Benthic TMDL Revision and Development for the Middle Fork Holston and Tributaries Located in Smyth, Washington, and Wythe Counties

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Acronyms

AllForX	All-Forest Load Multiplier
CADDIS	Causal Analysis Diagnosis Decision Information System
CBP	Chesapeake Bay Program
CREP	Conservation Reserve Enhancement Program
CV	Coefficient of Variation
EQIP	Environmental Quality Incentive Program
FWS	U.S Fish and Wildlife Service
GWLF	Generalized Watershed Loading Function
HSG	Hydrologic Soil Group
ISW	Industrial Stormwater
JMU	James Madison University
LA	Load Allocation
LTA	Long-Term Average
MDL	Maximum Daily Load
MOS	Margin of Safety
MRPDC	Mt. Rogers Planning District Commission
MS4	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
PWTP	Potable Water Treatment Plant
POC	Pollutant(s) of Concern
SCS-CN	Soil Conservation Service Curve Number
SSURGO	Soil Survey Geographic database
SWCB	State Water Control Board
SWCD	Soil and Water Conservation District
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
TSS	Total Suspended Sediment
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
VADEQ	Virginia Department of Environmental Quality
VDOT	Virginia Department of Transportation
VGIN	Virginia Geographic Information Network
VLCD	Virginia Land Cover Dataset
VPDES	Virginia Pollutant Discharge Elimination System
VSCI	Virginia Stream Condition Index
VSMP	Virginia Stormwater Management Program or Permit
WLA	Wasteload Allocation
WQMIRA	Water Quality Monitoring, Information and Restoration Act

1.0 EXECUTIVE SUMMARY

1.1. Background

This TMDL study covers the Middle Fork Holston and several tributaries (collectively referred to herein as MF Holston and Tribs), which are in Smyth, Washington, and Wythe Counties. Cedar Creek, Greenway Creek, Byers Creek, Hall Creek, and Tattle Branch are all located within Washington County and drain to the MF Holston. The headwaters of the MF Holston begin in Wythe County and the MF Holston then flows through Smyth County and Washington County. The MF Holston flows through the towns of Marion and Chilhowie and the Hutton Creek tributary flows through the town of Glade Springs to the MF Holston before entering the South Holston Lake. From there, the flow continues to the Holston River before joining the Tennessee River, followed by the Ohio River and then the Mississippi River, ultimately entering the Gulf of Mexico.

> Definition:
>
> Watershed – All of the land area that drains to a particular point or body of water.

Lengths of the Middle Fork Holston and several tributaries are listed as impaired on Virginia's 2020 Section 305(b)/303(d) Water Quality Assessment Integrated Report due to water quality violations of the general aquatic life (benthic) standard. The impaired segments addressed in this document are shown in **Table 1-1**. The watersheds of the impaired streams are show in **Figure 1-1**.

Table 1-1. Impaired segments addressed in this TMDL study.

TMDL Watershed	305(b) Segment ID	Cause Group Code 303(d) Impairment ID	Listing Station	Year Initially Listed
Byers/Hall Creek	VAS-O05R_BYS01A94 (0.49 mi) VAS-O05R_HAL01A94 (6.91 mi)	O05R-01-BEN	6CBYS000.08	2004
Cedar Creek	VAS-O05R_CED01A94 (5.61 mi)	O05R-01-BEN	6CCED000.14	2004
Greenway Creek	VAS-O05R_GRW01A02 (5.02 mi)	O05R-02-BEN	6CGRW002.31	2010
Tattle Branch	VAS-O05R_TAT01A02 (2.77 mi)	O05R-01-BEN	6CTAT000.50	2004
Middle Fork Holston	VAS-O03R_MFH05A04 (3.42 mi) VAS-O05R_MFH04A00 (9.19 mi) VAS-O05R_MFH05A04 (3.80 mi)	O03R-01-BEN, O05R-05-BEN, O05R-05-BEN	6CMFH055.88 6CMFH023.41 6CMFH011.31	2010, 2008, 2006

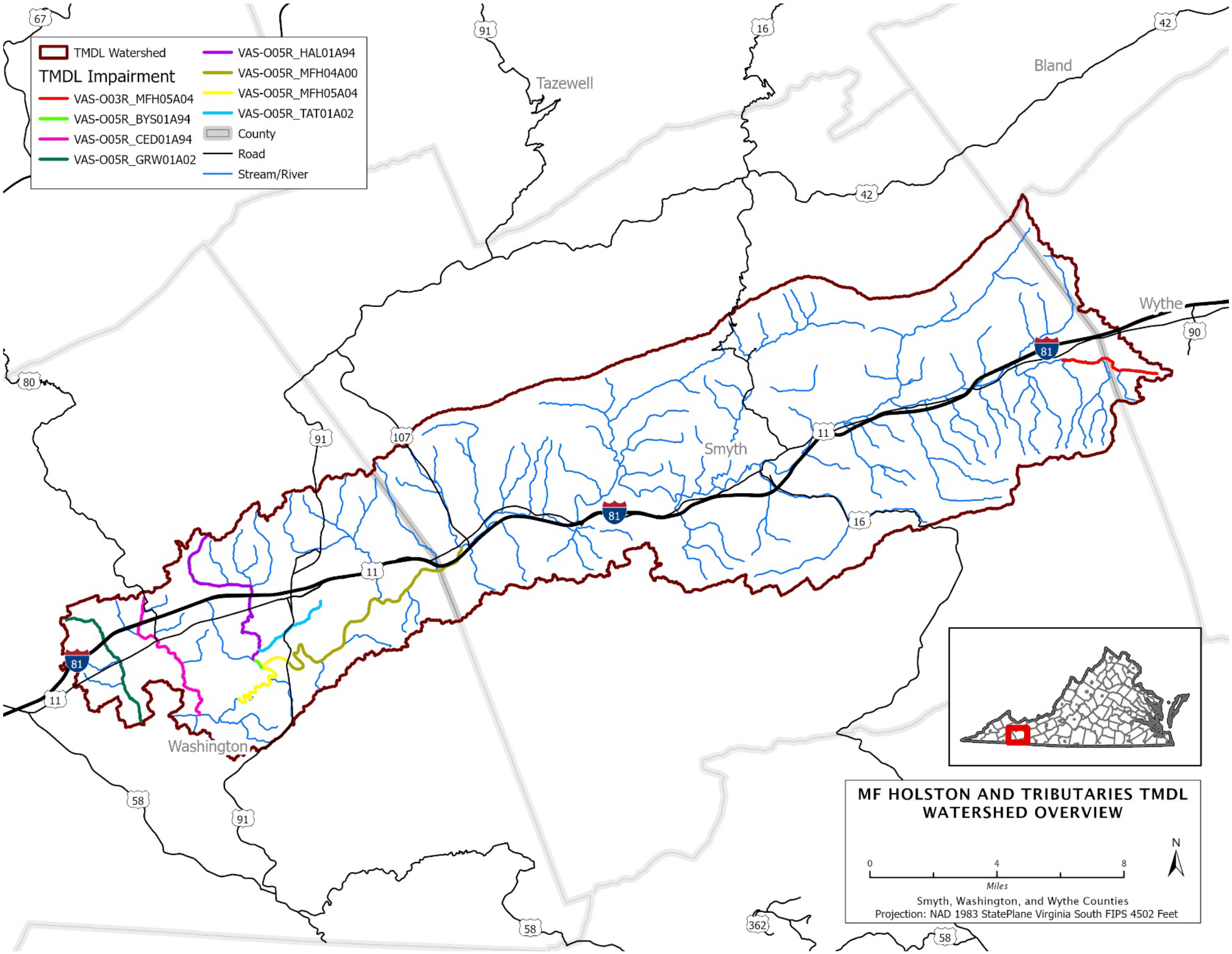

Figure 1-1. Location of the Middle Fork Holston and tributaries watersheds and impairments.

1.2. The Problem

1.2.1. Impaired Aquatic Life

The Commonwealth of Virginia establishes designated uses for all the waters in the state. Some of these uses include recreation, fishing, wildlife, and aquatic life. Water quality standards have been developed to ensure that some of these uses are met, while others are assessed using narrative criteria. One of those standards is the expectation that every stream will support a healthy and diverse community of bugs and fish (the aquatic life standard). The Virginia Department of Environmental Quality (VADEQ) determines whether this standard is met by monitoring the benthic macroinvertebrate community (bugs and worms that live on the bottom of the stream) in our waterways. The health and diversity of these bugs and worms are assessed using the Virginia Stream Condition Index (VSCI). The VSCI is a multimetric index used to derive stream health scores ranging from 0 to 100. Scores below 60 are categorized as impaired. **Figure 1-2** shows the various monitoring stations throughout the watershed, color-coded by the average score at each site. Red and yellow icons indicate that the streams do not support a healthy and diverse community of aquatic life. This shows that the various impaired streams in this study fail the aquatic life standard, and pollutants within the watershed need to be identified and reduced. At some monitoring stations (e.g. 6CGRW002.31 on Greenway Creek impairment VAS-O05R_GRW01A02), the average is just above the threshold of 60 and shown in green on **Figure 1-2**, but the segment remains impaired due to samples frequently reported below 60.

A benthic stressor analysis study was conducted in 2021 to determine the cause(s) of benthic impairments in the Middle Fork Holston and Tribs Watersheds (**Appendix D**). The study found that the primary stressor to aquatic life in each of the impaired streams was sediment. This correlates with the findings of previous stressor analyses which also determined sediment to be the most probable stressor in Cedar Creek, Hall/Byers Creek, and Hutton Creek (TetraTech, 2003) and in the Middle Fork Holston River (Engineering Concepts, Inc, 2009) in support of previous TMDL development efforts that are revised in this study (**Section 2.5**).

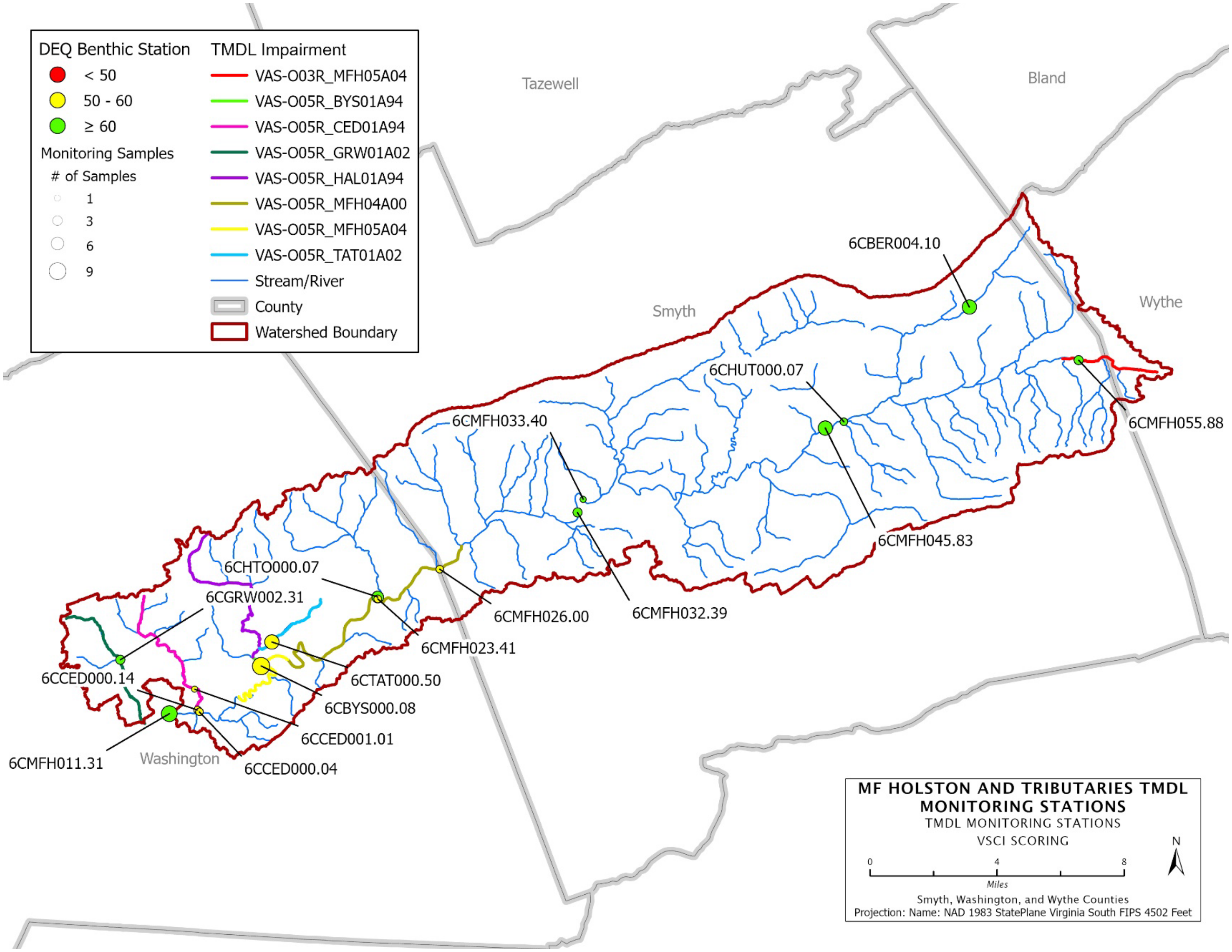

Figure 1-2. Average stream health score summaries in the Middle Fork Holston watersheds.

1.2.2. Too Much Sediment

Excess sediment was identified as the primary stressor in each of the MF Holston and Tribs watersheds. When it rains, sediment is washed off the land surface into nearby creeks and rivers. The amount of soil that is washed off depends upon how much it rains and the characteristics of the surrounding watershed. Rain falling on a construction site or highly tilled cropland without a cover crop may carry a large amount of sediment to a stream. Other land types, like forests and well-maintained pasture, contribute much less sediment to waterways during rainfall events. The presence of adequate streamside 'buffers' of healthy forest cover can serve to protect stream banks, provide shade, and filter pollutants such as sediment out of surface runoff before it reaches the stream. When that soil gets into nearby streams, it can destroy valuable habitat for aquatic macroinvertebrates that live underneath and between rocks and gravel on the bottom of the stream. Without this valuable habitat, the diversity of aquatic life in a stream may be severely limited.

1.3. The Study

To study the problem of excess sediment in the MF Holston and Tribs, a combination of monitoring and computer modeling was utilized. Monitoring was used to tell how much sediment is in the streams at any given time and how aquatic life conditions have changed over time. The computer model was used to estimate where the sediment is coming from and make predictions about how stream conditions would change if those sources were reduced.

> Frequently Asked Question:
>
> *Why use a computer model?*
> Sampling and testing tell you a lot about the present and the past, but nothing about the future. A computer model is a tool that can help you make predictions about the future. This is necessary to figure out how much effort is needed to clean up a stream.

For this purpose, a computer model called the Generalized Watershed Loading Function model (or GWLF) was used. This model considers the slope, soils, land cover, erodibility, and runoff to estimate the amount of soil eroded in the watershed and deposited in the stream. The model was calibrated against real-world flow measurements to ensure that it produced accurate results. The calibrated model was then used to estimate the sediment reductions that would be needed to completely restore a healthy aquatic life to the impaired streams in the watershed.

> Definition:
>
> TMDL – Total Maximum Daily Load. This is the amount of a pollutant that a stream can receive and still meet water quality standards. The term TMDL is also used more generally to describe the state's formal process for cleaning up polluted streams.

The modeling analysis (TMDL study) develops an equation that is called a Total Maximum Daily Load (TMDL) because it determines the maximum amount of a pollutant that can get into a certain stream without harming the stream or the creatures living in it. This TMDL report summarizes the TMDL study and sets goals for a clean-up plan.

1.4. Current Conditions

For this report, the Virginia Geographic Information Network (VGIN) 2016 Virginia Land Cover Dataset (VLCD) (VGIN, 2021) was used to represent the current land use with minor modifications (discussed in **Section 3.4**). The primary landcover in each watershed in this study is hay/pasture followed by forest/trees and urban/suburban development. Cropland is only a small percent of the land cover in each watershed. The land cover distribution for each impaired watershed is shown in **Figure 1-3** through **Figure 1-10**.

This land cover dataset combined with an accounting of the permitted discharges represent the major pollutant sources in the watershed. The GWLF model was used to figure out the relative contribution of sources of sediment in the impaired watersheds. **Figure 1-3** through **Figure 1-10** show the distribution of sediment contributions from various sources in the watersheds under what is called 'existing conditions' (approximating when the monitoring was done). The permitted sources in the watersheds include three Virginia Pollutant Discharge Elimination System (VPDES) individual permits, one potable water treatment plant general permit, two nonmetallic mineral mining general permits, one vehicle wash facility general permit, 13 domestic sewage general permits, 17 industrial stormwater general permits, and 18 active construction general permits in the Middle Fork Holston watersheds. The sediment loads from permitted sources were calculated based on the permit language, reported discharge data, and land cover type and area (detailed in **Section 4.3.2**). In the Upper MF Holston, Cedar Creek, Byers Creek, and Hall Creek the land cover is predominantly hay, pasture, and forest land and as such a significant amount of the sediment loads are derived from hay and pasture lands. Tattle Branch and Greenway Creek are predominantly hay/pasture and their sediment load is primarily from hay/pasture, but they also have a higher urban/suburban sediment contribution due to their higher level of urban/suburban land cover. In the Lower MF Holston watersheds, having a larger network of streams makes the stream bank and bed erosion a significant portion of its sediment load.

> Definition:
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> Point Source – pollution that comes out of a pipe (like at a sewage treatment plant).
> Nonpoint Source – pollution that does not come out of a pipe but comes generally from the landscape (usually as runoff).

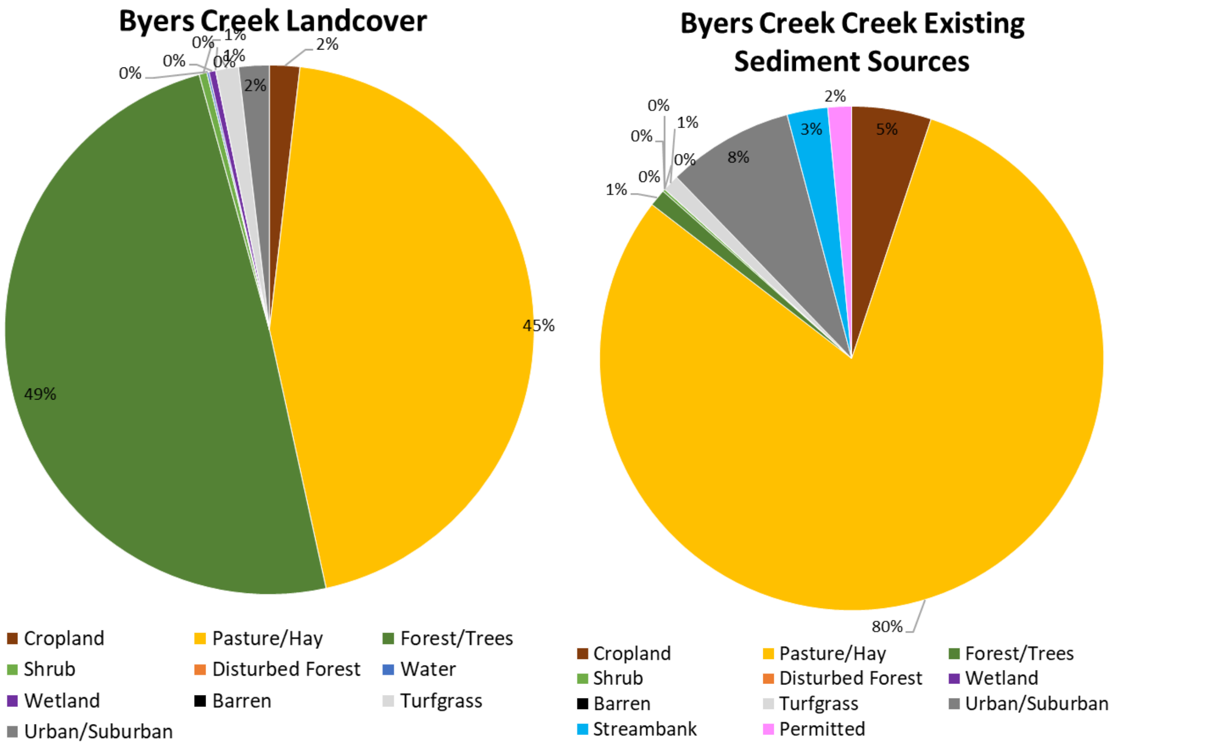

Figure 1-3. Land cover and existing source load distributions in the Byers Creek watershed (excluding Hall Creek and Tattle Branch watersheds).

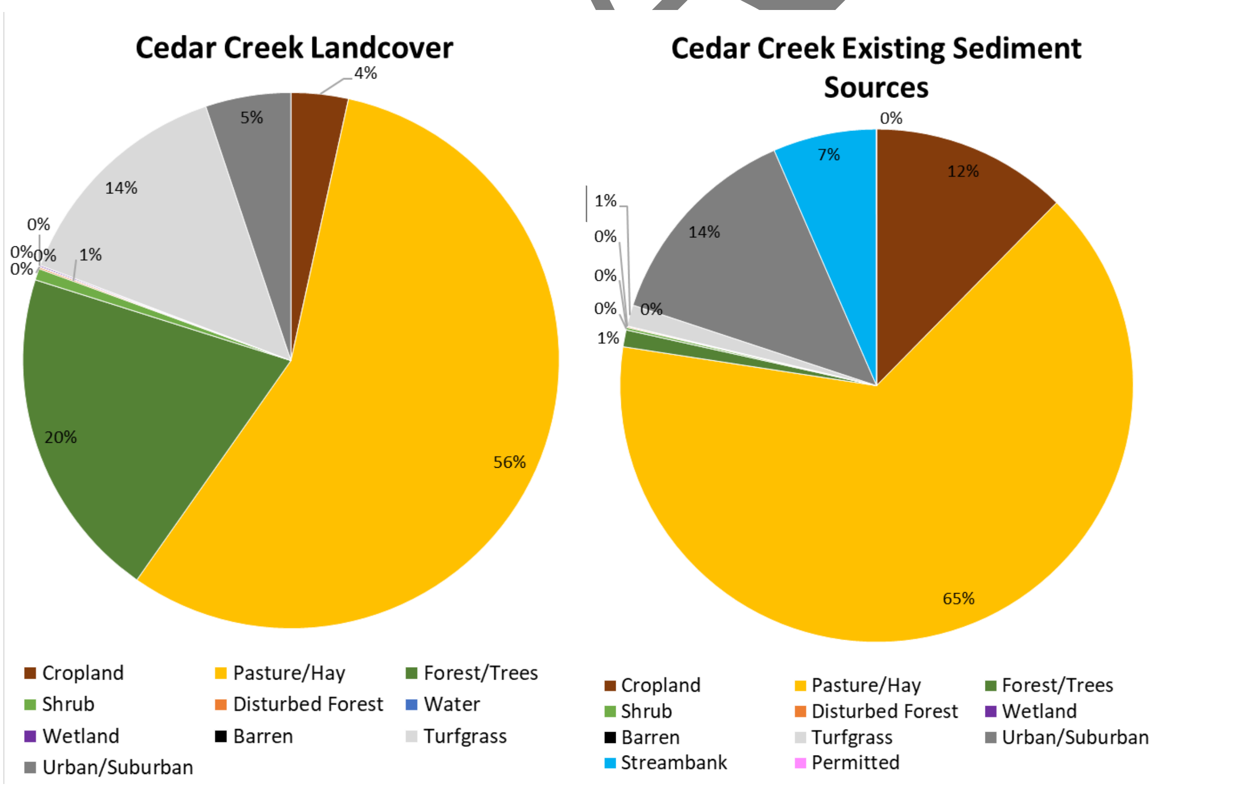

Figure 1-4. Land cover and existing source load distributions in the Cedar Creek watershed.

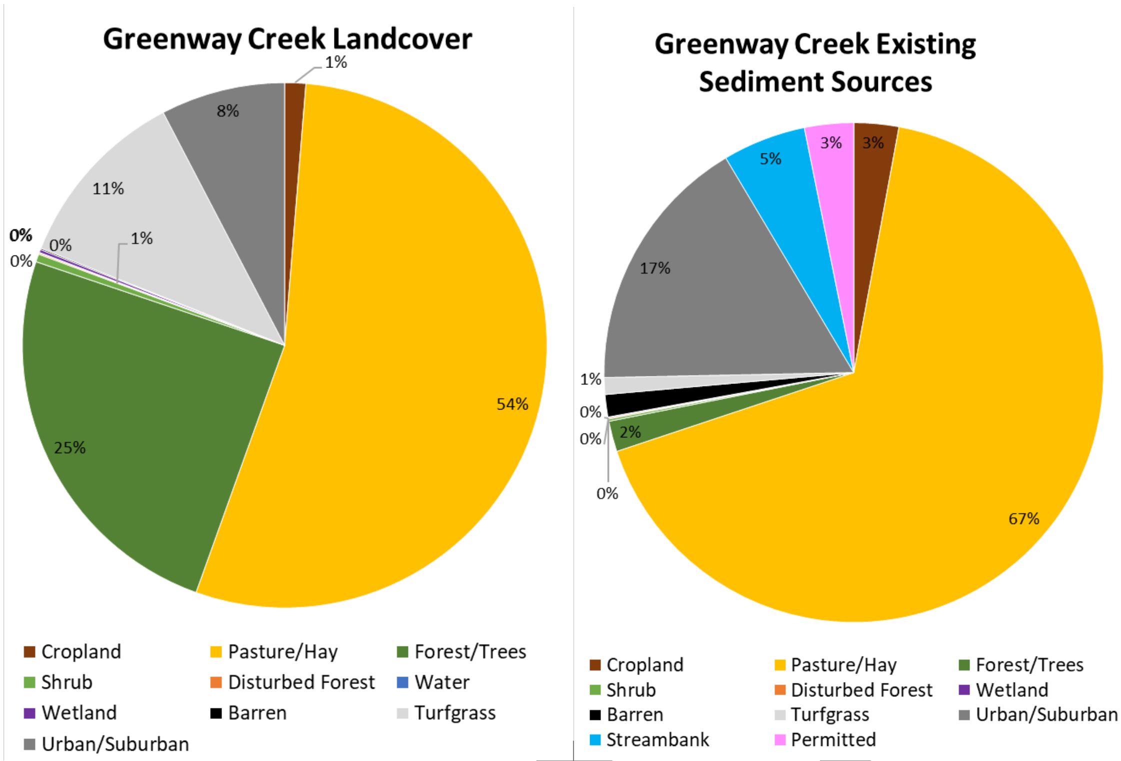

Figure 1-5. Land cover and existing source load distributions in the Greenway Creek watershed.

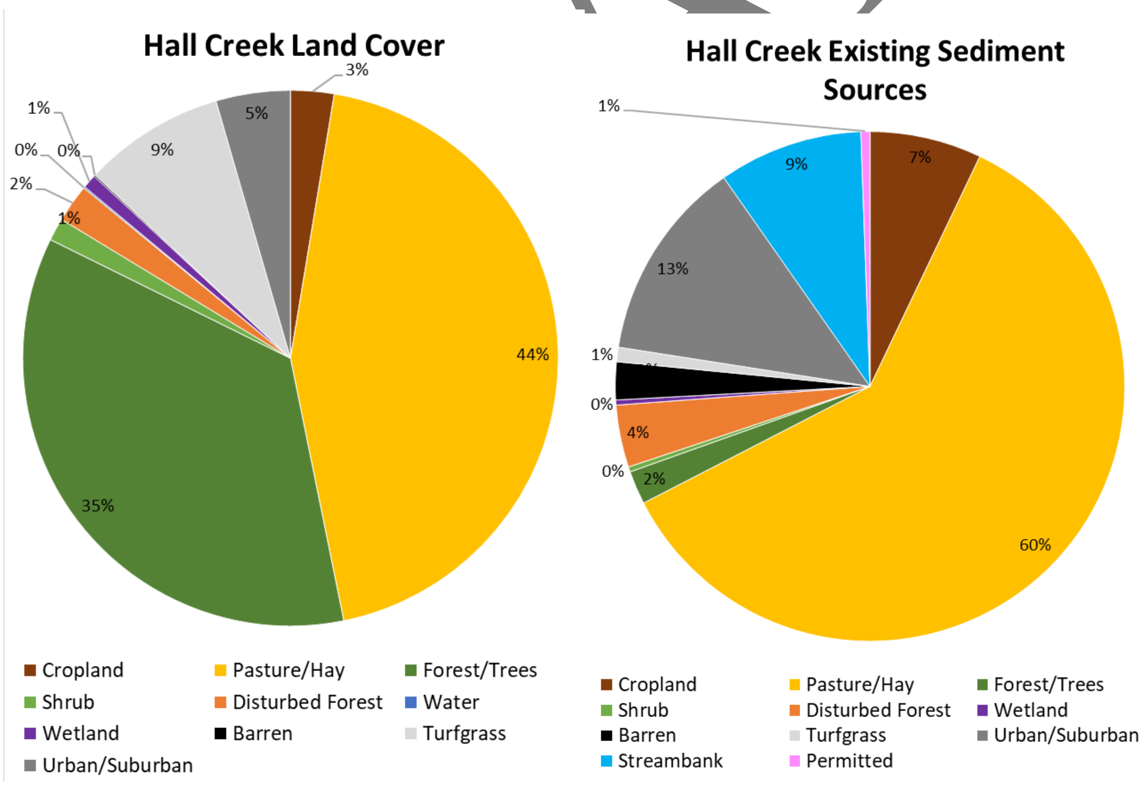

Figure 1-6. Land cover and existing source load distributions in the Hall Creek watershed (excluding Tattle Branch watershed).

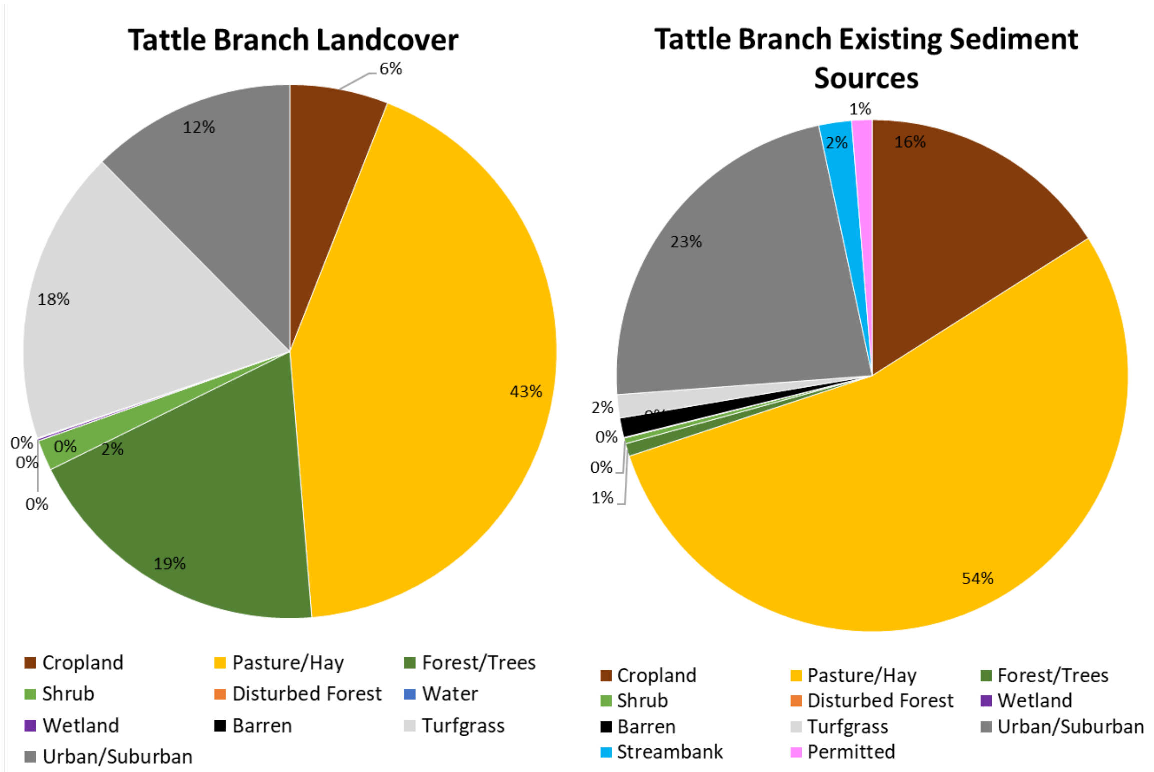

Figure 1-7. Land cover and existing source load distributions in the Tattle Branch watershed.

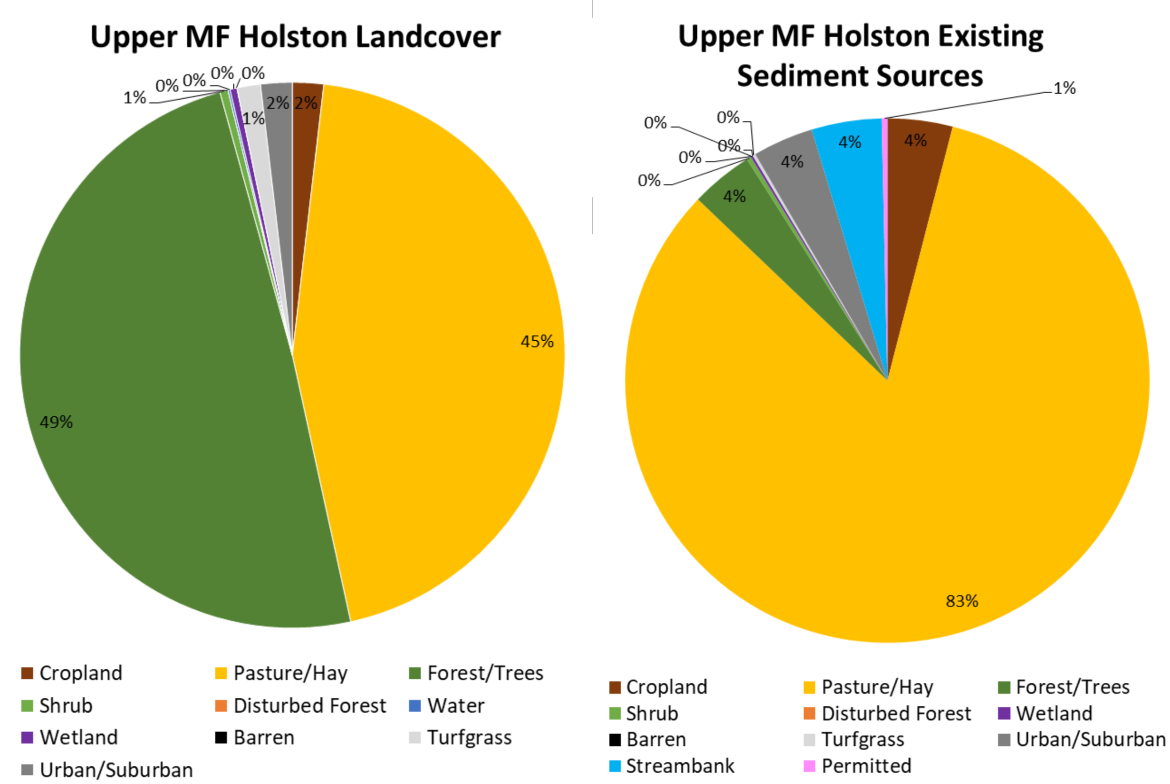

Figure 1-8. Land cover and existing source load distributions in the Upper MF Holston watershed.

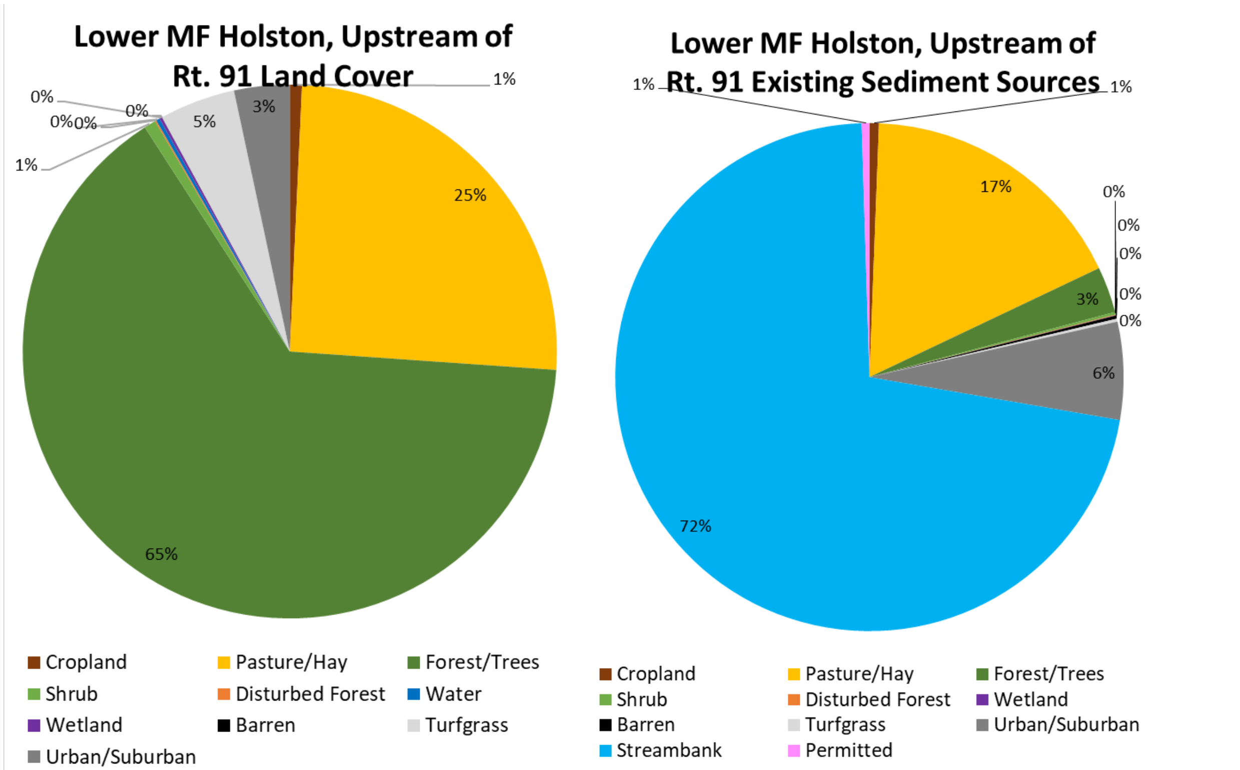

Figure 1-9. Land cover and existing source load distributions (excluding Upper MF Holston) in the Lower MF Holston, Upstream of Rt. 91 watershed.

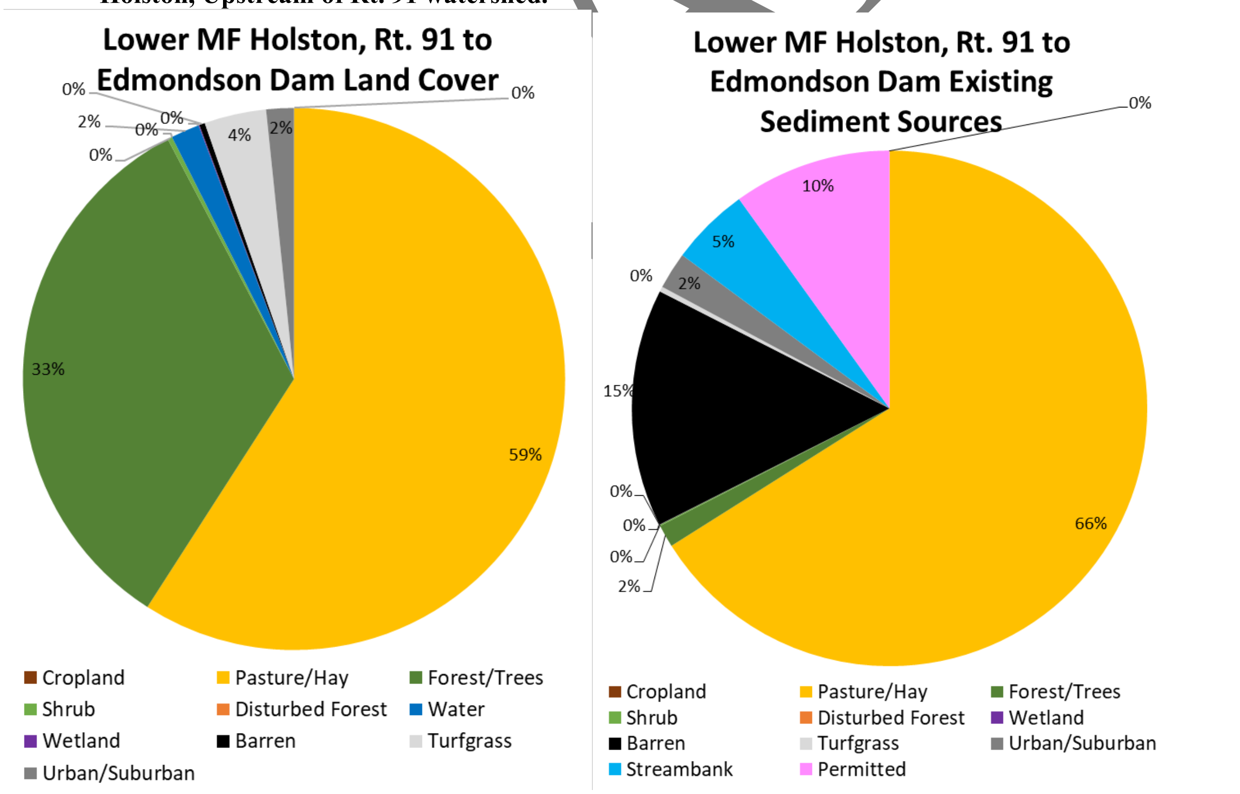

Figure 1-10. Land cover and existing source load distributions in the Lower MF Holston, Rt. 91 to Edmondson Dam watershed (excluding Lower MF Holston, Upstream of Rt. 91, Upper MF Holston, Byers Creek, Hall Creek and Tattle Branch Watersheds).

1.5. Future Goals (the TMDL)

After figuring out where the sediment in the impaired streams is currently coming from, a computer model was used to figure out how much sediment loads need to be reduced to clean up each stream. The ultimate goal for these streams is to have sediment levels that allow for diverse and abundant aquatic life. The reductions in sediment needed to meet these goals are shown in **Table 1-2**.

Table 1-2. Percent reductions in sediment needed to clean up the impaired waters.

Watershed	Crop, Pasture, Hay	Forest, Trees, Shrubs, Wetland	Developed Pervious and Impervious Areas, Turfgrass	Streambank Erosion	Permitted Sources
Tattle Branch	65.9%	0%	10.5%	10.1%	0%
Hall Creek	65%	0%	24.9%	25%	0%
Byers Creek	68.3%	0%	33%	68.3%	0%
Cedar Creek	68.6%	0%	25.2%	68.5%	0%
Greenway Creek	18.7%	0%	10%	18.7%	0%
Upper MF Holston	3.1%	0%	1.1%	1.2%	0%
Lower MF Holston, upstream of Rt. 91	20.7%	0%	5.7%	20.7%	0%
Lower MF Holston, Rt.91 to Edmondson Dam	1%	0%	1%	1%	0%

In order to obtain healthy sediment levels in the impaired streams, significant reductions are needed from several sediment sources. Sediment loads from agricultural land cover need to be reduced by between 65.9% in Tattle Branch and 3.1% in the upper Middle Fork Holston watershed. Sediment loads from urban/suburban land cover need to be reduced by between 33% in Byers Creek and 1.1% in upper Middle Fork Holston watershed. Recommended streambank erosion reductions were generally matched with the reductions of the other categories. The reductions applied to upstream impairments mathematically indicate that no further reductions from the Lower MF Holston, Rt. 91 to Edmondson Dam, would be needed. However, DEQ recommends including 1% reduction to anthropogenic nonpoint sources. This small reduction provides additional reasonable assurance that this stream segment will achieve delisting by increasing the BMP funding opportunities.

The total maximum daily load, or TMDL, is equal to the total amount of sediment per year that would be entering each of these streams after the recommended reductions are made (**Table 1-3** through **Table 1-10**). This load includes permitted sources as well as future growth to account for potential future permitted sources. These annual loads are converted to daily maximum loads as well, as described in **Section 6.3** (**Table 1-11** through **Table 1-18**). If sediment loads are reduced to these amounts, healthy aquatic life should be restored in these streams.

1.5.1. Annual Average Loads

Table 1-3. Annual average sediment TMDL components for Tattle Branch. Reduction scenarios to achieve this TMDL are presented in Table 1-19 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Tattle Branch (VAS-O05R_TAT01A02)	**15,800**	**363,200**	**42,110**	**421,100**
ISW Permits	*3,190*			
Construction Permits	*842*			
NMMM Permits	*3,347*			
Future Growth (2%)	*8,422*			

Table 1-4. Annual average sediment TMDL components for Hall Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-20 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)*	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Hall Creek (VAS-O05R_HAL01A94)	**117,600**	**1,142,000**	**140,000**	**1,400,000**
VPDES Permits	*86,800*			
Construction Permits	*2,799*			
Future Growth (2%)	*28,000*			

* Upstream inputs from Tattle Branch (WLA and LA) are included in Hall Creek LA.

Table 1-5. Annual average sediment TMDL components for Byers Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-21 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)*	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Byers Creek (VAS-O05R_BYS01A94)	**38,870**	**1,461,000**	**166,700**	**1,667,000**
ISW Permits	*2,200*			
Construction Permit	*3,334*			
Future Growth (2%)	*33,340*			

* Upstream inputs from Tattle Branch and Hall Creek (WLAs and LAs) are included in Byers Creek LA.

Table 1-6. Annual average sediment TMDL components for Cedar Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-22 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Cedar Creek (VAS-O05R_CED01A94)	**12,920**	**471,000**	**53,770**	**537,700**
Vehicle Wash Permit	*914*			
Construction Permits	*1,075*			
Domestic Sewage Permit	*183*			
Future Growth (2%)	*10,750*			

Table 1-7. Annual average sediment TMDL components for Greenway Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-23 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Greenway Creek (VAS-O05R_GRW01A02)	**43,580**	**1,058,000**	**122,400**	**1,224,000**
ISW Permits	*15,690*			
Construction Permits	*3,232*			
Domestic Sewage	*183*			
Future Growth (2%)	*24,480*			

Table 1-8. Annual average sediment TMDL components for Upper MF Holston. Reduction scenarios to achieve this TMDL are presented in Table 1-24 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Upper MF Holston (VAS-O03R_MFH05A04)	**36,770**	**1,187,000**	**136,000**	**1,360,000**
PWTP Permit	*6,853*			
Construction Permits	*2,720*			
Future Growth (2%)	*27,200*			

Table 1-9. Annual average sediment TMDL components for the Lower MF Holston, upstream of Rt. 91. Reduction scenarios to achieve this TMDL are presented in Table 1-25 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)*	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Lower MF Holston, upstream of Rt. 91 (VAS-O05R_MFH04A00)	**1,109,000**	**34,120,000**	**3,914,000**	**39,140,000**
VPDES	*161,300*			
Construction Permits	*65,170*			
ISW Permits	*71,930*			
NMMM Permits	*26,710*			
Domestic Sewage Permits	*732*			
Future Growth (2%)	*782,800*			

* Upstream inputs from Upper MF Holston River (WLAs and LAs) are included in Lower MF Holston, upstream of Rt. 91, LA.

Table 1-10. Annual average sediment TMDL components for the Lower MF Holston, Rt. 91 to Edmondson Dam. Reduction scenarios to achieve this TMDL are presented in Table 1-26 (Scenario 1).

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)*	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Lower MF Holston, Rt. 91 to Edmondson Dam (VAS-O05R_MFH05A04)	**963,700**	**38,460,000**	**4,380,000**	**43,800,000**
Domestic Sewage Permit	*91*			
Construction Permits	*87,590*			
Future Growth (2%)	*876,000*			

* Upstream inputs from Lower MF Holston River, upstream of Rt. 91 and Byers Creek (WLAs and LAs) are included in Lower MF Holston, Rt. 91 to Edmondson Dam, LA.

1.5.2. Maximum Daily Loads

Table 1-11. Maximum 'daily' sediment loads and components for Tattle Branch. Reduction scenarios to achieve this TMDL are presented in Table 1-3 and Table 1-19 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Tattle Branch (VAS-O05R_TAT01A02)	**43**	**1,824**	**208**	**2,075**
ISW Permits	*8.7*			
Construction Permits	*2.3*			
NMMM Permits	*9.2*			
Future Growth	*23.1*			

Table 1-12. Maximum 'daily' sediment loads and components for Hall Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-4 and Table 1-20 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Hall Creek (VAS-O05R_HAL01A94)	**322**	**6,440**	**751**	**7,513**
VPDES Permits	*237.7*			
Construction Permits	*7.7*			
Future Growth	*76.6*			

* Upstream inputs from Tattle Branch (WLA and LA) are included in Hall Creek LA.

Table 1-13. Maximum 'daily' sediment loads and components for Byers Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-5 and Table 1-21 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Byers Creek (VAS-O05R_BYS01A94)	**106**	**8,274**	**931**	**9,311**
ISW Permits	*6.0*			
Construction Permit	*9.1*			
Future Growth	*91.3*			

* Upstream inputs from Tattle Branch and Hall Creek (WLAs and LAs) are included in Byers Creek LA.

Table 1-14. Maximum 'daily' sediment loads and components for Cedar Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-6 and Table 1-22 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Cedar Creek (VAS-O05R_CED01A94)	**35**	**2,562**	**288**	**2,885**
Vehicle Wash Permit	*2.5*			
Construction Permits	*2.9*			
Domestic Sewage Permit	*0.5*			
Future Growth	*29.4*			

Table 1-15. Maximum 'daily' sediment loads and components for Greenway Creek. Reduction scenarios to achieve this TMDL are presented in Table 1-7 and Table 1-23 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Greenway Creek (VAS-O05R_GRW01A02)	**119**	**6,036**	**684**	**6,836**
ISW Permits	*43.0*			
Construction Permits	*8.8*			
Domestic Sewage	*0.5*			
Future Growth	*67.0*			

Table 1-16. Maximum 'daily' sediment loads and components for Upper MF Holston. Reduction scenarios to achieve this TMDL are presented in Table 1-8 and Table 1-24 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Upper MF Holston (VAS-O03R_MFH05A04)	**101**	**6,735**	**760**	**7,596**
PWTP Permit	*18.8*			
Construction Permits	*7.4*			
Future Growth	*74.5*			

Table 1-17. Maximum 'daily' sediment loads and components for the Lower MF Holston, upstream of Rt.91. Reduction scenarios to achieve this TMDL are presented in Table 1-9 and Table 1-25 (Scenario 2).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Lower MF Holston, upstream of Rt. 91 (VAS-O05R_MFH04A00)	**3,035**	**141,600**	**16,070**	**160,700**
VPDES	*441.6*			
Construction Permits	*178.4*			
ISW Permits	*196.9*			
NMMM Permits	*73.1*			
Domestic Sewage Permits	*2.0*			
Future Growth	*2,143*			

* Upstream inputs from Upper MF Holston River (WLAs and LAs) are included in Lower MF Holston, upstream of Rt. 91, LA.

Table 1-18. Maximum 'daily' sediment loads and components for Lower MF Holston, Rt. 91 to Edmondson Dam. Reduction scenarios to achieve this TMDL are presented in Table 1-10 and Table 1-26 (Scenario 1).

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Lower MF Holston, Rt. 91 to Edmondson Dam (VAS-O05R_MFH05A04)	**2,638**	**224,000**	**25,180**	**251,800**
Domestic Sewage Permit	*0.3*			
Construction Permits	*239.8*			
Future Growth	*2,398*			

* Upstream inputs from Lower MF Holston River, upstream of Rt. 91 and Byers Creek (WLAs and LAs) are included in Lower MF Holston, Rt. 91 to Edmondson Dam, LA

1.5.3. Allocation Scenarios

There are many ways to reduce pollutants to reach water quality (TMDL) goals. Several versions of these reduction plans, or allocation scenarios, were developed. These were presented to the Technical Advisory Committee which determined the preferred scenarios for each watershed (see **Table 1-19** through **Table 1-26**). These scenarios focused greater recommended reductions on the greater loads associated with agricultural sources in the watersheds, while still maintaining some recommended reductions on urban sources to balance the responsibility and available funding. Model TSS pollutant and calculated totals of those results were rounded to four significant figures.

Table 1-19. Allocation scenarios for Tattle Branch sediment loads.

Tattle Branch Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	116,700	50.3	58,020	65.9	39,810	36.6	74,020	25.1	87,440
Hay	12,880	50.3	6,403	65.9	4,393	36.5	8,181	58.0	5,411
Pasture	380,900	50.3	189,300	65.9	129,900	36.5	241,900	58.0	160,000
Forest	2,008	-	2,008	-	2,008	-	2,008	-	2,008
Trees	3,869	-	3,869	-	3,869	-	3,869	-	3,869
Shrub	2,665	-	2,665	-	2,665	-	2,665	-	2,665
Harvested	-	-	-	-	-	-	-	-	-
Wetland	327	-	327	-	327	-	327	-	327
Barren	8,968	50.3	4,457	10.1	8,062	85.0	1,345	19.0	7,264
Turfgrass	10,680	50.3	5,310	10.2	9,595	85.0	1,603	19.0	8,655
Developed Pervious	2,232	50.3	1,109	10.6	1,995	85.0	335	56.0	982
Developed Impervious	164,400	50.3	81,720	10.6	147,000	85.0	24,670	56.0	72,350
Streambank Erosion	15,060	50.3	7,485	10.1	13,540	85.0	2,259	19.0	12,200
ISW Permits	7,753	-	3,190	-	3,190	-	3,190	-	3,190
Construction Permits (0.2%)	842	-	842	-	842	-	842	-	842
NMMM Permits	856	-	3,347	-	3,347	-	3,347	-	3,347
Future Growth (2%)	8,422	-	8,422	-	8,422	-	8,422	-	8,422
MOS (10%)	42,110	-	42,110	-	42,110	-	42,110	-	42,110
TOTAL	**780,800**	**46.1**	**420,600**	**46.1**	**421,100**	**46.1**	**421,100**	**46.1**	**421,100**

Table 1-20. Allocation scenarios for Hall Creek sediment loads.

Hall Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	109,900	54.1	50,430	65.0	38,460	43.9	61,640	30.0	76,920
Hay	31,390	54.1	14,410	65.0	10,990	43.9	17,610	62.0	11,930
Pasture	902,800	54.1	414,400	65.0	316,000	43.9	506,500	62.0	343,100
Forest	20,120	-	20,120	-	20,120	-	20,120	-	20,120
Trees	12,710	-	12,710	-	12,710	-	12,710	-	12,710
Shrub	4,986	-	4,986	-	4,986	-	4,986	-	4,986
Harvested	61,140	-	61,140	-	61,140	-	61,140	-	61,140
Wetland	4,968	-	4,968	-	4,968	-	4,968	-	4,968
Barren	37,110	54.1	17,030	24.4	28,050	81.2	6,976	30.0	25,970
Turfgrass	14,230	54.1	6,533	24.4	10,760	81.3	2,662	30.0	9,964
Developed Pervious	2,321	54.1	1,065	25.0	1,741	81.3	434	50.0	1,161
Developed Impervious	195,900	54.1	89,930	25.0	146,900	81.3	36,640	50.0	97,960
Streambank Erosion	141,700	54.1	65,060	25.0	106,300	81.2	26,650	35.0	92,130
Tattle Branch* (Scenario 2)	738,700	-	379,000	-	379,000	-	379,000	-	379,000
VPDES Permits	6,137	-	86,800	-	86,800	-	86,800	-	86,800
Construction Permits	2,799	-	2,799	-	2,799	-	2,799	-	2,799
Future Growth (2%)	28,000	-	28,000	-	28,000	-	28,000	-	28,000
MOS (10%)	140,000	-	140,000	-	140,000	-	140,000	-	140,000
TOTAL	**2,455,000**	**43.0**	**1,399,000**	**43.0**	**1,400,000**	**43.0**	**1,400,000**	**43.0**	**1,400,000**

* Upstream input from Tattle Branch existing/allocated load. Tattle Branch MOS is included in Hall Creek MOS.

Table 1-21. Allocation scenarios for Byers Creek sediment loads.

Byers Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	Existing TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)
Cropland	29,140	65.0	10,200	68.3	9,237	63.6	10,610	54.2	13,350
Hay	15,580	65.0	5,451	68.3	4,937	63.6	5,669	67.0	5,140
Pasture	443,100	65.0	155,100	68.3	140,500	63.6	161,300	67.0	146,200
Forest	1,747	-	1,747	-	1,747	-	1,747	-	1,747
Trees	4,503	-	4,503	-	4,503	-	4,503	-	4,503
Shrub	950	-	950	-	950	-	950	-	950
Harvested	-	-	-	-	-	-	-	-	-
Wetland	-	-	-	-	-	-	-	-	-
Barren	-	-	-	-	-	-	-	-	-
Turfgrass	6,069	65.0	2,124	33.0	4,066	78.0	1,335	54.2	2,780
Developed Pervious	707	65.0	248	33.0	474	78.0	156	56.0	311
Developed Impervious	45,580	65.0	15,950	33.0	30,540	78.0	10,030	56.0	20,060
Streambank Erosion	14,870	65.0	5,206	68.3	4,715	63.6	5,414	54.2	6,812
Hall Creek* (Scenario 2)	2,315,000	-	1,260,000	-	1,260,000	-	1,260,000	-	1,260,000
ISW Permits	5,347	-	2,200	-	2,200	-	2,200	-	2,200
Construction Permit	3,334	-	3,334	-	3,334	-	3,334	-	3,334
Future Growth (2%)	33,340	-	33,340	-	33,340	-	33,340	-	33,340
MOS (10%)	166,700	-	166,700	-	166,700	-	166,700	-	166,700
TOTAL	**3,086,000**	**46.0**	**1,667,000**	**46.0**	**1,667,000**	**46.0**	**1,667,000**	**46.0**	**1,667,000**

* Upstream input from Hall Creek existing/allocated load. Hall Creek MOS is included in Byers Creek MOS.

Table 1-22. Allocation scenarios for Cedar Creek sediment loads.

Cedar Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	Existing TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)	Red. (%)	Allocation TSS (lb/yr)
Cropland	150,700	62.1	57,130	68.5	47,480	58.1	63,160	53.8	69,640
Hay	32,530	62.1	12,330	68.6	10,220	58.1	13,630	66.0	11,060
Pasture	758,000	62.1	287,300	68.6	238,000	58.1	317,600	66.0	257,700
Forest	5,202	-	5,202	-	5,202	-	5,202	-	5,202
Trees	7,741	-	7,741	-	7,741	-	7,741	-	7,741
Shrub	1,949	-	1,949	-	1,949	-	1,949	-	1,949
Harvested	867	-	867	-	867	-	867	-	867
Wetland	288	-	288	-	288	-	288	-	288
Barren	-	-	-	-	-	-	-	-	-
Turfgrass	16,320	62.1	6,185	26.0	12,080	76.6	3,819	55.0	7,344
Developed Pervious	1,967	62.1	746	25.1	1,474	76.6	460	55.0	885
Developed Impervious	161,100	62.1	61,060	25.1	120,700	76.6	37,700	55.0	72,500
Streambank Erosion	79,410	62.1	30,090	68.5	25,010	76.6	18,580	54.9	35,810
Vehicle Wash Permit	59	-	914	-	914	-	914	-	914
Construction Permits (0.2%)	1,075	-	1,075	-	1,075	-	1,075	-	1,075
Domestic Sewage Permit	183	-	183	-	183	-	183	-	183
Future Growth (2%)	10,750	-	10,750	-	10,750	-	10,750	-	10,750
MOS (10%)	53,770	-	53,770	-	53,770	-	53,770	-	53,770
TOTAL	**1,282,000**	**58.1**	**537,600**	**58.1**	**537,700**	**58.1**	**537,700**	**58.1**	**537,700**

Table 1-23. Allocation scenarios for Greenway Creek sediment loads.

Greenway Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	38,010	16.9	31,590	18.7	30,900	9.5	34,400	10.0	34,210
Hay	37,190	16.9	30,900	18.7	30,230	9.5	33,660	17.4	30,720
Pasture	839,600	16.9	697,700	18.7	682,600	9.5	759,900	17.4	693,500
Forest	16,470	-	16,470	-	16,470	-	16,470	-	16,470
Trees	9,453	-	9,453	-	9,453	-	9,453	-	9,453
Shrub	1,895	-	1,895	-	1,895	-	1,895	-	1,895
Harvested	1,046	-	1,046	-	1,046	-	1,046	-	1,046
Wetland	681	-	681	-	681	-	681	-	681
Barren	18,890	16.9	15,700	10.0	17,000	46.0	10,200	7.0	17,570
Turfgrass	14,230	16.9	11,820	10.0	12,810	46.0	7,683	7.0	13,230
Developed Pervious	2,706	16.9	2,249	10.0	2,435	46.0	1,461	17.4	2,235
Developed Impervious	216,600	16.9	180,000	10.0	195,000	46.0	117,000	17.4	178,900
Streambank Erosion	70,500	16.9	58,580	18.7	57,320	9.5	63,800	17.4	58,230
ISW Permits	38,120	-	15,690	-	15,690	-	15,690	-	15,690
Construction Permits	3,232	-	3,232	-	3,232	-	3,232	-	3,232
Domestic Sewage Permits	183	-	183	-	183	-	183	-	183
Future Growth (2%)	24,480	-	24,480	-	24,480	-	24,480	-	24,480
MOS (10%)	122,400	-	122,400	-	122,400	-	122,400	-	122,400
TOTAL	**1,456,000**	**15.9**	**1,224,000**	**15.9**	**1,224,000**	**15.9**	**1,224,000**	**15.9**	**1,224,000**

Table 1-24. Allocation scenarios for Upper MF Holston sediment loads.

Upper MF Holston Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	49,140	3.0	47,670	3.1	47,620	1.7	48,310	1.1	48,600
Hay	33,120	3.0	32,130	3.1	32,090	1.7	32,560	3.1	32,090
Pasture	986,300	3.0	956,700	3.1	955,800	1.7	969,600	3.1	955,800
Forest	36,790	-	36,790	-	36,790	-	36,790	-	36,790
Trees	10,500	-	10,500	-	10,500	-	10,500	-	10,500
Shrub	3,316	-	3,316	-	3,316	-	3,316	-	3,316
Harvested	-	-	-	-	-	-	-	-	-
Wetland	1,811	-	1,811	-	1,811	-	1,811	-	1,811
Barren	-	-	-	-	-	-	-	-	-
Turfgrass	2,166	3.0	2,101	1.1	2,142	31.7	1,479	1.1	2,142
Developed Pervious	1,157	3.0	1,122	1.1	1,144	31.7	790	1.1	1,144
Developed Impervious	44,760	3.0	43,420	1.1	44,270	31.7	30,570	1.1	44,270
Streambank Erosion	52,900	3.0	51,310	1.2	52,270	1.7	52,000	3.1	51,260
PWTP Permit	1,608	-	6,853	-	6,853	-	6,853	-	6,853
Construction Permits (0.2%)	2,720	-	2,720	-	2,720	-	2,720	-	2,720
Future Growth (2%)	27,200	-	27,200	-	27,200	-	27,200	-	27,200
MOS (10%)	136,000	-	136,000	-	136,000	-	136,000	-	136,000
TOTAL	**1,390,000**	**2.2**	**1,360,000**	**2.2**	**1,360,000**	**2.2**	**1,360,000**	**2.2**	**1,360,000**

Table 1-25. Allocation scenarios for Lower MF Holston, upstream of Rt.91 sediment loads.

Lower MF Holston, upstream of Rt. 91		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	235,100	19.7	188,800	20.7	186,400	16.9	195,400	9.0	213,900
Hay	209,100	19.7	167,900	20.7	165,800	16.9	173,700	19.8	167,700
Pasture	6,906,000	19.7	5,546,000	20.7	5,477,000	16.9	5,739,000	19.8	5,539,000
Forest	1,128,000	-	1,128,000	-	1,128,000	-	1,128,000	-	1,128,000
Trees	122,600	-	122,600	-	122,600	-	122,600	-	122,600
Shrub	70,950	-	70,950	-	70,950	-	70,950	-	70,950
Harvested	17,900	-	17,900	-	17,900	-	17,900	-	17,900
Wetland	7,032	-	7,032	-	7,032	-	7,032	-	7,032
Barren	91,140	19.7	73,190	5.7	85,950	58.4	37,910	9.0	82,940
Turfgrass	80,830	19.7	64,910	5.7	76,220	58.4	33,620	9.0	73,550
Developed Pervious	14,700	19.7	11,810	5.7	13,870	58.4	6,117	19.8	11,790
Developed Impervious	2,452,000	19.7	1,969,000	5.7	2,312,000	58.4	1,020,000	19.8	1,966,000
Streambank Erosion	29,290,000	19.7	23,520,000	20.7	23,230,000	16.9	24,340,000	19.8	23,490,000
Upper MF Holston* (Scenario 2)	1,254,000	-	1,224,000		1,224,000		1,224,000		1,224,000
VPDES	33,390	-	161,300		161,300		161,300		161,300
Construction Permits	65,170	-	65,170		65,170		65,170		65,170
ISW Permits	174,800	-	71,930		71,930		71,930		71,930
NMMM Permits	26710	-	26710		26710		26710		26710
Domestic Sewage Permits	732	-	732		732		732		732
Future Growth (2%)	782,800	-	782,800		782,800		782,800		782,800
MOS (10%)	3,914,000	-	3,914,000		3,914,000		3,914,000		3,914,000
TOTAL	**46,880,000**	**16.5**	**39,130,000**	**16.5**	**39,140,000**	**16.5**	**39,140,000**	**16.5**	**39,140,000**

* Upstream input from Upper MF Holston River existing/allocated load. Upper MF Holston MOS is included in Lower MF Holston, upstream of Rt. 91, MOS.

Table 1-26. Allocation scenarios for Lower MF Holston, Rt. 91 to Edmondson Dam.

Lower MF Holston, Rt. 91 to Edmondson Dam		Scenario 1	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	-	-	-
Hay	21,230	1.0	21,010
Pasture	562,700	1.0	557,000
Forest	8,338	-	8,338
Trees	4,162	-	4,162
Shrub	668	-	668
Harvested	-	-	-
Wetland	133	-	133
Barren	132,100	1.0	130,700
Turfgrass	2,809	1.0	2,781
Developed Pervious	168	1.0	166
Developed Impervious	20,340	1.0	20,140
Streambank Erosion	43,720	1.0	43,280
Lower MF Holston, upstream of Rt. 91 (Scenario 2)	42,960,000		35,220,000
Byers Creek (Scenario 2)	2,919,000		1,501,000
Domestic Sewage Permit	91		91
Construction Permits	87,590		87,590
Future Growth (2%)	876,000		876,000
MOS (10%)	4,380,000		4,380,000
TOTAL	**52,020,000**	**17.6**	**42,860,000**

* Upstream inputs from Lower MF Holston River, upstream of Rt. 91 and Byers Creek existing/allocated loads. Lower MF Holston, upstream of Rt. 91 and Byers Creek MOSs are included in Lower MF Holston Rt. 91 to Edmondson Dam.

1.6. Public Participation

Throughout this study, VADEQ asked for the help of local residents and knowledgeable stakeholders – those who have a particular interest in or may be affected by the outcome of the project. Public participation keeps stakeholders informed, and it allows for stakeholder input to ensure information in the study is accurate. While the project was progressing, VADEQ held two public meetings and two Technical Advisory Committee (TAC) meetings. The final public meeting was held on October 19th, 2023 to present the draft TMDL document and began the official public comment period. The 30-day public comment period ended Nov 20, 2023, and no comments were received.

1.7. Reasonable Assurance

Public participation in the development of the TMDL and implementation plans, follow-up monitoring, permit compliance, and current implementation progress within the watersheds all combine to provide reasonable assurance that these TMDLs will be implemented and water quality will be restored in the impaired watersheds.

> Frequently Asked Question:
>
> *How will the TMDL be implemented?*
>
> For point sources, TMDL reductions will be implemented through discharge permits. For nonpoint sources, TMDL reductions will be implemented through best management practices (BMPs). Landowners will be asked to voluntarily participate in state and federal programs that help defer the cost of BMP installation.

1.8. What Happens Next

VADEQ will present the final DRAFT TMDL report to the State Water Control Board, then submit it to the U.S. Environmental Protection Agency (USEPA) for approval. This report sets the clean-up goals for the MF Holston and Tribs watersheds, but the next step is a clean-up plan (or Implementation Plan) that lays out how those goals will be reached. Clean-up plans set intermediate goals and describe actions that should be taken to improve water quality in the impaired streams. Some of the potential actions that could be included in an implementation plan for the MF Holston and Tribs watersheds are listed below:

- Fence out cattle from streams and provide alternative water sources.
- Implement conservation tillage practices on cropland.
- Conduct stream bank restoration projects in areas where banks are actively eroding
- Leave a buffering band of 35 – 100 ft along the stream natural so that it filters out sediment from farm, residential, silviculture harvesting, roadways, or other developed lands. This is called a riparian buffer. These natural buffers can also provide shade to water bodies, another way to protect the water uses.
- Expand street sweeping programs in urban areas.
- Implement and/or retrofit, and maintain urban stormwater management practices.

- Reduce runoff by increasing green spaces and reducing hardened spaces (asphalt or concrete).

These and other actions that could be included in a clean-up plan are identified in the planning process along with associated costs and the extent of each practice needed. The clean-up plan also identifies potential sources of money to help in the clean-up efforts. Most of the money utilized to implement actions in the watersheds to date has been in the form of cost-share programs, which share the cost of improvements with the landowner. Additional funds for urban stormwater practices have been made available through various grant programs. Please be aware that the state or federal government will not fix the problems with the impaired streams. It is primarily the responsibility of individual landowners and local governments to take the actions necessary to improve these streams. The role of state agencies is to help with developing the plan and find money to support implementation, but making the improvements is up to those that live in the watershed. By increasing education and awareness of the problem, and by working together to each do our part, we can make the changes necessary to improve the streams.

VADEQ will continue to sample aquatic life in these streams and monitor the progress of clean-up. This sampling will let us know when the clean-up has reached certain milestones listed in the plan. To begin moving towards these clean-up goals, VADEQ recommends that concerned citizens come together and begin working with local governments, civic groups, soil and water conservation districts, and local health districts to increase education and awareness of the problem and promote those activities and programs that improve stream health.

2.0 INTRODUCTION

2.1. Watershed Location and Description

The Lower MF Holston watershed, crossing Wythe, Smyth, and Washington Counties, measures approximately 119,426 acres at Rt. 91, increasing to 131,380 acres at the Edmondson Dam. Edmondson Dam is noted by stakeholders as partially breached, while still retaining behind the dam accumulated sediment which can become re-suspended during storm events and transported downstream. The Debusk Mill Dam is also present on the MF Holston, approximately 1.8 river miles upstream of the Rt. 91 bridge. This structure is also reported by stakeholders as retaining accumulated sediment which can be re-suspended during storm events. The watershed of the Upper MF Holston impairment is approximately 3,542 acres and crosses Wythe and Smyth Counties. The tributaries addressed in this study are located within Washington County: Byers Creek is approximately 9,868 acres, Cedar Creek 4,645 acres, Greenway Creek 4,639 acres, Hall Creek 8,143 acres, and Tattle Branch 1,871 acres (**Figure 1-1**). The study watershed includes VAHU6 watersheds TH08, TH09, TH10, TH12, TH13, and TH14. Hall Creek and Tattle Branch are tributaries to Byers Creek. Byers, Cedar, and Greenway Creeks are all direct tributaries to the MF Holston River, which ultimately flows into the Gulf of Mexico.

2.2. Designated Uses and Applicable Water Quality Standards

Virginia's Water Quality Standards (9VAC25-260) consist of designated uses established for water bodies in the Commonwealth, and water quality criteria set to protect those uses. Virginia's Water Quality Standards protect the public and environmental health of the Commonwealth 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.).

2.2.1. Designation of Uses (9 VAC 25-260-10)

> "A. All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish" (SWCB, 2011).

MF Holston and Tribs currently do not support the aquatic life designated use based on biological monitoring of the benthic macroinvertebrate community.

2.2.2. General Standard (9VAC 25-260-20)

The following general standard protects the aquatic life use:

> "A. 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.
>
> Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled" (SWCB, 2011).

VADEQ's biological monitoring program is used to evaluate compliance with the above standard. This program monitors the assemblage of benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms) in streams to determine the biological health of the stream. Benthic macroinvertebrates are sensitive to water quality conditions, important links in aquatic food chains, major contributors to energy and nutrient cycling in aquatic habitats, relatively immobile, and easy to collect. These characteristics make them excellent indicators of aquatic health. Changes in water quality are reflected in changes in the structure and diversity of the benthic macroinvertebrate community. VADEQ assesses the health of the benthic macroinvertebrate community using the Virginia Stream Condition Index (VSCI). This index was first developed by Tetra Tech (2003) and later validated by VADEQ (2006). The VSCI is a multimetric index based on 8 biomonitoring metrics. The index provides a score from 0-100, and scores from individual streams are compared to a statistically derived cutoff value based on the scores of regional reference sites.

2.3. 305(b)/303(d) Water Quality Assessment

Under Section 305(b) of the Federal Clean Water Act, states are required to assess the quality of their water bodies in comparison to the applicable water quality standards. States are also required, under Section 303(d) of the Act, to prepare a list of water bodies that do not meet one or more water quality standards. This list is often called the "Impaired Waters List", the "303(d) List", the "TMDL List", or even the "Dirty Waters List". The Commonwealth of Virginia accomplishes both of these requirements through the publishing of an Integrated 305(b)/303(d) Water Quality Assessment Report every two years. Each report assesses water quality by evaluating monitoring data from a six-year window. The assessment window for the 2020 305(b)/303(d) Integrated Water Quality Assessment Report was from January 1, 2013 through December 31, 2018. According to VADEQ's current Water Quality Assessment Guidance (VADEQ, 2019), streams with a calculated VSCI score ≥60 are assessed as "fully supporting" the aquatic life designated use.

Streams with VSCI scores <60 are assessed as "impaired" or "not supporting" the aquatic life designated use.

2.3.1. Impairment Listings

According to Virginia's 2020 305(b)/303(d) Integrated Report (VADEQ, 2020), portions of the Byers/Hall Creek, Cedar Creek, Greenway Creek, Tattle Branch, and the Middle Fork Holston River are considered impaired (**Table 1-1**, **Figure 1-1**). Data collected to evaluate streams in the watersheds are collected by VADEQ and other government officials. All study streams are considered impaired for failure to support aquatic life use (i.e., a benthic impairment). During the 2020 assessment window (January 1, 2013 to December 31, 2018) the average VSCI score was 59.37 in Byers/Hall Creek, 54.47 in Cedar Creek, 60.37 in Greenway Creek, 59.29 in Tattle Branch; 60.29 in the headwaters of the MF Holston and 54.65 in the lower section of the MF Holston River. A summary of each stream's listing is presented below.

Byers/Hall Creek is impaired as Hall Creek along its mainstem from headwaters north of Emory through Emory and Henry College to the Byers Creek confluence (6.91 miles), where it is also impaired from the Hall Creek and Indian Run confluence downstream to Middle Fork Holston River confluence (0.49 miles). These segments were initially listed for an aquatic life use impairment on Virginia's 303(d) Report in 2004 based on data collected at VADEQ monitoring station 6CBYS000.08.

Cedar Creek is impaired from its confluence with East Fork Cedar Creek and West Fork Cedar Creek through Cedarville to the confluence with Middle Fork Holston (5.61 miles) and was first listed on Virginia's 303(d) Report in 2004 for an aquatic life use impairment. Cedar Creek was listed due to low VSCI scores at station 6CCED000.04.

Greenway Creek is impaired from its headwaters to the Middle Fork Holston River at Neff, west of Meadowview (5.02 miles) and was initially listed on Virginia's 303(d) Integrated Report in 2010 for an aquatic life use impairment. Greenway Creek was listed due to low VSCI scores at station 6CGRW002.31 in 2008. Continued monitoring has resulted in VSCI scores above and below the threshold of 60, resulting in an average above 60 without qualifying for delisting the impairment.

Tattle Branch is impaired from its headwaters to its confluence with Byers Creek (2.77 miles) and was initially listed on Virginia's 303(d) Report in 2004. Tattle Branch was listed due to low VSCI scores at stations 6CTAT000.50

The Middle Fork Holston River is impaired from the mainstem headwaters upstream of the Dutton Branch confluence at Groseclose (3.42 miles). This section was initially listed on Virginia's 303(d) Report in 2010 due to low VSCI scores at 6CMFH055.88. Continued monitoring at this station has resulted in VSCI scores above and below the threshold of 60, resulting in an average above 60 without qualifying for delisting the impairment.

Middle Fork Holston River is also impaired along its mainstem from Sulphur Spring Creek downstream to R. 91 bridge (9.19 miles), then from the Rt. 91 bridge downstream to the Edmondson Dam (3.80 miles). These sections were initially listed on Virginia's 303(d) Report in 2008 and 2006, respectively, based on low VSCI scores at stations 6CMFH023.41 and 6CMFH011.31.

2.4. TMDL Development

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that fail to meet designated water quality standards and are placed on the state's Impaired Waters List. A TMDL reflects the total pollutant loading that a water body can receive and still meet water quality standards. A TMDL establishes the maximum allowable pollutant loading from both point and nonpoint sources for a water body, allocates the load among the pollutant contributors, and provides a framework for taking actions to restore water quality.

2.4.1. Pollutants of Concern

TMDL target pollutants, or pollutants of concern (POC), are the physical or chemical substances that will be controlled and allocated in the TMDL to result in restored aquatic life (measured by benthic macroinvertebrate health). POCs must be pollutants that are controllable through source reductions, such as sediment, phosphorus, nitrogen, or other substances. Physical factors or environmental conditions, such as flow regimes, hydrologic modifications, or physical structures (like dams) cannot be TMDL POCs, even though these conditions influence ecological communities and may be sources of stress. The presence of both the Debusk Mill Dam and the partially breached Edmondson Dam impact the flow regime and sediment transport characteristics of the Middle Fork Hoston River. Dams retain sediment and dampen flow particularly from smaller storm events. As dams accumulate sediment over time, they become sources of sediment as well when accumulated sediment becomes re-suspended during storm events. Both Edmondson Dam and Debusk Mill Dam are reported by stakeholders as having accumulated enough sediment over time that they are both sinks and sources of sediment depending on the flow event.

In 2021, a stressor identification analysis study was conducted to determine the POC(s) contributing to the benthic impairments in the MF Holston and Tribs watersheds. This study is included in **Appendix D**. The stressor analysis study used a formal causal analysis approach developed by USEPA, known as CADDIS (Causal Analysis Diagnosis Decision Information

System). The CADDIS approach evaluates 14 lines of evidence that support or refute each candidate stressor as the cause of impairment. In each stream, each candidate stressor was scored from -3 to +3 based on each line of evidence. Total scores across all lines of evidence were then summed to produce a stressor score that reflects the likelihood of that stressor being responsible for the impairment. The study found that sediment (measured as total suspended solids or TSS) was a probable stressor in all the impaired reaches.

2.5. TMDL Revision

This study updates and revises two previously completed TMDLs. *Total Maximum Daily Load (TMDL) Development for Cedar Creek, Hall/Byers Creek, and Hutton Creek* was completed in December of 2003 (TetraTech, 2003) and *Bacteria and Benthic Total Maximum Daily Load Development for Middle Fork Holston River* was completed in October 2009 (Engineering Concepts, Inc., 2009).

Impaired (benthic) segments from these previous TMDLs have been combined into this current study, along with a Greenway Creek segment not previously included in a completed TMDL study. This study includes a new benthic stressor analysis to determine the most likely pollutant responsible for the impairments, which concurred with previous benthic stressor analyses in finding sediment to be the primary stressor (**Section 2.4.1**). This updated TMDL addresses the continued benthic impairment and adjusts for future growth, including a proposed expansion to the Hall Creek Waste Water Treatment Plant from 0.63 million gallons/day to 0.95 MGD. Several implementation plans have been developed and many BMPs have been implemented within the watersheds (**Section 4.4**) (MapTech, Inc., 2001 and 2013). A TMDL addressing bacteria was also developed in 2000 for Cedar, Hall, Byers, and Hutton Creeks (CH2M Hill, 2000).

Both the 2003 and 2009 TMDLs used a reference watershed approach to develop the target TMDL loads for their study watersheds. The reference watershed approach relies on a single watershed that is meeting benthic water quality criteria to set the target for TMDL reductions to meet. It relies on finding a watershed that is similar in land cover distribution, geography, climate, and size and modeling that reference watershed as well as modeling the study watershed(s). This limits the reference watershed method's ability to provide defensible targets. Since these previous TMDLs were developed, advances have been made in developing new methods to more defensibly develop target loads for pollutants like sediment which have no numeric criterion. In this study, the more robust AllForX method is used to set the TMDL targets. The AllForX method compares the level of pollutant loads above an all-forested simulation of many different comparison watersheds as they relate to VSCI scores, and is explained in more detail in **Section 5.0** and **Appendix C**.

3.0 WATERSHED CHARACTERIZATION

3.1. Topography and Ecoregion

The MF Holston and Tribs watershed is characterized by steep slopes and small tributary watersheds draining to the Middle Fork Holston, creating a long, linear watershed overall. The elevations of the watershed range from 1,800 to 4,100 ft (550 – 1250 m) based on elevation data from USGS 3D Elevation Program Digital Elevation Model (USGS 3DEP DEM) (USGS, 2022).

The Middle Fork Holston encompasses several different ecoregions within its watershed (**Figure 3-1**). The impaired tributaries addressed in this study are predominantly within the Southern Limestone/Dolomite Valleys and Low Rolling Hills, while the remainder of the watershed also includes sections of Southern Sandstone Ridges, Southern Dissected Ridges and Knobs, Southern Shale Valleys and Southern Sedimentary Ridges. A description of each ecoregion is below, adapted from Woods et al. (1999).

> The Southern Limestone/Dolomite Valleys and Low Rolling Hills ecoregion is a lowland characterized by broad, undulating, fertile valleys that are extensively farmed. Sinkholes, underground streams, and other karst features have developed on the underlying limestone/dolomite. The ecoregion is predominantly farmland/agriculture with scattered woodland in steeper areas.
>
> The Southern Sandstone Ridges ecoregion is composed of high, steep, forested ridges with narrow crests composed of folded interbedded Paleozoic sandstone and conglomerate with shale and siltstone forming sideslopes. The ecoregion is covered in Appalachian Oak Forest.
>
> The Southern Dissected Ridges and Knobs ecoregion is composed of broken, dissected, almost hummocky ridges which are morphologically distinct from the adjacent Southern Sandstone Ridges. It is underlain by Devonian age sedimentary rocks including sitlstone. It is predominately covered in Appalachian Oak Forest and some pastures.
>
> The Southern Shale Valleys ecoregion is characterized by rolling valleys and low hills and is underlain by fine grained rock such as shale and siltstone which are folded and faulted from the Paleozoic age. It is covered in Appalachian Oak Forest with bottomland forests also occurring.
>
> The Southern Sedimentary Ridges ecoregion is composed of high, steeply sloping ridges and deep, narrow valleys. Cambrian sedimentary and metasedimentary rocks, including sandstone and quartzite of the Chilowee Group underline the region. The ridge crests are underlain by resistant sandstone and quartzite, while the sideslopes are made up of phyllite,

shale, siltstone, and sandstone. The natural vegetation was Appalachian Oak Forest or, at higher elevations, Northern Hardwoods, and the region remains extensively forested.

3.2. Soils

The soil related parameters for the watershed were derived from the Soil Survey Geographic (SSURGO) dataset (USDA NRCS, 2022). The predominant factor analyzed was the hydrologic soil group (HSG). Hydrologic soil groups are an index of the rate at which water infiltrates through the soil with group A having the greatest rate of infiltration and D having the lowest rate of infiltration. Dual groups such as B/D indicate a naturally slow infiltration rate due to high water table, rather than a lack of infiltration capacity. When rainfall amounts exceed the capacity of the soil to infiltrate water, the excess water runs off and contributes to erosion. The Greenway, Cedar, and Byers/Hall Creek watersheds are dominated by HSG B (**Figure 3-2**). The Upper MF Holston impairment watershed has significant contributions of HSG B and C. The central portion of the MFHolston watershed contains large sections of HSG D.

3.3. Climate

Daily rainfall and temperature data for the watershed was obtained from Oregon State's spatially distributed PRISM model (Parameter-Elevation Regressions on Independent Slopes Model), which interpolates available datasets from a range of monitoring networks and is used as the official spatial climate data sets of the USDA. PRISM was utilized to obtain a more exact estimate of historical weather within the watershed, rather than relying on a nearby gauge outside of the watershed (PRISM, 2022). See Daly et al. 2008 for more information on the PRISM model. Local annual average precipitation generated from the PRISM model for years 2003 to 2020 was 48.2 inches, and the average modelled daily temperature during this time range was 53.9º F.

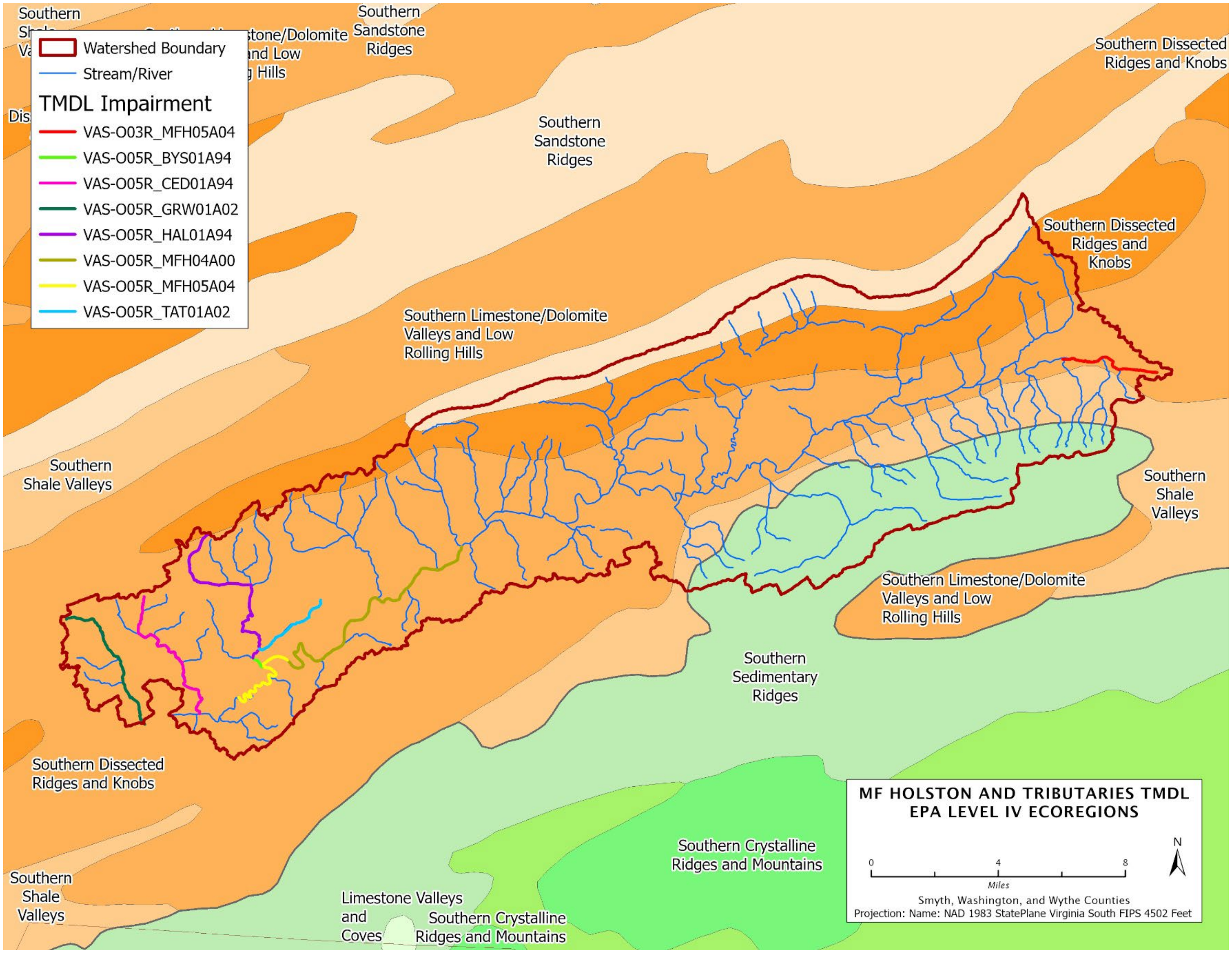

Figure 3-1. USEPA ecoregions included in the Middle Fork Holston TMDL watersheds.

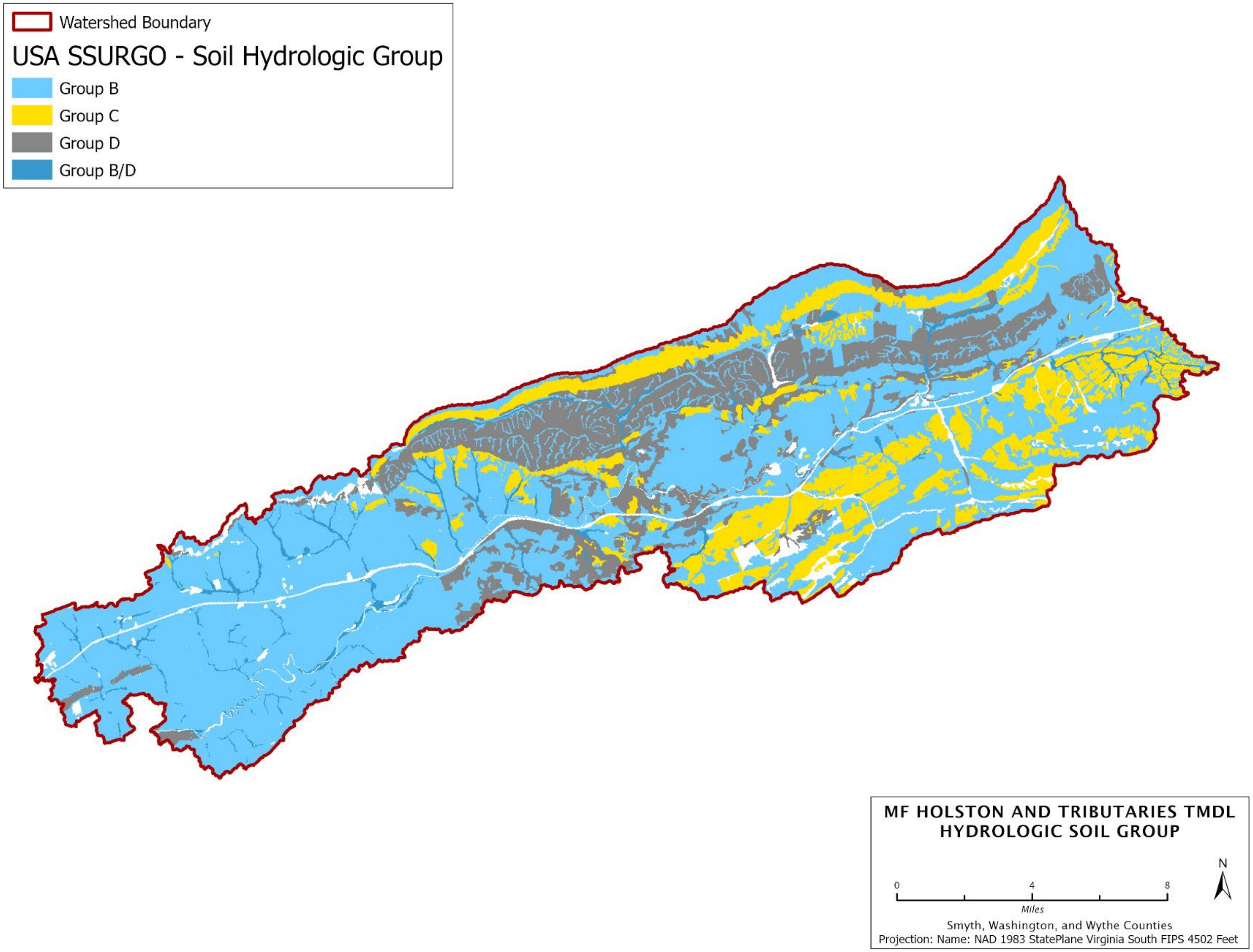

Figure 3-2. SSURGO hydrologic soil groups throughout the Middle Fork Holston TMDL watershed.

3.4. Landcover/Land Use

The 2016 VGIN Virginia Land Cover Dataset (VLCD) was used to determine the land cover distribution throughout the watershed (**Figure 3-3**) (VGIN, 2021). **Table 3-1** through **Table 3-8** summarize the land cover distributions for each of the impaired watersheds.

The VGIN dataset contains two different types of impervious land cover: extracted and local datasets. The local datasets impervious land cover is based on locally-developed datasets covering specifically building footprints, roads, and other known impervious areas. This land cover type is included in the computer model as entirely impervious. VGIN's extracted impervious land cover layer was developed using computer algorithms to extract additional areas that are likely impervious, beyond those areas identified in local datasets. When compared with aerial imagery, the extracted land cover set includes some areas that are not impervious. Based on visual comparisons, the extracted impervious land cover layer from VGIN was treated in the model as 80% developed impervious and 20% developed pervious.

The 'NWI/other' land cover type in the VGIN dataset is based on the combined National Wetlands Inventory and Tidal Marsh Inventory datasets and represents all identified wetland areas in those datasets.

The VGIN dataset contains categories for cropland and pasture, which were subdivided for modeling purposes using the 2020 Nonpoint Source (NPS) Assessment Land Use/Land Cover database maintained by the Virginia Department of Conservation and Recreation (VADCR) (VADCR, 2020). The VADCR NPS land use database includes acreage estimates for acres in conventional and conservation tillage, as well as hay and three quality-based categories of pasture by county and by VAHU6 watersheds. The ratio of conventional to conservation tillage for each modelled subwatershed was used to divide the VGIN cropland acres for that subwatershed into acreages of high till and low till, which were simulated using appropriately different parameters within the model, such as curve number, cover management (C) factor, and practice (P) factor. The VGIN pasture acres for each subwatershed were divided into four categories based on the NPS database: hay, pasture-good, pasture-fair, and pasture-poor. These categories were simulated with appropriately different curve number and C-factor values. Values for the various GWLF input parameters are detailed in **Appendix A**.

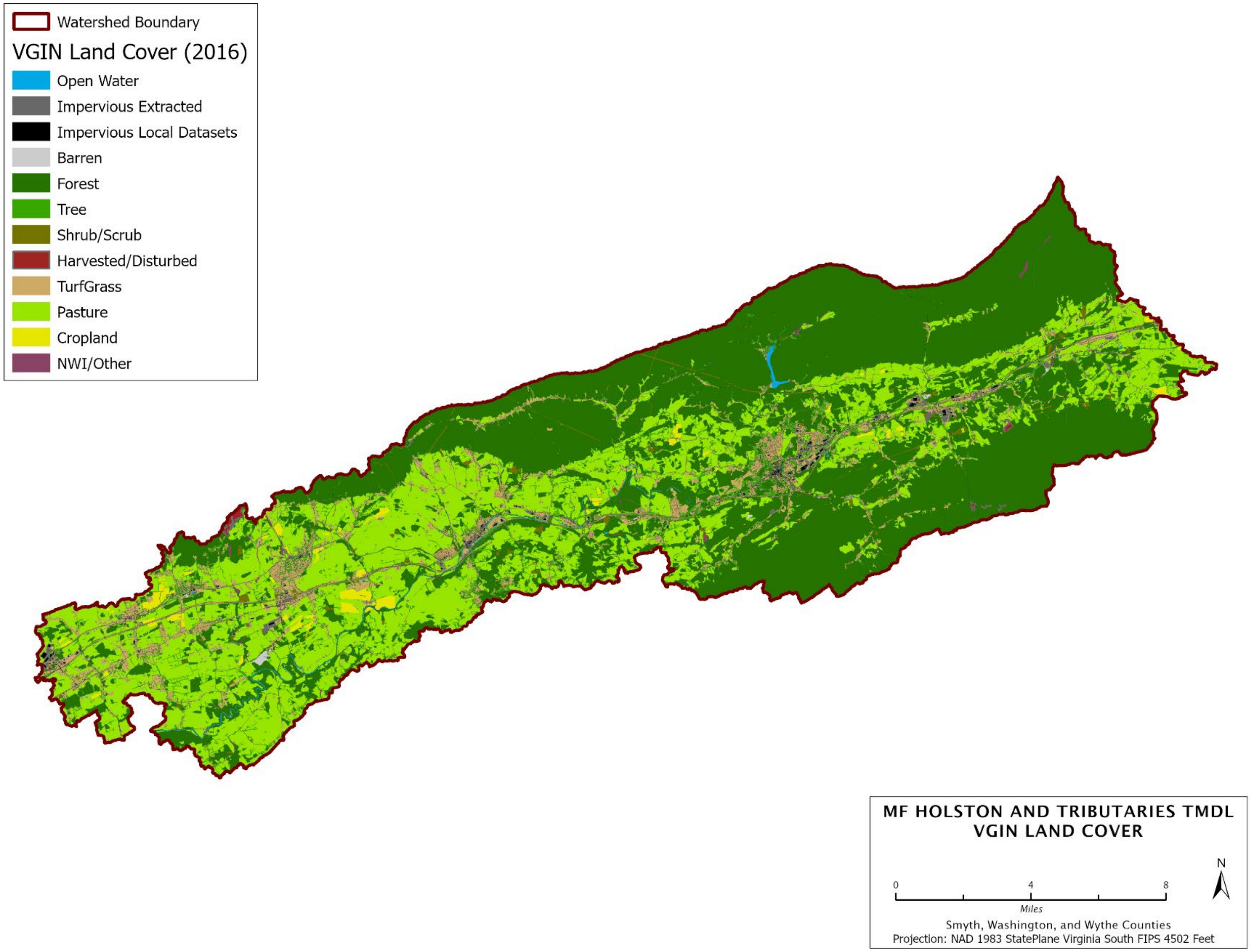

Figure 3-3. Land cover distribution used in the Middle Fork Holston Watersheds models

Table 3-1. Land cover distribution in the Tattle Branch watershed.

Tattle Branch Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	112	6.0
Hay	339	18.1
Pasture	460	24.6
Forest	191	10.2
Trees	165	8.8
Shrub	35	1.9
Harvested/Disturbed	-	0.0
Water	-	0.0
Wetland	2	0.1
Barren	1	0.1
Turfgrass	334	17.8
Developed, pervious	32	1.7
Developed, impervious	200	10.7
Total	*1,871*	*100*

Table 3-2. Land cover distribution in the Hall Creek watershed (excluding Tattle Branch watershed).

Hall Creek Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	164	2.6
Hay	1,176	18.8
Pasture	1,595	25.4
Forest	1,566	25.0
Trees	660	10.5
Shrub	86	1.4
Harvested/Disturbed	144	2.3
Water	5	0.1
Wetland	53	0.8
Barren	6	0.1
Turfgrass	535	8.5
Developed, pervious	32	0.5
Developed, impervious	250	4.0
Total	*6,272*	*100*

Table 3-3. Land cover distribution in the Byers Creek watershed (excluding Hall Creek and Tattle Branch watersheds).

Byers Creek Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	65	1.8
Hay	599	16.9
Pasture	985	27.8
Forest	1,504	42.4
Trees	238	6.7
Shrub	17	0.5
Harvested/Disturbed	-	0.0
Water	4	0.1
Wetland	15	0.4
Barren	-	0.0
Turfgrass	49	1.4
Developed, pervious	7	0.2
Developed, impervious	59	1.7
Total	*3,542*	*100*

Table 3-4. Land cover distribution in the Cedar Creek Watershed.

Cedar Creek Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	160	3.4
Hay	1,253	27.0
Pasture	1,362	29.3
Forest	458	9.9
Trees	477	10.3
Shrub	32	0.7
Harvested/Disturbed	4	0.1
Water	2	0.0
Wetland	4	0.1
Barren	-	0.0
Turfgrass	654	14.1
Developed, pervious	25	0.5
Developed, impervious	214	4.6
Total	*4,645*	*100*

Table 3-5. Land cover distribution in the Greenway Creek Watershed.

Greenway Creek Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	60	1.3
Hay	1,205	26.0
Pasture	1,309	28.2
Forest	770	16.6
Trees	374	8.1
Shrub	22	0.5
Harvested/Disturbed	4	0.1
Water	2	0.0
Wetland	9	0.2
Barren	4	0.1
Turfgrass	525	11.3
Developed, pervious	45	1.0
Developed, impervious	311	6.7
Total	*4,639*	*100*

Table 3-6. Land cover distribution in the Upper MF Holston Watershed.

Upper MF Holston Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	65	1.8
Hay	599	16.9
Pasture	985	27.8
Forest	1,504	42.4
Trees	238	6.7
Shrub	17	0.5
Harvested/Disturbed	-	0.0
Water	4	0.1
Wetland	15	0.4
Barren	-	0.0
Turfgrass	49	1.4
Developed, pervious	7	0.2
Developed, impervious	59	1.7
Total	*3,542*	*100*

Table 3-7. Land cover distribution in the Lower MF Holston, upstream of Rt. 91 watershed (excluding Upper MF Holston watershed).

Lower MF Holston, Upstream of Rt. 91 Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	848	0.7
Hay	10,953	9.5
Pasture	18,445	15.9
Forest	67,447	58.2
Trees	7,605	6.6
Shrub	832	0.7
Harvested/Disturbed	98	0.1
Water	248	0.2
Wetland	193	0.2
Barren	11	0.0
Turfgrass	5,312	4.6
Developed, pervious	403	0.3
Developed, impervious	3,486	3.0
Total	*115,884*	*100*

Table 3-8. Land cover distribution in the Lower MF Holston, Rt. 91 to Edmondson Dam watershed (excluding Lower MF Holston, Upstream of Rt. 91, Upper MF Holston, Byers Creek, Hall Creek, and Tattle Branch Watersheds).

Lower MF Holston, Rt. 91 to Edmondson Dam Watershed		
Land Cover Category	**Acres**	**Percentage**
Cropland	-	0.0
Hay	523	25.1
Pasture	710	34.0
Forest	537	25.7
Trees	156	7.5
Shrub	6	0.3
Harvested/Disturbed	-	0.0
Water	35	1.7
Wetland	1	0.1
Barren	7	0.3
Turfgrass	77	3.7
Developed, pervious	2	0.1
Developed, impervious	32	1.5
Total	*2,086*	*100*

3.5. Water Quality and Biological Monitoring Data

Biological, physical, and chemical data from 39 monitoring stations within the TMDL watersheds were used in developing the stressor analysis study. All monitoring stations provided water quality data, and 16 stations also have recorded benthic data. The data from these monitoring stations are explored in the attached benthic stressor analysis report (**Appendix D**) and benthic stations are summarized in **Table 3-9**. The various benthic monitoring stations are shown in **Figure 3-4**.

Table 3-9. Summary of benthic data collected in the study watersheds.

TMDL Watershed	Benthic Station ID	Location	Years Sampled
Byers Creek	6CBYS000.08	Rt. 735 at Bramblewood Farm	2002-2019
Tattle Branch	6CTAT000.50	Off Rt. 736 across from quarry	2005-2019
Cedar Creek	6CCED000.04	Rt. 706 bridge off Rt. 803 downstream of Mock Mill	2002
Cedar Creek	6CCED000.14	Off Rt. 803 downstream of Mock Mill	2012
Cedar Creek	6CCED001.01	Off Rt. 803	2005
Greenway Creek	6CGRW002.31	North of Neff	2008-2019
MF Holston	6CMFH011.31	Ford Off Rt 706 east of Neff	2007-2018
MF Holston	6CMFH023.41	East of Huff Airport	2005
MF Holston	6CMFH026.00	Off Rt. 608 Washington, Smyth Co. Line	2018
MF Holston	6CMFH032.39	Rt. 645 at railroad trestle above Seven Mile Ford	2000-2003
MF Holston	6CMFH033.40	Rt. 645 bridge at intersection with Rt. 64	2008
MF Holston	6CMFH045.83	Rt. 693 above Marion	2003-2018
MF Holston	6CMFH055.88	Rt. 680 at culvert	2008-2018
MF Holston	6CBER004.10	Off Rt. 694	2001-2004
MF Holston	6CHUT000.07	Near Mount Carmel	2007
MF Holston	6CHTO000.07	At Johnson Farm	2002-2012

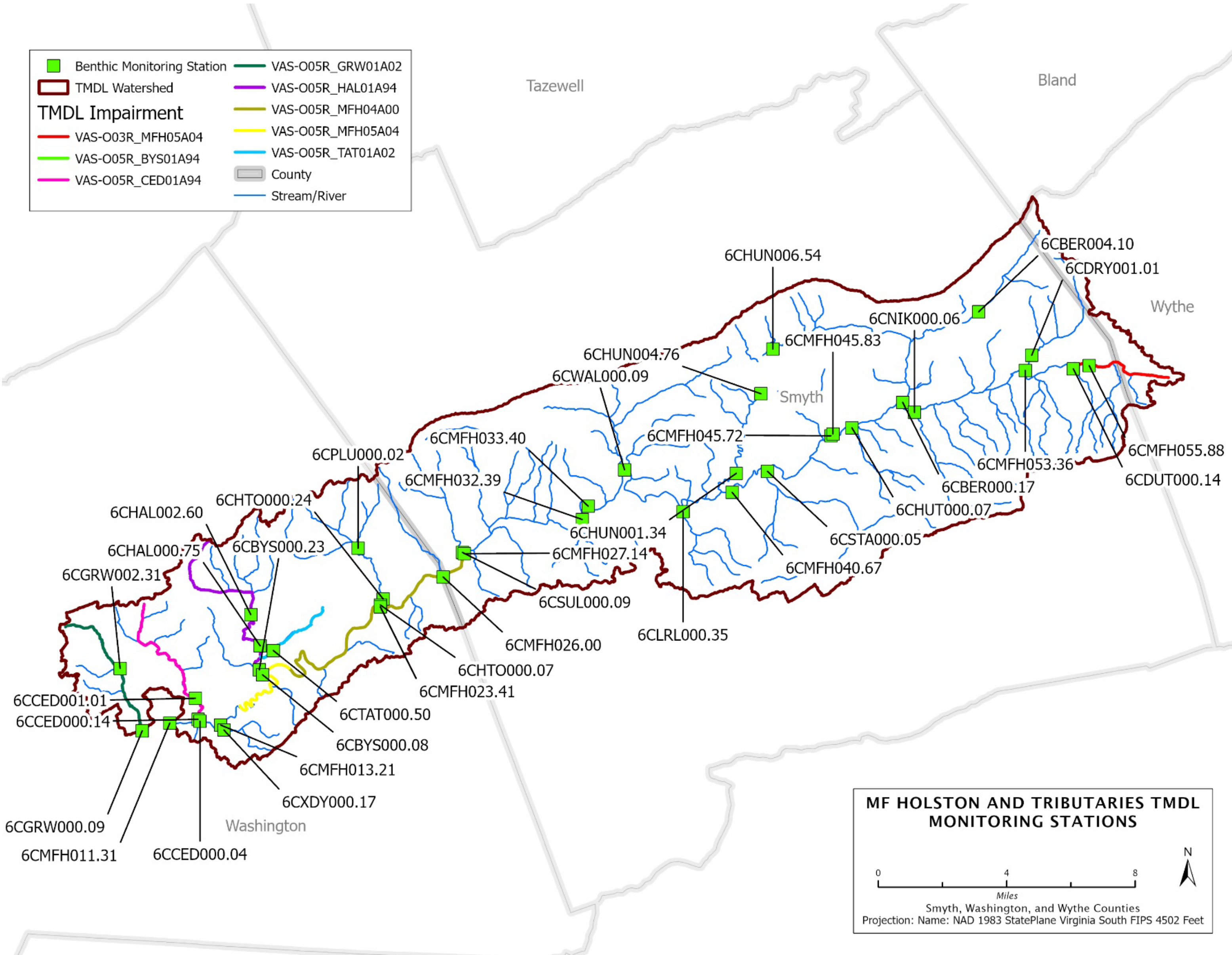

Figure 3-4. Locations of VADEQ monitoring stations in the Middle Fork Holston Watersheds.

4.0 MODELING PROCESS

A computer model was used in this study to simulate the relationship between pollutant loadings and in-stream water quality conditions.

4.1. Model Selection and Description

The model selected for development of the sediment TMDLs in the MF Holston and Tribs watersheds was the Generalized Watershed Loading Functions (GWLF) model, developed by Haith et al. (1992), with modifications by Evans et al. (2001), Yagow et al. (2002), and Yagow and Hession (2007). GWLF is based on loading functions, which are a compromise between the empiricism of export coefficients and the complexity and data-intensive nature of process-based simulations (Haith et al., 1992). GWLF operates in metric units, but outputs were converted to English units for this report.

GWLF is a continuous simulation model that operates on a daily timestep for water balance calculations and outputs monthly runoff, sediment, and nutrient yields for the watershed. The model allows for multiple different land cover categories to be incorporated, but spatially it is lumped, in the fact that it does not account for the spatial distribution of sources and has no method of spatially routing sources within the watershed.

Observed daily precipitation and temperature data is input, along with land cover distribution and a range of land cover parameters, which the model uses to estimate runoff and sediment loads in addition to dissolved and attached nitrogen and phosphorus loads. Surface runoff is calculated using the Soil Conservation Service Curve Number (SCS-CN) approach. Curve numbers are a function of soils and land use type. Erosion is calculated in GWLF based on the Universal Soil Loss Equation (USLE). USLE incorporates the erosivity of rainfall in the watershed area, inherent erodibility of the soils, length and steepness of slopes, as well as factors for cover and conservation practices that affect the impact of rainfall and runoff on the landscape. Impervious or urban sediment inputs are calculated in GWLF with exponential accumulation and washoff functions. GWLF incorporates a delivery ratio into the overall sediment supply to estimate sediment deposition before runoff carries it to a stream segment. GWLF's sediment transport algorithm takes into consideration the transport capacity of the runoff based on calculated runoff volume.

Stream bank and channel erosion is calculated using an algorithm by Evans et al. (2003) as incorporated in the AVGWLF (GWLF with an ArcView interface) version (Evans et al., 2001) of the GWLF model and corrected for a flow accumulation coding error (VADEQ, 2005). This algorithm incorporates the stream flow, fraction of developed land (i.e. impervious cover) in the watershed, and livestock density in the watershed with the area-weighted curve number and soil erodibility factors and the mean slope of the watershed.

Groundwater discharge to the stream is calculated using a lumped parameter for unsaturated and shallow saturated water zones throughout the watershed. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation from the unsaturated zone to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone contributes groundwater discharge to the stream based on a recession coefficient, and groundwater loss to a deep saturated zone can be modeled using a seepage coefficient.

4.2. Model Setup

Watershed data needed to run GWLF were generated using spatial data, water quality monitoring data, streamflow data, local weather data, literature values, stakeholder input, and best professional judgement. In general, the GWLF manual (Haith et al., 1992) served as the primary source of guidance in developing input parameters where newer published methods were not available. Values for the various GWLF input parameters for each model are detailed in **Appendix A**. A sensitivity analysis of the model to select parameters is presented in **Appendix B**.

Local weather data (spanning from April 1, 2000 to March 31, 2021) including daily rainfall and temperature data for the watershed was obtained from Oregon State's spatially distributed PRISM model (Parameter-Elevation Regressions on Independent Slopes Model), which interpolates available datasets from a range of monitoring networks and is used as the official spatial climate data sets of the USDA (PRISM, 2022). See Daly et al. 2008 for more information on the PRISM model. Daily weather was modeled at Seven Mile Ford (36.8079, -81.6195), near USGS gage #03474000, which was used for model calibration (see **Section 4.5**).

As the model does not account for the spatial distribution of sources and has no method of spatially routing sources within the watershed, the standard practice is to sub-divide larger watersheds into smaller subwatersheds that can be simulated individually to get a more granular assessment of the pollutant loads. The TMDL study area was divided into 20 subwatersheds to obtain a more granular assessment of the pollutant loads throughout the watershed. The TMDL study area was divided into 20 subwatersheds. The Lower MF Holston, Rt.91 to Edmondson Dam includes subwatersheds 2 through 18, with subwatershed 3 being the Lower MF Holston imapirment upstream of Rt. 91 and the Upper MF Holston impairment being subwatershed 9. Byers Creek encompasses subwatersheds 12 to 15, with Hall Creek being subwatershed 13, and Tattle Branch being subwatersheds 14 to 15. Cedar Creek encompasses subwatersheds 10 to 11 and Greenway Creek comprises of subwatersheds 19 to 20 (**Figure 4-1**). Locations of monitoring stations were used to guide subwatershed development to take advantage of available data. Junctions of streams were also used as breaking points to reduce subwatershed size, allowing large tributaries to be modeled independently.

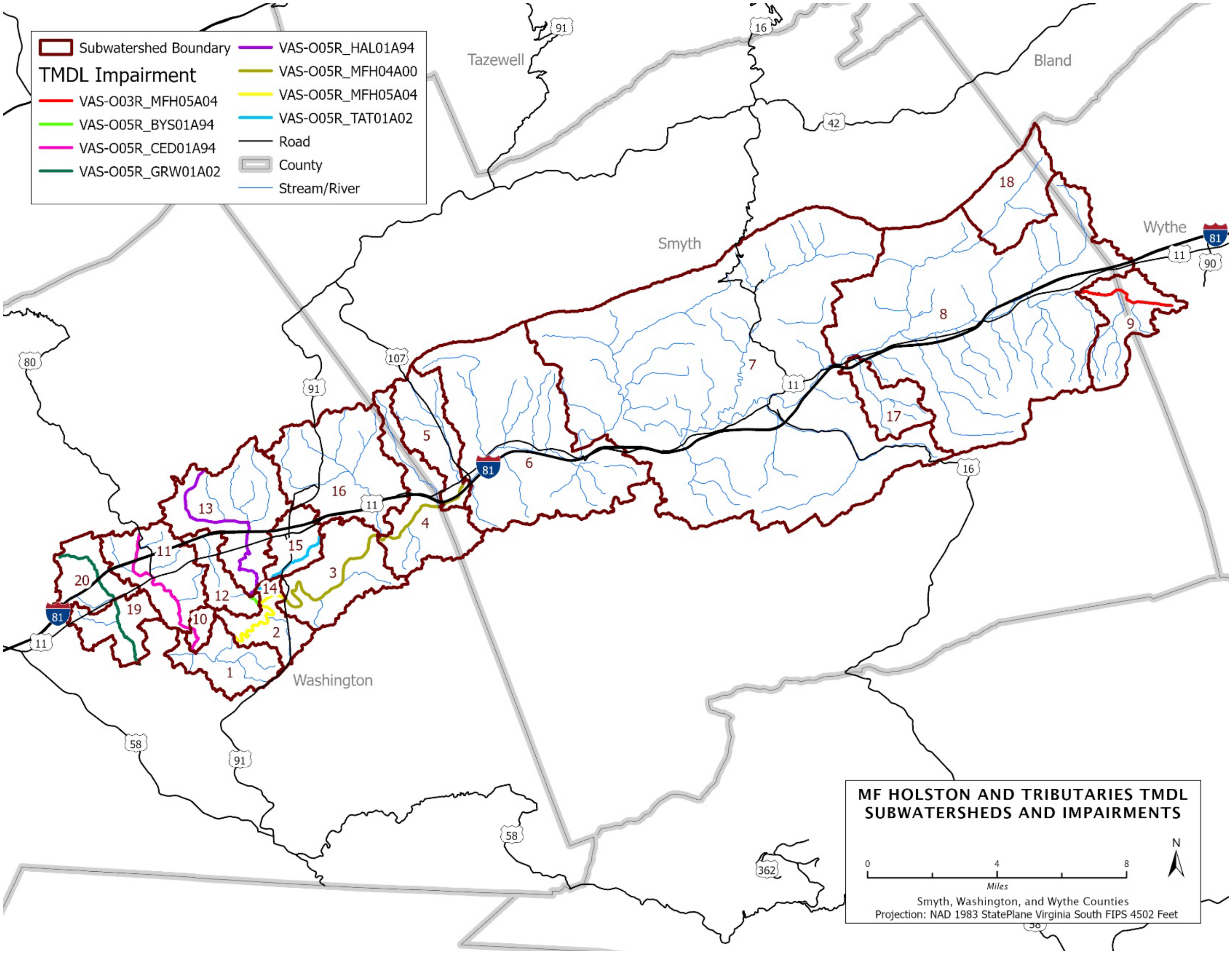

Figure 4-1. Middle Fork Holston TMDL model subwatersheds and impairments.

4.3. Source Assessment

Sediment can be delivered to streams by either point or nonpoint sources. Point sources include permitted sources such as water treatment facilities. Nonpoint sources encompass all of the other sources in the watersheds. Nonpoint sediment is primarily from surface runoff (all areas where drainage is not captured and converted to point source flows) and erosion happening within and on the banks of streams.

4.3.1. Nonpoint Sources

4.3.1.1. Surface Runoff

Sediment can be transported from both pervious and impervious surfaces during runoff events. Between rainfall events, sediment accumulates on impervious surfaces and can then be washed off these impervious surfaces by runoff. On pervious surfaces, soil particles are detached by rainfall impact and shear stress from overland flow and then transported with the runoff water to nearby streams. Various factors including rainfall intensity, storm duration, surface cover, topography, tillage practices, soil erosivity, and soil permeability all impact these processes.

VGIN 2016 land cover data was used to determine the distribution of different land cover types in the watersheds (with the modifications noted in **Section 3.4**) (VGIN, 2021). Values for various parameters affecting sediment loads were gleaned from literature guidance (CBP, 1998; Haith et al., 1992; Hession et al., 1997; CTBMPEP, 2016; SSDCEP, 2015). Slopes and overland flow lengths were generated based on elevation data from USGS 3D Elevation Program Digital Elevation Model (USGS 3DEP DEM) (USGS, 2022). Soil parameters were derived from the Soil Survey Geographic (SSURGO) dataset (USDA NRCS, 2022).

4.3.1.2. Streambank Erosion

Sediment is transported in stream systems as part of their natural processes. However, changes to the landscape can alter these processes, in turn changing the balance of sediment mobilization and deposition within the stream system.

Increases in impervious areas can increase the amount and rate of flow in streams following rainfall events, which provides more erosive power to the streams and increases the channel erosion potential. This is often the cause of the entrenchment, or downcutting, of urban streams – disconnecting higher flow events from the surrounding floodplain. The higher flows are then increasingly confined to the channel, thus mobilizing more sediment, both as total suspended sediment (TSS) in the water column and as bedload (the movement of larger particles along the bottom of the channel). Erosion of entrenched streams continues as steep banks are more susceptible to erosion and eventually mass wasting as chunks of undercut banks are dislodged into the stream. Sediment deposition between storm events and the highly mobile bed material during erosive storm flows negatively impact aquatic life.

Additionally, impacts to riparian (streambank) vegetation from livestock access and other management practices weaken the stability of the streambanks themselves as root system matrices break down. Weakened streambanks are more easily eroded by storm flows and can lead to excessive channel migration and eventual channel over-widening. Increasing channel width decreases stream depth which can lead to increased sediment deposition and increased water temperatures, which both negatively impact aquatic life.

Stream bank and channel erosion is calculated in GWLF using an algorithm by Evans et al. (2003) as incorporated in the AVGWLF version (Evans et al., 2001) of the GWLF model and corrected for a flow accumulation coding error (VADEQ, 2005). This algorithm estimates average annual streambank erosion as a function of cumulative stream flow, fraction of developed land (i.e., impervious cover) in the watershed, livestock density in the watershed, area-weighted curve number and soil erodibility factors, and the mean slope of the watershed. A calculated lateral erosion rate is then applied to an average bank height estimated from NRCS Regional Hydraulic Curves (USGS, 2005) and perennial stream length as estimated from the EPA ORD NHD at 1:100,000 scale. The EPA dataset was used rather than the USGS NHD at 1:24,000 scale due to inconsistencies in the delineation of intermittent and perennial streams in the study watersheds.

4.3.2. Point Sources

Various point sources of sediment exist within the MF Holston and Tribs watersheds. In this study, the permits included are based on data for July 2022. These point sources are permitted under the Virginia Pollutant Discharge Elimination System (VPDES) program and include individual permits as well as the following categories of general permits: potable water treatment plant, nonmetallic mineral mining, industrial stormwater, vehicle wash facility, domestic sewage, and construction stormwater. The approaches for determining loads from each of these permits are described below. Typically, wasteload allocations for VPDES general permits in a TMDL are aggregated by permit type.

As of the time of this report, there are no areas in the study watersheds covered by a Municipal Separate Storm Sewer System (MS4) permit. While Virginia Department of Transportation (VDOT) is required to comply with a statewide MS4 permit and I-81 and Route 11 both pass through the length of the watershed, VDOT's MS4 permit does not require special consideration for TMDL development outside of the census defined urban areas. Roads throughout the watersheds contribute sediment to the various drainage areas, and are included in the nonpoint source load associated with developed areas.

4.3.2.1. VPDES Individual Permit

There are three VPDES individual permits within the study area. The typical sediment load (Typical Load, lb/yr TSS) from the facilities were calculated from discharge monitoring report data and used to model existing conditions (**Table 4-1**). The permitted load, which is included in the wasteload allocation of the TMDL (Allocated Load, lb/yr TSS), was calculated based on the permitted discharge and concentration for each facility.

Table 4-1. Sediment loads associated with VPDES individual permit.

Permit No	Facility Name	Receiving Stream	Permitted Discharge (MGD)	Permitted Conc. (mg/L TSS)	Typical Load (lb/yr TSS)	Allocated Load (lb/yr TSS)
VA0026379	Chilhowie Regional Wastewater Treatment Plant	Lower MF Holston	0.999	30	3,454.7	91,279.3
VA0054381	DGIF - Marion State Fish Hatchery	Lower MF Holston	2.3	10	29,934.2	70,050.9
VA0087378	Washington Cnty Service Authority -Hall Creek WWTP	Hall Creek	0.95	30	6,136.8	86,802.2

4.3.2.2. Potable Water Treatment Plant General Permit

There is one VPDES potable water treatment plant (PWTP) general permit within the study area, associated with the Hutton Branch Water Treatment Plant (**Table 4-3**). The typical and permitted loads were calculated using the same method as for the VPDES individual permit.

Table 4-2. Sediment load associated with the potable water treatment general permit.

Permit No	Facility Name	Receiving Stream	Estimated Maximum Discharge (MGD)	Permitted Conc. (mg/L TSS)	Typical Load (lb/yr TSS)	Permitted Load (lb/yr TSS)
VAG640016	Hutton Branch Water Treatment Plant	Upper MF Holston	0.075	30	1,608	6,853

4.3.2.1. Nonmetallic Mineral Mining (NMMM) General Permit

There are two non-metallic mineral mining (NMMM) permits in the watershed for Cardinal Quarries – Bear Creek Quarry and Appalachian Aggregates LLC – Glade Stone Plant (**Table 4-3**). Process water from these facilities is from permitted sources of sediment at an average concentration of 30 mg/L TSS. Discharge rates were calculated based on provided DMR data. Outfalls associated with permit VAG840023 are identified as stormwater runoff only, without process water contribution. This permit is instead handled in the same way as Industrial Stormwater General Permits by using a 440 lb/ac/yr TSS loading rate to calculate the allocated load.

Table 4-3. Nonmetallic mineral mining general permits in the study area.

Permit No	Facility Name	Watershed	Average Flow (MGD)	Permitted Conc (mg/L TSS)	Typical Load (lb/yr TSS)	Allocated Load (lb/yr TSS)
VAG840023	Cardinal Quarries – Bear Creek Quarry	Lower MF Holston	-	-	-	26,708
VAG840153	Appalachian Aggregates LLC - Glade Stone Plant	Tattle Branch	0.04	30	856.23	3,347

4.3.2.2. Industrial Stormwater General Permit

There are seventeen industrial stormwater (ISW) general permits in the study area (**Table 4-5**). Sediment loads from industrial stormwater permits are included in this study. There is not currently a permitted loading rate for sediment for industrial stormwater sources in the general permit. However, the Chesapeake Bay TMDL now requires permittees to assess their discharges to determine if they are meeting benchmark pollutant concentrations for nutrients and sediment. As such, VADEQ developed a methodology to estimate the loads from ISW permitted areas. To develop existing loads, the regulated acreages for the permits were subtracted from the accounting of total acreages for the watershed. The allocated loads were calculated using the regulated industrial acreage and applying the loading rate of 440 lb/ac/yr TSS noted in the general permit. This value is cited in the permit (9VAC25-151-70) as used to estimate the loading from industrial stormwater facilities in Chesapeake Bay TMDL documentation.

Table 4-4. Industrial stormwater general permits in the study area.

Watershed	Permit No	Facility Name
Lower Middle Fork Holston	VAR050042	Marion Mold and Tool Incorporated
	VAR050045	Utility Trailer Manufacturing Co - Atkins
	VAR050132	Berry Iron and Metal
	VAR051525	General Dynamics Mission Systems - Marion Plant #3
	VAR051556	Rolling Frito Lay Sales LP - Marion Bin
	VAR051655	Royal Mouldings Limited
	VAR051781	D and D Sales
	VAR051866	American Wood Fibers
	VAR052229	C and A Fabricating Inc
	VAR052242	Heniff - Marion Terminal
	VAR052400	Mountain Empire Airport
Tattle Branch	VAR050748	Utility Trailer Manufacturing Company - Glade
Byers/Hall Creek	VAR052033	Larrys Used Auto Parts Inc
Greenway Creek	VAR050029	Wolf Hills Fabricators LLC
	VAR050035	Strongwell Highlands
	VAR051973	MXI Environmental Services LLC
	VAR052061	Hapco - Division of Kearney National Incorporated

4.3.2.3. Vehicle Wash Facility General Permit

There is one vehicle wash facility general permit in the watershed (**Table 4-5**). The discharge rate was based on provided permit data. Allocated sediment loads were calculated using the permitted discharge rate and the TSS concentration of 60 mg/L listed in the general permit.

Table 4-5. Vehicle wash facility general permits in the study area.

Permit No	Facility Name	Watershed	Permitted Discharge (MGD)	Permitted Conc. (mg/L TSS)	Typical Load (lb/yr TSS)
VAG750216	Azam Samma LLC - Samma Foodmart 2	Cedar Creek	0.005	60	913.71

4.3.2.4. Domestic Sewage General Permit

There are 13 domestic sewage general permits in the study area (**Table 4-6**). The domestic sewage general permit specifies a maximum flow rate of 1000 gallons per day at a sediment concentration of 30 mg/L. These permit limits were used to calculate a wasteload allocation of 91.44 lb/yr TSS for each of the domestic sewage permits in the TMDL.

Table 4-6. Domestic sewage general permit in the study area.

Receiving Stream	Permit Number	Aggregate Permitted Load (lb/yr TSS)
Cedar Creek	VAG409006	182.88
	VAG409187	
Greenway Creek	VAG400324	182.88
	VAG400585	
Lower MF Holston, Rt. 91 to Edmondson Dam	VAG400491	91.44
Lower MF Holston, upstream of Rt. 91.	VAG400071	731.52
	VAG400078	
	VAG400102	
	VAG400181	
	VAG400548	
	VAG400576	
	VAG400579	
	VAG409177	

4.3.2.5. Construction Stormwater General Permit

There are 18 active Virginia Stormwater Management Program (VSMP) permits for construction within the watersheds at the time of TMDL development (**Table 4-7**). These permits are a potential source of sediment and were assigned waste load allocations in the TMDL. Each permit contains an estimate of the permitted disturbed area; however, this area is generally not disturbed for the entire length of the permit's active status. To account for this discrepancy, the acreage estimated to be disturbed for each permit was divided over the length of the permit's active status (no less than one year). Any active permits in process of termination were excluded because at that stage in the permitting cycle all areas are stabilized.

Table 4-7. Disturbed acreage associated with active construction general permits within the watersheds.

Receiving Stream	Estimated Potential Disturbed Area (ac)
Greenway Creek	4.0
Middle Fork Holston above Rt. 91	80.3
Total	**84.3**

Disturbed acreage associated with construction permits was modeled as barren land cover, and the acres allocated to construction permits subtracted proportionally from all land cover values in the watershed so that areas were not double counted when developing the existing load estimates. Appropriate erosion and sediment control measures were assumed to be utilized on all construction projects, and for developing final WLAs for the allocation scenarios, loads were simulated with an 85% sediment removal efficacy based on Chesapeake Bay Expert Panel Guidance (ESCEP, 2014).

There have been no VSMP Construction General Permits within the past ten years in the Cedar Creek, Byers Creek, Hall Creek, Tattle Branch, or Upper Middle Fork Holston watersheds. To account for future construction permits in these watersheds, a portion of the TMDL was set aside (see **Section 6.0**) to address potential future construction efforts in the study watersheds.

To guide sizing this allocation, the VSMP construction permit loads developed for the two watersheds that did have active construction permits were analyzed. For the Greenway Creek watershed, the load calculated for the 4.0 ac permitted area was 0.26% of the total target TMDL load. For the Beaverdam Creek watershed, the load calculated for the 80.3 acres of permitted area was 0.17% of the total target TMDL load. The average of the percent of the TMDL target allocated to construction general permits in these watersheds with available permit data, 0.2%, was used to set an allocation for construction general permits in the watersheds that had no available data on construction general permits.

4.4. Best Management Practices

Many entities and private citizens have installed best management practices (BMPs) throughout the watersheds. Some BMPs have associated removal efficacies defined in the literature, which can be applied to the raw pollutant accumulation loads for the land areas draining to the BMP. Other BMPs can be simulated as a change in land use over the treated acreage, such as planting a riparian buffer and turning previous pastureland into forested areas. The active BMPs installed in the study watersheds included in the model are detailed in **Table 4-8**, along with their various removal efficacies. The Chesapeake Bay Phase 5.3 Community Model Documentation Section 6 (USEPA, 2010) was used to guide the TSS and TP removal estimates. Many more BMPs have been implemented in the watersheds but are not included in these calculations. This is because many of these BMPs, such as septic pump outs and replacements, specifically address bacteria and/or nutrient loads, but not sediment. This table was presented to the TAC at their second meeting and no changes were suggested.

Table 4-8. BMPs installed in the MF Holston and Tribs watershed.

Receiving Stream	Practice	Count	Extent Installed	Efficacy method (fraction removal, other)	TSS Removal (lb/year)
Lower MF Holston, Rt. 91 to Edmondson Dam	CREP Woodland Buffer Filter Area (CRFR-3)	1	1.04 ac	0.4	1,613
	CREP Stream Exclusion with Grazing Land Management (CRSL-6)	2	4,400 ln. ft	0.4, 0.24*	6,605
	Long Term Vegetative Cover on Cropland (SL-1)**	2	16 ac	Land cover change	29,657
	Stream Exclusion with Grazing Land Management (SL-6)	3	1,600 ln. ft	0.4, 0.24*	17,188
Lower MF Holston, upstream of Rt. 91	CREP Woodland Buffer Filter Area (CRFR-3)	7	24.1 ac	0.4	8,740
	CREP Stream Exclusion with Grazing Land Management (CRSL-6)	4	4,970 ln. ft	0.4, 0.24*	17,986
	Long Term Vegetative Cover on Cropland (SL-1)	1	33 ac	Land cover change	8,867
	Stream Exclusion with Grazing Land Management (SL-6)	8	25,951 ln. ft	0.4, 0.24*	47,385
	Grazing Land Management (SL-10)	2	142.98 ac	0.24	13,019
Upper MF Holston	CREP Woodland Buffer Filter Area (CRFR-3)	3	1.84 ac	0.4	8,071
	CREP Stream Exclusion with Grazing Land Management (CRSL-6)	2	1,146 ln. ft	04., 0.24*	1,884
	Livestock Exclusion with Riparian Buffers for TMDL Imp. (LE-1T)	2	1,300 ln. ft	0.6	2,384
	Stream Exclusion with Grazing Land Management (SL-6)	4	3,660 ln. ft	0.4, 0.24*	20,487
	Grazing Land Management (SL-10)	1	32.5 ac	0.24	8,177

Receiving Stream	Practice	Count	Extent Installed	Efficacy method (fraction removal, other)	TSS Removal (lb/year)
Cedar Creek	Stream Exclusion with Grazing Land Management (SL-6)	1	600 ln. ft	0.4, 0.24*	2,359
Byers Creek	CREP Woodland Buffer Filter Area (CRFR-3)	1	0.48 ac	0.4	371
	Stream Exclusion with Grazing Land Management (SL-6)	2	612 ln. ft	0.4,0.24*	9,209
	Grazing Land Management (SL-10)	1	117.43 ac	0.24	22,050
Hall Creek	CREP Woodland Buffer Filter Area (CRFR-3)	3	6.27 ac	0.4	3,683
	CREP Stream Exclusion with Grazing Land Management (CRSL-6)	3	3,080 ln. ft	0.4, 0.24*	49,759
	Long Term Vegetative Cover on Cropland (SL-1)	1	16.5 ac	Land cover change	11,779
	Stream Exclusion with Grazing Land Management (SL-6)	1	600 ln. ft	0.4, 0.24*	1,416
Tattle Branch	CREP Woodland Buffer Filter Area (CRFR-3)	1	0.36 ac	0.4	300
	CREP Stream Exclusion with Grazing Land Management (CRSL-6)	1	500 ln. ft	0.4, 0.24*	6,714
Greenway Creek	Stream Exclusion with Grazing Land Management (SL-6)	1	150 ln. ft	0.4, 0.24*	7,874

*No more than two times the acreage of the buffer area itself gets the filter reduction, otherwise landcover change; 0.4 TSS filtered area, 0.24 TSS Grazing management.

**No cropland was identified in the VLCD dataset, so model results of 'poor pasture' were used to generate reductions for SL-1, and the reductions applied to allocation loads of poor pasture.

4.5. Flow Calibration

GWLF was originally developed as a planning tool for estimating nutrient and sediment loadings in ungauged watersheds and was designed to be implemented without calibration. When appropriate data is available for comparison, though, calibration can improve the accuracy of GWLF. Because data was available, hydrologic calibration was performed as a preliminary modeling step to ensure that hydrology was being simulated as accurately as feasibly possible.

Historic daily flow data was available from USGS flow gauge #03474000 Middle Fork Holston at Seven Mile Ford from 1942 to present. Daily rainfall and temperature data for the watershed was obtained from Oregon State's spatially distributed PRISM model (Parameter-Elevation Regressions on Independent Slopes Model), which interpolates available datasets from a range of monitoring networks and is used as the official spatial climate data set of the USDA (PRISM, 2022). PRISM was utilized to obtain a more exact estimate of historic weather within the watershed, rather than relying on a nearby gauge outside of the watershed. See Daly et al. 2008 for more information on the PRISM model. Leaving a 'warm-up' period for the model (year 2000), the years from 2011 to 2020 were used as the calibration period, and years 2001 to 2010 were used as a validation dataset. These ranges are sufficiently long that a range of both dry and wet years are encompassed in each to better assess the model's performance.

Calibration efforts focused on adjusting watershed scale parameters, such as the recession coefficient and seepage coefficient, that cannot be calculated or estimated reliably from available guidance. The typical target ranges for GWLF calibration efforts are to achieve ±5% of the observed total flow and ±20% compared to seasonal flow distribution. While calibration efforts make a best effort at meeting the target for all criteria, this is not always possible as no model is a perfect simulation of the reality it is approximating. The final GWLF calibration results are shown in **Figure 4-2** and **Figure 4-3** and summarized in **Table 4-9**. The results of the calibration were also assessed for overall correlation by calculating an R^2 value for the datasets. Generally, for GWLF, an R^2 value greater than 0.7 indicates a strong positive correlation between simulated and observed data. Following calibration, the model output was run compared to the observed 2001-2010 discharge as a validation of the model calibration. The final GWLF validation results are summarized in **Table 4-9** and shown in **Figure 4-4** and **Figure 4-5**. All cumulative and seasonal target ranges were achieved for percent difference between simulated and observed flow, and R^2 values were 0.78 for the calibration range and 0.64 for the validation range.

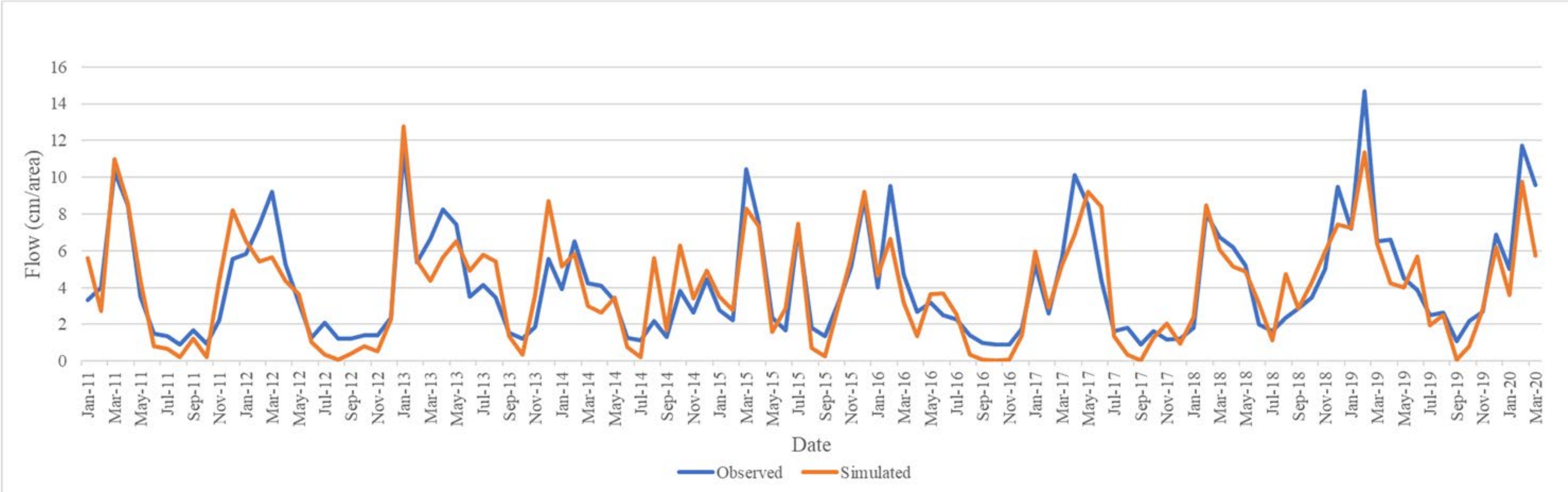

Figure 4-2. Calibration data set of simulated stream flow compared to observed flow (USGS#03474000).

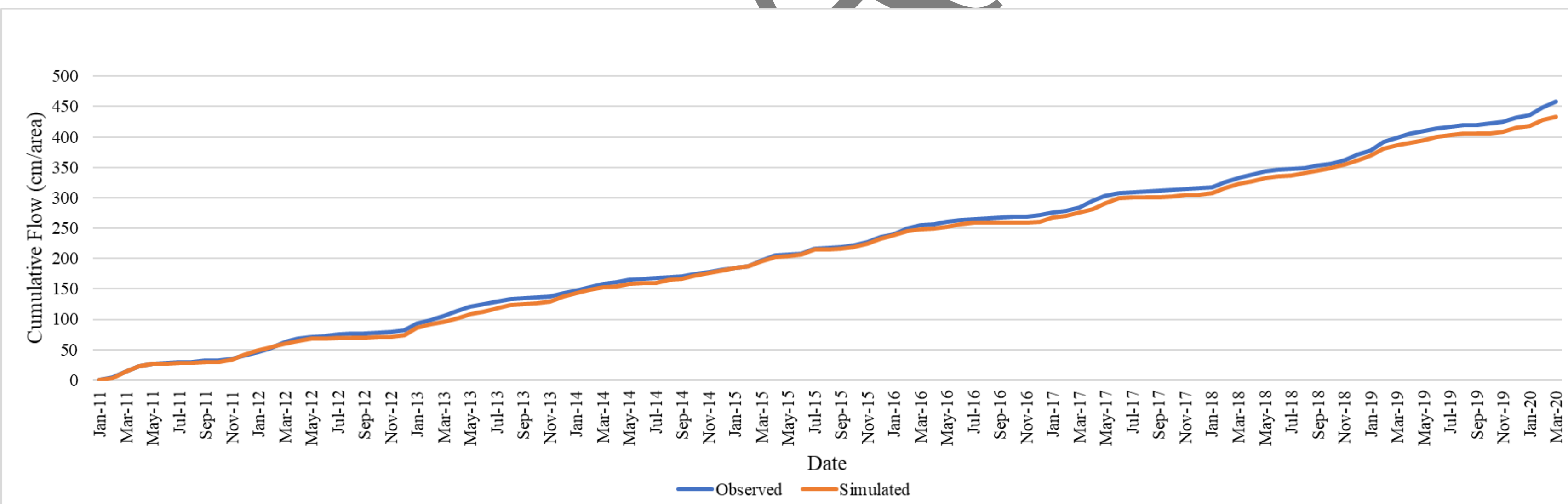

Figure 4-3. Calibration data set simulated cumulative flow from model compared to observed (USGS#03474000).

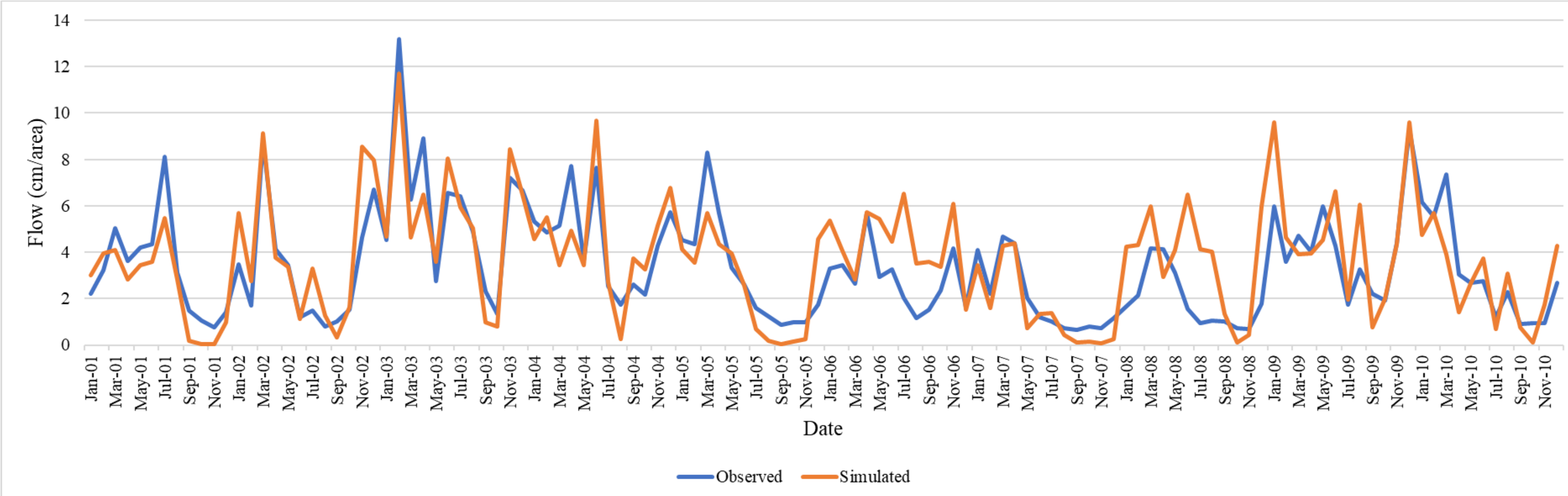

Figure 4-4. Validation data set of simulated stream flow compared to observed flow (USGS#03474000).

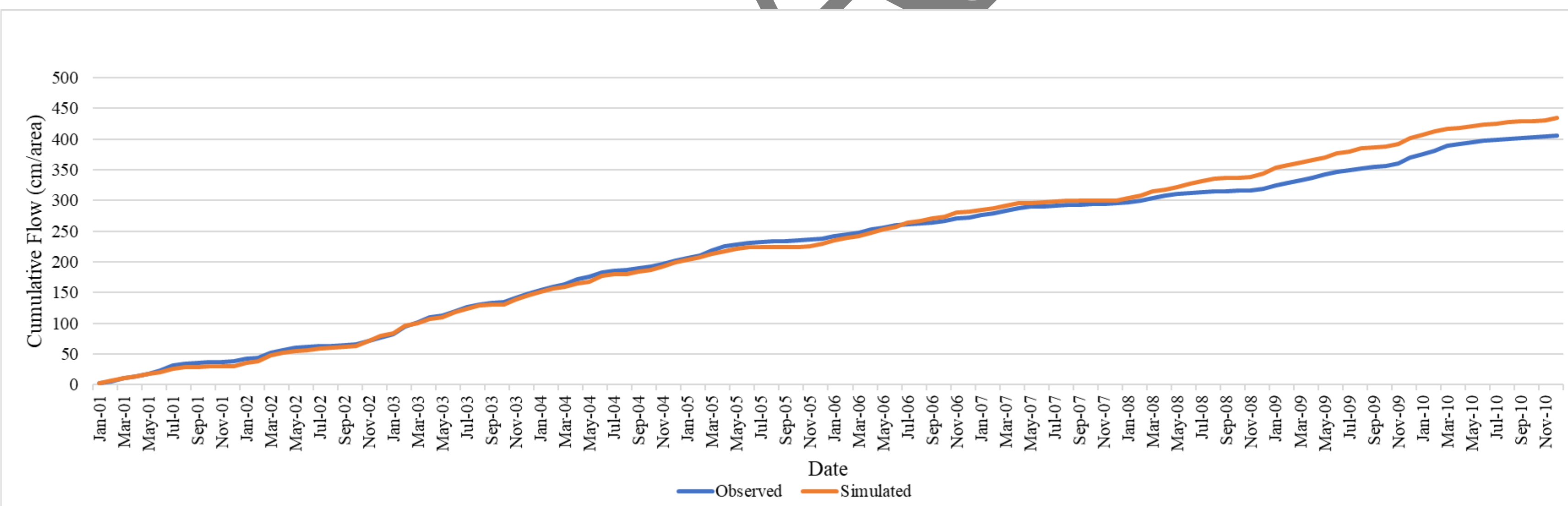

Figure 4-5. Validation data set simulated cumulative flow from model compared to observed (USGS#03474000).

Table 4-9. Results of hydrology calibration of GWLF model compared to observed data.

Criteria	Calibration Range Percent Difference (%)	Validation Range Percent Difference (%)
Total Cumulative Discharge	-4.50	6.94
Spring Discharge	-2.91	2.36
Summer Discharge	-9.57	14.68
Fall Discharge	7.81	16.88
Winter Discharge	-9.59	1.78
R^2	0.78	0.64

4.6. Consideration of Critical Conditions and Seasonal Variations

To quantify existing conditions and develop reduction allocations, the GWLF model simulated a 20-year period (2000 through 2020) with an additional buffer period of nine months at the beginning of the run serving as a ‘warm-up’ period for the model to equilibrate and minimize the impact of uncertain initial conditions. Using this extended modeling period allows the results to account for both annual and seasonal variations in hydrology and sediment loads.

The modeled time period encompasses a range of weather conditions for the area, including ‘dry’, ‘normal’, and ‘wet’ years, which allows the model to represent critical conditions during both low and high flows. Critical conditions during low flows are generally associated with point source loads, while critical conditions during high flows are generally associated with nonpoint source loads.

GWLF considers seasonal variation through several mechanisms. Daily time steps are used for weather data inputs and water balance equation calculations. GWLF also incorporates parameters that vary by month, including evapotranspiration cover coefficients and average hours per day of daylight. Additionally, the values for the rainfall erosivity coefficient are dependent on whether a given month is tagged as part of the growing season.

4.7. Existing Conditions

Existing sediment loads from the impaired watersheds were simulated in GWLF as described above. **Table 4-10** through **Table 4-17** summarize the resulting loads after applying the attenuation factors discussed in **Section 4.2**. While the model is run using weather data from a several year period to capture the range of seasonal and annual variation, the land cover and sources within the model do not vary over time as the model runs. Instead, the land cover and pollutant sources simulate a snapshot in time representing available data and active permits. In this model, the land cover is from 2016, and the permits and BMPs included are reflective of conditions in July 2022. These dates reflect the collected water quality monitoring data used to determine the necessity of developing this TMDL and to gauge the existing conditions in the model results. The monitoring window for sediment data analyzed for this study ran through June 2021.

Any apparent differences in calculated values are due to rounding. Model results and calculated totals of those results were rounded to four significant figures.

Table 4-10. Existing sediment loads in the Tattle Branch watershed, accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Tattle Branch Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	116,700	16.0
Hay	12,880	1.8
Pasture	380,900	52.2
Forest	2,008	0.3
Trees	3,869	0.5
Shrub	2,665	0.4
Harvested/Disturbed	0	0.0
Wetland	327	0.0
Barren	8,968	1.2
Turfgrass	10,680	1.5
Developed, pervious	2,232	0.3
Developed, impervious	164,400	22.5
Streambank	15,060	2.1
Permitted	9,452	1.3
Total	730,100	100

Table 4-11. Existing sediment loads in the Hall Creek watershed (excluding Tattle Branch watershed), accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Hall Creek Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	109,900	7.1
Hay	31,390	2.0
Pasture	902,800	58.3
Forest	20,120	1.3
Trees	12,710	0.8
Shrub	4,986	0.3
Harvested/Disturbed	61,140	3.9
Wetland	4,968	0.3
Barren	37,110	2.4
Turfgrass	14,230	0.9
Developed, pervious	2,321	0.1
Developed, impervious	195,900	12.7
Streambank	141,700	9.2
Permitted	8,936	0.6
Total	*1,548,000*	*100*

Table 4-12. Existing sediment loads in the Byers Creek watershed (excluding Hall Creek and Tattle Branch watersheds), accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Byers Creek Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	29,140	5.1
Hay	15,580	2.7
Pasture	443,100	77.6
Forest	1,747	0.3
Trees	4,503	0.8
Shrub	950	0.2
Harvested/Disturbed	-	-
Wetland	-	-
Barren	-	-
Turfgrass	6,069	1.1
Developed, pervious	707	0.1
Developed, impervious	45,580	8.0
Streambank	14,870	2.6
Permitted	8,682	1.5
Total	*570,900*	*100*

Table 4-13. Existing sediment loads in the Cedar Creek watershed, accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Cedar Creek Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	150,700	12.4
Hay	32,530	2.7
Pasture	758,000	62.3
Forest	5,202	0.4
Trees	7,741	0.6
Shrub	1,949	0.2
Harvested/Disturbed	867	0.1
Wetland	288	0.0
Barren	-	-
Turfgrass	16,320	1.3
Developed, pervious	1,967	0.2
Developed, impervious	161,100	13.2
Streambank	79,410	6.5
Permitted	1,317	0.1
Total	*1,217,000*	*100*

Table 4-14. Existing sediment loads in the Greenway Creek watershed, accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Greenway Creek Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	38,010	2.9
Hay	37,190	2.8
Pasture	839,600	64.1
Forest	16,470	1.3
Trees	9,453	0.7
Shrub	1,895	0.1
Harvested/Disturbed	1,046	0.1
Wetland	681	0.1
Barren	18,890	1.4
Turfgrass	14,230	1.1
Developed, pervious	2,706	0.2
Developed, impervious	216,600	16.5
Streambank	70,500	5.4
Permitted	41,540	3.2
Total	*1,309,000*	*100*

Table 4-15. Existing sediment loads in the Upper MF Holston watershed, accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Upper MF Holston Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	49,140	4.0
Hay	33,120	2.7
Pasture	986,300	80.4
Forest	36,790	3.0
Trees	10,500	0.9
Shrub	3,316	0.3
Harvested/Disturbed	-	-
Wetland	1,811	0.1
Barren	-	-
Turfgrass	2,166	0.2
Developed, pervious	1,157	0.1
Developed, impervious	44,760	3.7
Streambank	52,900	4.3
Permitted	4,329	0.4
Total	*1,226,000*	*100*

Table 4-16. Existing sediment loads in the Lower MF Holston, Upstream of Rt. 91 watershed (excluding Upper MF Holston Watershed), accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Lower MF Holston, Upstream of Rt. 91 Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	235,100	0.6
Hay	209,100	0.5
Pasture	6,906,000	16.9
Forest	1,128,000	2.8
Trees	122,600	0.3
Shrub	70,950	0.2
Harvested/Disturbed	17,900	0.0
Wetland	7,032	0.0
Barren	91,140	0.2
Turfgrass	80,830	0.2
Developed, pervious	14,700	0.0
Developed, impervious	2,452,000	6.0
Streambank	29,290,000	71.6
Permitted	300,800	0.7
Total	*40,930,000*	*100*

Table 4-17. Existing sediment loads in the Lower MF Holston, Rt. 91 to Edmondson Dam watershed (excluding Lower MF Holston, Upstream of Rt. 91, Upper MF Holston, Byers Creek, Hall Creek and Tattle Branch Watersheds), accounting for known BMPs (not including MOS or FG detailed in Section 6.0).

Lower MF Holston, Rt. 91 to Edmondson Dam Watershed		
Land Cover Category	**TSS (lb/yr)**	**Percentage**
Cropland	-	-
Hay	21,230	2.4
Pasture	562,700	63.7
Forest	8,338	0.9
Trees	4,162	0.5
Shrub	668	0.1
Harvested/Disturbed	-	-
Wetland	133	0.0
Barren	132,100	14.9
Turfgrass	2,809	0.3
Developed, pervious	168	0.0
Developed, impervious	20,340	2.3
Streambank	43,720	4.9
Permitted	87,680	9.9
Total	*884,000*	*100*

5.0 SETTING TARGET SEDIMENT LOADS

TMDL development requires an endpoint or water quality goal to target the impaired watershed(s). Many pollutants have numeric water quality criteria set in regulatory documentation, and it is assumed that compliance with these numeric criteria will lead the waterbody to achieve support of all designated uses. However, sediment does not have a numeric criterion established, as the acceptable level is expected to vary from stream to stream based on a range of contributing factors. Therefore, an alternative method must be used to determine the water quality target for sediment TMDLs.

The method used to set TMDL endpoint loads for the MF Holston and Tribs watersheds is called the “all-forest load multiplier” (AllForX) approach, which has been used in developing many sediment TMDLs in Virginia since 2014. AllForX is the ratio of the simulated pollutant load under existing conditions to the pollutant load from an all-forest simulated condition for the same watershed. In other words, AllForX is an indication of how much higher current sediment loads are above an undeveloped condition. These ratios were calculated for the watersheds of monitoring stations within the impaired watersheds as well as other nearby watersheds of similar size and within the same ecoregion as the TMDL watersheds (**Appendix C**). AllForX ratios were calculated for a total of 14 monitoring stations.

Three separate regressions were then developed using the 33rd percentile of Virginia Stream Condition Index (VSCI) scores at monitoring stations and the corresponding AllForX ratio calculated for each station. The 33rd percentile was used because DEQ biologists often prefer two consecutive years of benthic monitoring above the VSCI threshold of 60 to account for seasonal and annual variation before classifying the stream as unimpaired and delisting the stream. Based on a 6-yr assessment window and typical DEQ monitoring every 2 years, no more than a third (33%) of benthic scores could be below the threshold of 60 and meet the recommendations for delisting. This approach accounts for natural variability in VSCI scores over time and considers the methodology for assessing and delisting Virginia streams. Due to the variety of watersheds and impairments included in the study, three separate regressions were developed. The first regression was developed for watersheds with greater than 45,000 acres. Based on the first regression, a 33rd percentile VSCI score of 60 corresponded to a target AllForX ratio of 2.5 (**Figure 5-1**). The second regression was developed for watersheds less than 10,000 acres and impaired watersheds with less than 5.5% impervious landcover. In the second regression, a 33rd percentile VSCI score of 60 corresponded to a target AllforX ratio of 15.91 (**Figure 5-2**). The third regression was developed for watersheds less than 10,000 acres and impaired watersheds with greater than 10% impervious landcover. In the third regression, a 33rd percentile VSCI score of 60 corresponded to a target AllforX ratio of 30.92 (**Figure 5-3**). **Table 5-1** shows the target ratios developed for the MF Holston and Tribs. This means that the TMDL streams are expected to achieve consistently healthy benthic conditions if sediment loads are less than 2.5, 15.91, or 30.92 times the simulated load of an all-forested watershed, depending on the watershed. The AllForX target was then used to determine the allowable pollutant TMDL loads in each of the study watersheds.

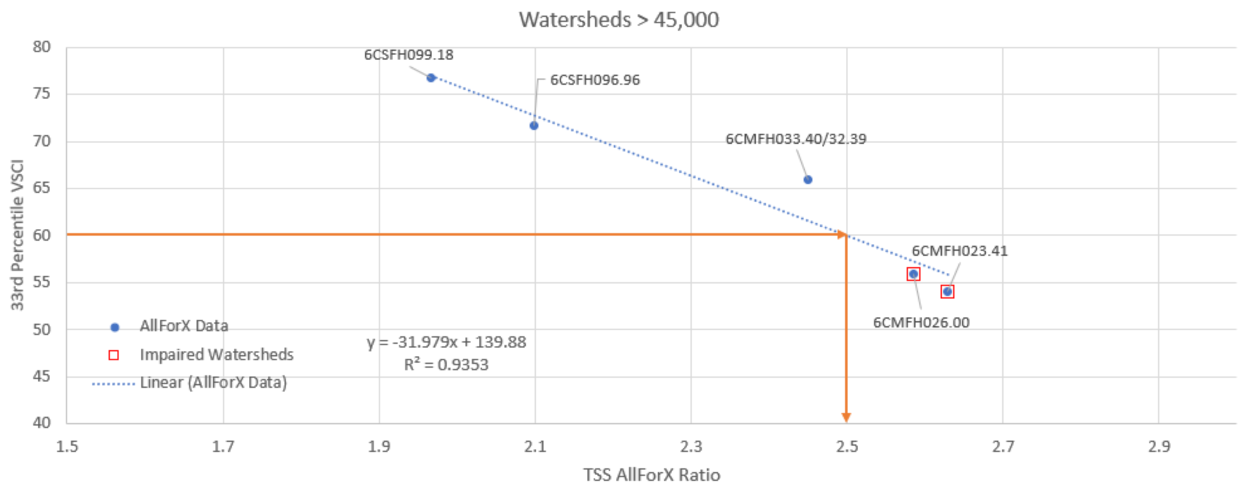

Figure 5-1. Regression between stream condition index and all-forest multiplier for sediment in the TMDL watersheds larger than 45,000 acres using the 33rd percentile of VSCI scores, resulting in an AllForX target value of 2.5.

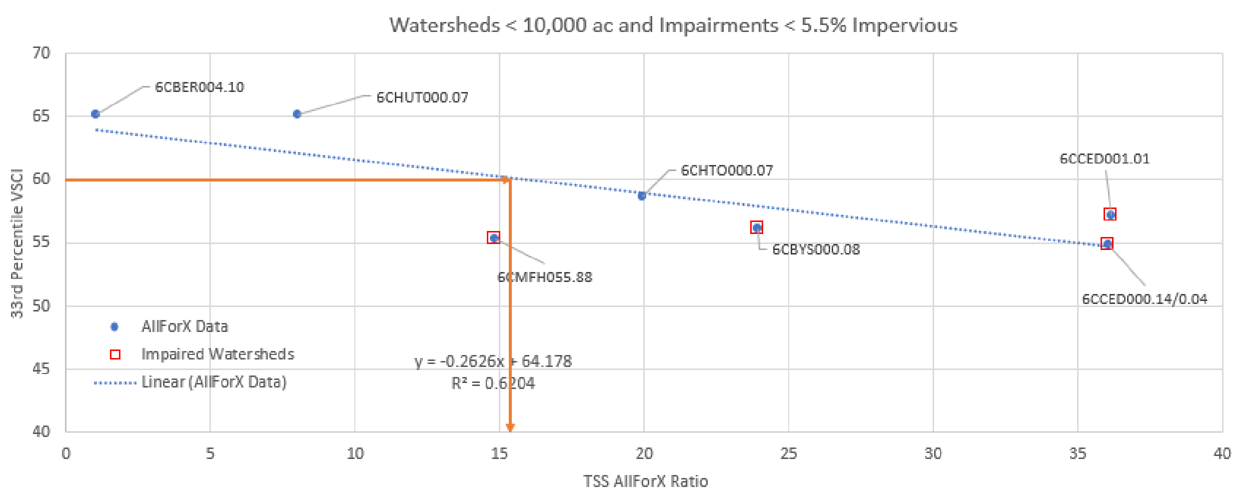

Figure 5-2. Regression between stream condition index and all-forest multiplier for sediment in the TMDL watersheds <10,000 ac and <5.5% impervious cover using the 33rd percentile of VSCI scores, resulting in an AllForX target value of 15.91.

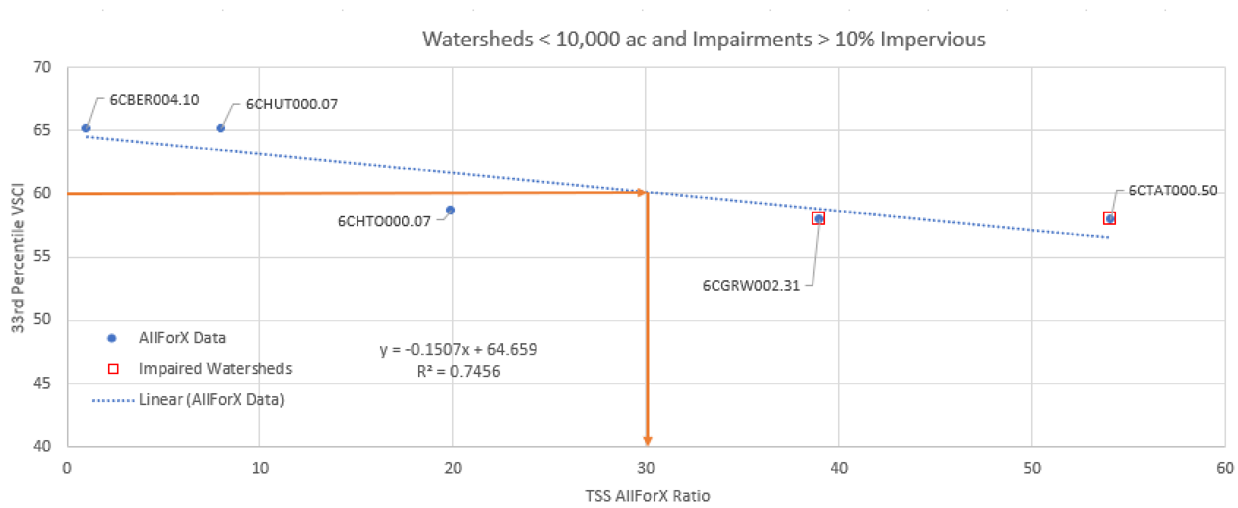

Figure 5-3. Regression between stream condition index and all-forest multiplier for sediment in the TMDL watersheds <10,000 ac and >10% impervious using the 33rd percentile of VSCI scores, resulting in an AllForX target value of 30.92.

Table 5-1. Target sediment loading rates and reductions as determined by AllForX regressions for MF Holston and Tribs TMDL.

Impaired Stream	AllforX Target Ratio	TSS All-Forested (lb/yr)	TSS Target (lb/yr)
Lower MF Holston, Rt. 91 to Edmondson Dam	2.5	17,533,093	43,795,725
Lower MF Holston, upstream of Rt. 91	2.5	15,668,467	39,138,096
Upper MF Holston	15.91	85,514	1,360,536
Cedar Creek	15.91	33,796	537,701
Byers Creek	15.91	104,791	1,667,235
Hall Creek	15.91	87,975	1,399,687
Tattle Branch	30.92	13,619.9	421,070
Greenway Creek	30.92	39,609	1,224,530

6.0 TMDL ALLOCATIONS

Total maximum daily loads are determined as the maximum allowable load of a pollutant among the various sources. Part of developing a TMDL is allocating this load among the various sources of the pollutant of concern (POC). Each TMDL is comprised of three components, as summed up in this equation:

$$TMDL = \sum WLA + \sum LA + MOS$$

where ΣWLA is the sum of the wasteload allocations (permitted sources),
ΣLA is the sum of the load allocations (nonpoint sources), and
MOS is a margin of safety.

The wasteload allocation (WLA) is calculated as the sum of all the permitted sources of the POC within the watershed as if they were discharging at their permitted allowable rate. A description of the permitted sources and their permitted loads are included in **Section 4.3.2**. A set-aside for future growth is also included in the WLA to account for potential future permitted activity in the watershed. The margin of safety (MOS) is determined based on the characteristics of the watershed and the model used to develop the TMDL loads (see **Section 6.1**). The overall load allocation (LA) is then calculated by subtracting the total WLA and MOS from the TMDL. Various allocation scenarios are typically developed to show different breakdowns of how this LA can be divided among the various nonpoint sources of the POC (**Section 6.4**).

For model runs to develop the annual existing loads and target loads using the AllForX methodology, a 20-year period was simulated (2000 through 2020) with an additional buffer period of nine months at the beginning of the run to serve as a 'warm-up' period for the model to equilibrate and minimize the impact of uncertain initial conditions. Using this extended modeling period allows the results to account for both annual and seasonal variations in hydrology and sediment loading.

6.1. Margin of Safety

To account for uncertainties inherent in model outputs, a margin of safety (MOS) is incorporated into the TMDL development process. The MOS can be implicit, explicit, or a combination of the two. An implicit MOS involves incorporating conservative assumptions into the modeling process to ensure that the final TMDL is protective of water quality in light of the unavoidable uncertainty in the modeling process. A MOS can also be incorporated explicitly into the TMDL development by setting aside a portion of the TMDL.

This TMDL includes both implicit and explicit MOSs. An example of implicit MOS assumptions incorporated into this TMDL are the inclusion of permitted loads at their maximum permitted rates, even when data shows that they are consistently discharging well below that threshold. An explicit MOS of 10% is also included in the sediment TMDLs. This is a typical value used in sediment TMDLs throughout the state to account for unavoidable uncertainties in the modeling process.

6.2. Future Growth

An allocation of 2% of the total load is specifically set aside for future growth within this TMDL. This leaves flexibility in the plan for future permitted loads to be added within the watersheds, as the development of a TMDL looks at a snapshot in time of a dynamic system within the watershed and is not meant to prevent future economic growth.

6.3. TMDL Calculations

Sediment was determined in the stressor analysis (**Appendix D**) as a primary cause of the benthic impairments in each of the impaired watersheds. TMDLs were developed for sediment in each impaired watershed.

6.3.1. Annual Average Loads

The final sediment average annual loads allocated in the TMDL are presented in **Table 6-1** through **Table 6-8**. GWLF output data, being in monthly increments, is most logically presented as annual aggregates. Total loads to downstream subwatersheds were summed from the loads of each contributing upstream subwatershed. Any apparent differences in calculated values are due to rounding. Model results and calculated totals of those results were rounded to four significant figures.

Table 6-1. Annual average sediment TMDL components for Tattle Branch. Reduction scenarios to achieve this TMDL are presented in Table 6-18.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Tattle Branch (VAS-O05R_TAT01A02)	**15,800**	**363,200**	**42,110**	**421,100**
ISW Permits	*3,190*			
Construction Permits	*842*			
NMMM Permits	*3,347*			
Future Growth (2%)	*8,422*			

Table 6-2. Annual average sediment TMDL components for Hall Creek. Reduction scenarios to achieve this TMDL are presented in Table 6-19.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)*	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Hall Creek (VAS-O05R_HAL01A94)	**117,600**	**1,142,000**	**140,000**	**1,400,000**
VPDES Permits	*86,800*			
Construction Permits	*2,799*			
Future Growth (2%)	*28,000*			

* Upstream inputs from Tattle Branch (WLA and LA) are included in Hall Creek LA.

Table 6-3. Annual average sediment TMDL components for Byers Creek. Reduction scenarios to achieve this TMDL are presented in Table 6-20.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)*	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Byers Creek (VAS-O05R_BYS01A94)	**38,870**	**1,461,000**	**166,700**	**1,667,000**
ISW Permits	*2,200*			
Construction Permit	*3,334*			
Future Growth (2%)	*33,340*			

* Upstream inputs from Tattle Branch and Hall Creek (WLAs and LAs) are included in Byers Creek LA.

Table 6-4. Annual average sediment TMDL components for Cedar Creek. Reduction scenarios to achieve this TMDL are presented in Table 6-21.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Cedar Creek (VAS-O05R_CED01A94)	**12,920**	**471,000**	**53,770**	**537,700**
Vehicle Wash Permit	*914*			
Construction Permits	*1,075*			
Domestic Sewage Permit	*183*			
Future Growth (2%)	*10,750*			

Table 6-5. Annual average sediment TMDL components for Greenway Creek. Reduction scenarios to achieve this TMDL are presented Table 6-22.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Greenway Creek (VAS-O05R_GRW01A02)	**43,580**	**1,058,000**	**122,400**	**1,224,000**
ISW Permits	*15,690*			
Construction Permits	*3,232*			
Domestic Sewage	*183*			
Future Growth (2%)	*24,480*			

Table 6-6. Annual average sediment TMDL components for Upper MF Holston. Reduction scenarios to achieve this TMDL are presented in Table 6-23.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Upper MF Holston (VAS-O03R_MFH05A04)	**36,770**	**1,187,000**	**136,000**	**1,360,000**
PWTP Permit	*6,853*			
Construction Permits	*2,720*			
Future Growth (2%)	*27,200*			

Table 6-7. Annual average sediment TMDL components for the Lower MF Holston, upstream of Rt. 91. Reduction scenarios to achieve this TMDL are presented in Table 6-24.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Lower MF Holston, upstream of Rt. 91 (VAS-O05R_MFH04A00)	**1,109,000**	**34,120,000**	**3,914,000**	**39,140,000**
VPDES	*161,300*			
Construction Permits	*65,170*			
ISW Permits	*71,930*			
NMMM Permits	*26,710*			
Domestic Sewage Permits	*732*			
Future Growth (2%)	*782,800*			

* Upstream inputs from Upper MF Holston River (WLAs and LAs) are included in Lower MF Holston, upstream of Rt. 91, LA.

Table 6-8. Annual average sediment TMDL components for the Lower MF Holston, Rt. 91 to Edmondson Dam. Reduction scenarios to achieve this TMDL are presented in Table 6-25.

Impairment	Allocated Point Sources (WLA) (lb/yr TSS)	Allocated Nonpoint Sources (LA) (lb/yr TSS)	Margin of Safety (MOS) (lb/yr TSS)	Total Maximum Daily Load (TMDL) (lb/yr TSS)
Lower MF Holston, Rt. 91 to Edmondson Dam (VAS-O05R_MFH05A04)	**963,700**	**38,460,000**	**4,380,000**	**43,800,000**
Domestic Sewage Permit	*91*			
Construction Permits	*87,590*			
Future Growth (2%)	*876,000*			

* Upstream inputs from Lower MF Holston River, upstream of Rt. 91 and Byers Creek (WLAs and LAs) are included in Lower MF Holston, Rt. 91 to Edmondson Dam, LA

6.3.2. Maximum Daily Loads

In 1991, the USEPA released a support document that included guidance for developing maximum daily loads (MDLs) for TMDLs (USEPA, 1991). A methodology detailed therein was used to determine the MDLs for the watersheds. The long-term average (LTA) daily loads, derived by dividing the average annual loads in **Table 6-1** through **Table 6-8** by 365.24, are converted to MDLs using the following equation:

$$MDL = LTA * \exp\left(Z_p\sigma_y - 0.5\sigma_y^2\right)$$

where Z_p = pth percentage point of the normal standard deviation, and
σ_y = sqrt(ln(CV^2+1)), with CV = coefficient of variation of the data.

The variable Z_p was set to 1.645 for this TMDL development, representing the 95th percentile. The CV values and final calculated multipliers to convert LTA to MDL are summarized in **Table 6-9**.

Table 6-9. "LTA to MDL multiplier" components for TSS TMDLs.

Watershed	CV of Average Annual Loads	"LTA to MDL Multiplier"
Tattle Branch	0.42	1.8
Hall Creek	0.51	1.96
Byers Creek	0.55	2.04
Cedar Creek	0.51	1.96
Greenway Creek	0.55	2.04
Upper MF Holston	0.55	2.04
Lower MF Holston, upstream of Rt. 91	0.27	1.5
Lower MF Holston, Rt. 91 to Edmondson Dam	0.58	2.1

The daily WLA was estimated as the annual WLA divided by 365.24. The daily MOS was estimated as 10% of the MDL. Finally, the daily LA was estimated as the MDL minus the daily MOS minus the daily WLA. These results are shown in **Table 6-10** through **Table 6-17**.

Table 6-10. Maximum 'daily' sediment loads and components for Tattle Branch.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Tattle Branch (VAS-O05R_TAT01A02)	**43**	**1,824**	**208**	**2,075**
ISW Permits	*8.7*			
Construction Permits	*2.3*			
NMMM Permits	*9.2*			
Future Growth	*23.1*			

Table 6-11. Maximum 'daily' sediment loads and components for Hall Creek.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Hall Creek (VAS-O05R_HAL01A94)	**322**	**6,440**	**751**	**7,513**
VPDES Permits	*237.7*			
Construction Permits	*7.7*			
Future Growth	*76.6*			

* Upstream inputs from Tattle Branch (WLA and LA) are included in Hall Creek LA.

Table 6-12. Maximum 'daily' sediment loads and components for Byers Creek.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Byers Creek (VAS-O05R_BYS01A94)	**106**	**8,274**	**931**	**9,311**
ISW Permits	*6.0*			
Construction Permit	*9.1*			
Future Growth	*91.3*			

* Upstream inputs from Tattle Branch and Hall Creek (WLAs and LAs) are included in Byers Creek LA.

Table 6-13. Maximum 'daily' sediment loads and components for Cedar Creek.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Cedar Creek (VAS-O05R_CED01A94)	**35**	**2,562**	**288**	**2,885**
Vehicle Wash Permit	*2.5*			
Construction Permits	*2.9*			
Domestic Sewage Permit	*0.5*			
Future Growth	*29.4*			

Table 6-14. Maximum 'daily' sediment loads and components for Greenway Creek.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Greenway Creek (VAS-O05R_GRW01A02)	**119**	**6,036**	**684**	**6,836**
ISW Permits	*43.0*			
Construction Permits	*8.8*			
Domestic Sewage	*0.5*			
Future Growth	*67.0*			

Table 6-15. Maximum 'daily' sediment loads and components for Upper MF Holston.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Upper MF Holston (VAS-O03R_MFH05A04)	**101**	**6,735**	**760**	**7,596**
PWTP Permit	*18.8*			
Construction Permits	*7.4*			
Future Growth	*74.5*			

Table 6-16. Maximum 'daily' sediment loads and components for the Lower MF Holston, upstream of Rt.91.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Lower MF Holston, upstream of Rt. 91 (VAS-O05R_MFH04A00)	**3,035**	**141,600**	**16,070**	**160,700**
VPDES	*441.6*			
Construction Permits	*178.4*			
ISW Permits	*196.9*			
NMMM Permits	*73.1*			
Domestic Sewage Permits	*2.0*			
Future Growth	*2,143*			

* Upstream inputs from Upper MF Holston River (WLAs and LAs) are included in Lower MF Holston, upstream of Rt. 91, LA.

Table 6-17. Maximum 'daily' sediment loads and components for Lower MF Holston, Rt. 91 to Edmondson Dam.

Impairment	Allocated Point Sources (WLA) (lb/day TSS)	Allocated Nonpoint Sources (LA) (lb/day TSS)*	Margin of Safety (MOS) (lb/day TSS)	Maximum Daily Load (MDL) (lb/day TSS)
Lower MF Holston, Rt. 91 to Edmondson Dam (VAS-O05R_MFH05A04)	**2,638**	**224,000**	**25,180**	**251,800**
Domestic Sewage Permit	*0.3*			
Construction Permits	*239.8*			
Future Growth	*2,398*			

* Upstream inputs from Lower MF Holston River, upstream of Rt. 91 and Byers Creek (WLAs and LAs) are included in Lower MF Holston, Rt. 91 to Edmondson Dam, LA

6.4. Allocation Scenarios

Multiple scenarios were run to determine possible options for reducing the sediment loads in the study watersheds to the recommended TMDL loads. Feedback from the TAC members guided the selection of the preferred allocation scenarios. Feedback from stakeholders indicated that reductions focused on agricultural sources would be the best fit. Most of the sediment load comes from agricultural sources; however, the stakeholder group agreed that adding reductions for urban sources was appropriate in case there is interest in urban BMPs in the watersheds. This scenario seemed more equitable to allow for future implementation to target BMPs that address both agriculture and urban sources. The various sediment allocation scenarios are presented in **Table 6-18** through **Table 6-25**. The preferred allocation scenario based on consensus with the TAC members for each watershed is Scenario 2.

The reductions from the TMDLs for Lower MF Holston, upstream of Rt. 91, and Byers Creek will meet the Lower MF Holston, Rt. 91 to Edmondson Dam, target load. No further reductions from this segment are needed. However, DEQ recommends including 1% reduction to Hay, Pasture, Barren, Turfgrass, Developed (Pervious and Impervious), and Streambank Erosion, as presented in Scenario 1. This small reduction provides additional reasonable assurance that this stream segment will achieve delisting by increasing the BMP funding opportunities.

Any apparent differences in calculated values are due to rounding. Model results and calculated totals of those results were rounded to four significant figures.

Table 6-18. Allocation scenarios for Tattle Branch sediment loads.

Tattle Branch Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	116,700	50.3	58,020	65.9	39,810	36.6	74,020	25.1	87,440
Hay	12,880	50.3	6,403	65.9	4,393	36.5	8,181	58.0	5,411
Pasture	380,900	50.3	189,300	65.9	129,900	36.5	241,900	58.0	160,000
Forest	2,008	-	2,008	-	2,008	-	2,008	-	2,008
Trees	3,869	-	3,869	-	3,869	-	3,869	-	3,869
Shrub	2,665	-	2,665	-	2,665	-	2,665	-	2,665
Harvested	-	-	-	-	-	-	-	-	-
Wetland	327	-	327	-	327	-	327	-	327
Barren	8,968	50.3	4,457	10.1	8,062	85.0	1,345	19.0	7,264
Turfgrass	10,680	50.3	5,310	10.2	9,595	85.0	1,603	19.0	8,655
Developed Pervious	2,232	50.3	1,109	10.6	1,995	85.0	335	56.0	982
Developed Impervious	164,400	50.3	81,720	10.6	147,000	85.0	24,670	56.0	72,350
Streambank Erosion	15,060	50.3	7,485	10.1	13,540	85.0	2,259	19.0	12,200
ISW Permits	7,753	-	3,190	-	3,190	-	3,190	-	3,190
Construction Permits (0.2%)	842	-	842	-	842	-	842	-	842
NMMM Permits	856	-	3,347	-	3,347	-	3,347	-	3,347
Future Growth (2%)	8,422	-	8,422	-	8,422	-	8,422	-	8,422
MOS (10%)	42,110	-	42,110	-	42,110	-	42,110	-	42,110
TOTAL	**780,800**	**46.1**	**420,600**	**46.1**	**421,100**	**46.1**	**421,100**	**46.1**	**421,100**

Table 6-19. Allocation scenarios for Hall Creek sediment loads.

Hall Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	109,900	54.1	50,430	65.0	38,460	43.9	61,640	30.0	76,920
Hay	31,390	54.1	14,410	65.0	10,990	43.9	17,610	62.0	11,930
Pasture	902,800	54.1	414,400	65.0	316,000	43.9	506,500	62.0	343,100
Forest	20,120	-	20,120	-	20,120	-	20,120	-	20,120
Trees	12,710	-	12,710	-	12,710	-	12,710	-	12,710
Shrub	4,986	-	4,986	-	4,986	-	4,986	-	4,986
Harvested	61,140	-	61,140	-	61,140	-	61,140	-	61,140
Wetland	4,968	-	4,968	-	4,968	-	4,968	-	4,968
Barren	37,110	54.1	17,030	24.4	28,050	81.2	6,976	30.0	25,970
Turfgrass	14,230	54.1	6,533	24.4	10,760	81.3	2,662	30.0	9,964
Developed Pervious	2,321	54.1	1,065	25.0	1,741	81.3	434	50.0	1,161
Developed Impervious	195,900	54.1	89,930	25.0	146,900	81.3	36,640	50.0	97,960
Streambank Erosion	141,700	54.1	65,060	25.0	106,300	81.2	26,650	35.0	92,130
Tattle Branch* (Scenario 2)	738,700	-	379,000	-	379,000	-	379,000	-	379,000
VPDES Permits	6,137	-	86,800	-	86,800	-	86,800	-	86,800
Construction Permits	2,799	-	2,799	-	2,799	-	2,799	-	2,799
Future Growth (2%)	28,000	-	28,000	-	28,000	-	28,000	-	28,000
MOS (10%)	140,000	-	140,000	-	140,000	-	140,000	-	140,000
TOTAL	**2,455,000**	**43.0**	**1,399,000**	**43.0**	**1,400,000**	**43.0**	**1,400,000**	**43.0**	**1,400,000**

* Upstream input from Tattle Branch existing/allocated load. Tattle Branch MOS is included in Hall Creek MOS.

Table 6-20. Allocation scenarios for Byers Creek sediment loads.

Byers Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	29,140	65.0	10,200	68.3	9,237	63.6	10,610	54.2	13,350
Hay	15,580	65.0	5,451	68.3	4,937	63.6	5,669	67.0	5,140
Pasture	443,100	65.0	155,100	68.3	140,500	63.6	161,300	67.0	146,200
Forest	1,747	-	1,747	-	1,747	-	1,747	-	1,747
Trees	4,503	-	4,503	-	4,503	-	4,503	-	4,503
Shrub	950	-	950	-	950	-	950	-	950
Harvested	-	-	-	-	-	-	-	-	-
Wetland	-	-	-	-	-	-	-	-	-
Barren	-	-	-	-	-	-	-	-	-
Turfgrass	6,069	65.0	2,124	33.0	4,066	78.0	1,335	54.2	2,780
Developed Pervious	707	65.0	248	33.0	474	78.0	156	56.0	311
Developed Impervious	45,580	65.0	15,950	33.0	30,540	78.0	10,030	56.0	20,060
Streambank Erosion	14,870	65.0	5,206	68.3	4,715	63.6	5,414	54.2	6,812
Hall Creek* (Scenario 2)	2,315,000	-	1,260,000	-	1,260,000	-	1,260,000	-	1,260,000
ISW Permits	5,347	-	2,200	-	2,200	-	2,200	-	2,200
Construction Permit	3,334	-	3,334	-	3,334	-	3,334	-	3,334
Future Growth (2%)	33,340	-	33,340	-	33,340	-	33,340	-	33,340
MOS (10%)	166,700	-	166,700	-	166,700	-	166,700	-	166,700
TOTAL	**3,086,000**	**46.0**	**1,667,000**	**46.0**	**1,667,000**	**46.0**	**1,667,000**	**46.0**	**1,667,000**

* Upstream input from Hall Creek existing/allocated load. Hall Creek MOS is included in Byers Creek MOS.

Table 6-21. Allocation scenarios for Cedar Creek sediment loads.

Cedar Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	150,700	62.1	57,130	68.5	47,480	58.1	63,160	53.8	69,640
Hay	32,530	62.1	12,330	68.6	10,220	58.1	13,630	66.0	11,060
Pasture	758,000	62.1	287,300	68.6	238,000	58.1	317,600	66.0	257,700
Forest	5,202	-	5,202	-	5,202	-	5,202	-	5,202
Trees	7,741	-	7,741	-	7,741	-	7,741	-	7,741
Shrub	1,949	-	1,949	-	1,949	-	1,949	-	1,949
Harvested	867	-	867	-	867	-	867	-	867
Wetland	288	-	288	-	288	-	288	-	288
Barren	-	-	-	-	-	-	-	-	-
Turfgrass	16,320	62.1	6,185	26.0	12,080	76.6	3,819	55.0	7,344
Developed Pervious	1,967	62.1	746	25.1	1,474	76.6	460	55.0	885
Developed Impervious	161,100	62.1	61,060	25.1	120,700	76.6	37,700	55.0	72,500
Streambank Erosion	79,410	62.1	30,090	68.5	25,010	76.6	18,580	54.9	35,810
Vehicle Wash Permit	59	-	914	-	914	-	914	-	914
Construction Permits (0.2%)	1,075	-	1,075	-	1,075	-	1,075	-	1,075
Domestic Sewage Permit	183	-	183	-	183	-	183	-	183
Future Growth (2%)	10,750	-	10,750	-	10,750	-	10,750	-	10,750
MOS (10%)	53,770	-	53,770	-	53,770	-	53,770	-	53,770
TOTAL	**1,282,000**	**58.1**	**537,600**	**58.1**	**537,700**	**58.1**	**537,700**	**58.1**	**537,700**

Table 6-22. Allocation scenarios for Greenway Creek sediment loads.

Greenway Creek Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	38,010	16.9	31,590	18.7	30,900	9.5	34,400	10.0	34,210
Hay	37,190	16.9	30,900	18.7	30,230	9.5	33,660	17.4	30,720
Pasture	839,600	16.9	697,700	18.7	682,600	9.5	759,900	17.4	693,500
Forest	16,470	-	16,470	-	16,470	-	16,470	-	16,470
Trees	9,453	-	9,453	-	9,453	-	9,453	-	9,453
Shrub	1,895	-	1,895	-	1,895	-	1,895	-	1,895
Harvested	1,046	-	1,046	-	1,046	-	1,046	-	1,046
Wetland	681	-	681	-	681	-	681	-	681
Barren	18,890	16.9	15,700	10.0	17,000	46.0	10,200	7.0	17,570
Turfgrass	14,230	16.9	11,820	10.0	12,810	46.0	7,683	7.0	13,230
Developed Pervious	2,706	16.9	2,249	10.0	2,435	46.0	1,461	17.4	2,235
Developed Impervious	216,600	16.9	180,000	10.0	195,000	46.0	117,000	17.4	178,900
Streambank Erosion	70,500	16.9	58,580	18.7	57,320	9.5	63,800	17.4	58,230
ISW Permits	38,120	-	15,690	-	15,690	-	15,690	-	15,690
Construction Permits	3,232	-	3,232	-	3,232	-	3,232	-	3,232
Domestic Sewage Permits	183	-	183	-	183	-	183	-	183
Future Growth (2%)	24,480	-	24,480	-	24,480	-	24,480	-	24,480
MOS (10%)	122,400	-	122,400	-	122,400	-	122,400	-	122,400
TOTAL	**1,456,000**	**15.9**	**1,224,000**	**15.9**	**1,224,000**	**15.9**	**1,224,000**	**15.9**	**1,224,000**

Table 6-23. Allocation scenarios for Upper MF Holston sediment loads.

Upper MF Holston Watershed		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	49,140	3.0	47,670	3.1	47,620	1.7	48,310	1.1	48,600
Hay	33,120	3.0	32,130	3.1	32,090	1.7	32,560	3.1	32,090
Pasture	986,300	3.0	956,700	3.1	955,800	1.7	969,600	3.1	955,800
Forest	36,790	-	36,790	-	36,790	-	36,790	-	36,790
Trees	10,500	-	10,500	-	10,500	-	10,500	-	10,500
Shrub	3,316	-	3,316	-	3,316	-	3,316	-	3,316
Harvested	-	-	-	-	-	-	-	-	-
Wetland	1,811	-	1,811	-	1,811	-	1,811	-	1,811
Barren	-	-	-	-	-	-	-	-	-
Turfgrass	2,166	3.0	2,101	1.1	2,142	31.7	1,479	1.1	2,142
Developed Pervious	1,157	3.0	1,122	1.1	1,144	31.7	790	1.1	1,144
Developed Impervious	44,760	3.0	43,420	1.1	44,270	31.7	30,570	1.1	44,270
Streambank Erosion	52,900	3.0	51,310	1.2	52,270	1.7	52,000	3.1	51,260
PWTP Permit	1,608	-	6,853	-	6,853	-	6,853	-	6,853
Construction Permits (0.2%)	2,720	-	2,720	-	2,720	-	2,720	-	2,720
Future Growth (2%)	27,200	-	27,200	-	27,200	-	27,200	-	27,200
MOS (10%)	136,000	-	136,000	-	136,000	-	136,000	-	136,000
TOTAL	**1,390,000**	**2.2**	**1,360,000**	**2.2**	**1,360,000**	**2.2**	**1,360,000**	**2.2**	**1,360,000**

Table 6-24. Allocation scenarios for Lower MF Holston, upstream of Rt.91 sediment loads.

Lower MF Holston, upstream of Rt. 91		Scenario 1		Scenario 2 (preferred)		Scenario 3		Scenario 4	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	235,100	19.7	188,800	20.7	186,400	16.9	195,400	9.0	213,900
Hay	209,100	19.7	167,900	20.7	165,800	16.9	173,700	19.8	167,700
Pasture	6,906,000	19.7	5,546,000	20.7	5,477,000	16.9	5,739,000	19.8	5,539,000
Forest	1,128,000	-	1,128,000	-	1,128,000	-	1,128,000	-	1,128,000
Trees	122,600	-	122,600	-	122,600	-	122,600	-	122,600
Shrub	70,950	-	70,950	-	70,950	-	70,950	-	70,950
Harvested	17,900	-	17,900	-	17,900	-	17,900	-	17,900
Wetland	7,032	-	7,032	-	7,032	-	7,032	-	7,032
Barren	91,140	19.7	73,190	5.7	85,950	58.4	37,910	9.0	82,940
Turfgrass	80,830	19.7	64,910	5.7	76,220	58.4	33,620	9.0	73,550
Developed Pervious	14,700	19.7	11,810	5.7	13,870	58.4	6,117	19.8	11,790
Developed Impervious	2,452,000	19.7	1,969,000	5.7	2,312,000	58.4	1,020,000	19.8	1,966,000
Streambank Erosion	29,290,000	19.7	23,520,000	20.7	23,230,000	16.9	24,340,000	19.8	23,490,000
Upper MF Holston* (Scenario 2)	1,254,000	-	1,224,000		1,224,000		1,224,000		1,224,000
VPDES	33,390	-	161,300		161,300		161,300		161,300
Construction Permits	65,170	-	65,170		65,170		65,170		65,170
ISW Permits	174,800	-	71,930		71,930		71,930		71,930
NMMM Permits	26710	-	26710		26710		26710		26710
Domestic Sewage Permits	732	-	732		732		732		732
Future Growth (2%)	782,800	-	782,800		782,800		782,800		782,800
MOS (10%)	3,914,000	-	3,914,000		3,914,000		3,914,000		3,914,000
TOTAL	**46,880,000**	**16.5**	**39,130,000**	**16.5**	**39,140,000**	**16.5**	**39,140,000**	**16.5**	**39,140,000**

* Upstream input from Upper MF Holston River existing/allocated load. Upper MF Holston MOS is included in Lower MF Holston, upstream of Rt. 91, MOS.

Table 6-25. Allocation scenarios for Lower MF Holston, Rt. 91 to Edmondson Dam.

Lower MF Holston, Rt. 91 to Edmondson Dam		Scenario 1 (preferred)	
Source	**Existing TSS (lb/yr)**	**Red. (%)**	**Allocation TSS (lb/yr)**
Cropland	-	-	-
Hay	21,230	1.0	21,010
Pasture	562,700	1.0	557,000
Forest	8,338	-	8,338
Trees	4,162	-	4,162
Shrub	668	-	668
Harvested	-	-	-
Wetland	133	-	133
Barren	132,100	1.0	130,700
Turfgrass	2,809	1.0	2,781
Developed Pervious	168	1.0	166
Developed Impervious	20,340	1.0	20,140
Streambank Erosion	43,720	1.0	43,280
Lower MF Holston, upstream of Rt. 91 (Scenario 2)	42,960,000		35,220,000
Byers Creek (Scenario 2)	2,919,000		1,501,000
Domestic Sewage Permit	91		91
Construction Permits	87,590		87,590
Future Growth (2%)	876,000		876,000
MOS (10%)	4,380,000		4,380,000
TOTAL	**52,020,000**	**17.6**	**42,860,000**

* Upstream inputs from Lower MF Holston River, upstream of Rt. 91 and Byers Creek existing/allocated loads. Lower MF Holston, upstream of Rt. 91 and Byers Creek MOSs are included in Lower MF Holston Rt. 91 to Edmondson Dam MOS.

7.0 TMDL IMPLEMENTATION AND REASONABLE ASSURANCE

7.1. Regulatory Framework

There is a regulatory framework in place to help enforce the development and attainment of TMDLs and their stated goals on both the federal and the state level in Virginia. On the federal level, section 303(d) of the Clean Water Act and current USEPA regulations, while not explicitly requiring the development of TMDL implementation plans as part of the TMDL process, do require reasonable assurance that the load and waste load allocations can and will be implemented. Federal regulations also require that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)).

At the state level, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) 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). WQMIRA 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. After DEQ approves the TMDL study, staff will present the study to the State Water Control Board (SWCB) and request that the SWCB adopt TMDL WLAs as part of the Water Quality Management Planning Regulation (9 VAC 25-270), in accordance with §2.2-4006A.14 and §2.2-4006B of the Code of Virginia. DEQ-s public participation procedures relating to TMDL development can be found in DEQ's Guidance Memo No.14-2016 (VADEQ, 2014).

VADEQ regulates stormwater discharges associated with permitted activities through its VPDES program and stormwater discharges from construction sites and MS4s through its VSMP program. All new or revised permits must be consistent with the assumptions and requirements of any applicable TMDL WLA.

7.2. Implementation Plans

Implementation plans set intermediate goals and describe actions (with associated costs) that can be taken to clean up impaired streams. Some of the actions that may be included in an implementation plan to address excess sediment include:

- Fence out cattle from streams and provide alternative water sources
- Implement conservation tillage practices on cropland
- Conduct stream bank restoration projects in areas where banks are actively eroding

- Leave a band of 35 – 100 ft along the stream natural so that it buffers or filters out sediment from farm or residential land (a riparian buffer)
- Expand street sweeping programs in urban areas
- Reduce runoff by increasing green spaces and reducing hardened spaces (asphalt or concrete)

Overall, implementation of TMDLs works best with a targeted, staged approach, directing initial efforts where the biggest impacts can be made with the least effort so that money, time, and other resources are spent efficiently to maximize the benefit to water quality. Progress towards meeting water quality goals defined in the implementation plan will be assessed during implementation by the tracking of new BMP installations and continued water quality monitoring by VADEQ. Several BMPs have already been implemented in the watershed and were accounted for in the development of this TMDL (**Section 4.4**).

Implementation plans also identify potential sources of funding to help in the clean-up efforts. Funds are often available in the form of cost-share programs, which share the cost of improvements with the landowner. Potential sources of funding include USEPA Section 319 funding for Virginia's Nonpoint Source Management Program, the USDA's Conservation Reserve Enhancement Program (CREP) and its Environmental Quality Incentive Program (EQIP), the Virginia State Revolving Loan Program, and the Virginia Water Quality Improvement Fund. The Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans (VADEQ, 2017) contains information on a variety of funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts. Additional sources are also often available for specific projects and regions of the state. State agencies and other stakeholders may help identify funding sources to support the plan, but making the improvements is up to those that live in the watershed. Part of the purpose of developing a TMDL and implementation plan is to increase education and awareness of the water quality issues in the watershed and encourage residents and stakeholders to work together to improve the watershed.

7.3. Reasonable Assurance

The following activities provide reasonable assurance that these TMDLs will be implemented, and water quality will be restored in the MF Holston and Tribs watershed.

- Regulatory frameworks – Existing federal and state regulations require that new and existing permits comply with the developed TMDLs. State law also requires that implementation plans be developed to meet TMDL goals.
- Funding sources – Numerous funding sources (listed above) are available to defray the cost of TMDL implementation.

- Public participation – Public participation in the TMDL process informs and mobilizes watershed residents and stakeholders to take the necessary actions to implement the TMDL.
- Continued monitoring – Water quality and aquatic life monitoring will continue in the TMDL watersheds and track progress towards the TMDL goals. VADEQ will continue monitoring benthic macroinvertebrates and habitat in accordance with its biological monitoring program stations throughout the watershed.
- Current implementation actions – Many voluntary and subsidized best management practices have already been installed in these watersheds. The Soil and Water Conservation Districts and NRCS are actively working in these areas to promote and implement additional practices that can reduce sediment and phosphorus loads.

7.4. Attainability of Designated Use

The goal of a TMDL is to restore impaired waters so that numeric and narrative water quality standards (WQSs) are attained. WQSs consist of statements that describe water quality requirements and include three components: 1) designated uses, 2) water quality criteria to protect designated uses, and 3) an antidegradation policy. However, in some streams for which TMDLs have been developed, factors may prevent the stream from attaining its designated use. In order for a stream to be assigned a new designated use, a subcategory of a use, or a tiered use, the current designated use must be removed from the state water quality standards regulations and is subject to USEPA approval. To remove a designated use, the state must demonstrate that the use is not an existing use, and that downstream uses are protected. Such uses will be attained by implementing effluent limits required under §301b and §306 of the Clean Water Act and by implementing cost-effective and reasonable best management practices for nonpoint source control (9VAC25-260-10 paragraph I).

The state must also demonstrate that attaining the designated use is not feasible because of one or more of the following reasons:

- Naturally occurring pollutant concentration prevents the attainment of the use.
- Natural, ephemeral, intermittent, or low flow conditions prevent the attainment of the use unless these conditions may be compensated for by the discharge of sufficient volume of pollutant discharges without violating state water conservation.
- Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.
- Dams, diversion, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate the modification in such a way that would result in the attainment of the use.

- Physical conditions related to natural features of the waterbody, such as the lack of proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life use protection.
- Controls more stringent than those required by §301b and §306 of the Clean Water Act would result in substantial and widespread economic and social impact.

This and other information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted by the SWCB as amendments to the WQSs regulations. During the regulatory process, watershed stakeholders and other interested citizens, as well as the USEPA, are able to provide comment.

The process to address potentially unattainable reductions based on the above is as follows:

As a first step, measures targeted at the controllable, anthropogenic sources of all pollutants and non-pollutants causing or contributing to the biological impairment will be implemented. In addition, measures should be taken to ensure that discharge permits are fully implementing provisions required in the TMDL. The expectation would be for the reductions of all controllable sources to be to the maximum extent practicable. VADEQ will continue to monitor water quality in the impaired streams during and after the implementation of these measures to determine if WQSs are being attained. This effort will also help to evaluate if the modeling assumptions used in the TMDL were correct. In the best-case scenario, water quality goals will be met, and the stream's uses fully restored using pollution controls and BMPs. If, however, WQSs are not being met, and no additional pollution controls and BMPs can be identified, a UAA would then be initiated with the goal of re-designating the stream for a more appropriate use, subcategory of a use, or tiered use.

A 2006 amendment to the Code of Virginia under 62.1-44.19:7E provides an opportunity for aggrieved parties to present to the SWCB reasonable grounds indicating that the attainment of the designated use for a water is not feasible. The Board may then allow the aggrieved party to conduct a UAA according to the criteria listed above and a schedule established by the Board. The amendment further states that "if applicable, the schedule shall also address whether TMDL development or implementation for the water shall be delayed".

8.0 PUBLIC PARTICIPATION

Public participation was elicited at every stage of the TMDL study in order to receive input from stakeholders and to apprise the stakeholders of progress made. A series of two Technical Advisory Committee (TAC) meetings and two public meetings took place during the TMDL development process. The TAC included representatives from Holston River Soil and Water Conservation District, Evergreen Soil and Water Conservation District, Emory and Henry College, Washington County Service Authority, Mt. Rogers Planning District Commission, Smyth County Administrator, Natural Resources Conservation Services, Virginia Department of Wildlife Resources, U.S Fish and Wildlife Service, and Virginia Department of Forestry.

The first public meeting (7 attendees, December 2nd, 2022) was held at Emory & Henry College in the Van Dyke Center, Emory, VA. This meeting introduced attendees to DEQ's water quality planning process, the TMDL purpose and process, and then focused on reviewing the results of the benthic stressor analysis.

The first TAC meeting (15 attendees, September 8th, 2022) was held at the Southwest Virginia DEQ Regional office in Abingdon, VA. This meeting discussed the results of the benthic stressor analysis, the watershed modeling process, permitted sources in the watershed, and the initial results of the watershed model.

A second TAC meeting (21 attendees, July 11th, 2023) was also held in the Southwest Virginia DEQ Regional office. The meeting began with reviewing updates since the previous TAC meeting regarding stream network data source and updates to permit calculations. The group then discussed the target loading rates for the impaired watersheds developed using the AllForX regression methodology, reviewed the existing BMPSs in the watershed, and gathered input on the preferred allocation scenarios for the final TMDL.

A final public meeting was held on October 19th, 2023 at Emory & Henry College in the Van Dyke Center, Emory, VA to present the draft TMDL document. The public meeting marked the beginning of the official public comment period and was attended by 12 watershed residents and other stakeholders. The public comment period ended on November 30th, 2023. No comments were received during the public comment period.

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Appendix A - GWLF Model Parameters

Various GWLF parameters used for the Middle Fork Holston and tributaries watershed models are detailed below. **Table A-1** and **Table A-2** list the various watershed-wide parameters. The land use parameters for the watersheds are listed in **Table A-3** through **Table A-10**.

Table A-1. Watershed-wide GWLF parameters.

GWLF Parameter	Units	Value
Recession Coefficient	day^{-1}	0.075
Seepage Coefficient	day^{-1}	0.04
Leakage Coefficient	day^{-1}	0.01
Erosivity Coefficient (Nov-Mar)		0.28
Erosivity Coefficient (Apr-Oct)		0.1

Table A-2. Additional GWLF watershed parameters.

GWLF Parameter	Lower MF Holston, Rt. 91 to Edmondson Dam	Lower MF Holston, upstream of Rt.91	Upper MF Holston	Cedar Creek	Byers Creek	Hall Creek	Tattle Branch	Greenway Creek
Sediment Delivery Ratio	0.0696	0.0716	0.2043	0.1885	0.1506	0.1594	0.2471	0.1885
Unsaturated Water Capacity (cm)	13.82	13.14	15.44	21.86	20.70	20.52	21.72	20.43
aFactor	0.0001490	0.0001490	0.0001312	0.0001450	0.0001591	0.0001644	0.0002446	0.0001840
Total Stream Length (m)	437292	393982	17617	18343	33949.2	28488	4350.7	12572
Mean Channel Depth (m)	4.638	4.512	1.638	1.771	2.200	2.081	1.363	1.770
ET Cover Coefficient,	0.752 – 0.944	0.754 – 0.945	0.765 – 0.959	0.742 – 0.931	0.746 - 0.936	0.746 - 0.936	0.694 - 0.870	0.726 - 0.910

Table A-3. Land cover parameters for Lower Middle Fork Holston, Rt. 91 to Edmondson Dam.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	108.563	78.66	0.0596	n/a
Low_till	385.573	74.72	0.0073	n/a
Hay	5681.181	61.42	0.0023	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	7880.722	71.88	0.0232	n/a
Pasture_Poor	1347.037	81.25	0.0421	n/a
Forest	28911.003	66.01	0.0017	n/a
Trees	3646.715	63.48	0.0017	n/a
Shrub	400.0533	57.37	0.0129	n/a
Harvested Forest	97.930	62.42	0.0239	n/a
Water	118.768	98.00	0	n/a
Wetland	106.860	66.42	0.0038	n/a
Barren	9.989	75.20	0.4040	n/a
Turfgrass	2620.673	63.73	0.0017	n/a
Developed pervious	195.895	63.45	0.0040	n/a
Developed impervious	783.579	98.00	0	6.2
Impervious local dataset	873.432	98.00	0	2.8

Table A-4. Land cover parameters for Lower Middle Fork Holston, upstream of Rt. 91.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	79.894	78.89	0.0586	n/a
Low_till	289.913	74.96	0.0073	n/a
Hay	4675.006	62.04	0.0024	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	6674.608	72.32	0.0240	n/a
Pasture_Poor	1188.616	81.52	0.0434	n/a
Forest	27903.483	66.41	0.0017	n/a
Trees	3173.996	64.16	0.0018	n/a
Shrub	343.484	58.73	0.0139	n/a
Harvested Forest	39.801	68.51	0.0163	n/a
Water	102.238	98.00	0	n/a
Wetland	84.072	66.69	0.0038	n/a
Barren	4.479	80.36	0.4813	n/a
Turfgrass	2169.838	64.16	0.0017	n/a
Developed pervious	165.847	63.78	0.0041	n/a
Developed impervious	663.389	98.00	0	6.2
Impervious local dataset	771.392	98.00	0	2.8

Table A-5. Land cover parameters for Upper MF Holston.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	3.568	80.54	0.0691	n/a
Low_till	22.937	76.54	0.0084	n/a
Hay	242.447	63.83	0.0022	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	329.651	73.48	0.0223	n/a
Pasture_Poor	68.935	82.14	0.0395	n/a
Forest	608.485	61.68	0.0011	n/a
Trees	96.245	64.35	0.0017	n/a
Shrub	6.897	58.48	0.0111	n/a
Harvested Forest	0	0	0	n/a
Water	1.815	98.00	0.0000	n/a
Wetland	5.91271	69.35	0.0039	n/a
Barren	0.00000	0	0	n/a
Turfgrass	19.94410	67.56	0.0015	n/a
Developed pervious	2.78783	67.39	0.0058	n/a
Developed impervious	11.15131	98.00	0	6.2
Impervious local dataset	12.81253	98.00	0	2.8

Table A-6. Land cover parameters for Cedar Creek.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	14.931	78.01	0.0740	n/a
Low_till	49.822	74.01	0.0090	n/a
Hay	507.124	58.45	0.0016	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	505.245	69.35	0.0164	n/a
Pasture_Poor	45.945	79.24	0.0291	n/a
Forest	185.193	59.26	0.0007	n/a
Trees	193.056	58.85	0.0010	n/a
Shrub	13.105	48.00	0.0072	n/a
Harvested Forest	1.767	66.00	0.0078	n/a
Water	0.625	98.00	0	n/a
Wetland	1.701	65.56	0.0027	n/a
Barren	0	0	0	n/a
Turfgrass	264.511	61.80	0.0012	n/a
Developed pervious	9.927	62.13	0.0038	n/a
Developed impervious	39.708	98.0	0	6.2
Impervious local dataset	47.082	98.00	0	2.8

Table A-7. Pervious land cover parameters for Byers Creek.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	18.253	78.00	0.0623	n/a
Low_till	60.905	74.00	0.0076	n/a
Hay	657.084	58.66	0.0018	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	787.655	69.51	0.0178	n/a
Pasture_Poor	103.457	79.36	0.0316	n/a
Forest	713.045	54.37	0.0011	n/a
Trees	343.033	59.03	0.0012	n/a
Shrub	40.075	48.64	0.0068	n/a
Harvested Forest	58.129	58.24	0.0291	n/a
Water	2.169	98.00	0.0000	n/a
Wetland	21.369	65.36	0.0041	n/a
Barren	2.274	71.00	0.2213	n/a
Turfgrass	284.580	61.79	0.0014	n/a
Developed pervious	16.208	61.78	0.0037	n/a
Developed impervious	64.833	98.00	0.0000	6.2
Impervious local dataset	63.290	98.00	0.0000	2.8

Table A-8. Land cover parameters for Hall Creek.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	15.330	78.00	0.0638	n/a
Low_till	51.152	74.00	0.0077	n/a
Hay	476.021	58.75	0.0018	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	570.612	69.58	0.0183	n/a
Pasture_Poor	74.949	79.41	0.0325	n/a
Forest	633.852	54.24	0.0011	n/a
Trees	266.963	59.07	0.0013	n/a
Shrub	34.916	48.54	0.0069	n/a
Harvested Forest	58.129	58.24	0.0291	n/a
Water	2.169	98.00	0	n/a
Wetland	21.369	65.36	0.0041	n/a
Barren	2.274	71.00	0.2213	n/a
Turfgrass	216.478	61.81	0.0014	n/a
Developed pervious	13.005	61.88	0.0038	n/a
Developed impervious	52.021	98.00	0	6.2
Impervious local dataset	48.983	98.00	0	2.8

Table A-9. Land cover parameters for Tattle Branch.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	10.416	78.00	0.0623	n/a
Low_till	34.755	74.00	0.0076	n/a
Hay	129.829	58.16	0.0018	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	155.628	69.12	0.0180	n/a
Pasture_Poor	20.441	79.09	0.0320	n/a
Forest	73.033	55.29	0.0006	n/a
Trees	63.034	58.56	0.0011	n/a
Shrub	14.121	49.18	0.0061	n/a
Harvested Forest	0	0	0	n/a
Water	0	0	0	n/a
Wetland	0.947	64.47	0.0044	n/a
Barren	0.409	71.00	0.2060	n/a
Turfgrass	133.510	61.42	0.0012	n/a
Developed pervious	12.656	61.39	0.0025	n/a
Developed impervious	50.626	98.00	0	6.2
Impervious local dataset	28.104	98.00	0	2.8

Table A-10. Land cover parameters for Greenway Creek.

Land Cover	Area (ha)	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	5.611	78.08	0.0596	n/a
Low_till	18.723	74.08	0.0072	n/a
Hay	487.540	58.78	0.0019	n/a
Pasture_Good	0	0	0	n/a
Pasture_Fair	485.734	69.60	0.0188	n/a
Pasture_Poor	44.170	79.42	0.0333	n/a
Forest	311.638	62.32	0.0010	n/a
Trees	151.493	60.60	0.0014	n/a
Shrub	9.085	48.97	0.0090	n/a
Harvested Forest	1.459	59.88	0.0171	n/a
Water	0.718	98.00	0	n/a
Wetland	3.537	64.78	0.0032	n/a
Barren	1.586	71.00	0.1473	n/a
Turfgrass	212.354	61.98	0.0013	n/a
Developed pervious	18.107	61.82	0.0029	n/a
Developed impervious	72.430	98.00	0	6.2
Impervious local dataset	53.281	98.00	0	2.8

Appendix B - Sensitivity Analysis

Analyses were conducted to assess the sensitivity of the model to changes in hydrologic and water quality parameters, as well as to assess the potential impact of uncertainty in parameter determination. The sensitivity analysis was performed on the watershed draining to the outlet of subwatershed 6 (**Figure 4-1**), which is the approximate location of USGS flow gauge #03474000 Middle Fork Holston at Seven Mile Ford and the same watershed on which the hydrologic calibration was developed. Sensitivity analyses were run on the parameters listed in **Table B-1** and **Table B-2**. The outputs from model runs using the listed base parameter values were compared to model runs changing each of the parameters by +10% and -10% of the base value. The results are shown in **Table B-3**.

The relationships exhibit linear responses except for curve number (CN), seepage coefficient, and available water capacity (AWC). Changes in variables specific to sediment such as KLSCP had no impact on hydrology, which was to be expected. The evapotranspiration cover coefficients (ET-CV) had the largest impact on hydrology, followed by curve number and the recession and seepage coefficients. Sediment load was most proportionally influenced by ET-CV, followed by CN.

Table B-1. Land cover related parameters used in GWLF sensitivity analysis.

Land Cover	CN	KLSCP	Sediment Build-up (kg/ha-d)
High_till	78.44	0.0698	n/a
Low_till	74.72	0.0085	n/a
Hay	63.6	0.0026	n/a
Pasture_Good	0	0	n/a
Pasture_Fair	73.34	0.0256	n/a
Pasture_Poor	82.05	0.0453	n/a
Forest	66.83	0.0017	n/a
Trees	64.90	0.0018	n/a
Shrub	59.58	0.0145	n/a
Harvested Forest	67.63	0.0150	n/a
Water	98.00	0	n/a
Wetland	66.93	0.0039	n/a
Barren	80.36	0.4813	n/a
Turfgrass	64.53	0.0018	n/a
Developed pervious	63.84	0.0041	n/a
Developed impervious	98.00	0	6.2
Impervious local dataset	98.00	0	2.8

Table B-2. Watershed parameters used in GWLF sensitivity analysis.

Parameter	Units	Base Value
Recession Coefficient	day^{-1}	0.075
Seepage Coefficient	day^{-1}	0.04
Leakage Coefficient	day^{-1}	0.01
Unsaturated Available Water Capacity (AWC)	cm	12.05
Evapotranspiration Coefficient (ET-CV)	n/a	0.754-0.946

Table B-3. Results of the GWLF sensitivity analysis.

Model Parameter	Parameter Change (%)	Total Runoff Volume Change (%)	Total Sediment Load Change (%)
CN	+10	3.19%	7.17%
	-10	-2.40%	-7.90%
KLSCP	+10		1.67%
	-10		-1.67%
Sediment Build-up	+10		0.31%
	-10		-0.31%
Recession Coefficient	+10	3.05%	1.36%
	-10	-3.04%	-1.38%
Seepage Coefficient	+10	-2.96%	-1.48%
	-10	3.17%	1.58%
Leakage Coefficient	+10	0.05%	0.05%
	-10	-0.05%	-0.05%
AWC	+10	-0.03%	-0.02%
	-10	0.17%	0.11%
ET-CV	+10	-15.20%	--9.77%
	-10	15.25%	9.28%

Appendix C - AllForX Development

The method used to set TMDL endpoint loads for the MF Holston and Tribs Watersheds is called the "all-forest load multiplier" (AllForX) approach, introduced in **Section 5.0**. AllForX is the ratio calculated by dividing the simulated pollutant load under existing conditions by the pollutant load from an all-forest simulated condition for the same watershed. In other words, AllForX is an indication of how much higher current sediment loads are above an undeveloped condition. After calculating AllForX values for multiple comparison monitoring stations with a range of watershed health, three regressions were developed between the AllForX values and corresponding 33rd percentile VSCI scores at those stations (**Figure C-1**, **Figure C-2**, **Figure C-3**). This relationship between AllForX values and 33rd percentile VSCI scores can be used to quantify the AllForX value that corresponds to the VSCI threshold score of 60.

These multipliers were calculated for a total of 14 watersheds (**Figure C-4**). Comparison watersheds used in addition to the TMDL watersheds in developing the VSCI and AllForX regression were selected to be similar in size and located near the study watersheds, ideally within the same ecoregion, to minimize differences in flow regime, soils, and other physiographic properties. Additionally, the comparison watersheds must have adequate and recent VSCI data for a watershed to be a useful data point. These watersheds included both unimpaired and impaired streams to represent a wide distribution of current conditions.

For the purposes of building the AllForX regression, permitted sources were not included. This was to allow for flexibility to incorporate other watersheds into the regression that may have less available data. The same set of watershed models were run a second time, changing all of the land use parameters to reflect forested land cover while preserving the unique soil and slope characteristics of each watershed. The AllForX multiplier was calculated for each modeled watershed by dividing the original model loads by the all-forested model loads. This data is presented in **Table C-1**.

Regressions were then developed using the 33rd percentile of Virginia Stream Condition Index (VSCI) scores at monitoring stations and the corresponding AllForX ratio calculated for each station. The 33rd percentile was used because DEQ biologists often prefer two consecutive years of benthic monitoring above the VSCI threshold of 60 before delisting the stream as unimpaired to account for seasonal and annual variation. Based on a 6-yr assessment window and typical DEQ monitoring every 2 years, no more than a third (33%) of benthic scores could be below the threshold of 60 and meet the recommendations for delisting. This approach accounts for natural variability in VSCI scores over time and considers the methodology for assessing and delisting Virginia streams.

Early in the process, the significant difference in scale of the impaired watersheds included in the MFHolston and Tribs project was noted and developing separate AllForX regressions for the two distinct size categories and with appropriately-sized comparison watersheds was proposed. One of the suggested base criteria for selecting monitoring stations to serve as comparison watersheds in the AllForX methodology is that they be no less than half and no more than twice the size of the impaired TMDL watersheds. Watersheds for the listings stations on the downstream impairments on the Middle Fork Holston are greater than 100,000 acres, while the largest watershed to a listing station on the tributaries is less than 10,000 acres. This size discrepancy is an order of magnitude beyond the preliminary size threshold used in selecting comparison watersheds for AllForX regressions and supported developing separate regressions for ‘large’ and ‘small’ impaired watersheds.

Separating the impaired and comparison watersheds into two regressions by size (>45,000 ac vs <10,000 ac) resulted in a good fit for the larger watershed regression (R2 = 0.94), but still left a poor fit to the subset of smaller watersheds (preliminary R2 = 0.38). Further investigation identified a significant dichotomy in the land cover distributions of the impaired tributaries, with two (Tattle and Greenway) identified as having >10% impervious land cover while the remaining four impaired monitoring stations (Byers, Cedar’s two monitoring locations, and upper impairment on Middle Fork Holston) having less than 5.5% impervious land cover.

This separation in land cover distribution seemed indicative of a difference in impairment cause, i.e. sediment derived from largely agricultural practices vs. sediment problems derived from urban hydrology. Water quality and habitat impairment have repeatedly been correlated with impervious cover >10% (Center for Watershed Protection. Impacts of Impervious Cover on Aquatic Systems, 2003), which supports the inference. The 2016 TMDL study “Sediment TMDLs for Moores Creek, Lodge Creek, Meadow Creek, and Schenks Branch” in Albemarle County and the City of Charlottesville also incorporated separate AllForX regressions to develop sediment target loads for urban and rural TMDL watersheds within the study.

Based on the improved quality of fit and precedent for implementing multiple regressions to address significantly different TMDL watersheds within a single project, three separate regressions were developed for the MFHolston and Tribs project (watersheds included in each regression summarized in **Table C-1**):

- Watersheds >45,000 ac
- Watersheds <10,000 ac and TMDL impairment watersheds <5.5% impervious land cover
- Watersheds <10,000 ac and TMDL impairment watersheds >10% impervious land cover

Table C-1. Model run results for AllForX value development.

Monitoring Station Watershed	Acreage	33rd Percentile VSCI Score	AllForX Ratio	>45,000 ac	<10,000 ac and <5.5% impervious	<10,000 ac and >10% impervious
TMDL Watersheds						
6CMFH023.41	107,630.60	54.00	2.63	yes		
6CMFH026.00	102,725.07	55.95	2.59	yes		
6CMFH055.88	3,542.47	55.35	14.83		yes	
6CCED000.14/0.04	4,644.93	54.87	36.05		yes	
6CCED001.01	4,108.05	57.15	36.18		yes	
6CBYS000.08	9,927.21	56.09	23.95		yes	
6CTAT000.50	1,797.71	57.96	54.09			yes
6CGRW002.31	2,395.08	57.91	38.99			yes
Comparison Watersheds						
6CMFH033.40/32.39	83,896.39	65.91	2.45	yes		
6CSFH096.96	51,530.59	71.72	2.10	yes		
6CSFH099.18	47,435.78	76.72	1.97	yes		
6CHTO000.07	7,212.22	58.70	19.93		yes	yes
6CHUT000.07	2,223.08	65.17	8.02		yes	yes
6CBER004.10	3,731.51	65.16	1.05		yes	yes

The AllForX values were plotted against their associated 33rd percentile VSCI scores and three linear regressions were plotted through the values (**Figure C-1**, **Figure C-2**, **Figure C-3**). The first regression for sediment (TSS) resulted in an R^2 value of 0.935. The second regression for sediment (TSS) resulted in an R^2 value of 0.624. The third regression for sediment (TSS) resulted in an R^2 value of 0.745. Based on the first regression, a 33rd percentile VSCI score of 60 corresponded to a target AllForX ratio of 2.5 (**Figure C-1**). The second regression, a 33rd percentile VSCI score of 60 corresponded to a target AllforX ratio of 15.91 (**Figure C-2**). The third regression, a 33rd percentile VSCI score of 60 corresponded to a target AllforX ratio of 30.92 (**Figure C-3**). This means that the TMDL streams are expected to achieve consistently healthy benthic conditions if sediment loads are less than 2.5, 15.91, or 30.92, depending on the watershed, times the simulated load of an all-forested watershed. The allowable sediment TMDL load was then calculated by applying the AllForX threshold ratio where 33rd percentile VSCI = 60 (2.5,15.91,30.92) to the All-Forest simulated pollutant load of the target watershed to determine the final target TMDL loading. An explicit margin of safety was implemented based on this target loading rate, setting aside 10% of the allowable load specifically for the margin of safety.

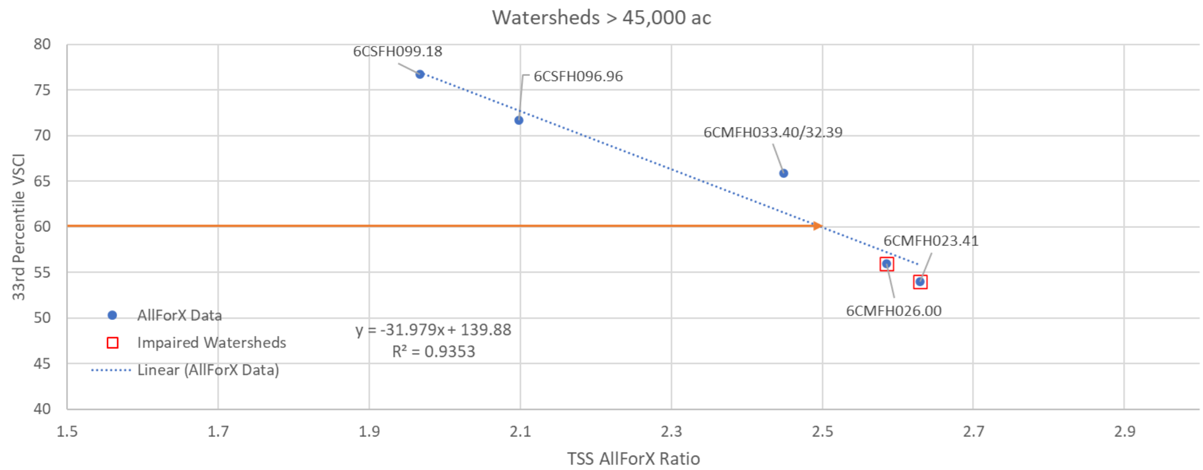

Figure C-1. Regression between stream condition index and all-forest multiplier for sediment in the TMDL watersheds >45,000 ac in size using the 33rd percentile of VSCI scores, resulting in an AllForX target value of 2.5.

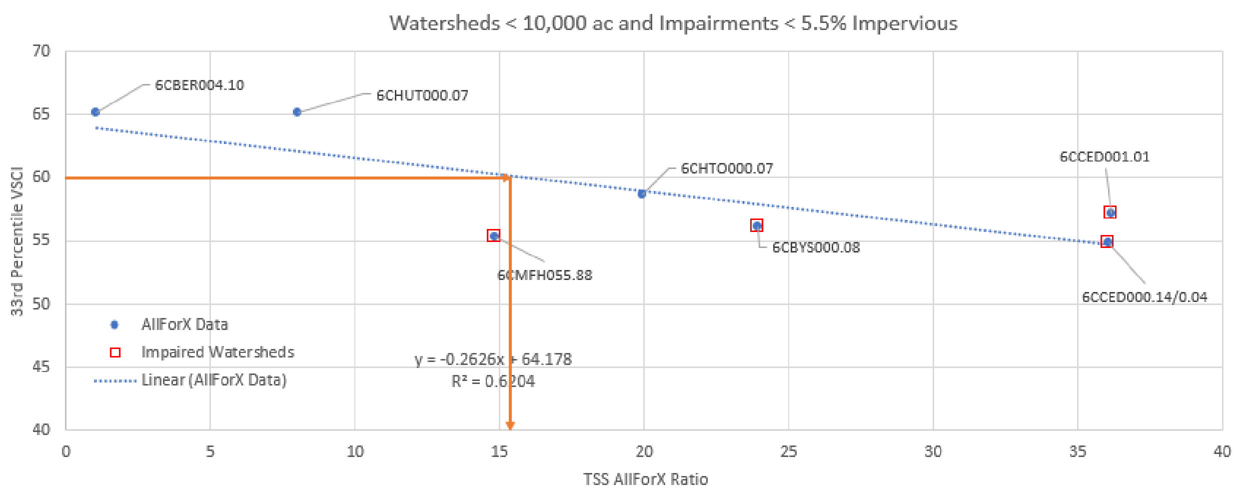

Figure C-2. Regression between stream condition index and all-forest multiplier for sediment in the TMDL watersheds <10,000 ac and <5.5% impervious cover using the 33rd percentile of VSCI scores, resulting in an AllForX target value of 15.91.

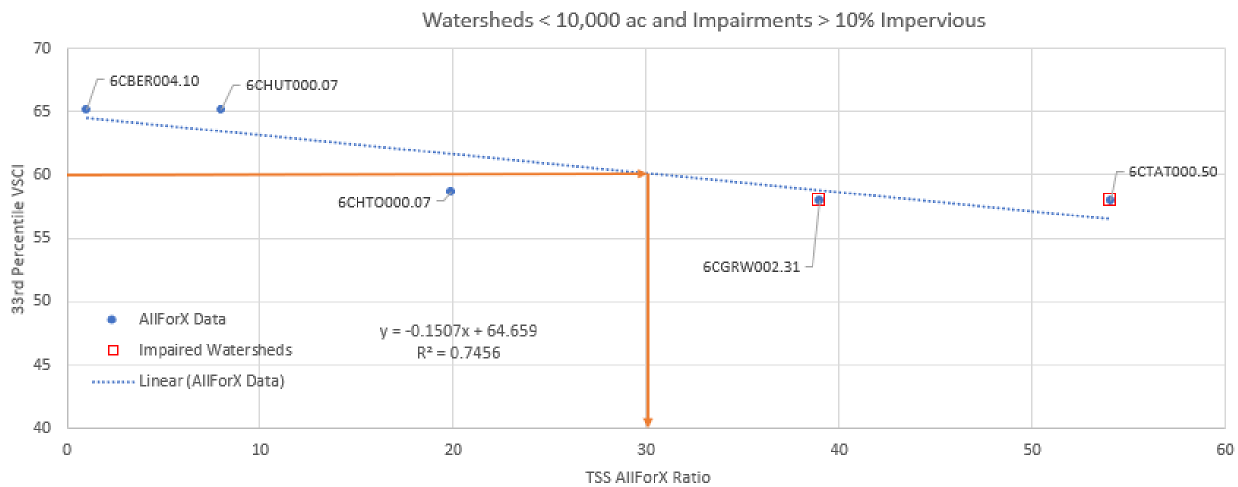

Figure C-3. Regression between stream condition index and all-forest multiplier for sediment in the TMDL watersheds <10,000 ac and >10% impervious using the 33rd percentile of VSCI scores, resulting in an AllForX target value of 30.92.

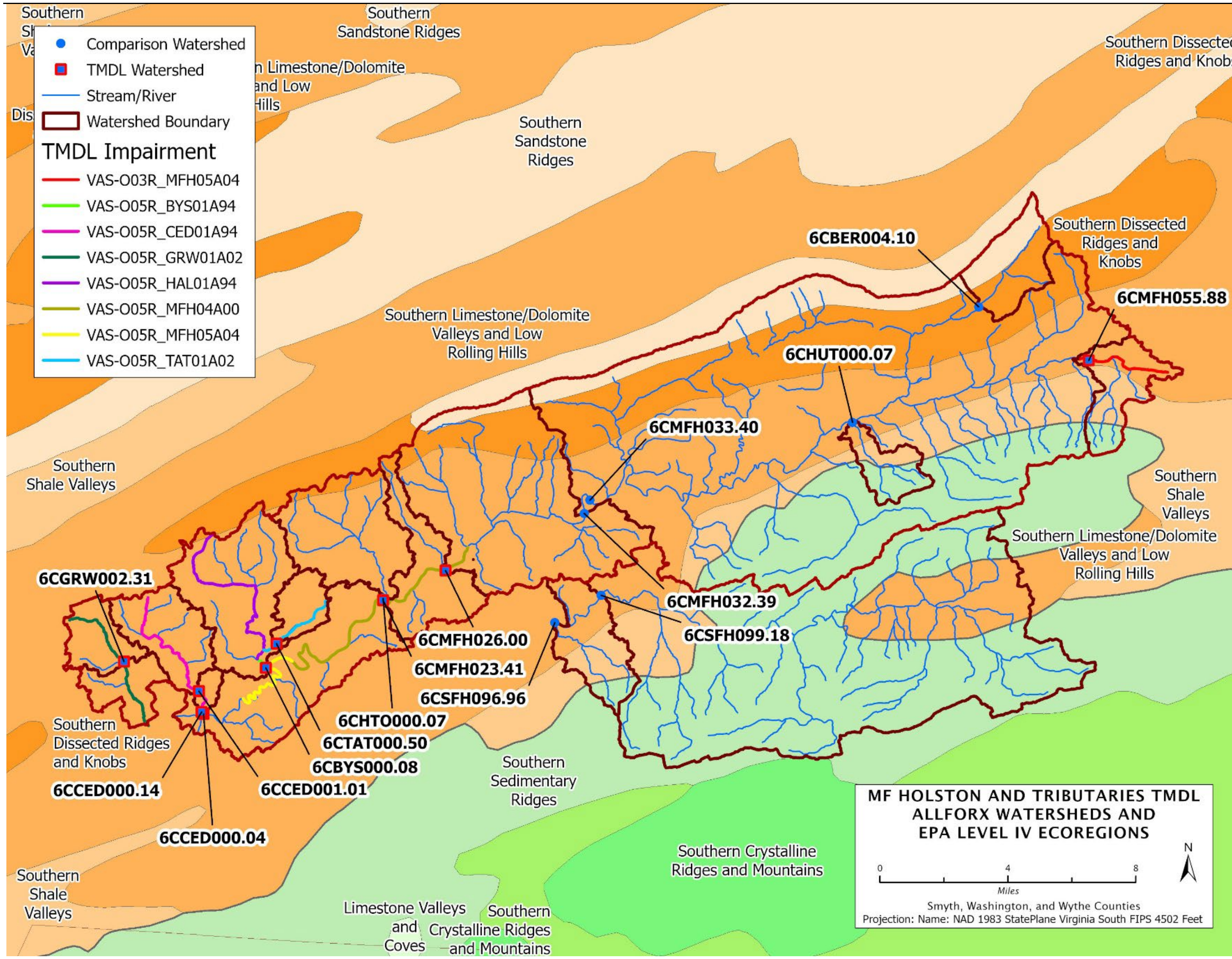

Figure C-4. Watersheds used in developing the AllForX regression.

Appendix D - Stressor Identification Analysis Report