Benthic TMDL Development for the Roanoke River, Virginia

Submitted to

Virginia Department of Environmental Quality

Prepared by

THE Louis Berger Group, INC.
2300 N Street, NW
Washington, DC 20037

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Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. The Roanoke River was included on Virginia's 1996 Section 303(d) TMDL Priority List and Report (DEQ, 1996) because of violations of the General Standard (benthic impairment). The headwaters of the Roanoke River originate in southwest Virginia. The Roanoke River flows through southcentral Virginia before crossing the North Carolina state line and discharging into the Albemarle Sound in North Carolina.

Impairment Listing

The Virginia Department of Environmental Quality (DEQ) uses biological monitoring of benthic macroinvertebrates as one method to assess support of the aquatic life use for a waterbody. Bioassessments of the benthic macroinvertebrate community of the Roanoke River were performed by DEQ using modified Rapid Bioassessment Protocols (EPA, 1999). Results of bioassessments indicated a moderately impaired benthic community at three monitoring stations on the river (4AROA202.20, 4AROA206.03, and 4AROA206.95). Therefore, since the river only partially supports the designated aquatic life use, the General Standard is being violated. As a result, the Roanoke River was included on the Section 303(d) list. Although biological assessments indicated the creek is impaired, additional analyses described in this report were required to identify the causal pollutant (stressor) and sources within the watershed.

The impaired benthic segments (ID #'s VAW-L04R-01 and VAW-L04R-02) are located on the mainstem Roanoke River in the upper section of the Roanoke River basin. Segment VAW-L04R-01 is 9.87 miles in length, beginning at the confluence of Mason Creek and the mainstem Roanoke River, and extending downstream to the Western Virginia Water Authority outfall on the Roanoke River. Approximately 1.46 miles of segment VAW-L04R-02 are listed for benthic impairment, beginning at the Western

Virginia Water Authority outfall on the Roanoke River, and ending at the backwaters of the Niagara Dam impoundment.

Watershed Characterization and Environmental Monitoring

The Roanoke River benthic impairment watershed is approximately 335,785 acres. Forested lands (69.9%), agricultural lands (17.5%), and developed lands (11.1%) represent the dominant land use types in the watershed. The Roanoke River benthic impairment watershed spans the Blue Ridge Mountain ecoregion and the Ridge and Valley ecoregion. The majority of soils in the watershed are comprised of the Berks-Weikert-Laidig, Carbo-Chilhowie-Frederick, Frederick-Carbo-Timberville, Hayesville-Parker-Peaks, and Groseclose-Litz-Shottower soils associations. Combined, these five soil associations account for almost 80 percent of the soils in the watershed.

Environmental monitoring data were vital to the identification of the pollutant stressor(s) that is impacting the benthic community of the Roanoke River. Available monitoring data included biological assessments, water quality monitoring data, and Discharge Monitoring Reports (DMR) for permitted facilities in the watershed. Biological monitoring data from 1994 to 2004 were analyzed. Instream water quality conditions were assessed primarily based on data collected at DEQ ambient monitoring stations, field data collected during biological monitoring surveys, and additional special monitoring studies. In addition, monitoring data contained in discharge monitoring reports were used to assess the impacts of the wastewater treatment facilities in the watershed.

Stressor Identification

Assessment of the primary stressor contributing to biological impairment in the Roanoke River was based on evaluations of candidate stressors that can potentially impact the river. The 2004 Water Quality Assessment 305(b)/303(d) Integrated Report Fact Sheet identified “urban nonpoint source runoff” and “sedimentation” as possible sources of impairment. Therefore, these pollutants were considered in the evaluation of candidate stressors along with other potential stressors such as nutrients, pH, temperature, ammonia, and toxic compounds. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed.

Assessment of the primary stressor contributing to biological impairment in the Roanoke River was based on evaluations of candidate stressors that can potentially impact the river. The 2004 Water Quality Assessment 305(b)/303(d) Integrated Report Fact Sheet identified “urban nonpoint source runoff” and “sedimentation” as possible sources of impairment. Therefore, these pollutants were considered in the evaluation of candidate stressors along with other potential stressors such as nutrients, pH, temperature, ammonia, and toxic compounds. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed. The potential stressors were classified as:

- **Non-stressors**: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

- **Possible stressors**: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

- **Most probable stressors**: The stressors with the most complete data linking them to the poorer benthic community.

Metals and organics data collected in the Roanoke River show no evidence of toxicity; however, the toxicity testing results and historic stormwater monitoring data provide some qualitative evidence that toxic pulses may enter the river during storm events during the first flush. While it cannot be conclusively stated that toxicity is a most probable stressor affecting the benthic invertebrate communities, the possibility of some acute toxicity associated with stormwater flows should be further investigated, and the issues associated with elevated stormwater flows should be addressed in the implementation of the Roanoke River benthic impairment TMDL. Therefore, toxicity was classified as a possible stressor impacting benthic invertebrates in the biologically impaired segments of the Roanoke River

Based on the evidence and data evaluated, sediment was identified as the most probable stressor impacting benthic invertebrates in the biologically impaired segments of the Roanoke River. Habitat scores indicate increased substrate embeddedness and decreased habitat quality in the impaired segments as a result of the surrounding urban environment. Potential sources of sediment loading in the watershed include urban stormwater runoff, streambank erosion, and sediment loss from habitat degradation associated with urbanization.

Improvement of the benthic community in the biologically impaired segments of the Roanoke River is dependent upon controlling stormwater to reduce sediment loading from urban runoff and streambank erosion, as well as restoring instream and riparian habitat to alleviate the impacts of urbanization on the river. To address these issues, a sediment TMDL was developed for the biologically impaired segments of the Roanoke River.

Reference Watershed Approach

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric TMDL endpoint for the Roanoke River.

The watershed draining to the DEQ biomonitoring station at river mile 224.54 on the Roanoke River was selected as the reference watershed for the Roanoke River benthic TMDL development. Reduction of sediment loading in the impaired watershed to the level determined for the reference watershed (adjusted for area) is expected to restore support of the aquatic life use for the Roanoke River.

Sediment Loading Determination

Sediment sources within the Roanoke River watershed include both point and non-point sources. Point sources include solids loading from permitted discharge facilities and land-based loading from areas covered by municipal separate storm sewer system (MS4) permits. Non-point sources include sediment derived from the erosion of lands present throughout the watershed and the erosion of stream banks within the Roanoke River.

Sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for the Roanoke River. Sediment loadings from land erosion were determined using the Generalized Watershed Loading Functions (GWLF) model. GWLF model simulations were performed for 1993 to 2003 in order to account for seasonal variations and to reflect the period of biomonitoring assessments that resulted in the impairment listing of the Roanoke River. Average annual sediment loads were computed for each land source based on the 10 year simulation period. In addition, average annual sediment loads from instream bank erosion, point sources, and MS4 permitted areas were determined. Point source loadings were computed based on the permitted discharge loading rate for total suspended solids. Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al (2003). An area-weighted method was used to determine the land-based load attributed to MS4s present in the watershed.

Under the reference watershed approach, the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Roanoke River reference watershed is smaller than the impaired watershed, the reference watershed parameters were adjusted to reflect the size of the impaired watershed. Sediment loadings computed for this area-adjusted watershed were used for TMDL allocations.

TMDL Allocation

Sediment TMDL allocations for the Roanoke River were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Total Maximum Daily Load (Based on the Sediment Load of the Adjusted Reference Watershed)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

The wasteload allocation represents the total sediment loading allocated to point sources. The load allocation represents the total sediment loading allocated to non-point sources. A margin of safety is applied to account for uncertainty in methodologies and determination of sediment loadings. An explicit margin of safety of 10% was used for the Roanoke River benthic TMDL.

The total wasteload allocated to the point source facilities was based on the permitted discharge loading rate for total suspended solids for each facility. Load allocations for non-point sources and wasteload allocations for the MS4s were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural, transitional, and developed lands and instream erosion by 69.5%, the sediment TMDL endpoint is achieved. The TMDL for the Roanoke River is presented in Table E-1 and the recommended TMDL allocations and the percent reduction required for all watershed sources are presented in Table E-2. Table E-3 presents the sediment allocations for the permitted point source dischargers. Table E-4 depicts the sediment allocations for each MS4 permitee.

Table E-1: Sediment TMDL for Roanoke River (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
21,079	13,782	5,189	2,108

Table E-2: Sediment TMDL Allocations for Roanoke River (tons/year)

Source	Land Use Type	Allocated	Percent Reduction
Land Sources	Deciduous Forest	785.0	0.0
	Evergreen Forest	80.9	0.0
	Mixed Forest	157.3	0.0
	Pasture/Hay	450.9	69.5
	Row Crop	940.2	69.5
	Low Intensity Residential	4.3	69.5
	High Intensity Residential	0.5	69.5
	Commercial/Industrial	305.1	69.5
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Herbaceous	0.0	0.0
	Quarries/Strip Mines/Gravel Pits	111.7	69.5
	Transitional	213.6	69.5
	Urban/Recreational Grasses	1.3	69.5
MS4 Allocations	Deciduous Forest	79.0	0.0
	Evergreen Forest	6.1	0.0
	Mixed Forest	29.3	0.0
	Pasture/Hay	160.7	69.5
	Row Crop	62.3	69.5
	Low Intensity Residential	38.1	69.5
	High Intensity Residential	22.1	69.5
	Commercial/Industrial	988.9	69.5
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Herbaceous	0.0	0.0
	Quarries/Strip Mines/Gravel Pits	122.6	69.5
	Transitional	98.1	69.5
	Urban/Recreational Grasses	9.7	69.5
	Instream Erosion	2956.4	69.5
Instream Erosion	-	10730.7	69.5
Point Sources	-	615.3	0.0
Total		**18,971**	**67.5**

Table E-3: Point Sources Sediment TMDL Allocations

Facility Name	Permit Number	Annual Sediment Loads (tons/yr)	Allocated Loads (tons/yr)	Percent Reduction
Western Virginia Water Authority	VA0025020	472.2	472.2	0
Roanoke Electric Steel Corporation	VA0001589	92.9	92.9	0
Shawville Town STP	VA0024031	9.1	9.1	0
Carvin Cove Water Filtration Plant	VA0001473	17.6	17.6	0
Crystal Springs WTP	VA0091065	8.8	8.8	0
Norfolk Southern Railway Company - Shaffers Crossings	VA0001597	1.62	1.62	0
Ellison Lafayette WWTP	VA0062219	11.2	11.2	0
Blacksburg Country Club STP	VA0027481	1.57	1.57	0
Roanoke Moose Lodge	VA0077895	0.21	0.21	0
		Total Allocated Load	**615.3**	**0**

The MS4 allocations detailed in Table E-2 are broken down by MS4 Urban area and shown in Table E-4.

Table E-4: Sediment TMDL Wasteload Allocations for MS4 Urban Areas

MS4 Permit Holder	Permit Number	Sediment Allocation (Tons/Year)
Roanoke County	VAR040022	1823
City of Roanoke	VAR040004	1487
Town of Vinton	VAR040026	128
Botetourt County	VAR040023	327
City of Salem	VAR040010	589
VDOT Roanoke Urban Area	VAR040017	27
Virginia Western Community College	VAR040030	2
Virginia Medical Center	VAR040050	10
VDOT Montgomery County Urban Area	VAR040016	4
Town of Blacksburg	VAR040019	102
Town of Christianburg	VAR040025	75
	Total	**4573**

The MS4 sediment loads shown in Table E-4 include the loads from individual MS4s permits for urban areas as well as loads from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, General Permits for Carwashes, and General Permits for Construction Sites. Table E-5 depicts the breakdown of loads other than the individual MS4-permits loads for each urban area. Table E-6 shows the wasteload allocation for each specific MS4 permit.

Table E-5: Wasteload Allocation for Stormwater Permits by MS4 Urban Area* (tons/year)

MS4 Urban Area	Individual Permits	General Permits	Mines	Concrete Facilities	Carwashes	Construction Sites	Totals
Roanoke County	-	19.65	-	-	-	123.95	143.60
City of Roanoke	108.1	316.8	7	0.9	0.1	101.11	534.01
Town of Vinton	-	-	-	-	-	8.70	8.70
Botetourt County	-	0.62	15.6	2.43	-	22.23	40.88
City of Salem	18.4	101.6		0.2		40.05	160.25
VDOT Roanoke Urban Area	-	-	-	-	-	1.84	1.84
Virginia Western Community College	-	-	-	-	-	0.14	0.14
Virginia Medical Center	-	-	-	-	-	0.68	0.68
VDOT Montgomery County Urban Area	-	-	-	-	-	0.27	0.27
Town of Blacksburg	12.3	-	-	-	-	6.94	19.24
Town of Christianburg	-	-	-	-	-	5.10	5.10
Total	**138.8**	**438.67**	**22.6**	**3.53**	**0.1**	**311**	**914.7**

* Does not include the load for the specific MS4 urban area permit – Shown in Table E-6 below. The breakdown by individual permit is shown in Appendix D

Based on the number of disturbed land-acres specified in the stormwater construction permits issued between 2002 and 2004, it is estimated that on the average approximately

467 acres are annually under construction. The total allocated load was calculated based on a per acre loading unit of 10.97 metric tons of sediment per hectare, the disturbed construction area of 476 acres, and a sediment delivery ratio of 0.136. This corresponds to an average total sediment allocation of 311 tons/year (Appendix D, Table D-7).

Table E-6: Wasteload Allocation for each Individual MS4 Permit

MS4 Permit Holder	Permit Number	Sediment Allocation (Tons/Year)
Roanoke County	VAR040022	1680.0
City of Roanoke	VAR040004	953.0
Town of Vinton	VAR040026	119.30
Botetourt County	VAR040023	286.1
City of Salem	VAR040010	428.8
VDOT Roanoke Urban Area	VAR040017	25.2
Virginia Western Community College	VAR040030	1.9
Virginia Medical Center	VAR040050	9.3
VDOT Montgomery County Urban Area	VAR040016	3.7
Town of Blacksburg	VAR040019	82.8
Town of Christianburg	VAR040025	69.90
	Total	**3659.3**

Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement.

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

Public Participation

Watershed stakeholders had opportunities to provide input and to participate in the development of the TMDL. Three public meetings were held in Roanoke, Virginia. Forty-one people attended the first meeting on October 7, 2004. Eleven people attended the second meeting on August 4, 2005 and twenty two people attended the third public meeting on August 9, 2005. In addition, several comments were received and are submitted with this report.

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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 the impaired biological communities is an important first step in developing a TMDL that accurately specifies the pollutant load reductions necessary for the river 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 on the mainstem Roanoke River. The first section of this report presents the regulatory guidance and defines the applicable water quality criteria for biological impairment. In the subsequent sections of this report, watershed and environmental monitoring data collected on the Roanoke River are presented and discussed. Stressors which may be impacting the river are then analyzed in the stressor identification section. Based on this analysis, candidate stressors impacting benthic invertebrate communities in the river were identified. A TMDL was developed for the primary stressor determined to be impacting the benthic community. The modeling approach, TMDL endpoint identification, and TMDL allocations are presented in subsequent sections. Finally, TMDL implementation and public participation are discussed.

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding 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 non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Virginia is the Department of Environmental Quality (DEQ). DEQ works in coordination with the Virginia Department of Conservation and Recreation (DCR), the Department of Mines, Minerals, and Energy (DMME), and the Virginia Department of Health (VDH) to develop and implement a more effective TMDL process. DEQ is the lead agency for the development of TMDLs statewide and focuses its efforts on all aspects of reduction and prevention of pollution to state waters. 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), and coordinates public participation throughout the TMDL development process. The role of DCR is to initiate non-point source pollution control programs statewide through the use of federal grant money. DMME focuses its efforts on issuing surface mining permits and National Pollution Discharge Elimination System (NPDES) permits for industrial and mining operations. Lastly, VDH classifies waters for shellfish growth and harvesting, and conducts surveys to determine sources of contamination (DEQ, 2001).

As required by the Clean Water Act and WQMIRA, DEQ develops and maintains a listing of all impaired waters in the state that details the pollutant(s) causing each impairment and the potential source(s) of each pollutant. This list is referred to as the Section 303(d) List of Impaired Waters. In addition to Section 303(d) List development, WQMIRA directs DEQ to develop and implement TMDLs for listed waters (DEQ, 2001a). DEQ also solicits participation and comments from watershed stakeholders and 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

The Roanoke River was initially listed on Virginia’s 1996 Total Maximum Daily Load Priority List and Report (DEQ, 1996), and was subsequently included on Virginia’s 1998 and 2002 Section 303(d) Lists of Impaired Waters (DEQ, 2002) and in the 2004 Water Quality Assessment 305(b)/303(d) Integrated Report (DEQ, 2004) because of violations of the water quality standards for fecal coliform bacteria and total PCBs, and the General

Standard (benthic impairment). This report addresses the benthic impairment; PCB and fecal coliform impairments will be addressed in separate TMDL reports. Biological assessments conducted at DEQ monitoring stations (4AROA202.20, 4AROA205.67, 4AROA206.03, 4AROA206.95) located on the Roanoke River indicate an impaired benthic macroinvertebrate community, which resulted in the Section 303(d) listing.

The headwaters of the Roanoke River originate in southwest Virginia. The Roanoke River flows through southcentral Virginia before crossing the North Carolina state line and discharging into the Albemarle Sound in North Carolina (Figure 1-1). The Roanoke River is also commonly referred to as the Staunton River prior to its confluence with the Dan River at Kerr Reservoir. The impaired benthic segments (ID #'s VAW-L04R-01 and VAW-L04R-02) are located on the mainstem Roanoke River in the upper section of the Roanoke River basin. Segment VAW-L04R-01 is 9.87 miles in length, beginning at the confluence of Mason Creek and the mainstem Roanoke River, and extending downstream to the Western Virginia Water Authority outfall on the Roanoke River. Approximately 1.46 miles of segment VAW-L04R-02 are listed for benthic impairment, beginning at the Western Virginia Water Authority outfall on the Roanoke River, and ending at the backwaters of the Niagara Dam impoundment. Figure 1-2 depicts the stream segments on the Roanoke River listed for benthic impairment, and also presents the Roanoke River watershed delineated at the downstream limit of the impaired segments.

Figure 1-1: Location of the Roanoke River Basin

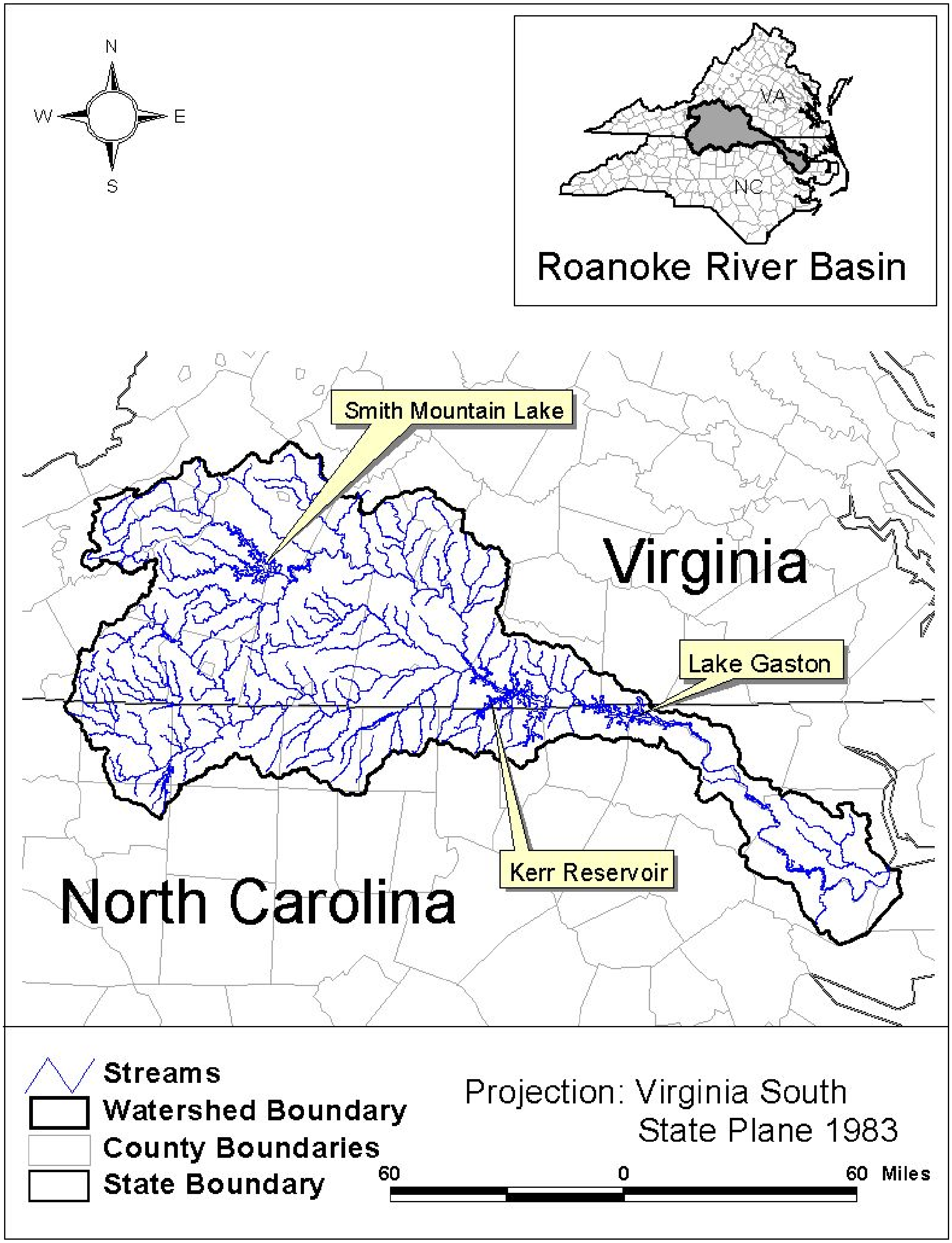
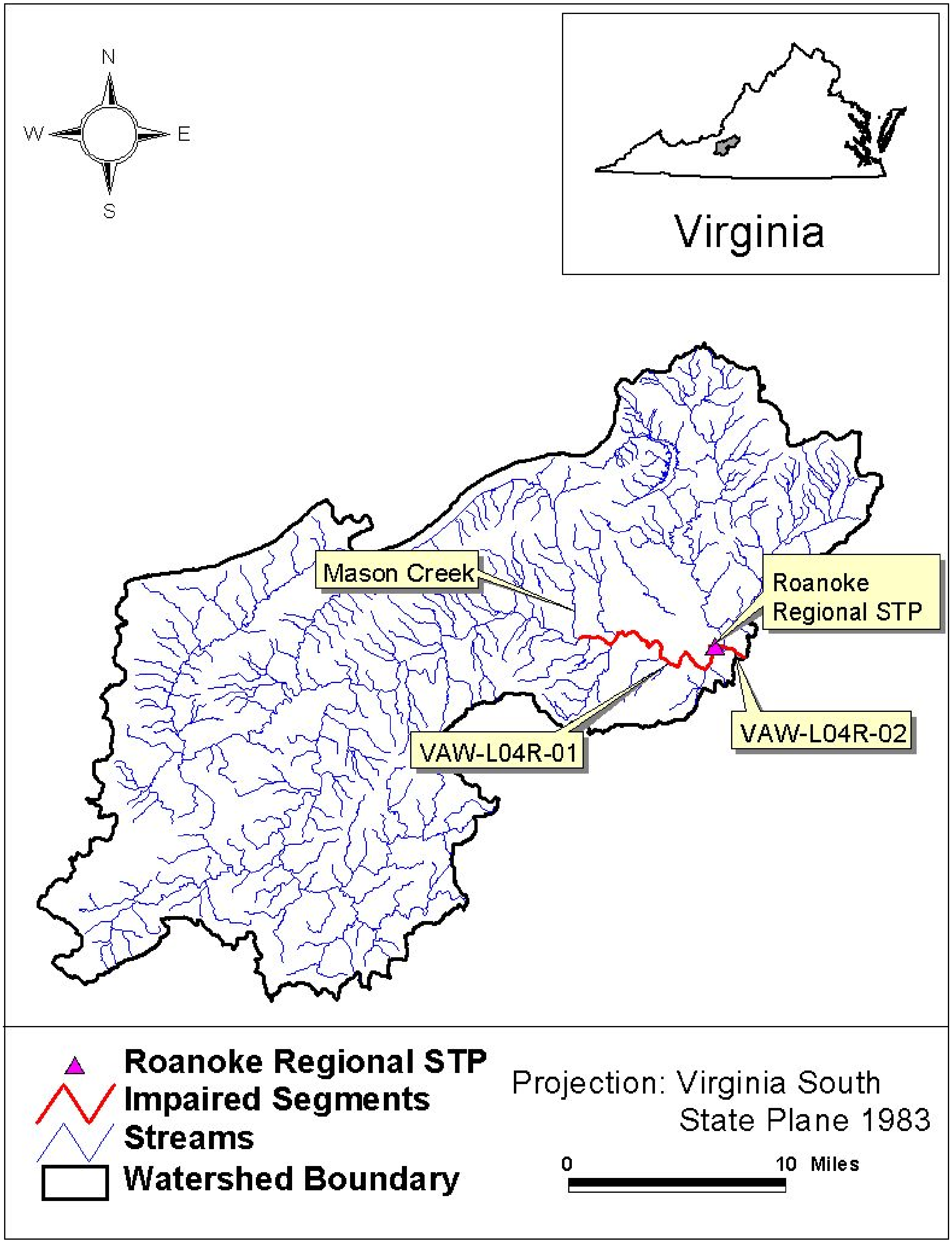


Figure 1-2: Roanoke River Benthic Impairment Segments and Delineated Watershed



1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *water quality standards* "means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect 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)."*

The listed segments defined in Section 1.2 do not support the propagation and growth of aquatic life in the Roanoke River, based on the biological assessment surveys conducted on the 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 biological assessments conducted on the Roanoke River indicate that some pollutant(s) are interfering with attainment of the General Standard, as impaired invertebrate communities have been observed in the listed segments of the river. Although biological assessments are indicative of the impacts of pollution, the specific pollutant(s) and source(s) are not necessarily known based on biological assessments alone.

2.0 Watershed Characterization

The physical conditions of the Roanoke River benthic impairment watershed were characterized using a geographic information system (GIS) developed for the watershed. The purpose of the watershed characterization was to provide an overview of the conditions in the watershed related to the benthic impairment present in the listed segments of the river. Information contained in the watershed GIS was used in the stressor identification analysis, as well as for the subsequent TMDL development. In particular, physical watershed features such as topography, soils types, and land use conditions were characterized. In addition, the number and location of permitted discharge facilities and DEQ monitoring stations in the watershed were summarized.

2.1 Physical Characteristics

Important physical characteristics of the Roanoke 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.

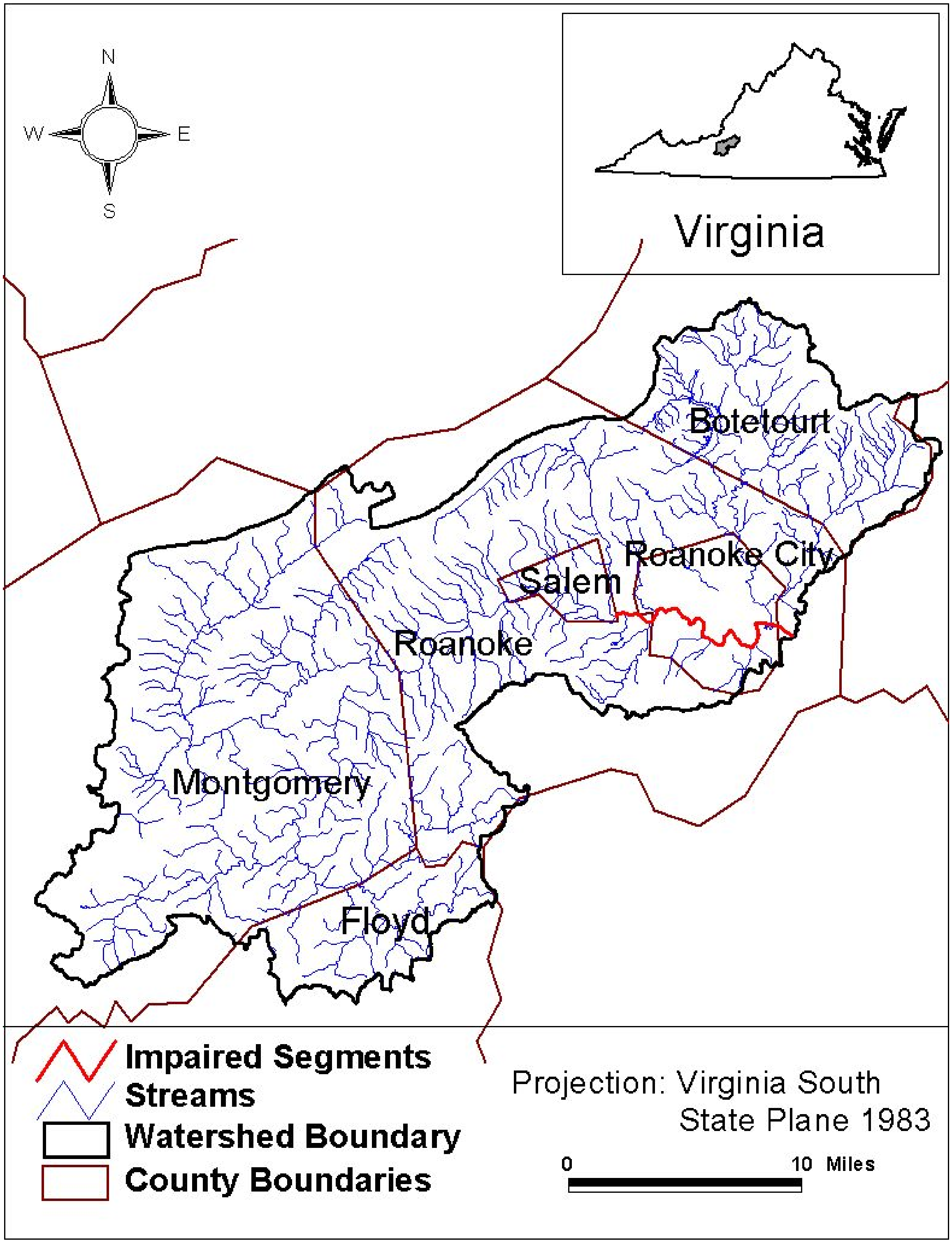
2.1.1 Watershed Location and Boundary

The Roanoke River benthic impairment watershed flows through sections of Roanoke, Montgomery, Floyd, and Botetourt Counties, as well as the Cities of Roanoke and Salem (Figure 2-1). The watershed is approximately 335,785 acres or 525 square miles. The impaired segment of the Roanoke River flows through the City of Roanoke.

2.1.2 Stream Network

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

Figure 2-1: Stream Network for the Roanoke River Benthic Impairment Watershed



2.1.3 Topography

A digital elevation model (DEM) was used to characterize topography in the watershed. DEM data obtained from BASINS show that elevation in the watershed ranges from 822 to 3,564 feet above mean sea level, with an average elevation of 2,163 feet above mean sea level.

2.1.4 Soils

The Roanoke River watershed soil characterization was based on the NRCS State Soil Geographic (STATSGO) Database for Virginia. There are nine general soil associations present in the portion of the watershed draining to the benthic impairment (Table 2-1). The majority of soils in the watershed are comprised of the Berks-Weikert-Laidig, Carbo-Chilhowie-Frederick, Frederick-Carbo-Timberville, Hayesville-Parker-Peaks, and Groseclose-Litz-Shottower soils associations. Combined, these five soil associations account for almost 80 percent of the soils in the watershed.

Table 2-1: Soil Types in the Roanoke River Benthic Impairment Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
VA001	Berks-Weikert-Laidig	17.5	B/D
VA002	Carbo-Chilhowie-Frederick	19.0	B/D
VA003	Frederick-Carbo-Timberville	12.6	B/D
VA004	Moomaw-Jefferson-Alonzville	7.5	C
VA005	Wallen-Dekalb-Drypond	7.7	C
VA007	Hayesville-Parker-Peaks	12.2	C
VA016	Shottower-Laidig-Weikert	5.4	C
VA017	Groseclose-Litz-Shottower	17.9	B
VA020	Rubble Land-Porters-Hayesville	0.2	B

Source: State Soil Geographic (STATSGO) Database for Virginia

The hydrologic soil groups of each of the soil associations are also presented in Table 2-1. 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 was based on USGS National Land Cover Data (NLCD). The distribution of land uses in the Roanoke River benthic impairment watershed, by land area and percentage, is presented in Table 2-3. Forested lands (69.9%), agricultural lands (17.5%), and developed lands (11.1%) represent the dominant land use types in the watershed. Brief descriptions of land use classifications are presented in Table 2-4. Figure 2-2 displays a map of the land uses within the watershed. Forested lands are ubiquitous throughout the watershed. Agricultural lands are concentrated in the headwaters of the basin, and in the Tinker Creek watershed in the northeastern section of the Roanoke River benthic impairment watershed. Urban and industrial areas are associated with the cities of Roanoke and Salem.

Table 2-3: Roanoke River Benthic Impairment Watershed Land Use Distribution

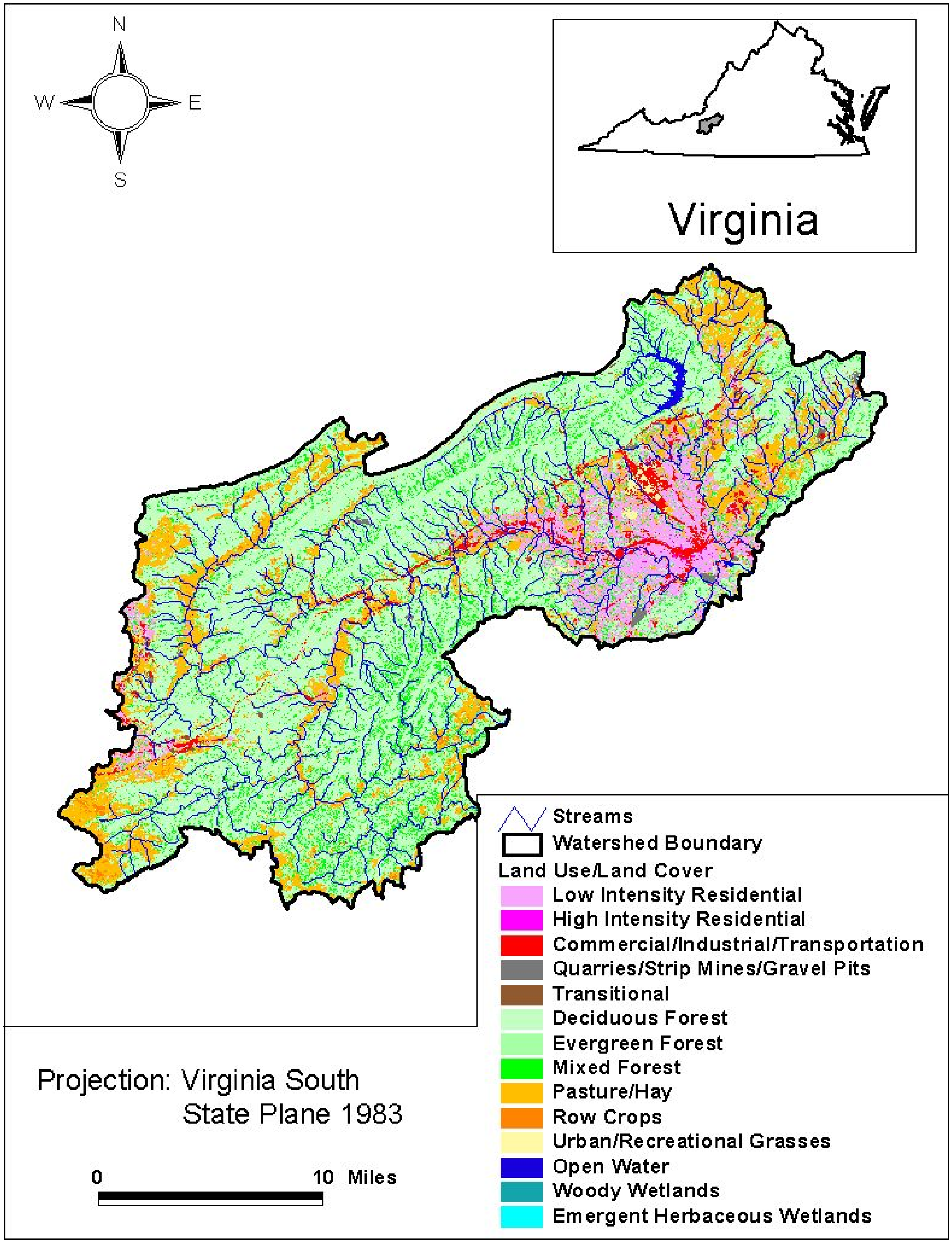
General Land Use Category	NLCD Land Use Type	Acres	Percent of Watershed	Total Percent
Water/ Wetlands	Open Water	1,336.9	0.4	0.5
	Woody Wetlands	99.2	0.03	
	Emergent Herbaceous Wetlands	77.7	0.02	
Developed	Low Intensity Residential	27,777.8	8.3	11.1
	High Intensity Residential	352.6	0.1	
	Commercial/Industrial/Transportation	9,118.3	2.7	
Agriculture	Pasture/Hay	53,261.1	15.9	17.5
	Row Crop	5,291.6	1.6	
Forest	Deciduous Forest	178,732.2	53.2	69.9
	Evergreen Forest	17,919.4	5.3	
	Mixed Forest	38,444.5	11.4	
Other	Quarries/Strip Mines/Gravel Pits	1152.9	0.3	1.0
	Transitional	1265.3	0.4	
	Urban/Recreational Grasses	955.7	0.3	
Total		**335,785**	**100**	**100**

Table 2-4: Descriptions of NLCD Land Use Types

Land Use Type	Description
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water
Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential	Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.
Commercial/ Industrial/ Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crop	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.
Quarries/Strip Mines/Gravel Pits	Areas of extractive mining activities with significant surface expression.
Transitional	Areas of sparse vegetative cover (less than 25 percent that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.)
Urban/ Recreational Grasses	Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

Source: National Land Cover Data (NLCD)

Figure 2-2: Land Use in the Roanoke River Benthic Impairment Watershed

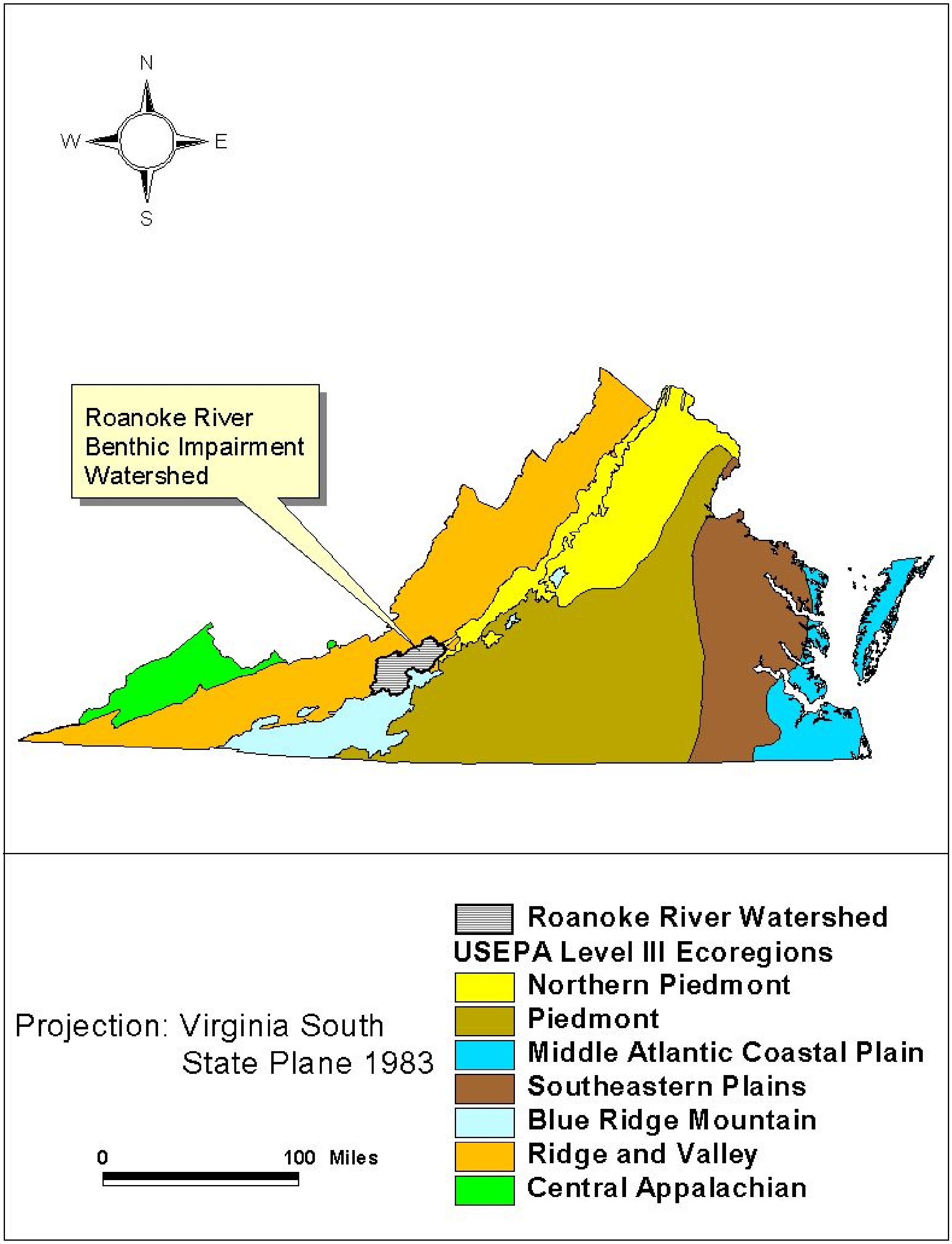


2.1.6 Ecoregion Classification

The Roanoke River benthic impairment watershed spans the Blue Ridge Mountain ecoregion and the Ridge and Valley ecoregion, USEPA Level III classification numbers 66 and 67, respectively (Woods et al., 1999). The location of the Roanoke River benthic impairment watershed within these ecoregions is presented in Figure 2-3. The Blue Ridge Mountain ecoregion extends from southern Pennsylvania to northern Georgia. Topography in the region varies from narrow ridges to hilly plateaus to higher elevation mountainous areas. The Blue Ridge Mountain ecoregion is characterized primarily by forested slopes, high-gradient, cool, clear streams, and rugged terrain. The Blue Ridge Mountain ecoregion is also characterized by a mixture of igneous, metamorphic, and sedimentary geology.

The Ridge and Valley ecoregion extends from Wayne County, Pennsylvania, through Virginia in a southwesterly direction, and is characterized by alternating forested ridges and agricultural valleys; approximately 50 percent of the region is forested. The Ridge and Valley ecoregion is situated between higher elevation mountainous regions with greater forest cover. The region's roughly parallel ridges and valleys are comprised of a variety of geologic materials, including limestone, dolomite, shale, siltstone, sandstone, chert, mudstone, and marble. Elevation in the region ranges from about 500 feet to 4,300 feet above mean sea level.

Figure 2-3: Virginia Level III Ecoregions



2.2 Permitted Discharge Facilities

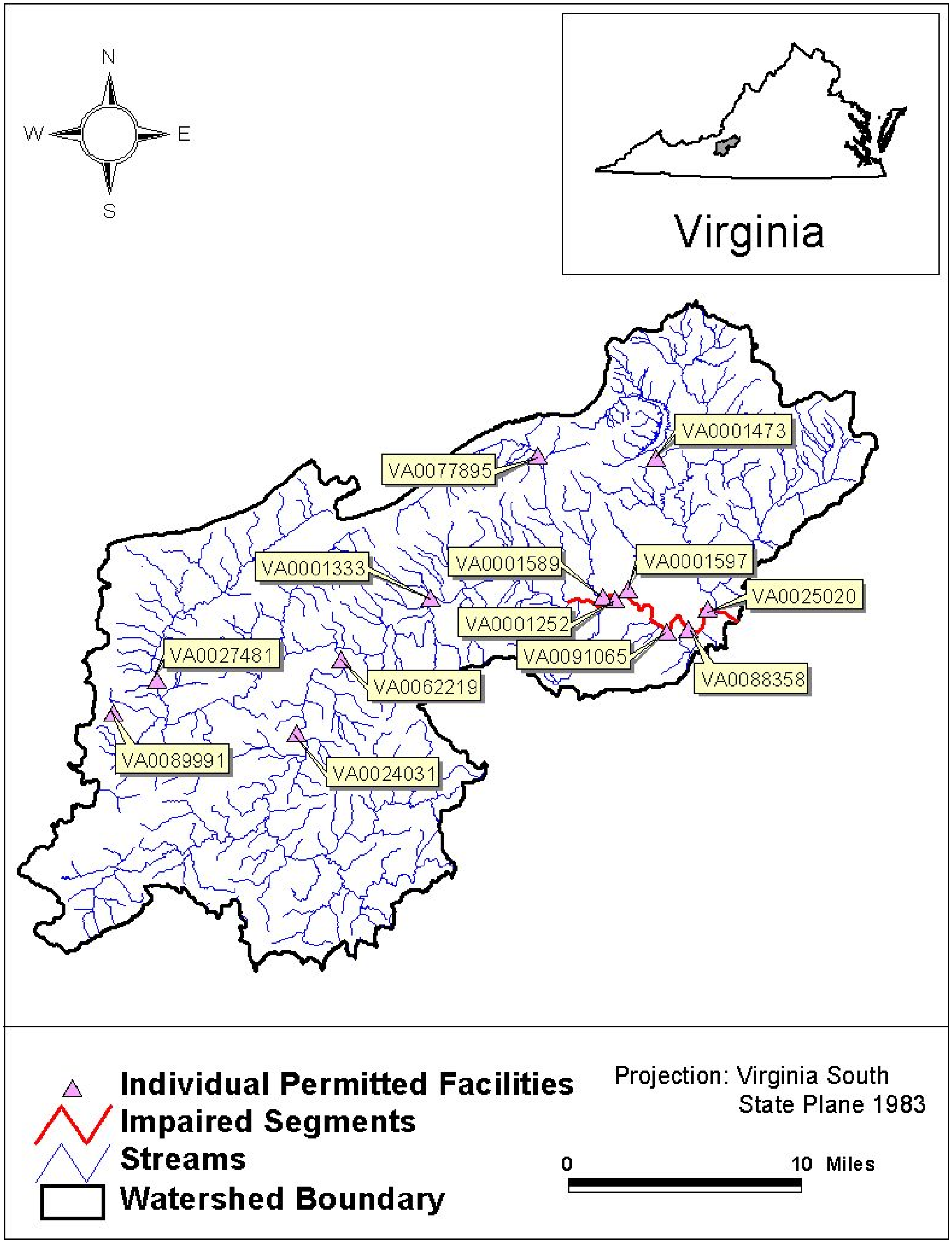
There are 12 facilities holding active individual discharge permits in the Roanoke River benthic impairment watershed. The permit number, type, permitted flow, receiving waterbody, and status of each of the facilities holding individual permits are presented in Table 2-5 and their locations are presented in Figure 2-4. There are also a total of 152 active general permits in the Roanoke River benthic impairment watershed; 77 stormwater permits issued to industrial sites, 38 stormwater permits issued to construction sites, 17 permits issued to domestic sewage facilities, 11 permits issued to concrete facilities, 7 permits issued to mines, 1 permit issued to a cooling water facility, and 1 permit issued to a carwash (Appendix A). Based on the number of disturbed land-acres specified in the stormwater construction permits issued between 2002 and 2004, it is estimated that on the average approximately 467 acres are annually under construction.

Table 2-5: Facilities Holding Individual Permits in the Roanoke River Benthic Watershed

Permit Number	Facility Name	Facility Type	Design Flow (gpd)[1]	Receiving Waterbody	Status
VA0001252	Associated Asphalt Inc.	Industrial	54,000	Roanoke River	Active
VA0001333	Koppers Inc.	Industrial	600,000	Roanoke River	Active
VA0001473	Carvins Cove Water Filtration Plant	Industrial	474,000	Carvins Creek, UT	Active
VA0001589	Roanoke Electric Steel Corp.	Industrial	39,000	Peters Creek	Active
VA0001597	Norfolk Southern Railway Co.	Industrial	50,000	Lick Run, UT	Active
VA0024031	Shawsville Town STP	Municipal	200,000	SF Roanoke River	Active
VA0025020	Western Virginia Water Authority	Municipal	42,000,000	Roanoke River	Active
VA0027481	Blacksburg Country Club STP	Municipal	35,000	NF Roanoke River	Active
VA0062219	Elliston-Lafayette WWTP	Municipal	25,000	SF Roanoke River	Active
VA0077895	Roanoke Moose Lodge	Municipal	4,700	Mason Creek	Active
VA0088358	Fred Whitaker Co.	Industrial	151,000	Roanoke River	Active
VA0089991	Federal Mogul Corp.	Industrial	65,000	Wilson Creek, UT	Active
VA0091065	Crystal Springs WTP	Industrial	92,000	Roanoke River	Active

1: Gallons per Day

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

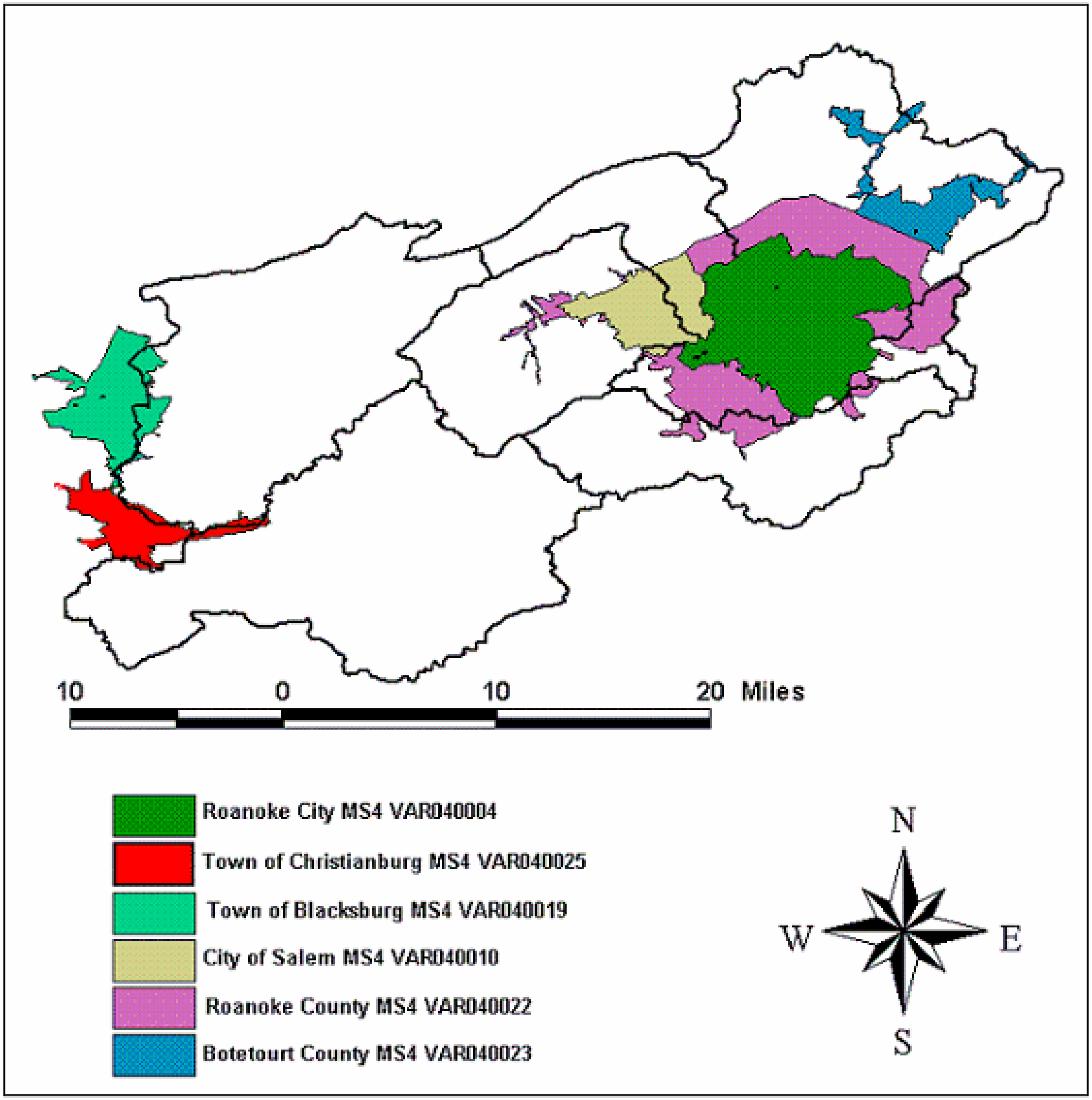


In addition to the individual and general permits presented above, eleven (11) Municipal Separate Storm Sewer (MS4) permits have been issued to Cities, Towns, Counties, and other facilities within the Roanoke River Benthic Watershed. Table 2-6 lists all the MS4 permit holders with the area covered by each individual MS4. The acreages for the VDOT Roanoke Urban Area MS4 and the VDOT Montgomery County Urban Area MS4 were estimated using the roads length within the urban areas and assuming a 25 foot-road-width. The roads' length for each urban area was extracted from the VDOT document listing the length of the road segments maintained by the Commonwealth of Virginia (VDOT), or Virginia local jurisdictions or the Federal Government (VDOT 2003). Combined, these MS4 permits cover approximately 21.6% of the Roanoke River benthic impairment watershed. Figure 2-5 presents the major MS4 located within the Roanoke River Benthic Watershed.

Table 2-6: MS4 Permits Present in Roanoke River Benthic Watershed

MS4 Permit Holder	Permit Number	Area (Acres)
Roanoke County	VAR040022	28,907
City of Roanoke	VAR040004	23,577
Town of Vinton	VAR040026	2,024
Botetourt County	VAR040023	5,180
City of Salem	VAR040010	9,332
VDOT Roanoke Urban Area	VAR040017	436
Virginia Western Community College	VAR040030	35
Virginia Medical Center	VAR040050	160
VDOT Montgomery County Urban Area	VAR040016	60
Town of Blacksburg	VAR040019	1,613
Town of Christianburg	VAR040025	1,193
	Total	**72,517**

Figure 2-5: Location of MS4 Boundaries in the Roanoke River



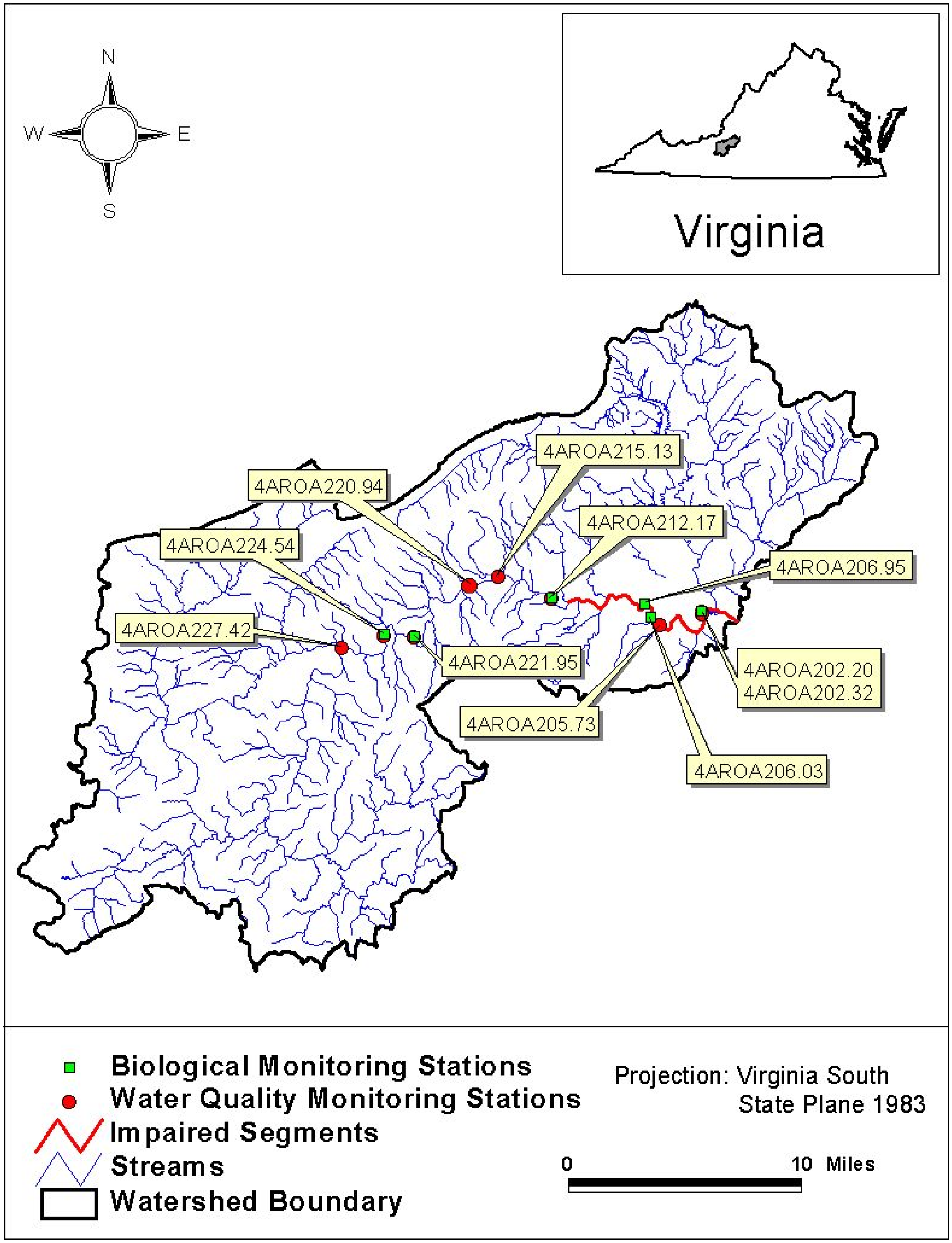
2.3 DEQ Monitoring Stations

DEQ has several monitoring stations on the Roanoke River which are used for biological and ambient water quality monitoring. DEQ biological monitoring stations are where DEQ biologists evaluate the aquatic community's health through macroinvertebrate sampling and analysis. Chemical parameters such as pH, nutrients, solids, metals, and organic data are collected at ambient DEQ water quality monitoring stations. A summary list of the DEQ monitoring stations located on the mainstem Roanoke River is presented in Table 2-7, and the locations of these stations are presented in Figure 2-6. It should be noted that additional water quality monitoring data were collected at tributary stations located within the Roanoke River benthic impairment watershed. These data were evaluated as part of the benthic stressor analysis; however, because the biological impairment is located on the mainstem Roanoke River, discussion of water quality data in this report is limited to those data collected at mainstem Roanoke River stations on or above the impaired biological segments. Station identification numbers include the abbreviated creek name and the river mile on that creek where the station is located. The river mile number represents the distance from the confluence with a larger waterbody. In the case of the Roanoke River, the monitoring stations specified in Table 2-7 are located approximately 200 miles above the Albemare Sound.

Table 2-7: Summary of Monitoring Stations on the Mainstem Roanoke River

Station ID	Station Type	Period Of Record
4AROA202.20	Ambient and biological	1967-2004
4AROA202.32	Ambient water quality	2004
4AROA205.73	Ambient water quality	2003-2004
4AROA206.03	Biological assessment	1997
4AROA206.95	Biological assessment	1997-2004
4AROA212.17	Ambient and biological	1967-2004
4AROA215.13	Ambient and biological	2003-2004
4AROA220.94	Ambient water quality	2003-2004
4AROA221.95	Ambient and biological	2002
4AROA224.54	Ambient and biological	1988-2004
4AROA227.42	Ambient water quality	1970-2004

Figure 2-6: DEQ Monitoring Stations in the Roanoke River Benthic Impairment Watershed

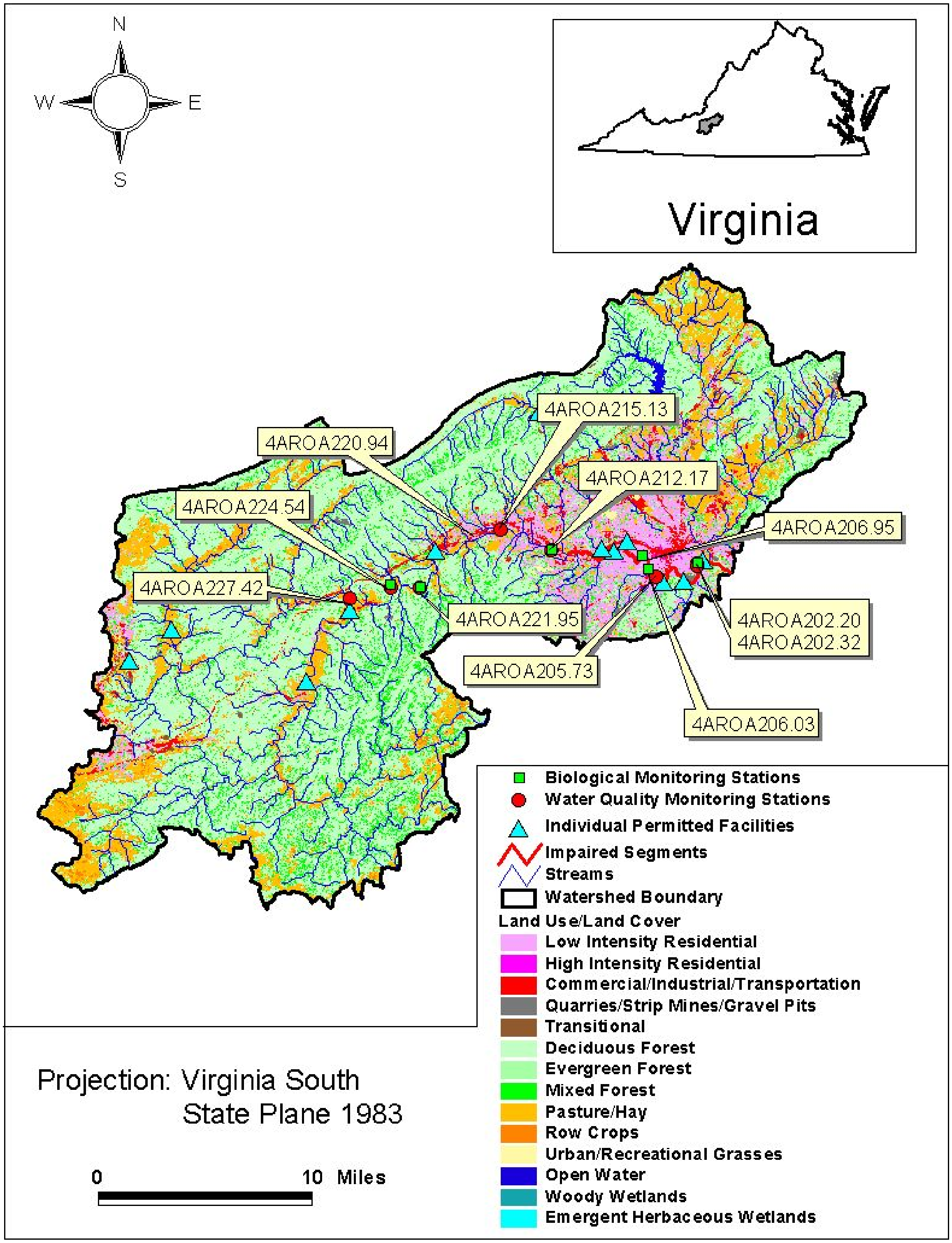


The benthic invertebrate communities at stations 4AROA202.20, 4AROA206.03, and 4AROA206.95 are classified as impaired based on DEQ bioassessments. Station 4AROA224.54 is the biological monitoring station that was used as a reference station for bioassessments. Additional biological and/or water quality data were collected at stations 4AROA202.32, 4AROA205.73, 4AROA212.17, 4AROA215.13, 4AROA220.94, 4AROA221.95, and 4AROA227.42 on the Roanoke River mainstem. A detailed discussion of environmental monitoring data is presented in Section 3.0.

2.4 Overview of the Roanoke River Benthic Impairment Watershed

Forested lands (69.9%), agricultural lands (17.5%), and developed lands (11.1%) represent the dominant land uses in the Roanoke River benthic impairment watershed. There are 13 facilities holding active individual discharge permits in the watershed, and 152 facilities holding active general permits. Biological monitoring has been conducted by DEQ at seven mainstem Roanoke River stations on or upstream of the impaired biological segments, and DEQ has collected ambient water quality data at nine mainstem stations in the watershed. The land use and the locations of the facilities and monitoring stations in the watershed are shown in the summary map presented in Figure 2-7.

Figure 2-7: Overview of the Roanoke River Benthic Impairment Watershed



3.0 Environmental Monitoring

The first step in benthic TMDL development is the identification of the pollutant stressor(s) that is 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 segments of the Roanoke River. Analyzed data included available biological and water quality monitoring data, Discharge Monitoring Reports (DMR) from the permitted facilities, results from a recent DEQ instream toxicity study conducted on the Roanoke River, and historic stormwater monitoring data. The collection period, content, and monitored sites for these data are summarized in Table 3-1. The locations of permitted discharge facilities and monitoring stations were presented previously in Figures 2-4 and 2-5.

Table 3-1: Inventory of Environmental Monitoring Data for the Roanoke River Benthic Impairment

Data Type	Collection Period	Monitoring Stations											Permitted Facilities	Roanoke Tributaries
		4AROA202.20	4AROA202.32	4AROA205.73	4AROA206.03	4AROA206.95	4AROA212.17	4AROA215.13	4AROA220.94	4AROA221.95	4AROA224.54	4AROA227.42		
DEQ Biological Monitoring	1994-2004	X			X	X	X	X		X	X			
DEQ Ambient Water Quality Monitoring	1967-2004	X	X	X			X	X	X	X	X	X		
DEQ Field Water Quality Monitoring	1994-2004	X	X	X			X	X	X	X	X	X		
DEQ Toxicity Study	April 2004	X				X								
Discharge Monitoring Reports (DMR)	1999- 2003												X	
Roanoke River Stormwater Study	1982-1983													X

3.1 Biological Monitoring Data

The impaired segments of the Roanoke River were included on Virginia's 1996 Total Maximum Daily Load Priority List and Report, 1998 and 2002 Section 303(d) Lists of Impaired Waters, and 2004 Water Quality Assessment 305(b)/303(d) Integrated Report based on biomonitoring results obtained between 1994 and 2004. A modified version of the EPA Rapid Bioassessment Protocols II (RBPII) was used to assess the biological condition of the river's benthic invertebrate communities. The RBPII method compares these metrics to a reference station (in this case 4AROA224.54). Candidate RBPII metrics, as specified in EPA's Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers, Second Edition (Barbour et al., 1999), are presented in Table 3-2. The 5-year average RBPII Scores calculated for the Roanoke River biological monitoring stations and used to specify the Section 303(d) listings are presented in Table 3-3.

Virginia DEQ bioassessments follow a paired reference approach using upstream stations located in the same watershed. The DEQ protocol uses eight standard metrics to compare monitored and reference sites. These metrics include taxa richness, composition, and tolerance/intolerance measures (Table 3-2).

DEQ field data sheets and bioassessment forms completed for each biological assessment conducted on the mainstem Roanoke River contained the following information:

- Assessment ratings for each station for each survey event
- The numbers and types of macroinvertebrates present at each station
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of the each survey

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

Category	Metric	Definition	Expected Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera 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 Measures	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease
	% 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	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

Table 3-3: 5-year Average RBPII Scores at Roanoke River Monitoring Stations

Station	5-year Average	
	RBPII Score	Assessment
4AROA202.20	52.18	Moderately Impaired
4AROA205.67	34.78	Moderately Impaired
4AROA206.03	55.10	Moderately Impaired
4AROA206.95	47.83	Moderately Impaired
4AROA212.17	59.51	Slightly Impaired
4AROA224.54*	100	Non-impaired

* Monitoring Station 4AROA224.54 (Roanoke River at Dixie Caverns) was used as the reference station for bioassessments

3.1.1 Virginia Stream Condition Index (SCI) Scores

Using the data collected during biomonitoring surveys, biological assessment scores were calculated using the Virginia Stream Condition Index (SCI) currently being developed by DEQ. The SCI is an eco-regionally-calibrated index comprised of eight metrics that are listed in Table 3-4. The metrics used in calculation of an SCI score are similar to the metrics used in RBPII assessments. However, unlike RBPII, the reference condition of the SCI is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 60 has been proposed for assessing results obtained with the SCI. Streams that score greater than 60 are considered to be non-impaired, whereas streams that score less than 60 are considered impaired.

Calculated SCI scores for the biomonitoring stations located on or above the biologically impaired segments of the Roanoke River are presented in Table 3-5. SCI scores calculated for stations 4AROA202.20, 4AROA206.03, and 4AROA206.95 were consistently below the proposed impairment cutoff score of 60; therefore, these stations are considered to be impaired. The DEQ 2004 assessment guidance memorandum states that biological impairments are listed based on assessments that confirm moderate or severe impairment of the benthic community (DEQ, 2004). Therefore, because biological assessments conducted at station 4AROA212.17 showed only a slightly impaired benthic community (SCI score 57), the biological impairment listings for the Roanoke River were not extended to this station. Stations 4AROA215.13, 4AROA221.95, and 4AROA224.54 all have average SCI scores above the proposed impairment cutoff, and are thus considered to be non-impaired. Station 4AROA224.54 served as the reference station for the biological assessments.

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

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 Ephemoroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemoroptera	Decrease	% Ephemoroptera 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
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

Table 3-5: Virginia SCI Scores for the Roanoke River

Collection Period	SCI Score						
	4AROA202.20	4AROA206.03	4AROA206.95	4AROA212.17	4AROA215.13	4AROA221.95	4AROA224.54
Fall 1994	37.5			52.0			62.0
Spring 1995	45.0			56.5			64.7
Fall 1995	32.8			57.2			50.4
Spring 1996	30.2			70.1			55.8
Fall 1996	31.0			53.7			57.5
Spring 1997	50.8		53.7	55.0			62.9
Fall 1997	33.8	35.1	42.5	52.5			59.1
Spring 1998		54.1	48.9	59.5			68.1
Fall 1998		38.5	36.4	48.7			52.3
Spring 1999			46.3	62.3			73.3
Fall 1999				57.4			70.7
Spring 2000				50.0			65.4
Fall 2000	39.6		48.9	63.6			70.0
Fall 2001	55.9		54.5	61.5			63.5
Spring 2002						59.3	
Fall 2002						73.0	
Fall 2003	39.3			55.2	59.5		59.8
Spring 2004	58.6		60.6	61.2	64.5		58.4
Average	**41.3**	**42.5**	**49.0**	**57.3**	**62.0**	**66.2**	**62.1**

3.1.2 Habitat Assessment Scores

A suite of habitat variables were visually inspected at the biomonitoring stations as part of every biological assessment conducted on the Roanoke River. Habitat parameters that were examined include channel alteration, sedimentation, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. Each parameter was assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. Box plots depicting the minimum, maximum, 25th percentile, 50th percentile, and 75th percentile of selected habitat parameters scored at each of the monitoring stations are presented in Figures 3-1 to 3-3. Box plots of all scored habitat parameters are presented in Appendix B.

Substrate and streambank conditions at the biological monitoring stations declined as sampling moved from upstream to downstream (Figures 3-1 and 3-2). Embedded substrates result from fine sediment particles settling on the streambed and silting over invertebrate habitat; thus, the declining substrate embeddedness scores indicate that sediment loading is increasing at stations located on the biologically impaired segments as compared to the non-impaired upstream stations. Similarly, total habitat scores, defined as the sum of all habitat parameter scores, also decreased from upstream to downstream (Figure 3-3).

Figure 3-1: Substrate Embeddedness Scores for Roanoke River Monitoring Stations

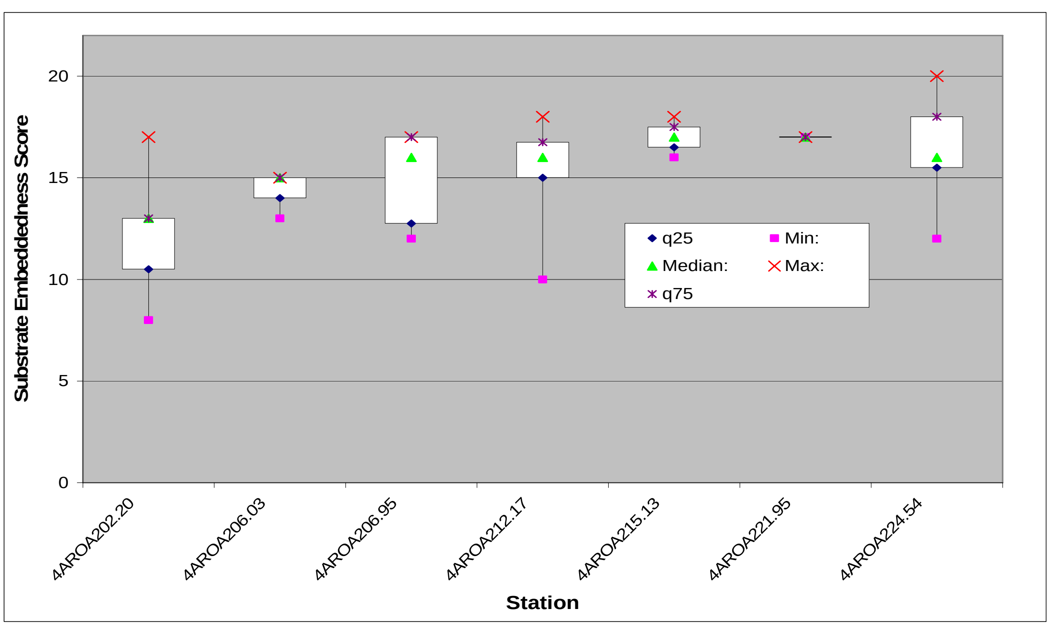


Figure 3-2: Riparian Vegetation Scores for Roanoke River Monitoring Stations

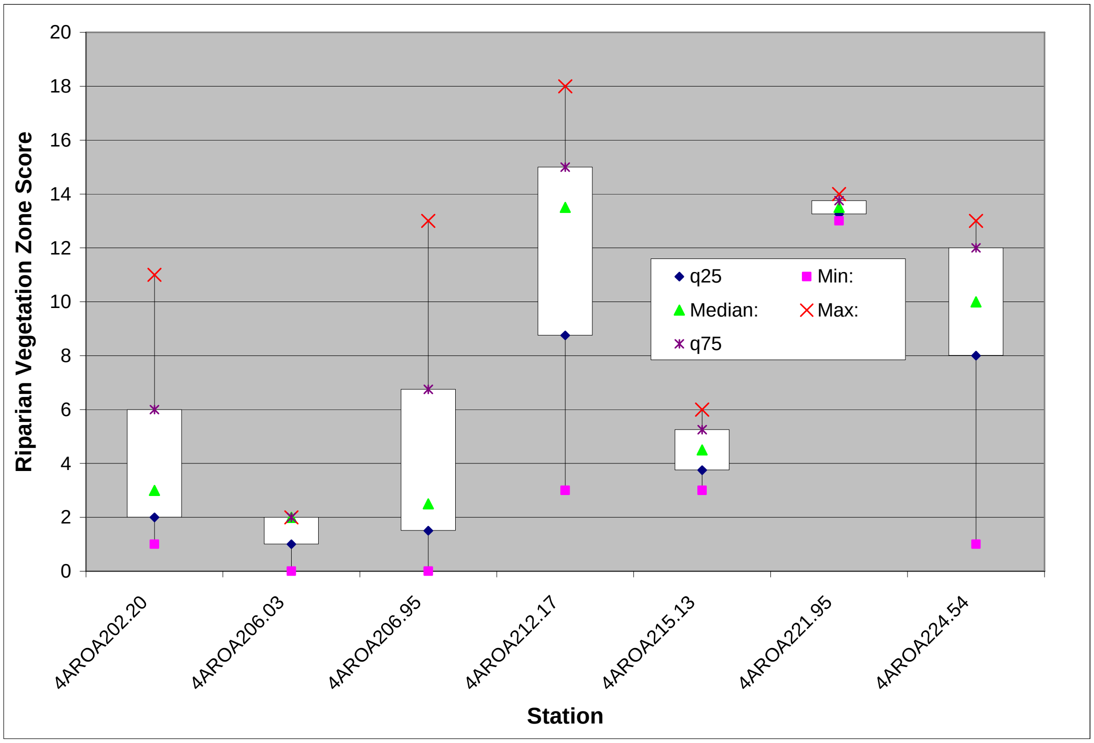
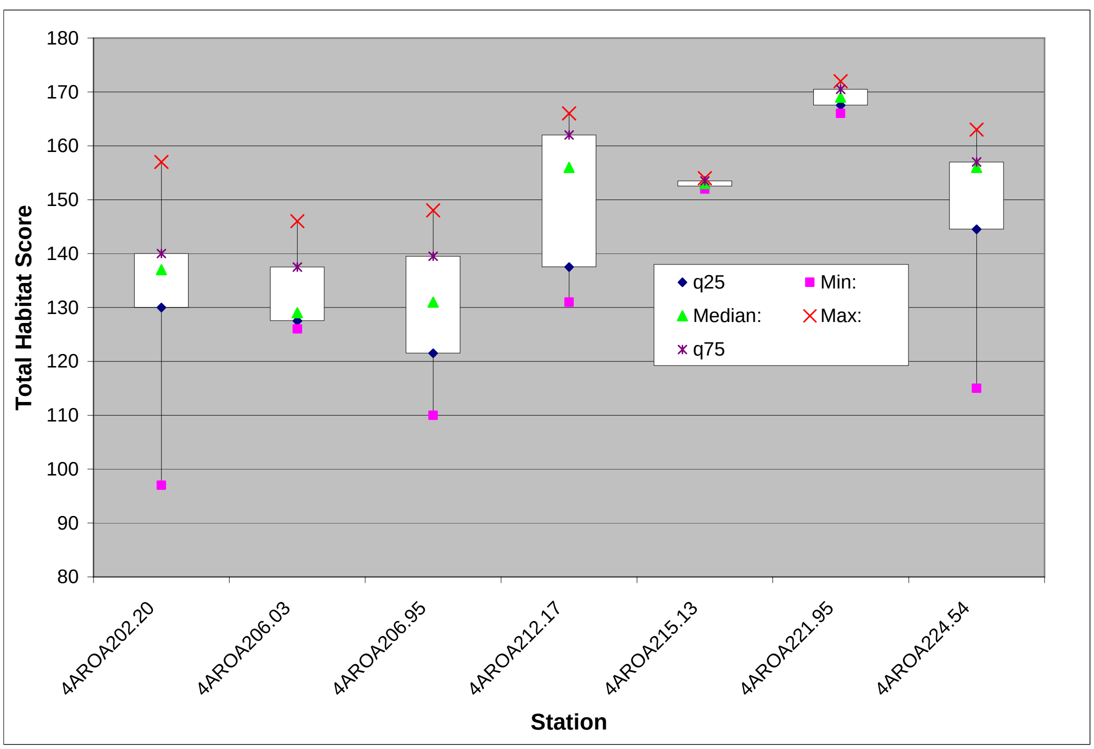


Figure 3-3: Total Habitat Scores for Roanoke River Monitoring Stations



3.2 Water Quality Monitoring

There are nine DEQ ambient water quality monitoring stations located on the mainstem Roanoke River on or above the biologically impaired segments. Information on each ambient monitoring station is summarized in Table 3-6. Monitoring stations 4AROA202.20, 4AROA212.17, and 4AROA227.42 represent the largest sources of water quality data available in the study area.

Table 3-6: Ambient Water Quality Monitoring Stations Located on the Roanoke River

Station Id	Station Location	Period of Record	River Mile	No. Sampling events
4AROA202.20	13th Street Bridge above Western Virginia Water Authority	1967-2004	202.20	493
4AROA202.32	Upstream of 14th Street Bridge	2004	202.32	4
4AROA205.73	Franklin Road Bridge, Roanoke, VA	2003-2004	205.73	21
4AROA212.17	Route 11 Bridge below Eaton, Inc.	1967-2004	212.17	269
4AROA215.13	Mill Lane Bridge, Salem, VA	2003-2004	215.13	10
4AROA220.94	Route 639 Bridge south of Wabun, VA	2003-2004	220.94	15
4AROA221.95	Above Route 639 Bridge near Wabun, VA	2002	221.95	2
4AROA224.54	Route 639 Bridge near Dixie Caverns	1988-2004	224.54	15
4AROA227.42	Route 773 at gaging station in Lafayette, VA	1970-2004	227.42	491

3.2.1 Instream Water Quality Data

Instream water quality data collected on the mainstem Roanoke River is presented in Figures 3-4 to 3-13. Where data were collected at more than three stations, box plots depict the minimum, maximum, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of the water quality parameters observed at each of the monitoring stations. The Roanoke River is classified as a Class IV waterbody (Mountainous Zone Waters) along the length of the impaired segments, as defined in Virginia Water Quality Standards (9 VAC 25-260-50). Thus, water quality parameters in the biologically impaired segments must meet the Class IV standards (Table 3-7).

Field dissolved oxygen, temperature and pH values have been in compliance with numeric criteria for Class IV waters at both the impaired segments (station 4AROA202.20) and upstream of the biological impairment (Figures 3-4 to 3-7). Diurnal dissolved oxygen data collected in September 2004 at both an impaired (4AROA202.20) and reference (4AROA224.54) station indicate that instream oxygen concentrations remained above the minimum and daily average water quality standards at both stations throughout several days (Figure 3-5). Biochemical oxygen demand concentrations at the stations were also low (Figure 3-8). Additionally, no upstream to downstream trends, or temporal trends, are evident in the field data. Average turbidity was low across sites, but did increase at downstream monitoring stations (Figure 3-9). Additionally, although no recent stormwater monitoring data are available in the watershed, stormwater samples collected from 1982-1983 as part of the Roanoke Metropolitan Area Water Quality Management Study (Virginia Water Control Board, 1983) demonstrated elevated suspended solids concentrations (averages of 863 mg/L, 1941 mg/L, and 2007 mg/L) were present historically at three monitoring stations on tributaries flowing into the Roanoke River. Total nitrogen, ammonia, and total phosphorus concentrations were generally low at all monitoring stations (Figures 3-10 to 3-12). The low nutrient concentrations observed corroborate the diurnal dissolved oxygen data that show diurnal variation in instream oxygen concentrations is within the normal range of 1-2 mg/L. Several violations of the Virginia fecal coliform geometric mean water quality standard occurred at monitoring stations located on the mainstem Roanoke River (Figure 3-13);

fecal coliform TMDLs are currently being developed for the impaired segments and will be presented in a separate report.

Table 3-7: Virginia Water Quality Standards for Roanoke River Biologically Impaired Segments

Class	Description of Waters	Dissolved Oxygen (mg/L)		pH	Maximum Temperature (Deg. C)
		Minimum	Daily Average		
IV	Mountainous Zones Waters	4.0	5.0	6.5-9.5	31

Figure 3-4: Dissolved Oxygen Concentrations at Roanoke River Monitoring Stations

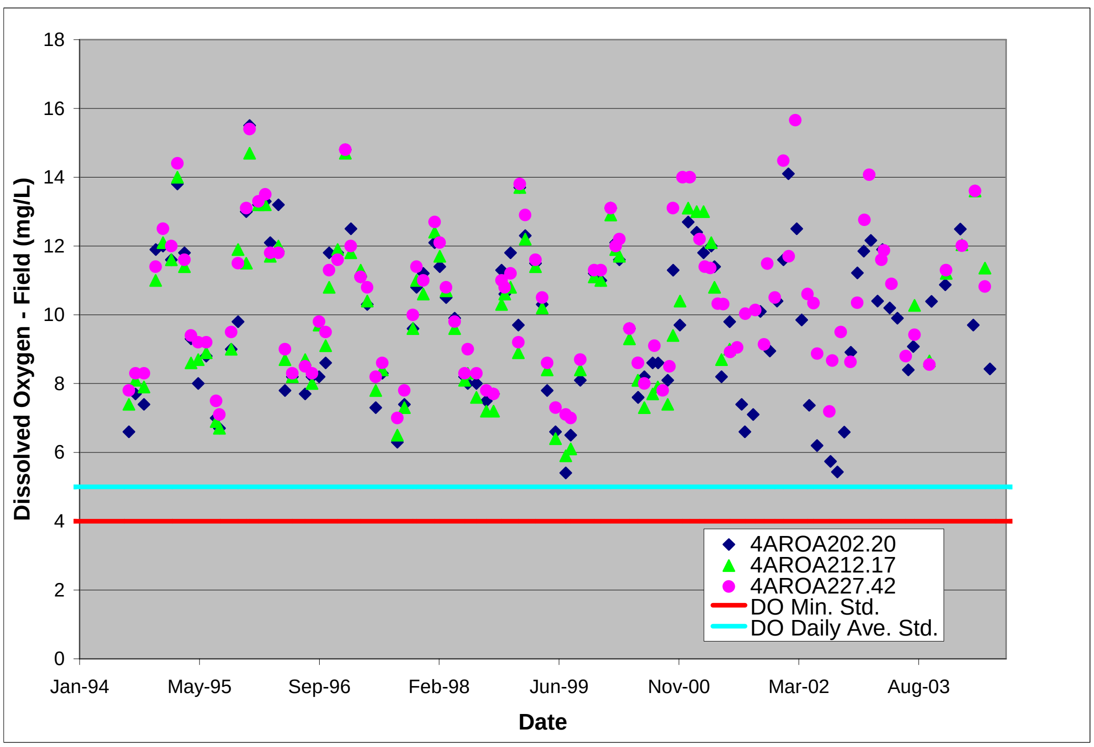


Figure 3-5: Diurnal Dissolved Oxygen at Roanoke River Monitoring Stations

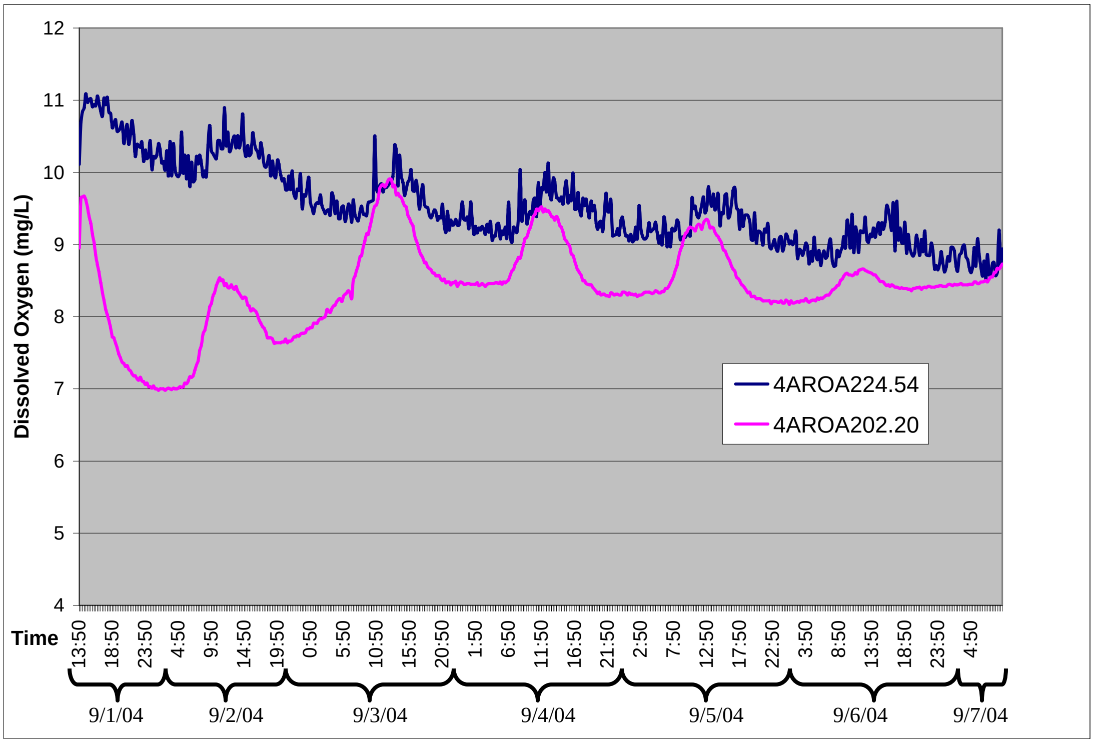


Figure 3-6: Field Temperature at Roanoke River Monitoring Stations

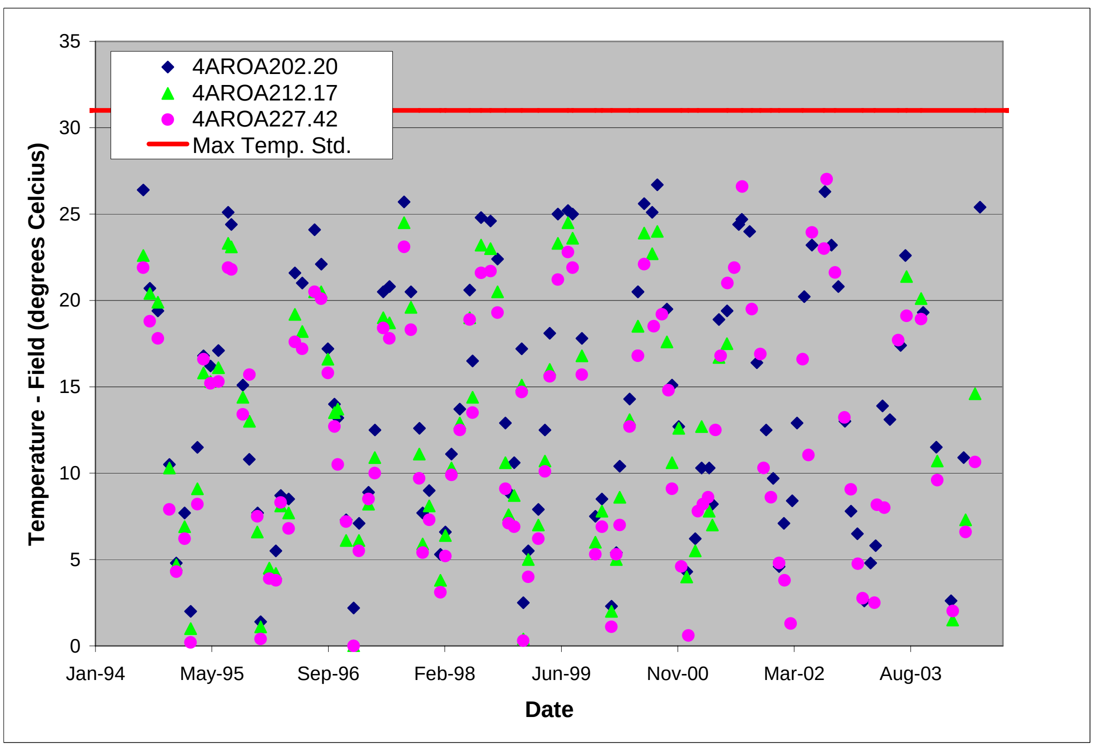


Figure 3-7: pH Levels at Roanoke River Monitoring Stations

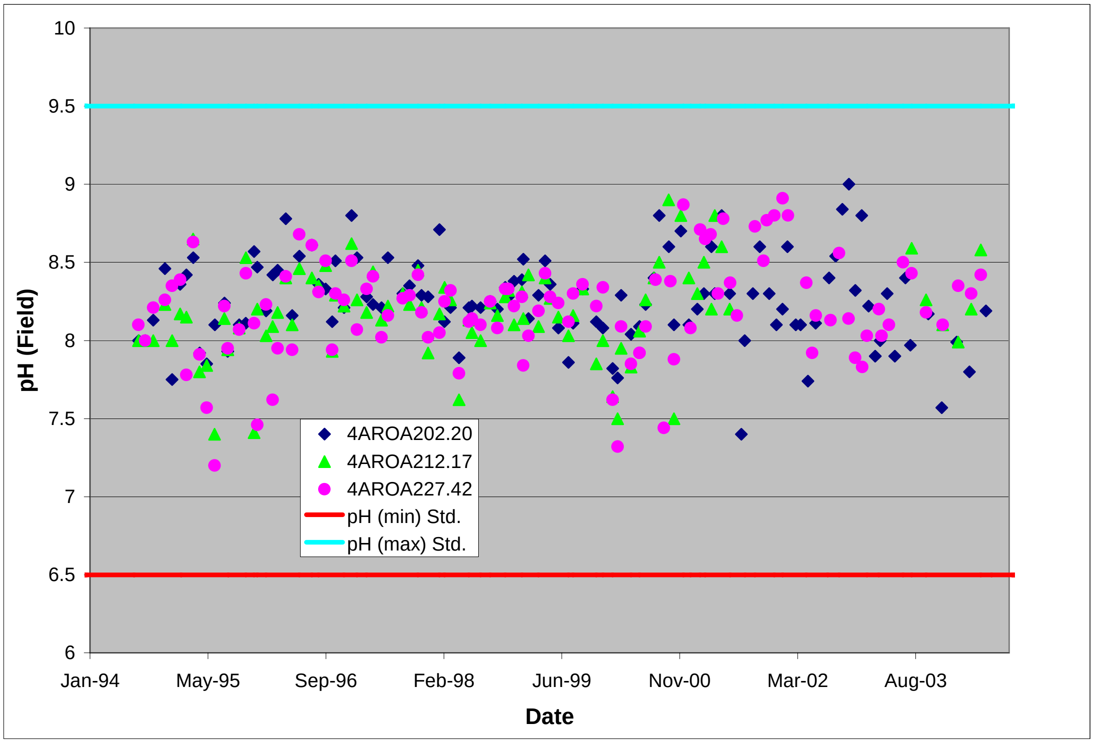


Figure 3-8: Biochemical Oxygen Demand at Roanoke River Monitoring Stations

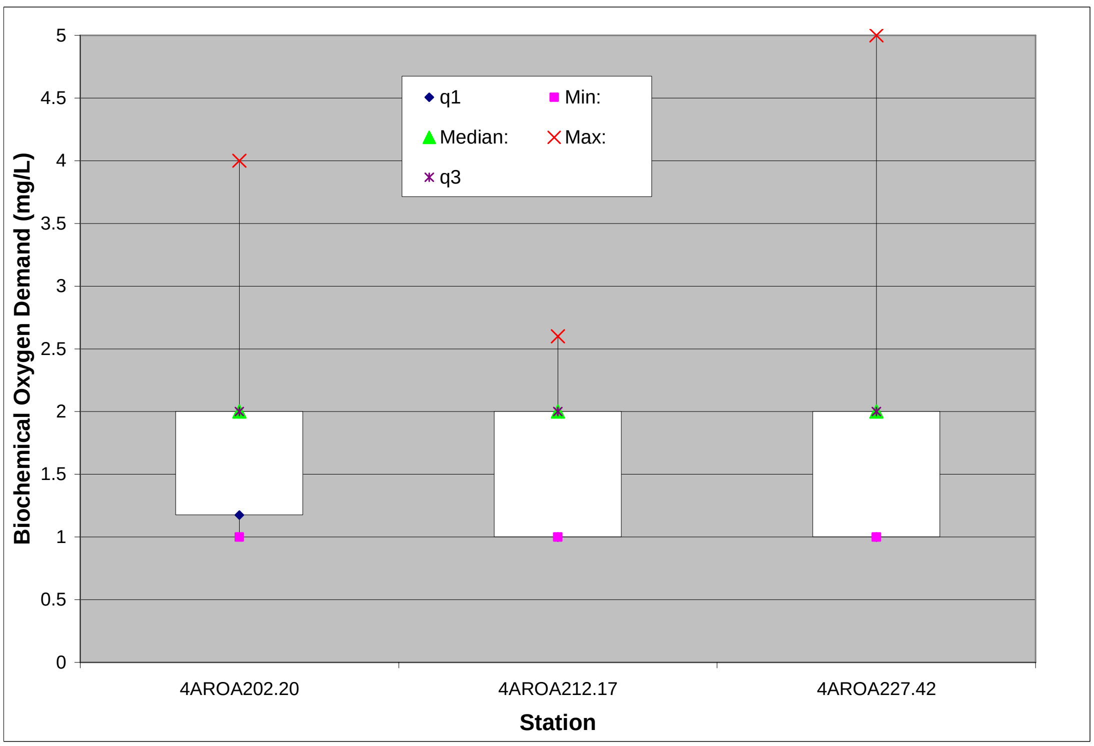


Figure 3-9: Turbidity at Roanoke River Monitoring Stations

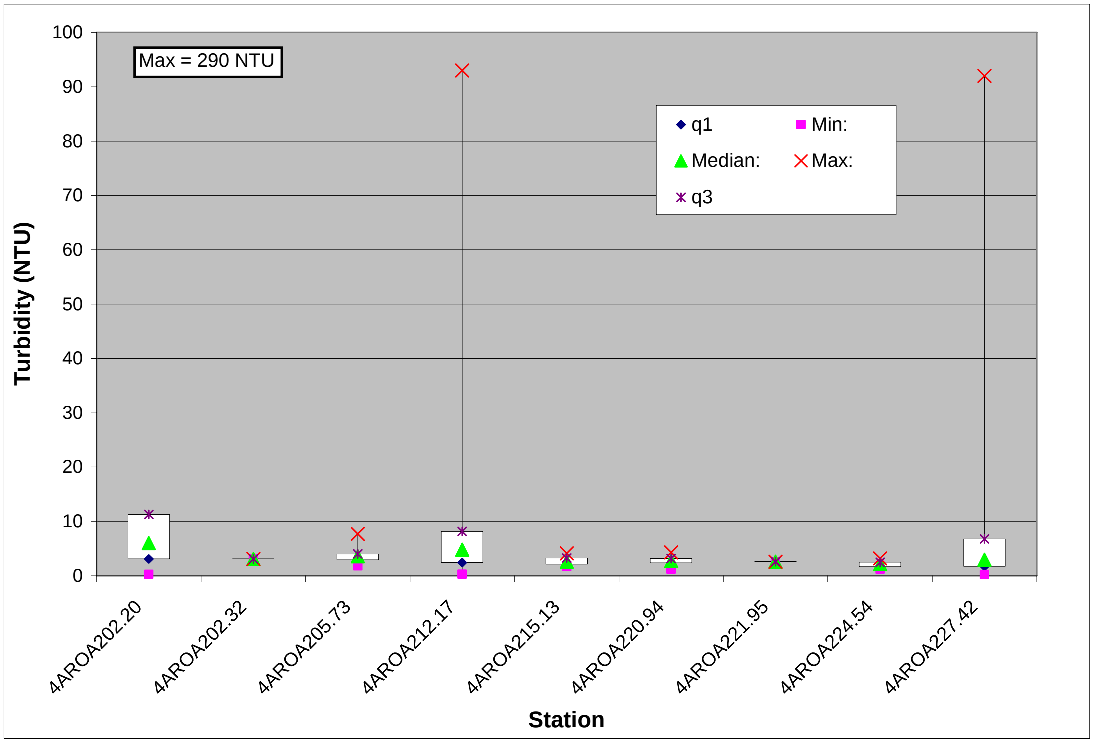


Figure 3-10: Total Nitrogen Concentrations at Roanoke River Monitoring Stations

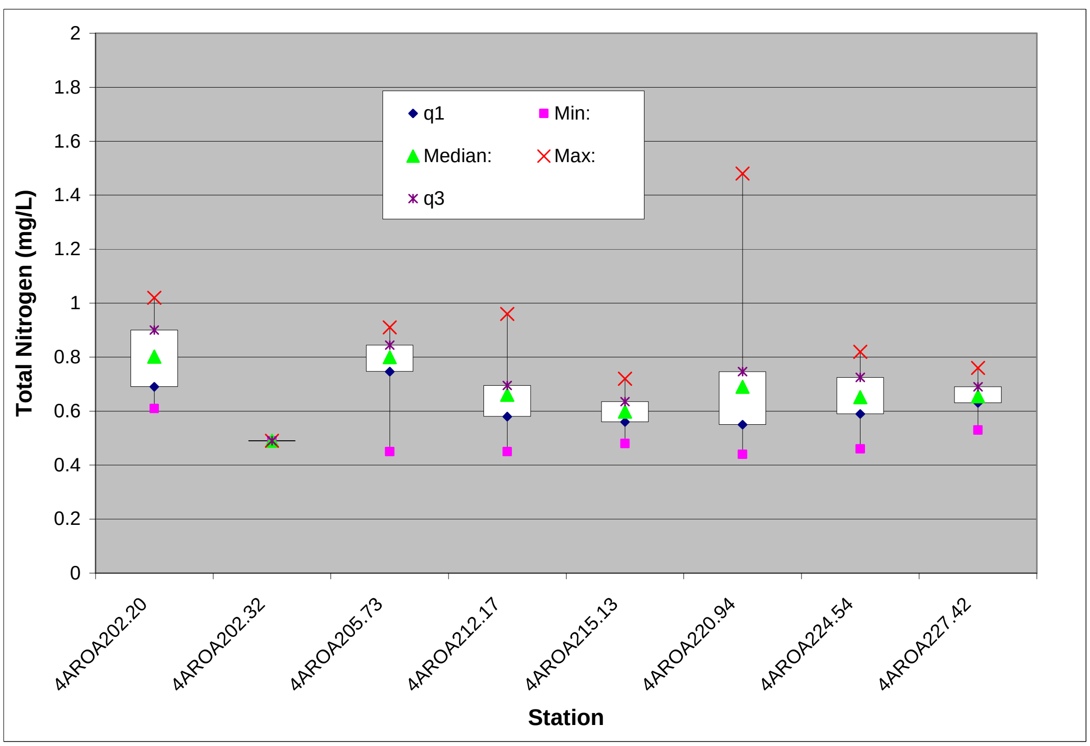


Figure 3-11: Ammonia Concentrations at Roanoke River Monitoring Stations

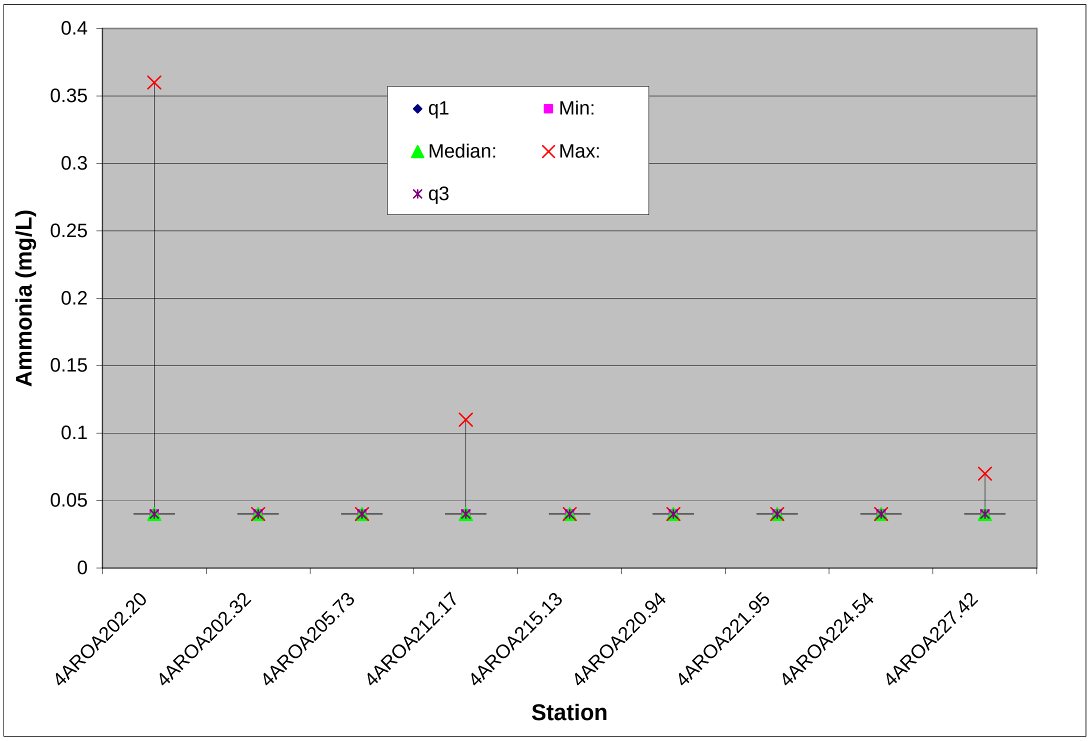


Figure 3-12: Total Phosphorus Concentrations at Roanoke River Monitoring Stations

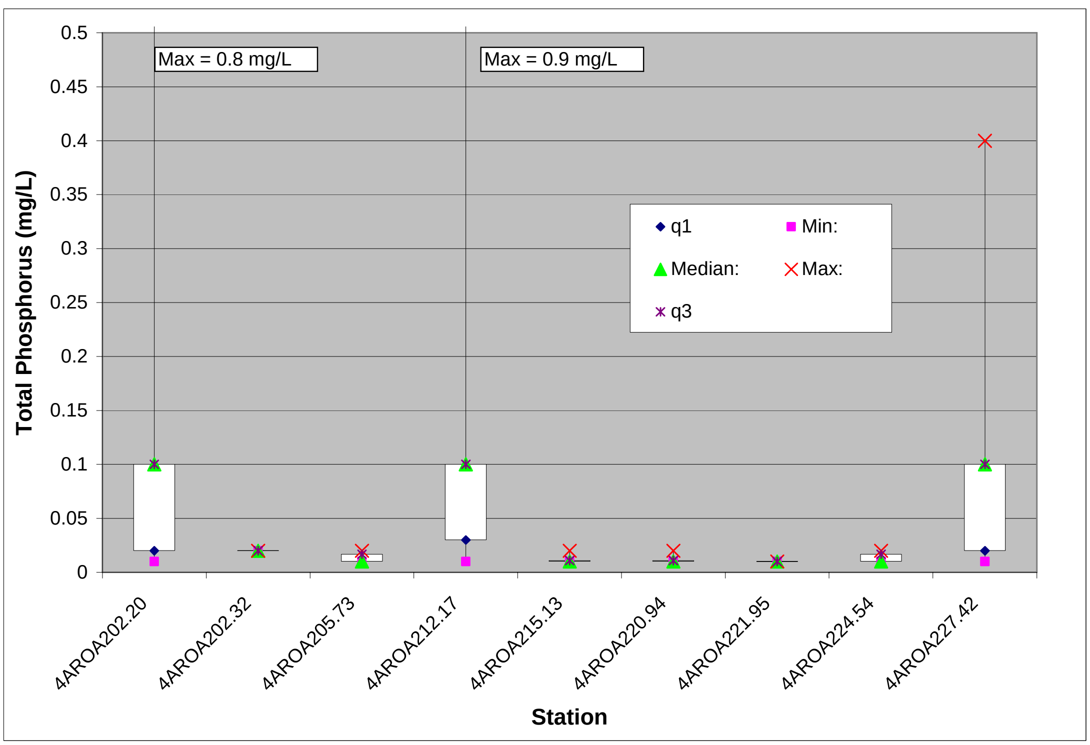
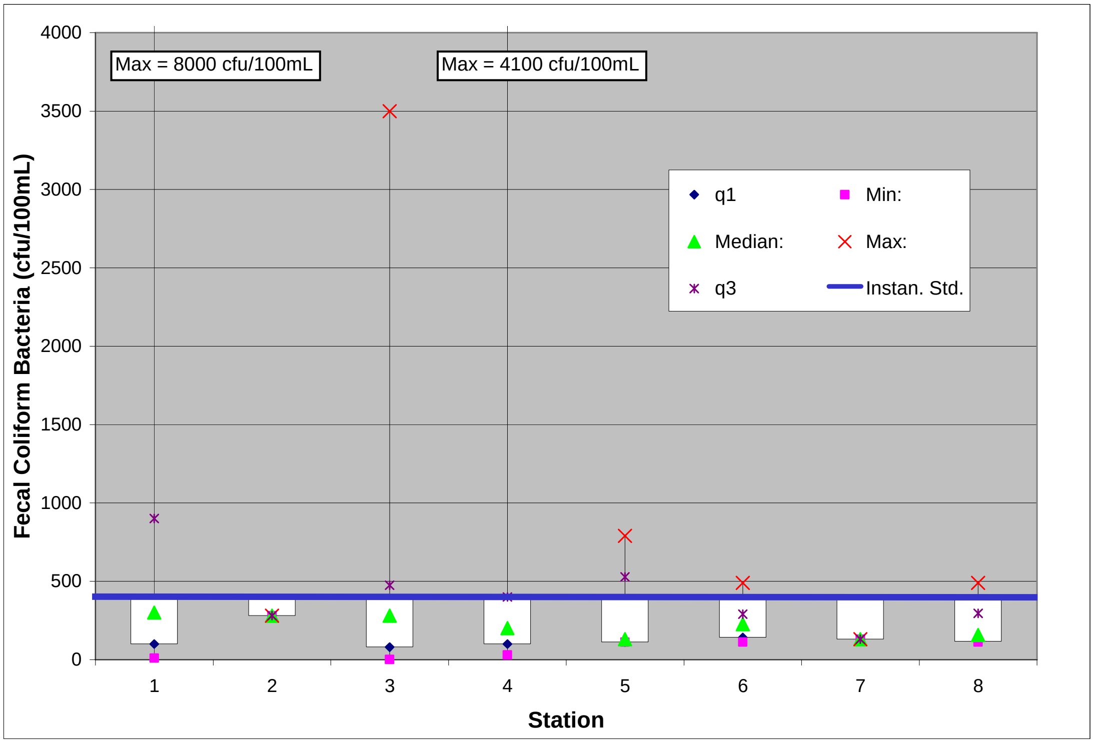


Figure 3-13: Fecal Coliform Concentrations at Roanoke River Monitoring Stations



3.2.2 Metals Data

Both dissolved and sediment metals data were collected by DEQ on the mainstem Roanoke River. Dissolved metals data were collected at two stations on the impaired segments, stations 4AROA202.20 and 4AROA202.32 (Table 3-8). Sampling was conducted in June 2001 and May 2004. As noted in Table 3-8, the criteria for many metals parameters are expressed as a function of total hardness as calcium carbonate and the Water Effect Ratio (WER), a measure of biological availability. In these instances, criteria were calculated using the average observed hardness of 162 mg/L as $CaCO_3$ and a WER of one. As indicated in Table 3-8, the observed instream metals concentrations did not violate either the acute or chronic freshwater aquatic life use criteria.

Sediment metals data were collected at stations 4AROA202.20, 4AROA202.32, and 4AROA212.17 on the impaired segments, as well as several stations upstream and downstream of the biological impairment (Table 3-9). Sediment metals data were collected on 14 occasions between 1995 and 2004. There are currently no water quality standards established for sediment metals; however, the 2004 DEQ assessment guidance memorandum (DEQ, 2004) establishes consensus based sediment screening values for use in determining aquatic life use support (Table 3-9). Sediment Cadmium concentrations exceeded the 4,980 µg/kg screening value on several occasions at stations 4AROA202.20 and 4AROA212.17; in these instances, DEQ guidance states that “one or more exceedances of the sediment screening value results in a fully supporting but having observed effects status for aquatic life use support” (DEQ, 2004). However, the most recent sediment samples indicate that Cadmium concentrations were below detection limits, and dissolved Cadmium data showed that concentrations were below acute and chronic aquatic life use standards. All other observed sediment metals concentrations were below the consensus based sediment screening values.

Although there has been no recent metals data collected under storm flow conditions in the Roanoke River watershed, metals concentrations were analyzed in stormwater samples collected from 1982-1983 as part of the Roanoke Metropolitan Area Water Quality Management Study (Virginia Water Control Board, 1983). Stormwater samples collected at monitoring stations on two tributaries flowing into the Roanoke River showed that chromium, lead, and zinc concentrations exceeded Virginia’s dissolved freshwater water quality standards, and in some instances were consistently above the specified criteria. For example, the available data showed stormwater metals concentrations in Snyder’s Branch were elevated as high as 600 µg/L for lead, 1,200 µg/L for zinc, and over 500 µg/L for chromium. Virginia’s acute and chronic freshwater aquatic life criteria for these metals parameters are specified in Table 3-8.

Table 3-8: Summary of Dissolved Metals Data Collected on Biologically Impaired Segments

Metals Parameter	Collection Period	River Mile	Number of Samples	Dissolved Freshwater Aquatic Life Criteria		Violation
				Acute (µg/L)	Chronic (µg/L)	
Arsenic	2001, 2004	202.20, 202.32	3	340	150	No
Cadmium	2001, 2004	202.20, 202.32	3	6.75[a]	1.66[a]	No
Chromium	2001, 2004	202.20, 202.32	3	845.8[a]	110[a]	No
Copper	2001, 2004	202.20, 202.32	3	21.2[a]	13.5[a]	No
Lead	2001, 2004	202.20, 202.32	3	219.8[a]	24.9[a]	No
Mercury	2001, 2004	202.20, 202.32	3	1.4	0.77	No
Nickel	2001, 2004	202.20, 202.32	3	274.2[a]	30.8[a]	No
Selenium	2001, 2004	202.20, 202.32	3	20	5	No
Silver	2001, 2004	202.20, 202.32	3	7.9[a]	NA	No
Zinc	2001, 2004	202.20, 202.32	3	176.3[a]	177.8[a]	No

a: Dissolved Criteria calculated based on an average observed hardness of 162 mg/L as CaCO3 and a Water Effect Ratio of 1
NA: No criteria specified

Table 3-9: Summary of Sediment Metals Data Collected on Biologically Impaired Segments

Metals Parameter	Collection Period	Number of Samples	River Mile	Freshwater Aquatic Life Support	
				Sediment Screening Value[a] (µg/kg)	Violation
Arsenic	1995-2004	14	202.20, 202.32, 212.17	33,000	No
Cadmium	1995-2004	14	202.20, 202.32, 212.17	4,980	Yes
Chromium	1995-2004	14	202.20, 202.32, 212.17	111,000	No
Copper	1995-2004	14	202.20, 202.32, 212.17	149,000	No
Lead	1995-2004	14	202.20, 202.32, 212.17	128,000	No
Mercury	1995-2004	14	202.20, 202.32, 212.17	1060	No
Nickel	1995-2004	14	202.20, 202.32, 212.17	48,600	No
Selenium	1995-2004	14	202.20, 202.32, 212.17	NA	NA
Silver	1995-2004	14	202.20, 202.32, 212.17	NA	NA
Zinc	1995-2004	14	202.20, 202.32, 212.17	459,000	No

a: Screening values specified in DEQ 2004 assessment guidance memorandum
NA: No value specified

3.2.3 Organics Data

Organics data collected on the Roanoke River by DEQ include dissolved samples analyzed for Alpha, Beta, and Delta Benzene Hexachloride, Endosulfan Sulfate, Alpha Endosulfan, Endrin, Gamma-BHC, Heptachlor Epoxide, Dichlorodiphenyldichloroethane (DDD), Dichlorodiphenyldichloroethylene (DDE), and Dichlorodiphenyltrichloroethane (DDT), as well as sediment samples analyzed for numerous organics parameters. All available organics data collected on the mainstem Roanoke River were analyzed to determine whether the examined parameters complied with Virginia's established water quality standards and sediment screening values. No monitored organics parameters violated acute or chronic dissolved freshwater criteria specified in Virginia's water quality standards. Additionally, none of the available sediment organics data violated the sediment screening values specified in the DEQ 2004 assessment guidance memorandum (DEQ, 2004).

3.2.4 Toxicity Testing

Toxicity testing was performed on water samples collected from the Roanoke River by DEQ on April 12th, 14th, and 16th, 2004 at stations 4AROA202.20 and 4AROA206.95. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and <u>Ceriodaphnia</u> dubia as test organisms. Results indicated <u>Ceriodaphnia</u> mortality and reproduction in the Roanoke 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 to <u>Ceriodaphnia</u> in the Roanoke River samples.

Fathead minnow growth in the Roanoke River water samples was also not statistically different from growth in the control samples. However, fathead minnow survival in samples collected at both station 4AROA202.20 and station 4AROA206.95 did significantly vary from minnow survival in the control samples. Minnow survival in samples collected at station 4AROA202.20 was 75% and was statistically different from the laboratory control, although the EPA Region 3 laboratory in Wheeling indicated that in their professional judgment, this result "probably did not represent a biological effect." Fathead minnow survival in samples collected at station 4AROA206.95 was 65%, also statistically different from the laboratory control. The EPA Region 3 laboratory in Wheeling indicated that in their professional judgment, this result "was probably biologically significant", and that it was necessary to compare the observed toxicity testing results with other water quality data collected at these sites to determine the presence of toxicity.

3.3 Discharge Monitoring Reports

Discharge Monitoring Reports (DMR) for each of the 13 facilities discharging into the Roanoke River benthic impairment watershed that hold individual permits were obtained and analyzed. Table 3-10 summarizes the violations of permitted discharge limits that occurred at each of the facilities. The violations include:

- The Norfolk Southern Railway Company facility located at Shaffers Crossing (permit # VA0001597), which has exceeded its permitted limits for suspended solids and oil and grease. The facility discharges into an unnamed tributary to Lick Run.

- The town of Shawsville Sewage Treatment Plant (STP) (permit # VA0024031), which has exceeded its permitted limits for ammonia, phosphorus, and fecal coliform bacteria.

- The Blacksburg Country Club STP (permit # VA0027481), which has exceeded its permitted limits for biochemical oxygen demand, flow, and suspended solids.

- The Western Virginia Water Authority (permit # VA0025020) which has exceeded its permitted limits for biochemical oxygen demand, chloride, cyanide, flow, mercury, nickel, phosphorus, selenium, total Kjeldahl nitrogen, and suspended solids. However, all these discharge violations occurred downstream of the benthic monitoring stations. The plant is the largest facility present in the watershed, and has also experienced overflows during rainfall events in which untreated sewage been discharged directly into the river. The Western Virginia Water Authority is under a consent order to correct these permit violations, and is currently being upgraded to improve it capabilities.

Whole Effluent Toxicity (WET) data were reported by two permitted facilities. Data collected at Norfolk Southern Railway Company – Shaffers Crossing in December 2003 indicated that acute WET values were below detection limits. Data collected at the Roanoke Electric Steel Corporation in May and July of 1999 indicated that chronic WET values were 0 and 13.8 mg/L, respectively. Neither facility has a maximum WET concentration limit specified in its current NPDES permit. The permitted discharge limits for the 13 facilities holding individual permits are presented in Appendix C.

Table 3-10: Exceedances of Permitted Discharge Limits for Facilities in the Roanoke River Benthic Impairment Watershed

Permit No. (Outfall No.)	Parameter Description	First DMR Date	Last DMR Date	No. DMRs	DMR Reported Values				No. Exceedances of Permit Limits			
					Quantity		Concentration		Quantity		Concentration	
					Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
VA0001597 (2)	Oil & Grease	10-Feb-99	10-Jul-04	132	-	-	3.43	46.00	-	-	4	2
	TSS	10-Feb-99	10-Jul-04	132	-	-	16.78	180.00	-	-	10	10
VA0024031 (1)	Ammonia, As N Jan-May	10-Feb-99	10-Jun-04	88	1.17	6.74	4.53	28.70	0	0	16	18
	Coliform, Fecal	10-Feb-99	10-Jun-04	130	-	-	25.30	-	-	-	4	-
	Phosphorus, Total (As P)	10-Feb-99	10-Jul-04	132	0.13	0.61	0.52	2.20	0	0	4	4
VA0025020 (1)	BOD5	10-Feb-99	10-Jul-04	264	246.83	1,511.92	1.67	10.01	6	3	8	4
	CL2, Inst. Res. Max.	10-Feb-99	10-May-04	128	0.00	0.00	5.74	50.00	0	0	4	4
	Cyanide, Total (As Cn)	10-Apr-99	10-Jul-04	192	0.07	2.28	0.63	17.00	1	1	3	3
	Flow	10-Feb-99	10-Jul-04	264	38.59	68.11	-	-	45	0	-	-
	Mercury, Total Recoverable	10-Apr-99	10-Jul-04	192	0.00	0.08	0.02	0.50	1	1	6	6
	Nickel, Total Recoverable	10-Apr-99	10-Jul-04	192	0.12	6.18	1.42	45.00	0	1	0	3
	Phosphorus, Total (As P)	10-Feb-99	10-Jul-04	264	18.92	145.21	0.13	0.93	15	15	20	20
	Selenium, Total Recoverable	10-Apr-99	10-Jul-04	192	0.06	1.74	0.40	11.00	1	1	3	3
	TKN, Apr-Sep	10-May-99	10-Jul-04	160	160.77	1,795.14	1.10	13.73	9	12	12	28
	TSS	10-Feb-99	10-Jul-04	264	108.87	1,676.00	0.75	10.36	12	9	16	12
VA0027481 (1)	BOD5	10-Feb-99	10-Jul-04	132	1.11	12.90	11.92	51.00	6	4	12	6
	Flow	10-Feb-99	10-Jul-04	132	0.03	0.32	-	-	42	0	-	-
	TSS	10-Feb-99	10-Jul-04	132	1.60	13.11	17.84	162.00	14	8	18	14

4.0 Stressor Identification Analysis

TMDL development for benthic impairment requires identification of pollutant stressor(s) that are impacting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segments of the Roanoke River was performed using the available environmental monitoring and watershed characterization data discussed in previous sections.

Assessment of the primary stressor contributing to biological impairment in the Roanoke River was based on evaluations of candidate stressors that can potentially impact the river. The 2004 Water Quality Assessment 305(b)/303(d) Integrated Report Fact Sheet identified "urban nonpoint source runoff" and "sedimentation" as possible sources of impairment. Therefore, these pollutants were considered in the evaluation of candidate stressors along with other potential stressors such as nutrients, pH, temperature, ammonia, and toxic compounds. Each candidate stressor was evaluated on the basis of available monitoring data, field observations, and consideration of potential sources in the watershed. The potential stressors were classified as:

- **Non-stressors**: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

- **Possible stressors**: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

- **Most probable stressors**: The stressors with the most complete data linking them to the poorer benthic community. Table 4.1 summarizes the results.

Table 4-1: Summary of Stressor Identification in the Roanoke River Watershed

Parameter	Location in Document
Non-Stressors	
Dissolved Oxygen, Temperature and pH	Section 4.1.1
Nutrients	Section 4.1.3
Possible Stressors	
Metals, Organics, and Other Toxics	Section 4.2.1
Most Probable Stressors	
Sediment	Section 4.3.1

4.1 Non-Stressors

4.1.1 Dissolved Oxygen, pH, and Temperature

Adequate dissolved oxygen levels are necessary for invertebrates and other aquatic organisms to survive in the benthic sediments of rivers or streams. Decreases in instream oxygen levels can result in oxygen depleted or anoxic sediments, which adversely impacts the river's benthic community. Dissolved oxygen concentrations in the Roanoke River appear to be adequate to fully support a healthy biological community. Field dissolved oxygen measurements taken at monitoring stations on the Roanoke River exceeded the minimum daily average or instantaneous dissolved oxygen standards on all occasions (Figure 3-4). Additionally, diurnal dissolved oxygen data collected at both an impaired and reference station showed that oxygen levels remained above the minimum concentrations at all times throughout several days (Figure 3-5). Normal diurnal dissolved oxygen swings were observed in the Roanoke River. This is important because in some polluted waters, dissolved oxygen concentrations vary greatly as a result of primary production and respiration. Because both field and diurnal dissolved oxygen data showed no violations of water quality standards, it appears that dissolved oxygen is not a likely stressor to the benthic community in the Roanoke River.

Similarly, field measurements indicated adequate temperature and pH values on and upstream of the biologically impaired segments (Figures 3-6 and 3-7). There have been no observed violations of Class IV water quality standards for pH and temperature. . Therefore, pH and temperature do not appear to be impacting the benthic community in the Roanoke River.

4.1.2 Nutrients

High nitrogen and phosphorus concentrations can stimulate algal growth, which may result in eutrophic conditions, high organic loading, and decreased dissolved oxygen. Also, the combination of high phosphorus concentrations and low nitrogen levels can potentially cause toxicity by shifting the algal community to nitrogen-fixing cyanobacterial forms, many of which emit toxins. Nutrients do not appear to be a stressor impacting the biologically impaired segments of the Roanoke River. Total nitrogen concentrations were below 1 mg/L in almost all of the observed samples (Figure 3-10). Additionally, concentrations of ammonia, which is toxic to aquatic organisms in high concentrations, were very low across all monitoring stations (Figure 3-11). Observed total phosphorus concentrations on the mainstem Roanoke River were typically low (Figure 3-12); of the 160 phosphorus samples collected after the DEQ total phosphorus detection limit was changed to 10 µg/L in 1999, only 28 samples exceeded the 30 µg/L phosphorus concentration identified as a breakpoint above which algal biomass increases (Dodds et al., 2002). The highest observed phosphorus concentrations at the Roanoke River stations occurred in September 1995, when a 6 week dry weather period was followed by a series of precipitation events totaling approximately two inches of rainfall. The elevated concentrations observed during this wet weather period which was preceded by a prolonged dry weather period are likely more indicative of stormwater control problems than excessive nutrient inputs. Total nitrogen and phosphorus concentrations do increase fairly significantly below the Western Virginia Water Authority (Table 3-10), but still remain relatively low below the outfall.

Instream chlorophyll A values were also extremely low on and above the biologically impaired segments. Periphyton is typically the dominant form of algae present in lotic systems. Although no benthic chlorophyll data were available on the impaired segments, the low nutrient concentrations and consistently adequate dissolved oxygen concentrations measured in the mainstem Roanoke River, as well as field observations taken during low flow conditions, indicate that periphyton levels in the river are low and are not impairing the benthic invertebrate community. For these reasons, nutrients do not appear to be a stressor in the biologically impaired segments of the Roanoke River.

4.2 Possible Stressors

4.2.1 Metals, Organics, and other Toxics

Analysis of the available water quality data indicated no parameters exceeded Virginia's established water quality standards (Table 3-8), and only sediment Cadmium values exceeded the sediment screening values (Table 3-9). Levels of ammonia, which is toxic to aquatic organisms in high concentrations, were low across all monitoring stations, and suggests that ammonia is not adversely impacting benthic invertebrates in the biologically impaired segments of the Roanoke River. Concentrations of organic compounds also did not exceed the established water quality standards or sediment screening values.

Instream toxicity testing indicated no toxic effects on Ceriodaphnia survival and reproduction, or fathead minnow growth. However, minnow survival rates in samples collected at the two monitoring stations on the Roanoke River were statistically different than survival rates in the control samples. The EPA Region 3 laboratory in Wheeling, WV indicated that in their professional judgment, the difference in mortality rates between the sample taken at station 4AROA202.20 and the control was “probably not biologically significant”, while the difference between the sample taken at station 4AROA206.95 and the control “probably was biologically significant.” In both instances, the EPA Region 3 laboratory emphasized that these results were qualitative in nature, and needed to be compared to other available water quality data.

Metals and organics data collected by DEQ do not suggest the presence of toxicity in the Roanoke River. However, it should be noted that these data are typically collected under base flow and dry weather conditions, and may not capture the “first flush” of stormwater which typically carries the majority of pollutants to streams. The toxicity samples were collected by DEQ immediately following a large storm event (Jason Hill, personal communication), and therefore may have captured pollutants that had been recently flushed into the stream via stormwater runoff. While the DEQ metals and organics data indicate that there are no chronic toxicity problems in the Roanoke River, the toxicity testing results suggest the possibility of some acute toxicity after storm events. Although no recent stormwater monitoring has been conducted in the watershed, the available historical data, while limited, do show elevated metals concentrations in tributaries to the Roanoke River during storm events.

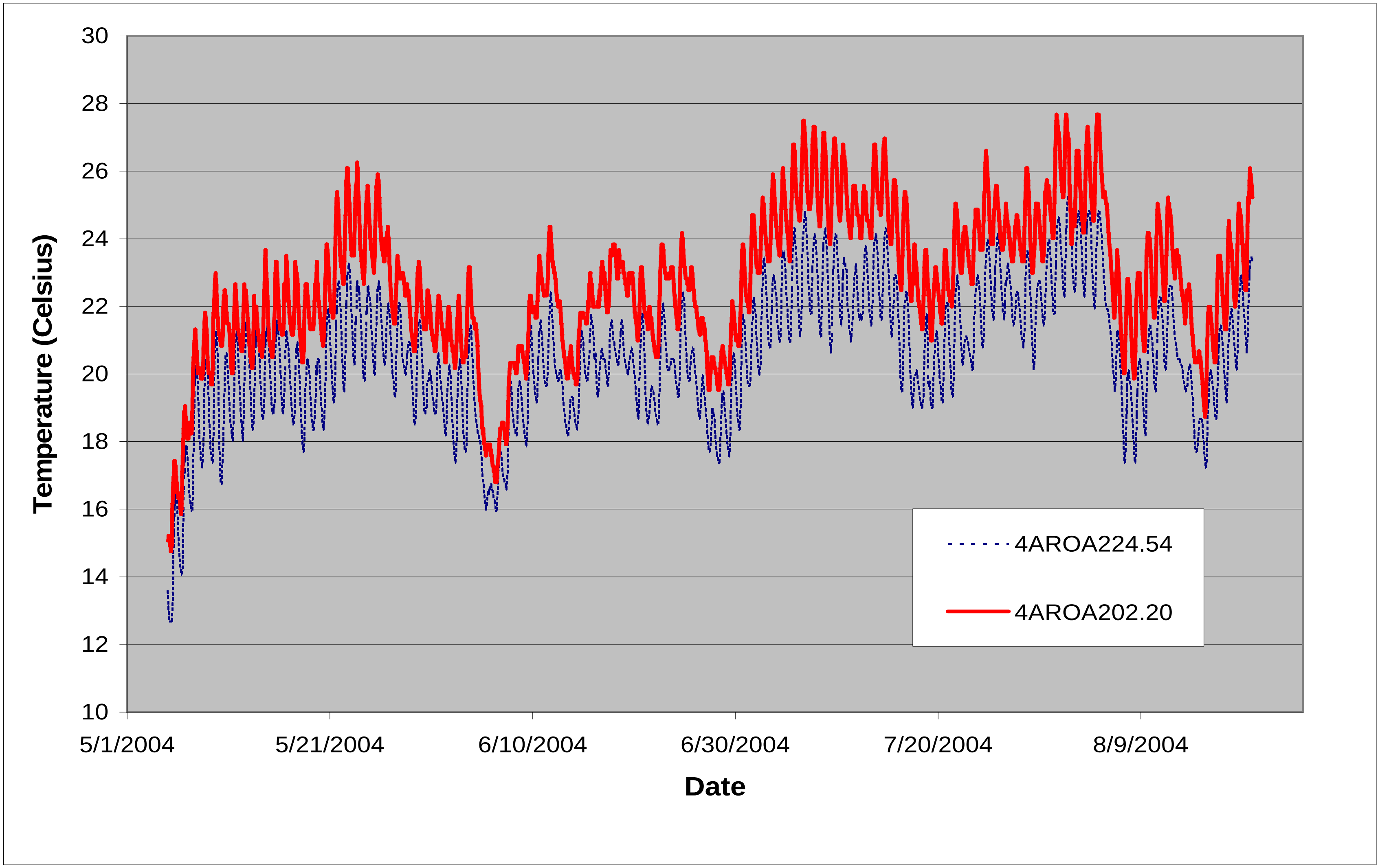
The available toxics data and toxicity testing results do not decisively prove or disprove that toxicity is adversely impacting benthic invertebrates in the Roanoke River. Metals and organics data collected in the Roanoke River show no evidence of toxicity; however, the toxicity testing results and historic stormwater monitoring data provide some qualitative evidence that toxic pulses may enter the river during storm events. While it cannot be conclusively stated that toxicity is a primary stressor impacting the benthic invertebrate communities, the possibility of some acute toxicity associated with stormwater flows should be further investigated, and the issues associated with elevated stormwater flows should be addressed in the implementation of the Roanoke River benthic impairment TMDL.

4.3 Most Probable Stressors

4.3.1 Sediment

Excessive sediment loading can negatively impact benthic invertebrate communities by silting over invertebrate habitat, choking invertebrates with suspended sediment particles, and bringing invertebrates into contact with other pollutants that enter surface water via adhesion to sediment particles. In the Roanoke River, evidence of increasing sediment loading from upstream and continuing down to the biologically impaired segments is provided by habitat assessment scores that show poorer substrate embededdness scores in the downstream impaired segments (Figure 3-1). Additionally, other habitat metrics such as riparian vegetation may indicate a corresponding decrease as the Roanoke River flows out of primarily rural lands into the urbanized areas of Salem and Roanoke Cities (Figure 3-2). Temperature logger data collected in the summer of 2004 also suggests that habitat degradation is related to urbanization. The lack of vegetation in urban areas results in exposure to the sun which increases water temperatures. The temperatures recorded at the most downstream station (4AROA202.20) in Roanoke City were an average of ten degrees higher than temperatures recorded at an upstream station (4AROA224.54) which is located in a more rural area (Figure 4-1). In addition to exposure to direct sunlight and consequently increasing stream temperature, removing riparian vegetation can result in an increase in sediment loading from bank erosion limiting the ability of the riparian zone to filter out sediment and other pollutants before they enter the river. In general, the transition from the primarily forested upland watershed to the heavily urbanized surroundings of the Roanoke River as it flows through the Cities of Salem and Roanoke decreases overall habitat quality (Appendix B) and provides the opportunity for sediment to enter the river.

Figure 4-1: Longitudinal Temperature Changes in the Roanoke River



The 2004 Water Quality Assessment 305(b)/303(d) Integrated Report Fact Sheet identified “urban nonpoint source runoff” and “sedimentation as a result of interceptor replacement along the Roanoke River” as the causes of benthic impairment in the Roanoke River. There have been and there are multiple other activities in the watershed which would have contributed to increased sediment loading and changes to the stream hydrology. The observed biological impairments correspond with the river’s passage through the urbanized areas of Salem and Roanoke City. The increased imperviousness of urban areas results in less infiltration during precipitation events, and consequently a higher volume of runoff that enters the river with greater velocity. As indicated by the large number of stormwater permits issued in the Roanoke River benthic impairment watershed (Appendix A), many of which are concentrated in the City of Roanoke, the high degree of urbanization adjacent to the biologically impaired segments likely results in high stormwater flows during rainfall events. These stormwater flows can wash off sediment as well as other materials including toxic substances and metals that have built up on impervious surfaces into the river and also can contribute to sediment loading via channel bed and bank erosion. No recent stormwater monitoring has been conducted in the watershed. However, historical data, while limited, indicate elevated suspended solids concentrations in runoff during storm events in the Roanoke River watershed. It should also be noted that although the stormwater monitoring data are approximately 20 years old, no large-scale urban stormwater management practices or other stormwater pollution reduction strategies have been implemented in the Roanoke metropolitan area in the previous 20 years. More recent data collected on the mainstem Roanoke River show turbidity values are generally low, but do increase at downstream stations, and are elevated in some instances. Sediment loading resulting from the replacement of a sewage interceptor that runs parallel to the Roanoke River is also listed by DEQ as a potential source of the benthic impairment. The interceptor replacement created a large disturbance to the streambank, removing riparian vegetation and exposing large quantities of sediment. In addition to sediment delivered to the stream during the course of this project, the removal of riparian vegetation and other streambank disturbances have likely contributed to habitat deterioration along the biologically impaired segments of the river. This may facilitate loading of sediment and other pollutants that adversely affect benthic invertebrate communities by reducing or eliminating the filtering capacity of the riparian zone during storm events.

For the reasons stated above, sediment is considered to be a primary stressor that is impacting benthic invertebrates in the mainstem Roanoke River.

4.4 Stressor Identification Summary

The data and analysis presented in this report indicate that dissolved oxygen, temperature, and pH levels in the biologically impaired segments of the river are adequate to support a healthy invertebrate community, and are classified as non-stressors contributing to the benthic impairment. The low nutrient and chlorophyll concentrations present in the impaired segments indicate that nutrient pollution and eutrophication are not probable stressors in the biologically impaired segments of the Roanoke River.

While some evidence suggests that toxicity associated with stormwater flows may be a probable stressor, recent metals and organics data collected by DEQ do not support this claim. The possibility of some acute toxicity associated with stormwater flows should be further investigated; however, because many toxic pollutants enter surface waters attached to sediment particles, the implementation of stormwater control measures to reduce sediment loadings to the Roanoke River during wet weather conditions would also serve to alleviate potential sources of acute toxicity.

Based on the evidence and data discussed in the preceding sections, sediment has been identified as the most probable stressor impacting benthic invertebrates in the biologically impaired segments of the Roanoke River. Habitat scores indicate increased substrate embeddedness and decreased habitat quality in the impaired segments as a result of the surrounding urban environment. Potential sources of sediment loading in the watershed include urban stormwater runoff, streambank erosion, and sediment loss from habitat degradation associated with urbanization.

Improvement of the benthic community in the biologically impaired segments of the Roanoke River is dependent upon controlling stormwater to reduce sediment loading from urban runoff and streambank erosion, as well as restoring instream and riparian habitat to alleviate the impacts of urbanization on the river. To address these issues, a sediment TMDL will be developed for the biologically impaired segments of the Roanoke River.

5.0 TMDL Endpoint Identification

TMDL development requires the determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Endpoints are normally expressed as the numeric water quality criteria for the pollutant causing the impairment. Compliance with numeric water quality criteria, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have established numeric water quality criteria. In these cases, a reference watershed approach may be used to define the TMDL endpoint.

The Roanoke River was initially included on the Virginia Section 303(d) list for violations of the General Standard (benthic impairment). As detailed in Section 4.0, sediment has been identified as the primary stressor causing the benthic impairment in the river. Currently, Virginia does not have numeric criteria for sediment. Therefore, a reference watershed approach was used to establish the numeric sediment TMDL endpoint for the Roanoke River.

5.1 Reference Watershed Approach

Under the reference watershed approach, the TMDL endpoint for an impaired watershed is established based on conditions in a similar, but non-impaired reference watershed. In terms of benthic impairment caused by excessive sediment, the TMDL endpoint is the sediment loading rate in the non-impaired reference watershed. Reduction of the sediment loading rate in the impaired watershed to levels comparable to the reference watershed is assumed to be sufficient for recovery of the benthic community in the impaired watershed.

Selection of an appropriate reference watershed is based on similarities in watershed characteristics such as soils, topography, land uses, and ecology. Similar watersheds help to ensure similarities in the benthic communities that potentially may inhabit the streams. Similar watersheds also provide for similar watershed hydrology which influences pollutant loading rates to the stream.

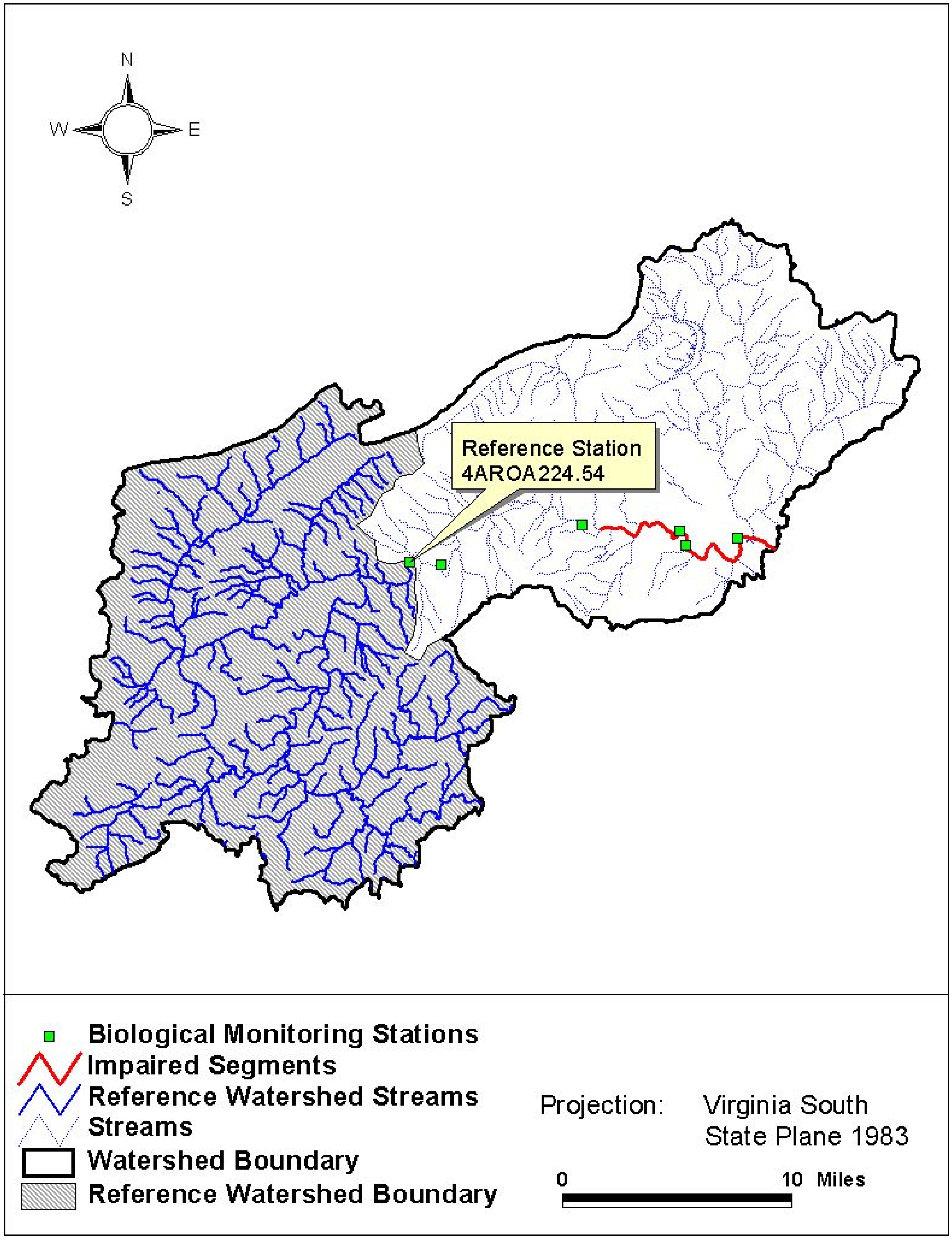
5.2 Selected Reference Watershed

The watershed draining to the DEQ biomonitoring station at river mile 224.54 on the Roanoke River was selected as the reference watershed for the Roanoke River benthic TMDL development. Table 5-1 summarizes important criteria considered in the selection of the reference watershed for the Roanoke River. Since the selected reference watershed is a sub-basin of the impaired watershed, the physical characteristics of the two watersheds are very similar. Figure 5-1 displays a map of the impaired and reference watersheds.

Table 5-1 Criteria Used in Reference Watershed Selection

Criteria	Relevance
Biomonitoring Data	Biomonitoring data is required to confirm the non-impairment status of the reference watershed and allows for comparisons with the impaired watershed.
Ecoregion	The reference and impaired watersheds should belong to the same ecoregion to help ensure similarities in stream ecology.
Topography	Topography influences hydrology and is a major component of stream habitat that affects the structure and composition of benthic communities.
Land Uses	The selected reference watersheds should reflect similar land use distributions. The water quality of streams in a watershed is greatly influenced by land use. Similar land use distributions help to establish achievable TMDL endpoints.
Soils	Soil composition influences watershed runoff, erosion, and stream ecology.
Watershed Size	The reference watershed should be similar in size to the impaired watershed since watershed area influences pollutant loading rates to the stream.
Location	Close proximity to the impaired watershed generally improves overall watershed similarity. In addition, the reference watershed should be near a weather station that may be used to characterize precipitation at both watersheds in order to standardize model simulations.

Figure 5-1: Roanoke River Reference Watershed



5.2.1 Biomonitoring Data

Virginia SCI scores were calculated for the biomonitoring station above which the Roanoke River reference station was delineated, and compared with biomonitoring stations located on the impaired biological segment (Table 5-2). At river mile 224.54, located at Dixie Caverns, the Roanoke River is non-impaired and is fully supporting the river's aquatic life use.

Table 5-2: Comparison of Virginia SCI Scores

Assessment Date	SCI Score			
	Roanoke River Impaired Station 4AROA202.20	Roanoke River Impaired Station 4AROA206.03	Roanoke River Impaired Station 4AROA206.95	Roanoke River Reference Station 4AROA224.54
Fall 1994	37.5			62.0
Spring 1995	45.0			64.7
Fall 1995	32.8			50.4
Spring 1996	30.2			55.8
Fall 1996	31.0			57.5
Spring 1997	50.8		53.7	62.9
Fall 1997	33.8	35.1	42.5	59.1
Spring 1998		54.1	48.9	68.1
Fall 1998		38.5	36.4	52.3
Spring 1999			46.3	73.3
Fall 1999				70.7
Spring 2000				65.4
Fall 2000	39.6		48.9	70.0
Fall 2001	55.9		54.5	63.5
Spring 2002				
Fall 2002				
Fall 2003	39.3			59.8
Spring 2004	58.6		60.6	58.4
Average	**41.3**	**42.5**	**49.0**	**62.1**

5.2.2 Land Use

A comparison of land use distributions in the Roanoke River impaired and reference watersheds is provided in Table 5-3. Both the impaired and reference watersheds are primarily forested; the percentage of these watersheds comprised of forest land cover is 69.9% and 77.9%, respectively. The Roanoke River impaired and reference watersheds also contain similar percentages of agricultural lands. The Roanoke River impaired watershed encompasses the Cities of Roanoke and Salem, and thus contains a slightly greater percentage of developed lands than the reference watershed.

Table 5-3: Summary of Land Use Distributions for Roanoke River Impaired and Reference Watersheds

Land Use Category	Percent of Total Watershed	
	Roanoke Impaired Watershed	Roanoke Reference Watershed
Forest	69.9	77.6
Agricultural	17.5	19.0
Developed	11.1	2.7
Water/Wetlands	0.5	0.2
Other	1.0	0.5
Total	**100**	**100**

5.2.3 Soils Distribution

A summary of the soils distributions for the Roanoke River impaired and reference watersheds are provided in Table 5-4. The soils distribution in the Roanoke River reference watershed is similar to and representative of the soils distribution in the impaired watershed.

Table 5-4: Summary of Soil Distributions for Roanoke River Impaired and Reference Watersheds

Soil Id	Soil Name	Hydrologic Group	% of Total Watershed	
			Roanoke Impaired Watershed	Roanoke Reference Watershed
VA001	Berks-Weikert-Laidig	B/D	17.5	18.9
VA002	Carbo-Chilhowie-Frederick	B/D	19.0	30.3
VA003	Frederick-Carbo-Timberville	B/D	12.6	7.6
VA004	Moomaw-Jefferson-Alonzville	C	7.5	4.4
VA005	Wallen-Dekalb-Drypond	C	7.7	2.0
VA007	Hayesville-Parker-Peaks	C	12.2	17.3
VA016	Shottower-Laidig-Weikert	C	5.4	0.0
VA017	Groseclose-Litz-Shottower	B	17.9	19.1
VA020	Rubble Land-Porters-Hayesville	B	0.2	0.4

6.0 Sediment Load Determination

A reference watershed approach was used to develop the sediment TMDL for the Roanoke River watershed as discussed in the previous section. The drainage area above the non-impaired reference biomonitoring station located at river mile 224.54 served as the reference watershed (Figure 5-1). The sediment loadings for the reference watershed define the numeric TMDL endpoint for the impaired watershed. Therefore, sediment loadings were determined for both the reference and impaired watersheds in order to quantify sediment loading reductions necessary to achieve the designated aquatic life use for the Roanoke River.

6.1 Sediment Source Assessment

Excessive sedimentation can adversely affect benthic invertebrate communities through the loss of habitat or food sources. Sediment can be delivered to the stream from point sources located in the watershed and it can be carried in the form of non-point source runoff from non-vegetated or protected land areas. In addition, sediment can be generated in the stream through the processes of scour and deposition which are primarily a function of stream flow. During periods of high flow, erosion of the stream channel occurs. The eroded materials are deposited downstream as stream flow decreases. These processes adversely impact the benthic macroinvertebrate community through loss of habitat and degradation of water quality.

Potential sediment sources within the Roanoke River watershed are discussed in the next section followed by a presentation of the methodology used to quantify these sources for the TMDL development.

6.1.1 Non-Point Sources

The erosion of land is dependent upon many factors including land use type and cover, soils type, and topography. The land use types in the Roanoke River watershed were characterized using NLCD data, while soil types were characterized using the STATSGO database. The land use distribution for the Roanoke River watershed was previously shown in Table 2-3 and a summary of soil types was provided in Table 2-1. The delivery of eroded soils to the stream is primarily influenced by watershed size. Sediment loadings from generalized land use types present in the Roanoke River watershed are discussed below.

Forested Lands

Sediment loads from forested lands are typically low due to extensive root systems and vegetative cover that serve to stabilize soils. In addition, forest canopies intercept and dampen rainfall impacts.

Agricultural lands

Sediment loads from agricultural lands tend to be elevated due to the exposure of soil that occurs in agricultural practices. Cropland and pastureland are two sources of elevated sediment loads.

Developed Lands

Developed lands consist of both pervious and impervious surfaces. Impervious surfaces are not subject to soil erosion, but sediment loads may result from the washoff of solids deposited on impervious surfaces. Sediment loads from developed lands tend to be high. In addition, elevated levels of uncontrolled stormwater runoff from developed lands contribute to streambank erosion as discussed below.

Water/Wetlands

The amount of sediment loading from water and wetland areas typically is not significant.

Barren Lands

Transitional lands represent areas of sparse vegetative cover often due to land use activities such as forest clearcuts and construction lands. Due to increased levels of soil exposure, sediment loads from transitional lands typically are high.

6.1.2 Point Sources

Sediment loadings from point sources are attributable to the suspended solids present in discharge effluent. There are 9 permitted facilities having a permit limit for TSS (Table 6-1). Municipal separate storm sewer systems (MS4s) transport storm water runoff that is ultimately discharged into local rivers and streams without treatment. The cities of Roanoke and Salem, as well as portions of Roanoke, Botetourt, and Montgomery Counties, and three facilities located within the Roanoke City metropolitan area, are covered by MS4 permits which regulate their stormwater discharges. Common pollutants from MS4s include oil and grease from roadways, pesticides from lawns, trash, and sediments. Combined, these MS4 permits cover approximately 21.6% of the Roanoke River benthic impairment watershed (Table 2-6).

6.1.3 Instream Bank Erosion

Sediment derived from instream bank erosion is also dependent upon numerous watershed characteristics. Land use types present in the watershed may affect hydrology of the watershed. In particular, highly developed lands may lead to increased stream flows that erode the stream channel and banks. Likewise, watersheds defined by steep topography may experience high levels of runoff that cause instream erosion. The level of instream erosion is dependent on the erodibility of the soil, normally defined as the soil K factor. Since the Roanoke River benthic impairment watershed contains a significant percentage of developed lands, the overall amount of sediment generated by instream erosion would be expected to be high.

6.2 Technical Approach for Estimating Sediment Loads

6.2.1 Non-Point Source Sediment

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 simulation 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 described by a lumped parameter watershed water balance 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. 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. Sediment loadings from each source area are summed to obtain a watershed total.

6.2.2 Point Source Loadings

There are nine point source facilities in the Roanoke River impaired watershed that discharge directly into the Roanoke River and its tributaries (Table 6-1). For the purpose of TMDL development, annual point source loadings were computed based on the permitted discharge loading rate for total suspended solids for each facility.

Table 6-1: Point Sources in the Roanoke River Impaired Watershed

Facility Name	Permit Number	Permitted Load (Kg/day)	Annual Sediment Loading (tons/yr)
Western Virginia Water Authority	VA0025020	1174	472.2
Roanoke Electric Steel Corporation	VA0001589	231	92.9
Shawville Town STP	VA0024031	22.7	9.1
Carvin Cove Water Filtration Plant	VA0001473	NA	17.6
Crystal Springs WTP	VA0091065	NA	8.8

Facility Name	Permit Number	Permitted Load (Kg/day)	Annual Sediment Loading (tons/yr)
Norfolk Southern Railway Company - Shaffers Crossings	VA0001597	NA	1.62
Ellison Lafayette WWTP	VA0062219	28	11.2
Blacksburg Country Club STP	VA0027481	3.9	1.57
Roanoke Moose Lodge	VA0077895	0.21	0.21

Eight of the 13 facilities holding individual permits possess general stormwater permits as part of their NPDES discharge permit. These facilities and their allocated stormwater loads are presented in Appendix D. Additionally, stormwater sediment loads allocated to the 152 general permits present in the watershed are also presented in Appendix D.

The MS4 permits state that the Cities, Counties, and facilities holding MS4s are permitted to discharge into the Roanoke River impaired watershed. However, stormwater permits typically do not have numeric limits for sediment. To separate sediment loading attributed to the MS4s from other land-based sediment loading, an area weighted sediment load was determined for the MS4s, in which the percentage of sediment loading from each source area attributed to the MS4s was proportional to the percentage of that source area in the Roanoke River impaired watershed covered by the various MS4 permits. The percentage of sediment loads attributed from source areas is presented in Table 6-2. Additionally, stormwater runoff from MS4s results in increased stream bank erosion. Bank erosion resulting from MS4 stormwater runoff and bank erosion resulting from overland runoff were also separated using an area weighted approach, in which the percentage of sediment loading from bank erosion attributed to the MS4 was proportional to the percentage of the Roanoke River impaired watershed covered by the MS4 permits. Since 72,517 acres of the 335,785 total acres in the Roanoke River impaired watershed is covered by MS4 urban areas, 21.6 percent of the sediment load from instream erosion was attributed to the MS4 urban areas. These MS4 urban sediment loads include the loads from individual MS4s permits for urban areas as well as loads from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, General Permits for Carwashes, and General Permits for Construction Sites. The breakdown of these loads is presented in Chapter 7. Sediment from other land sources in the watershed and the remainder of the bank erosion sediment load were attributed to the land-based load rather than treated as a point source load.

Table 6-2: Area Weighted Percentages for Roanoke River MS4 Sediment Load Allocation for Land Sources

Source	Land Use Type	Acres in Roanoke River Watershed	Acres covered by MS4 Permits	Percent of Load Attributed to MS4s
Land Sources	Open Water	1336.9	329.3	24.6
	Low Intensity Residential	27777.8	24991.0	90.0
	High Intensity Residential	352.6	345.4	98.0
	Commercial/Industrial	9118.3	6968.4	76.4
	Quarries/Strip Mines	1152.9	603.3	52.3
	Transitional	1265.3	398.4	31.5
	Deciduous Forest	178732.2	16345.2	9.1
	Evergreen Forest	17919.4	1252.3	7.0
	Mixed Forest	38444.5	6037.5	15.7
	Pasture/Hay	53261.1	13993.1	26.3
	Row Crop	5291.6	329.1	6.2
	Urban/Recreational Grasses	955.7	842.6	88.2
	Woody Wetlands	99.2	6.5	6.5
	Emergent Wetlands	77.7	10.0	12.9
Total	-	**335,785**	**72,452**	**21.6**

6.2.3 Instream Erosion

Instream erosion in the Roanoke 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 is 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.

$$a = (0.00147*PD) + (0.000143*AD) - (0.000001*CN) + (0.000425*KF) + (0.000001*MS) - 0.000016$$

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 Roanoke River watershed was obtained from 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. Livestock densities for the watershed were based on county livestock inventories. The 'a' factors for the Roanoke River reference and impaired watersheds were computed.

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 Roanoke River was obtained from the National Hydrography Dataset (NHD). Bank height was estimated from field surveys of the Roanoke River. Mean soil bulk density was obtained from the STATSGO database. Annual sediment loads from streambank erosion were computed as the summation of monthly loads.

6.3 GWLF Model Setup and Calibration

6.3.1 GWLF Model Development

GWLF model simulations were performed for 1993 to 2003 in order to reflect the period of biomonitoring assessments that resulted in the impairment listing for the Roanoke River. In addition, the 10 year simulation period accounts for both seasonal and annual variations in hydrology and sediment loading. Models were developed for both the reference and impaired watersheds. Model simulations were performed using BasinSim 1.0, which is a windows interface program for GWLF that facilitates the creation of model input files and processing of model results.

As stated previously, under the reference watershed approach the TMDL endpoint is based on sediment loadings for the reference watershed. Since the Roanoke River reference watershed is smaller than the impaired watershed, sediment loadings for the reference watershed were adjusted to reflect the size of the impaired watershed. This was accomplished by running the GWLF model for an area-adjusted reference watershed. The area of each land use in the reference watershed was multiplied by the ratio of the impaired watershed to the reference watershed. In addition, instream erosion for the adjusted reference watershed was calculated using the total stream length of the impaired watershed.

6.3.2 Weather Data

Daily precipitation and temperature data for the Roanoke International Airport weather station (Station ID 7285) were obtained from the National Climatic Data Center and used for model simulations. The Roanoke International Airport station is located in Roanoke County. This weather station is in approximately the center of the Roanoke River impaired watershed, and thus provided the most accurate precipitation and temperature coverage for the watershed.

6.3.3 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 NLCD land use types present in the watershed (Table 6-3) were used to define model source areas. Therefore, a total of 14 source areas were defined in the model. As necessary, GIS analyses were employed to obtain area weighted parameter values for each given source area.

Table 6-3: Land Use Distribution Used in GWLF Model for the Roanoke River Watershed

General Land Use Category	NLCD Land Use Type	Acres	Percentage of Watershed	Total Percent
Forested	Deciduous Forest	178732.2	53.2	69.9
	Evergreen Forest	17919.4	5.3	
	Mixed Forest	38444.5	11.4	
Agricultural	Pasture/Hay	53261.1	15.9	17.5
	Row Crop	5291.6	1.6	
Developed	Low Intensity Residential	27777.8	8.3	11.1
	High Intensity Residential	352.6	0.1	
	Commercial/Industrial	9118.3	2.7	
Water/Wetlands	Open Water	1336.9	0.4	0.5
	Woody Wetlands	99.2	0.03	
	Emergent Wetlands	77.7	0.02	
Barren	Quarries/Strip Mines	1152.9	0.3	1.0
	Transitional	1265.3	0.4	
	Urban/Recreational Grasses	955.7	0.3	
	Total	**335,785**	**100**	**100**

Source: National Land Cover Data (NLCD)

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 soils 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 coverages 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.

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).

6.3.4 Hydrology Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended for it to be implemented without calibration. Nonetheless, comparisons were made between predicted and observed stream flow for the Roanoke River impaired and reference watersheds to ensure the general validity of the model.

The USGS gage on the Roanoke River at Roanoke, VA (station 2055000) was selected for hydrology calibration based on the period of available monitoring data, its location in the watershed, and the proximity of the gage to the weather station used to develop the model precipitation inputs. Figure 6-1 provides the location of the flow gage and weather station in relation to the Roanoke River watershed.

GWLF parameters relating to hydrology were calibrated based on the Roanoke River flow data collected at USGS station 2055000. The groundwater seepage coefficient and the unsaturated zone available water capacity were adjusted to obtain a best fit with observed data. Results of the hydrology calibration for impaired and reference watersheds are shown in Figures 6-2 and 6-3. In general, model predictions reflect the flow variations observed at the USGS gage station.

Figure 6-1: Location of USGS Flow Gage and Weather Station

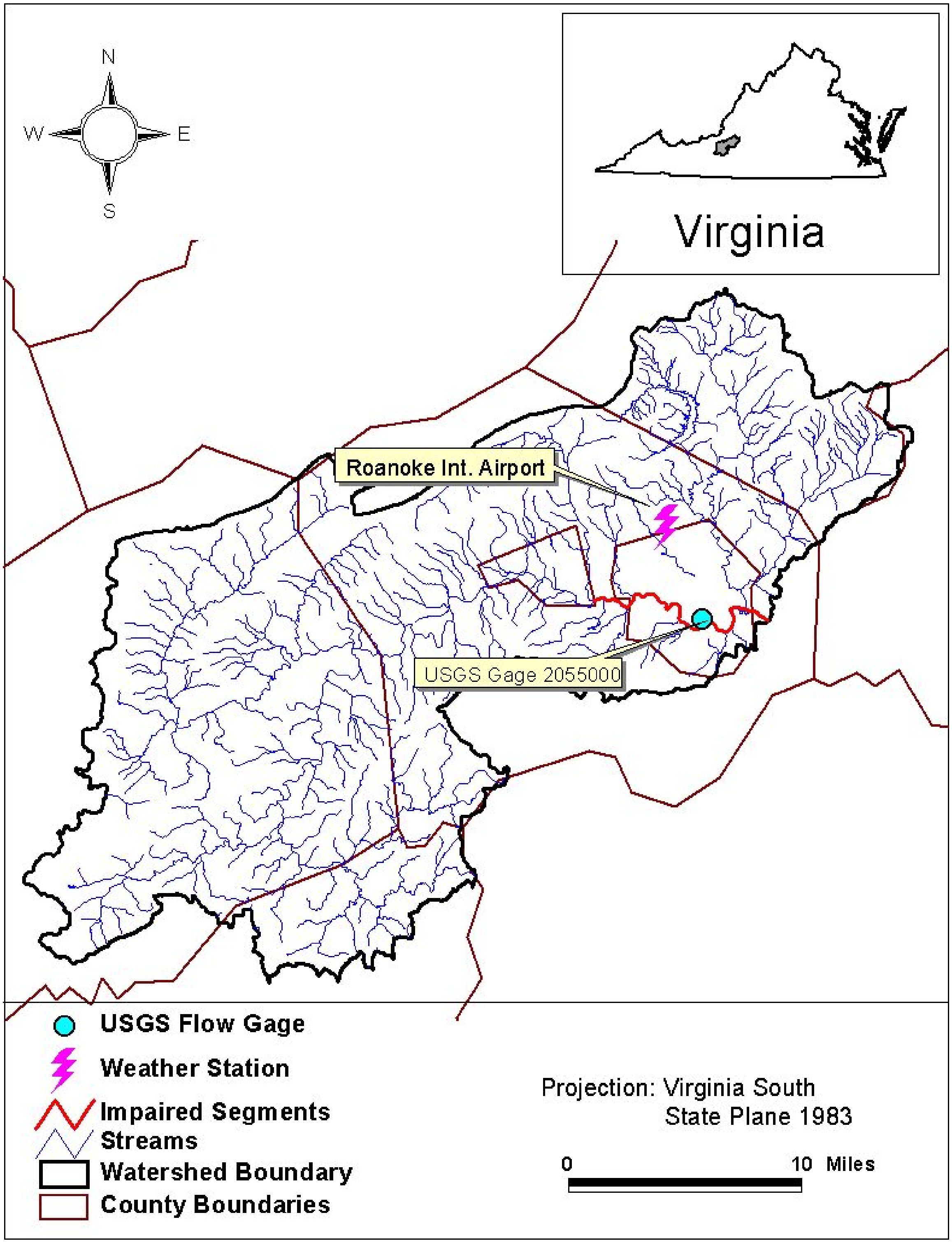


Figure 6-2: Hydrology Calibration Results for Roanoke River Impaired Watershed

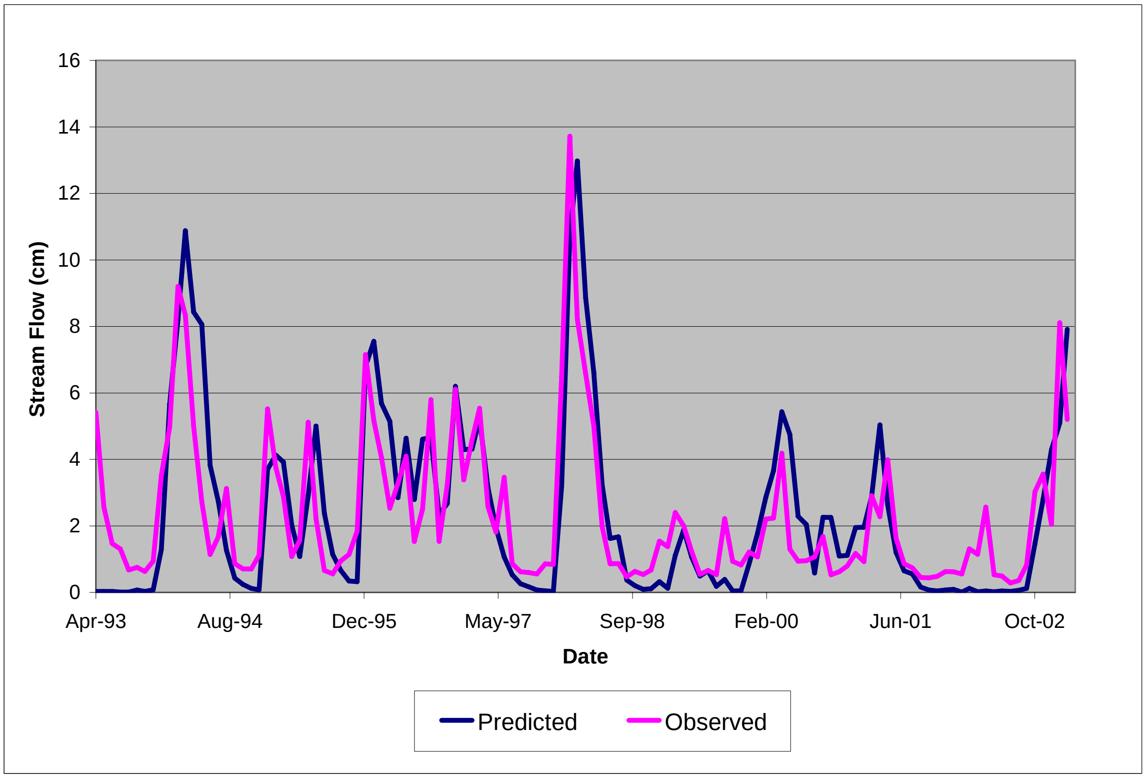
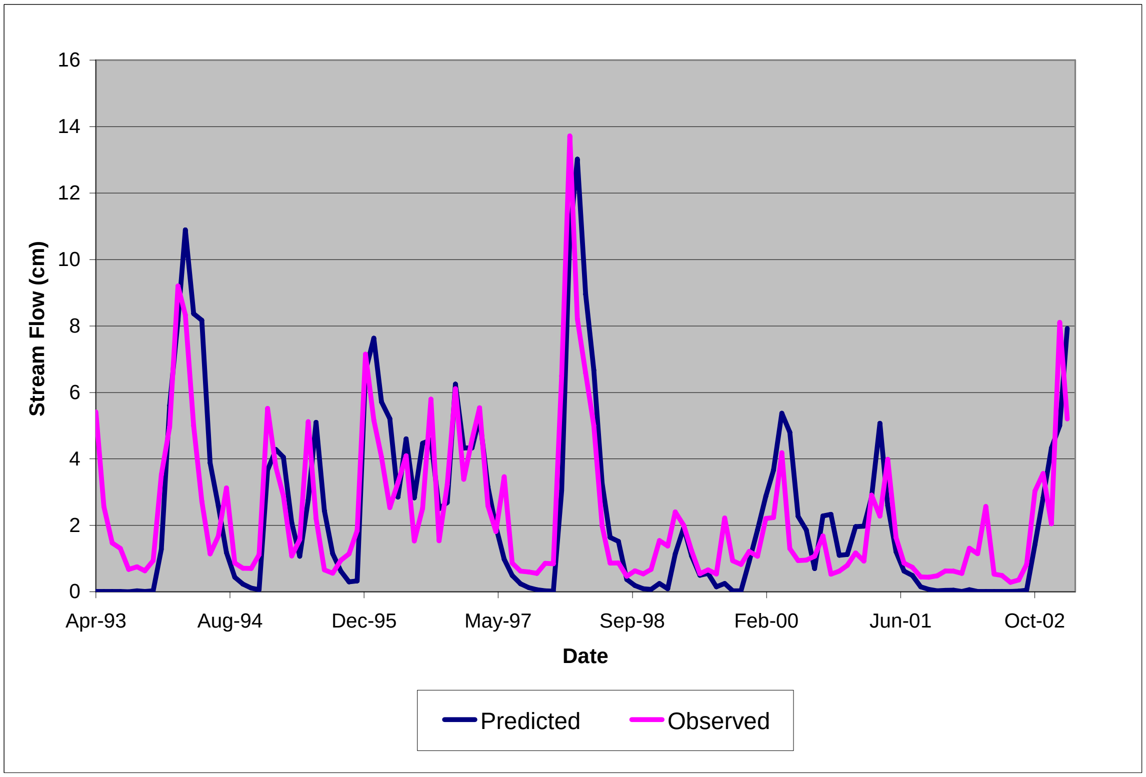


Figure 6-3: Hydrology Calibration Results for Roanoke River Reference Watershed



6.4 Sediment Load Estimates

6.4.1 Sediment Loads from Non-Point Sources

The hydrologically calibrated model was used to estimate sediment loadings from each source area in the Roanoke River impaired and reference watersheds. Based on the 10 year simulation period from 1993 to 2003, average annual sediment loads were computed for each land source in each watershed. These results are presented Table 6-4.

Table 6-4: Roanoke River Average Annual Sediment Loads (tons/yr) from Land Sources

Land Use Type	Reference Watershed (tons/yr)	Impaired Watershed (tons/yr)
Deciduous Forest	972.7	864.0
Evergreen Forest	100.5	87.0
Mixed Forest	197.2	186.6
Pasture/Hay	2088.1	2003.7
Row Crop	5260.2	3284.7
Low Intensity Residential	27.3	138.9
High Intensity Residential	3.4	74.0
Commercial/Industrial	1642.2	4239.9
Urban/Recreational Grasses	2.4	36.0
Quarries/Strip Mines/Gravel Pits	407.6	767.4
Transitional	779.5	1021.3
Open Water	0.0	0.0
Woody Wetlands	0.0	0.0
Emergent Wetlands	0.0	0.0

6.4.2 Sediment Loads from Instream Erosion

Instream erosion was estimated based on the streambank lateral erosion rate equation introduced by Evans, et al. (2003), as described in Section 6.2.3. The ‘a’ factor used in the streambank erosion equation was computed using watershed specific data for the impaired and reference watersheds. Computed ‘a’ factors and annual sediment loads from streambank erosion are presented in Table 6-5.

Table 6-5: Roanoke River Annual Instream Erosion Estimates

Watershed	Computed ‘a’ Factor	Instream Erosion (tons/yr)
Impaired Watershed	2.04E-04	44846.4
Reference Watershed	8.71E-05	9490.3

6.5 Existing Sediment Loadings – All Sources

In summary, average annual sediment loads for the Roanoke River impaired and reference watersheds were determined as follows:

- Erosion and sediment yield from land sources were modeled using GWLF.
- Instream bank erosion was computed based on the method described by Evans et al. (2003).
- Sediment loads from point sources were calculated based on the permitted total suspended solids loading rate for each facility.
- An area-weighted percentage of the land based and bank erosion sediment load was used to partition sediment loading attributed to the MS4s and sediment loading attributed to other sources.

Average annual sediment loads from all sources for the Roanoke River impaired and reference watersheds are summarized in Table 6-6. The total existing sediment load in the impaired watershed is 58,068 tons per year. The area-adjusted reference watershed load of 20,972 tons per year represents the TMDL endpoint. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for the Roanoke River.

Table 6-6: Roanoke River Average Annual Sediment Loadings (tons/yr)

Source	Land Use Type	Reference Watershed	Impaired Watershed
Land Sources	Deciduous Forest	972.7	864.0
	Evergreen Forest	100.5	87.0
	Mixed Forest	197.2	186.6
	Pasture/Hay	2088.1	2003.7
	Row Crop	5260.2	3284.7
	Low Intensity Residential	27.3	138.9
	High Intensity Residential	3.4	74.0
	Commercial/Industrial	1642.2	4239.9
	Urban/Recreational Grasses	2.4	36.0
	Quarries/Strip Mines/ Gravel Pits	407.6	767.4
	Transitional	779.5	1021.3
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Wetlands	0.0	0.0
Instream Erosion	-	9490.3	44846.4
Point Sources	-	0.0	615.3
Total		**20,972**	**58,165**

As stated previously, the existing sediment load in the Roanoke River impaired watershed was distributed between the existing MS4-permitted areas and other non-point sources using an area weighted method. Table 6-7 presents the existing sediment loading in the impaired watershed attributed to the MS4s and other non-point sources. The MS4 sediment loads shown in Table 6-7, include the loads from individual MS4s permits for urban areas, and also loads from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, General Permits for Carwashes, and General Permits for Construction Sites.

Table 6-7: Existing Sediment Loading in the Roanoke River Attributed to the MS4s and other Non-Point Sources

Source	Land Use Type	Total Sediment Load (tons/year)	Percent Attributed to MS4s	Sediment Load Attributed to MS4s (tons/year)	Sediment Load Attributed to Land Sources (tons/year)
Non-Point Sources	Open Water	0.0	24.6	0.0	0.0
	Low Intensity Residential	138.9	90.0	125.0	13.9
	High Intensity Residential	74.0	98.0	72.5	1.5
	Commercial/Industrial	4239.9	76.4	3239.3	1000.6
	Quarries/Strip Mines	767.4	52.3	401.4	366.0
	Transitional	1021.3	31.5	321.7	699.6
	Deciduous Forest	864.0	9.1	78.6	785.4
	Evergreen Forest	87.0	7.0	6.1	80.9
	Mixed Forest	186.6	15.7	29.3	157.3
	Pasture/Hay	2003.7	26.3	527.0	1476.7
	Row Crop	3284.7	6.2	203.7	3081.0
	Urban/Recreational Grasses	36.0	88.2	31.8	4.2
	Woody Wetlands	0.0	6.5	0.0	0.0
	Emergent Wetlands	0.0	12.9	0.0	0.0
Instream Erosion	-	44846.4	21.6	9686.8	35159.6
Total	-	**57,550**		**14,723**	**42,827**

7.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Sediment was identified as the primary stressor to the benthic community in the Roanoke River impaired watershed and a reference watershed approach was used for TMDL development. The total average annual sediment loading for the area-adjusted reference watershed (Table 6-6) represents the TMDL endpoint for the Roanoke River impaired watershed. Reduction of sediment loading in the impaired watershed to the level computed for the area-adjusted reference watershed is expected to restore support of the aquatic life use for the Roanoke River.

7.1 Basis for TMDL Allocations

Sediment TMDL allocations for the Roanoke River impaired watershed were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:

TMDL= Total Maximum Daily Load (Based on the Sediment Load of the Area-Adjusted Reference Watershed)

WLA = Wasteload Allocation

LA = Load Allocation

MOS = Margin of Safety

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

7.1.1 Margin of Safety

An explicit margin of safety of 10% was used for the Roanoke River to account for uncertainties in the methodologies used to determine sediment loadings.

7.1.2 Wasteload Allocation

The wasteload allocated to point sources in the watershed was based on the permitted discharge loading rate for total suspended solids for each facility as shown in Table 7-1. Because the facilities typically contribute only non-settleable solids, and their overall contribution to the total annual watershed sediment load is small, no reductions are required for these sources.

The Cities of Roanoke and Salem, as well as portions of Roanoke, Botetourt, and Montgomery Counties, and three facilities located within the Roanoke City metropolitan area, are covered by MS4 permits which are included in the wasteload allocations. As discussed in Section 6.0, land-based loads were allocated to the MS4 based on an area weighted method. The MS4 wasteload allocations by land use type for all the permitees are presented in Table 7-2. Table 7-3 shows the individual sediment allocation for each MS4 urban area. As indicated in Table 7-2, a 69.5 percent reduction in urban, agricultural, and transitional land-based sources and instream erosion allocated to the MS4s is required to achieve the TMDL endpoint. Wasteload allocations were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions.

Wasteload allocations for facilities in the watershed holding general stormwater permits are presented in Appendix D. The majority of the facilities holding general stormwater permits is located in areas covered by MS4 permits, and is thus included in the MS4 wasteload allocation.

Appendix D provides a finer breakdown of the wasteload allocation by providing specific wasteload allocations for each facility holding a general stormwater permit.

Table 7-1: Point Source Wasteload Allocations for Roanoke River

Facility Name	Permit Number	Annual Sediment Loads (tons/yr)	Allocated Loads (tons/yr)	Percent Reduction
Western Virginia Water Authority	VA0025020	472.2	472.2	0
Roanoke Electric Steel Corporation	VA0001589	92.9	92.9	0
Shawville Town STP	VA0024031	9.1	9.1	0
Carvin Cove Water Filtration Plant	VA0001473	17.6	17.6	0
Crystal Springs WTP	VA0091065	8.8	8.8	0
Norfolk Southern Railway Company - Shaffers Crossings	VA0001597	1.62	1.62	0
Ellison Lafayette WWTP	VA0062219	11.2	11.2	0
Blacksburg Country Club STP	VA0027481	1.57	1.57	0
Roanoke Moose Lodge	VA0077895	0.21	0.21	0
		Total Allocated Load	615.3	0

Table 7-2: MS4 Wasteload Allocation by Land Use Type

Source	Land Use Type	Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Point Sources - MS4s	Open Water	0.0	0.0	0
	Low Intensity Residential	125.0	38.1	69.5
	High Intensity Residential	72.5	22.1	69.5
	Commercial/Industrial	3239.3	988.9	69.5
	Quarries/Strip Mines	401.4	122.6	69.5
	Transitional	321.7	98.1	69.5
	Deciduous Forest	78.6	78.6	0
	Evergreen Forest	6.1	6.1	0
	Mixed Forest	29.3	29.3	0
	Pasture/Hay	527.0	160.7	69.5
	Row Crop	203.7	62.3	69.5
	Urban/Recreational Grasses	31.8	9.7	69.5
	Woody Wetlands	0.0	0.0	0
	Emergent Wetlands	0.0	0.0	0
	Instream Erosion	9686.8	2956.4	69.5
Total		**14,723**	**4,573**	**69.5**

Table 7-3: MS4 Wasteload Allocation by MS4 Urban Area

MS4 Permit Holder	Permit Number	Sediment Allocation (Tons/Year)
Roanoke County	VAR040022	1823
City of Roanoke	VAR040004	1487
Town of Vinton	VAR040026	128
Botetourt County	VAR040023	327
City of Salem	VAR040010	589
VDOT Roanoke Urban Area	VAR040017	27
Virginia Western Community College	VAR040030	2
Virginia Medical Center	VAR040050	10
VDOT Montgomery County Urban Area	VAR040016	4
Town of Blacksburg	VAR040019	102
Town of Christianburg	VAR040025	75
	Total	**4573**

The MS4 sediment allocations shown in Table 7-3 cover the entire MS4 urban areas, therefore include the loads from individual MS4s permits, and also load from Individual Stormwater Permits, General Stormwater Permits, General Permits for Mines, General Permits for Concrete Facilities, General Permits for Carwashes, and General Permits for Construction Sites. Table 7-4 depicts the breakdown of loads other than the individual MS4-permits loads for each urban area. Table 7-5 shows the wasteload allocation for each specific MS4 permit.

Table 7-4: Wasteload Allocation for Stormwater Permits by MS4 Urban Area*

MS4 Urban Area	Individual Permits	General Permits	Mines	Concrete Facilities	Car-washes	Construction Sites	Totals
Roanoke County	-	19.65	-	-	-	123.95	143.60
City of Roanoke	108.1	316.8	7	0.9	0.1	101.11	534.01
Town of Vinton	-	-	-	-	-	8.70	8.70
Botetourt County	-	0.62	15.6	2.43	-	22.23	40.88
City of Salem	18.4	101.6		0.2		40.05	160.25
VDOT Roanoke Urban Area	-	-	-	-	-	1.84	1.84
Virginia Western	-	-	-	-	-	0.14	0.14

MS4 Urban Area	Individual Permits	General Permits	Mines	Concrete Facilities	Car-washes	Construction Sites	Totals
Community College							
Virginia Medical Center	-	-	-	-	-	0.68	0.68
VDOT Montgomery County Urban Area	-	-	-	-	-	0.27	0.27
Town of Blacksburg	12.3	-	-	-	-	6.94	19.24
Town of Christianburg	-	-	-	-	-	5.10	5.10
Total	**138.8**	**438.67**	**22.6**	**3.53**	**0.1**	**311**	**914.7**

* Does not include the load for the specific MS4 urban area permit – Shown in Table 7-5 below. The breakdown by individual permit is shown in Appendix D

Table 7-5: Wasteload Allocation for each Individual MS4 Permit

MS4 Permit Holder	Permit Number	Sediment Allocation (Tons/Year)
Roanoke County	VAR040022	1680.0
City of Roanoke	VAR040004	953.0
Town of Vinton	VAR040026	119.30
Botetourt County	VAR040023	286.1
City of Salem	VAR040010	428.8
VDOT Roanoke Urban Area	VAR040017	25.2
Virginia Western Community College	VAR040030	1.9
Virginia Medical Center	VAR040050	9.3
VDOT Montgomery County Urban Area	VAR040016	3.7
Town of Blacksburg	VAR040019	82.8
Town of Christianburg	VAR040025	69.90
	Total	**3659.3**

7.1.3 Load Allocation

Load allocations for non-point sources not covered under the MS4 permits were based on an equal percent reduction from controllable sources. Loads from forested lands are considered to be representative of the natural condition and therefore were not subject to reductions. By reducing sediment loads from agricultural, transitional, and developed lands and instream erosion by 69.5%, the sediment TMDL endpoint is achieved. The existing and allocated sediment loads for each non-point source in the Roanoke River impaired watershed are presented in Table 7-6. In addition, the necessary percent reduction is shown for each source.

Table 7-6: Load Allocations for Roanoke River

Source	Land Use Type	Average Annual Sediment Load (tons/yr)		Percent Reduction
		Existing	Allocated	
Non-point Sources	Open Water	0.0	0.0	0
	Low Intensity Residential	13.9	4.3	0
	High Intensity Residential	1.5	0.5	69.5
	Commercial/Industrial	1000.6	305.1	69.5
	Quarries/Strip Mines	366.0	111.7	69.5
	Transitional	699.6	213.6	69.5
	Deciduous Forest	785.4	785.4	0
	Evergreen Forest	80.9	80.9	0
	Mixed Forest	157.3	157.3	0
	Pasture/Hay	1476.7	450.9	69.5
	Row Crop	3081.0	940.2	69.5
	Urban/Recreational Grasses	4.2	1.3	69.5
	Woody Wetlands	0.0	0.0	0
	Emergent Wetlands	0.0	0.0	0
	Instream Erosion	35159.6	10730.7	69.5
Total		**42,827**	**13,782**	**68**

7.2 Overall Recommended TMDL Allocations

The total load and wasteload allocations and margin of safety for the Roanoke River are summarized in Table 7-7. Recommended allocations for each source in the watershed are provided in Table 7-8. Overall, the sediment load in the Roanoke River watershed must be reduced by 67.5% to meet the established TMDL endpoint.

Table 7-7: Sediment TMDL for Roanoke River (tons/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
21,079	13,782	5,189	2,108

Table 7-8: Summary of TMDL Allocations for Roanoke River (tons/yr)

Source	Land Use Type	Allocated	Percent Reduction
Land Sources	Deciduous Forest	785.0	0.0
	Evergreen Forest	80.9	0.0
	Mixed Forest	157.3	0.0
	Pasture/Hay	450.9	69.5
	Row Crop	940.2	69.5
	Low Intensity Residential	4.3	69.5
	High Intensity Residential	0.5	69.5
	Commercial/Industrial	305.1	69.5
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Herbaceous	0.0	0.0
	Quarries/Strip Mines/Gravel Pits	111.7	69.5
	Transitional	213.6	69.5
	Urban/Recreational Grasses	1.3	69.5
MS4 Allocation	Deciduous Forest	79.0	0.0
	Evergreen Forest	6.1	0.0
	Mixed Forest	29.3	0.0
	Pasture/Hay	160.7	69.5
	Row Crop	62.3	69.5
	Low Intensity Residential	38.1	69.5
	High Intensity Residential	22.1	69.5
	Commercial/Industrial	988.9	69.5
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Herbaceous	0.0	0.0
	Quarries/Strip Mines/Gravel Pits	122.6	69.5
	Transitional	98.1	69.5
	Urban/Recreational Grasses	9.7	69.5
	Instream Erosion	2956.4	69.5
Instream Erosion	-	10730.7	69.5
Point Sources	-	615.3	0.0
Total		**18,971**	**67.5**

7.3 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 Roanoke River, the primary stressor resulting in the benthic impairment in the river is excessive sediment loading, which has led to siltation and the loss of benthic habitat. On an average annual basis, land-based sources and in-stream erosion account for 99.1% of the total sediment load to the stream; this includes non-point source loading, and loading attributed to the MS4s present in the watershed. Point source facilities contribute only 0.1% of the sediment load, based on the permitted TSS concentrations and design flows for permitted facilities. Therefore, most of the sediment load is delivered under high flow conditions associated with stormwater runoff.

Since sediment loading occurs throughout the year, primarily due to land-based runoff, and its impacts on benthic invertebrates are often a function of cumulative loading, it is appropriate to consider sediment loading on an annual basis. Therefore, TMDL allocations were developed based on average annual loads determined from the 10 year simulation period performed using the GWLF model.

7.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and sediment loading as a result of hydrologic and climatological 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 10 year simulation performed with GWLF adequately captures seasonal variations.

8.0 Implementation

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairments on the Roanoke River. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan, and to monitor stream water quality to determine if water quality standards are being attained.

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

8.1 Staged Implementation

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the most efficient sediment BMPs for both urban and rural watersheds are infiltration and retention basins, riparian buffer zones, grassed waterways, streambank protection and stabilization, and wetland development or enhancement. The iterative implementation of BMPs in the watershed has several benefits:

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

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

8.2 Stage 1 Scenarios

The TMDL allocation scenario to reduce sediment loading to the Roanoke River was presented in Section 7.0. Under this scenario, the sediment TMDL endpoint is achieved by reducing sediment loads from agricultural, transitional, and developed lands by 69.5%, as well as reducing instream erosion by 69.5%. Allocated sediment loads and the percent reduction required for all watershed sources are presented in Table 8-1.

Table 8-1: Recommended Stage 1 TMDL Allocations for the Roanoke River

Source	Land Use Type	Allocated	Percent Reduction
Land Sources	Deciduous Forest	785.0	0.0
	Evergreen Forest	80.9	0.0
	Mixed Forest	157.3	0.0
	Pasture/Hay	450.9	69.5
	Row Crop	940.2	69.5
	Low Intensity Residential	4.3	69.5
	High Intensity Residential	0.5	69.5
	Commercial/Industrial	305.1	69.5
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Herbaceous	0.0	0.0
	Quarries/Strip Mines/Gravel Pits	111.7	69.5
	Transitional	213.6	69.5
	Urban/Recreational Grasses	1.3	69.5
MS4 Allocation	Deciduous Forest	79.0	0.0
	Evergreen Forest	6.1	0.0
	Mixed Forest	29.3	0.0
	Pasture/Hay	160.7	69.5
	Row Crop	62.3	69.5
	Low Intensity Residential	38.1	69.5
	High Intensity Residential	22.1	69.5
	Commercial/Industrial	988.9	69.5
	Open Water	0.0	0.0
	Woody Wetlands	0.0	0.0
	Emergent Herbaceous	0.0	0.0
	Quarries/Strip Mines/Gravel Pits	122.6	69.5
	Transitional	98.1	69.5
	Urban/Recreational Grasses	9.7	69.5
	Instream Erosion	2956.4	69.5
Instream Erosion	-	10730.7	69.5
Point Sources	-	615.3	0.0
	Total	**18,971**	**67.5**

8.3 Link to Ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts aimed at restoring water quality in the Roanoke River watershed.

8.4 Reasonable Assurance for Implementation

8.4.1 Follow-Up Monitoring

VADEQ will continue to monitor stations 4AROA202.20, 4AROA206.03, 4AROA206.95, 4AROA212.17, 4AROA215.13, 4AROA221.95, and 4AROA224.54 in accordance with its biological monitoring program. VADEQ will continue to use data from these monitoring stations and related ambient monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

8.4.2 Regulatory Framework

While section 303(d) of the Clean Water Act and current EPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. EPA also requires that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the TMDL WLA pursuant to 40 CFR §122.44 (d)(1)(vii)(B). All such permits should be submitted to EPA for review.

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (the "Act") directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section 62.1-44.19.7). The Act also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. EPA outlines the minimum elements of an approvable implementation plan in its 1999 "Guidance for Water Quality-Based Decisions: The TMDL Process." The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth intends to utilize the Virginia NPDES (VPDES) program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process, and with the exception of stormwater related permits, permitted sources are not usually addressed during the development of a TMDL implementation plan.

For the implementation of the TMDL's LA component, a TMDL implementation plan addressing at a minimum the WQMIRA requirements will be developed. An exception are the municipal separate storm sewer systems (MS4s) which are both covered by NPDES permits and expected to be included in TMDL implementation plans, as described in the stormwater permit section below.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources to assist in this endeavor.

In response to a Memorandum of Understanding (MOU) between EPA and DEQ, DEQ submitted a draft Continuous Planning Process to EPA in which DEQ commits to regularly updating the state's Water Quality Management Plans. The WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

DEQ staff will present both EPA-approved TMDLs and TMDL implementation plans to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

DEQ staff will also request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9VAC 25-720), except in those cases when permit limitations are equivalent to numeric criteria contained in the Virginia Water Quality Standards, such as is the case for bacteria. This regulatory action is in accordance with §2.2-4006A.4.c and §2.2-4006B of the Code of Virginia. SWCB actions relating to water quality management planning are described in the public participation guidelines referenced above and can be found on DEQ's web site under http://www.deq.state.va.us/tmdl/pdf/ppp.pdf.

8.4.3 Stormwater Permits

DEQ and DCR coordinate separate State programs that regulate the management of pollutants carried by storm water runoff. DEQ regulates storm water discharges associated with "industrial activities", while DCR regulates storm water discharges from construction sites, and from municipal separate storm sewer systems (MS4s).

EPA approved DCR's VPDES storm water program on December 30, 2004. DCR's regulations became effective on January 29, 2005. DEQ is no longer the regulatory agency responsible for administration and enforcement of the VPDES MS4 and construction storm water permitting programs. More information is available on DCR's web site through the following link: http://www.dcr.virginia.gov/sw/vsmp.

It is the intention of the Commonwealth that the TMDL will be implemented using existing regulations and programs. One of these regulations is DCR's Virginia Stormwater Management Program (VSMP) Permit Regulation (4 VAC 50-60-10 et. seq). Section 4VAC 50-60-380 describes the requirements for stormwater discharges. Also, federal regulations state in 40 CFR §122.44(k) that NPDES permit conditions may consist of "Best management practices to control or abate the discharge of pollutants when:…(2) Numeric effluent limitations are infeasible,…".

Part of the Roanoke watershed is covered by 11 permits for small municipal separate storm sewer systems (MS4s) (Table 8-2). The permits state, under Part II.A., that the "permittee must develop, implement, and enforce a stormwater management program designed to reduce the discharge of pollutants from the MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act and the State Water Control Law."

Table 8-2: MS4 Permit Holders in the Roanoke River Watershed

MS4 Permit Holder	Permit Number
Roanoke County	VAR040022
City of Roanoke	VAR040004
Town of Vinton	VAR040026
Botetourt County	VAR040023
City of Salem	VAR040010
VDOT Roanoke Urban Area	VAR040017
Virginia Western Community College	VAR040030
Virginia Medical Center	VAR040050
VDOT Montgomery County Urban Area	VAR040016
Town of Blacksburg	VAR040019
Town of Christianburg	VAR040025

The permit also contains a TMDL clause that states: "If a TMDL is approved for any waterbody into which the small MS4 discharges, the Board will review the TMDL to determine whether the TMDL includes requirements for control of stormwater discharges. If discharges from the MS4 are not meeting the TMDL allocations, the Board will notify the permittee of that finding and may require that the Stormwater Management Program required in Part II be modified to implement the TMDL within a timeframe consistent with the TMDL." ("Board" means the Soil and Water Conservation Board)

For MS4/VSMP general permits, the Commonwealth expects the permittee to specifically address the TMDL wasteload allocations for stormwater through the implementation of programmatic BMPs. BMP effectiveness would be determined through ambient in-stream monitoring. This is in accordance with recent EPA guidance (EPA Memorandum on TMDLs and Stormwater Permits, dated November 22, 2002). If future monitoring indicates no improvement in stream water quality, the permit could require the MS4 to expand or better tailor its stormwater management program to achieve the TMDL wasteload allocation. However, only failing to implement the programmatic BMPs identified in the modified stormwater management program would be considered a violation of the permit. Any changes to the TMDL resulting from water quality standards changes on the Roanoke River would be reflected in the permit.

Wasteload allocations for stormwater discharges from storm sewer systems covered by a MS4 permit will be addressed in TMDL implementation plans. An implementation plan will identify types of corrective actions and strategies to obtain the wasteload allocation for the pollutant causing the water quality impairment. Permittees need to participate in the development of TMDL implementation plans since recommendations from the process may result in modifications to the stormwater management plan in order to meet the TMDL.

Additional information on Virginia's Stormwater Phase 2 program and a downloadable menu of Best Management Practices and Measurable Goals Guidance can be found at http://www.dcr.virginia.gov/sw/vsmp.htm .

8.4.4 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the "Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans". Potential sources for implementation may include the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, EPA Section 319 funds, the Virginia State Revolving Loan Program, Virginia Agricultural Best Management Practices Cost-Share Programs, the Virginia Water Quality Improvement Fund, tax credits and landowner contributions. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

9.0 Public Participation

The development of the Roanoke River benthic TMDL would not have been possible without public participation. A technical advisory committee (TAC) meeting and two public meetings were held for in the Roanoke River watershed. The following is a summary of the meeting objectives.

TAC Meeting and Public Meeting No. 1. The TAC meeting and the first public meeting were held in Roanoke, Virginia on October 7, 2004 to present the following:

- the process for TMDL development
- the listed benthic segment of the Roanoke River
- data that caused the segment to be on the 303(d) list
- data and information needed for TMDL development
- preliminary findings regarding potential stressors

Copies of the presentation were available for public distribution. Representatives of various state and local government agencies and stakeholders attended the TAC meeting; meeting participants were contacted by DEQ via email and phone. A total of 41 people attended the meeting including various stakeholders and citizens. This meeting was publicly noticed in the *Virginia Register*. No written comments were received during the 30-day comment period.

Public Meeting No. 2. The second public meeting was held in Shawsville, Virginia at East Montgomery High School in the evening of August 4, 2005 to discuss the identified pollutant stressor, the methodology employed to determine watershed loadings of the stressor, and the Draft TMDL. Eleven people attended this public meeting. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

Public Meeting No. 3. The third public meeting was held in Roanoke, Virginia at the DEQ regional office on August 9, 2005 to discuss the identified pollutant stressor, the methodology employed to determine watershed loadings of the stressor, and the Draft

TMDL. Twenty-two people attended the meeting. Copies of the presentation and the draft TMDL report executive summary were available for public distribution. The meeting was public noticed in *The Virginia Register of Regulations.*

References

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APPENDIX A: General Permits Issued in the Roanoke River Benthic Impairment Watershed

Table A-1: General Stormwater Permits Issued to Construction Sites in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR101921	Blue Ridge Ready Mix - Roanoke Plant	Western terminus of Blue Ridge Dr.	Barnhart Creek	5	History
VAR103260	Emery Creek	2415 Franklin St	Bowman Hollow	6.95	History
VAR103992	Phillips Brook	2841 Franklin St	Bowman Hollow	6.95	Active
VAR101306	VDOT - Route 865, Roanoke County	Near Adney Gap, Virginia	Camp Creek and U.T. to Camp Creek	5.4	History
VAR103295	Plantation Road Sanitary Sewer Project	Plantation Road	Carvin Creek	3	History
VAR103119	Lucas South Main Property	2301 South Main Street	Cedar Run	3.87	Active
VAR100144	Wal-Mart Stores Inc - Bonsack	Challenger Ave	Cook Creek	52.1	History
VAR104040	Virginia Varsity Self Storage, Botetourt Facility	45 Hillview Dr	Cook Creek, UT	4	Active
VAR101049	Roanoke Regional Airport - Runway 2/24	5202 Aviation Dr NW	Deer Branch Creek/Lick Run Creek	31	History
VAR102145	First Team Auto Mall - Nissan	6900 Peters Creek Rd	Deer Branch	2	History
VAR103442	New Barrens Court	New Barrens Court	Deer Branch, UT	1.5	Active
VAR103700	Roanoke Regional Airport - Runway 15/33	5202 Aviation Dr	Deer Branch Creek	45	History
VAR420266	Roanoke Regional Airport	5202 Aviation Drive, NW	Deer Branch and Lick Run	20	History
VAR102236	East End Utility Project	East of I81 to Eastern Corporate Limits	Den Creek, UT	30	History
VAR102280	Kings Crest	Fieldgate Rd and Coronado Dr	Dry Branch	10	History
VAR101265	Roanoke Regional Airport - Runway 15	5202 Aviation Drive	East Side - Deer Branch Cr.; West Side-Lick Run	29	History
VAR100096	VDOT - Salem Residency 8787	St RT 674 Montgomery County	Elliot Creek, UT	8.5	History
VAR102087	Kelseywood Subdivision	c/o Gay and Keesee Inc	Falling Branch, UT	9.864	History
VAR102170	Shelor Dodge	Christiansburg	Falling Branch, UT	4.583	History
VAR102314	Christiansburg Electrical & Plumbing Inc	Cumberland Dr Lot 2	Falling Branch, UT	0.02	History

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR102434	Pilot Homes Mini - Storage		Falling Branch, UT	2.95	History
VAR102918	Falling Branch S/D Section 8 Phase V	Copper Beach Court	Falling Branch, UT	0.836	History
VAR101893	VDOT Powers Property 0081 080 116 N501 (58050)	Disposal/Borrow area on Calvin Powers Property	Gish Branch and UT to Gish Br	1.66	History
VAR100646	VDOT - Salem Residency I81 Exit 140	Exit 140 City of Salem	Gish Branch	5.39	History
VAR100513	Glade Creek Phase B	3843 Glade Creek Blvd	Glade Creek	15	History
VAR102277	Village Court	off of Springtree Dr	Glade Creek	3.5	Active
VAR102278	Huntridge Grove	Stayman Dr off of Huntridge Rd	Glade Creek	13.05	History
VAR102586	Integrity Windows Inc	4050 Integrity Dr	Glade Creek	34.84	Active
VAR103327	Elizabeth Arden	1751 Blue Hills Dr NE	Glade Creek, UT	8	History
VAR100647	VDOT - Salem Residency I81 Exit 137	Exit 137 Salem City	Horners Branch	5.18	History
VAR100116	Roanoke Regional Airport	5202 Aviation Drive, NW	Lick Run	8.51	History
VAR101264	Roanoke Regional Airport - Overflow Parking Lot	5202 Aviation Drive	Lick Run	5.4	History
VAR100340	Roanoke Regional Airport	5202 Aviation Drive, NW	Lick Run Creek	20	History
VAR101394	VDOT - Salem Residency (12532)	c/o Paul Johnson @PO Box 3071	Mason Creek	11.3	History
VAR420287	VDOT - Salem Residency Green Ridge Rd	Green Ridge Rd	Mason Creek and Peters Creek	7.1	History
VAR101268	Sam's Club #8220-01	1455 Towne Square Blvd	MS4 to Machine Creek?	9	History
VAR103480	RADAR New Transit Facility	2762 Shenandoah Ave NW	MS4 to Roanoke River	3.31	History
VAR103292	Roselawn off-site Sewer	Roselawn	Mud Lick Creek	1.5	History
VAR102182	Cresthill Commons	Millcrest Ct & Garstview Cir	Mudlick Creek	9.8	History
VAR102958	Hidden Valley High School	Titan Trail	Mudlick Creek	10	History
VAR103689	Structures Office Park	1012 feet to the intersection of McVitty Rd	Mudlick Creek	1.22	History
VAR103089	Phillips Residence	605 Rich Cir	North Fork Roanoke River, UT	0.25	History
VAR101909	VWCC College Services Building Project	South Campus between Parking Lots 1 & 9	Ore Branch	2.3	History
VAR101910	VWCC Parking Lot Expansion & Connector Road	South Campus between Parking Lots 1 & 9	Ore Branch	4.2	History

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR103197	Grace Covenant New Sanctuary Building	756 Peters Cr Rd	Peters Creek, UT	1.6	History
VAR102421	Salem City Water Treatment Plant	On the north bank of the Roanoke River, 1500 feet downstream of the bridge on Mill Lane in Salem, VA	Roanoke River	7	Active
VAR102916	Hoffman Medical Imaging Inc	1200 Southside Dr	Roanoke River, UT	2.9	Application
VAR102974	West Main Office Park	1955 W Main St	Roanoke River	1.5	History
VAR103192	Freedom First Credit Union	RT 419 Electric Rd & Indiana St	Roanoke River	2.21	History
VAR101649	Roanoke River Flood Reduction Project	Coyner Springs Clean Fill Disposal Area	Roanoke River	55	Active
VAR102746	The Village at Brandon Oaks	3930 Brandon Ave SW	Roanoke River	3.559	History
VAR102782	Roanoke Stadium Amphitheatre Phase I	1670 Courtland Ave	Roanoke River	22	History
VAR103023	Plantation Pipe Line Roanoke R Crossing	2005 Greenbrier Ave	Roanoke River	1.3	Active
VAR420319	Norfolk and Western CDD Landfill	Patterson Ave (2400 Block)	Roanoke River/Mason Creek	15.05	History
VAR101894	VDOT Botetourt Co 0825 011 242 N501 (64859)	Route 825 Botetourt	Rulman Br and UT to Rulman Br	1.5	History
VAR102126	Botetourt Center at Greenfield Recreation Park	Etzler Rd 97 Preston Parkway	Rulman Branch to Tinker Creek	50	History
VAR100099	VDOT - Salem Residency 52416	RT 81 Montgomery Co	Smith Creek	6	History
VAR104029	Roanoke College	Peery Dr	Snyder Branch	4	Active
VAR420269	VDOT - Salem District - Rte 638 (0638 060 P08 N501	RT 638 Montgomery Co	South Fork Roanoke River and Georges River, UT	15	History
VAR103228	Christiansburg Baptist Church		Storm water ditch to sinkhole	4	History
VAR103988	Semco Inc	1967 Blue Hills Dr	UT to Tinker Creek	7	Active
VAR103615	VDOT - Salem Residency 63706	Rte 81 near Salem	Tinker, Mason, Peters, Carvins Creeks, Deer, Honne	1.2	History
VAR100401	VDOT - Salem District - Rte 665 (0665 011 226 C501	RT 665 Botetourt Co	Tinker creek, UT and Town Branch, UT	8	History
VAR100648	VDOT - Salem District - I81 Exit 150	Exit 150 Botetourt Co	Tinker Creek	14.05	History

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR101231	VDOT-Botetourt Co (0605-011-241,C501 [15194]	RT 605	U.T. to Tinker Creek	8.3	History
VAR102274	Shaw Connex Incorporated	81 Connex Way	UT to Tinker Creek	1.6	History
VAR102275	Meadowbrook Phase III	End of Northbrook Dr	Tinker Creek	4.5	Active
VAR102276	Fellowship Baptist Church	5022 Hollins Rd	Tinker Creek	4	History
VAR102287	Metalsa Roanoke Inc	184 Vista Dr - Vista Corporate Park	Tinker Creek	13.5	History
VAR102368	Cypress Court	VA Secondary Route 605	UT to Tinker Creek	9.5	Active
VAR102503	First Choice Homes LLC Grading Plan	Belle Avenue NE Lot 7 Roanoke City	UT to Tinker Creek	1.5	History
VAR102583	Seekers Run	between RT 1507 and RT 1452 Sequoia Dr	UT to Tinker Creek	2.1	History
VAR102675	The Glebe	250 Glebe Road	UT to Tinker Creek	77.5	History
VAR102819	Medallion Hills Subdivision	ST RT 779 Catawba Rd	UT to Tinker Creek	8	History
VAR102870	Magic City Ford Truck Center	Orange Ave and Williamson Rd	UT to Tinker Creek		Application
VAR103019	Botetourt Commons Shopping Center	Kroger Shopping Center	UT to Tinker Creek	22.7	History
VAR103080	Berkley Commons	Westover Ave & Berkley Court	UT to Tinker Cr.	4.5	History
VAR103293	Stonegate Subdivision	1 Stonegate Dr	UT to Tinker Creek	7	History
VAR103395	Ashley Plantation	919 Greenfield St	UT to Tinker Creek	220	History
VAR103442	New Barrens Court	New Barrens Court	UT to Tinker Creek	1.5	History
VAR103443	Sowder Farm Subdivision	1007 Country Club Rd	unnamed tributary to tinker creek	2.5	History
VAR103702	Roanoke City - Mountain View Elementary School	5901 Plantation Circle	UT to Tinker Creek, lower	4.28	History
VAR103949	Belle Ave Townhouses	Belle Ave	UT to Tinker Cr; Roanoke City MS4	0.75	Active
VAR104041	Affordable Mini Storage LLC	1250 Lee Highway	UT to Tinker Creek	2.25	Application
VAR102176	Canterbury Park Section 14 Steeple Hunt	old Locke Ct and Salisbury Dr	U.T. to Mudlick Creek	7	History
VAR102177	Stone Manor	along Roselawn Rd	U.T. to Mudlick Creek	21.72	History
VAR103879	Roanoke County Center of Research and Technology	Glenmary Dr	UT to Callahan Branch	25	Active
VAR102869	Achievement Center	Dwight and Olsen Rd	UT to Carvins Creek (Middle)	3.5	Application

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR102438	Hunters Crossing	Ramble Rd	UT to Cedar Run	2.79	History
VAR102441	Elliott Rd Lot 1	615 Elliott Rd	UT to Cedar Run	0.12	History
VAR103082	Knollwood Commons - Phase II - Section I	N/A	UT to Cedar Run	7	Active
VAR101902	Lowe's Home Center	Challenger Ave US Route 460	UT to Cook Creek	12	History
VAR102014	Roanoke City Schools Transportation Facility	5401 Barns Ave NW	UT to Deer Branch	9.6	History
VAR102951	Oak Knoll Subdivision	8102 Barrens Rd	UT to Deer Branch	7	Active
VAR101967	Skycrest	3454 - 3502 Roanoke St	UT to Den Cr	2.7	Active
VAR101969	Springtree Health Care Center	King Street near Springtree Dr	UT to Glade Cr	9.5	History
VAR102284	Applewood, Section 12	Crumpacker Dr and Appletree Dr	UT to Glade Creek	2	History
VAR102285	Samuel's Gate Section 9 Detention Facility	Apple Harvest Dr and Windcrest Ln	UT to Glade Creek	11	History
VAR102286	Cortland Meadows	Fieldview Dr intersects Cortland Rd	UT to Glade Creek	14	History
VAR103053	Wedgwood 2530 and 2600 Juniper	E Ruritan Rd	UT to Glade Creek	26	Active
VAR103297	Valley Gateway Business Park Improvements	Valley Gateway Blvd	UT to Glade Creek	3.04	History
VAR103567	Parkway Wesleyan Church	3845 Orange Ave	UT to Glade Creek	11.53	History
VAR103703	Herman L Horn Elementary School	1002 Ruddle Road	UT to Glade Creek	6.95	History
VAR103768	Samuel's Gate Section 11	Extension of Apple Harvest	UT to Glade Creek	14.66	Application
VAR103991	Villa Heights Baptist Church	4080 Challenger Ave	UT to Glade Creek	1.75	Active
VAR102166	Supreme Hospitality LLC T/A Holiday Inn	Litchell Rd Exit 137 off I-81	UT to Horner's Branch Creek & Cole Hollow Branch	1.77	History
VAR101374	VDOT - Salem Residency	PO Box 3071	UT to Mason Creek	6.9	History
VAR102915	Automotive Frame	1648 Lynchburg Turnpike	UT to Mason Creek	3	History
VAR103474	National College of Business Technology	1813 E Main St	UT to mason creek	2	History
VAR103573	Bradford Court	607 Bland St	UT to Mason Creek	3.5	Active
VAR102802	YMCA Parking Lot Construction	962 Kime Ln	UT to Masons Cove	6.2	Active
VAR102499	Stoneridge at Bent Mountain	Route 889 Mill Creek Road	UT to Mill Creek	7	History
VAR102181	Glen Meadow	Glen Meadow Dr	UT to Mudlick Creek	5.46	History

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR102700	Old Stable Village	1701 1733 Beckys Lane	UT to Mudlick Creek	4	Active
VAR102180	Glen Laurel Place	Laurel Drive	UT to Murray Run	5.52	History
VAR102781	Seaside Heights LLC	4510 Brambleton Ave	UT to Murray Run	1.75	Application
VAR103759	Fink's Jewelers	3545 Electric Road	UT to Murray Run	1.2	History
VAR102439	Shelor Estates	1051 Nik Ryan Dr	UT to North Fork	0.11	History
VAR102442	Cedar Hill	205 Cedar Hill Dr	UT to North Fork	0.11	History
VAR102444	The Orchards Phase 3B	Cherry Lane	UT to North Fork	12.75	History
VAR102175	Southwoods	between I 581 & Franklin Rd	UT to Ore Branch	4	History
VAR103461	Slate Hill, McNeil and Woodcliff	Franklin Rd	UT to Ore Branch	25	History
VAR103370	Timber Ridge Subdivision	Virginia Secondary RT 628	UT to Peters Creek	2.5	Active
VAR103925	North Valley Seventh Day Adventists	North Ridge Ln	UT to Peters Creek	2	Active
VAR102491	New Facility for Fellowship Community Church	Red Lane	UT to Roanoke River	9.76	History
VAR102569	Village on the Crest Keagy Lane	1302 to 1319 Keagy Lane SW	UT to Roanoke River	4.2	Active
VAR102916	Hoffman Medical Imaging Inc	1200 Southside Dr	UT to Roanoke River	2.9	History
VAR103029	Russlen Farms Phase I	Ext of Millwood Dr and ext of Millwheel Dr	UT to Roanoke River	40	History
VAR103882	North Oaks Subdivision	Red Lane	UT to Roanoke River	8.52	Application
VAR104030	1st Mideastern Foxcroft Manor	Goodwin Ave	UT to Roanoke River	12	Application
VAR103334	First Citizens Bank	510 McClanahan St	UT to Roanoke River	1.08	History
VAR103460	Wolf Creek Subdivision, Richards Wood	Lots 11, 12, 13, 14	UT to Roanoke River	1	History
VAR103618	Buck Plumbing and Heating	1845 Westland Ave SW	UT to Roanoke River	1.2	History
VAR103923	Vinton Off Track Betting Facility	1135 Vinyard Rd, Edgefield Subdivison	UT to Roanoke River	4.75	Active
VAR103957	Blue Ridge Parkway	mile post 121 to mile post 135.9	UT to Roanoke River	7.25	Active
VAR101888	VDOT Marshall Disposal 6460 060 F19 C501	Marshall Disposal Area South of EBL Route 460	UT to Wilson Creek	2.5	History
VAR101890	VDOT Skelton Property 6460 060 F19 C501	Skelton Property Disposal Site off of Route 642	UT to Wilson Creek	1	History

Permit Number	Facility	Location	Receiving Waterbody	Disturbed Area (acres)	Status
VAR102306	Falling Creek Estates Lot 46 Section 8	Toddsbury Dr	UT to Wolf Creek	1	History
VAR103067	Vinton Business Center McDonald Farm	Hardy Rd	UT to Wolf Creek	2.5	History
VAR103079	Kingston Estates	525-644 Castleridge Rd & 418-539 Cambridge Court	UT to Wolf Creek	22	Active
VAR103086	Cardinal Insulated Glass in Vinton Bus Center	Hardy Rd	UT to Wolf Creek	30	History
VAR103486	Edgefield Section Two	2800 Edgefield Dr	UT to Wolf Creek	17	History
VAR103529	Greenway Landing	20 Greenway Landing Place	UT to Wolf Creek	2.81	History
VAR103884	Village at Stone Creek	Wolf Run	UT to Wolf Creek	2.33	History
VAR100231	VDOT - Salem District - IVHS 060-101 C501	RT IVHS 060-101,C501	Wilson Creek	60	History
VAR100251	VDOT - Salem District - Rte 460 (6460 060 F19 C502	RT 460 Montgomery Co	Wilson Creek, UT	131	History
VAR100254	VDOT - Salem District - Rte 460 (6460 060 F19 C501	RT 460 Montgomery Co	Wilson Creek	200	History
VAR100397	VDOT - Salem District - IVHS (060 101 C502 B603)	RT IVHS Montgomery Co	Wilson Creek	19	History
VAR102085	VT - Transportation Institute Warehouse & Phase II	3500 Transportation Research Plaza	Wilson Creek, UT	4.2	History
VAR102747	Shelor Dodge North	Christiansburg	Wilson Creek, UT	2.49	History
VAR100120	VDOT - Salem Residency 11911	Hardy Rd Vinton	Wolf Creek	11	History
VAR102639	Vinton Town Wolf Creek Interceptor	1359 Hardy Rd and along Wolf Cr	Wolf Creek	0.5	History
VAR103529	Greenway Landing	20 Greenway Landing Place	Wolf Creek, UT	2.81	Application

Table A-2: General Stormwater Permits Issued to Industrial Facilities in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Receiving Waterbody
VAR050011	Architectural Concrete Products Incorporated	Tinker Creek/Carvin Creek/Glade Creek
VAR050027	Auto Salvage & Sales, Inc.	Tinker Creek/Carvin Creek/Glade Creek
VAR050174	Carbone of America Corporation	Masons Creek
VAR050178	BFI Waste Systems LLC - Roanoke	Roanoke River
VAR050179	CEI - Roanoke	Tinker Creek
VAR050206	Con-Way Southern Express-NRO	Lick Run
VAR050207	1915 Plantation Rd LLC	Lick Run
VAR050220	Blue Ridge Stone - Portable Rip Rap Plant	Glade Creek
VAR050251	Federal Mogul Corp - Blacksburg	Cedar Run Creek
VAR050251	Federal Mogul Corp - Blacksburg	Wilson Creek UT
VAR050337	Sewell Products Inc	Mill Race
VAR050436	Norfolk Southern Corp - Roadway Material Yard	Roanoke River
VAR050437	Estes Express Lines Incorporated	Roanoke River, UT
VAR050448	United Parcel Service Inc - Roanoke	Lick Run
VAR050457	Waste Management of Virginia - Salem	Roanoke River, UT
VAR050460	Yellow Freight System Inc - Roanoke	Tinker Creek
VAR050461	L H Sawyer Paving Co Inc	Roanoke River
VAR050462	Southern States Cooperative Inc - Vinton Feed Mill	Tinker Creek
VAR050496	Federal Express Corp - ROAA Station	Lick Run
VAR050506	Timber Truss Housing Systems Inc	Roanoke River, UT
VAR050507	Watkins Motor Lines - ROANOKE TERMINAL	Little Bear Creek
VAR050515	Yokohama Tire Corp	Roanoke River, UT
VAR050519	FedEx Freight East, Inc.	UT to Lick Run
VAR050520	O'Neal Steel Inc	Tinker Creek
VAR050522	Progress Rail Services Corp - Roanoke	Roanoke River
VAR050526	RR Donnelley and Sons Company - Roanoke	Branch Creek
VAR050530	Shenandoah Auto Parts	Lick Run
VAR050539	Kenan Transport Co	Tinker Creek, UT
VAR050547	ITT Industries - Night Vision	Carvin Creek
VAR050643	Akzo Nobel Coatings Inc	Roanoke River
VAR050717	Cycle Systems Incorporated	Ore Branch
VAR050741	Medeco Security Locks Inc	Roanoke River, UT
VAR050743	Hanson Concrete Products Inc - Roanoke	Roanoke River
VAR050744	Hanson Concrete Products Inc - Salem #1	Roanoke River
VAR050745	Hanson Concrete Products Inc - Salem #2	Roanoke River
VAR050749	Valleydale Foods Incorporated	Roanoke River
VAR050760	VT - Virginia Tech Airport	Slate Branch, UT
VAR050762	Novozymes Biologicals Inc	Unnamed ditch to Mason Creek
VAR050775	Star City Auto Parts Inc	Roanoke River
VAR050843	Estes Express Lines Inc - Roanoke	Tinker Creek
VAR051245	KIK Virginia Incorporated	Mill Race
VAR520005	Vishay Vitramon Inc	Tinker Creek
VAR520131	Virginia DMA - OMS #10	Roanoke River
VAR050516	Mennel Milling Company	Roanoke River
VAR050144	North 11 Asphalt Plant - Roanoke	Carvins Creek
VAR050340	Eagle Picher Wolverine Gasket Division Blacksburg	Cedar Run
VAR050204	Eagle Picher Wolverine Gasket Division Cedar Run	Cedar Run UT
VAR051460	Dynax American Corporation	Cook Creek
VAR050272	Roanoke Regional Airport	Deer Branch Creek
VAR050277	General Shale Products LLC Plant No 35 and 36	Glade Creek
VAR050277	General Shale Products LLC Plant No 35 and 36	Glade Creek UT
VAR051492	Virginia Transformer Corp	Glade Creek, UT
VAR050134	Greater Roanoke Transit Company	Lick Run

Permit Number	Facility	Receiving Waterbody
VAR050145	Holland-Richards Vault Service	Mason Creek
VAR050175	General Electric Industrial Systems	Masons Creek
VAR050148	Salem Frame Company	Mill Race to Roanoke River
VAR050146	Hedge Metal Company Incorporated	Roanoke River
VAR050147	Rowe Furniture Corporation	Roanoke River
VAR050176	John W Hancock Jr Incorporated	Roanoke River
VAR520200	Hancock Rack Systems	Roanoke River
VAR050143	Virginia Scrap Iron & Metal Incorporated	Roanoke River
VAR050208	Walker Machine & Foundry Corp	Roanoke River
VAR051371	Roanoke Regional Water Pollution Control Plant	Roanoke River
VAR050135	Virginia Scrap Iron & Metal Company Inc	Roanoke River
VAR050274	USPS Roanoke Vehicle Maintenance Service	Roanoke River
VAR050273	Ralph Smith Inc Steel Fabrication	Roanoke River UT
VAR050176	John W Hancock Jr Incorporated	Roanoke River, UT
VAR050150	Graham White Manufacturing Company	Snyders Branch
VAR050142	Southern States Cooperative Inc Cloverdale	Tinker Creek
VAR050143	Virginia Scrap Iron & Metal Incorporated	Tinker Creek
VAR050180	Hooker Furniture Corporation - Roanoke	Tinker Creek
VAR050275	Old Dominion Auto Salvage	Tinker Creek
VAR050747	Parts Unlimited	Tinker Creek
VAR050757	Metalsa Roanoke Inc	Tinker Creek
VAR051199	Pitt Ohio Express Roanoke Terminal - Plantation Rd	Tinker Creek
VAR051262	Shorewood Packaging Corporation - Roanoke	Tinker Creek
VAR051315	A D Weddle Company Inc	Tinker Creek
VAR051227	Old Virginia Brick Co Inc - Salem	UT to Roanoke River
VAR051480	J and J Asphalt Incorporated	UT to Roanoke River
VAR051478	Precision Steel	UT, Glade Creek
VAR051352	MRSWA Solid Waste Transfer Station MRF	Wilson Creek

Table A-3: General Permits Issued to Domestic Sewage Facilities in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Receiving Waterbody
VAG402004	Epstein, William Residence	North Fork Roanoke River UT
VAG402003	Miller Robert Residence	Roanoke River North Fork UT
VAG402063	R W Bowers Commercial Development	Glade Creek Tributary
VAG402059	R W Bowers Parcel No 6	Glade Creek Tributary
VAG402061	R W Bowers Parcel No 7	Glade Creek Tributary
VAG402019	Hensley, Wendell Residence	Cedar Run
VAG402021	McMahan, Raymond Residence	Cedar Run Branch
VAG402012	Miller, Edith Residence	Gish Branch
VAG402002	Bryant, Gary Residence	Mason Creek Tributary
VAG402020	Virginian Markette Inc	Mill Creek
VAG402091	Pierce Kenneth R Residence	UT to Flatwoods Branch
VAG402093	Hilton Residence James	UT to Womack Branch
VAG402046	Lorton/Fowler Residence	Wilson Creek
VAG402054	Halsey, Charles Residence	Wilson Creek
VAG402041	Cabin Creek Antiques	Crush Run
VAG402062	Harold Shad Residence	Craft Branch to Toms Creek
VAG402082	Phillips and Lytton	Plum Creek

Table A-4: General Permits Issued to Mines in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Receiving Waterbody
VAG840052	Sisson And Ryan Quarry	Spring Branch, UT
VAG842008	Sisson And Ryan Quarry	Not applicable
VAG840053	Acco Stone Co - Blacksburg	Wilson Creek, UT
VAG840155	Highland Park Quarry	North Fork Roanoke River, UT
VAG842004	Acco Stone Co - Blacksburg	Mill Branch
VAG840067	Rockydale Quarries / Adams Asphalt Plant	Ore Branch, UT
VAG842018	Boxley Materials Company	Healing springs, UT

Table A-5: General Permits Issued to Concrete Facilities in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Receiving Waterbody
VAG110169	Construction Materials Company - Blacksburg	UT Cedar Run
VAG110012	Chandler Concrete Of VA Inc Seventh St	Roanoke River
VAG110018	Chandler Concrete Of Virginia Inc - Norfolk Avenue	Roanoke River
VAG110026	Salem Ready Mix Concrete Inc	Paint Bank Branch
VAG112014	Concrete Ready Mixed Corp - Roanoke	Roanoke River
VAG112015	Concrete Ready Mixed Corp - Salem	Roanoke River
VAG110025	Construction Materials Co Roanoke	Roanoke River
VAG110125	Blue Ridge Ready Mix - Roanoke Plant	Barhardt Creek
VAG110013	Chandler Concrete of Virginia Inc - Plant 703	Tinker Creek
VAG110024	Construction Materials Company - Botetourt	Buffalo Creek
VAG112016	Concrete Ready Mixed Corp - Cloverdale	Tinker Creek

Table A-6: General Permits Issued to Carwashes in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Receiving Waterbody
VAG750059	ProWash USA	Deer Branch, UT

Table A-7: General Permits Issued to Cooling Water Facilities in the Roanoke River Benthic Impairment Watershed

Permit Number	Facility	Receiving Waterbody
VAG250048	The Spectacle Lens J&J Vision Care	5568 Airport Road, Roanoke

APPENDIX B: Habitat Parameters Assessed and Scored at Biological Monitoring Stations

Figure B-1: Substrate Embeddedness Scores for Roanoke River Monitoring Stations

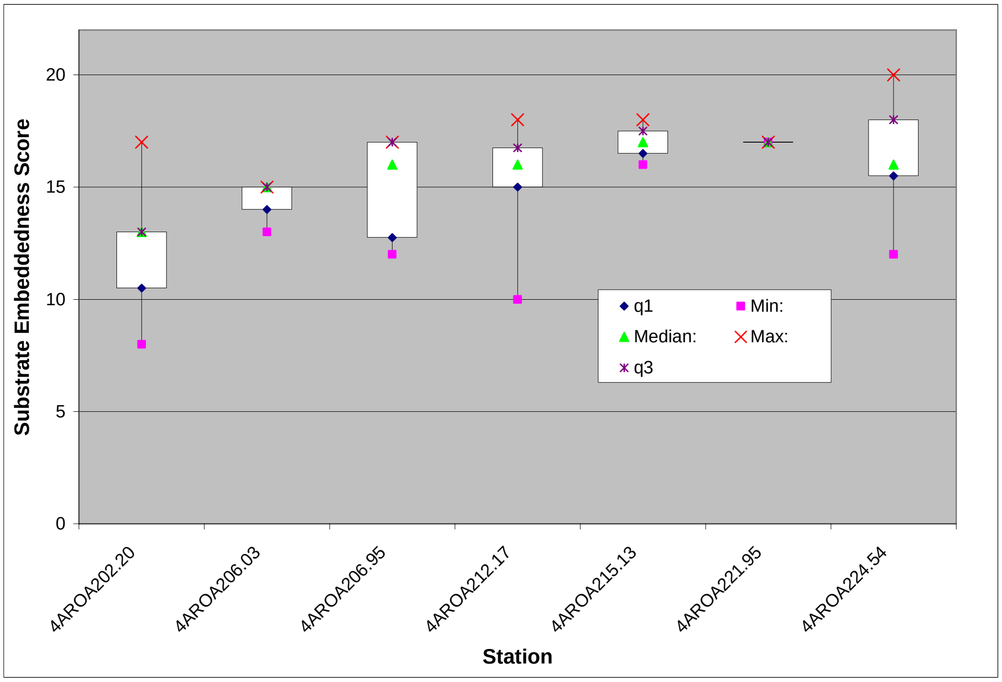


Figure B-2: Channel Alteration Scores for Roanoke River Monitoring Stations

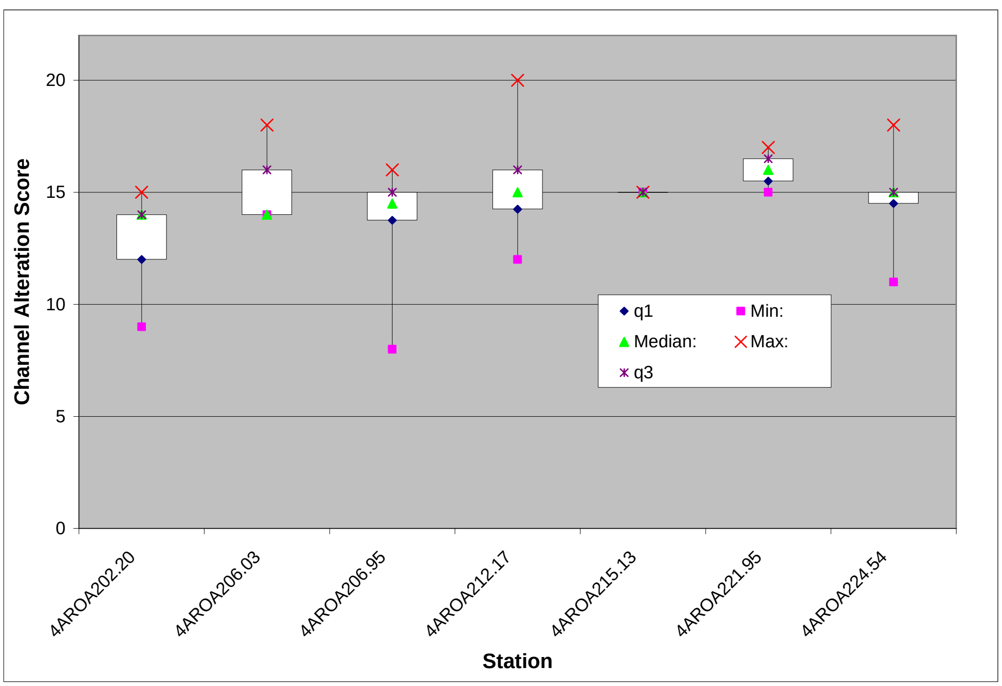


Figure B-3: Bank Stability Scores for Roanoke River Monitoring Stations

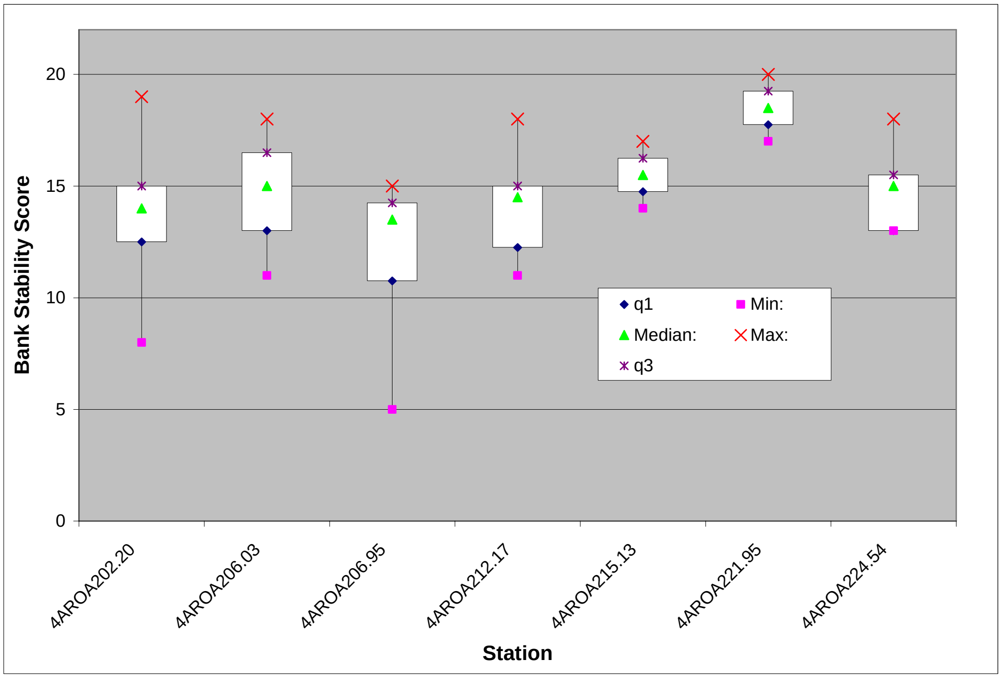


Figure B-4: Bank Vegetation Scores for Roanoke River Monitoring Stations

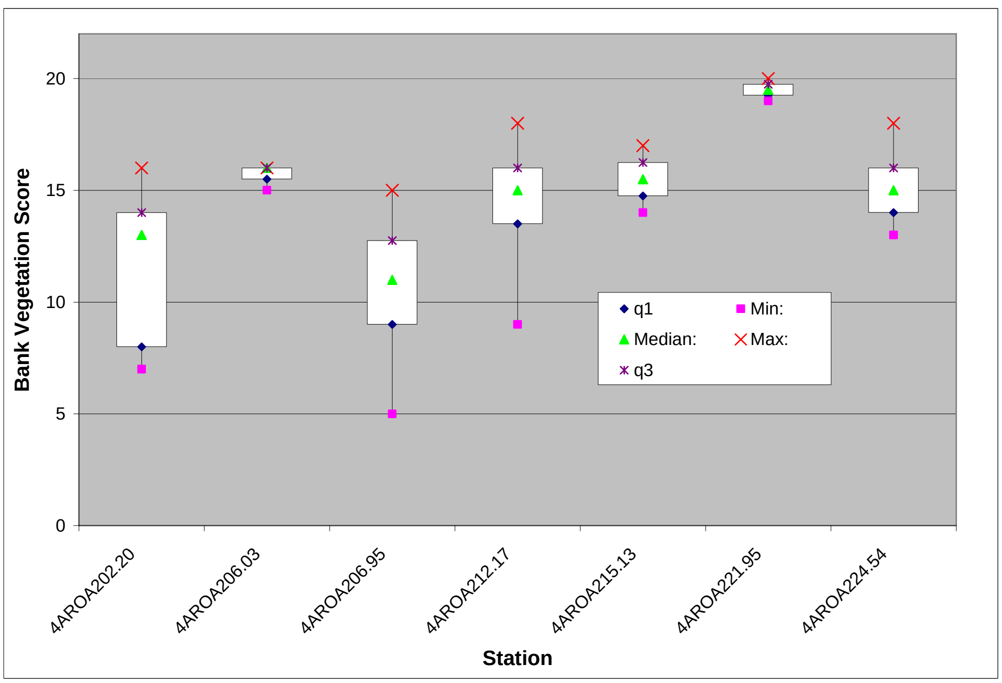


Figure B-5: Channel Flow Scores for Roanoke River Monitoring Stations

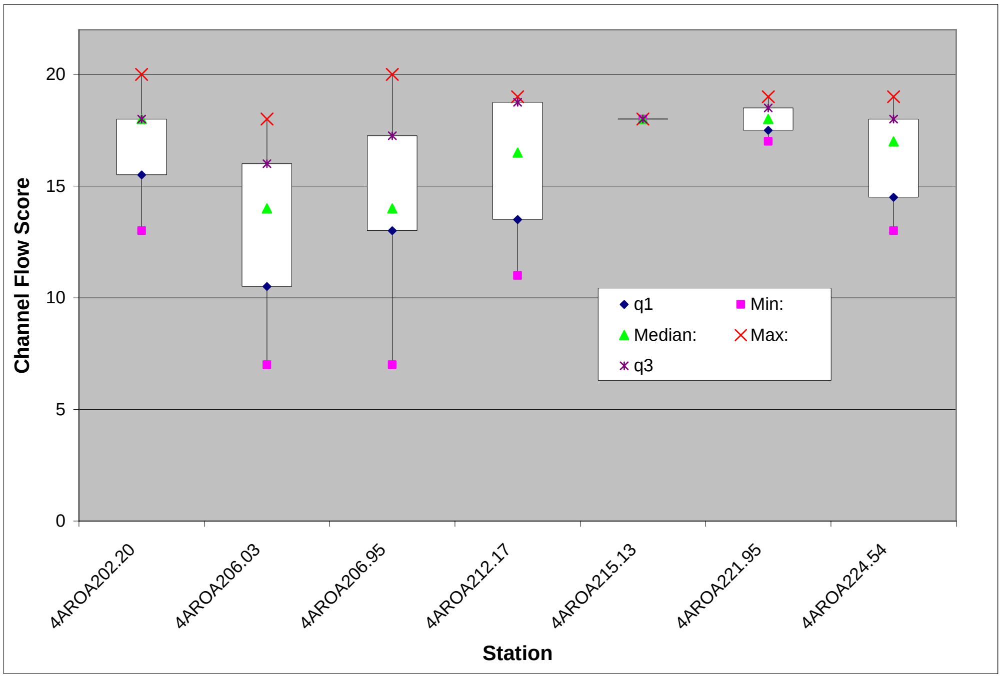


Figure B-6: Riffle Frequency Scores for Roanoke River Monitoring Stations

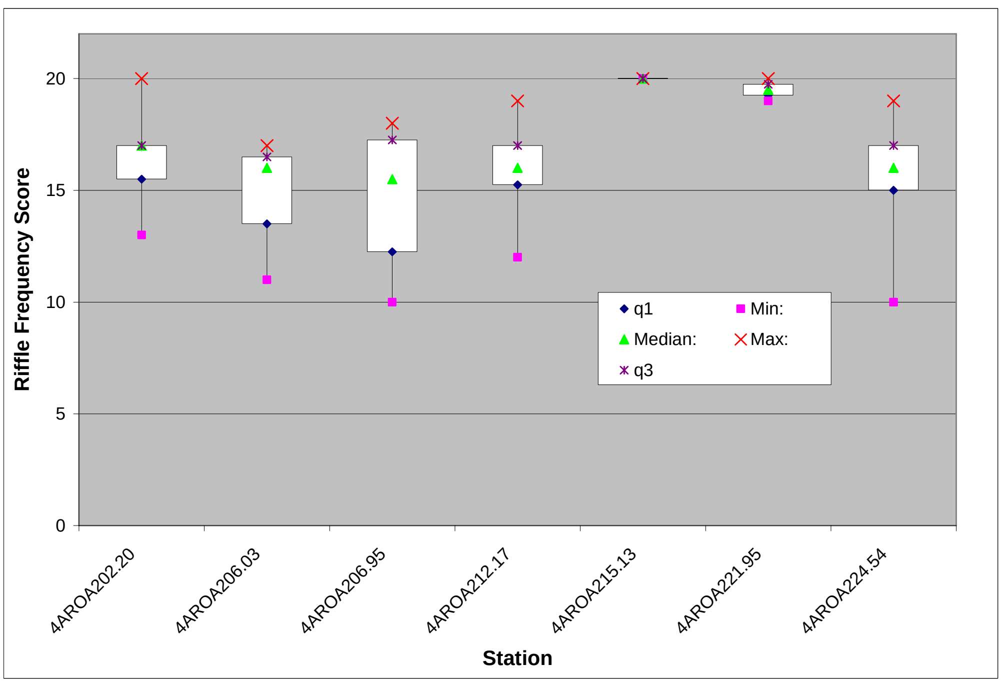


Figure B-7: Riparian Vegetative Zone Scores for Roanoke River Monitoring Stations

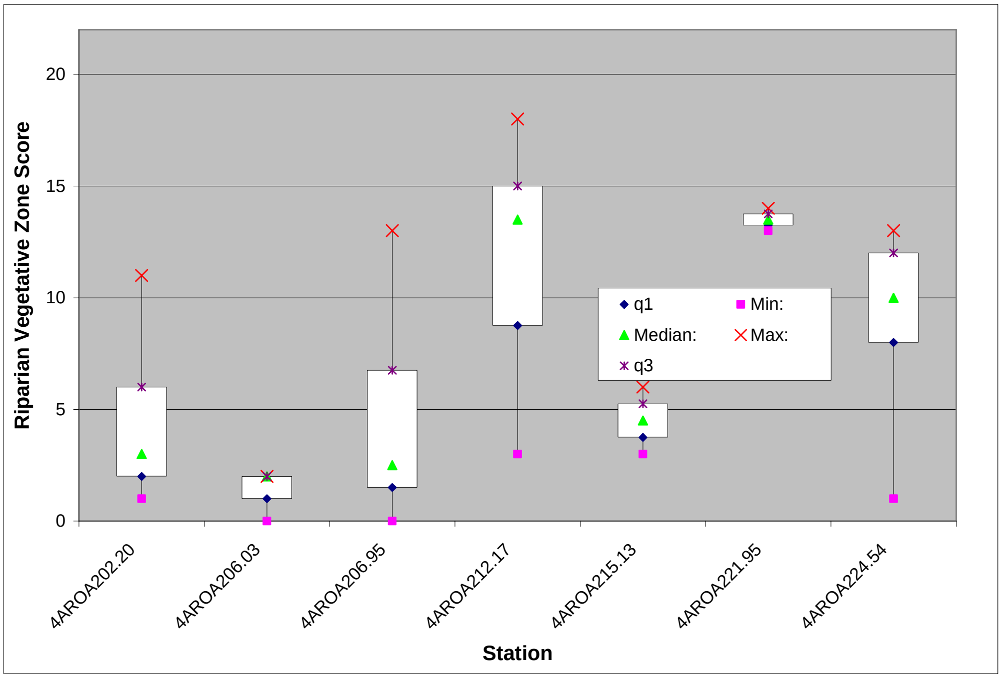


Figure B-8: Sedimentation Scores for Roanoke River Monitoring Stations

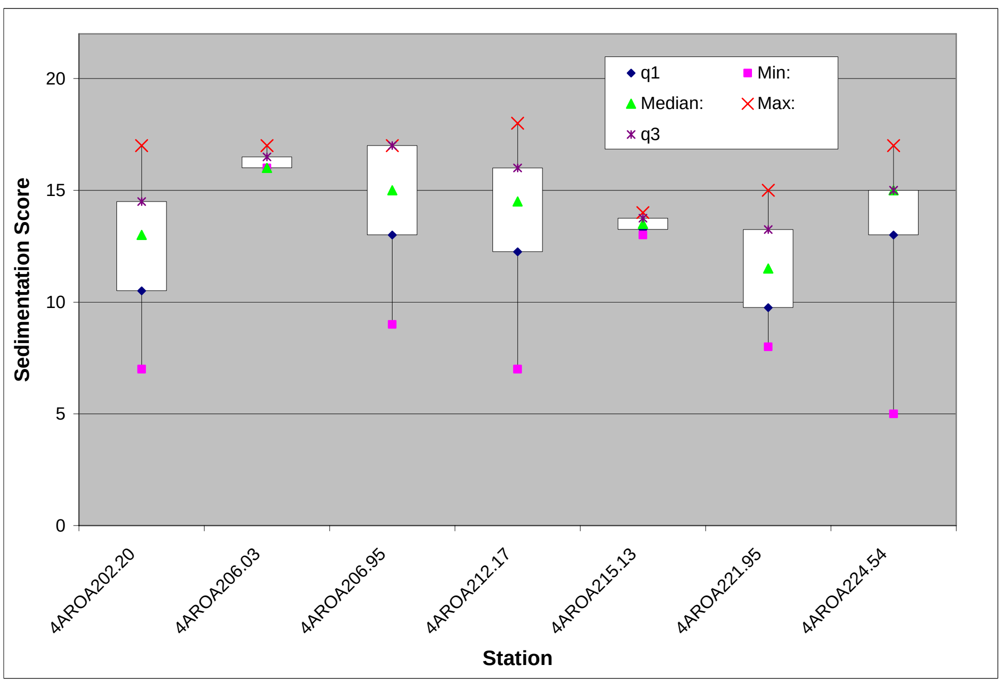


Figure B-9: Channel Velocity Scores for Roanoke River Monitoring Stations

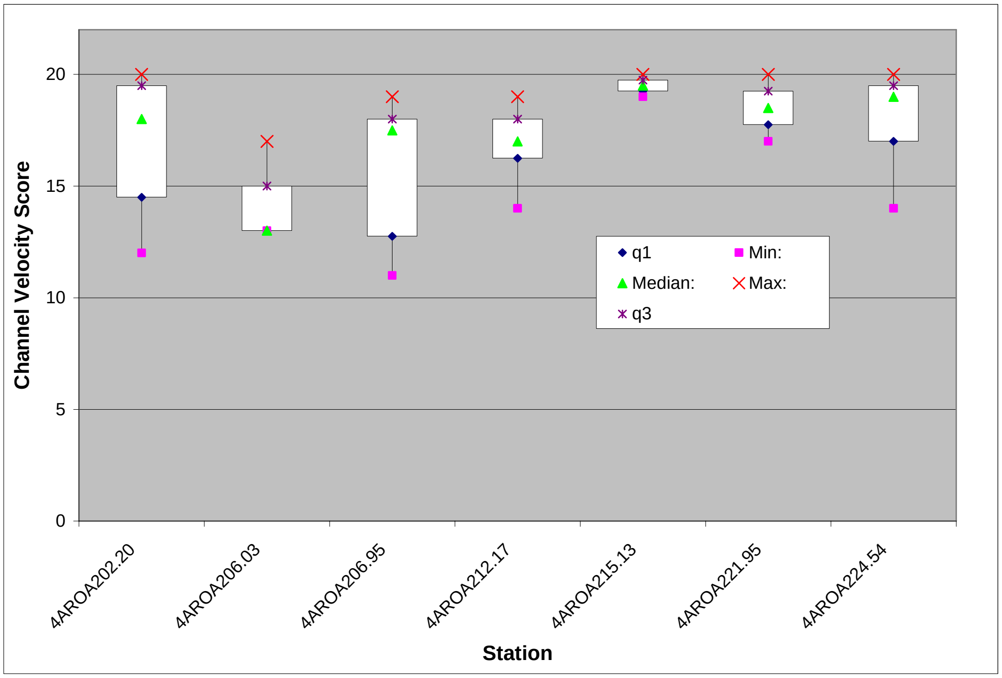
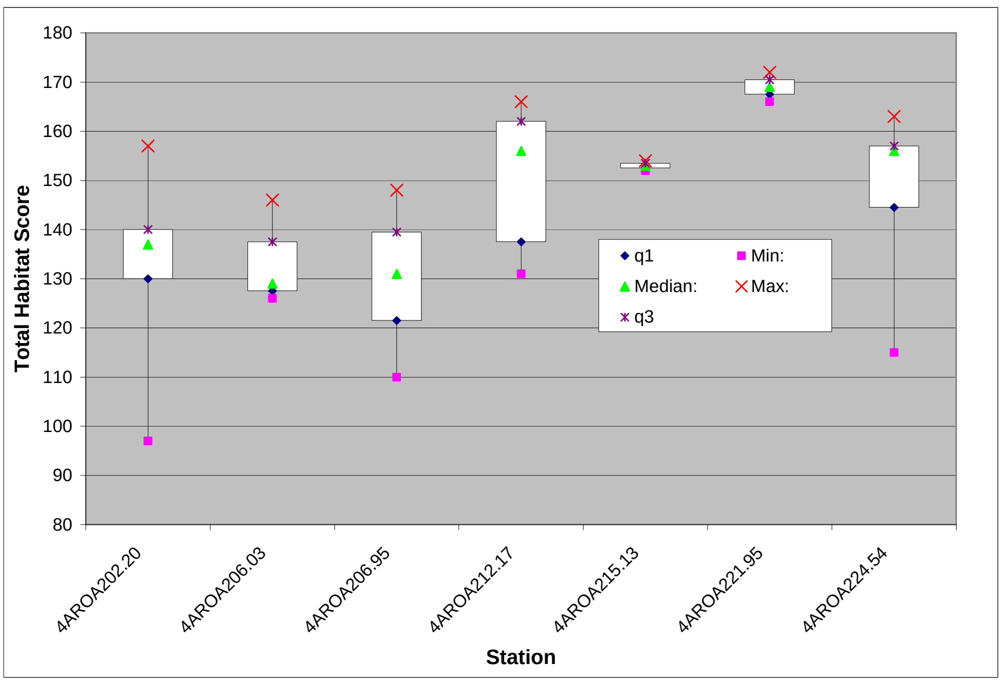


Figure B-10: Total Habitat Scores for Roanoke River Monitoring Stations



APPENDIX C: Permitted Discharge Limits for Facilities Holding Individual Permits

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
Associated Asphalt Inc	VA0001252	Minor	Industrial	0.054	1	Carbon, Total Organic	*********	*********	*********	110
						Flow	NL	NL	*********	*********
						Petroleum Hydrocarbons, Total Recoverable	*********	*********	30	*********
						pH	*********	*********	*********	9.5
						TSS	*********	*********	*********	NL
Koppers Inc	VA0001333	Minor	Industrial	0.6	1	Acenaphthene	********	********	*********	NL
						Acenaphthylene	********	********	*********	NL
						Anthracene (As C6H4(CH)2C6H4)	********	********	*********	NL
						Benzo(A)Anthracene	********	********	*********	NL
						Benzo(A)Pyrene	********	********	*********	NL
						Benzo(B)Fluoranthene	********	********	*********	NL
						Benzo(K)Fluoranthene	********	********	*********	NL
						Chrysene, Total	********	********	*********	NL
						COD	*********	*********	*********	NL
						Dibenz(A,H)Anthracene	********	********	*********	NL
						Flow	*********	NL	*********	*********
						Fluoranthene	********	********	*********	NL
						Fluorene (As F)	********	********	*********	NL
						Hardness, Total (As CaCO3)	********	********	*********	NL
						Indeno(1,2,3-Cd)Pyrene	********	********	*********	NL

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra- tion Avg.	Concentra- tion Max.
						Iron, Total Recoverable	********	********	*********	NL
						Naphthalene (As C10H8)	********	********	*********	NL
						Oil & Grease	*********	*********	*********	NL
						pH	*********	*********	*********	9.5
						Phenanthrene	********	********	*********	NL
						Pyrene (As C16H10)	********	********	*********	NL
						TSS	*********	*********	*********	NL
						Zinc, Total Recoverable	********	********	*********	NL
					2	Acenaphthene	********	********	*********	NL
						Acenaphthylene	********	********	*********	NL
						Anthracene (As C6H4(CH)2C6H4)	********	********	*********	NL
						Benzo(A)Anthracene	********	********	*********	NL
						Benzo(A)Pyrene	********	********	*********	NL
						Benzo(B)Fluoranthene	********	********	*********	NL
						Benzo(K)Fluoranthene	********	********	*********	NL
						Chrysene, Total	********	********	*********	NL
						COD	*********	*********	*********	NL
						Dibenz(A,H)Anthracene	********	********	*********	NL
						Flow	*********	NL	*********	*********
						Fluoranthene	********	********	*********	NL
						Fluorene (As F)	********	********	*********	NL
						Hardness, Total (As CaCO3)	********	********	*********	NL
						Indeno(1,2,3-Cd)Pyrene	********	********	*********	NL
						Lead, Total Recoverable	********	********	*********	NL
						Naphthalene (As C10h8)	********	********	*********	NL

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
						Oil & Grease	*********	*********	*********	NL
						Ph	*********	*********	*********	9.5
						Phenanthrene	********	********	*********	NL
						Pyrene (As C16h10)	********	********	*********	NL
						TSS	*********	*********	*********	NL
						Zinc, Total Recoverable	********	********	*********	NL
Roanoke City - Carvins Cove Water Filtration Plant	VA0001473	Minor	Industrial	0.474	1	CL2, Inst Res Max	********	********	0.004	0.004
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9.5
						TSS	*********	*********	30	60
					2	CL2, Inst Res Max	********	********	0.004	0.004
						Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9.5
						TSS	*********	*********	30	60
Roanoke Electric Steel (RES) Corporation	VA0001589	Major	Industrial	0.039	1	Aluminum, Total Recoverable	*********	*********	*********	NL
						Chromium, Hexavalent Dissolved	*********	*********	*********	NL
						COD	*********	*********	*********	NL
						Copper, Dissolved (ug/L As Cu)	*********	*********	*********	NL
						Flow, Precipitation Event	*********	NL	*********	*********
						pH	*********	*********	*********	NL
						TSS	*********	*********	*********	NL
						Zinc, Dissolved (ug/L As Zn)	*********	*********	*********	NL
					2	Aluminum, Total Recoverable	*********	*********	*********	NL
						Copper, Dissolved (ug/L As Cu)	*********	*********	*********	NL
						Flow, Precipitation Event	*********	NL	*********	*********

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra- tion Avg.	Concentra- tion Max.
						pH	*********	*********	*********	NL
						TSS	*********	*********	*********	NL
						Zinc, Dissolved (ug/L As Zn)	*********	*********	*********	NL
					3	Aluminum, Total Recoverable	*********	*********	*********	NL
						COD	*********	*********	*********	NL
						Copper, Dissolved (ug/L As Cu)	*********	*********	*********	NL
						Flow, Precipitation Event	*********	NL	*********	*********
						Lead, Dissolved	*********	*********	*********	NL
						pH	*********	*********	*********	NL
						TSS	*********	*********	*********	NL
						Zinc, Dissolved (ug/L As Zn)	*********	*********	*********	NL
					4	Aluminum, Total Recoverable	*********	*********	*********	NL
						COD	*********	*********	*********	NL
						Flow, Precipitation Event	*********	NL	*********	*********
						pH	*********	*********	*********	NL
						TSS	*********	*********	*********	NL
					5	CL2, Total	NL	NL	53	108
						Copper, Total Recoverable	NL	NL	80.8	99.4
						Flow	NL	NL	*********	*********
						Lead, Total Recoverable	NL	NL	72.9	89.6
						Oil & Grease	55	165	NL	NL
						pH	*********	*********	*********	9
						pH, Individual Excursion Time	********	60	*********	*********
						pH, Total Excursion Time	*********	446	*********	*********
						Temperature, Water (Deg. C)	*********	*********	*********	31

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
						TSS	231	633	NL	NL
						Zinc, Total Recoverable	NL	NL	340	418
Norfolk Southern Railway Co - Shaffers Crossing	VA0001597	Minor	Industrial	0.05	2	Carbon, Total Organic	*********	*********	*********	110
						Copper, Total Recoverable	********	********	29	29
						Flow	NL	NL	*********	*********
						Oil & Grease	*********	*********	10	15
						Petroleum Hydrocarbons, Total Recoverable	*********	*********	NL	NL
						pH	*********	*********	*********	9
						TSS	*********	*********	30	60
					5	Flow, Precipitation Event	*********	NL	*********	*********
						Nitrite+Nitrate-N,Total	*********	*********	*********	NL
						pH	*********	*********	*********	9
					902	Copper, Dissolved (ug/L As Cu)	*********	*********	*********	NL
						Flow, Precipitation Event	*********	NL	*********	*********
						Nitrite+Nitrate-N,Total	*********	*********	*********	NL
						pH	*********	*********	*********	9
						Phosphorus, Total (As P)	*********	*********	*********	NL
						TSS	*********	*********	*********	60
Shawsville Town - Sewage Treatment Plant	VA0024031	Minor	Municipal	0.2	1	Ammonia, As N Jan-May	7.6	7.6	10.1	10.1
						BOD5	22.7	34	30	45
						Coliform, Fecal	*********	*********	200	*********
						DO	*********	*********	*********	*********
						E.Coli	********	********	126	*********
						Flow	0.2	NL	*********	*********
						pH	*********	*********	*********	9

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
						Phosphorus, Total (As P)	0.8	1.1	1	1.5
						TSS	22.7	34	30	45
					SF1	Cation Exchange Capacity (Meq/100g)	*********	*********	NL	*********
						Magnesium, Exchangeable (mg/kg)	*********	*********	NL	*********
						pH	*********	*********	*********	NL
						Phosphorus, Available (mg/kg)	*********	*********	NL	*********
						Potassium, Exchangeable (mg/kg)	*********	*********	NL	*********
					SO1	Alkalinity, Sludge As %	*********	*********	NL	*********
						Ammonium-N, Sludge Dry Weight (mg/kg)	*********	*********	NL	*********
						Arsenic, Sludge	*********	*********	41	75
						Cadmium, Sludge	*********	*********	39	85
						Copper, Sludge	*********	*********	1500	4300
						Description Of Pathogen Option Used	*********	*********	*********	*********
						Lead, Sludge	*********	*********	300	840
						Level Of Pathogen Requirements Achieved	*********	*********	*********	*********
						Mercury, Sludge	*********	*********	17	57
						Molybdenum, Sludge	*********	*********	NL	75
						Nickel, Sludge	*********	*********	420	420
						Nitrate, Total, Sludge As N	*********	*********	NL	*********
						pH, Sludge	*********	*********	*********	NL
						Phosphorus, Total Sludge	*********	*********	NL	*********
						Plant Available Nitrogen	*********	*********	NL	*********
						Potassium, Total Sludge	*********	*********	NL	*********
						Selenium, Sludge	*********	*********	100	100
						Solids, Total, Sludge As Percent	*********	*********	NL	*********

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
						TKN, Sludge, Dry Weight (mg/kg)	*********	*********	NL	*********
						Vector Attraction Reduction Option Used	*********	*********	*********	*********
						Zinc, Sludge	*********	*********	2800	7500
					SP1	Annual Amt Sludge Disposed By Other Mthd	*********	NL	*********	*********
						Annual Amt Sludge Disposed In Landfill	*********	NL	*********	*********
						Annual Amt Sludge Disposed Surface Unit	*********	NL	*********	*********
						Annual Amt Sludge Incinerated	*********	NL	*********	*********
						Annual Amt Sludge Land Applied	*********	NL	*********	*********
						Annual Sludge Production Total	*********	NL	*********	*********
Roanoke City Regional Water Pollution Control Plan	VA0025020	Major	Municipal	42	1	BOD5	795	1192	5	7.5
						Chromium, Hexavalent Dissolved	*********	*********	7.7	9.5
						CL2, Total	*********	*********	0.0031	0.0039
						CL2, Total Contact	*********	*********	*********	*********
						Cyanide, Total (As Cn)	*********	*********	8.1	10
						DO	*********	*********	*********	*********
						E.Coli	*********	*********	126	*********
						Flow	42	NL	*********	*********
						Mercury, Total Recoverable	*********	*********	0.014	0.018
						Nickel, Total Recoverable	*********	*********	29	36
						pH	*********	*********	*********	9
						Phosphorus, Total (As P)	32	48	0.2	0.3
						Selenium, Total Recoverable	********	********	5.1	6.2
						TKN, Apr-Sep	318	477	2	3
						TKN, Oct-Mar	636	795	4	5
						TSS	397	795	2.5	5

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
					SO1	Arsenic, Sludge	********	41	NL	75
						Cadmium, Sludge	********	39	NL	85
						Copper, Sludge	********	1500	NL	4300
						Description Of Pathogen Option Used	********	********	*********	NL
						Lead, Sludge	********	300	NL	840
						Level Of Pathogen Requirements Achieved	********	********	*********	NL
						Mercury, Sludge	********	17	NL	57
						Molybdenum, Sludge	********	********	NL	75
						Nickel, Sludge	********	420	NL	420
						Selenium, Sludge	********	100	NL	100
						Solids, Total, Sludge As Percent	********	********	NL	*********
						Vector Attraction Reduction Option Used	********	********	*********	NL
						Zinc, Sludge	********	2800	NL	7500
					SP1	Annual Amt Sludge Disposed By Other Mthd	********	NL	*********	*********
						Annual Amt Sludge Disposed In Landfill	********	NL	*********	*********
						Annual Amt Sludge Disposed Surface Unit	********	NL	*********	*********
						Annual Amt Sludge Incinerated	********	NL	*********	*********
						Annual Amt Sludge Land Applied	********	NL	*********	*********
						Annual Sludge Production Total	********	NL	*********	*********
Blacksburg Country Club Sewage Treatment Plant	VA0027481	Minor	Municipal	0.035	1	BOD5	3.9	5.9	30	45
						CL2, Inst Tech Min Limit	*********	*********	*********	*********
						CL2, Total	********	********	0.41	0.5
						CL2, Total Contact	*********	*********	*********	*********
						Flow	0.035	NL	*********	*********

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
						pH	*********	*********	*********	9
						TSS	3.9	5.9	30	45
Montgomery County PSA - Elliston-Lafayette WWTP	VA0062219	Minor	Municipal	0.25	1	BOD5	28	43	30	45
						CL2, Inst Tech Min Limit	*********	*********	*********	*********
						CL2, Total	*********	*********	0.099	0.1
						CL2, Total Contact	*********	*********	*********	*********
						DO	*********	*********	*********	*********
						Flow	0.25	NL	*********	*********
						pH	*********	*********	*********	9
						Phosphorus, Total (As P)	1.9	*********	2	*********
						TSS	28	43	30	45
Roanoke Moose Lodge	VA0077895	Minor	Municipal	0.0047	1	BOD5	0.24	0.37	14	21
						BOD5	0.53	0.8	30	45
						CL2, Inst Tech Min Limit	*********	*********	*********	*********
						CL2, Total	*********	*********	0.07	0.09
						CL2, Total Contact	*********	*********	*********	*********
						DO	*********	*********	*********	*********
						Flow	0.0047	NL	*********	*********
						pH	*********	*********	*********	9
						TKN (N-Kjel)	0.09	0.14	5.5	8.2
						TSS	0.53	0.8	30	45
Fred Whitaker Co	VA0088358	Minor	Industrial	0.151	1	Flow	NL	NL	*********	*********
						Temperature, Water (Deg. C)	*********	*********	*********	31
Federal Mogul Corp -	VA0089991	Minor	Industrial	0.065	1	Flow	NL	NL	*********	*********
						pH	*********	*********	*********	9.5

Facility Name	Permit No.	Major/ Minor	Municipal/ Industrial	Design Flow	Outfall No.	Parameter Description	Quantity Average	Quantity Maximum	Concentra-tion Avg.	Concentra-tion Max.
Blacksburg						Trichloroethylene (TCE) (790106)	*********	*********	5	5
Crystal Springs WTP	VA0091065	Minor	Industrial	0.092	1	Flow	NL	NL	*********	*********
						pH	********	********	*********	9.5
						TSS	********	********	30	60

APPENDIX D: General Permit & Individual Permit Stormwater TMDL Allocations

The TSS allocation for each permitted facility was calculated using a DEQ assigned TSS concentration and the corresponding runoff amount generated on the site based on the facility area or the facility discharge. The TSS allocated load for each permit type was calculated as follows:

- For individual permitted facilities, the allocated load was calculated based on a TSS concentration of 100 mg/L, the facility area, and 72.54 cm of runoff per year. The annual average runoff of 72.54 cm corresponds to an annual average rainfall of 40.8 inches (103.63 cm) and an industrial land cover with 70 percent imperviousness.
- For general stormwater permits issued to industrial facilities, the allocated load was calculated based on a TSS concentration of 100 mg/L, the facility area, and 72.54 cm of runoff per year.
- For general permits issued to domestic sewage facilities, the allocated load was calculated based on a TSS concentration of 30 mg/L and a flow value of 1,000 gallons per day.
- For general permits issued to mines, the allocated load was calculated based on a TSS concentration of 30 mg/L, the facility area, and 45.9 cm of runoff per year.
- For general permits issued to concrete facilities, the allocated load was calculated based on a TSS concentration of 30 mg/L, the facility area, and 72.54 cm of runoff per year.
- For general stormwater permits issued to carwashes, the allocated load was calculated based on a TSS concentration of 60 mg/L, the facility area, and 72.54 cm of runoff per year.
- For general stormwater permits issued to construction sites, the total allocated load was calculated based on a per acre loading unit of 10.97 metric tons of sediment per hectare, the disturbed construction area, and a sediment delivery ratio of 0.136. Table D-7 depicts the combined sediment load from all construction sites based on an average annual disturbed area of 467 acres. The average annual acreage of 467 acres was derived using information from the VADEQ Comprehensive Environmental Database System (CEDS) database for the period of 2002 to 2004.

Table D-1: Stormwater TMDL Allocations for Individual Permitted Facilities

Permit Number	Facility	TSS Stormwater Allocation (tons/yr)
VA0001252	Associated Asphalt Inc.	2.78
VA0001333	Koppers Inc.	18.24
VA0001589	Roanoke Electric Steel Corp.	56.55
VA0001511	Norfolk Southern Railway Co - East End Shops	35.70
VA0001597	Norfolk Southern Railway Co. - Shaffers Crossing	28.83
VA0025020	Western Virginia Water Authority	34.17
VA0088358	Fred Whitaker Co.	0.97
VA0089991	Federal Mogul Corp.	12.30

Table D-2: TMDL Allocations for General Stormwater Permits Issued to Industrial Facilities

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAR050027	Auto Salvage & Sales, Inc.	Tinker Creek	Roanoke City	0.53
VAR050134	Greater Roanoke Transit Company	Lick Run	Roanoke City	0.81
VAR050135	Virginia Scrap Iron & Metal Company Inc	Roanoke River	Roanoke City	1.66
VAR050143	Virginia Scrap Iron & Metal Incorporated	Roanoke River	Roanoke City	1.66
VAR050144	North 11 Asphalt Plant - Roanoke	Carvins Creek	Roanoke City	27.43
VAR050145	Holland-Richards Vault Service	Mason Creek	Roanoke City	0.25
VAR050178	BFI Waste Systems LLC - Roanoke	Roanoke River	Roanoke City	0.63
VAR050207	1915 Plantation Rd LLC	Lick Run	Roanoke City	0.63
VAR050208	Walker Machine & Foundry Corp	Roanoke River	Roanoke City	2.40
VAR050272	Roanoke Regional Airport	Deer Creek	Roanoke City	179.22
VAR050273	Ralph Smith Inc Steel Fabrication	Roanoke River UT	Roanoke City	0.67
VAR050274	USPS Roanoke Vehicle Maintenance Service	Roanoke River	Roanoke City	3.56
VAR050275	Old Dominion Auto Salvage	Tinker Creek	Roanoke City	3.46
VAR050436	Norfolk Southern Corp - Roadway Material Yard	Roanoke River	Roanoke City	0.49
VAR050437	Estes Express Lines Incorporated	Roanoke River, UT	Roanoke City	2.33
VAR050460	Yellow Freight System Inc	Tinker Creek	Roanoke City	1.62
VAR050496	Federal Express Corp - ROAA Station	Lick Run	Roanoke City	1.69
VAR050516	Mennel Milling Company	Roanoke River	Roanoke City	0.32
VAR050519	FedEx Freight East, Inc.	UT to Lick Run	Roanoke City	1.73
VAR050520	O'Neal Steel Inc	Tinker Creek	Roanoke City	6.46
VAR050522	Progress Rail Services Corp - Roanoke	Roanoke River	Roanoke City	3.95

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAR050530	Shenandoah Auto Parts	Lick Run	Roanoke City	0.60
VAR050539	Kenan Transport Co	Tinker Creek, UT	Roanoke City	1.62
VAR050643	Akzo Nobel Coatings Inc	Roanoke River	Roanoke City	1.13
VAR050717	Cycle Systems Incorporated	Ore Branch	Roanoke City	1.77
VAR050743	Hanson Concrete Products Inc - Roanoke	Roanoke River	Roanoke City	0.77
VAR050757	Metalsa Roanoke Inc	Tinker Creek	Roanoke City	12.96
VAR050843	Estes Express Lines Inc - Roanoke	Tinker Creek	Roanoke City	0.99
VAR051315	A D Weddle Company Inc	Tinker Creek	Roanoke City	2.36
VAR051371	Roanoke Regional Water Pollution Control Plant	Roanoke River	Roanoke City	34.20
VAR051460	Dynax American Corporation	Cook Creek	Roanoke City	5.15
VAR051478	Precision Steel	Glade Creek UT	Roanoke City	1.69
VAR051480	J and J Asphalt Incorporated	UT, Roanoke River	Roanoke City	0.18
VAR051492	Virginia Transformer Corp	Glade Creek, UT	Roanoke City	2.89
VAR520005	Vishay Vitramon Inc	Tinker Creek	Roanoke City	7.10
VAR520131	Virginia DMA - OMS #10	Roanoke River	Roanoke City	0.92
VAR520200	Hancock Rack Systems	Roanoke River	Roanoke City	0.85
VAR051199	Pitt Ohio Express Roanoke Terminal - Plantation Rd	Tinker Creek	Roanoke City	0.92
VAR051262	Shorewood Packaging Corporation	Tinker Creek	Roanoke City	0.85
VAR050146	Hedge Metal Company Incorporated	Roanoke River	Salem City	0.11
VAR050148	Salem Frame Company	Mill Race to Roanoke River	Salem City	11.44
VAR050150	Graham White Manufacturing Company	Snyders Branch	Salem City	7.28
VAR050174	Carbone of America Corporation	Masons Creek	Salem City	2.54
VAR050175	General Electric Industrial Systems	Masons Creek	Salem City	24.40
VAR050176	John W Hancock Jr Incorporated	Roanoke River	Salem City	0.85
VAR050457	Waste Management of Virginia - Salem	Roanoke River, UT	Salem City	1.98
VAR050506	Timber Truss Housing Systems Inc	Roanoke River, UT	Salem City	19.13
VAR050515	Yokohama Tire Corp	Roanoke River, UT	Salem City	18.00
VAR050744	Hanson Concrete Products Inc Salem1	Roanoke River	Salem City	1.73
VAR050745	Hanson Concrete Products Inc Salem2	Roanoke River	Salem City	4.41
VAR050749	Valleydale Foods Incorporated	Roanoke River	Salem City	3.18

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAR050762	Novozymes Biologicals Inc	Unnamed ditch to Mason Creek	Salem City	0.56
VAR051227	Old Virginia Brick Co Inc - Salem	UT to Roanoke River	Salem City	5.26
VAR050179	CEI - Roanoke	Tinker Creek	Roanoke County	11.22
VAR050206	Con-Way Southern Express-NRO	Lick Run	Roanoke County	2.4
VAR050462	Southern States Cooperative Inc - Vinton Feed Mill	Tinker Creek	Roanoke County	0.39
VAR050547	ITT Industries - Night Vision	Carvin Creek	Roanoke County	3.60
VAR050747	Parts Unlimited	Tinker Creek	Roanoke County	1.70
VAR050775	Star City Auto Parts Inc	Roanoke River	Roanoke County	0.35
VAR050011	Architectural Concrete Products Incorporated	Tinker Creek	Botetourt County	0.49
VAR050142	Southern States Cooperative Inc Cloverdale	Tinker Creek	Botetourt County	12.00
VAR050204	Eagle Picher Wolverine Gasket Division Cedar Run	Cedar Run UT	Montgomery County	4.41
VAR050340	Eagle Picher Wolverine Gasket Division Blacksburg	Cedar Run	Montgomery County	4.13
VAR051352	MRSWA Solid Waste Transfer Station MRF	Wilson Creek	Montgomery County	44.20
VAR050147	Rowe Furniture Corporation	Roanoke River	Outside MS4	12.21
VAR050180	Hooker Furniture Corporation - Roanoke	Tinker Creek	Outside MS4	11.00
VAR050220	Blue Ridge Stone - Portable Rip Rap Plant	Glade Creek	Outside MS4	4.97
VAR050251	Federal Mogul Corp - Blacksburg	Cedar Run Creek	Outside MS4	12.28
VAR050337	Sewell Products Inc	Mill Race	Outside MS4	1.27
VAR050448	United Parcel Service Inc - Roanoke	Lick Run	Outside MS4	15.07
VAR050461	L H Sawyer Paving Co Inc	Roanoke River	Outside MS4	0.60
VAR050507	Watkins Motor Lines - Roanoke Terminal	Little Bear Creek	Outside MS4	0.71
VAR050526	RR Donnelley and Sons Company - Roanoke	Branch Creek	Outside MS4	43.63
VAR050741	Medeco Security Locks Inc	Roanoke River, UT	Outside MS4	9.64
VAR050760	VT - Virginia Tech Airport	Slate Branch, UT	Outside MS4	587.89
VAR051245	KIK Virginia Incorporated	Mill Race	Outside MS4	1.27
VAR050277	General Shale Products LLC Plant No 35 and 36	Glade Creek	Outside MS4	6.46

Table D-3: TMDL Allocations for General Permits Issued to Domestic Sewage Facilities

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAG402063	R W Bowers Commercial Development	Glade Creek Tributary	Botetourt County	0.05
VAG402059	R W Bowers Parcel No 6	Glade Creek Tributary	Botetourt County	0.05
VAG402061	R W Bowers Parcel No 7	Glade Creek Tributary	Botetourt County	0.05
VAG402004	Epstein, William Residence	North Fork Roanoke River UT	Outside MS4	0.05
VAG402041	Cabin Creek Antiques	Crush Run	Outside MS4	0.05
VAG402054	Halsey, Charles Residence	Wilson Creek	Outside MS4	0.05
VAG402062	Harold Shad Residence	Craft Branch to Toms Creek	Outside MS4	0.05
VAG402093	Hilton Residence James	UT to Womack Branch	Outside MS4	0.05
VAG402046	Lorton/Fowler Residence	Wilson Creek	Outside MS4	0.05
VAG402021	McMahan, Raymond Residence	Cedar Run Branch	Outside MS4	0.05
VAG402082	Phillips and Lytton	Plum Creek	Outside MS4	0.05
VAG402091	Pierce Kenneth R Residence	UT to Flatwoods Branch	Outside MS4	0.05
VAG402020	Virginian Markette Inc	Mill Creek	Outside MS4	0.05
VAG402002	Bryant, Gary Residence	Mason Creek Tributary	Outside MS4	0.05
VAG402019	Hensley, Wendell Residence	Cedar Run	Outside MS4	0.05
VAG402003	Miller Robert Residence	Roanoke River North Fork UT	Outside MS4	0.05
VAG402012	Miller, Edith Residence	Gish Branch	Outside MS4	0.05

Table D-4: TMDL Allocations for General Permits Issued to Mines

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAG840067	Rockydale Quarries / Adams Asphalt Plant	Ore Branch, UT	Roanoke City	7.02
VAG842018	Boxley Materials Company	Healing springs, UT	Botetourt County	15.60
VAG842004	Acco Stone Co - Blacksburg	Mill Branch	Outside MS4	3.71
VAG840052	Sisson And Ryan Quarry	Spring Branch, UT	Outside MS4	6.42
VAG842008	Sisson And Ryan Quarry	Not applicable	Outside MS4	N/A
VAG840053	Acco Stone Co - Blacksburg	Wilson Creek, UT	Outside MS4	3.70
VAG840155	Highland Park Quarry	North Fork Roanoke River, UT	Outside MS4	2.26

Table D-5: TMDL Allocations for General Permits Issued to Concrete Facilities

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAG110125	Blue Ridge Ready Mix - Roanoke Plant	Barhardt Creek	Roanoke City	0.56
VAG110012	Chandler Concrete Of Va Inc Seventh St	Roanoke River	Roanoke City	0.07
VAG110018	Chandler Concrete Of Virginia Inc - Norfolk Avenue	Roanoke River	Roanoke City	0.035
VAG110013	Chandler Concrete of Virginia Inc - Plant 703	Tinker Creek	Roanoke City	0.21
VAG112014	Concrete Ready Mixed Corp - Roanoke	Roanoke River	Roanoke City	0.035
VAG112015	Concrete Ready Mixed Corp - Salem	Roanoke River	Salem City	0.07
VAG110026	Salem Ready Mix Concrete Inc	Paint Bank Branch	Salem City	0.11
VAG110025	Construction Materials Co Roanoke	Roanoke River	Montgomery County	0.11
VAG110169	Construction Materials Company - Blacksburg	UT Cedar Run	Montgomery County	5.05

Table D-6: TMDL Allocations for General Permits Issued to Carwashes

Permit Number	Facility	Receiving Waterbody	MS4 Area	TSS Allocation (tons/yr)
VAG750059	ProWash USA	Deer Branch, UT	Roanoke City	0.11

Table D-7: TMDL Allocation for General Stormwater Permits Issued to Construction Sites

Annual Average Disturbed Area (acres)	Total TSS Allocation (tons/yr)
467	311