050128	Bassett Chair Company					
VAR050129	Bassett Fiberboard Plant					
VAR050136	Bassett Superior Lines					
VAR050137	BFI Bassett					
VAR050164	Stanley Furniture Co Inc - Martinsville					
VAR050165	American Furniture Company Inc - Redd Level					
VAR050197	Henry County Plywood Corporation					
VAR050199	Hooker Furniture Corporation - Panel Plant					
VAR050200	Hooker Furniture Corporation - Martinsville					
VAR050215	Chatham Oil Company					
VAR050216	First Piedmont Corp					
VAR050248	Pine Products Incorporated					
VAR050249	Smurfit Stone - Martinsville					
VAR050254	American Standard Building Systems Inc					
VAR050445	Georgia Pacific Corrugated I LLC					
VAR050455	Ridgeway Furniture					
VAR050501	Gravely Auto Sales & Recycling					
VAR050523	Southern Finishing Company Inc					
VAR050532	Stanley Furniture Co Inc - Stanleytown					
VAR050721	Quikrete - Martinsville					
VAR050746	Martinsville Concrete Products Inc					
VAR050751	Griffith Lumber Co Inc					
VAR050752	DeShazo Oil Co Inc					
VAR050758	W-L Construction and Paving Inc - Fieldale					
VAR051003	W Henry Hardy Inc - Martinsville					
VAR051260	Blue Ridge Solvents and Coatings Incorporated					
VAR051279	Nelson Auto Salvage					
VAR051473	Smart Machine Technologies Inc					
VAR051544	Springs Global US - Martinsville Plant					
VAR051576	Cycle Systems Inc - Martinsville					
VAR051604	MasterBrand Cabinets Incorporated					
VAR051623	Bassett Mirror Company Inc - North Bassett Plant					
VAR051662	DuPont					
VAR051716	Tri State Foam Products					
VAR051728	Adams Construction Co - Horsepasture Drum Plant					
VAR051736	A and B Used Parts					
VAR051747	Swing Transport Incorporated					

* Based upon VA DEQ regional adjusted 2007 permit data (facilities are in general permit review status, currently).

6.1.3 Load Allocation

Load allocations for Total PAH in sediment were applied to urban land uses that are not included in the WLA. **Table 6-2** shows the existing, allocated load, and required reduction for Total PAH in the Smith River watershed.

Table 6- 2: Load Allocation for the Smith River			
Source	Existing Total PAH	Allocated Total PAH	Percent Reduction
	kg/day	kg/day	
Urban Land (Low, medium, high intensity, open space)*	0.121	0.107	12%
*Excluding the area from general permitted facilities located in the Smith River watershed			

6.2 Overall Recommended TMDL Allocations

The TMDL load, load allocation, wasteload allocation, and margin of safety for Total PAH in sediment for the Smith River are summarized in **Table 6-3**.

Table 6- 3: Overall Recommended TMDL Allocations for Total PAH in Sediment for the Smith River (kg/day)			
TMDL	Wasteload Allocation	Load Allocation	Margin of Safety (MOS)
0.120	0.013	0.107	Implicit

6.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of the Smith River, the GWLF model was run for a multi-year period to insure that the TMDL development accounts for a wide range of environmental conditions including dry- and wet-weather conditions.

6.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and sediment loading as a result of hydrologic and climatologic patterns. Seasonal variations were explicitly incorporated in the modeling approach for this TMDL. GWLF is a continuous simulation model that incorporates seasonal variations in hydrology and sediment loading by using a daily time-step for water balance calculations. Therefore, the 5 year simulation performed with GWLF adequately captures seasonal variations.

7.0 TMDL Implementation

Once a TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources in the stream (see section 7.4.2). For point sources, all new or revised VPDES/NPDES permits must be consistent with the TMDL WLA, which includes a set aside for future growth, pursuant to 40 CFR 122.44 (d)(1)(vii)(B) and must be submitted to EPA for approval. The measures for non point source reductions, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.virginia.gov/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

7.1 Reasonable Assurance for Implementation

7.1.1 Regulatory Framework

The Commonwealth of Virginia intends to use existing regulations and programs to implement the benthic TMDL for the Smith River. The regulatory framework gives reasonable assurance that the TMDL endpoint for benthic TMDL is not exceeded in the Smith River. Toxicity due to elevated concentrations of total PAH in sediment was determined to be the cause of the impairment in the Smith River based on the available observed data. Toxicity has been detected in several sections of the Smith River, particularly downstream of Martinsville Dam. Although several industrial facilities in the watershed are no longer active, pollutants discharged from these facilities may have accumulated in the river sediments. In addition, a comparison of PAH isomer ratios using recent data has indicated that urban runoff is a dominant source of total PAH. Urban runoff includes stormwater runoff from the deposition of pyrogenic PAH coumpounds, fossil fuel combustion products, onto various surfaces (example: motor vehicles emission particulates on roadways/pavement).

Natural attenuation and best management practices (BMP) for the urban runoff are considered appropriate actions to meet the TMDL target. Natural attenuation includes the natural processes of photo- and bio-degradation (decay) and burial of total PAH in sediment. BMPs include practices that filter sediments and their attached PAH toxins from urban runoff (e.g. fossil fuel leaks/spills, incomplete combustion of biomass or fossil fuels, and fossil fuel based asphalt sealants).

7.1.2 Phased TMDL Monitoring Plan

Additional data collection is necessary to support the PAH stressor and/or identify other potential stressors to the benthic macroinvertebrate community. Given the current budget climate, funding for additional sampling is not guaranteed however; the preliminary sampling plan discussed below was designed to fill in current gaps in the dataset and will be prioritized and implemented as funding permits.

Toxicity testing:

1. Toxicity monitoring to evaluate current loading from point source(s).
2. Instream water column chronic toxicity testing at VA DEQ monitoring stations 4ASRE033.19, 4ASRE031.00, 4ASRE026.38, 4ASRE024.30, 4ASRE022.90, 4ASRE022.30, 4ASRE019.00, and 4ASRE015.43.

Physical, Chem., Toxins (PAH, others, etc):

1. Grab sediment (and potentially grab water) samples at toxicity testing sites. Samples will be held and analysis will depend upon the results of the toxicity tests. If toxicity is demonstrated, then follow up with appropriate chemistry testing. Sediment toxicity tests should take precedent over water test – if available funding would also recommend water tests.

2. Evaluate critical flow and change in temperature condition(s): continual monitoring in USGS gage station below Martinsville Dam, (required flow from calibrated pressure transducer, water temperature with minimum 15 minute interval data for one or more years. Additional probes not required, but may be added for turbidity, specific conductivity, pH, other). This would be used to help support more accurate the Instream Waste Concentration (IWC) for Martinsville STP permitting.
3. Monitor PAH in sediment at appropriate sampling locations distributed from NC state line, upstream to Fieldale station in order to delineate PAH gradient. Proposed sediment PAH sampling stations include: VA DEQ monitoring stations 4ASRE033.19, 4ASRE031.00, 4ASRE026.77 (upstream of Martinsville Dam), 4ASRE026.38, 4ASRE024.30, 4ASRE022.90, 4ASRE022.30, 4ASRE020.75, 4ASRE019.00, VA DEQ will create a new station at river mile 16 (approximately), 4ASRE015.43, 4ASRE011.08, 4ASRE007.09, and VA DEQ will create new station at river mile 5 (approximately).

Benthics:

1. VA DEQ will continue monitoring benthic macroinvertebrates and evaluate habitat coincidentally with toxicity testing and sediment testing at selected sites.
2. VA DEQ will continue monitoring benthic macroinvertebrates and evaluate habitat at VA DEQ monitoring station 4ASRE033.19, 4ASRE031.00, 4ASRE024.30, 4ASRE022.90, 4ASRE022.30, 4ASRE019.00, and 4ASRE015.43 once in the spring and once in the fall.

7.1.3 Schedule to Complete TMDL Development:

The above monitoring plan should be completed in one year, twelve months from May 1, 2010. Additional time until November 1, 2011 (through month eighteen) is allowed for completion of analyses, and reporting of results. The results should be evaluated and the Smith River Phased Benthic TMDL development should be completed and the report modified or amended to represent new information, and submitted to EPA for approval as a final TMDL, within two years (i.e. by May 1, 2012).

8.0 Public Participation

The development of the Smith River Benthic TMDL would not have been possible without public participation, which included two public meetings and three Steering Committee meetings held in Collinsville, Virginia. Email invitations were sent out prior to the public meetings. Meeting information was also posted on local Community Calendar web pages. The public notices for the meetings were also posted in the Virginia Register and signs displayed meeting date, time and location information at bridges throughout the watershed. The following is a summary of the meetings.

Public Meeting #1. This meeting was held on August 8th, 2007 at Henry County Administrative Building in Collinsville, Virginia. Copies of the presentation were available for public distribution.

Public Meeting #2. This meeting was held on March 29th, 2010 at Henry County Administrative Building in Collinsville, Virginia. Copies of the presentation were available for public distribution.

Steering Committee Meeting #1: This meeting was held on May 30th, 2007 at Henry County Administrative Building in Collinsville, Virginia. A meeting handout and copies of the presentations were distributed to attendees.

Steering Committee Meeting #2: This meeting was held on January 29th 2008 at Henry County Administrative Building in Collinsville, Virginia. A meeting handout and copies of the presentations were distributed to attendees.

Steering Committee Meeting #3: This meeting was held on March 29th, 2010 at Henry County Administrative Building in Collinsville, Virginia. A meeting handout was distributed to attendees and copies of the presentation were available for download on DEQ's website.

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APPENDIX A: VSCI Trend Analysis

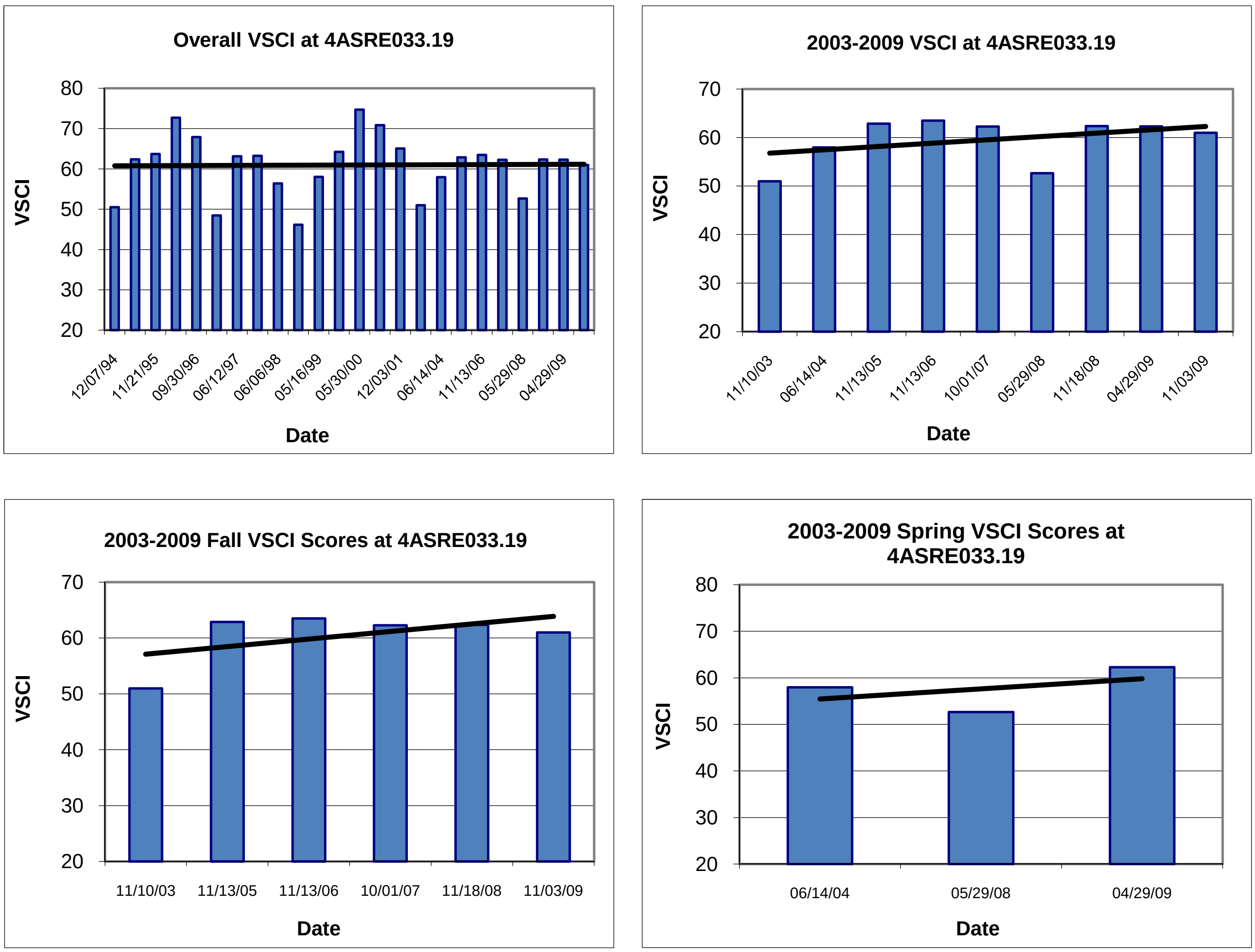

Figure A-1. VSCI Trend Analysis for Station 4ASRE033.19

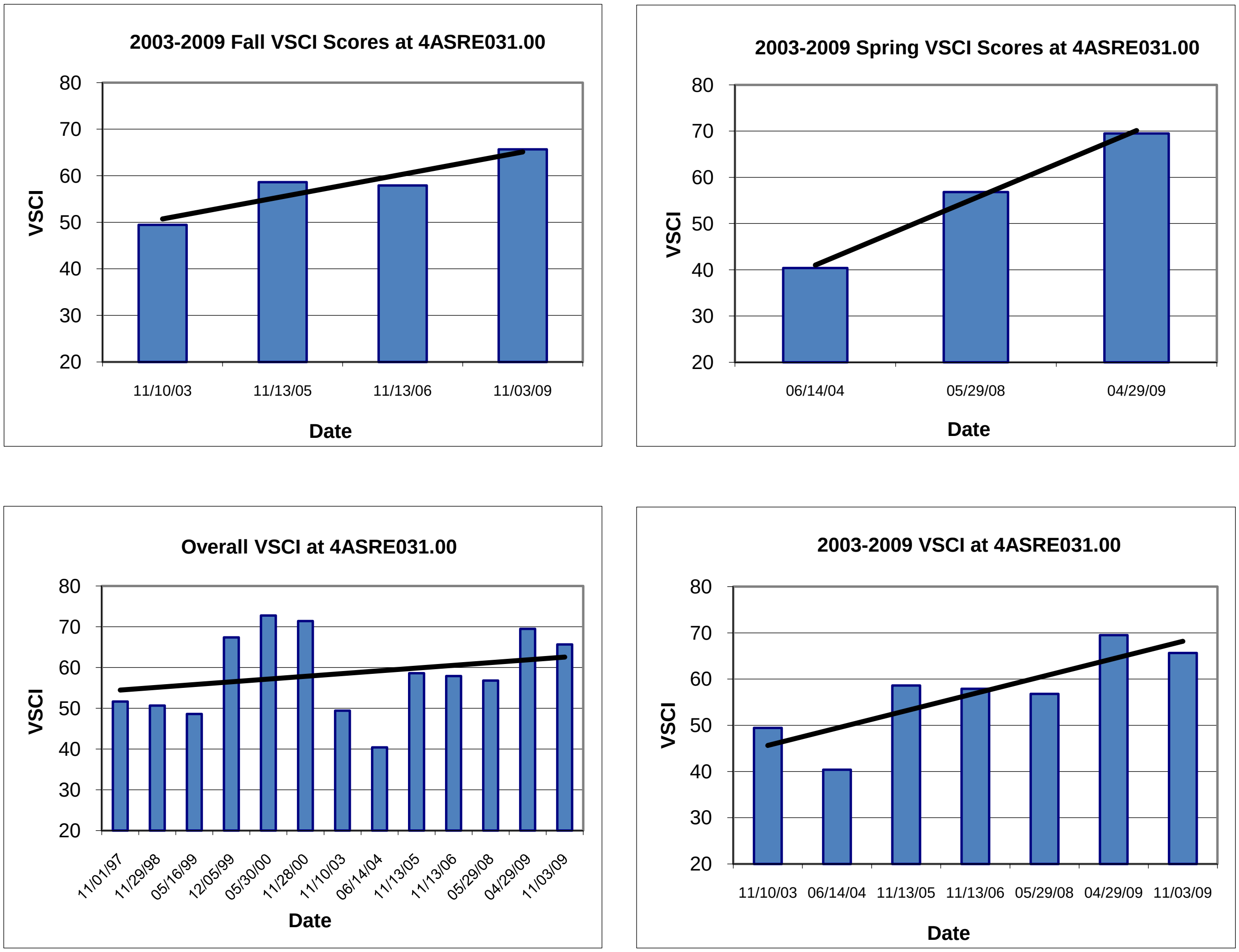

Figure A-2. VSCI Trend Analysis for Station 4ASRE031.00

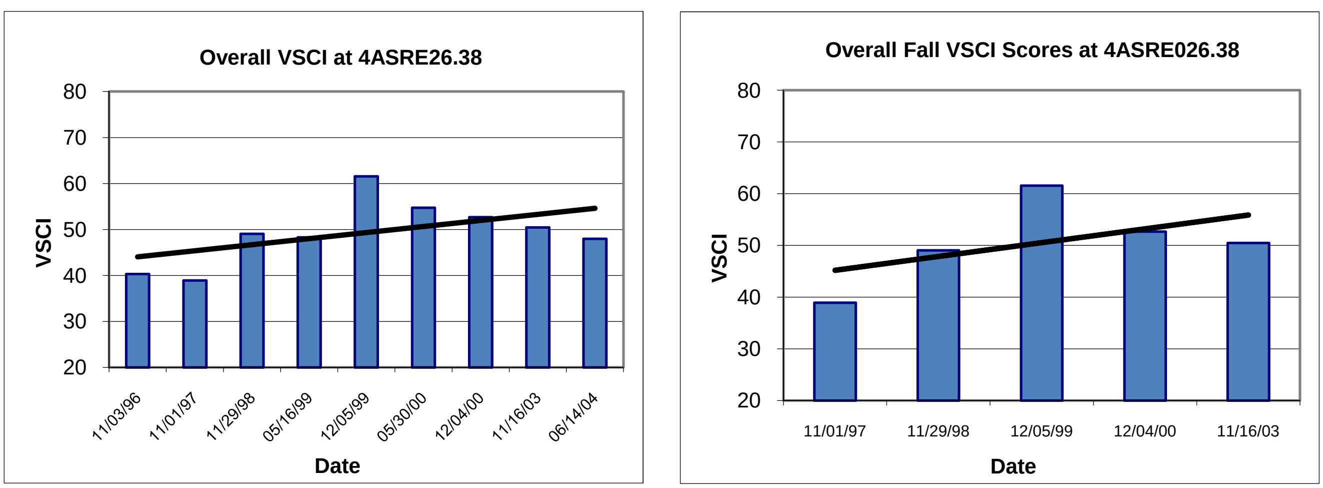

Figure A-3. VSCI Trend Analysis for Station 4ASRE026.38

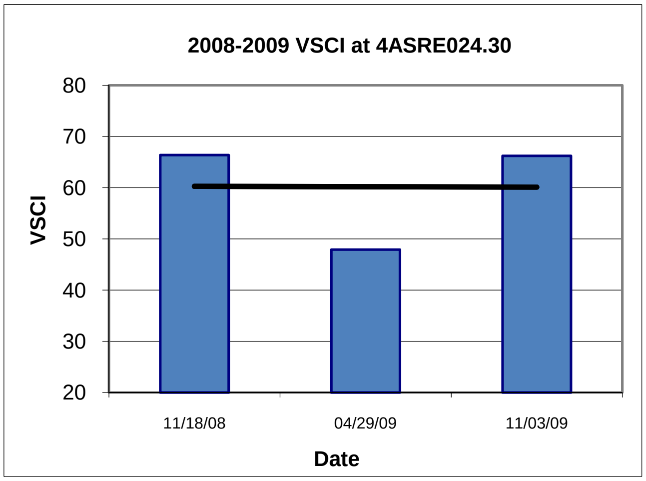

Figure A-4. VSCI Trend Analysis for Station 4ASRE024.30

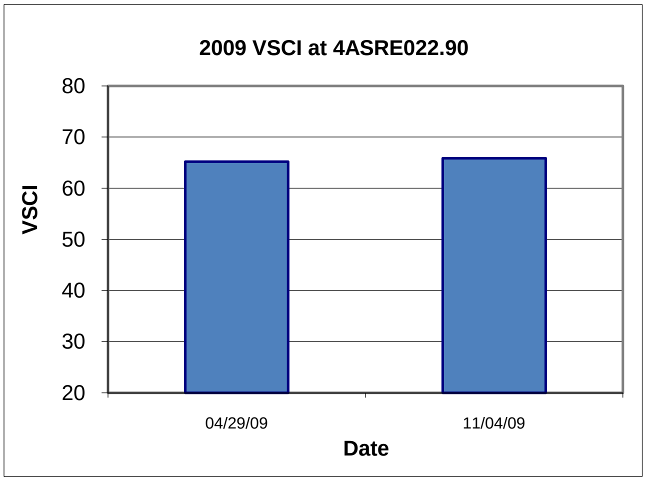

Figure A-5. VSCI Trend Analysis for Station 4ASRE022.90

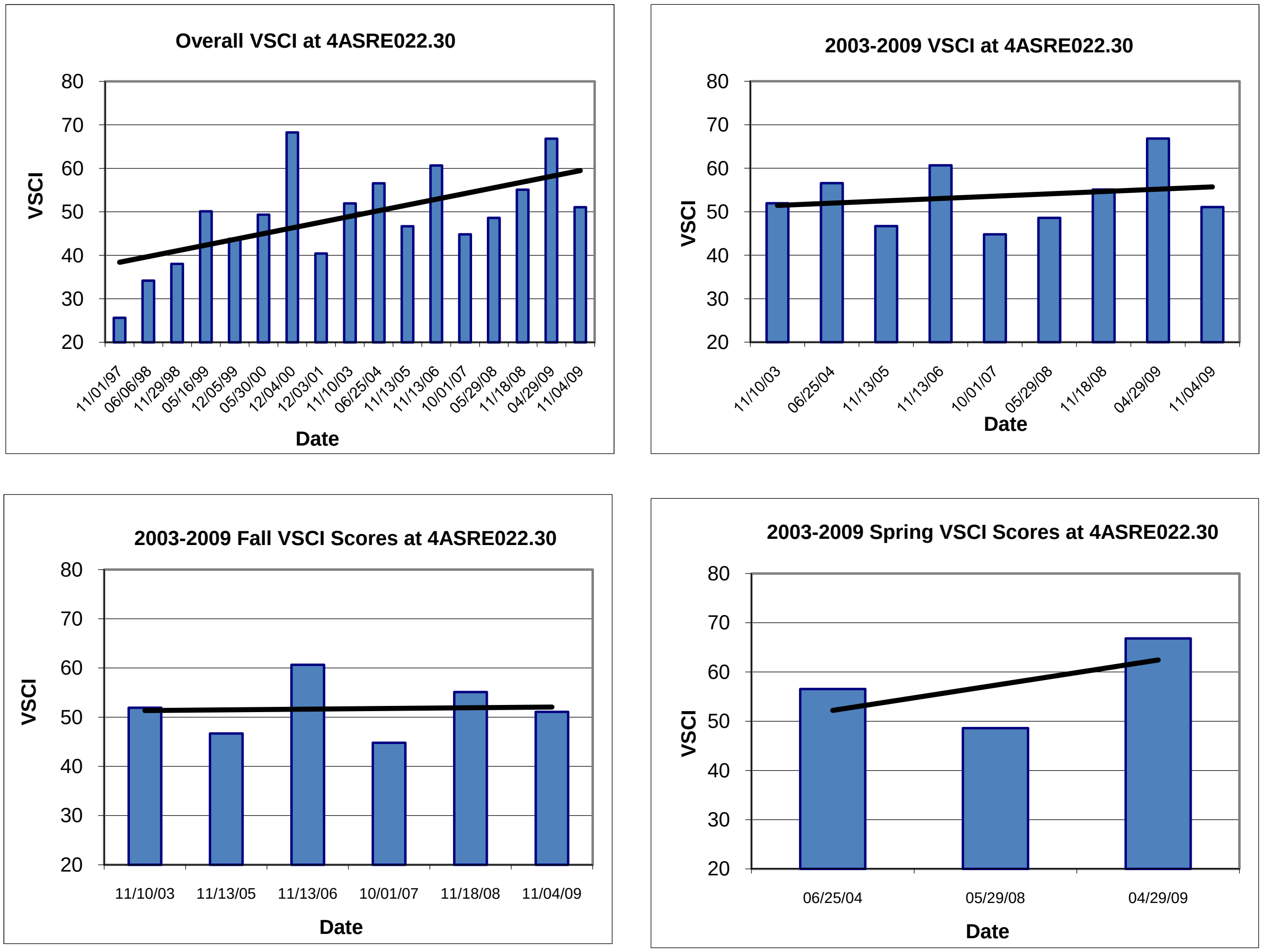

Figure A-6. VSCI Trend Analysis for Station 4ASRE022.30

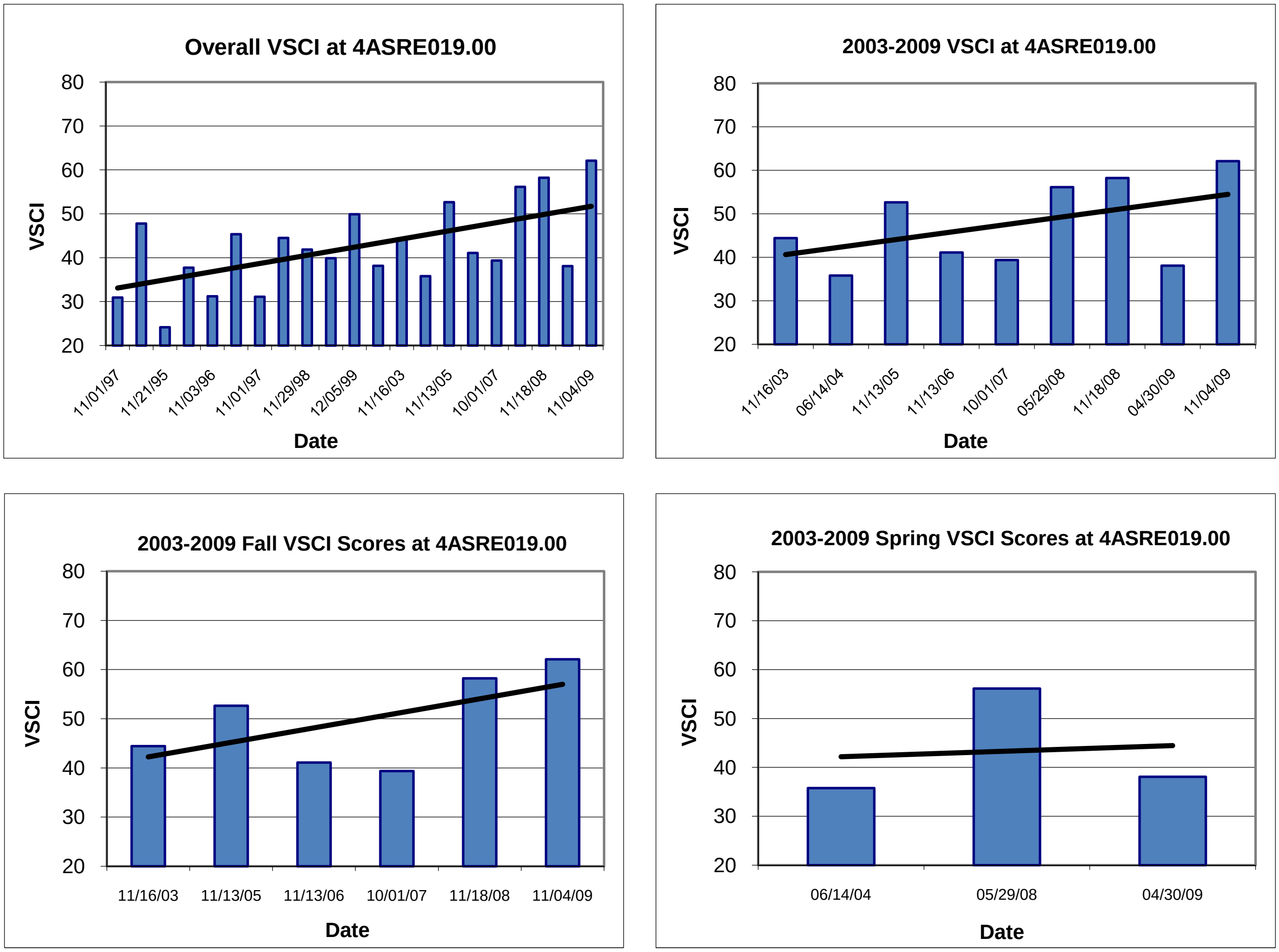

Figure A-7. VSCI Trend Analysis for Station 4ASRE019.00

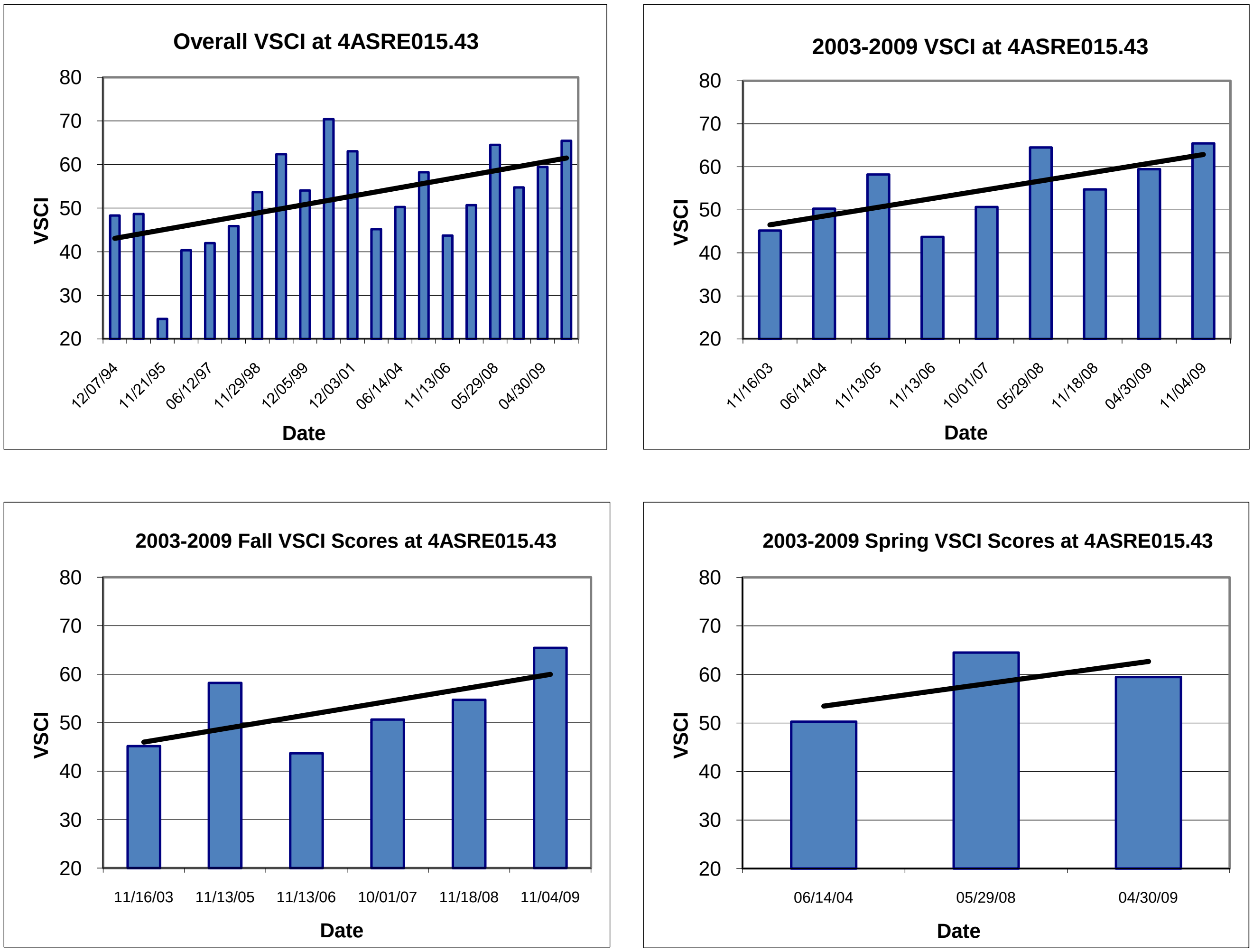

Figure A-8. VSCI Trend Analysis for Station 4ASRE015.43

APPENDIX B: Water Quality Data

Table B-1: Summary of Instream Water Quality Data Collected in the Benthic Impaired Segment of the Smith River (1996 through 2007) at Stations 4ASRE026.27 and 4ASRE22.71

Station ID		4ASRE026.27				4ASRE022.71			
Parameter	Units	No of Samples	Min	Max	Avg	No of Samples	Min	Max	Avg
Temperature	°C	21	4.40	21.60	12.65	65	4.10	23.50	13.28
DO	mg/L	20	8.20	15.20	10.86	65	7.20	12.80	10.21
Field pH		21	7.25	8.10	7.65	65	6.45	8.80	7.50
Spec. Conductance	µmhos/cm	21	54.00	250.00	81.92	64	42.00	132.00	76.69
Chloride	mg/L	-	-	-	-	64	3.70	21.40	8.45
Turbidity	FTU	-	-	-	-	64	2.58	287.00	18.17
Turbidity	NTU	21	3.15	25.50	7.77	-	-	-	-
TSS[1]	mg/L	21	3.00	21.00	7.19	65	3.00	331.00	16.28
VSS[2]	mg/L	-	-	-	-	65	3.00	49.00	4.26
BOD_5	mg/L	-	-	-	-	63	1.00	4.00	1.78
Total NH_3-N	mg/L	21	0.04	0.16	0.05	64	0.04	0.63	0.07
NO_3-N	mg/L	21	0.12	0.54	0.23	64	0.07	0.40	0.20
TN[3]	mg/L	21	0.27	0.77	0.44	64	0.30	2.00	0.63
PO_4-P	mg/L	-	-	-	-	64	0.01	0.20	0.04
TP	mg/L	21	0.01	0.05	0.02	64	0.02	0.96	0.11
Chl*a*[4]	ug/L	-	-	-	-	-	-	-	-

[1] TSS = total suspended solids (= total non-filterable residue)

[2] VSS = volatile suspended solids (= total volatile residue)

[3] combination of measured and computed (TN = TKN + NO3-N + NO2-N) values

[4] Phytoplankton

NTU = Nephelometric Turbidity Units; FTU = Formazin Turbidity Unit

Table B-2: Summary of Instream Water Quality Data Collected in the Benthic Impaired Segment of the Smith River (1996 through 2007) at Stations 4ASRE021.58 and 4ASRE20.75

Station ID		4ASRE021.58				4ASRE020.75			
Parameter	Units	No of Samples	Min	Max	Avg	No of Samples	Min	Max	Avg
Temperature	°C	44	4.30	24.00	14.15	2	15.10	15.84	15.47
DO	mg/L	44	6.90	12.60	9.74	2	9.37	10.51	9.94
Field pH		44	6.42	8.90	7.58	2	6.97	7.33	7.15
Spec. Conductance	µmhos/cm	43	60.00	358.00	135.37	2	86.90	104.00	95.45
Chloride	mg/L	34	5.90	95.50	26.62	-	-	-	-
Turbidity	FTU	9	2.51	78.90	15.36	-	-	-	-
Turbidity	NTU	9	2.51	78.90	15.36	1	8.4	8.4	8.4
TSS[1]	mg/L	44	3.00	316.00	18.61	1	5.00	5.00	5.00
VSS[2]	mg/L	35	3.00	56.00	5.37	1	3.00	3.00	3.00
BOD_5	mg/L	32	2.00	4.00	2.19	-	-	-	-
Total NH_3-N	mg/L	43	0.04	0.57	0.08	1	0.04	0.04	0.04
NO_3-N	mg/L	34	0.23	1.47	0.52	1	0.20	0.20	0.20

Table B-2: Summary of Instream Water Quality Data Collected in the Benthic Impaired Segment of the Smith River (1996 through 2007) at Stations 4ASRE021.58 and 4ASRE20.75

Station ID		4ASRE021.58				4ASRE020.75			
Parameter	**Units**	**No of Samples**	**Min**	**Max**	**Avg**	**No of Samples**	**Min**	**Max**	**Avg**
TN[3]	mg/L	43	0.53	2.52	1.11	1	0.42	0.42	0.42
PO_4-P	mg/L	34	0.02	0.24	0.09	1	0.05	0.05	0.05
TP	mg/L	43	0.03	0.96	0.12	1	0.03	0.03	0.03
Chl*a*[4]	ug/L	-	-	-	-	1	1.42	1.42	1.42

[1] TSS = total suspended solids (= total non-filterable residue)

[2] VSS = volatile suspended solids (= total volatile residue)

[3] combination of measured and computed (TN = TKN + NO3-N + NO2-N) values

[4] Phytoplankton

NTU = Nephelometric Turbidity Units; FTU = Formazin Turbidity Unit

Table B-3: Summary of Instream Water Quality Data Collected in the Benthic Impaired Segment of the Smith River (1996 through 2007) at Stations 4ASRE019.00 and 4ASRE15.43

Station ID		4ASRE019.00				4ASRE015.43			
Parameter	**Units**	**No of Samples**	**Min**	**Max**	**Avg**	**No of Samples**	**Min**	**Max**	**Avg**
Temperature	°C	20	3.50	22.60	14.41	53	3.40	26.00	14.51
DO	mg/L	20	7.90	13.30	10.32	53	7.30	12.90	10.34
Field pH		20	6.90	8.90	7.62	53	6.74	8.90	7.76
Spec. Conductance	µmhos/cm	20	64.00	254.00	89.77	52	67.80	600.00	159.87
Chloride	mg/L	-	-	-	-	33	13.90	147.00	44.92
Turbidity	FTU	-	-	-	-	9	2.56	47.90	16.25
Turbidity	NTU	9	2.17	43.30	13.55	9	2.56	47.9	16.25
TSS[1]	mg/L	9	3.00	25.00	7.67	40	3.00	51.00	10.18
VSS[2]	mg/L	-	-	-	-	34	3.00	12.00	3.79
BOD_5	mg/L	-	-	-	-	33	2.00	3.00	2.03
Total NH_3-N	mg/L	9	0.04	0.04	0.04	43	0.04	0.19	0.06
NO_3-N	mg/L	9	0.32	0.76	0.45	34	0.18	1.01	0.39
TN[3]	mg/L	9	0.46	1.18	0.70	43	0.42	1.92	0.93
PO_4-P	mg/L	-	-	-	-	34	0.03	0.17	0.08
TP	mg/L	9	0.03	0.12	0.06	43	0.03	0.24	0.10
Chl*a*[4]	ug/L	-	-	-	-	-	-	-	-

[1] TSS = total suspended solids (= total non-filterable residue)

[2] VSS = volatile suspended solids (= total volatile residue)

[3] combination of measured and computed (TN = TKN + NO3-N + NO2-N) values

[4] Phytoplankton

NTU = Nephelometric Turbidity Units; FTU = Formazin Turbidity Unit

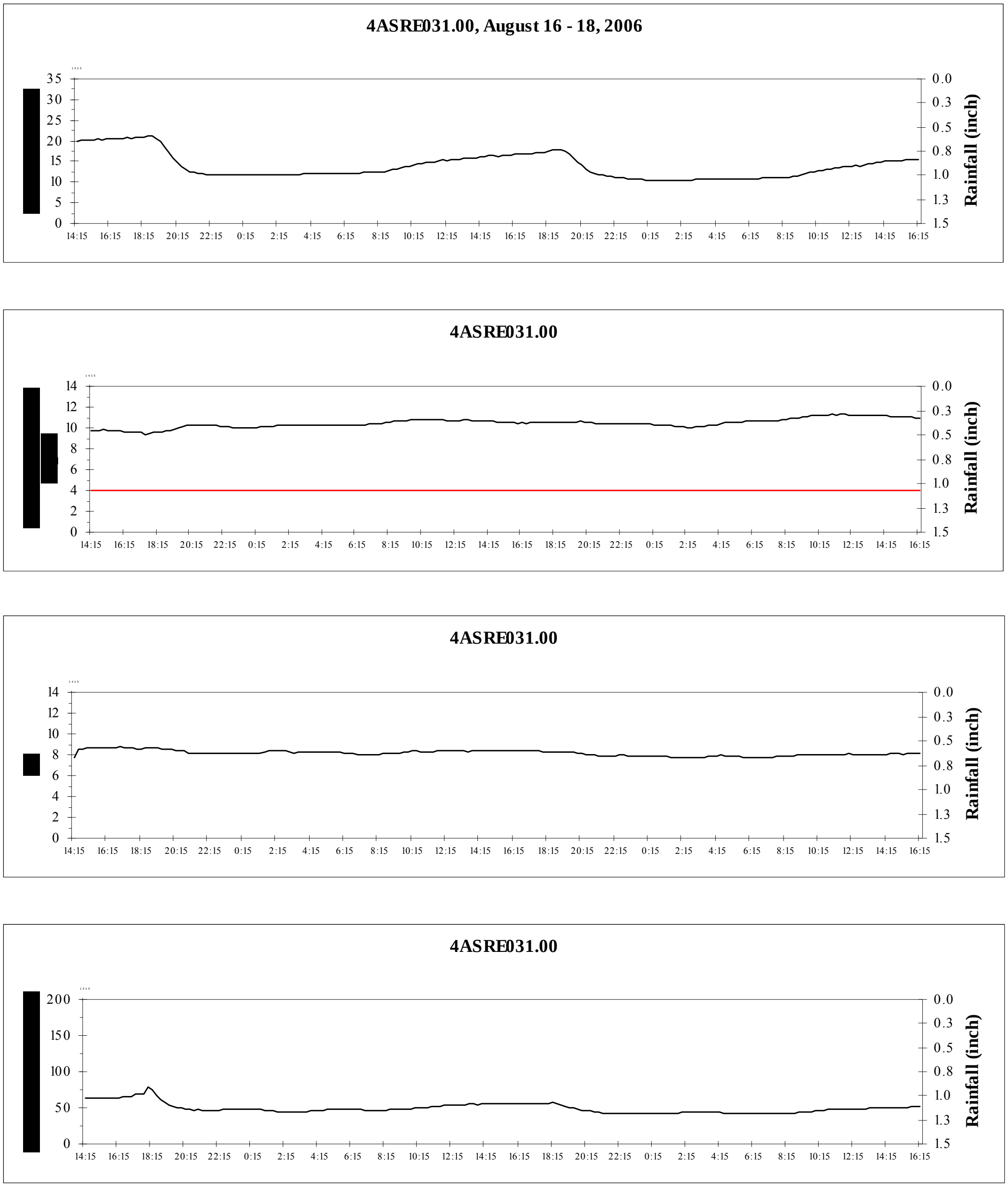

Figure B-1: Continuous Measurements for Temperature, Dissolved Oxygen, pH, and Specific Conductivity at Monitoring Station 4ASRE031.00 (August 16-18, 2006)

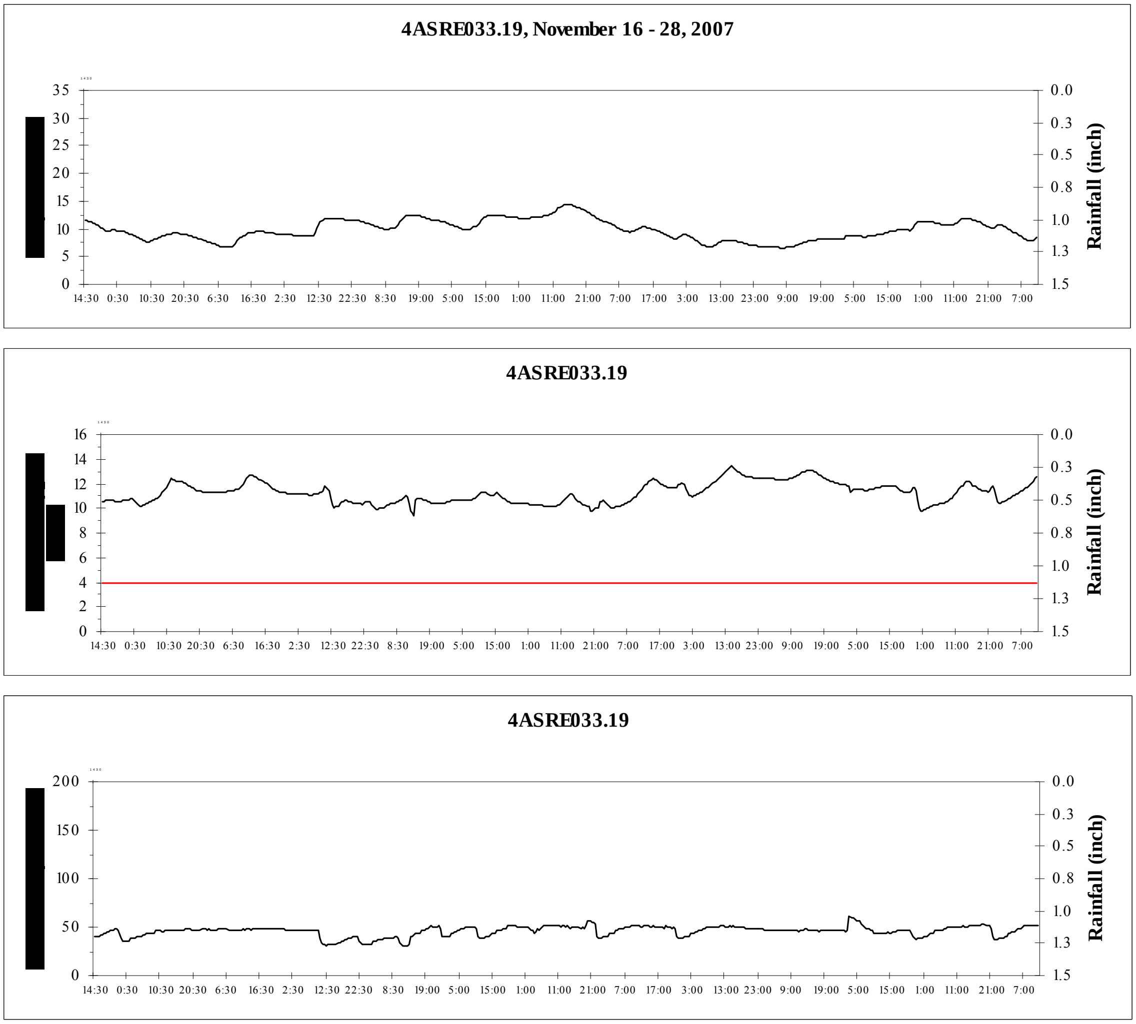

Figure B-2: Continuous Measurements for Temperature, Dissolved Oxygen, and Specific Conductivity at Monitoring Station 4ASRE033.19 (November 16-28, 2007)

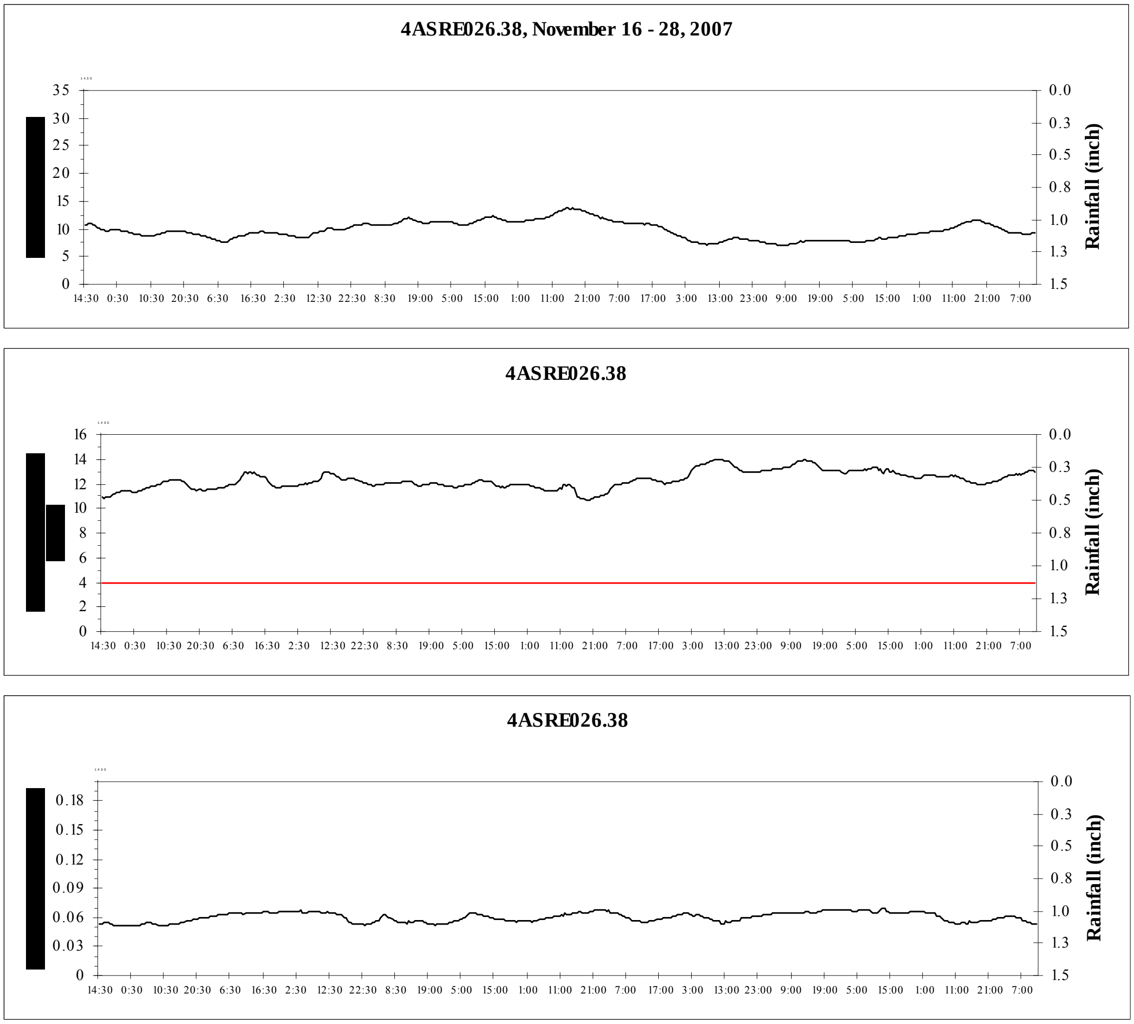

Figure B-3: Continuous Measurements for Temperature, Dissolved Oxygen, and Specific Conductivity at Monitoring Station 4ASRE026.38 (November 16-28, 2007)

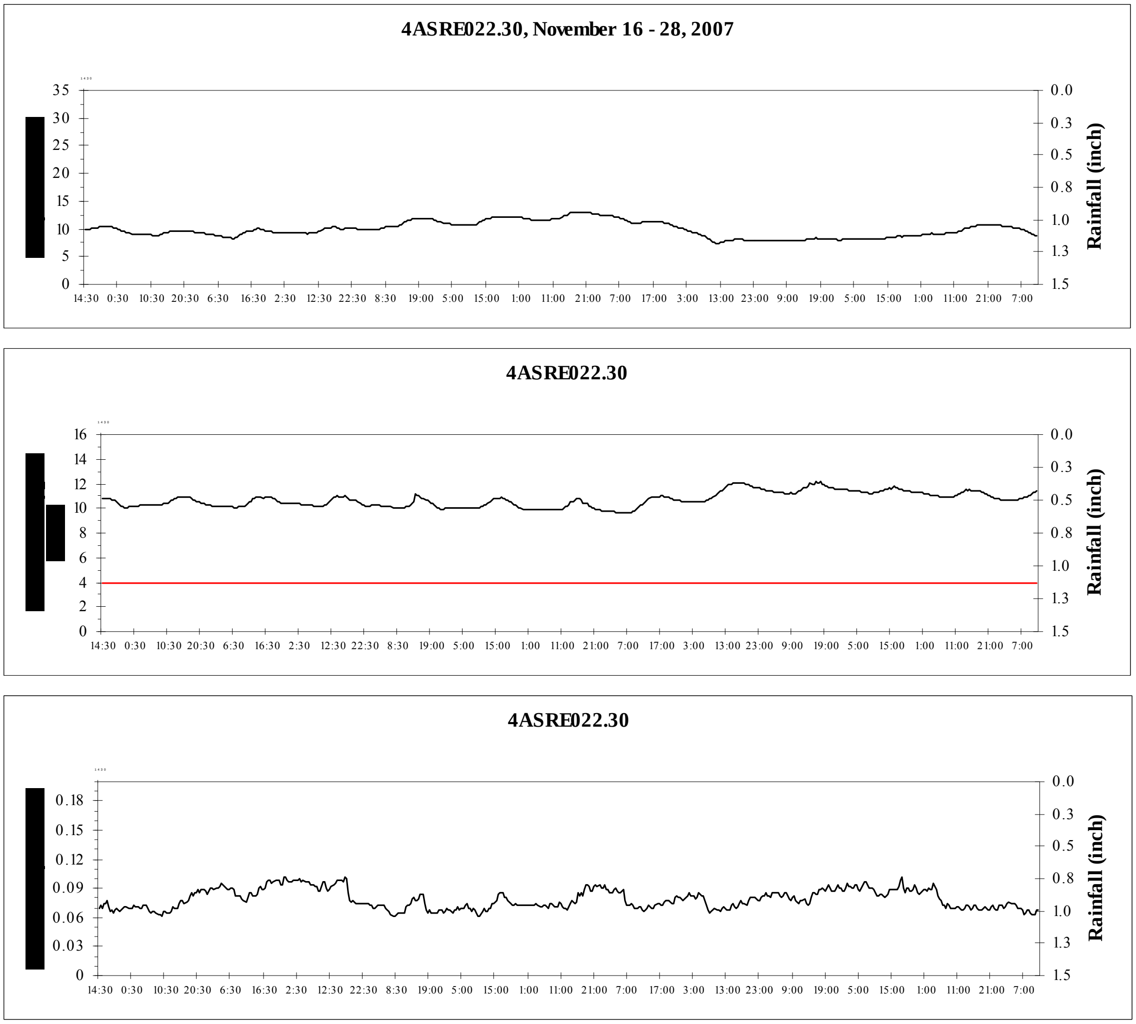

Figure B-4: Continuous Measurements for Temperature, Dissolved Oxygen, and Specific Conductivity at Monitoring Station 4ASRE022.30 (November 16-28, 2007)

APPENDIX C: Sediment and Fish Tissue Data

For the sediment and fish tissue analysis two screening values were chosen as references to indicate toxicity, the consensus based Threshold Effect Concentration (TEC) and Probable Effects Concentration (PEC). The TEC and PEC values were calculated by first identifying the published sediment quality guidelines (SQGs) from various sources (probable effects levels, effect range median values, severe effect levels and toxic effect thresholds) and then determining the geometric means of these SQGs. These consensus based TECs and PECs were calculated only if three or more published SQGs were available for a chemical substance or group of substances. Below is a legend detailing which colors correspond to which screening value exceedances.

Table C-1: Legend for the Smith River Screening Values

Color	Exceeded Screening Value
Red	Threshold Effects Concentration (TEC)
Black (Bold)	Probable Effects Concentration (PEC)

The following tables summarize the sediment and fish tissue analysis for the Smith River from 1996-2002. Note, stations highlighted in grey are within the impaired section of the Smith River:

Table C-2: Sediment Polycyclic Aromatic Hydrocarbons (PAHs) in the Smith River

Compound	Threshold Effects Concentration (TEC)	Probable Effects Concentration (PEC)	4ASRE055.62 (9/8/99) ppb	4ASRE046.90 (9/7/99) ppb	4ASRE033.19 (8/10/09) ppb	4ASRE029.50 (8/14/96) ppb	4ASRE026.77 (8/11/09) ppb	4ASRE026.27 (8/18/99) ppb	4ASRE026.06 (6/13/02) ppb	4ASRE022.30 (8/12/09) ppb	4ASRE019.00 (8/18/99) ppb	4ASRE019.00 (8/12/09) ppb	4ASRE011.08 (9/18/97) ppb	4ASRE007.09 (9/18/97) ppb
Total PAH	**1,610**	**22,800**	40.92	39.34	257.92	**2,214.80**	779.50	528.35	**4,971.29**	86.40	360.17	**2,060.50**	**2,338.60**	1,416.34
High MW PAH		**	28.67	30.71	231.62	1,184.32	684.10	448.16	4,632.28	72.79	318.70	1,649.20	951.13	501.05
Low MW PAH		**	12.25	8.63	26.30	356.45	95.44	80.18	339.02	13.59	41.47	411.34	174.79	41.18
naphthalene	**176**	**561**	2.53	3.12			4.27	4.43	9.15		1.59	13.20	7.42	
2-methylnaphthalene		**	1.05	0.63		30.14	4.27	3.91	12.40		0.41	11.90		4.62
1-methylnaphthalene		**	2.36	0.29				2.48	9.01		0.42			
biphenyl		**	0.18	0.00				0.00	5.85		0.00			
2,6-dimethylnaphthalene		**	0.70	0.49				0.93	7.18		0.20			
acenaphthylene		**	0.14	0.00				0.96	2.17		0.31	4.39		
acenaphthene		**	0.78	0.00				1.24	6.08		0.00	8.15		
2,3,5-trimethylnaphthalene		**	1.72	0.00				1.05	5.32		0.36			
fluorene	**77**	**536**	0.10	0.00				1.43	11.30		1.16	20.70	8.18	
phenanthrene	**204**	**1,170**	1.41	2.57	12.00	129.05	39.90	45.67	202.41	6.31	26.69	161.00	144.50	31.64
anthracene	**57.2**	**845**	0.38	0.35	14.30	**197.26**	47.00	13.36	30.82	7.28	7.69	**192.00**	14.69	4.93
1-methylphenanthrene		**	0.88	1.17				4.73	37.32		2.63		26.11	13.57
fluoranthene	**423**	**2,230**	6.36	4.89	46.20	235.80	134.00	94.52	**497.35**	16.00	82.26	**387.00**	297.05	117.60
pyrene	**195**	**1,520**	3.10	3.34	37.00	**215.23**	108.00	75.20	**442.54**	12.60	64.08	**293.00**	**237.72**	100.43
benz(a) anthracene	**108**	**1,050**	3.55	1.42	31.00	**452.84**	101.00	41.29	**375.09**	11.20	29.87	**169.00**	**128.01**	87.03
chrysene	**166**	**1,290**	4.78	1.71	18.50	159.64	60.50	43.93	**387.65**	6.79	28.25	142.00	156.13	104.36
benzo(b) fluoranthene		**	4.21	1.53	14.80	118.46	66.20	35.14	529.75	4.37	19.10	183.00	114.22	88.32
benzo(k) fluoranthene		**	2.24	1.09	19.00	74.67	53.40	34.95	382.83	6.79	22.88	137.00	119.29	85.34
benzo (e) pyrene		**	1.57	0.57		108.87		22.73	369.69		9.29		90.40	72.18
benzo (a) pyrene	**150**	**1,450**	0.00	0.65	21.70	120.81	69.10	33.38	**628.46**	6.79	18.33	**181.00**	103.16	69.46
perylene		**	2.85	13.95		142.99		5.96	182.95		4.24		46.88	42.40
indeno(1,2,3-cd) pyrene		**	0.00	1.57	16.60	75.32	39.90	21.63	365.31	3.88	15.80	68.30	72.77	49.49
dibenzo(a,h) anthracene	**33**	**	0.00	0.00	8.32		18.50	12.50	**140.58**		5.57	**40.70**	29.05	22.17
benzo(ghi) perylene		**	0.00	0.00	18.50	151.52	33.50	26.93	330.07	4.37	19.03	48.20	64.04	44.02

Table C-3: Sediment Polychlorinated Biphenyls (PCBs) in the Smith River

Compound	Threshold Effects Concentration (TEC)	Probable Effects Concentration (PEC)	4ASRE055.62 (9/8/99) ppb	4ASRE046.90 (9/7/99) ppb	4ASRE046.90 (9/16/02) ppb	4ASRE029.50 (8/14/96) ppb	4ASRE026.27 (8/18/99) ppb	4ASRE026.06 (6/13/02) ppb	4ASRE019.00 (8/18/99) ppb	4ASRE011.08 (9/18/97) ppb	4ASRE007.09 (9/18/97) ppb
Total PCBs	**59.80**	**676**	0.96	0.56	1.26	**70.05**	0.87	5.60	0.30	0.60	0.38
Total Chlordane	**3.24**	**17.6**				**25.02**	0.44	**4.12**		0.36	
Sum DDE	**3.16**	**31.3**	0.31	0.60	0.21	**42.42**	0.93	0.36	0.37		
Sum DDD	**4.88**	**28**				**11.31**	0.33	0.14			
Sum DDT	**4.16**	**62.9**	2.98	0.25	0.07	1.62	0.69	0.66		0.28	
Total DDT	**5.28**	**572**	3.30	0.86	0.29	**55.35**	1.96	1.16	0.37	0.28	
Total BDE		**			0.15			2.85			
Hexachlorobenzene		**				6.31					
Heptachlor		**				6.52		0.07			
Pentachloroanisole		**				5.53		0.14			
alpha BHC		**				0.18					
delta BHC		**				3.59					
OCDD		**	1.14	0.29	0.09	4.01	0.94		0.42	0.53	

Table C-4: Sediment Metals in the Smith River

Compound	Threshold Effects Concentration (TEC)	Probable Effects Concentration (PEC)	4ASRE055.62 (9/8/99) ppm	4ASRE046.90 (9/7/99) ppm	4ASRE046.90 (9/16/02) ppm	4ASRE033.19 (8/10/09) ppm	4ASRE029.50 (8/14/96) ppm	4ASRE026.77 (8/11/09) ppm	4ASRE026.27 (8/18/99) ppm	4ASRE026.06 (6/13/02) ppm	4ASRE022.30 (8/12/09) ppm	4ASRE019.00 (8/18/99) ppm	4ASRE019.00 (8/12/09) ppm	4ASRE011. 08 (9/18/97) ppm	4ASRE007.09 (9/18/97) ppm
Aluminum	**	**	1.8	2.5	2.4		3.3		0.14	1.3		0.66		1.6	1.3
Silver	**	**	0.12	0.12	0.062		1.5	0.1	0.12	<0.02		0.12	0.1	0.24	0.14
Arsenic	**9.79**	**33**	<0.5	<0.5	**49**	0.3	0.59	0.9	<0.5	7.5	0.4	<0.5	0.5	7.5	6
Cadmium	**0.99**	**4.98**	0.13	0.17	0.030		<0.01	0.2	0.025	0.11	0.1	0.065	0.2	0.028	0.024
Chromium	**43.4**	**111**	**61**	**46**	31	17.9	**54**	36.6	30	36	26.5	27	27	35	38
Copper	**31.6**	**149**	**66**	27	**33**		10		4.1	31		3.6		17	11
Mercury	**0.18**	**1.06**	0.071	0.079	0.018	0.008	**0.23**	0.03	0.019	0.027	0.01	0.02	0.02	**0.24**	0.15
Nickel	**22.7**	**48.6**	<0.1	21	13		9.8		14	16		<0.1		2.1	1.8
Lead	**35.8**	**128**	12	13	8.5	5.5	9.9	11.4	12	17	6.8	4.3	8.9	8.4	6.1
Antimony	**	**	<0.5	<0.5	<0.5		<0.5		<0.5	<0.5		<0.5		<0.5	<0.5
Selenium	**	**	<0.5	<0.5	1.9		<0.5	0.3	<0.5	<0.5		<0.5		<0.5	<0.5
Thallium	**	**	<0.3	<0.3	<0.3		<0.3		<0.3	<0.3		<0.3		<0.3	<0.3
Zinc	**121**	**459**	116	82	42		**148**		96	55		43		77	68
Barium	**	**				53.5		150			160		155		

Table C-5: Fish Tissue Polycyclic Aromatic Hydrocarbons (PAHs) in the Smith River

Compound	DEQ Screening Value (ppb)	4ASRE055.62 (9/7/99) ppb				4ASRE046.90 (9/8/99) ppb			4ASRE046.90 (9/16/02) ppb				4ASRE026.27 (8/18/99) ppb				4ASRE026.06 (6/13/02) ppb			4ASRE019.00 (8/18/99) ppb		
		Largemouth Bass	Bluegill	Carp	Gizzard Shad	Largemouth Bass	Carp	Catfish species	Largemouth Bass - 1	Largemouth Bass - 2	Gizzard Shad	Carp	Brown Trout	Bluegill	Chub	White Sucker	Brown Trout	Redbreast Sunfish	Bull Chub	Redbreast Sunfish	Sucker species	Roanoke Hogsucker
Total PAH	**	2.17	2.44	2.09	2.99	1.71	1.57	2.76	15.11	8.76	15.26	9.82	2.23	4.25	2.25	2.94	27.21	12.75	8.07	2.35	1.27	1.81
sum PAH	**15**	0.21	0.14	0.13	0.31	0.14	0.01	0.02	0.17	0.18	0.16	0.13	0.11	0.29	0.14	0.04	0.03	0.02	0.02	0.15	0.09	0.10
naphthalene	**220000**	0.49	0.83	0.54	0.64	0.41	0.63	0.89	3.36	1.26	2.75	1.56	0.09	0.58	0.22	0.61	0.89	1.19	0.59	0.32	0.56	0.24
2-methylnaphthalene	**	0.00	0.27	0.15	0.00	0.09	0.18	0.24	3.77	1.21	3.29	1.93	0.00	0.00	0.00	0.00	0.80	0.43	0.27	0.00	0.00	0.12
1-methylnaphthalene	**	0.20	0.00	0.06	0.00	0.08	0.00	0.00	1.99	0.62	1.82	1.06	0.00	0.00	0.00	0.00	0.55	0.26	0.21	0.00	0.00	0.00
biphenyl	**540000**	0.00	0.00	0.05	0.12	0.00	0.00	0.23	0.21	0.15	0.25	0.19	0.00	0.00	0.12	0.14	0.80	0.40	0.28	0.00	0.00	0.11
2,6-dimethylnaphthalene	**	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.31	0.79	0.34	0.00	0.00	0.00	0.16	0.95	0.29	0.08	0.00	0.00	0.00
acenaphthylene	**	0.06	0.00	0.06	0.00	0.02	0.00	0.00	0.18	0.10	0.33	0.18	0.00	0.00	0.00	0.00	0.00	0.03	0.05	0.00	0.00	0.00
acenaphthene	**650000**	0.22	0.00	0.06	0.00	0.00	0.07	0.12	0.09	0.10	0.12	0.09	0.08	0.00	0.13	0.17	2.16	0.57	0.46	0.00	0.00	0.00
2,3,5-trimethylnaphthalene	**	0.22	0.00	0.18	0.25	0.25	0.00	0.00	0.38	0.58	0.80	0.42	0.00	0.00	0.00	0.00	1.37	0.59	0.27	0.00	0.20	0.00
fluorene	**430000**	0.21	0.00	0.08	0.00	0.08	0.00	0.39	0.24	0.08	0.30	0.26	0.00	0.00	0.09	0.11	3.56	0.91	0.67	0.00	0.00	0.00
phenanthrene	**	0.00	0.20	0.18	0.29	0.13	0.17	0.00	0.85	0.69	0.88	0.68	0.51	0.97	0.52	0.40	9.55	4.54	2.23	0.57	0.00	0.00
anthracene	**3200000**	0.00	0.08	0.03	0.08	0.14	0.03	0.13	0.41	0.44	0.50	0.39	0.23	0.12	0.11	0.23	1.30	0.65	0.57	0.10	0.00	0.66
1-methylphenanthrene	**	0.00	0.11	0.05	0.13	0.05	0.00	0.11	0.41	0.29	0.33	0.28	0.08	0.73	0.30	0.00	0.34	0.26	0.23	0.34	0.00	0.07
fluoranthene	**430000**	0.00	0.12	0.00	0.39	0.00	0.24	0.23	0.97	1.35	1.21	0.93	0.30	0.47	0.00	0.21	3.51	1.75	1.28	0.21	0.00	0.17
pyrene	**320000**	0.00	0.20	0.18	0.35	0.11	0.13	0.08	0.59	0.53	0.67	0.53	0.18	0.41	0.25	0.16	0.87	0.61	0.56	0.30	0.13	0.04
benz(a) anthracene	**15**	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.16	0.13	0.27	0.17	0.12	0.00	0.12	0.15	0.07	0.04	0.04	0.08	0.00	0.00
chrysene	**15**	0.00	0.08	0.07	0.00	0.07	0.00	0.00	0.29	0.26	0.38	0.20	0.14	0.00	0.08	0.00	0.34	0.08	0.11	0.04	0.07	0.00
benzo(b) fluoranthene	**15**	0.09	0.09	0.03	0.06	0.07	0.07	0.12	0.22	0.20	0.19	0.20	0.23	0.09	0.11	0.12	0.09	0.06	0.08	0.09	0.10	0.07
benzo(k) fluoranthene	**15**	0.09	0.08	0.07	0.09	0.07	0.06	0.09	0.20	0.17	0.10	0.18	0.13	0.08	0.07	0.14	0.00	0.05	0.06	0.06	0.08	0.07
benzo (e) pyrene	**	0.09	0.07	0.00	0.11	0.00	0.00	0.05	0.16	0.17	0.19	0.17	0.00	0.06	0.00	0.10	0.06	0.06	0.05	0.13	0.00	0.07
benzo (a) pyrene	**15**	0.20	0.11	0.12	0.13	0.13	0.00	0.00	0.10	0.12	0.08	0.06	0.05	0.27	0.11	0.00	0.00	0.00	0.00	0.12	0.07	0.08
perylene	**	0.12	0.11	0.05	0.18	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.09	0.23	0.00	0.23	0.00	0.00	0.00	0.00	0.05	0.11
indeno(1,2,3-cd) pyrene	**15**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
dibenzo(a,h) anthracene	**15**	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
benzo(ghi) perylene	**NA**	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

*** As of the 2010 Water Quality Assessment, DEQ uses 20 ppb. Data collected prior to 2003 is outside of the assessment window thus, the 20 ppb screening value does not apply.**

Table C-6: Fish Tissue Polychloronated Biphenyls (PCBs) in the Smith River

Compound	DEQ Screening Value (ppb)	4ASRE055.62 (9/7/99) ppb				4ASRE046.90 (9/8/99) ppb			4ASRE046.90 (9/16/02) ppb				4ASRE026.27 (8/18/99) ppb				4ASRE026.06 (6/13/02) ppb				4ASRE019.00 (8/18/99) ppb		
		Largemouth Bass	Bluegill	Carp	Gizzard Shad	Largemouth Bass	Carp	Catfish species	Largemouth Bass - 1	Largemouth Bass - 2	Gizzard Shad	Carp	Brown Trout	Bluegill	Chub	White Sucker	Brown Trout	Redbreast Sunfish	Bull Chub	Northern Hogsucker	Redbreast Sunfish	Sucker species	Roanoke Hogsucker
Total PCBs	**54 ***	6.06	2.50	8.21	8.60	9.48	19.63	2.40	1.99	2.02	4.57	7.90	30.52	9.18	10.70	6.38	77.36	6.60	8.82	8.04	4.63	10.18	5.90
Total Chlordane	**310**	1.84	0.28	1.66	1.94	1.50	4.76	0.95	0.50	0.78	5.19	1.80	6.85	2.16	4.17	2.63	16.43	2.97	3.66	2.29	1.52	3.89	1.85
Sum DDE	**320**	2.38	0.50	2.25	1.70	2.40	11.98	1.14	0.61	0.66	1.29	4.21	2.77	0.58	1.02	0.52	8.37	0.65	0.51	0.25	0.44	0.52	0.39
Sum DDD	**450**	0.12	0.11	0.19	0.28	0.21	0.57		0.04	0.08	0.15	0.77	0.45	0.18	0.20	0.22	0.92	0.09	0.13	0.08	0.17	0.18	0.20
Sum DDT	**320**			0.05		0.11	0.19			0.04	0.03	0.05	0.30		0.10	0.10				0.04		0.18	
Total DDT	**320**	2.50	0.61	2.49	1.98	2.71	12.74	1.14	0.64	0.77	1.47	5.03	3.52	0.76	1.32	0.83	9.28	0.74	0.64	0.38	0.61	0.88	0.59
Total BDE	**5000**	0.30	8.42	2.44	3.39	2.99	3.02	0.32	3.15	3.09	3.14	3.19	14.56	3.88	3.73	3.12	89.26	1.79	7.49	15.04	1.99	6.73	3.72
Hexachlorobenzene	**67**				0.09						0.03	0.04	0.09				0.09			0.03		0.10	
Heptachlor epoxide	**12**	0.06	0.37				0.07				0.07	0.06	1.49	0.62	0.30	0.31					0.28	0.43	0.15
Pentachloroanisole	******										0.04	0.07					0.90	0.07	0.17	0.16			
$C_{13}H_{10}Cl_{2O}$ - triclosan derivative	******										0.04												

Table C-7: Fish Tissue Metals in the Smith River

Compound	DEQ Screening Value (ppm)	4ASRE055.62 (9/7/99) ppm				4ASRE046.90 (9/8/99) ppm			4ASRE046.90 (9/16/02) ppm				4ASRE026.27 (8/18/99) ppm				4ASRE026.06 (6/13/02) ppm			4ASRE019.00 (8/18/99) ppm		
		Largemouth Bass	Bluegill	Carp	Gizzard Shad	Largemouth Bass	Carp	Catfish species	Largemouth Bass - 1	Largemouth Bass - 2	Gizzard Shad	Carp	Brown Trout	Bluegill	Chub	White Sucker	Brown Trout	Redbreast Sunfish	Bull Chub	Redbreast Sunfish	Sucker species	Roanoke Hogsucker
Arsenic	**0.072**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5	<0.5	<0.5	<0.05	<0.05	<0.05	<0.5	<0.5	<0.5
Cadmium	**11**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chromium	**32**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	**0.3**	0.026	<0.01	<0.01	<0.01	<0.01	0.037	<0.01	0.24	0.14	0.022	0.007	<0.01	<0.01	<0.01	<0.01	0.10	0.043	0.022	<0.01	0.01	0.01
Lead	******	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**0.17**	<0.1	**1.40**	<0.1	<0.1	<0.1	**0.26**	**0.10**	<0.1	<0.1	<0.1
Selenium	**54**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

APPENDIX D: *DuPont de Nemours & Co*

Appendix D is a summary of the assessments and remediation activities that have been carried out at the DuPont site. This information was presented in a 2007 Comprehensive RCRA Facility Investigation (RFI) Report for DuPont (CRG 2007).

Site History

- March 1982 – EPA Region III contractor (Ecology and Environment, Inc.) identifies 19 waste disposal units in Field Investigation Team (FIT) Report; No further actions are recommended.
- Early 1986 – Hazardous Waste Permit is issued by EPA and VA Department of Waste Management (expires 1996).
- July 1991 – Amendment to DuPont's RCRA permit (VAD 00 311 4865) requires Verified Investigations (VI) for five of the 19 identified Solid Waste Management Units (SWMU) presented in **Table 2-6.**
- April 27, 1993 – VI Plan (VIP), developed by DuPont Environmental Remediation Services (DERS), is approved by EPA and implementation is initiated.
- Summer and Fall 1993 – VIP is implemented.
- February 1994 – VI Report is submitted to the EPA.
- August 1995 – The Hazardous Waste Permit (issued 1986) expires and through an agreement between EPA and DuPont, the Corrective Action program is continued.
- January 30, 1996 – Notice of Deficiency (NOD) is issued by EPA regarding the 1994 VI Report.
- April 25, 1997 – RFI Workplan is issued and verbally approved by EPA Region III Office. The following monitoring tools are implemented:
    - October 1997 – 13 saprolite monitoring wells installed across the site
    - April-June 1998 – Soil Borings at seven Units
    - Summer 1998 – Four double-cased monitoring wells installed at four sites
    - 1998 – Quarterly groundwater sampling in new wells
    - 1999 – Soil borings completed at one unit, two deep bedrock wells installed, River-Aquifer interaction study completed
- April 1999 – DuPont submits RFI Data Summary Report summarizing data collected since the 1997 RFI Workplan was initiated.
- May 1999 – Two work plans are submitted by DuPont regarding data collection in the Unit I/DuPont Precision Concepts (DPC) area of concern (AOC) and Fire Training Area (FTA).
- December 4, 2000 – RFI Update Report is submitted summarizing results of the RFI as well as the FTA and Unit I/AOC DPC investigations. Report recommends conducting interim stabilization measure (ISM) at the Unit I AOC.
- 2002 to September 2004 – EPA and DuPont document that the site is in compliance with the EPA's CA Environmental Indicators (EI) 725 and 750.

- July 10, 2005 – EPA, VADEQ and DuPont discuss RFI status and data gaps are identified.
- July 2005 – *2005 Supplemental RFI Investigation* work plan is submitted to address data gaps.
- November-December 2008 – EPA provides DuPont draft comments on the 2007 Comprehensive RFI Report. DuPont and EPA agree to develop Supplemental Investigation sampling program.
- October 2009 – DuPont submits EPA 2009 Annual Monitoring and Supplemental RFI Data Report summarizing data collected since the 2009 RFI Workplan was initiated. The results are discussed below.

Table D-1: Solid Waste Management Units (SWMUs) and Areas of Concern (AOCs) at the DuPont de Nemours & Co. Site

Site Name	Description
Unit A	Nylon fiber landfills
Unit B	Inactive coal ash pond
Unit C	Former burning ground
Unit D	Inactive flyash pond
Unit E	Spinneret burial area
Unit F	Former trash/ash landfill
Unit G	Closed flyash landfill
Unit H	Former finish oil disposal ponds (Units H1, H2, H3, also Smith River sampling)
Unit I	Former lab disposal pits
Unit J	Spent finish oil collective system
AOC FTA	Fire training field
AOC DPC	Manufacture of proprietary equipment for nylon production
Bedrock Production Wells	Four water wells 300 – 550 feet deep
Construction Landfill	Mostly construction debris and nylon fiber
Dredge Spoil Area	Adjacent to intake channel
Former Incinerator Area	Trash, waste nylon yarn, and paper burning from 1967 to 1976
Former No. 6 Fuel Storage	Built in 1947 to hold 247,000 gallons of No. 6 fuel oil
Former Dowtherm Area	Non-contact heat transfer fluid

Summary and Results of 2007 Sampling

The following section summarizes the sampling results from the 2007 Comprehensive RFI Report DuPont Martinsville, Virginia.

Soil:
Soil constituent concentrations were compared to both residential and industrial Risk-based screening criteria (RBSCs) as well as background soil samples reported on in the

2000 RFI Update. In addition, soil concentrations were compared to RBSCs for protection of groundwater with a dilution attenuation factor (DAF) of 20. These RBSCs are referred to as soil screening levels (SSLs). Samples were divided into surface soil (0-2 feet below ground) and subsurface soil (2+ feet below ground). The sites with constituents of potential concern (COPCs) in the soil that exceeded residential and industrial RSBCs are listed below.

- Unit B: Arsenic, benzo(b)fluoranthene, and benzo(a)pyrene) exceeded residential, direct contact RBSCs. Arsenic exceeded the industrial RBSC.
- Unit C: Benzo[b]fluoranthene and benzo[a]pyrene) and arsenic exceeded residential RBSCs. Arsenic exceeded the industrial RBSC.
- Unit D: Arsenic exceeded the industrial RBSC, and chloroform and Trichloroethene (TCE) exceeded the SSL RBSC.
- Unit F: Arsenic exceeded the industrial RBSC.
- Unit H1: Eight metals, three Volatile organic compound (VOCs), five Polynuclear aromatic hydrocarbons (PAHs), and one dioxin-like Polychlorinated biphenyl (PCB) exceeded the residential Risk-based screening criteria (RBSC). Perchloroethene (PCE), TCE, iron, and one dioxin-like PCB exceeded industrial RBSC.
- Unit H2: PCE exceeded the industrial direct contact RBSC.
- Unit I: Carbon tetrachloride is the dominant constituent at this site and is being monitored.
- Area of concern (AOC) Fire Training Area (FTA): In surface soil, four VOCs (benzene, ethyl benzene, toluene, and xylene) and five PAHs exceeded the residential RBSCs. Benzene and benzo(a)pyrene exceeded the industrial RBSC. In subsurface soil, benzene, ethyl benzene, toluene, xylene, seven PAHs, and total petroleum hydrocarbon diesel range (TPH-diesel) exceeded residential RBSCs. Additionally, benzene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and TPH-diesel exceeded industrial RBSCs.
- AOC DuPont Precision Concepts (DPC): Carbon tetrachloride, chloroform, methylene chloride, PCE and TCE exceeded the SSLs.
- Former Incinerator Area: Arsenic, benzo(a)pyrene, dibenzo(a,h)anthracene, and iron exceeded industrial RBSCs.
- Former No. 6 Fuel Oil Storage Tank: Diesel fuel exceeded the residential and industrial RBSC and the SSL.
- Former Construction Landfill: arsenic and benzo(a)pyrene exceeded industrial RBSCs.

Groundwater:

Groundwater constituents were compared to Federal Maximum Contaminant Levels, (MCL) or the EPA Region 3 risk-based screening criteria (RBSCs) for tap water. The sites with constituents of potential concern (COPCs) in the groundwater that exceeded the lower of the Federal Maximum Contaminant Levels (MCLs) or the USEPA Region 3 risk-based screening criteria for tap water are listed below.

- Unit D: Arsenic exceeded the RBSC for tap water.
- Unit H2: PCE, cis1-2-DCE, TCE, and vinyl chloride exceeded the tap water RBSC.
- Unit H3: PCE and TCE exceeded tap water RBSCs but are below the Federal MCLs.
- Unit I: Carbon tetrachloride is the dominant constituent, chloroform, PCE, TCE, methylene chloride, and cis-1,2-DCE exceeded the tap water RBSC, and all but cis-1,2-DCE exceeded the Federal MCL.
- AOC FTA: Total petroleum hydrocarbons-diesel range organics (TPH-DRO) has been detected at levels below the tap water RBSC and Federal MCL.
- AOC DPC: 1,1,2 trichloroethane, bromodichloromethane, carbon tetrachloride, chloroform, cis-1,2-DCE, PCE, and TCE exceeded Region III tap water RBSCs.
- Former No. 6 Fuel Oil Storage Tank: PCE, TCE, and chloroform were above the tap water RBSCs.
- Former Construction Landfill: Carbon tetrachloride, chloroform, cis-1,2-DCE, PCE, TCE, and CFC-11 exceeded tap water RBSCs. PCE and TCE exceeded the Federal MCLs.

Surface Water:
The Surface-water concentrations were compared to the lower of Virginia water quality standards (VAC 25-260-5) for human fish consumption and aquatic organisms. When no criteria were available in Virginia, the National Ambient Water Quality Criteria were utilized. Samples were taken from four types of sources: golf course ponds, groundwater springs near Unit H, outfall channel, intake channel. Surface water sampling was also conducted at 8 stations in the surrounding meander of the Smith River. No detections were observed in downstream surface water samples. The sites with constituents of potential concern (COPCs) in the surface water that were detected or exceeded the lower of Virginia water quality standards or National Ambient Water Quality Criteria are listed below.

- Unit H1: Smith River sampling (SW-03) was conducted quarterly and chloroform was detected in September 2002.
- Unit H2: six VOCs were detected periodically, believed to be from units H1 and H2
- Unit I: Smith River sampling (SW-08) is at the end of the Intake Channel and SW-04 and SW-05 are located in the Smith River just outside the Intake Channel.

Carbon tetrachloride was found to be the dominant constituent at SW-08, SW-04, and SW-05, with the highest levels during dry periods, however, concentrations are typically low and limited to the Intake Channel.
- AOC DPC: 13 surface water samples were collected along the bank of the Smith River and the Outcall Channel and carbon tetrachloride and chloroform were detected. Carbon tetrachloride and PCE exceeded the Virginia Water Quality Standards for aquatic life and human health (VA WQS).

Summary and Results of 2009 Sampling

The following summarizes the sampling results from DuPont's 2009Annual Monitoring and Supplemental RFI Data Report.

Soil:
- Dredge Spoil Area: Sediment dredged from the Intake Channel adjacent to the spoil area showed detectable amounts of PAHs. However, concentrations were considered consistent with those observed in urban areas, and less than screening criteria consistent with site land use (industrial).

Groundwater:
- Unit B: Naphthalene was detected (both filtered and unfiltered) in a discharge pipe but was below the EPA screening limit.
- Unit D: A single detection of acenaphthylene was recorded, but was below the screening criteria (lower of Virginia WQS and Region III Freshwater Screening Benchmarks) from structurally similar acenaphthene.
- Unit H1: Total PCB concentrations were well below applicable screening criteria (lower of federal maximum contaminant level or tap water EPA regional screening levels).
- Unit H3: Surrounding groundwater was nondetect for arsenic, indicating that the coal ash in Unit H3 has not released arsenic to groundwater.
- Unit I: Concentrations of carbon tetrachloride in groundwater showed a noticeable decline between 2007 and 2009.
- AOC DPC: Volatile organic compound (VOC) concentrations were stable. Low ug/L concentrations of cis-1,2 dichloroethene suggest limited biodegradation is occurring
- AOC FTA: No semi-volatile organic compounds (SVOCs) or benzene, toluene, ethylbenzene or xylene (BTEX) constituents detected.
- Former No. 6 Fuel Storage: Very low concentrations (below the reporting limit, but above the Method Detection Limit) of ethyl benzene and four SVOCs detected

Surface Water:
- Unit D: Thick vegetation (grass and small trees) had been established, and is expected to stabilize the fly ash in place.