Assessment of erosion, sedimentation, and water quality impacts of the Mountain Valley Pipeline and Equitrans Expansion Project's proposed crossing of the Jefferson National Forest as it pertains to the U.S. Forest Service's Draft Supplemental Environmental Impact Statement dated December 2022

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Executive Summary

The U.S. Department of Agriculture Forest Service in cooperation with the U.S. Bureau of Land Management (BLM) prepared a Draft Supplemental Environmental Impact Statement (DSEIS), dated December 2022, in response to the U.S. Court of Appeals for the Fourth Circuit 25 January 2022 decision that vacated and remanded the Forest Service's 11 January 2021 decision approving the Jefferson National Forest (JNF) plan amendment and the BLM's 14 January 2021 right-of-way decision and right-of-way grant for the Mountain Valley Pipeline (MVP).

Most relevant to this assessment, the Court directed the Forest Service "to consider the [U.S. Geological Survey] USGS data and any other relevant information indicating that the modeling used in the [Environmental Impact Statement] EIS may not be consistent with data about the actual impacts of the Pipeline and its construction" (U.S. Court of Appeals, 2022).

The Forest Service's 2022 DSEIS sought to address the deficiencies identified by the Fourth Circuit's January 2022 decision and new circumstances and relevant information since December 2020 that are relevant to the environmental concerns and decision framework, and have a bearing on the proposed action or its effects.

A Forest Service decision is needed because the proposed project is inconsistent with several Forest Plan standards and cannot be constructed on the JNF unless the Forest Service amends these standards. Furthermore, there is a need to determine what terms and conditions, or stipulations, should be provided to the BLM to protect resources and the public interest consistent with the Mineral Leasing Act, 30 U.S.C. § 185(h) (the above summarized from DSEIS, 2022).

Six of the 11 Forest Plan standards proposed to be modified (FW-5, FW-8, FW-9, FW-13, FW-14, 11-003) would exempt from those standards "the MVP construction zone and right-of-way, for which applicable mitigation measures identified in the approved [Plan of Development] POD (e.g., Appendix C-1 to C-3, Erosion and Sediment Control Plan) and MVP Project design requirements must be implemented" (DSEIS, 2022).

The 2022 DSEIS (p. 23) concludes that the "short term effects [of the proposed action on water resources] would be minor, which is consistent with the conclusions in the [Federal Energy Regulatory Commission] FERC [Final Environmental Impact Statement] FEIS and 2020 [Final Supplemental Environmental Impact Statement] FSEIS. ... Effects on water resources would be minimized through implementation of measures in the POD, such as [Best Management Practices] BMPs and the use of [Erosion Control Devices] ECDs as modeled in Revised Universal Soil Loss Equation, Version 2 (RUSLE2). Long-term impacts would be associated with post-construction restoration and operation and would be minor in intensity, which is consistent with the conclusions in the FERC FEIS and 2020 FSEIS. The USGS data and other relevant information considered in this DSEIS do not indicate that the modeling used in the 2020 FSEIS is inconsistent with data about the actual impacts of the pipeline and its construction."

The 2022 DSEIS concludes that the proposed action will have minor impacts on downstream water resources. Additionally, the DSEIS states that "[c]omprehensive analysis of the modeling results and real-world data indicates that the ECDs that were installed and maintained are effective at managing sediment yields." (p. 39, DSEIS, 2022).

However, my assessment raises several issues with the modeling and monitoring, upon which this decision was based, that suggest the impacts are likely much larger than reported. **This assessment of the 2022 DSEIS shows why the real-world data and the modeling do not align. That is, a consistent story emerges that identifies deficiencies with the RUSLE/RUSLE2 modeling** (section 2) **that has led to pollution incidents and failures of the designed erosion control devices** (section 5) **resulting in in-stream turbidity levels that have increased by 20% to 200%** (section 3.2) **instead of the 0.1% to 2.6% increase in sediment yield suggested by the RUSLE2 modeling**. A summary of these issues is highlighted here and discussed fully farther below:

1. RUSLE/RUSLE2 modeling results do not provide meaningful information on potential impacts to water quality.

    1.1. 2022 DSEIS essentially dismisses the Court's request to consider the monitoring data in the context of the modeling results. If the RUSLE2 estimates cannot be reasonably compared to measured data, then there is no way to independently validate the RUSLE2 results and assure their validity.

1.2. RUSLE/RUSLE2 modeling results are not conveyed in a way that allows for a meaningful review of the potential impacts to water quality. The sedimentation modeling estimated that sediment yields during construction would increase by less than 0.001 to 0.011 tons/ac/yr (median: 0.003 tons/ac/yr) above the baseline. Translating these delivered sediment loads from the RUSLE/RUSLE2 model into more meaningful units, between 6 and 28 football fields per year would be covered in 1/8-inch thick sediment deposition due to the extra sediment generated during the construction scenario in each of the different Hydrologic Unit Code (HUC)-12 basins. Furthermore, measuring turbidity alone is not likely to provide a meaningful assessment of the impacts that may be occurring on the streambed due to sedimentation.

2. The validity of RUSLE/RUSLE2 results in the JNF are questionable given the model's applicability and high uncertainty.

2.1. RUSLE/RUSLE2 model is highly uncertain for the steep slopes of the JNF. The RUSLE/RUSLE2 model is most applicable for slopes less than 20% with very limited data to support the validity of model results derived from slopes greater than 20-30%. Nearly 57% of the total length of the MVP crossing of the JNF has a slope >20% and 26% of the total length has a slope >30%. This means that the RUSLE/RUSLE2 model is most applicable to only 43% of the MVP study area in the JNF and there is very limited data (in deriving the fundamental RUSLE/RUSLE2 model equations) to support the validity of the RUSLE/RUSLE2 model results obtained from 26% of the MVP study area in the JNF.

2.2. The baseline sediment delivery estimate is likely off by at least 500% on the basis of one parameter (C factor for forest). The baseline estimate of annual soil loss is being overestimated, which underestimates the relative (to baseline) soil loss estimates for the proposed action scenarios. This suggests that the RUSLE/RUSLE2 modeling is not conservative.

3. Analysis of the USGS data was not adequately conducted.

3.1. Regression analysis is not a valid approach for analyzing the USGS data given the changing land surface conditions after construction began. Because the conditions on the ground had changed over time (non-stationary) in the post-construction period, all the post-construction data cannot be grouped together for a statistical analysis investigating changes relative to the data from the pre-construction period.

3.2. Analysis of the USGS data indicates that construction has increased turbidity by 20% to 200%, which further underscores the poor applicability of the RUSLE2 modeling and suggests that predicted water quality impacts are being severely underestimated.

4. It is unclear whether the errors and uncertainty in the MVP monitoring data overwhelm any meaningful results from this dataset. The error and uncertainty associated with MVP's field data collection of suspended-sediment data were not mentioned. This error and uncertainty would propagate into the developed statistical relation between turbidity and suspended-sediment concentration. This error and uncertainty can easily and commonly does result in inaccuracies in reported suspended-sediment concentrations of one order of magnitude or more.

5. Ongoing water quality problems and damages suggest that the erosion control devices are not effective.

6. Tropical Storm Michael (October 2018) was not an extreme rainfall event and erosion control devices should not have failed.

Assessment of erosion, sedimentation, and water quality impacts of the MVP

1. RUSLE/RUSLE2 modeling results do not provide meaningful information on potential impacts to water quality

1.1. 2022 DSEIS essentially dismisses the Court's request to consider the monitoring data in the context of the modeling results

The basis for assessing erosion and sedimentation was the use of the "Revised Universal Soil Loss Equation (RUSLE) model used to estimate annual erosion of soils within a watershed and RUSLE, Version 2 (RUSLE2) used to estimate site-specific annual erosion of soils due to project activities on the JNF" (p. 38, DSEIS, 2022). The model results and way they were reported in the 2022 DSEIS, however, were ineffective for estimating the in-stream impacts of the proposed project.

The 2022 DSEIS (p. 38) points out that "[t]here are inherent limitations associated with comparing modeling outputs against monitoring data." I agree that there are inherent limitations in doing so, but not to the extent that the 2022 DSEIS identifies. Specifically, these limitations relate to comparing annual soil loss predictions in units of mass of sediment per land surface area per time (typically as tons per acre per year; tons/ac/yr) from RUSLE/RUSLE2 with instantaneous or continuous (typically at 15 minute intervals) at-a-point, in-stream water quality monitoring data and information in terms of turbidity in units of FNU or suspended-sediment concentration in units of mass of sediment per volume of water (typically as milligrams per liter; mg/L). Additionally, the USGS monitoring data are only available at a few locations and started monitoring for a short time period before construction began, which limits the types of analysis possible. However, that does not preclude gaining some insight about some of the changes that were observed, which are discussed in section 3.2.

Rather than engaging with these issues, however, the 2022 DSEIS essentially dismisses the Court's request to consider the monitoring data in the context of the modeling results, relying on a narrow interpretation that such a comparison or consideration requires "inputting historical data to compute erosion values that are compared to values measured at a particular site" (p. 38, DSEIS, 2022; citing USDA, 2008a). This interpretation results in a significant contradiction in the Forest Service's conclusions.

First, the 2022 DSEIS (p. 38) cites USDA (2008a) in stating that "[t]he most important part of RUSLE2's validation is whether RUSLE2 leads to the *desired erosion control decision*, not how well RUSLE2 estimates compare to measured data" (emphasis added). This statement as a justification for the limitations of RUSLE2 is problematic for a few reasons. First, how would the "desired erosion control decision" be known if a realistic amount of sediment erosion those erosion control devices are meant to prevent is unknown? This suggests that the "erosion control decisions" are made as the user desires, independent of any scientific information on the actual soil erosion amounts that may be expected. Second, **if the RUSLE2 estimates cannot be reasonably compared to measured data, then there is no way to independently validate the RUSLE2 results and assure their validity**. This is a concern that was specifically mentioned by the Court in their previous decision (p. 21, U.S. Court of Appeals, 2022) and has not been addressed in the 2022 DSEIS. Additionally, the next sentence from USDA (2008a) states that, "*[v]alidation certainly involves evaluating RUSLE2's accuracy*, but many other considerations are also important in judging how well RUSLE2 serves its stated purpose" (emphasis added). This further underscores that an evaluation of the RUSLE/RUSLE2 results for accuracy are necessary.

The direct results output from RUSLE/RUSLE2 in terms of estimated annual soil loss in units of mass of sediment per land surface area per time (tons per acre per year; tons/ac/yr) are difficult to directly compare to measured data unless in-stream sediment data have been recorded for many years. However, I disagree with the statement that an adequate comparison between the RUSLE2 results and the in-stream measurements is not possible (see section 3.2). The RUSLE2 results are also presented in terms of estimated percent changes in annual soil loss in response to different erosion control decisions. Therefore, the relative magnitudes of percent change in the RUSLE2 results from baseline could, in general if the model was applicable to the landscape (see section 2.1), provide a reasonable basis for comparing with the percent change in in-stream water quality (in this instance, turbidity). A brief analysis toward this end is performed as an example in section 3.2, which suggests that the RUSLE2 modeling and associated predicted water quality impacts are being severely underestimated.

Second, the 2022 DSEIS (p. 38-39) states that "[t]he [RUSLE2] modeling results were used to identify ECDs to effectively minimize downstream surface water erosion and sediment effects that may occur during rainfall events. The [RUSLE2] model results are valuable for comparing annual estimated sediment loads under various land management scenarios but *do not predict in-stream sediment or turbidity concentrations* caused by specific rainfall events. The RUSLE2 modeling analysis for the JNF was *not intended to be representative of direct in-stream measurements; it was used as a conservative planning and analytical tool to identify areas with increased potential for sedimentation and address possible erosion problems with enhanced site-specific ECDs*. As described above, the RUSLE2 modeling analysis informed the decision on where to place ECDs and which type of ECDs to install" (emphasis added).

To summarize, the 2022 DSEIS is stating that the RUSLE2 modeling's purpose was to determine where to put ECDs and not to predict downstream impacts on water resources, such as via in-stream turbidity or suspended-sediment concentrations. This is inconsistent with the next paragraph of the 2022 DSEIS (p. 39), which begins with "[t]he RUSLE2 modeling estimated that enhanced ECDs would be effective at minimizing sedimentation *in* waterways" (emphasis added). It is not possible to claim both that the RUSLE2 modeling can show that ECDs would be effective at minimizing sedimentation *in* waterways and that the RUSLE2 modeling is not representative of in-stream conditions. The only way to know sedimentation *in* waterways is by being able to represent what is happening in the stream (in-stream conditions). At most, the RUSLE2 modeling could show that the ECDs could be effective at minimizing sediment delivery *to* waterways, but no further context has been provided for how the RUSLE2 model results relate to meaningful estimated water-quality impacts. I agree that the RUSLE2 modeling results, as shown, are not conveyed in a way that is comparable to in-stream conditions. Therefore, the RUSLE2 modeling results provide little value in assessing the impacts of the proposed action on downstream water resources, particularly in-stream conditions (see also section 1.2). Additionally, I disagree that the RUSLE2 modeling has shown that ECDs would be effective at minimizing sedimentation in waterways (see the rest of my entire assessment below).

1.2. RUSLE/RUSLE2 modeling results are not conveyed in a way that allows for a meaningful review of the potential impacts to water quality

Much of the Forest Service's impetus for suggesting that the proposed action would have minimal effect on sedimentation is the following summary of results from the RUSLE/RUSLE2 modeling (from p. 2, Geosyntec, 2020, and recurs in the 2022 DSEIS at p. 63-64 in support of modifying the Forest Plan standards and at p. 74-75 and p. 77 in relation to the substantive requirements):

"The [RUSLE/RUSLE2] model estimated that baseline sediment yields would vary from 0.15 to 0.43 tons/ac/yr at each HUC-12 watershed outlet, with a median of 0.35 tons/ac/yr for the study area. The model estimated that sediment yields during the tree clearing phase of the project would increase by less than 0.001 tons/ac/yr (median: less than 0.001 tons/ac/yr) above the baseline. The sedimentation modeling estimated that sediment yields during construction would increase by less than 0.001 to 0.011 tons/ac/yr (median: 0.003 tons/ac/yr) above the baseline. This correlates to an increase of 0.1% to 2.6% (median: 1.1%) compared to the baseline scenario. One year after construction is completed sediment yields would be reduced to about 0.01% to 0.5% (median: 0.4%) above baseline." (p. 39, DSEIS, 2022).

These results do not provide a basis for a meaningful review of potential impacts to water quality for several reasons. First, the amount of sediment generated by the proposed action comes from a small corridor of land along the MVP right-of-way of 1 to 120 acres for the HUC basins considered, and then that amount is divided by the much larger HUC basin areas of 31,000 to 2.4 million acres (Table 1). The resulting sediment yields that are reported, such as 0.35 tons/ac/yr or an increase of 0.003 tons/ac/yr, are thus arbitrarily small regardless of the units. But even if this were not the case, the unit of one ton/ac/yr does not easily provide a meaningful way to assess the actual downstream sedimentation impacts without further context.

To translate these numbers, the delivered sediment loads to the streams in each HUC basin from the RUSLE/RUSLE2 modeling (from p. 60, Table 5-1, Geosyntec, 2020) in tons/yr are shown in Table 1 for context. Note that these are the values prior to dividing by HUC-12 basin area to calculate a sediment yield in tons/ac/yr. The delivered sediment loads in tons/yr represent the annual mass of sediment that would be delivered to the stream under the different scenarios: baseline, felled, during (construction), and restoration. The increase in delivered sediment load from the baseline scenario (in tons/yr) is the difference between the delivered sediment load from the felled, during, and restoration scenarios with the baseline scenario. This represents the additional amount of sediment that is estimated from the RUSLE/RUSLE2 model to be delivered to the streams in each HUC-12 basin under the proposed scenarios (above baseline). These units of tons per acre are still not meaningful, so instead they were converted to the number of football fields (per year) that would be blanketed by a sediment layer 1/8-inch thick (Table 1). This calculation uses a bulk density of the delivered sediment of 1 ton/m^3 (based on a likely silt sediment grain size; Wu and Wang, 2006) and that a football field is 120 yards long (including both end zones) by 160 feet wide. Also note that the area of a football field is about 1.3 acres.

The sedimentation depth of 1/8-inch thick was chosen because it represents an amount of sediment that I expect would adversely affect the streambed, which would then likely affect sediment-sensitive biota. Translating the annual soil loss estimates into a relatable area and thickness is intended to provide context for these estimates and does not capture the full range of processes through which sedimentation can affect a streambed and the species-specific threshold value that would cause an adverse impact to biota (Collins et al., 2011; Wharton et al., 2017). The specific depth or amount of sediment deposition to cause an adverse impact to biota will depend on the grain size of sediment (clay, silt, or sand), how that sediment is depositing (draped on the streambed or filling the pore spaces of the streambed), the species of concern, and the timing relative to the species' sediment-sensitive life stages (Collins et al., 2011; Wharton et al., 2017). An adverse impact could occur due to a 1/16-inch draping of silt (as silt cover) on only a portion of the streambed.

For instance, habitat suitability for the adult candy darter (*Etheostoma osburni*) decreases substantially once silt cover is greater than 25% (Dunn & Angermeier, 2016). This means that for this species, at this life stage, and the way in which this mechanism of sedimentation affects the candy darter, the spatial extent of the amount of sediment that would cause an adverse impact would actually be eight times that reported in Table 1 (number of football fields with 1/8-inch thickness is equivalent to 8 times that number if considering 1/16-inch thickness and only needing to affect 25% of the streambed). If sedimentation is filling the pore spaces of the gravel streambed, which also affects biota (Wharton et al., 2017), given a typical gravel bed porosity of 0.4 (or 40% of the streambed is pore space; Wu and Wang, 2006), that means the spatial extents would actually be 2.5 times greater than reported in Table 1 (1/0.4). Additionally, sediment deposition of 1/4-inch is sufficient to bury macroinvertebrates (Collins et al., 2011), which means that spatial extents would be half of those reported in Table 1. These are a few examples for which sedimentation can have different impacts on different biota and how the sedimentation numbers in football fields at 1/8-inch thickness may still underestimate or overestimate the actual impact to a specific species.

Translating the delivered sediment loads from the RUSLE/RUSLE2 model into more meaningful units, **between 6 and 28 football fields per year would be covered in 1/8-inch thick sediment deposition due to the extra sediment generated during the construction scenario <u>in each</u> of the different HUC-12 basins** (Table 1). I emphasize *each* HUC-12 basin because for the entire study area of nine HUC-12 basins, this corresponds to nearly 127 football fields per year covered in 1/8-inch thick sediment deposition due to the extra sediment generated during the construction scenario. Furthermore, streams are narrow corridors where this deposition would occur, so for further context, one football field translates into the same area as a nearly 11-foot wide stream extending for one mile.

There are several important points to consider in interpreting these results. First, the sediment that is eroded from the hillslopes that is likely to make it to the streams has a range of grain sizes, from clay to silt to sand. Sediment in each of these size classes travels in the stream differently and affects biota differently. For example, the finest size, clay, is easily suspended in the water column, would cloud the water, can clog the pore spaces of the streambed, and most likely quickly wash farther downstream. The finest sediment would probably deposit on floodplains or in the next downstream reservoir, which for areas draining to the Roanoke River would be behind Niagara Dam in Roanoke or in Smith Mountain Lake in Virginia and for areas draining to the New River would be behind Bluestone Dam in the Bluestone Reservoir in West Virginia. Sand-sized sediment can travel suspended in the water column, but will most often be found deposited in the streambed between the coarser gravel streambed particles.

This accumulation of sand (and finer particles) around gravel streambed particles is called **embeddedness** by aquatic ecologists. Embeddedness is directly related to habitat quality and many species of aquatic biota are adversely affected by even modest levels of embeddedness (Collins et al., 2011; Kemp et al., 2011; Wharton et al., 2017; Wood & Armitage, 1997). Silt is between the sizes of clay and sand. It can be flushed downstream at high flows, but will also drape the gravel streambed, particularly in pools and in low velocity regions of streamflow around the channel margins or in-stream wood (Dunn & Angermeier, 2016). Siltation on the streambed can be problematic for biota even when it is just a dusting of silt coating gravel particles at thicknesses much less than 1/8 inch, as described above (Dunn & Angermeier, 2016; Wharton et al., 2017).

The RUSLE/RUSLE2 model results did not mention an expected grain size distribution of sediment delivered to streams. This could be estimated given the percentages of clay, silt, and sand that are reported in the same soil database used in the RUSLE/RUSLE2 modeling in combination with some estimation for how well each size fraction might be captured by a particular erosion control device. Such an estimate could help inform how close or far away the different impacts of generated sediment might be in local streams and distant reservoirs. The point here is that of the sediment that is delivered by the MVP activities, presented here as a number of football fields, some of it is likely to deposit locally on the streambed (sand and some silt; and in excess of 1/8-inch thick, see section 5) and some of it will also deposit in low velocity regions, floodplains, and reservoirs farther downstream (clay and some silt).

Another important note is that the turbidity sensors that are used to monitor in-stream water quality are only able to measure silt and clay suspended in the water column (as they affect the optical properties of the water), and not sand (Pearson et al., 2021). There are, however, sediment monitoring devices that can measure sand transport in the water column (Gray & Gartner, 2009; Pearson et al., 2021). **Measuring turbidity alone is not likely to provide a meaningful assessment of the impacts that may be occurring on the streambed due to sedimentation.** In addition to monitoring turbidity, in-stream measurements of physical habitat, such as embeddedness and silt cover (Dunn & Angermeier, 2016; Fitzpatrick et al., 1998), would be able to directly assess sedimentation impacts on the streambed. Furthermore, monitoring sediment alone does not fully assess the impacts to the ecosystem. The Virginia Department of Environmental Quality (VDEQ) completed measurements of fish assemblages and benthic macroinvertebrates during the Fall of 2017 to establish background conditions at many locations – including at the paired USGS sites discussed in the 2022 DSEIS (VDEQ, 2023a). The VDEQ monitoring plan will conduct continued monitoring only after *all* construction activities have been completed (VDEQ, 2023a). The VDEQ monitoring plan did not consider the possibility for start and stop of partial construction activities, which was a missed opportunity to provide important ongoing information about the impacts to the streambed and biota that could have better informed the 2022 DSEIS.

Relying on the sediment load delivered to waterways from the RUSLE/RUSLE2 modeling (particularly without knowing the sediment size) and turbidity data is not sufficient to determine if there is going to be an adverse impact to the streambed. To do so requires some way of translating sediment load and turbidity into information directly related to the waterbody and biota, such as via embeddedness and ecological integrity through biotic monitoring. **The 2022 DSEIS does not provide any specific metrics or thresholds for when an impact is negligible, minor, moderate, or significant** (p. 33). Thus, it is not apparent how the Forest Service makes the leap from the RUSLE/RUSLE2 modeling results and the turbidity data to assessing potential impacts, specifically to the streambed.

Furthermore, it is important to consider another factor in interpreting these results: the magnitude of an impact will depend on the size of the receiving waterbody. For the small streams that are most prevalent, even small accumulations of sediment that are being dismissed as minor amounts can have large impacts. The water quality impact on stream reaches has been summarized to some extent by Geosyntec (2020) but only as percent changes of sediment (in tons/yr or tons/ac/yr) delivered to stream reaches without any assessment on how that increased sediment delivered to that stream may actually affect water quality or sedimentation on the streambed.

Lastly, even though the delivered sediment loads from the RUSLE/RUSLE2 model have been translated into more meaningful units of between 6 and 28 football fields per year for each HUC-12 basin, **my full assessment below suggests that actual amounts are much higher**. Specifically, these numbers could easily be up to two orders of magnitude higher than estimated by the RUSLE/RUSLE2 modeling (see section 3.2). That is, rather than 6 to 28 football fields per year for each HUC-12 basin, that could be 600 to 2,800 football fields per year for each HUC-12 basin.

Table 1. Modeled sediment loads translated to meaningful impacts.

HUC-12 Name	[1]HUC-12 basin area, acres	[2]Modeled Disturbed Area within HUC-12, acres	[1]Delivered Sediment Load, tons/year				Increase in Delivered Sediment Load from Baseline Scenario, tons/year			Number of Football Fields Covered with 1/8 inch of Sediment Corresponding to the Volume Increase in Delivered Sediment, Football Fields at 1/8-inch thickness per year		
			Baseline	Felled	During	Restoration	Felled	During	Restoration	Felled	During	Restoration
Trout Creek-Craig Creek	33,194	33	6,835	6,842	6,947	6,862	7	112	27	**0.4**	**6.6**	**1.6**
Broad Run-Craig Creek	71,512	N/A[3]	13,293	13,299	13,386	13,315	6	93	22	**0.4**	**5.5**	**1.3**
Dry Run-North Fork Roanoke River	32,933	120	14,180	14,193	14,551	14,243	13	371	63	**0.8**	**21.8**	**3.7**
Upper Sinking Creek	33,799	103	12,841	12,848	13,086	12,888	7	245	47	**0.4**	**14.4**	**2.8**
Lower Sinking Creek	52,602	104	18,177	18,192	18,653	18,262	15	476	85	**0.9**	**28.0**	**5.0**
Little Stony Creek-New River	2,270,855	88	346,109	346,118	346,380	346,158	9	271	49	**0.5**	**16.0**	**2.9**
Stony Creek	31,296	92	11,039	11,084	11,143	11,082	45	104	43	**2.6**	**6.1**	**2.5**
Brush Creek-Rich Creek	34,121	78	11,782	11,827	11,913	11,831	45	131	49	**2.6**	**7.7**	**2.9**
Clendennin Creek-Bluestone Lake	2,395,871	1	355,602	355,643	355,954	355,683	41	352	81	**2.4**	**20.7**	**4.8**

[1] From Table 5-1, p. 60, Geosyntec, 2020.

[2] From Table 4-1, p. 22, Geosyntec, 2020.

[3] Value not reported in Table 4-1, p. 22, Geosyntec, 2020.

2. The validity of RUSLE/RUSLE2 results in the JNF are questionable given the model's applicability and high uncertainty

2.1. RUSLE/RUSLE2 model is highly uncertain for the steep slopes of the JNF

The extensive dataset used to develop the original Universal Soil Loss Equation (USLE) model included over 10,000 plot years of data collected over seven decades, but only included data with slopes between 3% and 18% (Renard et al., 2011; Wischmeier & Smith, 1978). The component of the RUSLE model that pertains to slope (Renard et al., 1997) is based off an extended dataset compiled by McCool et al. (1987), which included data with slopes primarily less than 20%, a few up to 25%, and only one up to 30%. The RUSLE documentation (Renard et al., 1997) mentions that data from McIsaac et al. (1987), containing data with slopes up to 84%, agrees with the underlying equations (slope steepness factor) in RUSLE. However, the dataset compiled by McIsaac et al. (1987) only includes two data points with 33% slope, three data points with 50% slope, and three data points with 84% slope. The RUSLE2 model is based on the same underlying data as RUSLE (USDA, 2008b). These few additional data points on steeper slopes do not extend the same level of confidence in the original RUSLE/RUSLE2 model, with an extensive dataset on shallow slopes, to landscapes with steep slopes. The point here is to emphasize that the **RUSLE/RUSLE2 model is most applicable for slopes less than 20% with very limited data to support the validity of model results derived from slopes greater than 20-30%.**

Geosyntec (p. 28, 2020) only considered slopes greater than 60% as potentially problematic in the context of the RUSLE/RUSLE2 modeling results, citing Liu et al. (2000) and Schmidt et al. (2019) for the assertion that there is little support in the underlying topographic factor relationship and *m* and *n* exponents when slope is greater than 60%. The topographic factor is a term of the RUSLE/RUSLE2 model that is defined by an equation that contains slope, the length of the hillslope, and exponents *m* and *n* on components of the equation. The topographic factor is how slope (shallow or steep) is incorporated in the RUSLE/RUSLE2 model and describes how slope affects soil erosion. This statement above by Geosyntec implicitly assumes that the RUSLE/RUSLE2 modeling is well supported when slope is less than 60%. There are two main issues here.

The first is that the modifications to the topographic factor relationship and *m* and *n* exponents for steep slopes, as suggested by Liu et al. (2000) and Schmidt et al. (2019), were not incorporated in Geosyntec's (2020) RUSLE/RUSLE2 modeling. Similar issues with the *m* and *n* exponents were pointed out previously by SPI-DAC (2020), but did not appear to be addressed in the 2022 DSEIS.

The second, and more important issue, is to again underscore that the RUSLE/RUSLE2 model is most applicable for slopes less than 20%, with very limited data to support the validity of model results derived from slopes greater than 20-30%. Liu et al. (2000) presented additional limited data from the Loess Plateau of China that included six data points with slopes around 40% and four data points with slopes of nearly 58%. Schmidt et al. (2019) presented data from the Swiss alpine grasslands with a range of slopes that included 12 data points (16 total, but they considered four points outliers). To reiterate, the dataset in support of RUSLE/RUSLE2 for slopes greater than 20% is very limited, particularly in relation to the many variables and many complex interactions that affect erosion.

From the RUSLE2 scientific documentation, "[e]rosion data available for empirically deriving RUSLE2 equations are very limited. The data set is small in relation to the many variables and their many complex interactions that affect erosion. The dataset is not a statistically robust data set because of non-uniform coverage of important variables. The data contain much unexplained variability that can not be resolved" (USDA, 2008b). This uncertainty and limitation directly applies to the RUSLE/RUSLE2 modeling results in the JNF, at a minimum, because of the steep slopes of the JNF above 20%.

An analysis of the slopes along the MVP pathway through the JNF illustrate that slopes above 20% are common. Slope was calculated as a percent (vertical distance divided by horizontal distance multiplied by 100) based on a 10-meter DEM using the Surface Parameters tool in ArcGIS Pro. The 10-meter DEM is the same dataset at the same resolution as was used in the RUSLE2 modeling (p. 27, Geosyntec, 2020; USGS, 2023). A spatial map of slope in the vicinity of the MVP crossing of the JNF is shown in Figure 1. There are two separate crossings of the MVP in the JNF. One crossing farthest to the northwest crosses Peters Mountain and the second crossing farthest to the southeast crosses Brush Mountain. The slope of the land surface along the MVP crossing was extracted every 3.28 feet (1 meter) for both crossings and are shown in Figures 2 and 3.

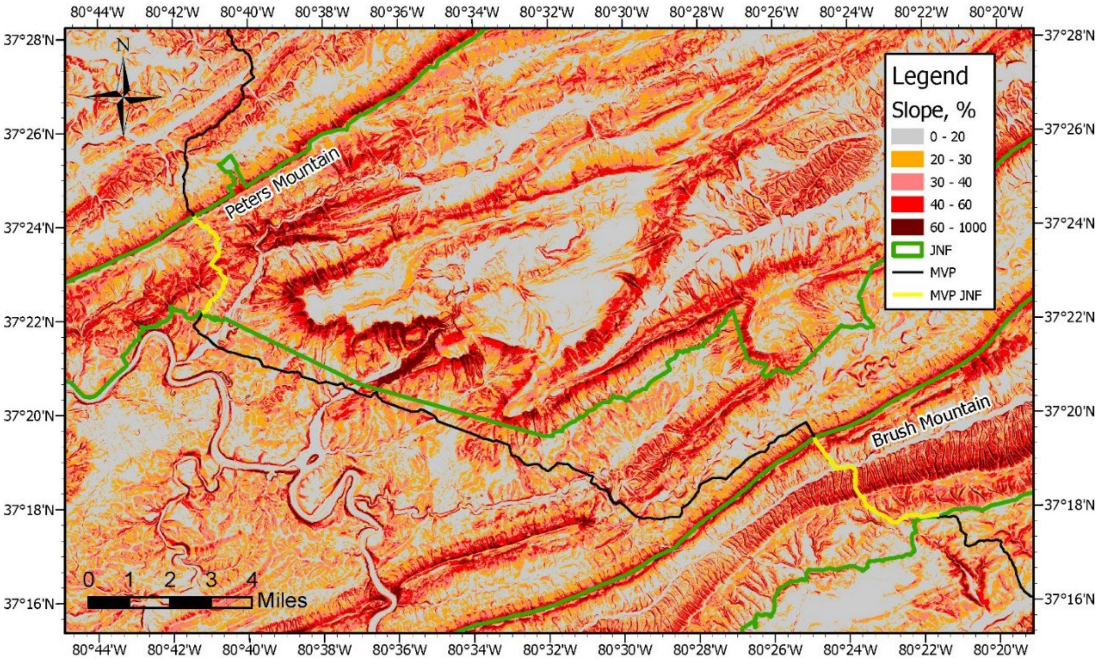

Figure 1. Land-surface slopes around the MVP in the JNF. Note the MVP crosses the JNF in two locations: Peters Mountain and Brush Mountain.

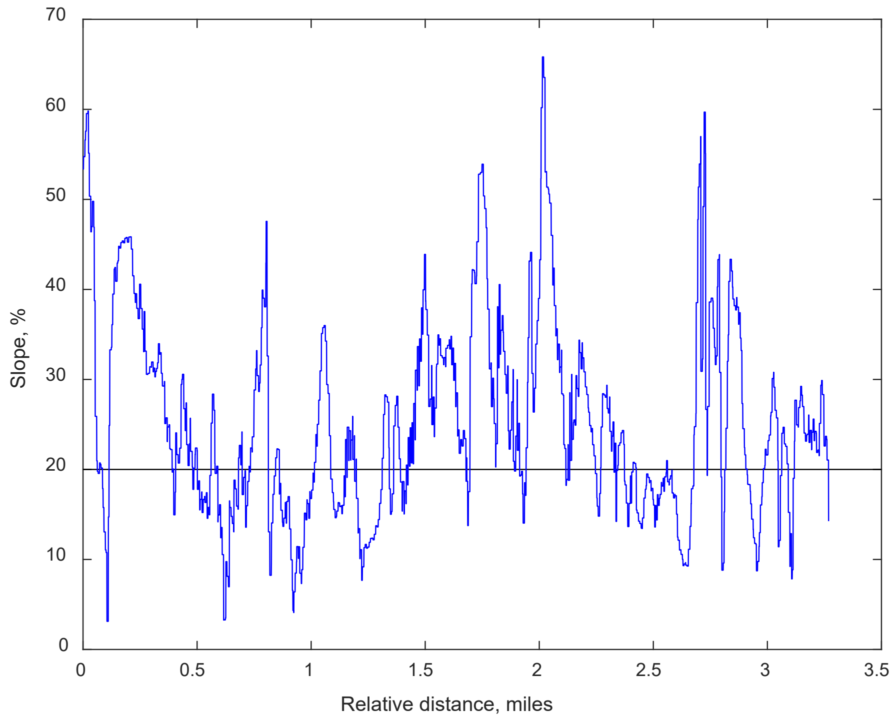

Figure 2. Slopes along the MVP crossing of the JNF at Peters Mountain. See Figure 1 for location. The relative distance of zero starts at the location farthest to the northwest.

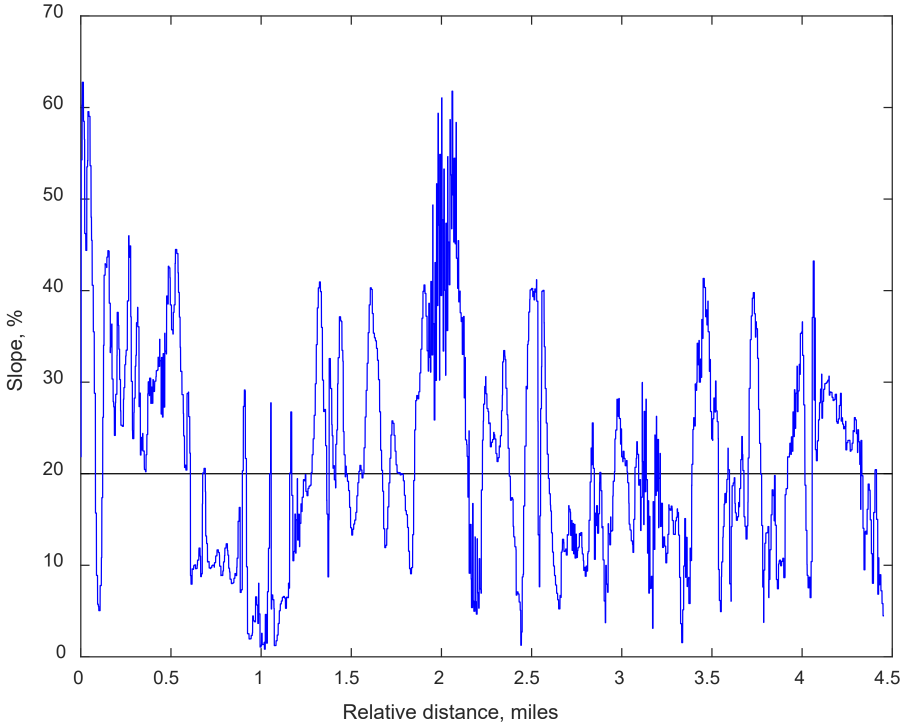

Figure 3. Slopes along the MVP crossing of the JNF at Brush Mountain. See Figure 1 for location. The relative distance of zero starts at the location farthest to the northwest.

The percentage of length, relative to the total length, of the MVP crossing of the JNF with slopes above certain values are summarized in Table 2 for both crossings and combined. Over 60% of the length of the MVP crossing of the JNF at Peters Mountain has a slope >20% and nearly 30% of the length has a slope >30% (Table 2). At Brush Mountain, over 50% of the length of the MVP crossing of the JNF has a slope >20% and over 20% of the length has a slope >30%. Combining both locations, nearly 57% of the total length of the MVP crossing of the JNF has a slope >20% and 26% of the total length has a slope >30% (Table 2). **This means that the RUSLE/RUSLE2 model is most applicable to only 43% of the MVP study area in the JNF (where slope is < 20%) and there is very limited data (in deriving the fundamental RUSLE/RUSLE2 model equations) to support the validity of the RUSLE/RUSLE2 model results obtained from 26% of the MVP study area in the JNF (where slope is > 30%).**

Table 2. Percentage of the length of the MVP crossing of the JNF above certain values of slope.

Slope threshold	Percentage of the length of the MVP crossing of the JNF above certain values of slope		
	at Peters Mountain	at Brush Mountain	both combined
>20%	63.5	51.9	56.8
>30%	29.9	23.2	26.0
>40%	10.9	7.2	8.8
>50%	3.6	1.9	2.6
>60%	0.5	0.3	0.4

2.2. The baseline sediment delivery estimate is likely off by at least 500% on the basis of one parameter

The cover and management factor (C factor) is one of several factors that are multiplied together in the RUSLE model to compute annual soil loss.[1] Any percentage change in any one factor directly propagates to an equivalent change in the computed annual soil loss estimate.

The C factor used in the RUSLE modeling (p. 30, Geosyntec, 2020) for the forest land type was 0.003, which is typically used in a wide variety of applications (Haan et al., 1994; Ranzi et al., 2012; Wischmeier & Smith, 1978). However, recent research has shown that forested hillslopes in the Appalachian region do not generate large sediment yields and, as a result, has suggested a smaller C factor of 0.0006 be applied for these conditions (Mahoney et al., 2021).

This means that the baseline estimate of annual soil loss was overestimated by 500% (0.003/0.0006×100; where multiplying by 100 converts the fraction into a percent). It also means that **the amount of sediment generated from clearing the forest in the proposed action will increase the annual soil loss estimates from the RUSLE/RUSLE2 model by 500%**. The baseline value is important because the impact of any proposed change is in relation to the baseline estimate. A conservative estimate of the baseline annual soil loss should be low and a conservative estimate of the proposed annual soil loss should be high so that the maximum potential change is communicated. **The overestimation of the baseline annual soil loss does not support the claim** (p. 24, Geosyntec, 2020) **that the RUSLE/RUSLE2 modeling is conservative**.

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[1] The RUSLE model calculates a spatial average annual soil loss, A in tons/acre/year as $A = R \times K \times LS \times C \times P$, where R = average annual rainfall runoff erosivity factor, K = soil erodibility factor, LS = topographic factor (referred to in section 3.1), C = cover management/land use factor (of relevance in this section), and P = erosion control practice factor (as shown in Geosyntec, 2020).

3. Analysis of the USGS data was not adequately conducted

3.1. Regression analysis is not a valid approach for analyzing the USGS data given the changing land surface conditions after construction began

The Forest Service's independent agency review of the USGS data described in the 2022 DSEIS used a regression approach that is not valid. It assumes that the vegetative cover and soil exposure is the same through the entirety of the period after the land management change has occurred. The land management change is the start of construction and the vegetative cover and soil exposure was not the same since construction began through the end of the time period used in the Forest Service's analysis. According to the 2022 DSEIS (p. 41, Table 4), construction started in July 2019 in the Roanoke River watershed (although pollution incidents began in 2018 upstream in the watershed, see section 5), which resulted in clearing of the land. Since then, it appears that much of the MVP right-of-way, including areas within the JNF, has been revegetated (p. 25, DSEIS, 2022). Therefore, the soil erosion generated right after construction is not the same amount of soil erosion that should be expected to occur after vegetation has grown back. Because the conditions on the ground had changed over time (non-stationary) in the post-construction period, all the post-construction data cannot be grouped together for a statistical analysis investigating changes relative to the data from the pre-construction period.

3.2. Analysis of the USGS data indicates that construction has increased turbidity by 20% to 200%, which further underscores the poor applicability of the RUSLE2 modeling and suggests that predicted water quality impacts are being severely underestimated

Turbidity data from three paired USGS gages were considered in the 2022 DSEIS (Roanoke River, Sinking Creek, and Little Stony Creek). Issues with the Forest Service's analysis of the Roanoke River dataset were described in the previous section (section 3.1), which was the only dataset that was actually analyzed. The other two were dismissed because of insufficient sample size for the analysis proposed. Given that the Forest Service only analyzed one of these three paired USGS stations, this limited dataset should have compelled the Forest Service to consider the data from the additional three nearby stations. The Forest Service excluded the other paired stations because they were outside the geographic boundary of the modeling performed by Geosyntec (p. 39, DSEIS, 2022). At the very least, an analysis of the other USGS paired stations could have provided further context for the impacts the MVP is having on in-stream turbidity that could be contextualized with a discussion about how specifically and quantitatively those three paired locations differ from the MVP crossing in the JNF. This point suggesting that the justification was not adequate for the Forest Service to exclude those other three paired stations was also highlighted by the Court in their recent decision (p. 21-22, U.S. Court of Appeals, 2022). The USGS data are limited for performing the statistical pre-/post-analysis of only peak flows that was conducted by the Forest Service in the 2022 DSEIS. However, these limitations do not preclude gaining some insight about some of the changes that were observed.

3.2.1. Roanoke River

In addition to the issues describe above, there are other issues with the paired USGS turbidity data on the Roanoke River that limit making adequate assessments about water quality impacts. **The major issue is that the MVP cuts across the upstream watershed in several places, so the upstream sensor may be reporting an already elevated turbidity reading because of the potentially more extensive construction work farther upstream in the watershed.** This is particularly relevant because construction did not extend all the way down to the Roanoke River between the turbidity sensors – the construction work for the stream crossing has not occurred. Other issues with the data itself include several data gaps (particularly at a few high flows that could have been relevant in assessing changes), there is limited pre-construction data, and the "post-construction" data captures incomplete construction work that was eventually halted, allowing vegetation to reestablish. These issues further limit the statistical pre-/post-analysis of only peak flows that was conducted by the Forest Service in the 2022 DSEIS.

However, that does not preclude gaining some insight about some of the changes that were observed. The largest changes in water quality are expected to occur during construction (July 2019, p. 41, Table 4, DSEIS, 2022; although pollution incidents began in 2018 upstream in the watershed, see section 5). The turbidity measurements for the first few major storm events in July 2019, during construction are shown in Figure 4 and 5.

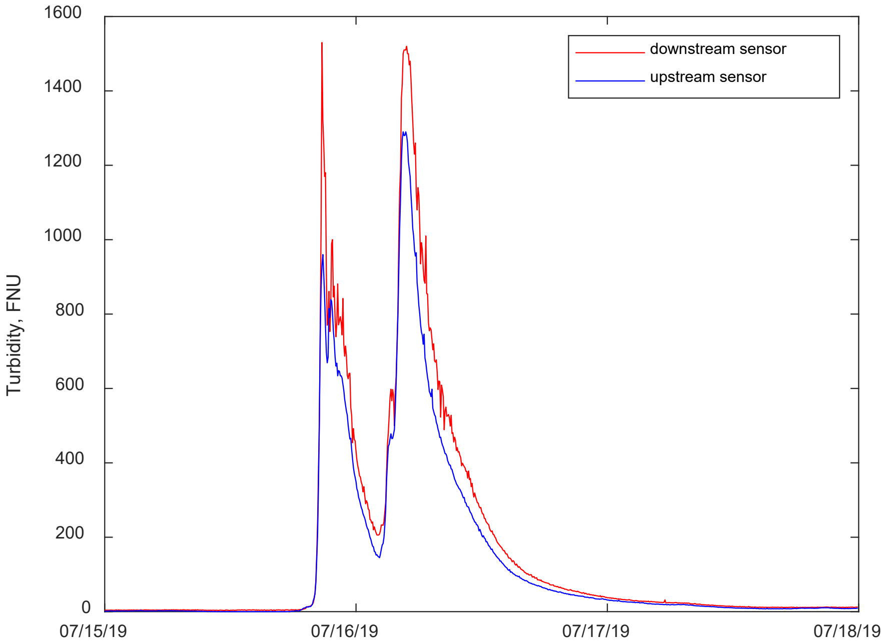

Figure 4. Turbidity measured at the paired USGS gages on the Roanoke River between 15 and 18 July 2019.

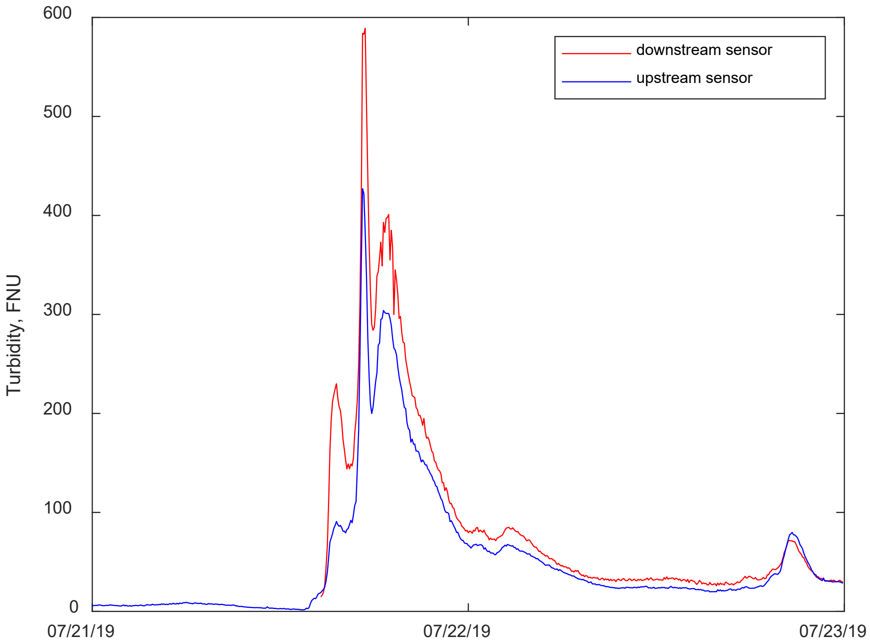

Figure 5. Turbidity measured at the paired USGS gages on the Roanoke River between 21 and 23 July 2019.

The peak turbidity values for each of these two storm events are shown in Table 3 along with the percent increase in turbidity from the upstream sensor to the downstream sensor. The first peak of each storm event exhibited the greatest increase from the upstream sensor to the downstream sensor of 60% and 150% for the first and second storm events, respectively. The later peaks of each storm event exhibited a 20% to 40% increase in turbidity from the upstream sensor to the downstream sensor (values from the table were rounded in the text for clarity). This shows that the turbidity in the Roanoke River has increased quite considerably downstream of the MVP crossing. These percentages could be compared to RUSLE2 modeling results, in general if the model was applicable to the landscape (see section 2.1), to assess if percent changes are in reasonable agreement.

Table 3. Peak turbidity values from the Roanoke River for two July 2019 storm events along with the percent increase in turbidity from the upstream sensor to the downstream sensor.

	Turbidity at upstream sensor, FNU	Turbidity at downstream sensor, FNU	Increase in turbidity at the MVP crossing, %
15-16 July 2019 event			
first peak	960	1,530	59
second peak	1,290	1,520	18
21 July 2019 event			
first peak	91	230	153
second peak	427	589	38
third peak	304	401	32

To reiterate from above (section 1.2), Geosyntec (p. 2, 2020) presents the following summary of the RUSLE2 modeling results that are relevant here, which the Forest Service (DSEIS, 2022, at p. 63-64 in support of modifying the Forest Plan standards and at p. 74-75 and p. 77 in relation to the substantive requirements) consistently relies on to justify that the proposed action would have minimal effect on sedimentation: “The sedimentation modeling estimated that sediment yields during construction would increase by less than 0.001 to 0.011 tons/ac/yr (median: 0.003 tons/ac/yr) above the baseline. This correlates to an increase of 0.1% to 2.6% (median: 1.1%) compared to the baseline scenario.” (p. 39, DSEIS, 2022).

The analysis of these two storm events on the Roanoke River (Table 3) indicates that **turbidity has increased by 20% to 150% during construction in contrast to the 0.1% to 2.6% increase in sediment yield suggested by the RUSLE2 modeling**. **This is a substantial difference that further underscores the poor applicability of the RUSLE2 modeling and suggests that predicted water quality impacts are being severely underestimated.** Going from a 2% increase in sediment predicted by RUSLE2 to a 20% or 150% increase in sediment indicated by the monitoring data represents an **underprediction of between one and two orders of magnitude**. This increase of 20% to 150% is likely an underestimate because, as noted above, the upstream sensor may be reporting an already elevated turbidity reading because of the potentially more extensive construction work farther upstream in the watershed (see also section 5). This change in turbidity was observed after the enhanced BMPs (erosion control devices) were in place.

Even though the timescales are different (single events for in-stream monitoring versus annual estimates in the RUSLE2 modeling), most of the annual sediment yield from a watershed can occur from just a few large storms (Curran et al., 2016; Walling & Webb, 1987). Therefore, percent changes in in-stream turbidity from a handful of storm events should be correlated with changes in annual sediment yield. Specifically, Curran et al. (2016) measured that 36% of the annual sediment load in 2011 for the Nisqually River in Washington occurred in two days during a typical winter storm.

3.2.2. Sinking Creek

The Sinking Creek paired dataset has similar issues as the Roanoke River dataset. Specifically, one major issue is that the MVP cuts across the upstream watershed in several places, so the upstream sensor may be reporting an already elevated turbidity reading because of the potentially more extensive construction work farther upstream in the watershed. As for the Roanoke River, this is particularly relevant because construction did not extend all the way down to Sinking Creek between the turbidity sensors because the construction work for the stream crossing has not occurred. Another major issue that is affecting the turbidity readings is that between the two USGS turbidity sensors on Sinking Creek, there are two springs that emerge from the karst system and enter the creek: Smokehole Spring and Tawney Spring (Saunders et al., 1981). Smokehole Spring contributes a substantial flow to Sinking Creek, particularly during high flow because much of the surface flow in the Clover Hollow watershed drops into the karst system, enters Smokehole Cave, and emerges at Smokehole Spring into Sinking Creek and not via the surface stream channel that enters Sinking Creek farther upstream. My research group has collected data from Smokehole Spring (related to a separate project) that shows that the turbidity during high flow from Smokehole Cave is very low relative to Sinking Creek (this data is currently unpublished, but will be published later in 2023). Irrespective of the data, it should not be surprising that water from an underground spring generally has lower turbidity than a creek draining surface waters. This is important because between the upstream sensor and the downstream sensor, low turbidity water from the spring is mixing with higher turbidity water from the creek, which in turn leads to lower turbidity in the creek just upstream of the MVP crossing compared to what was measured at the upstream turbidity sensor. The result is that the upstream turbidity sensor is reporting higher turbidity than is present just upstream of the MVP crossing and invalidates the comparison.

3.2.3. Little Stony Creek

According to the 2022 DSEIS (p. 41, Table 4), construction started in September 2021 in the Little Stony Creek watershed (although pollution incidents began in June 2021, see section 5). The storm event that generated the largest turbidity readings at both the upstream and downstream sensors since construction started occurred overnight between 21 and 22 August 2022 (Figure 6). A peak turbidity of 181 FNU was recorded at the upstream sensor and 557 FNU at the downstream sensor. This corresponded to more than a 200% increase in turbidity from the upstream sensor to the downstream sensor.

The paired USGS turbidity data from Little Stony Creek is even more limited for making comparisons than from the Roanoke River because construction started much later. This results in there being very few flow events generating turbidity that can be analyzed. However, this single event shows that **peak turbidity has increased by 200% after construction in contrast to the 0.1% to 2.6% increase in sediment yield suggested by the RUSLE2 modeling**. This is a substantial difference that further underscores the poor applicability of the RUSLE2 modeling and suggests that predicted water quality impacts are being severely underestimated. Going from a 2% increase in sediment predicted by RUSLE2 to a 200% increase in sediment indicated by the monitoring data represents an **underprediction of two orders of magnitude**.

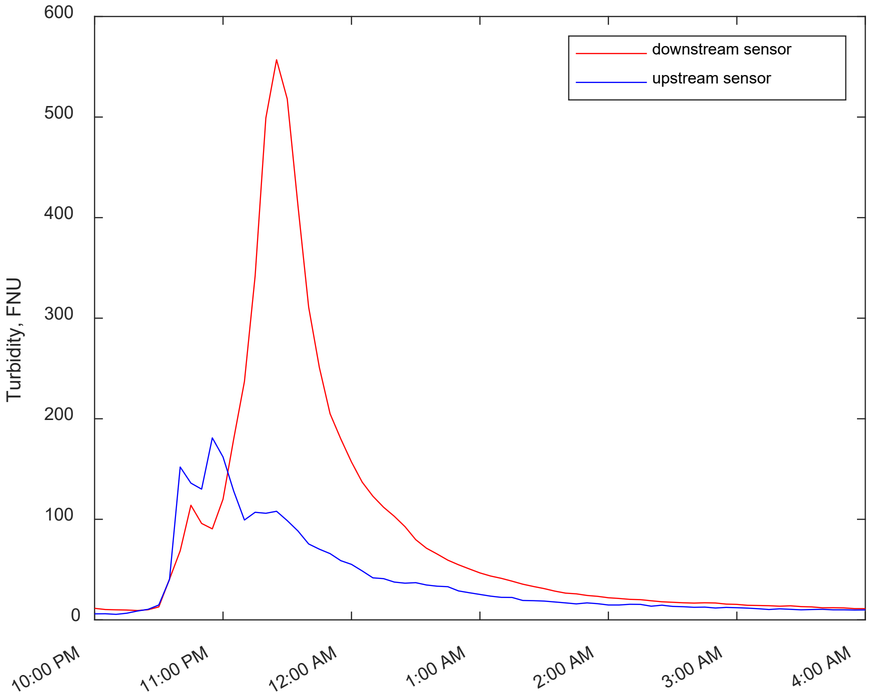

Figure 6. Turbidity measured at the paired USGS gages on Little Stony Creek for a 6-hour period between 10:00 PM on 21 August 2022 and 4:00 AM on 22 August 2022.

4. It is unclear whether the errors and uncertainty in the MVP monitoring data overwhelm any meaningful results from this dataset

MVP conducted sediment monitoring within multiple watersheds at 38 monitoring stations outside of the JNF near the pipeline route beginning in 2021 (DSEIS, 2022; FERC, 2023). The underlying data were not available for my independent review and assessment because they were designated a “Sensitive Administrative Record Document” due to the prevalence of protected species location and related information contained within (MVP, 2022). Instead, I relied on the assessment of this data by the Forest Service (DSEIS, 2022) and FERC on behalf of the U.S. Fish and Wildlife Service (FERC, 2023).

FERC (p. 1, 2023) suggested that “Mountain Valley performed continuous monitoring of suspended sediment concentrations” and later describe sediment data in terms of mass per water volume and mass per second. My concern is that **it is not possible to continuously and directly monitor suspended-sediment concentrations in streams** (Gray & Gartner, 2009). Instead, some surrogate of suspended sediment must be continuously measured, such as turbidity, and then many independent physical measurements of suspended-sediment concentration must be measured to develop an empirical regression equation relating the turbidity readings to the actual physical point samples of suspended sediment (Rasmussen et al., 2009; Uhrich et al., 2014). This step is not communicated at all by the Forest Service (DSEIS, 2022) or FERC (2023), which is the most critical step in ensuring the reported suspended-sediment concentrations are accurate. Given that there were 38 monitoring stations, each with presumably a turbidity sensor, and each location needing a sufficient number of suspended-sediment measurements over the entire range of flow conditions to develop the regression equations, I am surprised this dataset or at least the statistical quality of the regression equations was not mentioned. **The error and uncertainty associated with MVP’s field data collection of suspended-sediment data were not mentioned. This error and uncertainty would propagate into the developed statistical relation between turbidity and suspended-sediment concentration. This error and uncertainty can easily and commonly does result in inaccuracies in reported suspended-sediment concentrations of one order of magnitude or more** (Edwards & Glysson, 1999; Rasmussen et al., 2009; Uhrich et al., 2014).

Also, to report units of mass per second of sediment requires knowing the streamflow at all 38 monitoring locations. Specifically, mass per second of sediment is arrived at by multiplying the suspended-sediment concentration in mass per water volume by the streamflow discharge in water volume per second. Like suspended-sediment concentration, streamflow discharge is not continuously measured, but water level (typically) is continuously measured and then many independent measurements of streamflow discharge must also be measured to develop an empirical regression equation relating the water-level readings to the actual measurements of streamflow discharge (Rantz, 1982; Turnipseed & Sauer, 2010). These data and this process also have error and uncertainty, but it is generally less than for estimating suspended-sediment concentration. Again, the absence of any description of the quality assurance of this process makes me very hesitant to trust the accuracy of this data.

From what I can gather from the Forest Service (DSEIS, 2022) and FERC (2023) assessment, I am concerned that the errors and uncertainty in the resulting data overwhelm any meaningful results from this dataset.

5. Ongoing water quality problems and damages suggest that the erosion control devices are not effective

Wild Virginia (2022, 2023) compiled an extensive review of reports by inspectors from the Virginia Department of Environmental Quality (VDEQ) and from a company contracted by VDEQ to monitor MVP construction. The 2022 DSEIS downplays the environmental harm documented by the inspection reports because many violations are related to repairing the erosion control devices. Wild Virginia focused on incidents where "areas of offsite sediment deposition occurred" and the resulting sediment deposition in streams and wetlands that occurred for a subset of these instances. Wild Virginia (2022) found that water quality problems and damages are occurring and that most pollution is happening during construction regardless of "extreme" rainfall events. This is further evidence that the erosion control devices, as designed, are not adequate to properly control sediment erosion in this landscape.

In the Roanoke River watershed, upstream of the USGS monitoring stations, there were 250 MVP pollution incidents flagged by the VDEQ (Wild Virginia, 2023): 29 incidents of sediment deposited directly in streams or wetlands, 109 incidents of sediment deposited on land areas outside the erosion control devices, and at least 112 incidents where erosion control devices had failed (many of the incidents with sediment deposition also included incidents where the erosion control devices failed, but this number indicates only those incidents where the devices failed alone). These data only include incidents before 6 October 2021. Additionally, the VDEQ Virginia Water Protection (VWP) inspection reports highlight multiple instances of streams in the Roanoke River watershed with sedimentation along thousands of feet of up to several inches thick (VDEQ, 2023b). These incidents first began on 29 May 2018, with the first incident of sediment deposited directly in streams on 23 June 2018. This further underscores that sediment was being delivered to streams in the Roanoke River watershed well before the pre-/post-construction date of July 2019 used by the Forest Service (DSEIS, 2022) to assess changes in in-stream turbidity (section 3.1). **That is, the pre-construction turbidity data at the upstream gage would have already been higher than normal because of the MVP construction activity that was happening farther upstream.**

In the Little Stony Creek watershed, there were 21 MVP pollution incidents flagged by the VDEQ (Wild Virginia, 2023): 17 incidents of sediment deposited on land areas outside the erosion control devices and at least 4 incidents where erosion control devices had failed (again, this number only includes the incidents where the devices failed alone). These incidents first began on 10 June 2021 and these data only include incidents before 30 August 2021.

6. Tropical Storm Michael (October 2018) was not an extreme rainfall event and erosion control devices should not have failed

In October 2018, Hurricane Michael made landfall at the Florida panhandle and traveled northeast. Hurricane Michael was downgraded to Tropical Storm Michael by the National Weather Service before leaving Georgia. The largest amounts of rainfall in Virginia fell along the Virginia-North Carolina border, resulting in major flooding of the Dan River. Remnants of hurricanes can deliver large amounts of rainfall, but the rainfall totals north of Interstate 81 were modest (NWS, 2023).

The total rainfall (over a 3-day period) associated with Tropical Storm Michael on 10-12 October 2018 according to precipitation stations in Blacksburg (NCEI, 2023a) and Pearisburg, Virginia (NCEI, 2023b), and an unofficial estimate in Pembroke, Virginia (NWS, 2023) was around 3 to 3.5 inches (Table 4). The 3-day duration, 2-year and 5-year average recurrence interval rainfall amounts at these locations with 90% confidence interval values are also shown in Table 4 (based on partial duration series, NOAA, 2023). A 3-day duration, 2-year average recurrence interval rainfall is an amount of rain over a period of 3 days that is equaled or exceeded once in a 2-year period. The recurrence intervals of rainfall amounts are based on a statistical analysis of historical rainfall data. The probability that precipitation amounts (for a given duration and average recurrence interval) will be greater than the upper bound or less than the lower bound of the 90% confidence interval (the numbers in parenthesis in Table 4) is 5%. Due to climate change, extreme rainfall events have already increased in frequency and intensity and there is *high confidence* that they will continue to increase in the future (Carter et al., 2018; Easterling et al., 2017; Town of Blacksburg, 2020). This means that the rainfall amounts at a given recurrence interval (Table 4) are likely underestimates due to the effects of climate change. Therefore, engineering designs to historical rainfall amounts are likely underrepresenting the actual rainfall amounts due to climate change.

Table 4. The total rainfall (over a 3-day period) associated with Tropical Storm Michael on 10-12 October 2018 (NCEI, 2023a,b; NWS, 2023) and the 3-day duration, 2-year and 5-year average recurrence interval rainfall amounts (NOAA, 2023).

Location in Virginia	3-day rainfall from Tropical Storm Michael 10-12 October 2018, inches	2-year recurrence interval rainfall (90% confidence interval), inches	5-year recurrence interval rainfall (90% confidence interval), inches
Pearisburg	3.57	3.18 (2.99-3.42)	3.92 (3.66-4.19)
Pembroke	3.06	3.19 (2.98-3.44)	3.95 (3.68-4.24)
Blacksburg	3.26	3.49 (3.25-3.74)	4.39 (4.08-4.71)

In comparing the actual 3-day total rainfall amounts with the 3-day duration recurrence interval values, at Blacksburg and Pembroke, Virginia, Tropical Storm Michael was similar to a 2-year recurrence interval event and at Pearisburg, somewhere between a 2-year and 5-year event. This means that at Pembroke, Virginia, the rainfall that fell due to Tropical Storm Michael in October 2018 was similar to a rainfall amount that is equaled or exceeded once every 2 years.

Geosyntec (p. 44, 2020) states that "[m]ost sediment controls … are designed to withstand runoff from a 2-year to 10-year storm event, in accordance with applicable regulatory requirements." **If the soil erosion estimates from the RUSLE2 modeling and the erosion control devices were designed as stated to a 2-year to 10-year storm event, then the erosion control devices should have been able to handle the rainfall and associated erosion from Tropical Storm Michael.** Assuming the erosion control devices were designed appropriately to the RUSLE2 modeling results, this suggests that **the soil erosion estimates from the RUSLE2 modeling (that led to the design of ECDs) underestimated the actual erosion that occurred and that the soil erosion estimates were not conservative as is regularly stated in the 2022 DSEIS.**

Geosyntec (p. 44, 2020) also states that "[i]n response to the higher frequency of storm events with above average precipitation depths that occurred in the Project area in 2018, Mountain Valley substantially upgraded its controls in many areas, particularly those that have been prone to being overtopped in storms that exceed the design criteria." **The erosion control devices should have been able to handle the rainfall from Tropical Storm Michael in the project area and should not have been overtopped.** The increases in turbidity measured by the paired USGS turbidity sensors (described in section 3.2) all occurred after the erosion control devices had been upgraded. Again, this suggests that the RUSLE2 modeling was not capable of leading to a design of erosion control structures that can withstand storms within the design criteria.

Geosyntec (p. 44, 2020) further states that "[t]he use of enhanced BMPs [enhanced erosion control devices] that exceed the regulatory requirements mitigates the potential for extreme storms to contribute sediment loads that exceed the model's predicted loads, as well as reduces the expected sediment loads during normal precipitation events, but they have not been incorporated into the RUSLE2 model because they represent 'compliance plus' measures that go beyond those that FERC and the states require Mountain Valley to implement. [Thus, according to Geosyntec], the widespread implementation of enhanced BMPs that were not incorporated in the RUSLE2 model adds a measure of conservatism to the model output and provides increased confidence that storm events, including some unusually intense events, will not result in sediment loads exceeding those predicted by the model. [Geosyntec asserts that t]he BMPs modeled are conservative (i.e., predicting higher than expected soil loss) in their assumption of standard BMPs in comparison to the enhanced BMPs that have actually been installed in the field." Based on my discussion above, I disagree with nearly all of these statements. **The originally designed BMPs (erosion control devices) did not appear to be adequately designed to the regulatory standards; therefore, one should not assume that the enhanced BMPs go beyond the minimum requirements. It is not enough to "enhance" a failed design and call it sufficient without further analysis demonstrating that it will be sufficient.**

Conclusions

The 2022 DSEIS concludes that the proposed action will have minor impacts on downstream water resources. Additionally, the DSEIS states that "[c]omprehensive analysis of the modeling results and real-world data indicates that the ECDs that were installed and maintained are effective at managing sediment yields." (p. 39, DSEIS, 2022). However, my assessment raises several issues with the modeling and monitoring, upon which this decision was based, that suggest the impacts are likely much larger than reported. **This assessment of the 2022 DSEIS shows why the real-world data and the modeling do not align. That is, a consistent story emerges that identifies deficiencies with the RUSLE/RUSLE2 modeling** (section 2) **that has led to pollution incidents and failures of the designed erosion control devices** (section 5) **resulting in in-stream turbidity levels that have increased by 20% to 200%** (section 3.2) **instead of the 0.1% to 2.6% increase in sediment yield suggested by the RUSLE2 modeling**. A summary of these issues is highlighted again here:

1. RUSLE/RUSLE2 modeling results do not provide meaningful information on potential impacts to water quality.

    1.1. 2022 DSEIS essentially dismisses the Court's request to consider the monitoring data in the context of the modeling results. If the RUSLE2 estimates cannot be reasonably compared to measured data, then there is no way to independently validate the RUSLE2 results and assure their validity.

    1.2. RUSLE/RUSLE2 modeling results are not conveyed in a way that allows for a meaningful review of the potential impacts to water quality. The sedimentation modeling estimated that sediment yields during construction would increase by less than 0.001 to 0.011 tons/ac/yr (median: 0.003 tons/ac/yr) above the baseline. Translating these delivered sediment loads from the RUSLE/RUSLE2 model into more meaningful units, between 6 and 28 football fields per year would be covered in 1/8-inch thick sediment deposition due to the extra sediment generated during the construction scenario in each of the different HUC-12 basins. Furthermore, measuring turbidity alone is not likely to provide a meaningful assessment of the impacts that may be occurring on the streambed due to sedimentation.

2. The validity of RUSLE/RUSLE2 results in the JNF are questionable given the model's applicability and high uncertainty.

    2.1. RUSLE/RUSLE2 model is highly uncertain for the steep slopes of the JNF. The RUSLE/RUSLE2 model is most applicable for slopes less than 20% with very limited data to support the validity of model results derived from slopes greater than 20-30%. Nearly 57% of the total length of the MVP crossing of the JNF has a slope >20% and 26% of the total length has a slope >30%. This means that the RUSLE/RUSLE2 model is most applicable to only 43% of the MVP study area in the JNF and there is very limited data (in deriving the fundamental RUSLE/RUSLE2 model equations) to support the validity of the RUSLE/RUSLE2 model results obtained from 26% of the MVP study area in the JNF.

2.2. The baseline sediment delivery is likely off by at least 500% on the basis of one parameter (C factor for forest). The baseline estimate of annual soil loss is being overestimated, which underestimates the relative (to baseline) soil loss estimates for the proposed action scenarios. This suggests that the RUSLE/RUSLE2 modeling is not conservative.

3. Analysis of the USGS data was not adequately conducted.

3.1. Regression analysis is not a valid approach for analyzing the USGS data given the changing land surface conditions after construction began. Because the conditions on the ground had changed over time (non-stationary) in the post-construction period, all the post-construction data cannot be grouped together for a statistical analysis investigating changes relative to the data from the pre-construction period.

3.2. Analysis of the USGS data indicates that construction has increased turbidity by 20% to 200%, which further underscores the poor applicability of the RUSLE2 modeling and suggests that predicted water quality impacts are being severely underestimated.

4. It is unclear whether the errors and uncertainty in the MVP monitoring data overwhelm any meaningful results from this dataset. The error and uncertainty associated with MVP's field data collection of suspended-sediment data were not mentioned. This error and uncertainty would propagate into the developed statistical relation between turbidity and suspended-sediment concentration. This error and uncertainty can easily and commonly does result in inaccuracies in reported suspended-sediment concentrations of one order of magnitude or more.

5. Ongoing water quality problems and damages suggest that the erosion control devices are not effective.

6. Tropical Storm Michael (October 2018) was not an extreme rainfall event and erosion control devices should not have failed.

Disclaimer

J. Czuba has written this assessment as a professional and not as a representative of Virginia Tech.

Conflict of Interest Statement

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Dr. Czuba has over 16 years of experience measuring, modeling, and analyzing sediment transport in watersheds and within streams and rivers across the U.S. His research focuses on the development and application of modeling tools to predict the transport and fate of sediment and nutrients in rivers and inform river management, including: 1) understanding the fundamentals of stream and floodplain restoration, 2) transport on the branching structure of river networks, and 3) how water and sediment affect and are affected by plants, fish, and freshwater mussels.

Dr. Czuba has authored (or coauthored) 37 refereed journal articles, 9 USGS publications, and 17 conference proceedings papers. He has presented (or been coauthor on) over 130 presentations at local, regional, national, and international meetings and conferences to both technical and non-technical audiences. He has been successful in securing grants to support his research program, with over $3.8M total funding as principal investigator (PI) or co-PI during his career. He has received funding at the national, regional, state, and university levels. National funding sources include the National Science Foundation, U.S. Department of Agriculture, U.S. Geological Survey, U.S. Army Corps of Engineers, National Fish and Wildlife Foundation, and the Federal Interagency Sedimentation Project. Dr. Czuba has peer-reviewed 119 manuscripts in 31 different journals and has reviewed proposals 11 times for 8 different programs including the National Science Foundation, U.S. Department of Agriculture, European Research Council, Czech Science Foundation, and the Chilean Government.

Dr. Czuba is a co-lead of the Hydrology Committee within the Healthy and Productive Ecosystems Work Group for the Ohio River Basin Ecosystem Restoration Plan (2021-present). The purpose of this group is to craft an ecosystem restoration plan for the 15-state Ohio River Basin that will serve as the foundation for a multi-year, multi-billion-dollar federal investment to address threats to the ecosystem. Dr. Czuba is also actively involved in the Earth and Planetary Surface Processes Section of the American Geophysical Union, having served on the section’s Executive Committee, and involved in the American Society for Agricultural and Biological

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