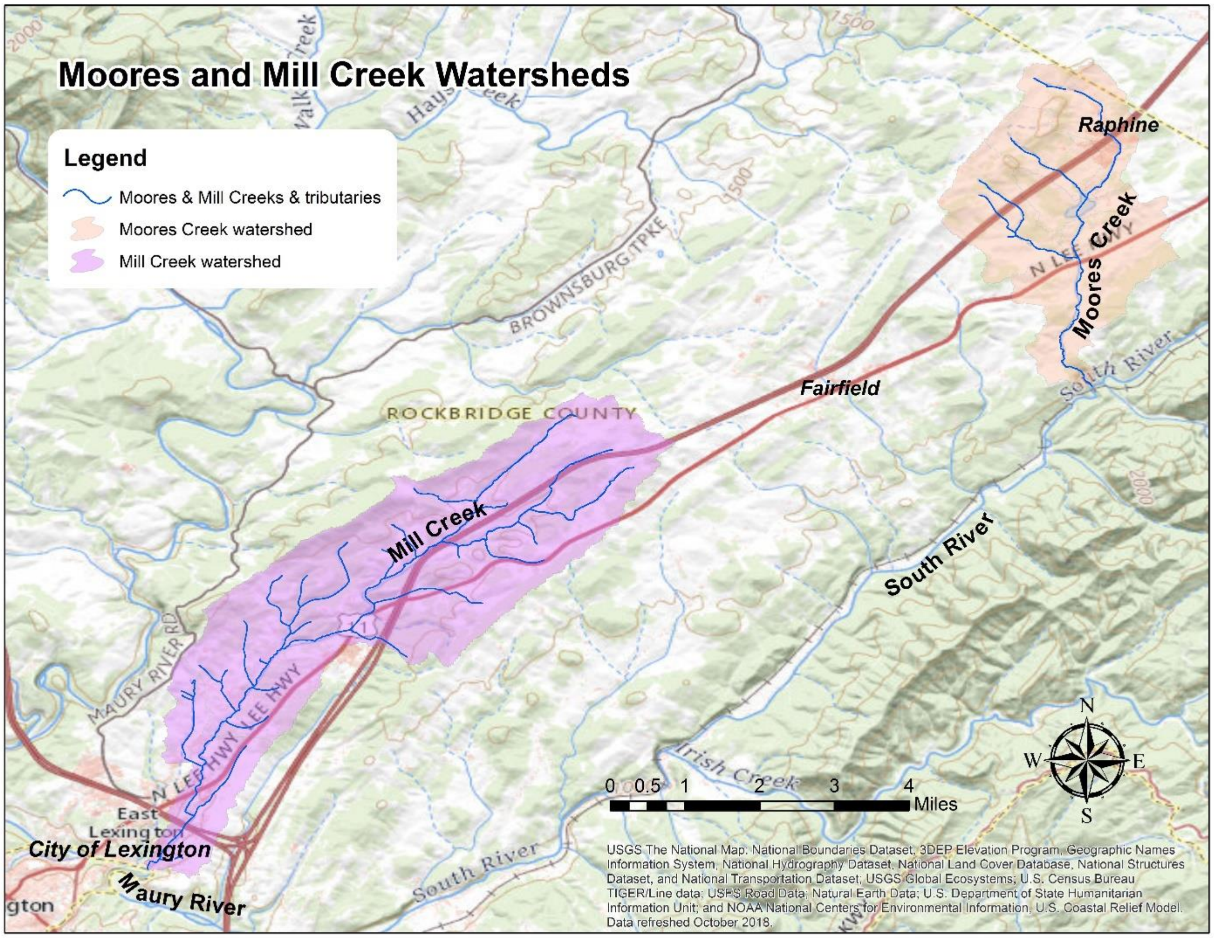
Moores and Mill Creek Technical Advisory Committee Meeting #2

Rockbridge County Administration Building, Lexington VA
August 11, 2022



A Brief Re-Cap

- Moores and Mill Creeks placed on Virginia's impaired waters list in 2006 and 2016, respectively
- Both streams have impaired benthic macroinvertebrate communities (bugs that live on the bottom of the stream)
- Benthic stressor analysis study indicated that sediment is the cause of impairment in both streams
- The VA Department of Environmental Quality (DEQ) and its contractor, Wetland Studies and Solutions Inc. (WSSI) are working to complete a Total Maximum Daily Load (TMDL) study for the streams. The study will identify sources of sediment in the watersheds, how much sediment they are contributing, and the sediment reductions needed from those sources to restore the benthic macroinvertebrate community.

- The role of the Technical Advisory Committee (TAC) in this process is to review data from the study and provide feedback on pollutant sources and reduction scenarios. The committee also shares information about the watersheds including:
    - Historic and current land use
    - Future development
    - Previous and planned restoration projects
    - Local monitoring efforts
    - Key stakeholder groups and contacts
- TAC reviews data related to:
    - Pollutants responsible for biological impairment
    - Pollutant sources
    - Pollutant reduction scenarios

Development of Moores and Mill Creek Watershed Model

Using the Generalized Watershed Loading Function Model

The Generalized Watershed Loading Function (GWLF) computer model is a tool that has been widely used across Virginia to simulate the transport of pollutants to our streams. This computer model was used to develop estimates of the amount of sediment entering Moores and Mill Creek from different sources in the watersheds.

The Moores and Mill Creek watersheds were broken up into a series of smaller subwatersheds. The GWLF model was used to generate monthly sediment yields for each subwatershed using daily water balance calculations and estimated loading rates for different and cover categories (e.g. pasture, cropland, urban impervious). The model includes a delivery ratio to estimate sediment deposition when simulating the movement of sediment from the land surface to the stream, as well as considering the transport capacity of the runoff and channel flow. GWLF also incorporates stream bank and channel erosion taking into consideration 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.

Hydrologic Calibration

While 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, hydrologic calibration was still performed as a preliminary modeling step. This is a process used to make sure that the model is accurately representing how stream flow changes in response to precipitation events. Capturing the hydrology of these watersheds correctly is key in simulating the path of sediment from the land to the stream. WSSI used the USGS flow gauge on Kerrs Creek to calibrate the Moores and Mill Creek watershed models. Since there is no gauge in either of the watersheds, Kerrs Creek was selected based on its proximity to Moores and Mill Creeks and its similar watershed characteristics. Daily rainfall and temperature data for the watershed were obtained from Oregon Stations PRISM model. Streamflow, rainfall, and temperature data from 2012 through 2021 were used to calibrate the model. During the calibration process, different parameters characterizing the watersheds were adjusted so that actual flow recorded at the Kerrs Creek gauge matched modeled flow estimates. Examples of these parameters include recession and seepage coefficients, and an evapotranspiration cover coefficient. The typical target range for GWLF calibration efforts is to achieve ±5% of the observed total flow. This target was achieved for Moores and Mill Creeks, with a difference of -2.29% between modeled and observed cumulative discharge during the calibration period. The Calibration results are shown below in Figure 1.

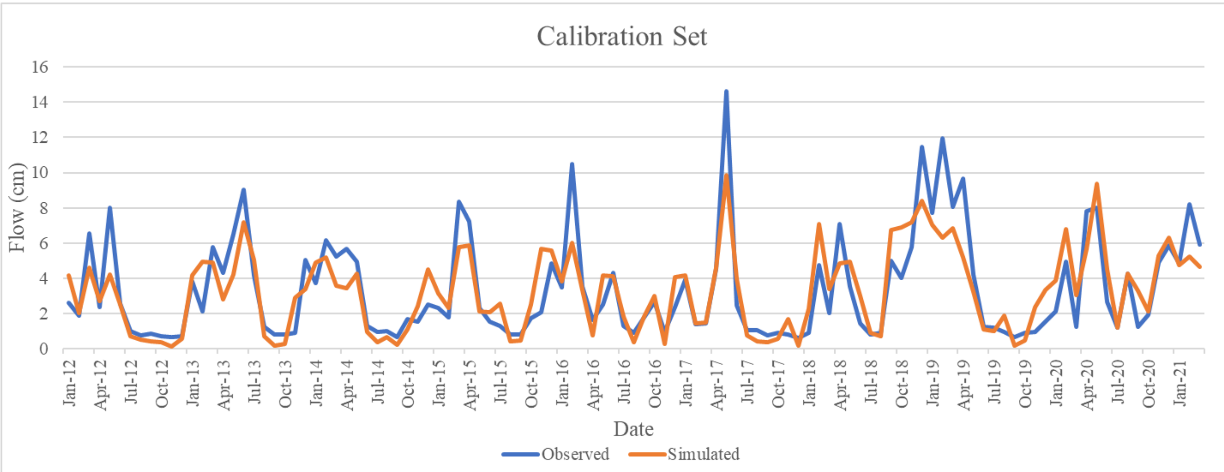


Figure 1. Calibration Data Set of Simulated Stream Flow Compared to Observed Flow at USGS Gauge

Hydrologic Validation

To ensure that the model was not just capturing stream flows during the calibration period (2012-2020), the model was validated for another time frame (2002-2011) following calibration. The results are shown below in Figure 2. Results for the validation period indicated that the model performed well outside of the calibration window for which watershed parameters were adjusted, with a difference of -2.86% between modeled and observed flows during the validation time frame.

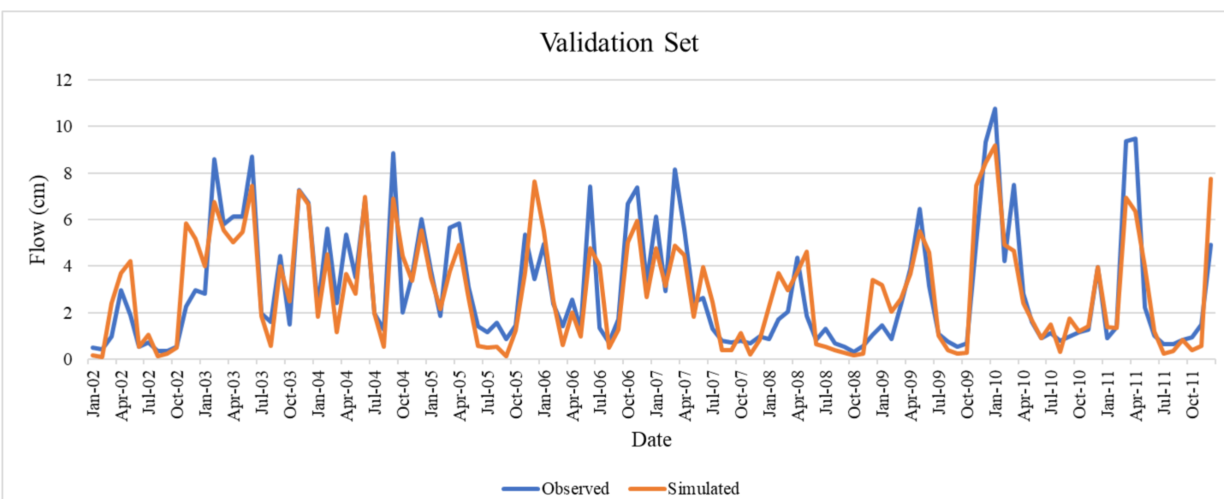


Figure 2. Validation Data Set of Simulated Stream Flow Compared to Observed Flow at USGS Gauge

Accounting for sediment sources

In order to develop more refined estimates of sediment loads from sources in Moores and Mill Creeks, the watersheds were divided into a series of smaller subwatersheds (3 in Moores Creek and 3 in Mill Creek). Land cover data from the Virginia Geographic Information Network (VGIN, 2016) was then used to estimate acres of the various land cover categories in each subwatershed (Table 1, Figure 3) Estimated sediment loading rates could then be applied to each land cover category to estimate the amount of sediment originating from that land cover category in each subwatershed.

Table 1. Moores and Mill Creek Watershed Land Cover Distributions

Land Use	Moores Creek		Mill Creek	
	Acres	Percentage	Acres	Percentage
Cropland	242	6.5%	106	1.5%
Hay	852	22.7%	1032	14.5%
Pasture	922	24.6%	1159	16.3%
Forest	568	15.1%	2654	37.3%
Trees	376	10.0%	968	13.6%
Shrub	0	0.0%	31	0.4%
Harvested	15	0.4%	0	0.0%
Water	26	0.7%	6	0.1%
Wetland	4	0.1%	1	0.0%
Barren	15	0.4%	9	0.1%
Turfgrass	536	14.3%	702	9.9%
Developed Pervious	20	0.5%	47	0.7%
Developed Impervious	176	4.7%	405	5.7%
Total	**3,753**	**100.0%**	**7,121**	**100.0%**

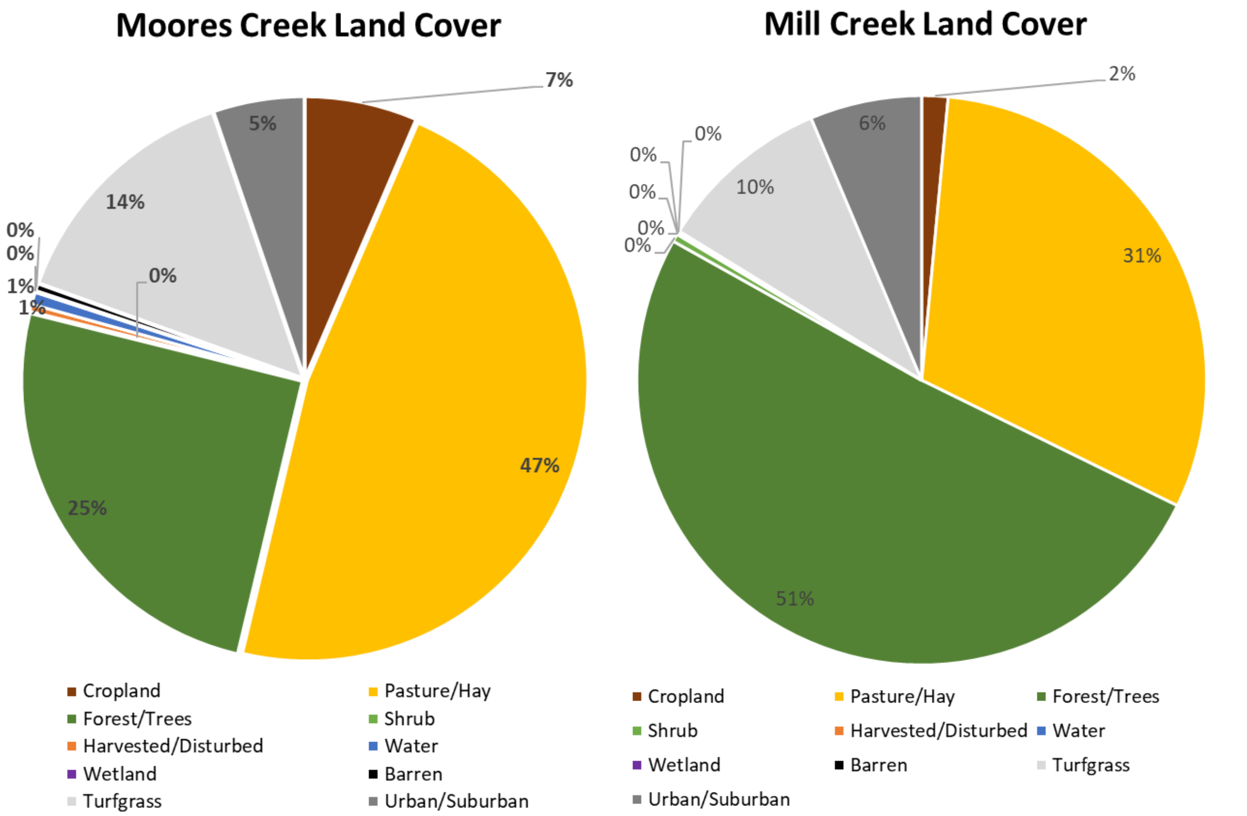


Figure 3. Moores and Mill Creek Watershed Land Cover Distributions

Permitted sediment sources

Permitted (point) sources of sediment were also accounted for in the TMDL study. Moores and Mill Creeks have construction sites covered under a Virginia Stormwater Management Program (VSMP) permit where land disturbance is occurring and the potential for sediment runoff is increased (Table 2). 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.

Appropriate erosion and sediment control measures are assumed to be utilized on all construction projects. Based on the Chesapeake Bay Expert Panel Guidance (ESCEP, 2014), it was assumed that these practices would be effective in retaining 85% of sediment from disturbed areas. This assumption was used to calculate the allocated sediment load shown in Table 2 below.

Table 2. Active Virginia Stormwater Management Program (VSMP) Permits in the Moores and Mill Creek Watersheds

Watershed	No. of permits	Estimated acres to be disturbed	Annual estimated acres disturbed	Allocated sediment load (lbs/yr)
Moores Creek	6	118.4	23.7	34,969
Mill Creek	3	21.7	4.3	6,409

Additionally, there is one Industrial Stormwater General Permit in the Mill Creek watershed (Table 3). These facilities are required to complete discharge monitoring from their stormwater outfalls to ensure compliance with pollutant concentration benchmarks included in the general permit (including sediment). The sediment benchmark concentration was converted into a loading rate of 440 lb/ac/yr of sediment, which was applied to the permitted acreage to establish the sediment wasteload allocation for this facility.

Table 3. Industrial Stormwater Permits in the Moores and Mill Creek Watersheds

Watershed	Permit no.	Facility Name	Allocated sediment load (lbs/yr)
Mill Creek	VAR052529	Devils Backbone Brewing Company	5,984

Setting sediment reduction targets

A key component of the TMDL study for Moores and Mill Creeks is the establishment of sediment reduction goals. While Virginia has water quality criteria that regulate the concentration of some pollutants in our waterways, there are no such criteria for sediment. Therefore, an alternative method must be used to determine the water quality target for sediment in the TMDL study.

The All Forest Load Multiplier (AllForX) Endpoint Approach

The AllForX approach has been used to establish sediment and nutrient reduction targets in many TMDLs studies completed 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 (see Moores Creek illustration in Figure 4). In other words, AllForX is an indication of how much higher current sediment loads are above an undeveloped condition.

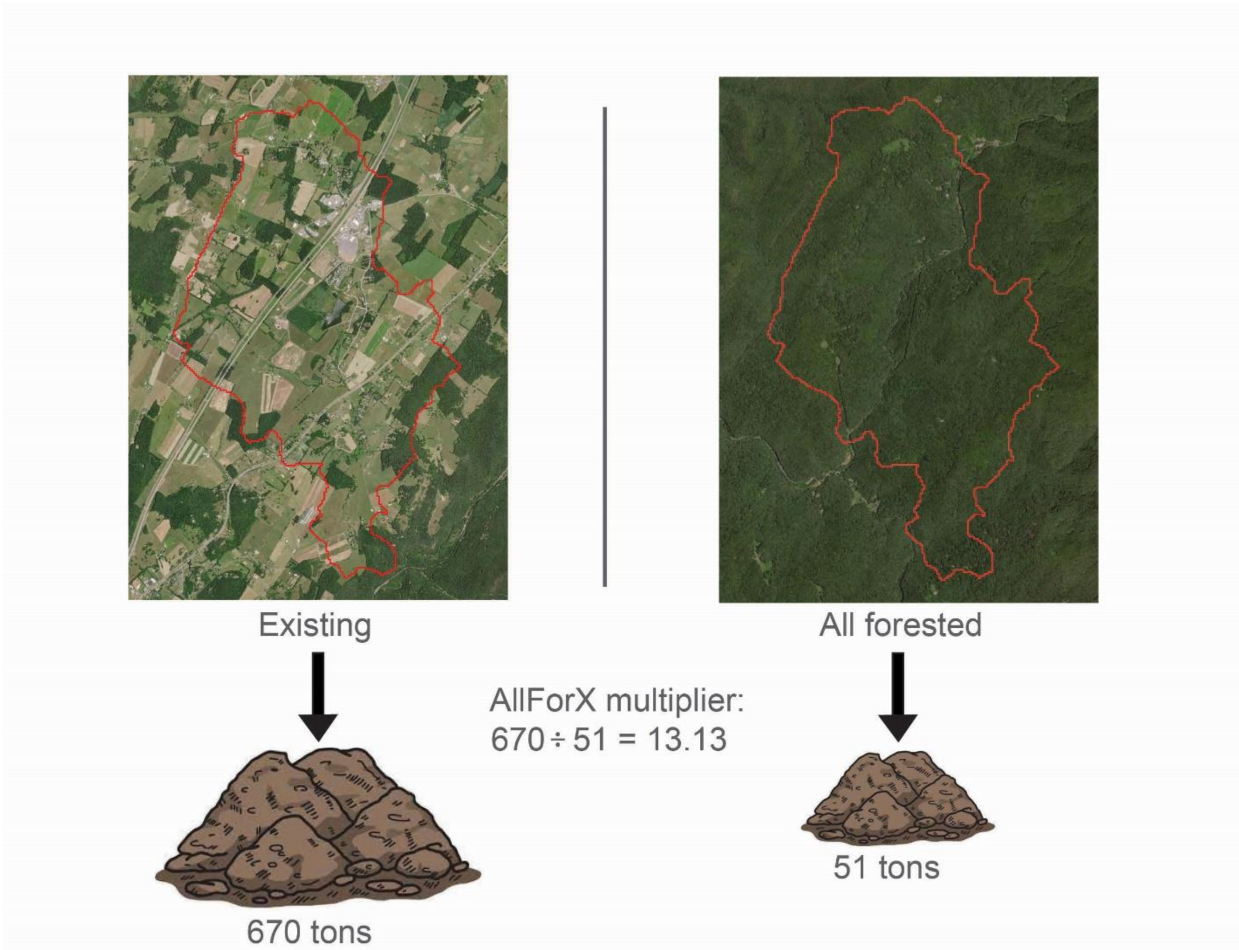


Figure 4. Illustration of Establishment of AllForX Multiplier for the Moores Creek Watershed

These multipliers are calculated for both unimpaired and impaired watersheds and then a regression is developed between the average Virginia Stream Condition Index (VSCI) scores at monitoring stations and the corresponding AllForX ratio for the watersheds contributing to the monitoring site. This regression can be used to quantify the value of AllForX threshold that corresponds to the benthic health threshold (VSCI < 60) as shown in Figure 5. The pollutant TMDL load can then be calculated by applying the AllForX threshold to the all-forest simulated pollutant load of the TMDL study watershed.

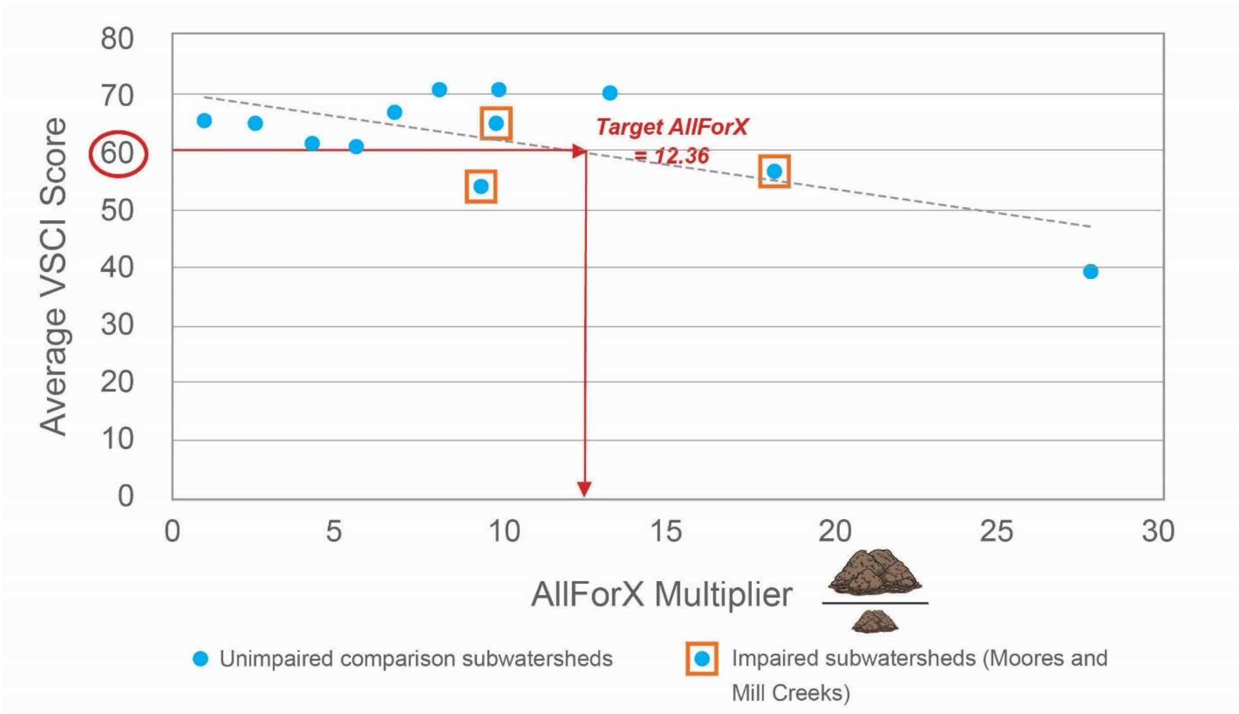


Figure 5. AllForX Regression Used to Establish Sediment Reduction Target for the Moores Creek Watershed

So what does this figure tell us?

If we can reduce the sediment load to Moores Creek by 6.3%, we will hit the AllForX target value of 12.36, which is the point at which average stream health scores typically fall above 60 (the threshold for impairment).

A separate regression was developed for Mill Creek to account for unique characteristics of the stream. Rather than using average VSCI scores for monitoring stations included in the regression, the 33rd percentile of scores in the past 10 years was used. The results of the benthic stressor analysis for Mill Creek indicate a borderline impairment, with VSCI scores repeatedly falling above and below the threshold of 60. As a result, using average VSCI scores from other streams to develop the regression indicated that no reduction in sediment was necessary in Mill Creek. Given the findings of the benthic stressor analysis, it is clear that this is not the case. Relative Bed Stability (RBS) monitoring results for Mill Creek revealed that bedrock is the predominant substrate in the stream, comprising over 40% of the stream bottom. Conversely, analyses showed relatively limited evidence of sediment deposition. With limited gravel and cobble available for colonization by macroinvertebrates, the effects of excess sediment deposition are magnified in the stream. This means that even a small amount of sediment can significantly reduce the availability of suitable habitat in Mill Creek, making a more conservative approach to TMDL development necessary. Using the 33rd percentile of VSCI scores to complete the AllForX regression for Mill Creek allows for these natural factors limiting available habitat to be considered. With VSCI scores in Mill Creek falling both above and below the listing threshold, using the 33rd percentile also accounts for the fact that DEQ reccomends two consecutive years of benthic monitoring above the VSCI threshold of 60 before delisting the stream as unimpaired. 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 qualifications for delisting. Figure 6 shows the regression developed for Mill Creek. Based on the 33rd percentile of results achieving a VSCI score of 60, the target AllForX ratio was determined to be 8.52 (Figure 6). The AllForX target of 8.52 was then used to determine an acceptable sediment load for Mill Creek.

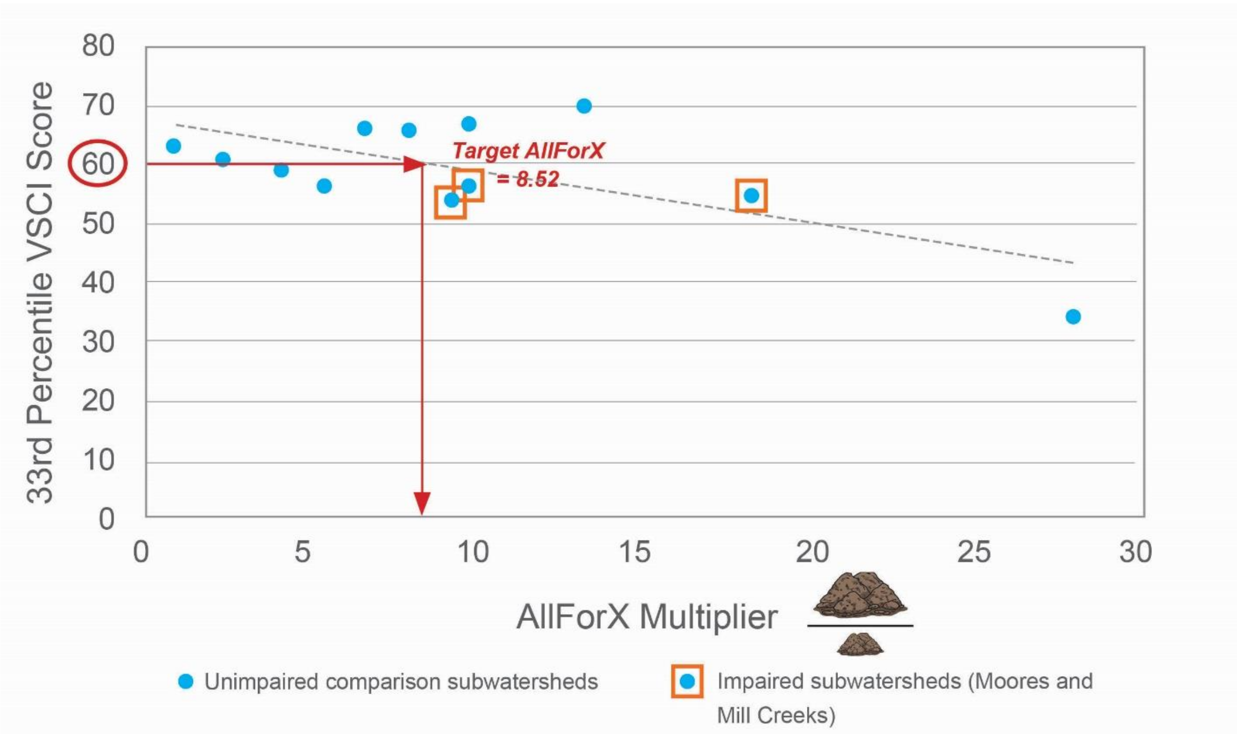


Figure 6. AllForX Regression Used to Establish Sediment Reduction Target for the Mill Creek Watershed

So what does this figure tell us?

If we can reduce the sediment load to Mill Creek by 13.5%, we will hit the AllForX target value of 8.52, which is the point at which the 33rd percentile of stream health scores typically fall above 60 (the threshold for impairment).

Establishing a TMDL Equation

Once sediment reductions were identified for Moores and Mill Creeks using the AllForX model, TMDL equations could be developed for each watershed. A TMDL equation consists of three parts illustrated below:

TMDL (lb sediment/year) = Load allocation + Wasteload allocation + Margin of safety

<u>Load allocation:</u> Sediment load originating from nonpoint sources (running off the land surface to the creek during precipitation events)

<u>Wasteload allocation</u>: Sediment load originating from point sources (permitted facilities that discharge the pollutant of concern). A future growth allocation is often included in this component of the TMDL equation to allow for issuance of discharge permits in the future. Both Moores and Mill Creeks have active Virginia Stormwater Management Program Permits (construction sites where land disturbance is occurring). Mill Creek has one Industrial Stormwater Permit.

<u>Margin of safety</u>: Since no model is perfect, a margin of safety is also included in the TMDL. This can be explicitly determined (e.g. 5% of the TMDL) or implicitly defined using conservative assumptions in the model. A 10% explicit margin of safety was selected for the Moores and Mill Creek TMDLs.

Existing Best Management Practices

Existing Best Management Practices (BMPs) that have been implemented within the watersheds were also accounted for in developing the TMDLs. BMPs that help to reduce sediment in the streams, either by land cover change or a sediment removal fraction, are incorporated into the final TMDL equation (Table 4). While only BMPs in Mill Creek are in the table, other BMPs exist in both watersheds, but are either maintenance practices or contribute only nutrient reductions without an associated sediment reduction.

Table 4. BMPs in the Mill Creek Watershed

BMP Code	BMP Type	Extent Installed	Efficacy method (fraction TSS removal, other)	TSS Removal (lb/year)
CRFR-3	CREP Woodland Buffer Filter Area	13.9 ac	0.4, land cover change	8801
FR-1	Afforestation of Crop, Hay and Pasture Land	3.9 ac	0.4, land cover change	2469
SL-6	Stream Exclusion With Grazing Land Management	300 lin.ft., 28.59 ac benefitted	0.4	8801
SL-6W	Stream Exclusion with Wide Width Buffer and Grazing Land Management	1605 lin.ft., 25.87 ac benefitted	0.4	7964

Developing Allocation Scenarios

Four different allocation scenarios have been developed for sediment to meet or exceed the TMDL target reductions established for Moores and Mill Creeks (Table 5 and 6, respectively). For each stream, Scenario 1 presents an even reduction across all anthropogenic sources. Scenario 2 focuses reductions on agricultural sources, and Scenario 3 focuses reductions on urban sources. Scenario 4 was included to provide a more tailored approach, with greater reductions recommended for the larger source (agricultural vs. urban). The allocation scenario reductions include a load allocation for each land cover classification in the watersheds, a wasteload allocation for permitted sediment sources, and a 10% margin of safety. The wasteload allocations also include a 2% future growth allocation to allow for issuance of discharge permits in the watersheds in the future. Input on these scenarios is requested from the Technical Advisory Committee so that an optimal scenario may be selected.

What's next?

Once an allocation scenario is selected, we can complete the TMDL study and share a draft with the committee for review. We will hold one final TAC meeting to discuss comments on the draft report and make plans for the final public meeting to share the study with the local community. This public meeting will be followed by a 30-day public comment period.

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Table 5. Potential Sediment Allocation Scenarios for the Moores Creek Watershed

Moores Creek Sediment		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	268,472	20.2	214,241	25.1	201,086	0.0	268,472	23.0	206,724
Hay	45,883	20.1	36,661	25.1	34,367	0.0	45,883	23.0	35,330
Pasture	703,440	20.1	562,049	25.1	526,877	0.0	703,440	23.0	541,649
Forest	9,573	-	9,573	-	9,573	-	9,573	-	9,573
Trees	15,217	-	15,217	-	15,217	-	15,217	-	15,217
Shrub	0	-	0	-	0	-	0	-	0
Harvested	3,424	-	3,424	-	3,424	-	3,424	-	3,424
Wetland	174	-	174	-	174	-	174	-	174
Barren	103,210	-	82,362	-	103,210	-	8,566	-	94,437
Turfgrass	30,754	20.2	24,541	0.0	30,754	91.8	2,522	8.4	28,170
Developed Pervious	1,946	20.1	1,555	0.0	1,946	91.7	162	8.5	1,781
Developed Impervious	121,888	20.1	97,388	0.0	121,888	91.7	10,117	8.5	111,527
Streambank Erosion	28,404	20.1	22,695	25.0	21,303	91.7	2,358	23.0	21,871
Const. Permits	34,969	-	34,969	-	34,969	-	34,969	-	34,969
MOS (10%)	125,554	-	125,554	-	125,554	-	125,554	-	125,554
Future Growth (2%)	25,111	-	25,111	-	25,111	-	25,111	-	25,111
TOTAL	**1,518,019** **0% red.**		**1,255,513** **17.3%**		**1,255,452** **17.3%**		**1,255,541** **17.3%**		**1,255,511** **17.3%**

Table 6. Potential Sediment Allocation Scenarios for the Mill Creek Watershed, existing and allocated scenarios including existing BMP reductions

Mill Creek Sediment		Scenario 1		Scenario 2		Scenario 3		Scenario 4	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	112,090	21.9	87,542	30.0	78,463	0.0	112,090	25.0	84,067
Hay	71,062	21.9	55,499	30.1	49,672	0.0	71,062	25.0	53,296
Pasture	891,547	21.9	696,298	30.1	623,191	0.0	891,547	25.0	668,660
Forest	76,919	-	76,919	-	76,919	-	76,919	-	76,919
Trees	55,668	-	55,668	-	55,668	-	55,668	-	55,668
Shrub	11,344	-	11,344	-	11,344	-	11,344	-	11,344
Harvested	0	-	0	-	0	-	0	-	0
Wetland	174	-	174	-	174	-	174	-	174
Barren	109,232	21.8	85,419	0.0	109,232	66.6	36,484	13.5	94,486
Turfgrass	49,833	21.8	38,970	0.0	49,833	66.7	16,595	13.5	43,106
Developed Pervious	8,277	21.9	6,464	0.0	8,277	66.7	2,756	13.6	7,151
Developed Impervious	267,573	21.9	208,974	0.0	267,573	66.7	89,102	13.6	231,183
Streambank Erosion	90,520	21.9	70,696	30.0	63,364	66.6	30,234	25.0	67,890
Const. Permits	6,409	-	6,409	-	6,409	-	6,409	-	6,409
ISW Permits	13,341	-	5,984	-	5,984	-	5,984	-	5,984
MOS (10%)	159,817	-	159,817	-	159,817	-	159,817	-	159,817
Future Growth (2%)	31,963	-	31,963	-	31,963	-	31,963	-	31,963
TOTAL	1,955,769		1,598,142		1,597,884		1,598,146		1,598,118
	0% red.		18.3%		18.3%		18.3%		18.3%