MONITORING YEAR 3 ANNUAL REPORT

Final

SHAKE RAG MITIGATION SITE

Madison County, NC
DEQ Contract No. 7190
DMS Project No. 100018
USACE Action ID No. SAW-2017-01570
DWR Certification No. 17-1157
RFP# 16-006991 (September 16, 2016)

French Broad River Basin
HUC 06010105

Data Collection Period: January – October 2022
Draft Submission Date: November 30, 2022
Final Submission Date: January 12, 2023

PREPARED FOR:

NC Department of Environmental Quality
Division of Mitigation Services
1652 Mail Service Center
Raleigh, NC 27699-1652

PREPARED BY:

Wildlands Engineering, Inc.
1430 South Mint Street, Suite 104
Charlotte, NC 28203

Phone: 704.332.7754
Fax: 704.332.3306

January 12, 2023

Mr. Matthew Reid
Western Project Manager
Asheville Regional Office
2090 U.S. 70 Highway
Swannanoa, NC 28778-8211

RE: Draft MY3 Report Review
Shake Rag Mitigation Site, Madison County
French Broad River Basin: 06010105
DMS Project ID No. 100018
DEQ Contract #7190

Dear Mr. Reid:

Wildlands Engineering, Inc. (Wildlands) has reviewed the Division of Mitigation Services (DMS) comments from the Draft Monitoring Year (MY) 3 report for the Shake Rag Mitigation Site. DMS' comments are noted below in **bold**. Wildlands' responses to those comments are noted in *italics*.

Please ensure the Monitoring Phase Performance Bond has been updated and approved by Kristie Corson before invoicing for Task 9.

Wildlands' response: The Monitoring Phase Performance Bond was approved by Kristie Corson on 1/10/2023. Wildlands will proceed with invoicing for Task 9.

Title Page: Please add RFP# 16-006991 (September 16, 2016) Under the DWR project number.

Wildlands' response: The RFP# was added to the title page under the DWR project number.

Page 1-3: Paragraph discussing MY3 vegetation monitoring results states less than 2% of monitored stems were documented with a vigor of 2. The following sentence states 22% of monitored stems were documented with a vigor of 2. Is the first instance intended to be a vigor of 1? Please review and update.

Wildlands' response: Yes, the first instance was intended to be a vigor of 1. The typo has been corrected in section 1.2.1.

Mowing encroachments were identified along UT4 and at a crossing on SRB Reach 5. Thank you for identifying the encroachment, adding additional posts and discussing with the landowner. In an effort to identify and resolve property issues early during the monitoring periods, please verify that the conservation easement boundary has been walked, marking and signage is up to spec, fencing is intact, and no additional encroachments have been identified.

Wildlands' response: During the MY3 data collection period (January – October 2022), the conservation easement was walked, and no additional encroachments were identified. The fencing was found to be intact, and the boundary is marked appropriately.

Page 1-4, Bankfull Events: Section indicates CG3 and CG5 were moved. CCPV indicates that it was CG3 and CG6 that were relocated. Please review and update.

Wildlands' response: The typo in section 1.2.4 has been corrected to indicate that CG6 (not CG5) was moved.

CG3 was relocated downstream approximately 15'; however, CG6 was relocated approximately 1,300' downstream from SRB R3 to SRB R5. Please provide a discussion regarding why this gauge was moved so far from the original location. At the 2022 Credit Release Meeting, DWR had questions regarding the location of CG6. WEI discussed relocating CG6 to better represent bankfull events because it was not installed in channel and only captured flow during bankfull events; however, location was not discussed.

Wildlands' response: The channel slope on SRB Reach 3 is 13.4% where CG6 was originally installed was proving difficult to capture bankfull events due to the flashy nature of this Rosgen A4a+/B4a type channel. The performance standard and the monitoring components from the final mitigation plan summarized in Table 5a indicates that only one crest gage is required for all restoration/EI reaches on SRB (Reach 3, 4, and 5). The crest gage was moved approximately 1,300' downstream where the channel slope decreases to 6.6% along SRB Reach 5, increasing the likelihood of capturing an over bank event along the SRB channel.

A 20' area of aggradation on SRB R4 is the only stream area of concern noted for the project in MY3. Numerous management activities were completed in MY3. Please verify that the site does not exhibit any additional areas of concern.

Wildlands' response: No additional stream areas of concern were observed in MY3.

Photo Point 14 UT8: Is UT8 maintaining a single thread channel? It is difficult to determine from photo point 14.

Wildlands' response: Though it is difficult to see from photo point 14, UT8 is still maintaining a single thread channel. Wildlands will make an effort in MY4 (2023) to capture this photo point earlier in the year before the wetland vegetation blocks the view of the channel.

Appendix 6: Recommend including Table 16: Areas of Concern and Management Actions from MY2 report. The problem description and repair activity will help provide context to pre and post repair photos.

Wildlands' response: Table 16 has been updated and added to the MY3 report appendix 6 to accompany the pre and post repair photos.

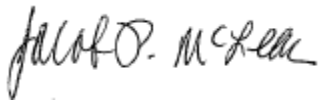
Electronic Support Files:

No comments.

Wildlands' response: Noted.

Enclosed please find two (2) hard copies and one (1) electronic copy on USB of the Final Monitoring Report. Please contact me at 828-545-3865 if you have any questions.

Sincerely,



Jake McLean
Project Manager
jmclean@wildlandseng.com

EXECUTIVE SUMMARY

Wildlands Engineering, Inc. (Wildlands) implemented a full-delivery stream mitigation project at the Shake Rag Mitigation Site (Site) for the North Carolina Department of Environmental Quality (DEQ) Division of Mitigation Services (DMS). The project restored, enhanced, and preserved a total of 9,273 linear feet (LF) of perennial and intermittent stream in Madison County, NC. The Site is located within the DMS targeted watershed for the French Broad River Basin Hydrologic Unit Code (HUC) 06010105110020 and the NC Division of Water Resources (NCDWR) Subbasin 04-03-04. The project is providing 6,655.600 stream mitigation units (SMUs) for the French Broad River Basin HUC 06010105 (French Broad 05).

The watershed has a long history of agricultural activity and most of the stressors to stream functions are related to historic and current land use practices. Prior to construction, the major stream stressors for the Site were livestock trampling and fecal coliform inputs, stream bed incision and bank scour, a lack of stabilizing stream bank and riparian vegetation, and ditching and/or piping from agricultural activities. The effects of these stressors resulted in degraded water quality and habitat throughout the Site's watershed when compared to reference conditions. The project approach for the Site focused on evaluating the Site's existing functional condition, its potential for recovery, and need for intervention.

The project goals defined in the mitigation plan (Wildlands, 2019) were established with careful consideration of 2009 French Broad River Basin Restoration Priorities (RBRP) goals and objectives to address stressors identified in the watershed. The established project goals include:

- Improve stream channel stability,
- Exclude livestock from stream channels,
- Reconstruct channels and flood-prone areas with appropriate geomorphology,
- Improve in-stream habitat,
- Reduce sediment and nutrient input from adjacent cattle pastures and unpaved roads,
- Restore and enhance native riparian and upland vegetation, and
- Permanently protect the Site from harmful uses.

The Site construction and as-built surveys were completed between December 2019 and February 2020. Monitoring Year (MY) 3 data collection and site visits were completed between March and October 2022 to evaluate the current conditions of the project.

Overall, the Site has met the required stream, vegetation, and hydrology success criteria for MY3. The average planted stem density for the Site is 508 stems per acre with all 9 vegetation plots meeting the MY3 requirement of 320 stems per acre. Geomorphic surveys indicate that cross-section bankfull dimensions closely match the baseline monitoring with some minor adjustments. At least one bankfull event was documented on all project reaches, except UT3 Reach 2, in MY3. Stream repairs were completed in April 2022 to address localized instances of bed and bank instability and are functioning as designed. The MY3 visual assessments revealed that invasive species populations have been successfully reduced due to ongoing treatments. Wildlands will continue to monitor these areas, and adaptive management will be implemented as necessary throughout the seven-year monitoring period to sustain the ecological health of the Site.

TABLE OF CONTENTS

APPENDICES

Section 1: PROJECT OVERVIEW

The Shake Rag Mitigation Site (Site) is located in Madison County approximately 19 miles north of Asheville and 4 miles northeast of the town of Mars Hill in the French Broad River Basin HUC 06010105110020 and NCDWR Subbasin 04-03-04 (Figure 1). Located in the Blue Ridge belt within the Blue Ridge physiographic province (NCGS, 1985), the project watershed is dominated by agricultural and steep forested land.

The Site encompasses three primary drainage areas including Shake Rag Branch (SRB), UT1, and UT6, all of which are comprised of smaller valleys. All project stream reaches within these drainages originate from steep, forested headwater valleys before transitioning to open pastureland situated in wider valley bottoms further downstream. The valley of Shake Rag Branch begins as a steep, colluvial, V-shaped valley, which gradually widens into a moderately confined alluvial bottom as it moves downstream. UT1A, UT3, UT4, and UT8 have steep valleys with much broader valley bottoms, while UT1, UT2, UT5, UT6, and UT7 flow through steep, colluvial, V-shaped valleys for their entire length in the project area. Shake Rag Branch drains 163 acres, UT1 drains 70 acres, and UT6 drains 43 acres of rural land.

Prior to construction activities, the Site was in hay production in the valley bottom, with cattle grazing along valley side slopes and access to the steeper forested areas. Riparian buffers were absent except in the steepest upper portions of the Site. The streams throughout the Site were in various stages of impairment related to the current and historical agricultural uses. Many of the streams were buried in rock-lined channels or pipes approximately 50 years ago. Pre-construction conditions are outlined in Table 4 of Appendix 1 and Table 11 of Appendix 4.

The final mitigation plan was submitted and accepted by DMS in January of 2019 and the IRT in March of 2019. Construction activities were completed in January 2020 by Baker Grading & Landscaping, Inc. Kee Mapping & Surveying, PLLC. completed the as-built survey in February 2020. Planting was completed following construction in the January 2020 by Bruton Natural Systems, Inc. A conservation easement has been recorded and is in place on 18 acres. The project is providing 6,655.600 SMUs for the French Broad River Basin HUC 06010105 (French Broad 05). Post-construction annual monitoring will be conducted for seven years with close-out anticipated to commence in 2027 given the success criteria are met.

Directions and a map of the Site are provided in Figure 1 and project components are illustrated for the Site in Figure 2.

1.1 Project Goals and Objectives

The Site is providing numerous ecological benefits within the French Broad River Basin. The project goals were established with careful consideration to address stressors that were identified in the RBRP (EEP, 2009).

The following project specific goals and objectives outlined in the mitigation plan (Wildlands, 2019) include:

Goals	Objectives
Improve the stability of stream channels.	Reconstruct stream channels slated for restoration with stable dimensions and appropriate depth relative to the existing flood-prone area. Add bank revetments and in-stream structures to protect restored/enhanced streams.
Exclude livestock from stream channels.	Install livestock fencing and watering systems as needed to exclude livestock from stream channels and riparian areas.
Reconstruct channels and flood prone areas with appropriate geomorphology.	Daylight buried or piped streams, remove man-made impoundments, and restore historic valley profiles. Reconstruct stream channels with bankfull dimensions and construct flood-prone areas consistent with reference reach findings.
Improve instream habitat.	Install habitat features such as cascading riffle-pool sequences, lunker logs, and brush toes on restored reaches. Add woody materials to channel beds. Construct pools of varying depth. Remove online farm pond.
Reduce sediment and nutrient input from adjacent cattle grazing areas and unpaved roads.	Construct one step-pool conveyance BMP to treat contributing 17-acre drainage area that is subject to nutrient and fecal coliform loading from cattle. Relocate unpaved roads outside of riparian corridor. Grade and plant forested buffer with native vegetation.
Restore and enhance native riparian and upland vegetation.	Convert active hay fields and cattle pasture to forested riparian buffers along all Site streams, which will slow and treat runoff from adjacent agriculture before entering streams. Protect and enhance existing forested riparian buffers. Treat invasive species.
Permanently protect the Site from harmful uses.	Establish a conservation easement on the Site. Exclude livestock from Site streams.

1.2 Monitoring Year 3 Data Assessment

Annual monitoring for MY3 was conducted between January and October 2022 to assess the condition of the project. The stream, vegetation, and hydrologic success criteria for the Site follows the approved success criteria presented in the Shake Rag Mitigation Plan (Wildlands, 2019).

1.2.1 Vegetation Assessment

Vegetation plot monitoring is being conducted in post-construction monitoring years 1, 2, 3, 5, and 7. Permanent plots are monitored in accordance with the guidelines and procedures developed by the Carolina Vegetation Survey-EEP Level 2 Protocol (Lee et al., 2008) and the 2016 USACE Stream and Wetland Mitigation Guidance to assess the vegetation success. A total of 5 permanent vegetation plots were established within the project easement area. All of the permanent plots were established as either a 10-meter by 10-meter square plot or 5-meter by 20-meter rectangular plot. In addition, 4 mobile vegetation plots were relocated in monitoring year 3 throughout the planted conservation easement to evaluate the random vegetation performance for the Site. These plots will be subsequently

reestablished in different random locations in monitoring years 5 and 7. Mobile vegetation plot assessments will document stems, species, and height using a circular or 100-meter square/rectangular plot. The final vegetative performance standard will be the survival of 210 planted stems per acre in the planted riparian areas at the end of the required seven-year monitoring period. The interim measure of vegetative success for the Site will be the survival of at least 320 planted stems per acre at the end of MY3 and at least 260 stems per acre at the end of MY5. In NC mountain counties, planted trees must average 6 feet in height at the end of MY5 and 8 feet in height at the end of MY7.

The MY3 vegetation survey was completed in August 2022, resulting in an average planted stem density of 508 stems per acre and an average tree height of about 3.0 feet for all monitored permanent and mobile vegetation plots. The Site has met the interim MY3 requirement of 320 planted stems per acre, with all 5 permanent plots (100%) and all 4 mobile plots (100%) exceeding this requirement. A survival rate of roughly 99% from MY2 was observed in the permanent vegetation plots. Less than 2% of monitored stems in permanent plot were documented with a vigor of 1, indicating that they may not survive next year. About 22% of the monitored stems were documented with a vigor of 2, signaling fair plant health with some damage present. These lower vigor ratings are due to damage from dry soil conditions, deer browse, insects, and some competition from dense herbaceous cover. Approximately 75% of the planted stems in permanent plots are thriving with a vigor of 3 or greater indicating plant health ranging from good to excellent and damage is rare. Natural volunteer trees species that were observed on the Site include sycamore (*Platanus occidentalis*), tulip poplar (*Liriodendron tulipifera*), honey locust (*Gleditsia triacanthos*), and box elder (*Acer negundo*). Please refer to Appendix 2 for vegetation plot photographs and Appendix 3 for vegetation data tables.

1.2.2 Vegetation Areas of Concern and Management Activity

MY3 visual assessments reveal that over 99% of the conservation easement is unaffected by invasive plant populations. Invasive species found on the Site include multiflora rose (*Rosa multiflora*), princess tree (*Paulownia tomentosa*), tree of heaven (*Ailanthus altisima*), silver grass (*Miscanthus sinensis*), wineberry (*Rubus phoenicolasius*), and Asian bittersweet (*Celastrus orbiculatus*). Invasive species treatments were completed in March and September 2022 with efforts focusing on wineberry, tree of heaven resprouts, Asian bitterweet, and scattered pockets of multiflora rose within the upper portions of Shake Rag Branch, UT1, UT2, and UT3 as well as the existing mature vegetation found along Shake Rag Branch Reach 4. These treatments were highly effective in reducing size and density of invasive species populations within the conservation easement. Populations of wineberry and tree of heaven have been reduced below the mapping threshold; therefore, they are not depicted on the Current Condition Plan View (CCPV) Figures. Additional treatments will continue as needed to help manage and eliminate remaining invasive species populations on the Site.

Overall, the herbaceous cover has continued to become well established throughout the Site. Small infrequent areas of poor herbaceous cover located along steeper side slopes of UT3 and Shake Rag Branch were noted in previous monitoring reports. In MY3, these areas were reseeded with a cover crop mix and are improving. In October 2022, Wildlands staff observed small areas of mowing overreach inside the conservation easement along UT4 and at the upper internal crossing along Shake Rag Branch Reach 5. Wildlands has successfully notified the landowner of the error and added additional posts to clarify the easement boundary in October 2022. The encroachments were very narrow (less than 3 feet into the easement) and supplemental plantings are not necessary at this time.

Vegetation areas of concern are documented on Table 7 and shown on the CCPV Figures 3.0 – 3.4 in Appendix 2.

1.2.3 Stream Assessment

Riffle cross-sections on the restoration and enhancement I reaches are stable and show minimal change in bankfull area, maximum depth ratio, and width-to-depth ratio. All riffle cross-sections should fall within the parameters defined for the designated stream type. Any significant deviations will be evaluated to assess possible signs of stream channel instability. Indicators most often include a vertically incising thalweg and/or eroding channel banks. Remedial action would not be taken if channel changes indicate a movement toward stability. As noted in the approved Mitigation Plan (Wildlands, 2019), Shake Rag Reach 5 is expected to have wider flood-prone widths and entrenchment ratios greater than 2.2. This is also evident for UT8 considering the existing landscape in the wider valley bottom.

Morphological surveys for MY3 were conducted in May 2022. Cross-section survey results indicate that channel dimensions are stable and functioning as designed on all restoration and enhancement I reaches with minimal adjustments. Some minor bed scour is present within cross-section 9 along Shake Rag Branch Reach 3, but it is small and isolated and is not a mapped area of concern. In previous years, riffle cross-section 3 along UT3 Reach 2 was representative of isolated areas of downcutting along this reach. Repairs were conducted in April 2022 along the section of UT3 Reach 2 that included cross section 3 and were captured in this year's survey. Deposition has occurred within pool cross-section 4 along UT3 Reach 2 and has caused a slight decrease in the cross-sectional area and depth. This is not a mapped area of concern as it is expected that this rock step pool will scour back down to the as-built depth during future high flow events. Please refer to Appendix 2 for the visual stability assessment tables, CCPV Figures 3.0 – 3.4, and reference photographs, and Appendix 4 for the morphological tables and plots. See Section 1.2.5 for further discussion about the stream repairs.

Based on a DMS Technical Workgroup memo from 10/19/2021 and concurrence by the DMS project manager received on 10/27/2021, pebble count collection is no longer required for MY1 through MY7. Therefore, pebble counts will not be conducted during the remaining monitoring years unless requested by the IRT or deemed necessary based on best professional judgement. A copy of the DMS Technical Workgroup Memo and the email confirmation from the DMS project manager are found in Appendix 4.

1.2.4 Stream Hydrology Assessment

Automated pressure transducers were installed to document stream hydrology within restoration and/or enhancement level I mitigation reaches throughout the seven-year monitoring period. Henceforth, these devices are referred to as "crest gages (CG)" for those recording bankfull events and "stream gages (SG)" for those recording baseflow.

Bankfull Events

At the end of the seven-year monitoring period, four or more bankfull flow events must have occurred in separate years within the restoration reaches. A total of 5 CGs were installed along restoration and enhancement I reaches. At as-built, the pressure transducers in the CGs were programmed to record data every 2 hours. This interval was likely too long to capture all bankfull events in the steep and flashy project streams, so the transducers were reprogrammed in MY1 to record data every 30 minutes. Reducing the recording interval has demonstrated to be successful in capturing changes in water level during high flow events on the Site. In MY3, the crest gages on UT3 (CG3) and Shake Rag Branch (CG6) were relocated to better capture floodplain access and bankfull events within these restored streams. The locations have been updated on the CCPV Figures in Appendix B. In MY3, all restoration reaches, except for UT3 Reach 2, recorded at least one bankfull event that were documented by crest gage data. So far through MY3, UT1 Reach 2 and UT2 Reach 2 have recorded 3 bankfull events in separate years, UT4 and Shake Rag Branch Reach 5 have recorded 2 bankfull events in separate years, and UT3 Reach 2 has had 1 bankfull event.

Baseflow Monitoring

Consistent flow must be documented in the restored intermittent channel (UT8) at the Site. Under periods of normal rainfall, stream flow must be documented to occur every year for at least 30 consecutive days during the seven-year monitoring period. An automated SG was installed at as-built within the upper third of UT8 to monitor baseflow. On UT8, 284 consecutive days were documented in MY3 indicating that this channel exceeded the success criteria for intermittent channels.

Please refer to Appendix 5 for hydrology summary data and plots.

1.2.5 Stream Areas of Concern and Management Activity

In MY2, numerous large storm events revealed localized instances of bed and bank instability and structure piping. Planned repair work and locations were summarized in the MY2 annual monitoring report (Wildlands, 2022). Wildlands completed the repairs in April 2022. This included plugging piping structures, reconfiguring boulders and riffle substrate around problematic structures, and regrading or providing toe protection to vulnerable banks. Herbaceous plugs and live stakes were added to repaired banks and disturbed areas were reseeded. MY3 stream and visual assessments revealed that repairs appear to be stable and functioning as designed with boulder structures and riffles maintaining vertical stability. A photolog of the pre- and post-repair areas and locations is provided in Appendix 6. Stream areas of minor concern outside of the repair areas will continue to be monitored in future years for signs of instability. Please refer to Appendix 2 for stream stability tables and CCPV Figures 3.0 – 3.4.

1.3 Monitoring Year 3 Summary

Overall, the Site has met the required stream, vegetation, and hydrology success criteria for MY3. The average planted stem density for the Site is 508 stems per acre with all 9 vegetation plots meeting the MY3 requirement of 320 stems per acre. Geomorphic surveys indicate that cross-section bankfull dimensions closely match the baseline monitoring with some minor adjustments. At least one bankfull event was documented on all project reaches, except UT3 Reach 2, in MY3. Stream repairs were completed in April 2022 to address localized instances of bed and bank instability and are functioning as designed. The MY3 visual assessments revealed that invasive species populations have been successfully reduced due to ongoing treatments. Wildlands will continue to monitor these areas, and adaptive management will be implemented as necessary throughout the seven-year monitoring period to sustain the ecological health of the Site.

Section 2: METHODOLOGY

Geomorphic data were collected following the standards outlined in The Stream Channel Reference Site: An Illustrated Guide to Field Techniques (Harrelson et al., 1994) and in the Stream Restoration: A Natural Channel Design Handbook (Doll et al., 2003). All Integrated Current Condition Mapping was recorded using a Trimble handheld GPS with sub-meter accuracy and processed using Pathfinder and ArcGIS. Stream gages were installed in riffles and monitored quarterly. Hydrologic monitoring instrument installation and monitoring methods are in accordance with the United States Army Corps of Engineers (USACE, 2003) standards. Vegetation monitoring protocols followed the Carolina Vegetation Survey-EEP Level 2 Protocol (Lee et al., 2008).

Section 3: REFERENCES

Doll, B.A., Grabow, G.L., Hall, K.A., Halley, J., Harman, W.A., Jennings, G.D., and Wise, D.E. 2003. Stream Restoration A Natural Channel Design Handbook.

Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Lee, Michael T., Peet, Robert K., Steven D., Wentworth, Thomas R. 2008. CVS-EEP Protocol for Recording Vegetation Version 4.2. Retrieved from: http://cvs.bio.unc.edu/protocol/cvs-eep-protocol-v4.2-lev1-2.pdf North Carolina Division of Mitigation Services. 2009. French Broad River Basin Restoration Priorities.

North Carolina Climate Retrieval and Observations Network of the Southeast Database (NCCRONOS). 2022. State Climate Office of North Carolina. Version 2.7.2. Station ID Mars Hill 2.2 SSE, NC. Accessed October 2022.

North Carolina Division of Mitigation Services (DMS), June 2017. DMS Annual Monitoring and Closeout Reporting Template.

North Carolina Division of Mitigation Services (DMS), June 2017. DMS Stream and Wetland Mitigation Plan Template and Guidance.

North Carolina Division of Water Resources. 2011. French Broad Basinwide Water Quality Plan.

North Carolina Division of Water Resources (NCDWR), 2015. Surface Water Classifications. http://portal.ncdenr.org/web/wq/ps/csu/classifications

North Carolina Ecosystem Enhancement Program. 2009. French Broad River Basin Restoration Priorities.

North Carolina Geological Survey (NCGS), 1985. Geologic Map of North Carolina: North Carolina Survey, General Geologic Map, scale 1:500,000. https://deq.nc.gov/about/divisions/energy-mineral-land-resources/north-carolina-geological-survey/ncgs-maps/1985-geologic-map-of-nc4

Rosgen, D. L. 1994. A classification of natural rivers. *Catena* 22:169-199.

Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.

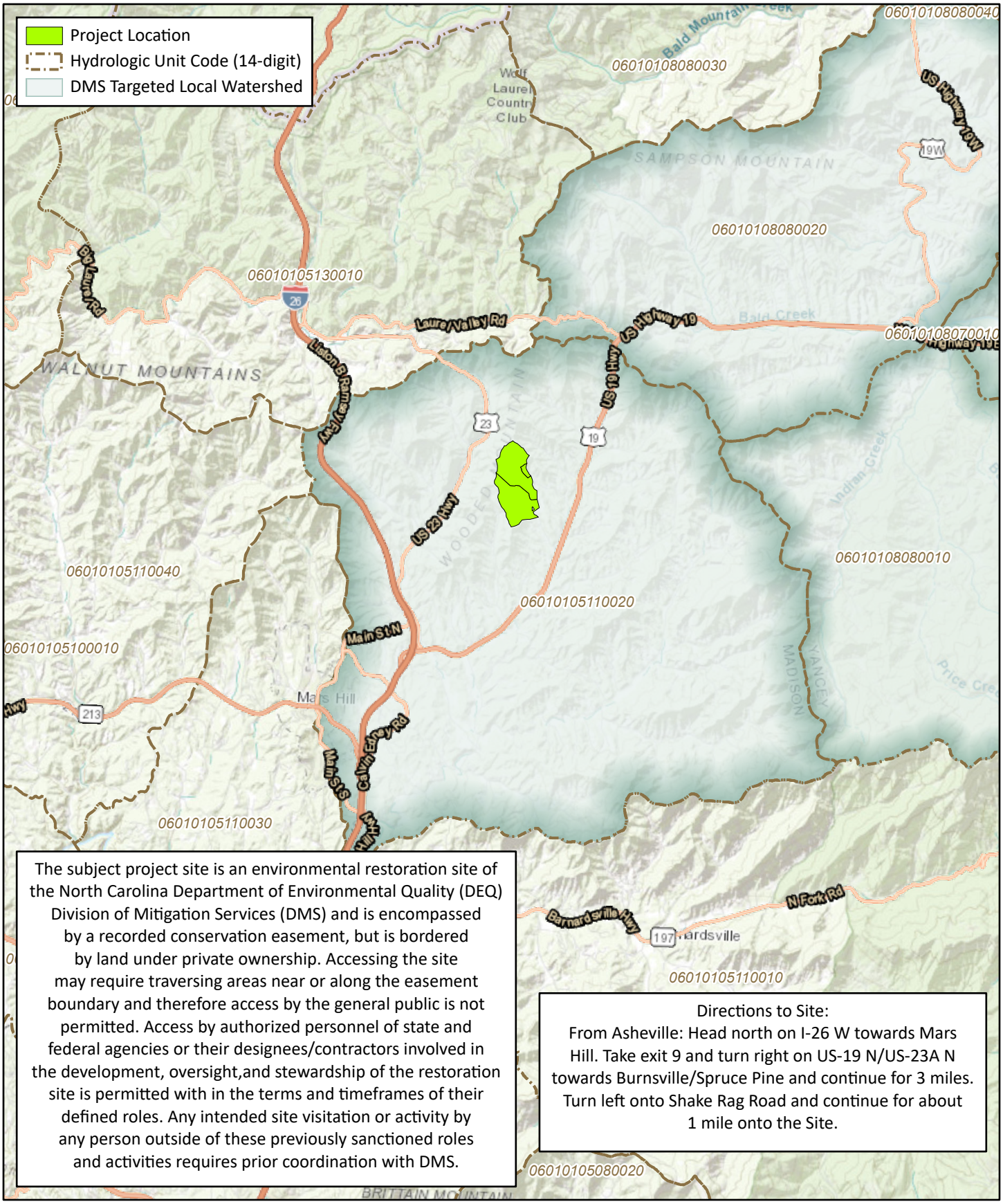
United States Army Corps of Engineers (USACE), October 2016. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.

Wildlands Engineering, Inc (Wildlands), 2019. Shake Rag Mitigation Site Mitigation Plan. DMS, Raleigh, NC.

Wildlands Engineering, Inc (Wildlands), 2020. Shake Rag Mitigation Site As-Built Baseline Monitoring Report. DMS, Raleigh, NC.

Wildlands Engineering, Inc (Wildlands), 2022. Shake Rag Mitigation Site Monitoring Year 2 Annual Report. DMS, Raleigh, NC.

APPENDIX 1. General Figures and Tables



The subject project site is an environmental restoration site of the North Carolina Department of Environmental Quality (DEQ) Division of Mitigation Services (DMS) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight,and stewardship of the restoration site is permitted with in the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with DMS.

Directions to Site:
From Asheville: Head north on I-26 W towards Mars Hill. Take exit 9 and turn right on US-19 N/US-23A N towards Burnsville/Spruce Pine and continue for 3 miles. Turn left onto Shake Rag Road and continue for about 1 mile onto the Site.

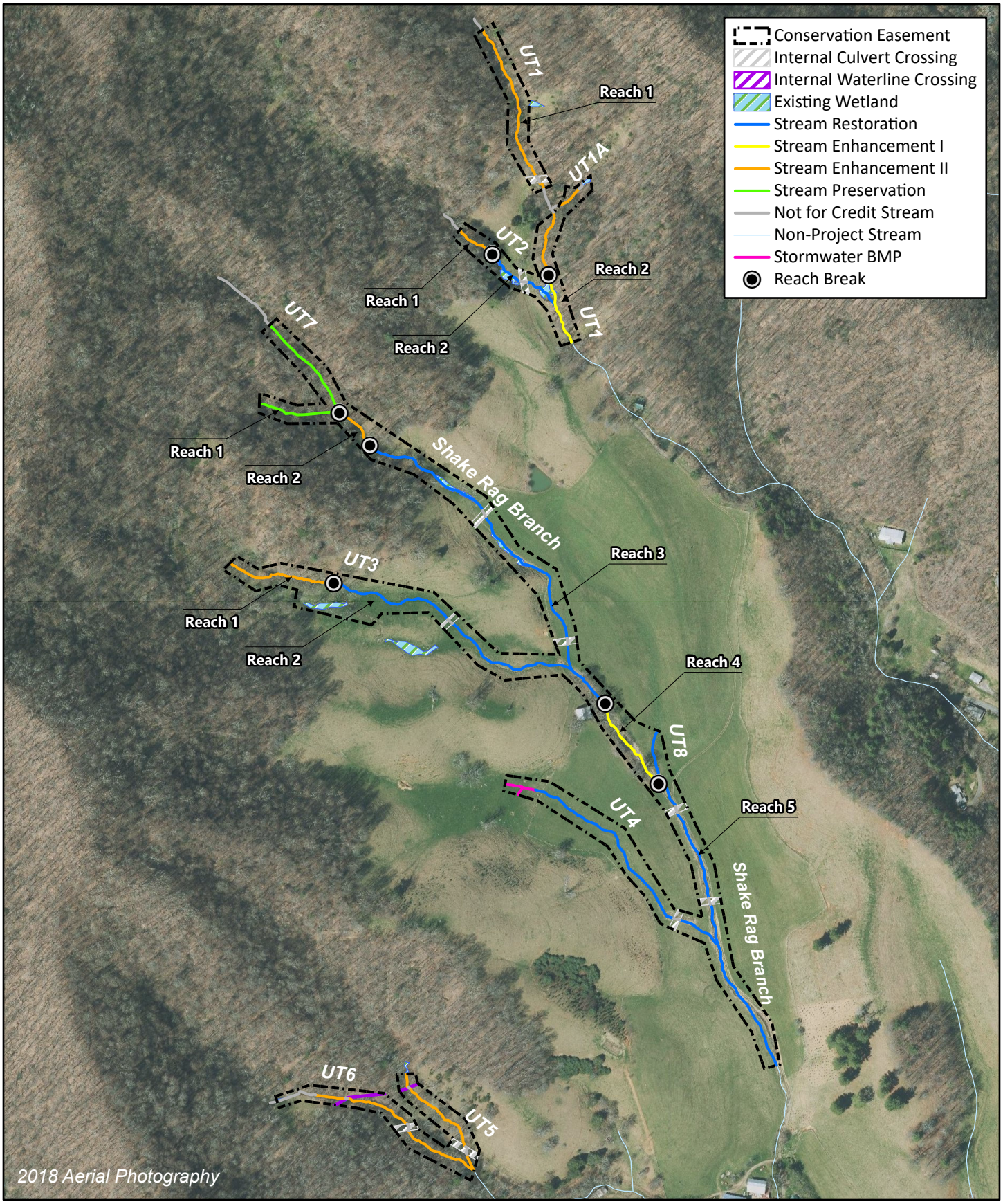
WILDLANDS ENGINEERING

0 1 2 Miles

N

Figure 1 Project Vicinity Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC



WILDLANDS ENGINEERING

0 250 500 Feet

N

Figure 2 Project Component/Asset Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC

Table 1. Mitigation Assets and Components

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Project Components								
Project Area/Reach	**Existing Footage (LF) or Acreage[1]**	**Mitigation Plan Footage/ Acreage**	**Mitigation Category**	**Restoration Level**	**Priority Level**	**Mitigation Ratio (X:1)**	**As-Built Footage/ Acreage[2]**	**Comments**
Shake Rag Branch R1	312	312	Cold	Preservation	N/A	10.000	312	N/A
Shake Rag Branch R2	175	175	Cold	Enhancement II	N/A	2.500	175	N/A
Shake Rag Branch R3	1,451	1,393	Cold	Restoration	P1	1.000	1,391	N/A
Shake Rag Branch R4	385	385	Cold	Enhancement I	N/A	1.500	385	N/A
Shake Rag Branch R5	1,216	1,134	Cold	Restoration	P1, P2	1.000	1,134	N/A
UT1 R1	934	907	Cold	Enhancement II	N/A	2.500	907	N/A
UT1 R2	255	278	Cold	Enhancement I	N/A	1.500	278	N/A
UT1A	100	100	Cold	Enhancement II	N/A	2.500	100	N/A
UT2 R1	164	164	Cold	Enhancement II	N/A	2.500	164	N/A
UT2 R2	296	304	Cold	Restoration	P1	1.000	304	N/A
UT3 R1	426	426	Cold	Enhancement II	N/A	2.500	426	N/A
UT3 R2	1,387	1,019	Cold	Restoration	P1	1.000	1,019	N/A
UT4	910	930	Cold	Restoration	P1	1.000	930	N/A
UT5	483	439	Cold	Enhancement II	N/A	2.500	444	N/A
UT6	707	673	Cold	Enhancement II	N/A	2.500	670	N/A
UT7	428	428	Cold	Preservation	N/A	10.000	428	N/A
UT8	210	206	Cold	Restoration	P1	1.000	206	N/A

Project Credits							
Restoration Level	**Stream**			**Riparian Wetland**		**Non-Riparian Wetland**	**Coastal Marsh**
	Warm	**Cool**	**Cold**	**Riverine**	**Non-Riv**		
Restoration	N/A	N/A	4,986.000	N/A	N/A	N/A	N/A
Re-establishment				N/A	N/A	N/A	N/A
Rehabilitation				N/A	N/A	N/A	N/A
Enhancement				N/A	N/A	N/A	N/A
Enhancement I	N/A	N/A	442.000				
Enhancement II	N/A	N/A	1,153.600				
Creation				N/A	N/A	N/A	N/A
Preservation	N/A	N/A	74.000	N/A	N/A	N/A	
Totals	**N/A**	**N/A**	**6,655.600**	**N/A**	**N/A**	**N/A**	**N/A**

Notes:

1. Some or all of SRB Reach 3, UT3 Reach 2, UT4, and UT8 were previously buried in rock-lined channels or pipes. Reported exiting lengths are estimates based upon land owner communication, remote sensing, and field verification to approximate the subsurface location and alignment.

2. The Site contains 12 internal easement crossings. This value excludes the affected length of proposed stream centerline within each crossing.

Table 2. Project Activity and Reporting History

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Activity or Report		Data Collection Complete	Completion or Delivery
Institution Date		N/A	May 2017
404 Permit		June 2019	June 2019
Mitigation Plan		February - October 2018	March 2019
Final Design - Construction Plans		June 2019	June 2019
Construction		July 2019 - January 2020	January 2020
Bare root and live stake plantings for reach/segments		December 2020	December 2020
Baseline Monitoring Document (Year 0)		December 2019 - March 2020	April 2020
Stream Repair/Maintenance		Spring 2020 & November 2020	November 2020
Year 1 Monitoring	Stream Survey	October 2020	November 2020
	Vegetation Survey	October 2020	
Invasive Species Treatment		June 2021	June 2021
Year 2 Monitoring	Stream Survey	June 2021	November 2021
	Vegetation Survey	August 2021	
Stream Repair/Maintenance		April 2022	April 2022
Invasive Species Treatment		March, September 2022	September 2022
Easement Boundary Maintenance		October 2022	October 2022
Year 3 Monitoring	Stream Survey	May 2022	November 2022
	Vegetation Survey	August 2022	
Year 4 Monitoring	Stream Survey		
	Vegetation Survey		
Year 5 Monitoring	Stream Survey		
	Vegetation Survey		
Year 6 Monitoring	Stream Survey		
	Vegetation Survey		
Year 7 Monitoring	Stream Survey		
	Vegetation Survey		

Table 3. Project Contact Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Designers Jake McLean, PE, CFM	**Wildlands Engineering, Inc.** 1430 South Mint Street, Suite 104 Charlotte, NC 28203 704.332.7754
Construction Contractors	**Baker Grading & Landscaping, Inc.** 1000 Bat Cave Road Old Fort, NC 28762
Planting Contractor	**Bruton Natural Systems, Inc.** PO Box 1197 Freemont, NC 27830
Seeding Contractor	**Baker Grading & Landscaping, Inc.**
Seed Mix Sources	**Baker Grading & Landscaping, Inc.**
Nursery Stock Suppliers Bare Roots Live Stakes Herbaceous Plugs	**Bruton Natural Systems, Inc.**
Monitoring Performers Monitoring, POC	**Wildlands Engineering, Inc.** Kristi Suggs 704.332.7754 Ext. 110

Table 4. Project Information and Attributes
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Project Information	
Project Name	Shake Rag Mitigation Site
	Madison County
Project Area (acres)	18.000
Project Coordinates (latitude and longitude)	35° 52' 41"N 82° 29' 47"W
Planted Acreage (Acre of Woody Stems Planted)	9.5
Project Watershed Summary Information	
Physiographic Province	Blue Ridge
River Basin	French Broad
USGS Hydrologic Unit 8-digit	06010105
USGS Hydrologic Unit 14-digit	06010105110020
DWR Sub-basin	04-03-04
Project Drainage Area (acres)	70 (UT1), 163 (Shake Rag Branch), 43 (UT6)
Project Drainage Area Percentage of Impervious Area	<1% (UT1), <1% (Shake Rag Branch), <1% (UT6)
2011 NLCD Land Use Classification	UT1: Forest (95%),Pasture/Hay (5%), Shrubland (0%), Urban (0%) Shake Rag Branch: Forest (49%), Pasture/Hay (49%), Shrubland (1%), Urban (1%) UT6: Forest (99%), Pasture/Hay (1%), Shrubland (0%), Urban (0%)

Reach Summary Information

Parameters	Shake Rag Branch					UT3		UT4	UT7	UT8
	R1	R2	R3	R4	R5	R1	R2			
Length of reach (linear feet) - Post-Restoration	312	175	1,391	385	1,134	426	1,019	930	428	206
Valley confinement (Confined, moderately confined, unconfined)	Confined	Moderately confined				Confined	Confined	N/A	Confined	N/A
Drainage area (acres)	10	26	76	77	163	12	38	32	13	19
Perennial, Intermittent, Ephemeral	P	P	P	P	P	P	P	P	P	P
NCDWR Water Quality Classification	WS-II; HQW									
Morphological Description (stream type) - Pre-Restoration	-	A4a+	A4a+	A4/B4a	A4	A4a+/B4a	A4a+	-	-	-
Morphological Description (stream type) - Post-Restoration	-	A4a+	A4a+/B4a	A4/B4a	A4/B4a	A4a+/B4a	A4a+/B4a	A4a+/B4a	-	A4/B4a
Evolutionary trend (Simon's Model) - Pre- Restoration	I	VI	II/III	V/VI	III/IV/V	VI	II/III/IV	II	I	II
FEMA classification	None									

Parameters	UT1		UT1A	UT2		UT5	UT6
	R1	R2		R1	R2		
Length of reach (linear feet) - Post-Restoration	907	278	100	164	304	444	670
Valley confinement (Confined, moderately confined, unconfined)	Confined	Moderately confined	Confined	Moderately Confined	Confined	Moderately confined	Moderately confined
Drainage area (acres)	38	70	6	29	31	18	25
Perennial, Intermittent, Ephemeral	P	P	P	P	P	P	P
NCDWR Water Quality Classification	WS-II; HQW						
Morphological Description (stream type) - Pre-Restoration	A4a+	A4a+	A4a+	A4a+/B4a	A4a+	B4a	B4a
Morphological Description (stream type) - Post-Restoration	A4a+	A4a+/B4a	A4a+	A4a+/B4a	A4a+/B4a	B4a	B4a
Evolutionary trend (Simon's Model) - Pre- Restoration	VI	V/VI	I	VI	II/III	VI	VI
FEMA classification	None						

Regulatory Considerations

Regulation	Applicable?	Resolved?	Supporting Documentation
Waters of the United States - Section 404	Yes	Yes	USACE Action ID# SAW-2017-00100
Waters of the United States - Section 401	Yes	Yes	DWR# 17-1157
Division of Land Quality (Erosion and Sediment Control)	Yes	Yes	NPDES Construction Stormwater General Permit NCG010000
Endangered Species Act	Yes	Yes	Categorical Exclusion Document in Mitigation Plan
Historic Preservation Act	Yes	Yes	Categorical Exclusion Document in Mitigation Plan
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	No	N/A	N/A
FEMA Floodplain Compliance	No	N/A	N/A
Essential Fisheries Habitat	No	N/A	N/A

Table 5a. Monitoring Component Summary

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Shake Rag Branch, UT3, UT4, UT8, and UT7

Parameter	Monitoring Feature	Quantity / Length by Reach										Frequency	Notes
		Shake Rag Reach 1	Shake Rag Reach 2	Shake Rag Reach 3	Shake Rag Reach 4	Shake Rag Reach 5	UT3 Reach 1	UT3 Reach 2	UT4	UT8	UT7		
Dimension	Riffle Cross-Section	N/A	N/A	2	1	1	N/A	1	1	1	N/A	Year 1, 2, 3, 5, and 7	1
	Pool Cross-Section	N/A	N/A	1	0	1	N/A	1	1	0	N/A		
Pattern	Pattern	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Profile	Longitudinal Profile	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Substrate	Reach Wide (RW) Pebble Count	N/A	N/A	1 RW	1 RW	1 RW	N/A	1 RW	1 RW	1 RW	N/A	Year 1, 2, 3, 5, and 7	3
Hydrology	Crest Gage (CG) and or/Stream Gage (SG)	N/A	N/A	1 CG			N/A	1 CG	1 CG	1 SG	N/A	Semi-Annual	4
Vegetation	CVS Level 2/Mobile plots	N/A	7 (4 permanent, 3 mobile)								N/A	Year 1, 2, 3, 5, and 7	5
Visual Assessment		Yes										Semi-Annual	
Exotic and Nuisance Vegetation												Semi-Annual	6
Project Boundary												Semi-Annual	7
Reference Photos	Photographs	21										Annual	

Notes:

1. Cross-sections were permanently marked with rebar to establish location. Surveys include points measured at all breaks in slope, including top of bank, bankfull, edge of water, and thalweg.

2. Pattern and profile will be assessed visually during semi-annual site visits. Longitudinal profile was collected during as-built baseline monitoring survey only, unless observations indicate widespread lack of vertical stability (greater than 10% of reach is affected) and profile survey is warranted in additional years to monitor adjustments or survey repair work.

3. Riffle 100-count substrate sampling were collected during the baseline monitoring only. A reachwide pebble count will be performed on each restoration or enhancement I reach during subsequent monitoring years for classification purposes only.

4. Crest gages and/or stream gages will be inspected and downloaded quarterly or semi-annually, evidence of bankfull events will be documented with a photo when possible. Transducers, if used, will be set to record stage once every 2 hours. The proposed gage on UT8 will be used for the sole purpose of documenting consecutive flow - an alternative proven method (e.g. game camera) may be used if agreed by IRT to be sufficient to demonstrate this requirement.

5. Both mobile and permanent vegetation plots will be utilized to evaluate the vegetation performance for 2% of the open areas planted acreage. Permanent vegetation monitoring plot assessments will follow CVS Level 2 protocols. Mobile vegetation monitoring plot assessments will document number of planted stems and species using a circular or 100 m2 square/rectangular plot. Planted shaded areas will be visually assessed.

6. Locations of exotic and nuisance vegetation will be mapped.
7. Locations of vegetation damage, boundary encroachments, etc. will be mapped.

Table 5b. Monitoring Component Summary

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT1, UT1A, UT2, UT5, and UT6

Parameter	Monitoring Feature	Quantity / Length by Reach							Frequency	Notes
		UT1 Reach 1	UT1 Reach 2	UT1A	UT2 Reach 1	UT2 Reach 2	UT5	UT6		
Dimension	Riffle Cross-Section	N/A	1	N/A	N/A	1	N/A	N/A	Year 1, 2, 3, 5, and 7	1
	Pool Cross-Section	N/A	0	N/A	N/A	0	N/A	N/A		
Pattern	Pattern	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2
Profile	Longitudinal Profile	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Substrate	Reach Wide (RW) Pebble Count	N/A	1 RW	N/A	N/A	1 RW	N/A	N/A	Year 1, 2, 3, 5, and 7	3
Stream Hydrology	Crest Gage (CG) and/or Stream Gage (SG)	N/A	1 CG	N/A	N/A	1 CG	N/A	N/A	Semi-Annual	4
Vegetation	CVS Level 2/Mobile Plots	2 (1 permanent, 1 mobile)					N/A	N/A	Year 1, 2, 3, 5, and 7	5
Visual Assessment		Yes							Semi-Annual	
Exotic and Nuisance Vegetation									Semi-Annual	6
Project Boundary									Semi-Annual	7
Reference Photos	Photographs	9							Annual	

Notes:

1. Cross-sections were permanently marked with rebar to establish location. Surveys include points measured at all breaks in slope, including top of bank, bankfull, edge of water, and thalweg.

2. Pattern and profile will be assessed visually during semi-annual site visits. Longitudinal profile was collected during as-built baseline monitoring survey only, unless observations indicate widespread lack of vertical stability (greater than 10% of reach is affected) and profile survey is warranted in additional years to monitor adjustments or survey repair work.

3. Riffle 100-count substrate sampling were collected during the baseline monitoring only. A reachwide pebble count will be performed on each restoration or enhancement I reach during subsequent monitoring years for classification purposes only.

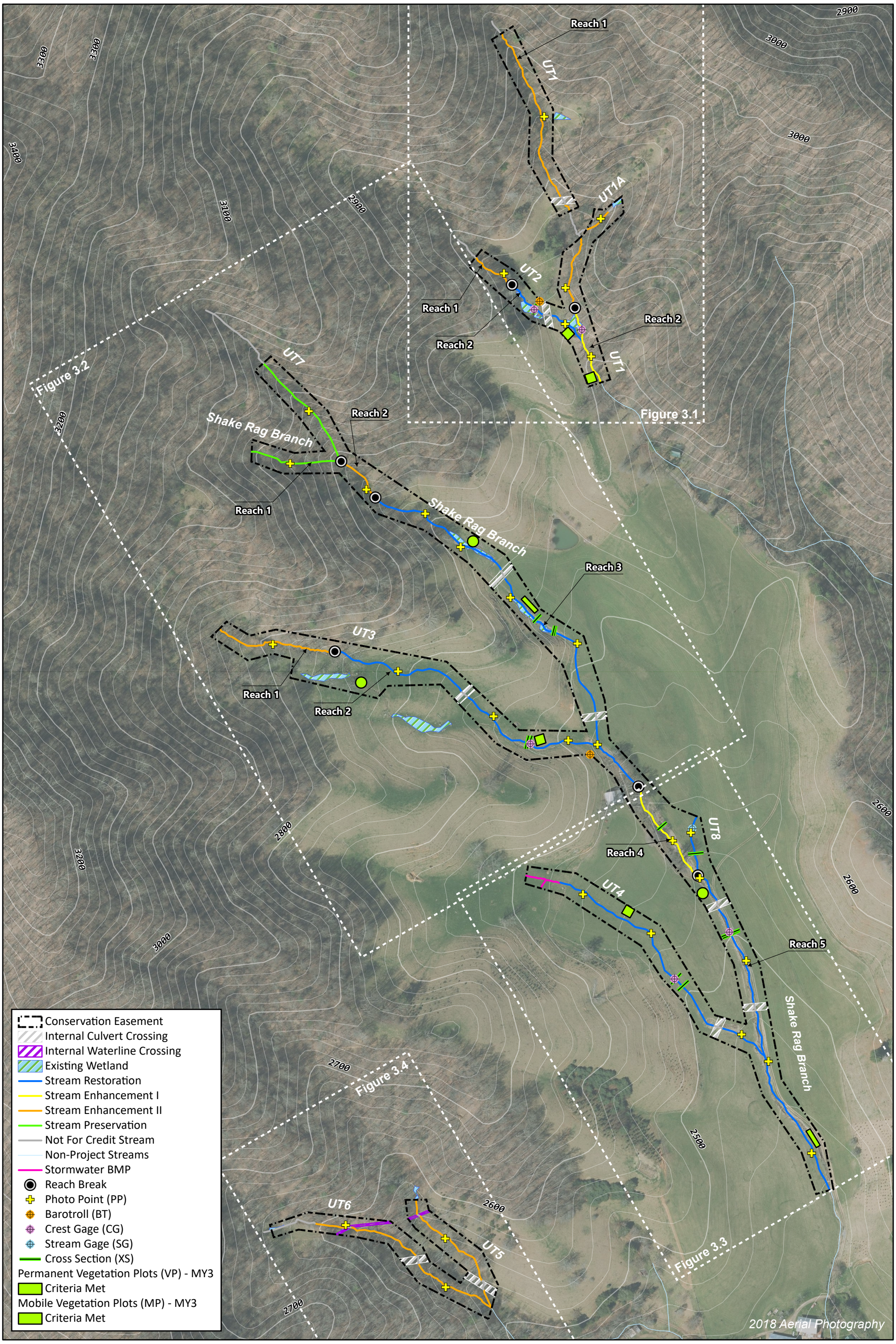
4. Crest gages and/or stream gages will be inspected and downloaded quarterly or semi-annually, evidence of bankfull events will be documented with a photo when possible. Transducers, if used, will be set to record stage once every 2 hours. The proposed gage on UT8 will be used for the sole purpose of documenting consecutive flow - an alternative proven method (e.g. game camera) may be used if agreed by IRT to be sufficient to demonstrate this requirement.

5. Both mobile and permanent vegetation plots will be utilized to evaluate the vegetation performance for 2% of the open areas planted acreage. Permanent vegetation monitoring plot assessments will follow CVS Level 2 protocols. Mobile vegetation monitoring plot assessments will document number of planted stems and species using a circular or 100 m2 square/rectangular plot. Planted shaded areas will be visually assessed with permanent vegetation photo points along UT5 and UT6.

6. Locations of exotic and nuisance vegetation will be mapped.

7. Locations of vegetation damage, boundary encroachments, etc. will be mapped.

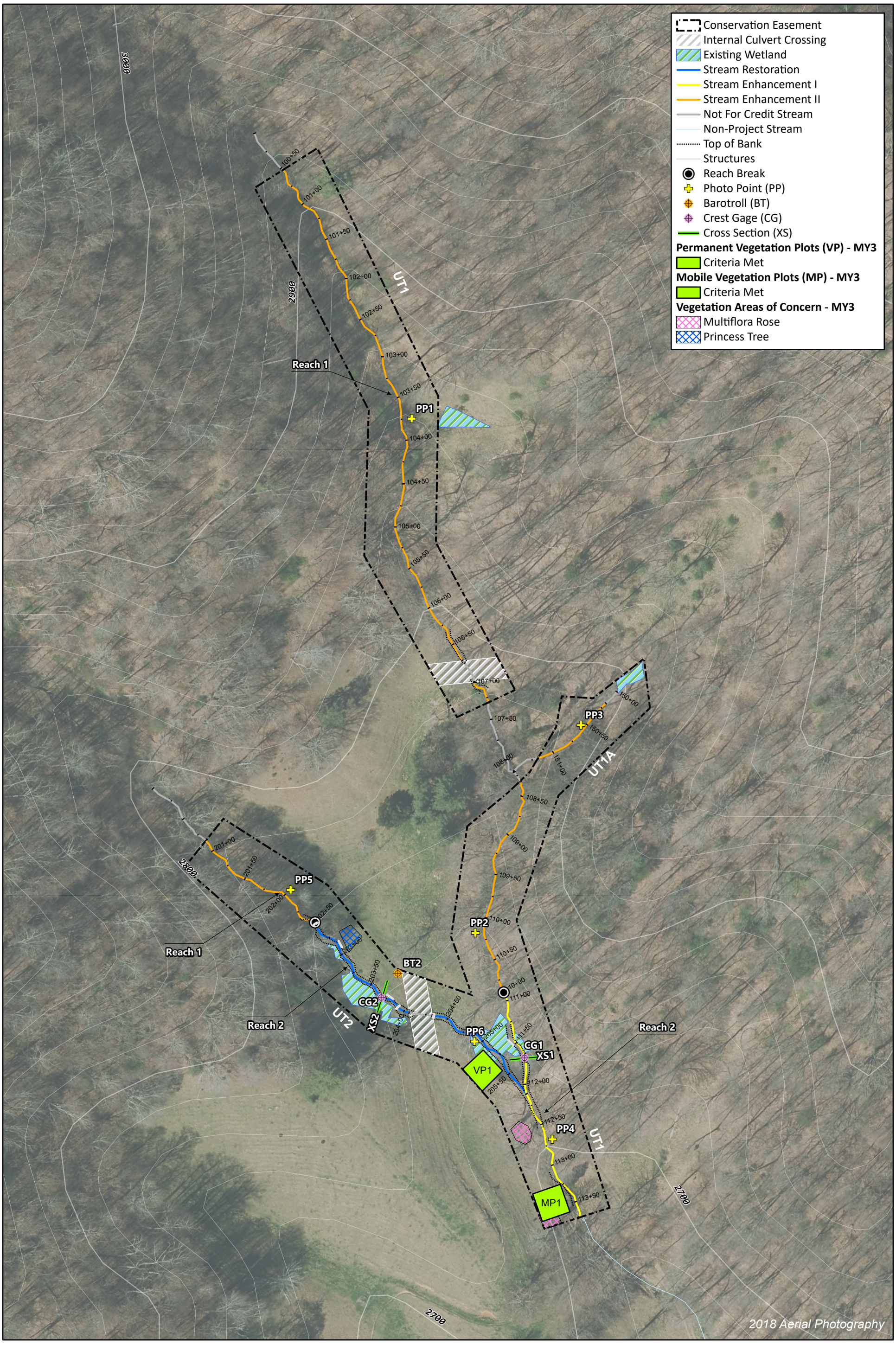
APPENDIX 2. Visual Assessment Data



WILDLANDS ENGINEERING

Figure 3.0 Current Condition Plan View Map (Key)
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC



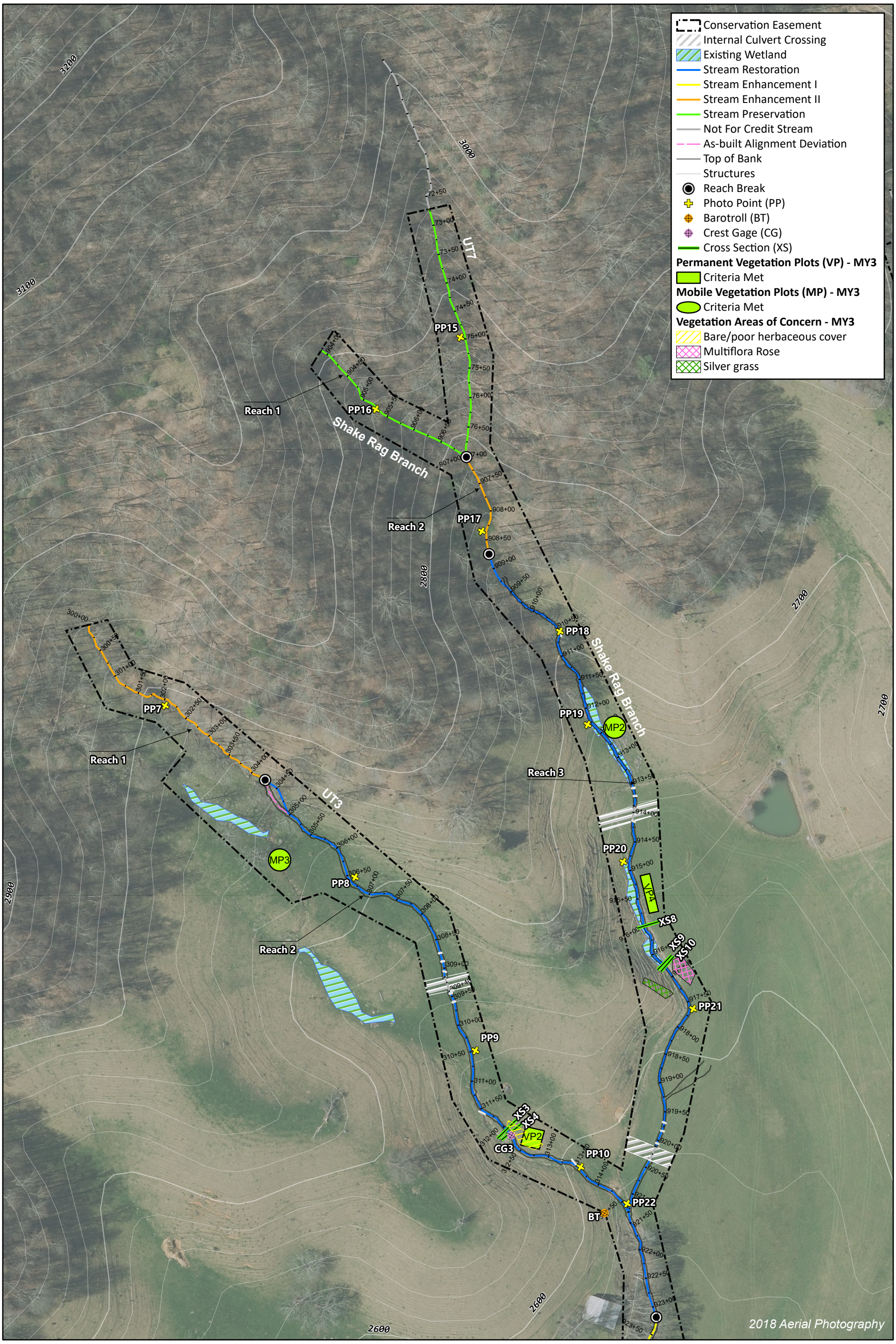
WILDLANDS ENGINEERING

0 100 200 Feet

N

Figure 3.1 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC

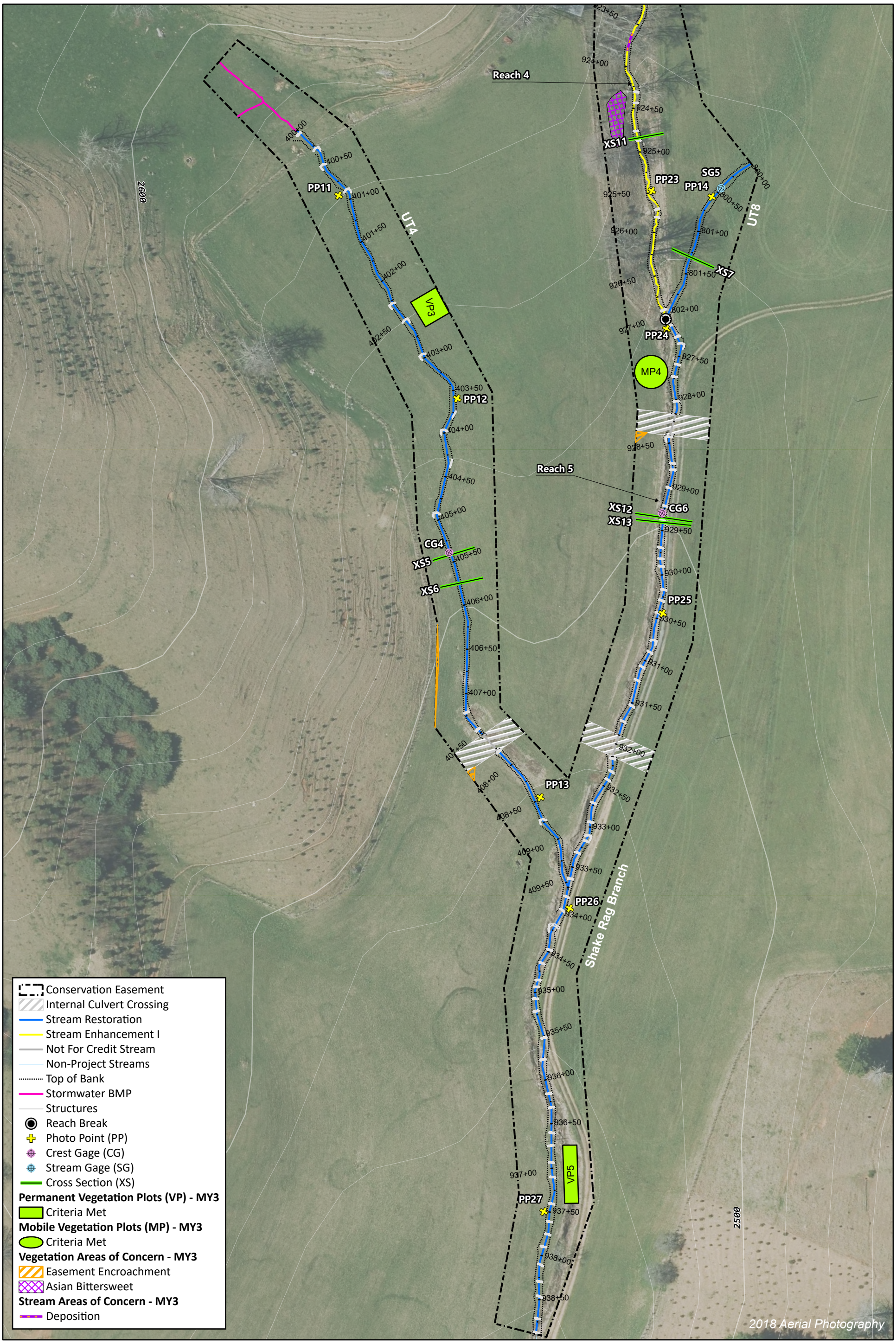


WILDLANDS ENGINEERING

0 150 300 Feet

Figure 3.2 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC

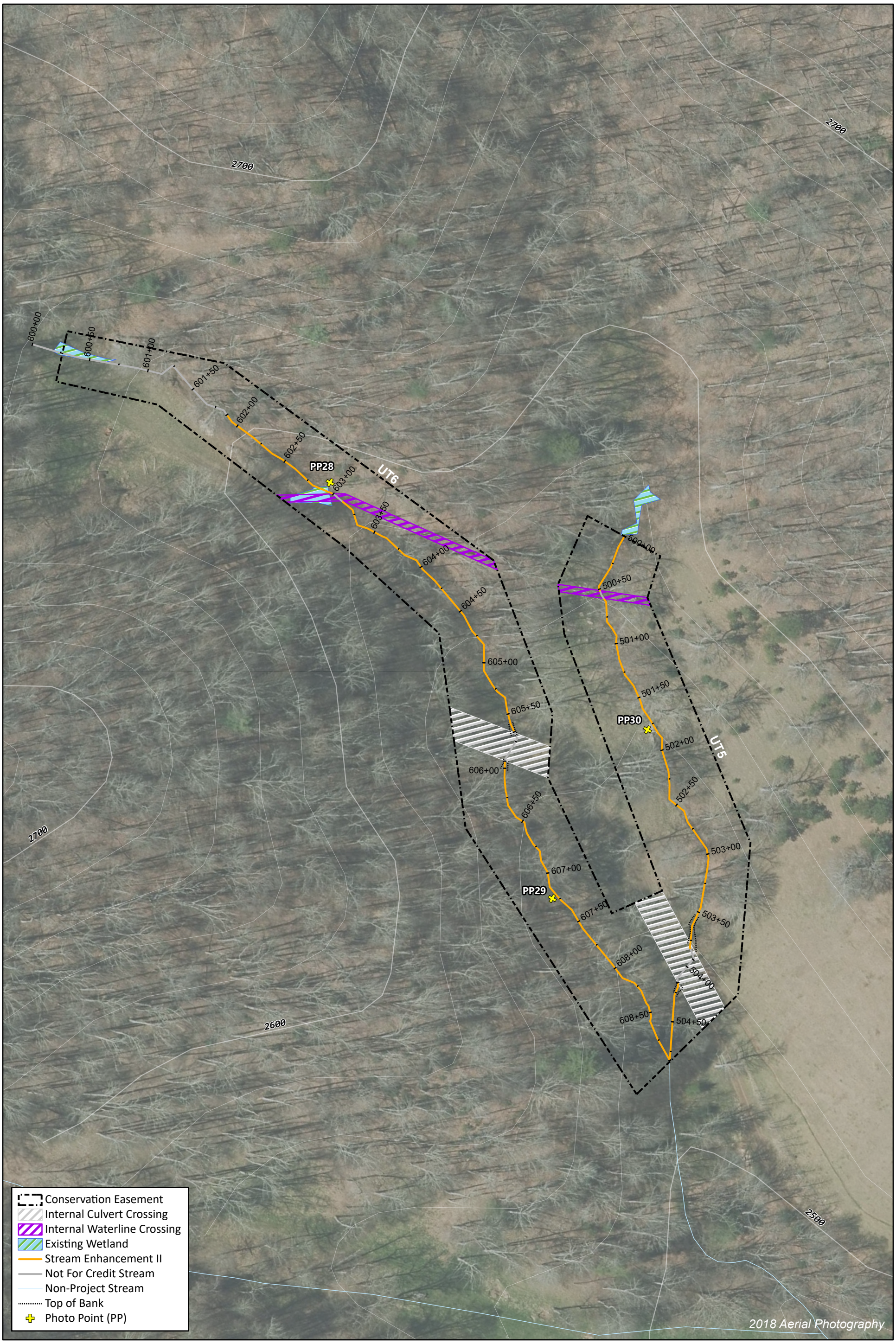


WILDLANDS ENGINEERING

0 100 200 Feet

Figure 3.3 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC



WILDLANDS ENGINEERING

0 75 150 Feet

Figure 3.4 Monitoring Plan View Map
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Madison County, NC

Table 6a. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: UT1 Reach 2
Assessed Length: 278

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	1	1			100%			
	3. Step Pool Condition	Depth Sufficient	0	0			N/A			
		Length Appropriate	0	0			N/A			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	2	2			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	1	1			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	1	1			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	2	2			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	1	1			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6b. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: UT2 Reach 2
Assessed Length: 304

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	2	2			100%			
	3. Step Pool Condition	Depth Sufficient	2	2			100%			
		Length Appropriate	2	2			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	6	6			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	4	4			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	4	4			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	6	6			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	4	4			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6c. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: UT3 Reach 2
Assessed Length: 1,019

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	2	2			100%			
	3. Step Pool Condition	Depth Sufficient	5	5			100%			
		Length Appropriate	5	5			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	9	9			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	7	7			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	7	7			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	9	9			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6d. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: UT4
Assessed Length: 930

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	3	3			100%			
	3. Step Pool Condition	Depth Sufficient	13	13			100%			
		Length Appropriate	13	13			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	18	18			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	16	16			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	16	16			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	18	18			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	15	15			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6e. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: UT8
Assessed Length: 206

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	16	16			100%			
	3. Step Pool Condition	Depth Sufficient	16	16			100%			
		Length Appropriate	16	16			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	16	16			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	16	16			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	16	16			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	16	16			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	16	16			100%			

[1]Excludes constructed riffles since they are evaluated in section 1.

Table 6f. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: Shake Rag Branch Reach 3
Assessed Length: 1,391

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	3	3			100%			
	3. Step Pool Condition	Depth Sufficient	7	7			100%			
		Length Appropriate	7	7			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	10	10			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	10	10			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	10	10			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	10	10			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6g. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: Shake Rag Branch Reach 4
Assessed Length: 385

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			1	20	97%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	1	1			100%			
	3. Step Pool Condition	Depth Sufficient	7	7			100%			
		Length Appropriate	7	7			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	8	8			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	8	8			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	8	8			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	8	8			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	7	7			100%			

[1]Cascading riffle sections evaluated as one riffle under the bed category and as one grade control under the engineered structures category.

Table 6h. Visual Stream Morphology Stability Assessment Table

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022
Reach: Shake Rag Branch Reach 5
Assessed Length: 1,134

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed[1]	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	57	57			100%			
	3. Step Pool Condition	Depth Sufficient	59	59			100%			
		Length Appropriate	59	59			100%			
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	N/A	N/A			N/A			
		Thalweg centering at downstream of meander bend (Glide)	N/A	N/A			N/A			
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures[1]	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	59	59			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	59	59			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	59	59			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	59	59			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	59	59			100%			

[1]Excludes riffles since they are evaluated in section 1.

Table 7. Vegetation Condition Assessment Table

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 3 - 2022

Date of Visual Assessments: February 2022, October 2022

Planted Acreage **9.5**

Vegetation Category	Definitions	Mapping Threshold (acres)	Number of Polygons	Combined Acreage	% of Planted Acreage
Bare Areas[1]	Very limited cover of both woody and herbaceous material	0.1	1	0.02	0.3%
Low Stem Density Areas[1]	Woody stem densities clearly below target levels based on MY3, 5, or 7 stem count criteria.	0.1	0	0.00	0.0%
		Total	**1**	**0.02**	**0.3%**
Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.1	0	0.00	0.0%
		Cumulative Total	**1**	**0.02**	**0.3%**

Easement Acreage **18.0**

Vegetation Category	Definitions	Mapping Threshold (SF)	Number of Polygons	Combined Acreage	% of Easement Acreage
Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1000	6	0.09	0.5%
Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	3	0.01	0.03%

[1]Areas mapped with bare area and low stem density are less than 0.1 acres.

Stream Photographs
MY3

	
Photo Point 1 – UT1 Reach 1, view upstream *(04/19/2022)*	**Photo Point 1** – UT1 Reach 1, view downstream *(04/19/2022)*
	
Photo Point 2 – UT1 Reach 1, view upstream *(04/19/2022)*	**Photo Point 2** – UT1 Reach 1, view downstream *(04/19/2022)*
	
Photo Point 3 – UT1A, view upstream *(04/19/2022)*	**Photo Point 3** – UT1A, view downstream *(04/19/2022)*

	
Photo Point 4 – UT1 Reach 2, view upstream *(04/19/2022)*	**Photo Point 4** – UT1 Reach 2, view downstream *(04/19/2022)*
	
Photo Point 5 – UT2 Reach 1, view upstream *(04/19/2022)*	**Photo Point 5** – UT1 Reach 1, view downstream *(04/19/2022)*
	
Photo Point 6 – UT2 Reach 2, view upstream *(04/19/2022)*	**Photo Point 6** – UT2 Reach 2, view downstream *(04/19/2022)*

	
Photo Point 7 – UT3 Reach 1, view upstream *(04/19/2022)*	**Photo Point 7** – UT3 Reach 1, view downstream *(04/19/2022)*
	
Photo Point 8 – UT3 Reach 2, view upstream *(04/19/2022)*	**Photo Point 8** – UT3 Reach 2, view downstream *(04/19/2022)*
	
Photo Point 9 – UT3 Reach 2, view upstream *(04/19/2022)*	**Photo Point 9** – UT3 Reach 2, view downstream *(04/19/2022)*

	
Photo Point 10 – UT3 Reach 2, view upstream *(04/19/2022)*	**Photo Point 10** – UT3 Reach 2, view downstream *(04/19/2022)*
	
Photo Point 11 – UT4, view upstream *(04/19/2022)*	**Photo Point 11** – UT4, view downstream *(04/19/2022)*
	
Photo Point 12 – UT4, view upstream *(04/19/2022)*	**Photo Point 12** – UT4, view downstream *(04/19/2022)*

	
Photo Point 13 – UT4, view upstream *(04/19/2022)*	**Photo Point 13** – UT4, view downstream *(04/19/2022)*
	
Photo Point 14 – UT8, view upstream *(05/12/2022)*	**Photo Point 14** – UT8, view downstream *(05/12/2022)*
	
Photo Point 15 – UT7, view upstream *(04/19/2022)*	**Photo Point 15** – UT7, view downstream *(04/19/2022)*

Photo Point 16 – SRB Reach 1, view upstream *(04/19/2022)*

Photo Point 16 – SRB Reach 1, view downstream *(04/19/2022)*

Photo Point 17 – SRB Reach 2, view upstream *(04/19/2022)*

Photo Point 17 – SRB Reach 2, view downstream *(04/19/2022)*

Photo Point 18 – SRB Reach 3, view upstream *(05/12/2022)*

Photo Point 18 – SRB Reach 3, view downstream *(05/12/2022)*

	
Photo Point 19 – SRB Reach 3, view upstream *(04/19/2022)*	**Photo Point 19** – SRB Reach 3, view downstream *(04/19/2022)*
	
Photo Point 20 – SRB Reach 3, view upstream *(04/19/2022)*	**Photo Point 20** – SRB Reach 3, view downstream *(04/19/2022)*
	
Photo Point 21 – SRB Reach 3, view upstream *(04/19/2022)*	**Photo Point 21** – SRB Reach 3, view downstream *(04/19/2022)*

Photo Point 22 – SRB Reach 3, view upstream *(04/19/2022)*

Photo Point 22 – UT3 Reach 2, view upstream *(04/19/2022)*

Photo Point 22 – SRB Reach 3, view downstream *(04/19/2022)*

Photo Point 23 – SRB Reach 4, view upstream *(04/19/2022)*

Photo Point 23 – SRB Reach 4, view downstream *(04/19/2022)*

	
Photo Point 24 – SRB Reach 4, view upstream *(04/19/2022)*	**Photo Point 24** – SRB Reach 5, view downstream *(04/19/2022)*
	
Photo Point 25 – SRB Reach 5, view upstream *(04/19/2022)*	**Photo Point 25** – SRB Reach 5, view downstream *(04/19/2022)*
	
Photo Point 26 – SRB Reach 5, view upstream *(04/19/2022)*	**Photo Point 26** – SRB Reach 5, view downstream *(04/19/2022)*

	
Photo Point 27 – SRB Reach 5, view upstream *(04/19/2022)*	**Photo Point 27** – SRB Reach 5, view downstream *(04/19/2022)*
	
Photo Point 28 – UT6, view upstream *(04/19/2022)*	**Photo Point 28** – UT6, view downstream *(04/19/2022)*
	
Photo Point 29 – UT6, view upstream *(04/19/2022)*	**Photo Point 29** – UT6, view downstream *(04/19/2022)*

	
Photo Point 30 – UT5, view upstream *(04/19/2022)*	**Photo Point 30** – UT5, view downstream *(04/19/2022)*

Culvert Crossing Photographs
MY3

	
Culvert Crossing – UT1 Reach 1, inlet view *(4/19/2022)*	**Culvert Crossing** – UT1 Reach 1, outlet view *(4/19/2022)*
	
Culvert Crossing – UT2 Reach 2, inlet view *(10/11/2022)*	**Culvert Crossing** – UT2 Reach 2, outlet view *(10/11/2022)*
	
Culvert Crossing – UT3 Reach 2, inlet view *(3/08/2022)*	**Culvert Crossing** – UT3 Reach 2, outlet view *(3/08/2022)*

	
Culvert Crossing – UT4, inlet view *(3/08/2022)*	**Culvert Crossing** – UT4, outlet view *(3/08/2022)*
	
Culvert Crossing – UT5, inlet view *(3/08/2022)*	**Culvert Crossing** – UT5, outlet view *(3/08/2022)*
	
Culvert Crossing – UT6, inlet view *(3/08/2022)*	**Culvert Crossing** – UT6, outlet view *(3/08/2022)*

	
Culvert Crossing – SRB Reach 3 at STA 914+00, inlet view *(3/08/2022)*	**Culvert Crossing** – SRB Reach 3 at STA 914+00, outlet view *(3/08/2022)*
	
Culvert Crossing – SRB Reach 3 at STA 920+25, inlet view *(3/08/2022)*	**Culvert Crossing** – SRB Reach 3 at STA 920+25, outlet view *(3/08/2022)*
	
Culvert Crossing – SRB Reach 5 at STA 928+25, inlet view *(3/08/2022)*	**Culvert Crossing** – SRB Reach 5 at STA 928+25, outlet view *(3/08/2022)*

	
Culvert Crossing – SRB Reach 5 at STA 932+00, inlet view *(3/08/2022)*	**Culvert Crossing** – SRB Reach 5 at STA 932+00, outlet view *(3/08/2022)*

Vegetation Plot Photographs
MY3

Permanent Vegetation Plot 1 – *(08/01/2022)*

Permanent Vegetation Plot 2 – *(08/01/2022)*

Permanent Vegetation Plot 3 – *(08/01/2022)*

Permanent Vegetation Plot 4 – *(08/01/2022)*

Permanent Vegetation Plot 5 – *(08/01/2022)*

Mobile Vegetation Plot 1 – North view – *(10/11/2022)*

Mobile Vegetation Plot 2 – North view – *(08/01/2022)*

Mobile Vegetation Plot 3 – North view – *(08/01/2022)*

Mobile Vegetation Plot 4 – North view – *(08/01/2022)*

APPENDIX 3. Vegetation Plot Data

Table 8. Vegetation Plot Criteria Attainment

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Permanent Vegetation Plot	MY3 Success Criteria Met (Y/N)	Tract Mean	Overal Mean
1	Y	100%	100%
2	Y		
3	Y		
4	Y		
5	Y		
Mobile Vegetation Plot	**MY3 Success Criteria Met (Y/N)**	**Tract Mean**	
1	Y	100%	
2	Y		
3	Y		
4	Y		

Table 9. CVS Permanent Vegetation Plot Metadata

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 3 - 2022

Database Name	cvs-eep-entrytool-v2.5.0 Shake Rag MY3.mdb
Database Location	L:\Active Projects\005-02164 Shake Rag\Monitoring\Monitoring Year 3\Vegetation Assessment
Computer Name	MIMI-PC
File Size	73781248
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	100018
Project Name	Shake Rag Mitigation Site
Description	Stream mitigation site located in Madision County, NC
River Basin	French Broad River Basin
Length(ft)	9,273 LF
Stream-to-edge Width (ft)	3 - 8
Area (sq m)	38445
Required Plots (calculated)	5
Sampled Plots	5
Required Plots (calculated)	5
Sampled Plots	5

Table 10a. Planted and Total Stem Counts
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Current Permanent Vegetation Plot Data (MY3 2022)																	
Scientific Name	**Common Name**	**Species Type**	**Permanent Plot 1**			**Permanent Plot 2**			**Permanent Plot 3**			**Permanent Plot 4**			**Permanent Plot 5**		
			PnoLS	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	Boxelder	Tree															6
Acer rubrum	Red Maple	Tree															
Betula nigra	River Birch	Tree	1	1	1	2	2	2	1	1	1	2	2	2	3	3	3
Diospyros virginiana	American Persimmon	Tree	2	2	2				1	1	1						
Fagus grandifolia	American Beech	Tree	1	1	1												
Fraxinus pennsylvanica	Green Ash	Tree				1	1	1	3	3	3	3	3	3			
Gleditsia triacanthos	Honey Locust	Shrub Tree						1									
Liriodendron tulipifera	Tulip Poplar	Tree	1	1	7	3	3	7	3	3	3	2	2	2	2	2	2
Nyssa sylvatica	Black Gum	Tree				1	1	1	1	1	1	1	1	1	3	3	3
Platanus occidentalis	Sycamore	Tree	3	3	7	1	1	1	2	2	2	2	2	2	2	2	2
Quercus alba	White Oak	Tree	3	3	3										1	1	1
Quercus falcata	Southern Red Oak	Tree	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1
Quercus rubra	Red Oak	Tree	2	2	2	1	1	1	1	1	1	2	2	2	3	3	3
		Stem count	14	14	24	11	11	16	13	13	13	13	13	13	15	15	21
		size (ares)		1			1			1			1			1	
		size (ACRES)		0.0247			0.0247			0.0247			0.0247			0.0247	
		Species count	8	8	8	7	7	8	8	8	8	7	7	7	7	7	8
		Stems per ACRE	567	567	971	445	445	647	526	526	526	526	526	526	607	607	850

Permanent Vegetation Plots Annual Mean													
Scientific Name	**Common Name**	**Species Type**	**MY3 (2022)**			**MY2 (2021)**			**MY1 (2020)**			**MY0 (2020)**		
			PnoLS	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	Boxelder	Tree			6						10			
Acer rubrum	Red Maple	Tree						2						
Betula nigra	River Birch	Tree	9	9	9	9	9	9	10	10	10	12	12	12
Diospyros virginiana	American Persimmon	Tree	3	3	3	3	3	3	3	3	3	3	3	3
Fagus grandifolia	American Beech	Tree	1	1	1	1	1	1	1	1	1	3	3	3
Fraxinus pennsylvanica	Green Ash	Tree	7	7	7	7	7	7	7	7	7	7	7	7
Gleditsia triacanthos	Honey Locust	Shrub Tree			1			1						
Liriodendron tulipifera	Tulip Poplar	Tree	11	11	21	12	12	17	12	12	24	12	12	12
Nyssa sylvatica	Black Gum	Tree	6	6	6	6	6	6	7	7	7	8	8	8
Platanus occidentalis	Sycamore	Tree	10	10	14	10	10	13	10	10	10	10	10	10
Quercus alba	White Oak	Tree	4	4	4	4	4	4	4	4	4	4	4	4
Quercus falcata	Southern Red Oak	Tree	6	6	6	6	6	6	6	6	6	1	1	1
Quercus rubra	Red Oak	Tree	9	9	9	9	9	9	10	10	10	15	15	15
		Stem count	66	66	87	67	67	78	70	70	92	75	75	75
		size (ares)		5			5			5			5	
		size (ACRES)		0.124			0.124			0.124			0.124	
		Species count	10	10	12	10	10	12	10	10	11	10	10	10
		Stems per ACRE	534	534	704	542	542	631	567	567	745	607	607	607

Color for Density

Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%
Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
P-all: Number of planted stems including live stakes
T: Total stems

Table 10b. Planted and Total Stem Counts
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Current Mobile Vegetation Plot Data (MY3 2022)						
Scientific Name	**Common Name**	**Species Type**	**Mobile Plot 1**	**Mobile Plot 2**	**Mobile Plot 3**	**Mobile Plot 4**
			PnoLS	**PnoLS**	**PnoLS**	**PnoLS**
Acer negundo	Boxelder	Tree				
Acer rubrum	Red Maple	Tree				
Betula nigra	River Birch	Tree	3	1	3	1
Diospyros virginiana	American Persimmon	Tree				
Fagus grandifolia	American Beech	Tree	1			
Fraxinus pennsylvanica	Green Ash	Tree			2	2
Gleditsia triacanthos	Honey Locust	Shrub Tree				
Liriodendron tulipifera	Tulip Poplar	Tree	4	1	2	2
Nyssa sylvatica	Black Gum	Tree		2		1
Oxydendum arboreum	Sourwood	Tree				1
Platanus occidentalis	Sycamore	Tree	1	1	6	1
Quercus alba	White Oak	Tree	1			
Quercus falcata	Southern Red Oak	Tree	2	3	2	
Quercus rubra	Red Oak	Tree			2	2
		Stem count	12	8	17	10
		size (ares)	1	1	1	1
		size (ACRES)	0.0247	0.0247	0.0247	0.0247
		Species count	6	5	6	7
		Stems per ACRE	486	324	688	405

Mobile Vegetation Plots Annual Mean						
Scientific Name	**Common Name**	**Species Type**	**MY3 (2022)**	**MY2 (2021)**	**MY1 (2020)**	**MY0 (2020)**
			PnoLS	**PnoLS**	**PnoLS**	**PnoLS**
Acer negundo	Boxelder	Tree				
Acer rubrum	Red Maple	Tree				
Betula nigra	River Birch	Tree	8	5	7	6
Diospyros virginiana	American Persimmon	Tree		3	3	
Fagus grandifolia	American Beech	Tree	1		4	3
Fraxinus pennsylvanica	Green Ash	Tree	4	4	3	1
Gleditsia triacanthos	Honey Locust	Shrub Tree				
Liriodendron tulipifera	Tulip Poplar	Tree	9	4	4	7
Nyssa sylvatica	Black Gum	Tree	3	1	3	8
Oxydendum arboreum	Sourwood	Tree	1			
Platanus occidentalis	Sycamore	Tree	9	6	11	9
Quercus alba	White Oak	Tree	1	7		3
Quercus falcata	Southern Red Oak	Tree	7	5	3	
Quercus rubra	Red Oak	Tree	4	6	8	17
		Stem count	47	41	46	54
		size (ares)	4	4	4	4
		size (ACRES)	0.099	0.099	0.099	0.099
		Species count	10	9	9	8
		Stems per ACRE	476	415	465	546

Color for Density

Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%
Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
P-all: Number of planted stems including live stakes
T: Total stems

Table 10c. Planted and Total Stem Counts
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Overall Annual Mean						
Scientific Name	**Common Name**	**Species Type**	**MY3 (2022)**	**MY2 (2021)**	**MY1 (2020)**	**MY0 (2020)**
			PnoLS	**PnoLS**	**PnoLS**	**PnoLS**
Acer negundo	Boxelder	Tree				
Acer rubrum	Red Maple	Tree				
Betula nigra	River Birch	Tree	17	14	17	18
Diospyros virginiana	American Persimmon	Tree	3	6	6	3
Fagus grandifolia	American Beech	Tree	2	1	5	6
Fraxinus pennsylvanica	Green Ash	Tree	11	11	10	8
Gleditsia triacanthos	Honey Locust	Shrub Tree				
Liriodendron tulipifera	Tulip Poplar	Tree	20	16	16	19
Nyssa sylvatica	Black Gum	Tree	9	7	10	16
Oxydendum arboreum	Sourwood	Tree	1			
Platanus occidentalis	Sycamore	Tree	19	16	21	19
Quercus alba	White Oak	Tree	5	11	4	7
Quercus falcata	Southern Red Oak	Tree	13	11	9	1
Quercus rubra	Red Oak	Tree	13	15	18	32
		Stem count	113	108	116	129
		size (ares)	9	9	9	9
		size (ACRES)	0.222	0.222	0.222	0.222
		Species count	11	10	10	10
		Stems per ACRE	508	486	522	580

Color for Density
Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%
Volunteer species included in total

PnoLS: Number of planted stems excluding live stakes
P-all: Number of planted stems including live stakes
T: Total stems

Table 10d. Planted Stem Average Heights

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Average Stem Height (ft) by Plot				
	MY0	**MY1**	**MY2**	**MY3**
Permanent Plot 1	2.4	2.7	2.6	3.2
Permanent Plot 2	2.4	1.9	1.8	1.9
Permanent Plot 3	2.5	2.8	2.9	3.5
Permanent Plot 4	2.4	2.8	3.2	4.0
Permanent Plot 5	2.6	2.1	2.2	2.5
Permanent Plot Site Average	**2.5**	**2.5**	**2.5**	**3.0**
Mobile Plot 1	1.9	2.5	2.4	2.8
Mobile Plot 2	2.0	2.6	1.9	2.9
Mobile Plot 3	1.8	2.9	2.3	3.1
Mobile Plot 4	2.3	2.6	1.8	3.1
Mobile Plot Site Average	**2.0**	**2.7**	**2.1**	**3.0**
Overall Site Average	**2.3**	**2.5**	**2.3**	**3.0**

APPENDIX 4. Morphological Summary Data and Plots

Table 11a. Baseline Stream Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT1 Reach 2, UT2 Reach 2, UT3 Reach 2, UT4

		Pre-Restoration Condition								Design								As-Built/Baseline							
Parameter	**Gage**	**UT1 Reach 2**		**UT2 Reach 2**		**UT3 Reach 2**		**UT4**		**UT1 Reach 2**		**UT2 Reach 2**		**UT3 Reach 2**		**UT4**		**UT1 Reach 2**		**UT2 Reach 2**		**UT3 Reach 2**		**UT4**	
		Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Dimension and Substrate - Riffle																									
Bankfull Width (ft)	N/A	5.3		3.1		4.5		N/A[1]		5.5		5.5		5.9		6.1		4.7		3.2		6.0		6.7	
Floodprone Width (ft)		15.7		21.6		7.2		N/A[1]		8	15	8	12	8	13	9	13	10		10		13		11	
Bankfull Mean Depth (ft)		0.8		0.5		0.5		N/A[1]		0.4		0.4		0.4		0.4		0.3		0.2		0.3		0.3	
Bankfull Max Depth (ft)		1.0		1.3		1.0		N/A[1]		0.5		0.5		0.6		0.6		0.4		0.3		0.6		0.6	
Bankfull Cross-sectional Area (ft^2)		4.3		1.6		2.3		N/A[1]		2.0		2.0		2.3		2.4		1.2		0.6		1.9		2.3	
Width/Depth Ratio		6.4		6.0		9.1		N/A[1]		15.0		15.0		15.0		15.0		18.4		16.9		18.4		19.7	
Entrenchment Ratio		3.0		7.0		1.6		N/A[1]		1.4	2.2	1.4	2.2	1.4	2.2	1.4	2.2	2.1		3.1		2.1		1.6	
Bank Height Ratio		1.0		1.0		2.7		N/A[1]		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
D_{50} (mm)		100		6		75		N/A[1]		---		---		---		---		64.0		67.4		61.8		71.7	
Profile																									
Riffle Length (ft)	N/A																								
Riffle Slope (ft/ft)										0.096	0.252	0.063	0.152	0.043	0.176	0.057	0.171	0.080	0.241	0.078	0.266	0.015	0.339	0.037	0.292
Pool Length (ft)																									
Pool Max Depth (ft)		1.4		---		1.2		N/A[1]		0.8	1.8	0.7	1.3	0.8	1.4	0.8	1.4	0.4	1.8	0.7	1.7	0.5	2.1	0.7	2.0
Pool Spacing (ft)		9	28	---		8	16	N/A[1]		8	17	6	14	6	15	9	18	7	20	7	22	5	36	14	34
Pool Volume (ft^3)																									
Pattern																									
Channel Beltwidth (ft)	N/A	N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Radius of Curvature (ft)		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Rc/Bankfull Width (ft/ft)		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Length (ft)		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Width Ratio		N/A[2]		N/A[2]		N/A[2]		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Substrate, Bed and Transport Parameters																									
Ri%/Ru%/P%/G%/S%	N/A																								
SC%/Sa%/G%/C%/B%/Be%																									
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$		0.5/15-20/100/ 300-400/>1400		0.25/0.7/5.5/ 15/250		20-25/45/75/ 150/270		N/A[1]										0.3/2/12.8/90/ 180/512		0.4/4/25.4/99.5/ 202.4/>2048		0.3/0.73/7.1/ 155.5/315.2/512		0.3/1.34/20.7/ 154.8/272.5/512	
Reach Shear Stress (Competency) lb/ft^2		2.6		3.3		4.1		2.8		3.8		3.3		4.1		2.8		2.0		1.8		3.7		2.3	
Max part size (mm) mobilized at bankfull										311		366		428		322		99		90		181		112	
Stream Power (Capacity) W/m^2																									
Additional Reach Parameters																									
Drainage Area (SM)	N/A	0.11		0.05		0.06		0.05		0.11		0.05		0.06		0.05		0.11		0.05		0.06		0.05	
Watershed Impervious Cover Estimate (%)		<1%								<1%								<1%							
Rosgen Classification		A4a+		A4a+		A4a+		N/A[1]		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a		A4a+/B4a	
Bankfull Velocity (fps)		8.1		7.4		8.3		N/A[1]		6.4		7.2		8.1		6.7		5.3		4.8		7.6		5.9	
Bankfull Discharge (cfs)		35		12		19		N/A[1]		13		14		19		16		6		3		21		14	
Q-NFF regression (2-yr)		---		---		---		---																	
Q-USGS extrapolation (1.2-yr)		16		9		10		9		---		---		---		---									
Max Q-Mannings		44		12		19		---		---		12		19		N/A[1]									
Valley Slope (ft/ft)		0.1262		0.1520		0.1757		0.1102		0.1164		0.1659		0.176		0.1102		---		---		---		---	
Channel Thalweg Length (ft)		255		296		1,387[1]		910[1]		278		304		1,019		930		278		304		1,019		930	
Sinuosity		1.05		1.01		1.03		N/A[1]		1.03		1.07		1.05		1.02		1.03		1.07		1.05		1.02	
Bankfull/Channel Slope (ft/ft)		0.1200		0.1500		0.1700		N/A[1]		0.1130		0.1550		0.1650		0.1080		0.1279		0.1592		0.1643		0.1093	

1. Some or all of UT3 Reach 2 and UT4 had been previous buried in rock-lined channel or pipes so cross-section data could not be collected. Reported lengths are estimates based upon land owner communiction, remote sensing, and field verification.

2. Pattern data is not applicable for A-type and B-type channels

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable

Table 11b. Baseline Stream Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT8, Shake Rag Branch

		Pre-Restoration Condition								Design								As-Built/Baseline							
Parameter	**Gage**	**UT8**		**Shake Rag Branch Reach 3**		**Shake Rag Branch Reach 4**		**Shake Rag Branch Reach 5**		**UT8**		**Shake Rag Branch Reach 3**		**Shake Rag Branch Reach 4**		**Shake Rag Branch Reach 5**		**UT8**		**Shake Rag Branch Reach 3**		**Shake Rag Branch Reach 4**		**Shake Rag Branch Reach 5**	
		Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Dimension and Substrate - Riffle																									
Bankfull Width (ft)	N/A	N/A[1]		3.3		5.1		6.7		5.2		5.8		7.2		8.8		5.3		5.2	5.5	7.6		8.1	
Floodprone Width (ft)		N/A[1]		25		15		9		7	11	8	13	10	16	12	19	36		10		19		46	
Bankfull Mean Depth (ft)		N/A[1]		0.5		0.6		0.7		0.4		0.4		0.5		0.6		0.3		0.3		0.5		0.4	
Bankfull Max Depth (ft)		N/A[1]		0.9		0.9		1.5		0.5		0.6		1.4		0.8		0.5		0.6		0.9		0.8	
Bankfull Cross-sectional Area (ft^2)		N/A[1]		1.7		2.9		5.0		1.9		2.4		3.6		5.1		1.4		1.6	1.7	4.0		3.5	
Width/Depth Ratio		N/A[1]		6.2		9.0		9.0		15.0		14.0		15.0		15.0		19.9		16.6	17.5	14.6		18.4	
Entrenchment Ratio		N/A[1]		7.5		2.9		1.3		1.4	2.2	1.4	2.2	1.4	2.2	1.4	2.2	6.8		1.8	1.9	2.5		5.8	
Bank Height Ratio		N/A[1]		1.1		1.0		3.1		1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
D_{50} (mm)		N/A[1]		N/A[1]		---		10-20		---		---		---		---		24.7		75.9	84.1	72.7		101.2	
Profile																									
Riffle Length (ft)	N/A																								
Riffle Slope (ft/ft)										0.045	0.161	0.064	0.166	0.065	0.120	0.040	0.123	0.012	0.151	0.052	0.421	0.038	0.094	0.040	0.143
Pool Length (ft)																									
Pool Max Depth (ft)		N/A[1]		---		---		1.8		0.7	1.3	0.8	1.4	1.0	1.8	1.2	2.0	0.7	1.4	0.4	2.2	0.8	1.9	0.8	2.4
Pool Spacing (ft)		N/A[1]		---		---		7	18	8	18	9	17	11	25	11	31	5	18	8	51	9	86	7	47
Pool Volume (ft^3)																									
Pattern																									
Channel Beltwidth (ft)	N/A	N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Radius of Curvature (ft)		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Rc/Bankfull Width (ft/ft)		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Length (ft)		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Meander Width Ratio		N/A[1]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]		N/A[2]	
Substrate, Bed and Transport Parameters																									
Ri%/Ru%/P%/G%/S%	N/A																								
SC%/Sa%/G%/C%/B%/Be%																									
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$		N/A[1]		N/A[1]		---		1-2/8-9/10-20/ 90-100/180										0.1/0.3/5.7/ 35.5/78.3/180		0.3/2/14.6/ 110.1/207.2/512		0.3/1.3/14.6/ 105.8/237.7/512		0.4/1.6/21.1/ 157.9/243.4/512	
Reach Shear Stress (Competency) lb/ft^2		---		3.2		---		2.4		---		3.2		---		2.4		1.2		2.5	2.6	2.4		1.8	
Max part size (mm) mobilized at bankfull										---		357		---		288		60		122	126	120		86	
Stream Power (Capacity) W/m^2																									
Additional Reach Parameters																									
Drainage Area (SM)	N/A	0.03		0.06		0.12		0.24		0.03		0.06		0.12		0.25		0.03		0.06		0.12		0.25	
Watershed Impervious Cover Estimate (%)		<1%								<1%								<1%							
Rosgen Classification		N/A[1]		A4a+		A4/B4a		A4		A4/B4a		A4a+/B4a		A4/B4a		A4/B4a		A4/B4a		A4a+/B4a		A4/B4a		A4/B4a	
Bankfull Velocity (fps)		N/A[1]		9.6		8.1		6.8		5.5		7.1		6.8		6.6		4.2		6.1	6.2	6.6		5.4	
Bankfull Discharge (cfs)		N/A[1]		16		23		34		10		17		24		34		6		10	11	26		19	
Q-NFF regression (2-yr)		---		---		---		---																	
Q-USGS extrapolation (1.2-yr)		6		10		17		29		---		---		---		---									
Max Q-Mannings		---		16		24		34		N/A[1]		16		24		34									
Valley Slope (ft/ft)		0.0901		0.1317		0.0976		0.0685		0.0901		0.1523		0.0832		0.0685		---		---		---		---	
Channel Thalweg Length (ft)		210 [1]		1,451 [1]		385		1,216		206		1,393		385		1,134		206		1,345		385		1,134	
Sinuosity		N/A[1]		1.03		1.07		1.04		1.06		1.03		1.08		1.01		1.06		1.03		1.08		1.01	
Bankfull/Channel Slope (ft/ft)		N/A[1]		0.1275		0.0913		0.0659		0.0850		0.1360		0.0770		0.0660		0.0761		0.1341		0.0775		0.0660	

1. Some or all of SRB Reach 3 and UT8 had been previous buried in rock-lined channel or pipes so cross-section data could not be collected. Reported lengths are estimates based upon land owner communiction, remote sensing, and field verification.

2. Pattern data is not applicable for A-type and B-type channels

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable

Table 11c. Reference Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Parameter	Gage	Reference Reach Data											
		Ironwood Tributary		UT to South Fork Fishing Creek		UT to Austin Branch (upstream)		UT to Austin Branch (downstream)		UT to Gap Branch		UT to Hampton Creek	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle													
Bankfull Width (ft)	N/A	5.0		4.1		6.7		6.2		6.2		6.8	
Floodprone Width (ft)		10		7		18		27		21		12	
Bankfull Mean Depth		0.6		0.4		0.5		0.7		0.6		0.7	
Bankfull Max Depth		0.8		0.7		0.8		1.2		1.0		1.0	
Bankfull Cross-sectional Area (ft^2)		2.7		1.8		3.6		4.4		3.8		4.6	
Width/Depth Ratio		9.1		9.3		12.8		8.8		10.1		10.0	
Entrenchment Ratio		2.1		1.7		2.6		4.3		3.4		1.7	
Bank Height Ratio		1.3		1.0		1.0		1.0		1.0		1.0	
D50 (mm)		0.9		1.2		59		59		19		Coarse gravel	
Profile													
Riffle Length (ft)	N/A	---		---		---		---		---		---	
Riffle Slope (ft/ft)		---		0.0240	0.2000	0.0810	0.2900	0.0250	0.0730	0.0110	0.1400	0.0500	0.1000
Pool Length (ft)		---		---		---		---		---		---	
Pool Max Depth (ft)		---		---		1.7		1.7		1.6		1.3	
Pool Spacing (ft)		---		6	32	10	17	14	31	18	27	11	19
Pool Volume (ft^3)													
Pattern													
Channel Beltwidth (ft)	N/A	---		---		---		---		---		---	
Radius of Curvature (ft)		---		---		---		---		---		---	
Rc/Bankfull Width (ft/ft)		---		---		---		---		---		---	
Meander Length (ft)		---		---		---		---		---		---	
Meander Width Ratio		---		---		---		---		---		---	
Substrate, Bed and Transport Parameters													
Ri%/Ru%/P%/G%/S%	N/A												
SC%/Sa%/G%/C%/B%/Be%													
d16/d35/d50/d84/d95/d100		0.26/0.5/0.91/19/ 97/128		0.1/0.3/1.2/11/ 24/64		11/42/59/130/ 170/256		11/42/59/130/ 170/256		0.4/8/19/102.3/ 257/>2048		---	
Reach Shear Stress (Competency) lb/ft^2													
Max part size (mm) mobilized at bankfull													
Stream Power (Capacity) W/m^2													
Additional Reach Parameters													
Drainage Area (SM)	N/A	0.03		0.02		0.12		0.12		0.04		0.25	
Watershed Impervious Cover Estimate (%)		---		---		---		---		---		---	
Rosgen Classification		A5a+		B5a		A4/B4a		A4/B4a		A4/B4a		A4/B4a	
Bankfull Velocity (fps)		4.9		4.1		7.3		6.2		5.0		6.6	
Bankfull Discharge (cfs)		13		8		26		27		19		31	
Q-NFF regression (2-yr)													
Q-USGS extrapolation (1.2-yr)													
Q-Mannings													
Valley Slope (ft/ft)		0.1418		0.1025		0.1000		0.0480		---		0.0840	
Channel Thalweg Length (ft)		---		---		---		---		---		---	
Sinuosity		1.2		1.25		1.00		1.20		---		1.10	1.20
Water Surface Slope (ft/ft)		---		---		---		---		---		---	
Bankfull/Channel Slope (ft/ft)		0.1139		0.0815		0.0986		0.0400		0.0680		0.0650	

SC: Silt/Clay <0.062 mm diameter particles
(---): Data was not provided
N/A: Not Applicable

Table 12a. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 3 - 2022

	UT1 Reach 2 Cross-Section 1, Riffle								UT2 Reach 2 Cross-Section 2, Riffle								UT3 Reach 2 Cross-Section 3, Riffle							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2709.81*	*2709.77*	*2709.75*	*2709.77*					*2738.54*	*2738.65*	*2738.70*	*2738.63*					*2617.65*	*2617.72*	*2617.44*	*2617.25*				
Low Bank Elevation	*2709.81*	*2709.86*	*2709.84*	*2709.75*					*2738.54*	*2738.74*	*2738.70*	*2738.63*					*2617.65*	*2617.60*	*2617.61*	*2617.36*				
Bankfull Width (ft)	4.7	5.0	5.3	3.0					3.2	3.0	3.0	2.6					6.0	3.7	6.3	3.3				
Floodprone Width (ft)	10	13	14	11					10	12	10	13					13	12	16	13				
Bankfull Mean Depth (ft)	0.3	0.3	0.3	0.4					0.2	0.3	0.2	0.2					0.3	0.4	0.4	0.7				
Bankfull Max Depth (ft)	0.4	0.6	0.6	0.5					0.3	0.4	0.3	0.5					0.6	0.6	1.2	1.1				
Bankfull Cross-Sectional Area (ft^2)	1.2	1.6	1.7	1.1					0.6	0.8	0.6	0.6					1.9	1.4	2.8	2.3				
Bankfull Width/Depth Ratio	18.4	15.4	16.7	8.1					16.9	10.7	16.3	10.4					18.4	9.7	14.4	4.7				
Bankfull Entrenchment Ratio	2.1	2.6	2.7	3.7					3.1	4.1	3.1	5.2					2.1	3.3	2.5	4.1				
Bankfull Bank Height Ratio	1.0	1.2	1.2	1.0					1.0	1.3	1.0	1.0					1.0	0.8	1.2	1.1				

	UT3 Reach 2 Cross-Section 4, Pool								UT4 Cross-Section 5, Riffle								UT4 Cross-Section 6, Pool							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base[2]**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2616.07*	*2616.04*	*2616.06*	*2616.11*					*2503.27*	*2503.37*	*2503.36*	*2503.40*					*2499.51*	*2499.56*	*2499.61*	*2499.27*				
Low Bank Elevation	*2616.07*	*2616.04*	*2616.06*	*2616.11*					*2503.27*	*2503.23*	*2503.24*	*2503.28*					*2499.51*	*2499.56*	*2499.61*	*2499.27*				
Bankfull Width (ft)	5.4	4.2	3.5	4.5					8.3	7.5	8.3	8.3					5.9	5.2	6.0	4.3				
Floodprone Width (ft)	---	---	---	---					14	13	13	13					---	---	---	---				
Bankfull Mean Depth (ft)	0.7	0.5	0.5	0.4					0.5	0.4	0.4	0.4					0.7	0.8	0.7	0.6				
Bankfull Max Depth (ft)	1.1	0.9	1.0	0.7					0.8	0.7	0.7	0.7					1.0	1.2	1.1	0.8				
Bankfull Cross-Sectional Area (ft^2)	4.0	2.1	1.8	2.0					4.3	3.1	3.3	3.3					4.4	4.1	4.4	2.5				
Bankfull Width/Depth Ratio	7.3	8.3	6.7	10.0					16.2	17.8	21.0	21.0					7.9	6.7	8.2	7.5				
Bankfull Entrenchment Ratio	---	---	---	---					1.7	1.7	1.6	1.6					---	---	---	---				
Bankfull Bank Height Ratio	---	---	---	---					1.0	0.8	0.9	0.9					---	---	---	---				

	UT8 Cross-Section 7, Riffle							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2520.23*	*2520.23*	*2520.32*	*2520.35*				
Low Bank Elevation	*2520.23*	*2520.23*	*2520.24*	*2520.30*				
Bankfull Width (ft)	5.3	4.2	5.0	5.2				
Floodprone Width (ft)	36	37	35	37				
Bankfull Mean Depth (ft)	0.3	0.3	0.2	0.2				
Bankfull Max Depth (ft)	0.5	0.5	0.4	0.6				
Bankfull Cross-Sectional Area (ft^2)	1.4	1.4	0.9	1.1				
Bankfull Width/Depth Ratio	19.9	12.8	26.2	24.1				
Bankfull Entrenchment Ratio	6.8	8.6	7.0	7.0				
Bankfull Bank Height Ratio	1.0	1.0	0.8	0.9				

[1]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

[2]Cross-section dimensions updated in MY1.

Table 12b. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)

Shake Rag Mitigation Site

DMS Project No. 100018

Monitoring Year 3 - 2022

	Shake Rag Branch Reach 3 Cross-Section 8, Riffle								Shake Rag Branch Reach 3 Cross-Section 9, Riffle								Shake Rag Branch Reach 3 Cross-Section 10, Pool							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2632.06*	*2631.95*	*2632.08*	*2631.98*					*2621.09*	*2620.96*	*2621.01*	*2621.00*					*2620.50*	*2620.23*	*2620.64*	*2620.42*				
Low Bank Elevation	*2632.06*	*2631.95*	*2632.01*	*2631.98*					*2621.09*	*2620.96*	*2621.11*	*2621.17*					*2620.50*	*2620.23*	*2620.64*	*2620.42*				
Bankfull Width (ft)	5.2	3.1	3.3	3.8					5.5	4.8	6.0	6.1					4.0	4.0	4.2	3.7				
Floodprone Width (ft)	10	11	10	10					10	9	11	14					---	---	---	---				
Bankfull Mean Depth (ft)	0.3	0.5	0.4	0.4					0.3	0.4	0.4	0.4					0.8	0.7	0.9	0.8				
Bankfull Max Depth (ft)	0.6	0.8	0.7	0.8					0.6	0.6	0.7	1.1					1.1	1.0	1.4	1.0				
Bankfull Cross-Sectional Area (ft^2)	1.6	1.6	1.4	1.6					1.7	1.7	2.3	2.7					3.0	2.8	3.8	2.9				
Bankfull Width/Depth Ratio	16.6	5.8	8.2	9.4					17.5	13.6	15.5	13.8					5.3	5.7	4.6	4.6				
Bankfull Entrenchment Ratio	1.9	3.6	3.0	2.7					1.8	1.9	1.8	2.3					---	---	---	---				
Bankfull Bank Height Ratio	1.0	1.0	0.9	1.0					1.0	1.0	1.2	1.2					---	---	---	---				
	Shake Rag Branch Reach 4 Cross-Section 11, Riffle								**Shake Rag Branch Reach 5 Cross-Section 12, Riffle**								**Shake Rag Branch Reach 5 Cross-Section 13, Pool**							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**MY7**
Bankfull Elevation	*2530.35*	*2530.43*	*2530.37*	*2530.46*					*2500.82*	*2500.82*	*2500.78*	*2500.80*					*2500.20*	*2500.12*	*2499.98*	*2499.96*				
Low Bank Elevation	*2530.35*	*2530.36*	*2530.25*	*2530.33*					*2500.82*	*2500.82*	*2500.76*	*2500.77*					*2500.20*	*2500.12*	*2499.98*	*2499.96*				
Bankfull Width (ft)	7.6	7.8	7.3	7.1					8.1	8.0	7.2	6.8					7.2	7.1	6.9	7.0				
Floodprone Width (ft)	19	16	14	17					46	46	46	52					---	---	---	---				
Bankfull Mean Depth (ft)	0.5	0.4	0.4	0.4					0.4	0.4	0.5	0.5					1.1	1.3	1.2	1.0				
Bankfull Max Depth (ft)	0.9	0.6	0.6	0.7					0.8	0.9	0.9	1.1					1.9	1.9	1.8	1.5				
Bankfull Cross-Sectional Area (ft^2)	4.0	3.4	3.0	3.0					3.5	3.5	3.4	3.3					8.1	8.9	8.0	6.6				
Bankfull Width/Depth Ratio	14.6	18.0	18.1	17.1					18.4	18.2	15.5	14.0					6.4	5.7	6.0	7.3				
Bankfull Entrenchment Ratio	2.5	2.1	1.9	2.4					5.8	5.7	6.4	7.6					---	---	---	---				
Bankfull Bank Height Ratio	1.0	0.9	0.8	0.8					1.0	1.0	1.0	1.0					---	---	---	---				

[1]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

Table 13a. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT1 Reach 2

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	4.7		5.0		5.3		3.0									
Floodprone Width (ft)	10		13		14		11									
Bankfull Mean Depth (ft)	0.3		0.3		0.3		0.4									
Bankfull Max Depth (ft)	0.4		0.6		0.6		0.5									
Bankfull Cross-sectional Area (ft^2)	1.2		1.6		1.7		1.1									
Width/Depth Ratio	18.4		15.4		16.7		8.1									
Entrenchment Ratio	2.1		2.6		2.7		3.7									
Bank Height Ratio	1.0		1.2		1.2		1.0									
D_{50} (mm)	64.0															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.080	0.241														
Pool Length (ft)																
Pool Max Depth (ft)	0.4	1.8														
Pool Spacing (ft)	7	20														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/2/12.8/90/180/512		0.4/18.4/34.8/87.7/143.4/512		0.3/1.3/8.0/81.3/128/180		N/A									
Reach Shear Stress (Competency) lb/ft^2	2.0															
Max part size (mm) mobilized at bankfull	99															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.11															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	5.3															
Bankfull Discharge (cfs)	6.4															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	278															
Sinuosity	1.03															
Bankfull/Channel Slope (ft/ft)	0.1279															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13b. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT2 Reach 2

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	3.2		3.0		3.0		2.6									
Floodprone Width (ft)	10		12		10		13									
Bankfull Mean Depth (ft)	0.2		0.3		0.2		0.2									
Bankfull Max Depth (ft)	0.3		0.4		0.3		0.5									
Bankfull Cross-sectional Area (ft^2)	0.6		0.8		0.6		0.6									
Width/Depth Ratio	16.9		10.7		16.3		10.4									
Entrenchment Ratio	3.1		4.1		3.1		5.2									
Bank Height Ratio	1.0		1.3		1.0		1.0									
D_{50} (mm)	67.4															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.078	0.266														
Pool Length (ft)																
Pool Max Depth (ft)	0.7	1.7														
Pool Spacing (ft)	7	22														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.4/4/25.4/99.5/ 202.4/>2048		0.7/10.2/33.9/105.6/ 158.4/512		0.1/1.7/14.1/107.3/ 165.3/362		N/A									
Reach Shear Stress (Competency) lb/ft^2	1.84															
Max part size (mm) mobilized at bankfull	90															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.05															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	4.8															
Bankfull Discharge (cfs)	3.0															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	304															
Sinuosity	1.07															
Bankfull/Channel Slope (ft/ft)	0.1592															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13c. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT3 Reach 2

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	6.0		3.7		6.3		3.3									
Floodprone Width (ft)	13		12		16		13									
Bankfull Mean Depth (ft)	0.3		0.4		0.4		0.7									
Bankfull Max Depth (ft)	0.6		0.6		1.2		1.1									
Bankfull Cross-sectional Area (ft^2)	1.9		1.4		2.8		2.3									
Width/Depth Ratio	18.4		9.7		14.4		4.7									
Entrenchment Ratio	2.1		3.3		2.5		4.1									
Bank Height Ratio	1.0		0.8		1.2		1.1									
D_{50} (mm)	61.8															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.015	0.339														
Pool Length (ft)																
Pool Max Depth (ft)	0.5	2.1														
Pool Spacing (ft)	5	36														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/0.73/7.1/ 155.5/315.2/512		1.5/10.4/35.4/121.2/ 179.7/512		SC/1.8/11.2/96.7/ 151.5/512		N/A									
Reach Shear Stress (Competency) lb/ft^2	3.68															
Max part size (mm) mobilized at bankfull	181															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.06															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	7.6															
Bankfull Discharge (cfs)	21.0															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	1,019															
Sinuosity	1.05															
Bankfull/Channel Slope (ft/ft)	0.1643															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13d. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT4

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	8.3		7.5		8.3		8.3									
Floodprone Width (ft)	14		13		13		13									
Bankfull Mean Depth (ft)	0.5		0.4		0.4		0.4									
Bankfull Max Depth (ft)	0.8		0.7		0.7		0.7									
Bankfull Cross-sectional Area (ft^2)	4.3		3.1		3.3		3.3									
Width/Depth Ratio	16.2		17.8		21.0		21.0									
Entrenchment Ratio	1.7		1.7		1.6		1.6									
Bank Height Ratio	1.0		0.8		0.9		0.9									
D_{50} (mm)	71.7															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.037	0.292														
Pool Length (ft)																
Pool Max Depth (ft)	0.7	2.0														
Pool Spacing (ft)	14	34														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/1.34/20.7/ 154.8/272.5/512		0.4/5.0/10.7/120.7/ 169.2/256		0.6/13.3/53.7/137/ 209.3/362		N/A									
Reach Shear Stress (Competency) lb/ft^2	2.28															
Max part size (mm) mobilized at bankfull	112															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.05															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	5.9															
Bankfull Discharge (cfs)	13.6															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	930															
Sinuosity	1.02															
Bankfull/Channel Slope (ft/ft)	0.1093															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13e. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

UT8

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	5.3		4.2		5.0		5.2									
Floodprone Width (ft)	36		37		35		37									
Bankfull Mean Depth (ft)	0.3		0.3		0.2		0.2									
Bankfull Max Depth (ft)	0.5		0.5		0.4		0.6									
Bankfull Cross-sectional Area (ft^2)	1.4		1.4		0.9		1.1									
Width/Depth Ratio	19.9		12.8		26.2		24.1									
Entrenchment Ratio	6.8		8.6		7.0		7.0									
Bank Height Ratio	1.0		1.0		0.8		0.9									
D_{50} (mm)	24.7															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.012	0.151														
Pool Length (ft)																
Pool Max Depth (ft)	0.7	1.4														
Pool Spacing (ft)	5	18														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.1/0.3/5.7/ 35.5/78.3/180		SC/0.4/18.3/53.4/ 79/362		SC/0.3/12.6/70.5/ 113.5/256		N/A									
Reach Shear Stress (Competency) lb/ft^2	1.23															
Max part size (mm) mobilized at bankfull	60															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.03															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4/B4a															
Bankfull Velocity (fps)	4.2															
Bankfull Discharge (cfs)	6.0															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	206															
Sinuosity	1.06															
Bankfull/Channel Slope (ft/ft)	0.0761															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13f. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Shake Rag Branch Reach 3

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	5.2	5.5	3.1	4.8	3.3	6.0	3.8	6.1								
Floodprone Width (ft)	10		9	11	10	11	10	14								
Bankfull Mean Depth (ft)	0.3		0.4	0.5	0.4		0.4									
Bankfull Max Depth (ft)	0.6		0.6	0.8	0.7		0.8	1.1								
Bankfull Cross-sectional Area (ft^2)	1.6	1.7	1.6	1.7	1.4	2.3	1.6	2.7								
Width/Depth Ratio	16.6	17.5	5.8	13.6	8.2	15.5	9.4	13.8								
Entrenchment Ratio	1.8	1.9	3.6	1.9	1.8	3.0	2.3	2.7								
Bank Height Ratio	1.0		1.0		0.9	1.2	1.0	1.2								
D_{50} (mm)	75.9	84.1														
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.052	0.421														
Pool Length (ft)																
Pool Max Depth (ft)	0.4	2.2														
Pool Spacing (ft)	8	51														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/2/14.6/ 110.1/207.2/512		0.4/18.4/34.8/87.7/ 143.4/1024		0.1/1.4/11/121.7/ 193.1/362		N/A									
Reach Shear Stress (Competency) lb/ft^2	2.5	2.6														
Max part size (mm) mobilized at bankfull	122	126														
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.06															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4a+/B4a															
Bankfull Velocity (fps)	6.1	6.2														
Bankfull Discharge (cfs)	10	11														
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	1,345															
Sinuosity	1.03															
Bankfull/Channel Slope (ft/ft)	0.1341															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13g. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Shake Rag Branch Reach 4

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	7.6		7.8		7.3		7.1									
Floodprone Width (ft)	19		16		14		17									
Bankfull Mean Depth (ft)	0.5		0.4		0.4		0.4									
Bankfull Max Depth (ft)	0.9		0.6		0.6		0.7									
Bankfull Cross-sectional Area (ft^2)	4.0		3.4		3.0		3.0									
Width/Depth Ratio	14.6		18.0		18.1		17.1									
Entrenchment Ratio	2.5		2.1		1.9		2.4									
Bank Height Ratio	1.0		0.9		0.8		0.8									
D_{50} (mm)	72.7															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.038	0.094														
Pool Length (ft)																
Pool Max Depth (ft)	0.8	1.9														
Pool Spacing (ft)	9	86														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.3/1.3/14.6/ 105.8/237.7/512		0.7/10.2/33.9/105.6/ 158.4/512		0.8/12.5/45/157.1/ 241.4/362		N/A									
Reach Shear Stress (Competency) lb/ft^2	2.4															
Max part size (mm) mobilized at bankfull	120															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.12															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4/B4a															
Bankfull Velocity (fps)	6.6															
Bankfull Discharge (cfs)	26															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	385															
Sinuosity	1.08															
Bankfull/Channel Slope (ft/ft)	0.0775															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

Table 13h. Monitoring Data - Stream Reach Data Summary
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Shake Rag Branch Reach 5

Parameter	As-Built/Baseline		MY1		MY2		MY3		MY4		MY5		MY6		MY7	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[2]																
Bankfull Width (ft)	8.1		8.0		7.2		6.8									
Floodprone Width (ft)	46		46		46		52									
Bankfull Mean Depth (ft)	0.4		0.4		0.5		0.5									
Bankfull Max Depth (ft)	0.8		0.9		0.9		1.1									
Bankfull Cross-sectional Area (ft^2)	3.5		3.5		3.4		3.3									
Width/Depth Ratio	18.4		18.2		15.5		14.0									
Entrenchment Ratio	5.8		5.7		6.4		7.6									
Bank Height Ratio	1.0		1.0		1.0		1.0									
D_{50} (mm)	101.2															
Profile																
Riffle Length (ft)																
Riffle Slope (ft/ft)	0.040	0.143														
Pool Length (ft)																
Pool Max Depth (ft)	0.8	2.4														
Pool Spacing (ft)	7	47														
Pool Volume (ft^3)																
Pattern																
Channel Beltwidth (ft)	N/A[1]															
Radius of Curvature (ft)	N/A[1]															
Rc/Bankfull Width (ft/ft)	N/A[1]															
Meander Length (ft)	N/A[1]															
Meander Width Ratio	N/A[1]															
Substrate, Bed and Transport Parameters																
Ri%/Ru%/P%/G%/S%																
SC%/Sa%/G%/C%/B%/Be%																
$D_{16}/D_{35}/D_{50}/D_{84}/D_{95}/D_{100}$	0.4/1.6/21.1/ 157.9/243.4/512		0.5/3.7/11/61.2/ 113.8/180		0.3/9.9/16.7/85.7/ 160.7/512		N/A									
Reach Shear Stress (Competency) lb/ft^2	1.8															
Max part size (mm) mobilized at bankfull	86															
Stream Power (Capacity) W/m^2																
Additional Reach Parameters																
Drainage Area (SM)	0.25															
Watershed Impervious Cover Estimate (%)	<1%															
Rosgen Classification	A4/B4a															
Bankfull Velocity (fps)	5.4															
Bankfull Discharge (cfs)	19															
Valley Slope (ft/ft)	---															
Channel Thalweg Length (ft)	1,134															
Sinuosity	1.01															
Bankfull/Channel Slope (ft/ft)	0.0660															

[1]Pattern data is not applicable for A-type and B-type channels

[2]MY1-MY7 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current low bank height.

SC: Silt/Clay <0.062 mm diameter particles

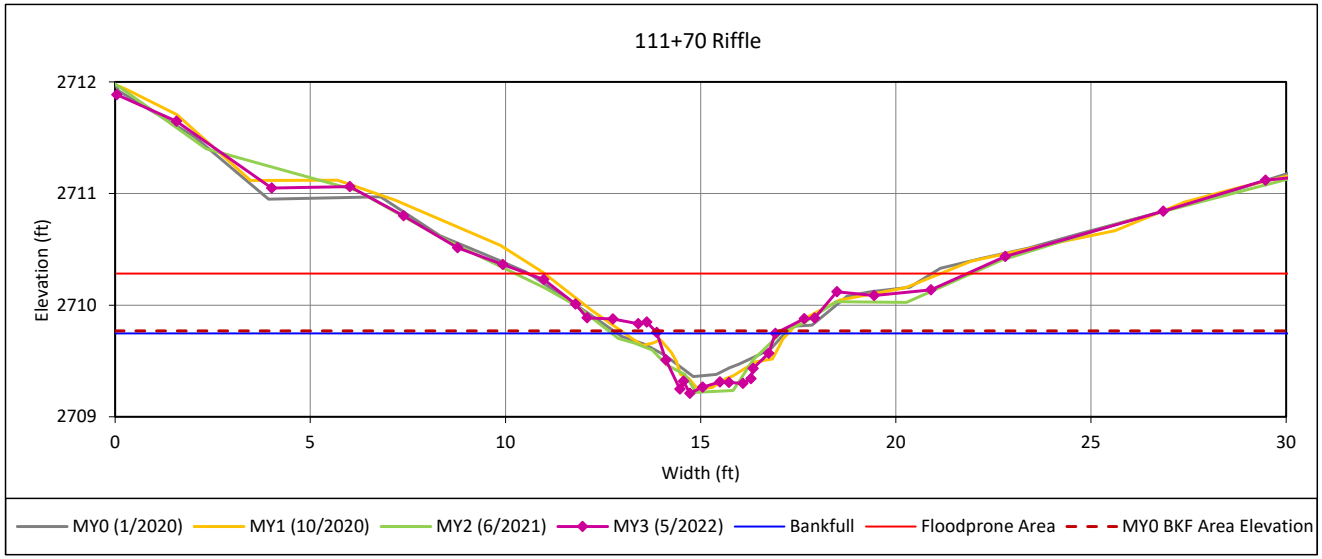
(---): Data was not provided

N/A: Not Applicable

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 1-UT1 Reach 2



Bankfull Dimensions	
1.1	x-section area (ft.sq.)
3.0	width (ft)
0.4	mean depth (ft)
0.5	max depth (ft)
3.4	wetted perimeter (ft)
0.3	hydraulic radius (ft)
8.1	width-depth ratio
11.3	W flood prone area (ft)
3.7	entrenchment ratio
1.0	low bank height ratio

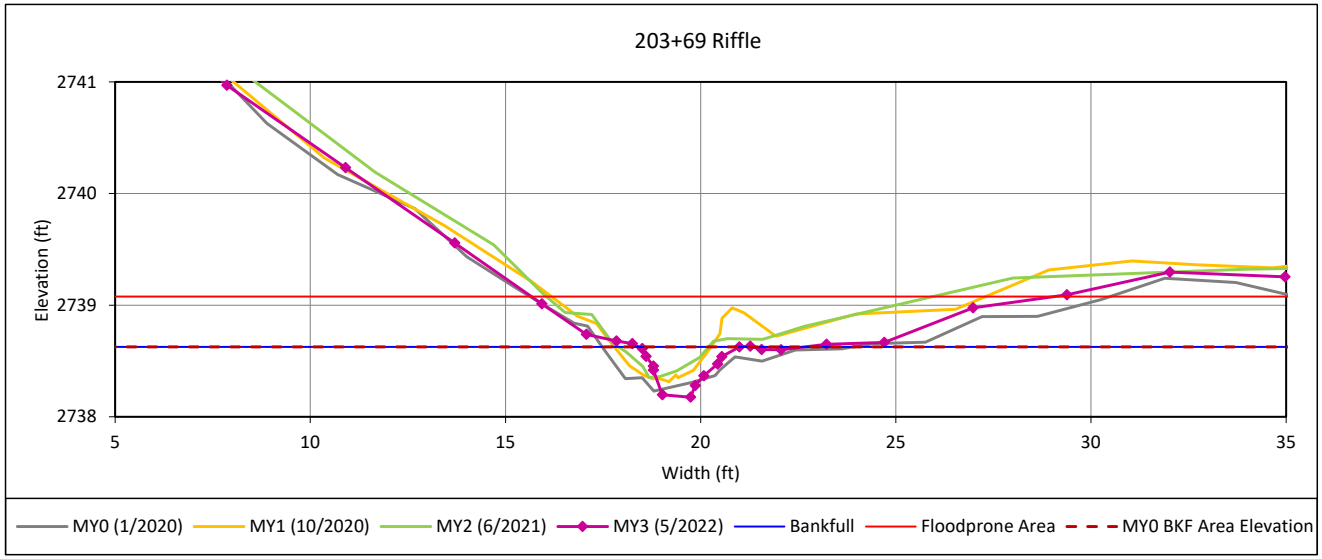
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 2-UT2 Reach 2



Bankfull Dimensions	
0.6	x-section area (ft.sq.)
2.6	width (ft)
0.2	mean depth (ft)
0.5	max depth (ft)
2.8	wetted perimeter (ft)
0.2	hydraulic radius (ft)
10.4	width-depth ratio
13.4	W flood prone area (ft)
5.2	entrenchment ratio
1.0	low bank height ratio

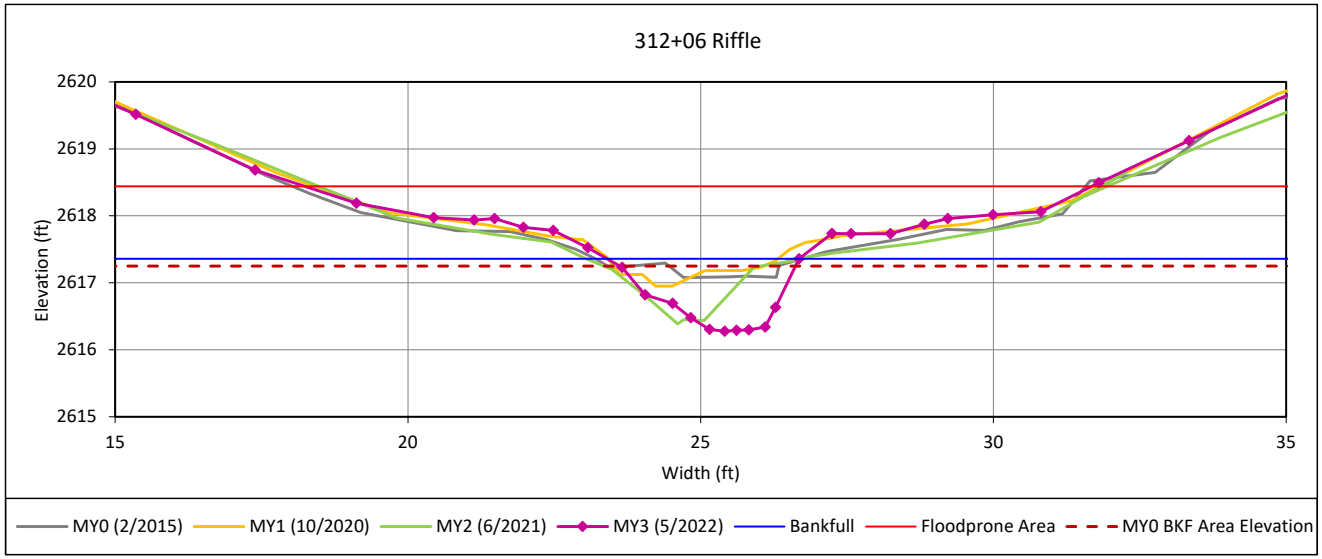
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 3-UT3 Reach 2



Bankfull Dimensions	
2.3	x-section area (ft.sq.)
3.3	width (ft)
0.7	mean depth (ft)
1.1	max depth (ft)
4.2	wetted perimeter (ft)
0.5	hydraulic radius (ft)
4.7	width-depth ratio
13.4	W flood prone area (ft)
4.1	entrenchment ratio
1.1	low bank height ratio

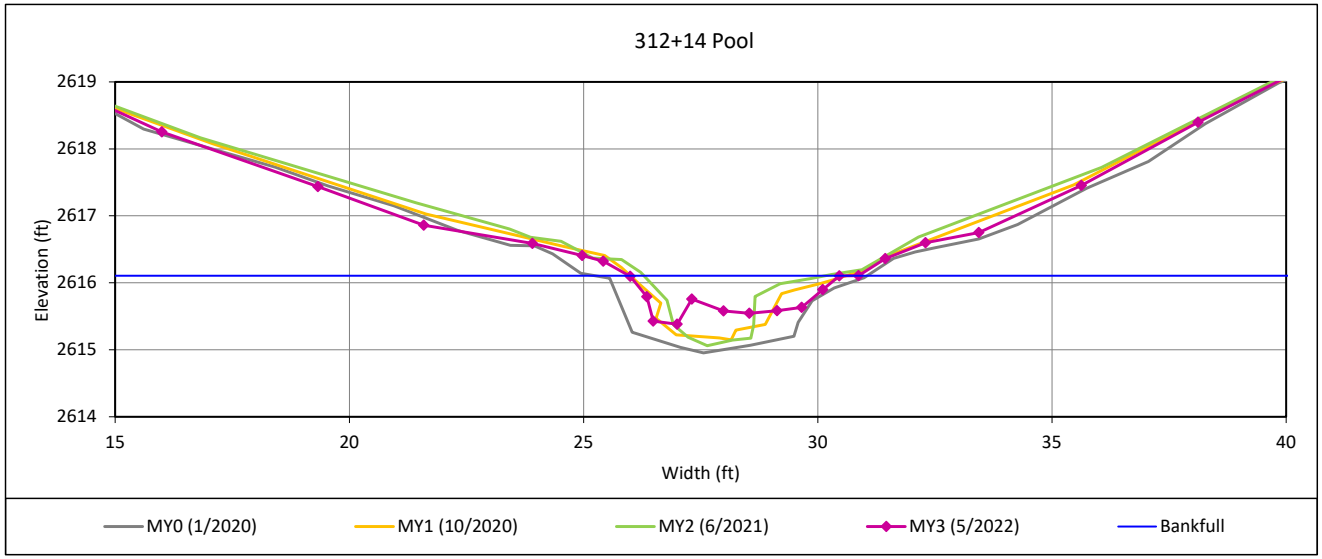
Survey Date: 5/2022
Field Crew: Wildlands Engineering
Note: Survey captures MY3 repairs with current low top of bank

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 4-UT3 Reach 2



Bankfull Dimensions	
2.0	x-section area (ft.sq.)
4.5	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
5.2	wetted perimeter (ft)
0.4	hydraulic radius (ft)
10.0	width-depth ratio

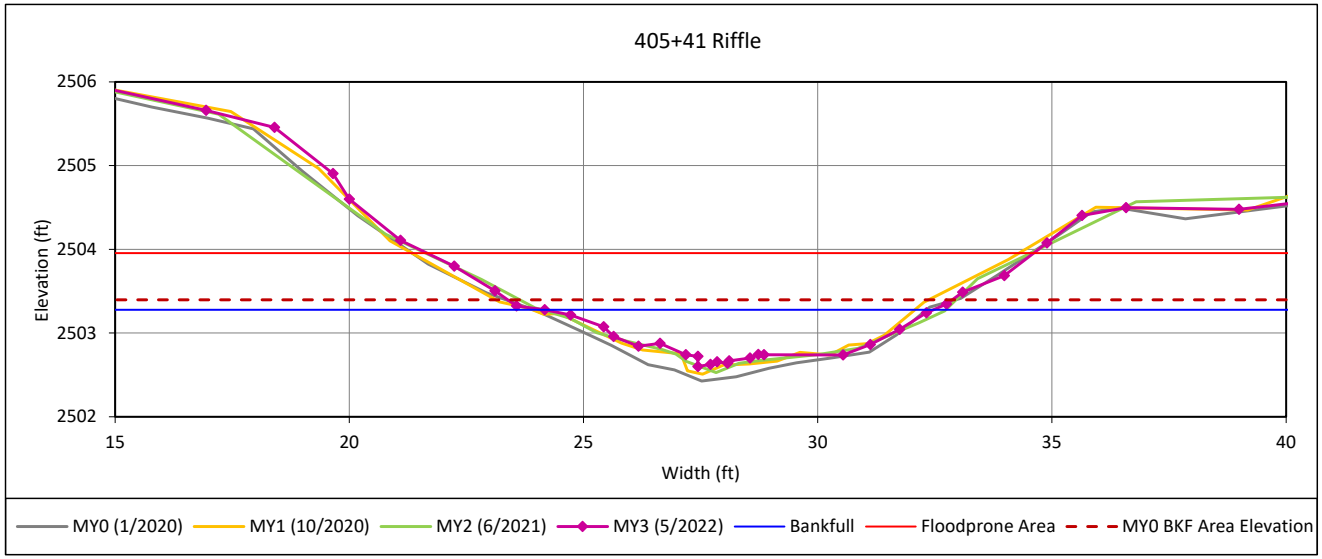
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 5-UT4



Bankfull Dimensions	
3.3	x-section area (ft.sq.)
8.3	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
8.6	wetted perimeter (ft)
0.4	hydraulic radius (ft)
21.0	width-depth ratio
12.9	W flood prone area (ft)
1.6	entrenchment ratio
0.9	low bank height ratio

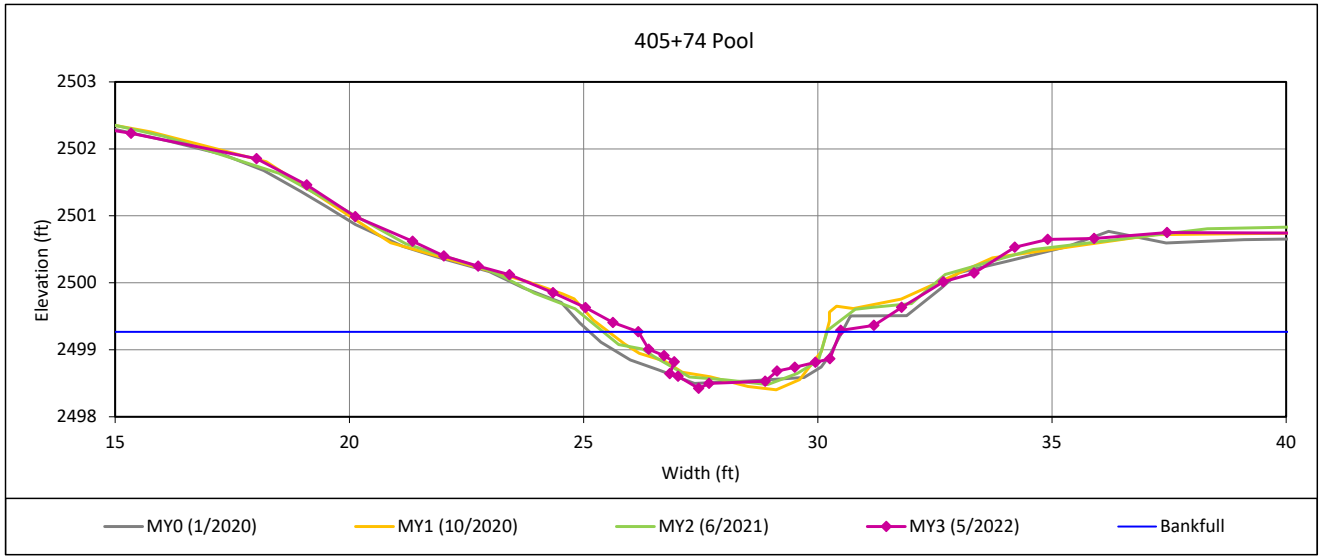
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 6-UT4



Bankfull Dimensions	
2.5	x-section area (ft.sq.)
4.3	width (ft)
0.6	mean depth (ft)
0.8	max depth (ft)
5.1	wetted perimeter (ft)
0.5	hydraulic radius (ft)
7.5	width-depth ratio

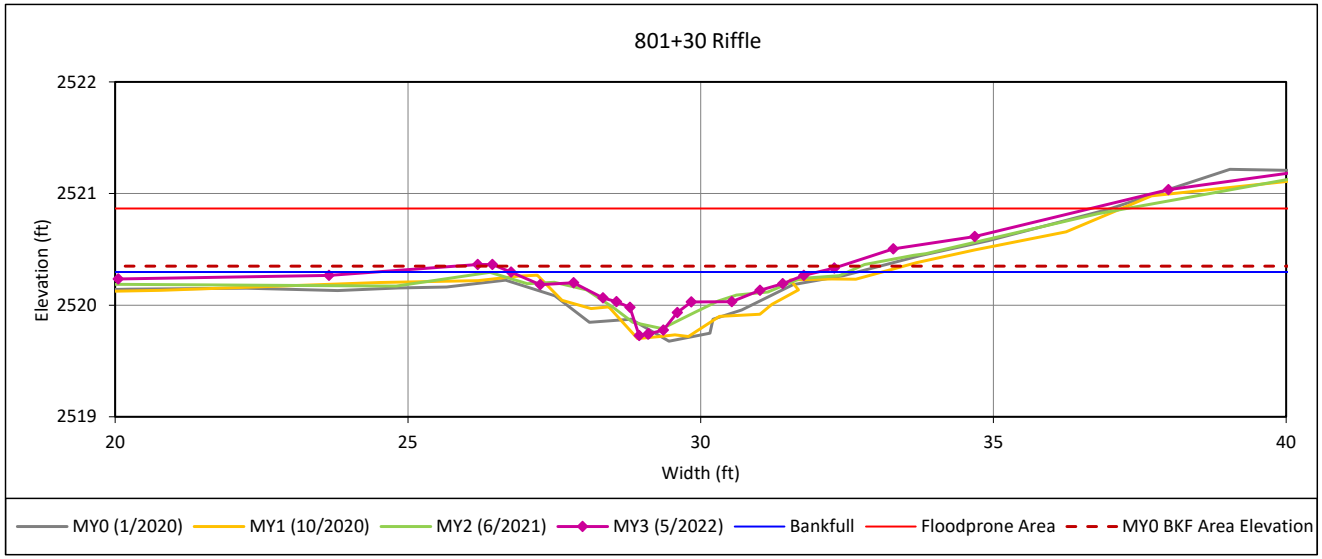
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 7-UT8



Bankfull Dimensions	
1.1	x-section area (ft.sq.)
5.2	width (ft)
0.2	mean depth (ft)
0.6	max depth (ft)
5.5	wetted perimeter (ft)
0.2	hydraulic radius (ft)
24.1	width-depth ratio
36.7	W flood prone area (ft)
7.0	entrenchment ratio
0.9	low bank height ratio

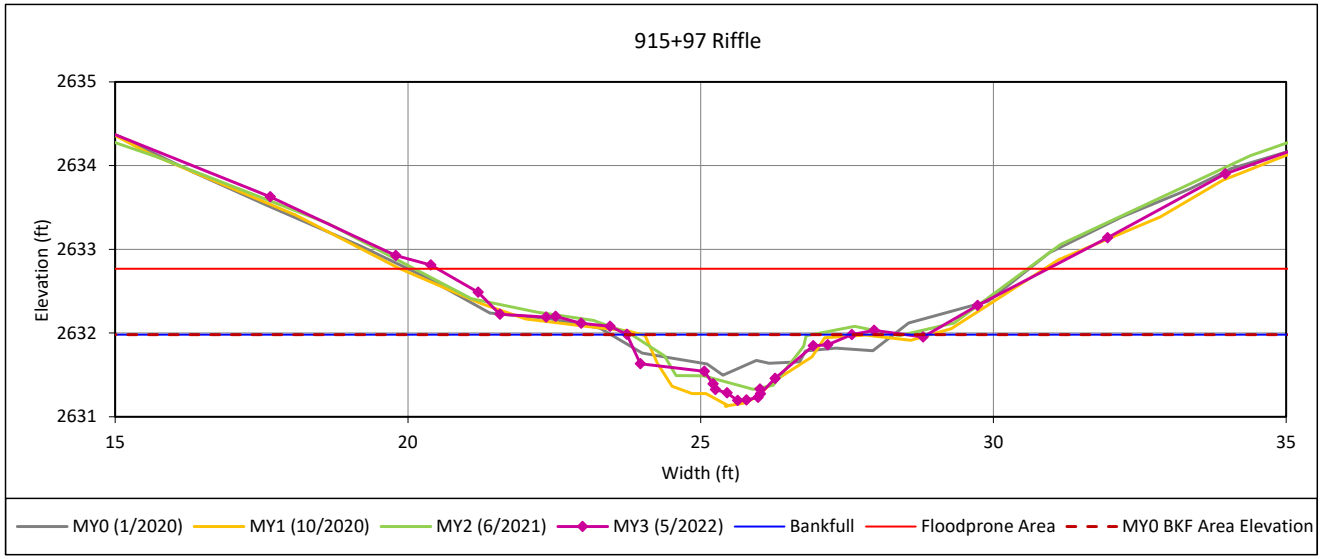
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 8-Shake Rag Branch Reach 3



Bankfull Dimensions	
1.6	x-section area (ft.sq.)
3.8	width (ft)
0.4	mean depth (ft)
0.8	max depth (ft)
4.5	wetted perimeter (ft)
0.3	hydraulic radius (ft)
9.4	width-depth ratio
10.4	W flood prone area (ft)
2.7	entrenchment ratio
1.0	low bank height ratio

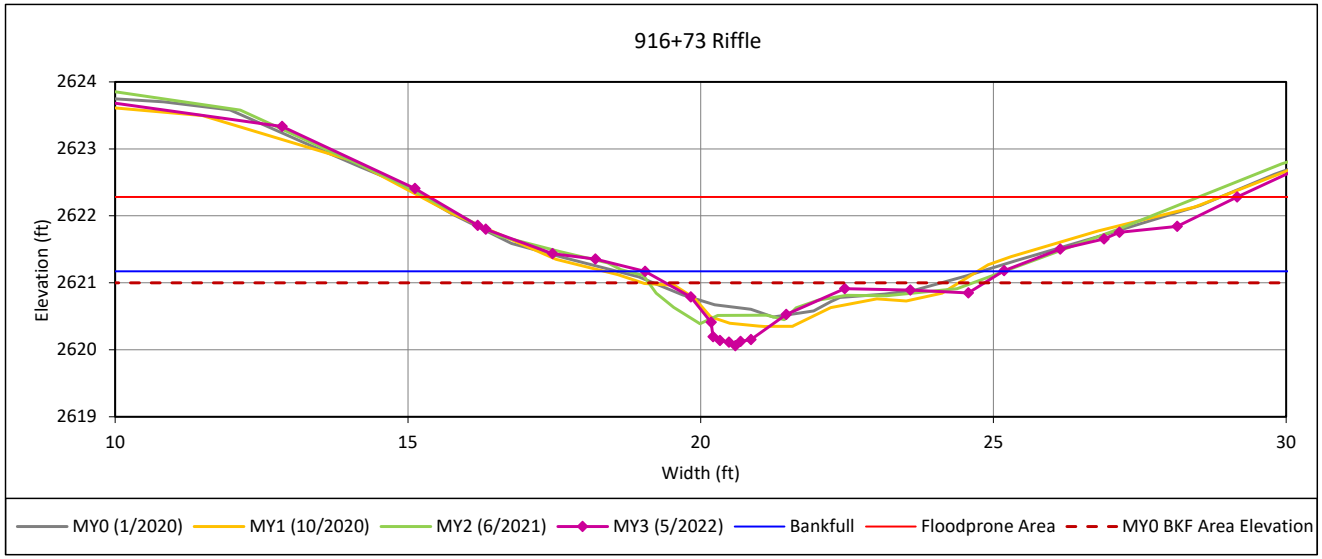
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 9-Shake Rag Branch Reach 3



Bankfull Dimensions	
2.7	x-section area (ft.sq.)
6.1	width (ft)
0.4	mean depth (ft)
1.1	max depth (ft)
6.9	wetted perimeter (ft)
0.4	hydraulic radius (ft)
13.8	width-depth ratio
13.8	W flood prone area (ft)
2.3	entrenchment ratio
1.2	low bank height ratio

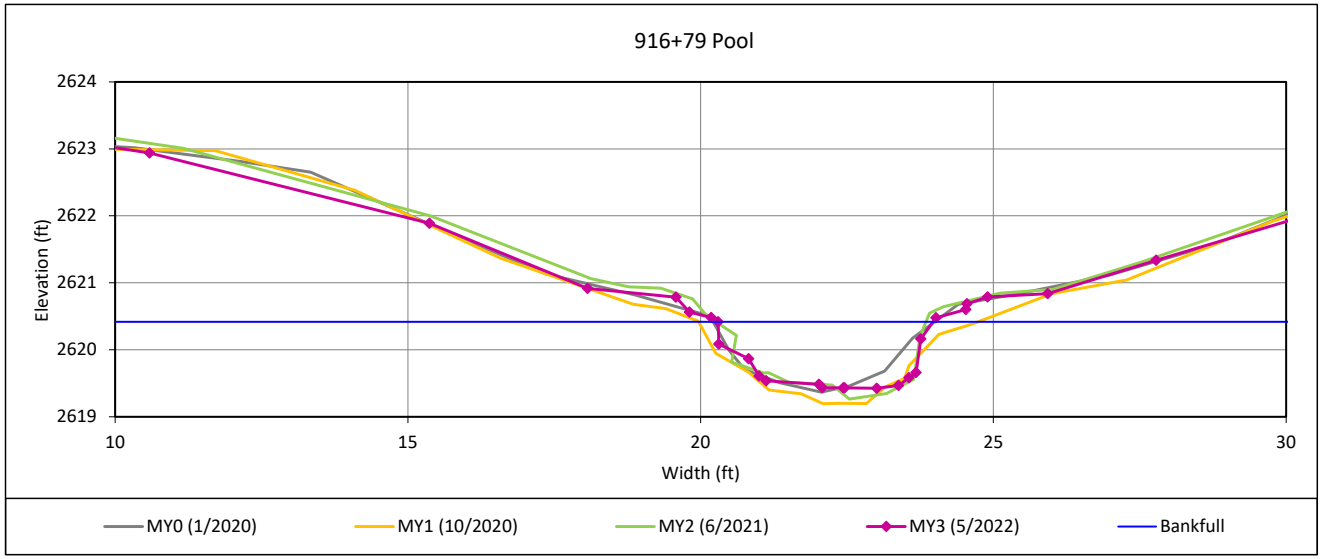
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 10-Shake Rag Branch Reach 3



Bankfull Dimensions	
2.9	x-section area (ft.sq.)
3.7	width (ft)
0.8	mean depth (ft)
1.0	max depth (ft)
4.8	wetted perimeter (ft)
0.6	hydraulic radius (ft)
4.6	width-depth ratio

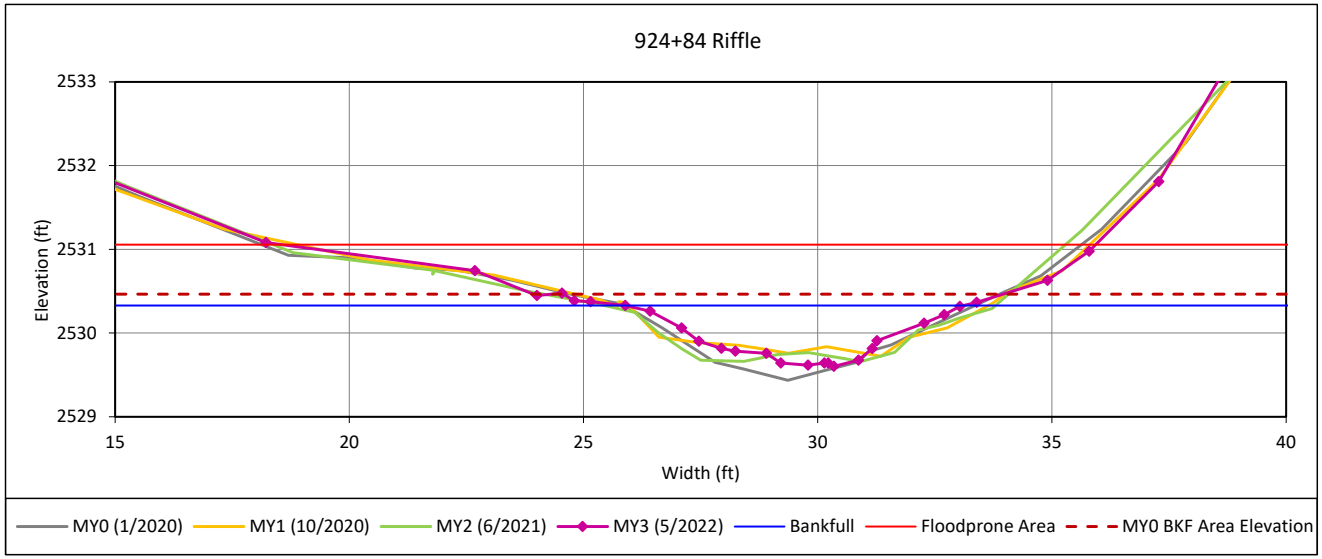
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 11-Shake Rag Branch Reach 4



Bankfull Dimensions	
3.0	x-section area (ft.sq.)
7.1	width (ft)
0.4	mean depth (ft)
0.7	max depth (ft)
7.4	wetted perimeter (ft)
0.4	hydraulic radius (ft)
17.1	width-depth ratio
17.4	W flood prone area (ft)
2.4	entrenchment ratio
0.8	low bank height ratio

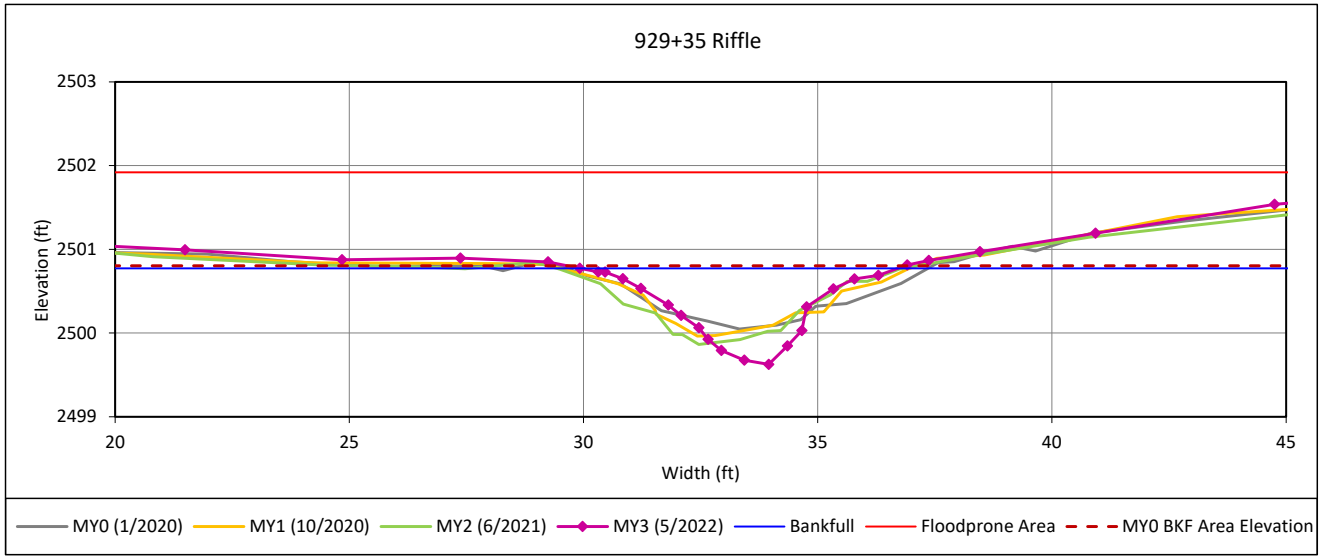
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 12-Shake Rag Branch Reach 5



Bankfull Dimensions	
3.3	x-section area (ft.sq.)
6.8	width (ft)
0.5	mean depth (ft)
1.1	max depth (ft)
7.4	wetted perimeter (ft)
0.4	hydraulic radius (ft)
14.0	width-depth ratio
51.9	W flood prone area (ft)
7.6	entrenchment ratio
1.0	low bank height ratio

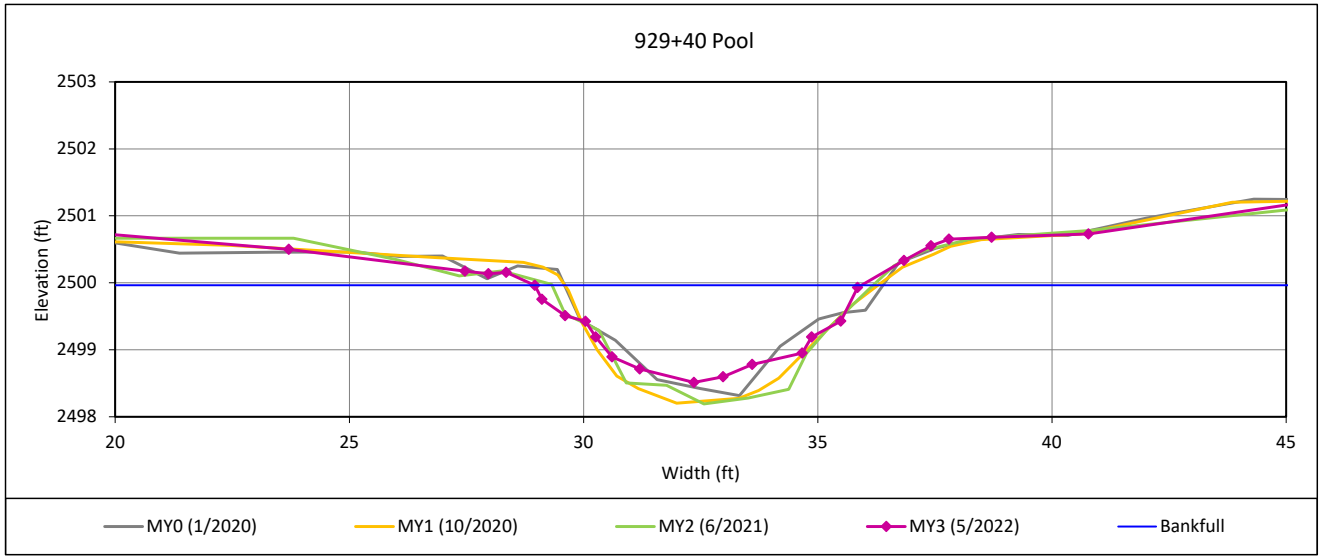
Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Shake Rag Mitigation Site
NCDMS Project No. 100018
Monitoring Year 3 - 2022

Cross-Section 13-Shake Rag Branch Reach 5



Bankfull Dimensions	
6.6	x-section area (ft.sq.)
7.0	width (ft)
1.0	mean depth (ft)
1.5	max depth (ft)
7.9	wetted perimeter (ft)
0.8	hydraulic radius (ft)
7.3	width-depth ratio

Survey Date: 5/2022
Field Crew: Wildlands Engineering

View Downstream

To: DMS Technical Workgroup, DMS operations staff

From: Periann Russell, Division of Mitigation Services (DMS)

RE: Pebble count data requirements

Date: October 19, 2021

The DMS Technical Work Group met September 29, 2021 to discuss Interagency Review Team (IRT) and DMS requirements for collecting pebble count data as part of monitoring (MY0-MYx). Agreement was reached between all attending parties that pebble count data will not be required during the monitoring period for all future projects.

Sediment data and particle distribution will still be required for the mitigation plan as part of the proposed design explanation and justification.

Pebble counts and/or particle distributions currently being conducted by providers for annual monitoring may be discontinued at the discretion of the DMS project manager. If particle distribution was listed as a performance standard in the project mitigation plan, the provider is required to communicate the intent to cease data collection with the DMS project manager. The absence of pebble count data in future monitoring reports where pebble count data was listed as part of monitoring in the mitigation plan must be documented in the monitoring report. The September 29, 2021 Technical Work Group meeting may be cited as the source of the new policy.

The IRT reserves the right to request pebble count data/particle distributions if deemed necessary during the monitoring period.

Kristi Suggs

From: Reid, Matthew <matthew.reid@ncdenr.gov>
Sent: Wednesday, October 27, 2021 1:26 PM
To: Kristi Suggs
Cc: Mimi Caddell
Subject: RE: [External] FW: Pebble Count Data Requirements

I am absolutely OK with not doing pebble counts anymore!

As stated in the memo, please add a statement in the monitoring reports citing the policy.

Thanks!

Matthew Reid
Project Manager – Western Region
North Carolina Department of Environmental Quality
Division of Mitigation Services

828-231-7912 Mobile
matthew.reid@ncdenr.gov

Western DMS Field Office
5 Ravenscroft Dr
Suite 102
Asheville, NC 28801

From: Kristi Suggs [mailto:ksuggs@wildlandseng.com]
Sent: Wednesday, October 27, 2021 1:24 PM
To: Reid, Matthew <matthew.reid@ncdenr.gov>
Cc: Mimi Caddell <mcaddell@wildlandseng.com>
Subject: [External] FW: Pebble Count Data Requirements

Matthew,

Jason Lorch in our Raleigh Office forwarded this meeting memo to me. It says that conducting pebble counts for DMS monitoring (MY0 – MY7) projects is no longer needed as long as it has been okayed by the DMS PM. Moving forward, are you going to allow us to stop doing them on your projects? If so, will DBB projects be treated the same? Please let me know. Thank you!

Kristi

Kristi Suggs | *Senior Environmental Scientist*
O: 704.332.7754 x110 **M**: 704.579.4828

Wildlands Engineering, Inc.
1430 S. Mint St, Suite 104
Charlotte, NC 28203

From: Jason Lorch <jlorch@wildlandseng.com>
Sent: Monday, October 25, 2021 9:05 AM
To: Kristi Suggs <ksuggs@wildlandseng.com>
Subject: FW: Pebble Count Data Requirements

FYI!

Jason Lorch, GISP | *Senior Environmental Scientist*
O: 919.851.9986 x107 **M**: 919.413.1214

Wildlands Engineering, Inc.
312 West Millbrook Road, Suite 225
Raleigh, NC 27609

From: Russell, Periann <periann.russell@ncdenr.gov>
Sent: Thursday, October 21, 2021 10:05 AM
To: King, Scott <Scott.King@mbakerintl.com>; Catherine Manner <catherine@waterlandsolutions.com>; Tugwell, Todd J CIV USARMY CESAW (US) <Todd.J.Tugwell@usace.army.mil>; adam.spiller@kci.com; Brad Breslow <bbreslow@res.us>; Davis, Erin B <erin.davis@ncdenr.gov>; gginn@wolfcreekeng.com; grant lewis <glewis@axiomenvironmental.org>; Jeff Keaton <jkeaton@wildlandseng.com>; katie mckeithan <Katie.McKeithan@mbakerintl.com>; Kayne Van Stell <kayne@waterlandsolutions.com>; Kevin Tweedy <ktweedy@eprusa.net>; Reid, Matthew <matthew.reid@ncdenr.gov>; Ryan Smith <rsmith@lmgroup.net>; Melia, Gregory <gregory.melia@ncdenr.gov>; Allen, Melonie <melonie.allen@ncdenr.gov>; Famularo, Joseph T <Joseph.Famularo@ncdenr.gov>; Rich@mogmit.com; Bryan Dick <Bryan.Dick@freese.com>; Ryan Medric <rmedric@res.us>; Kim Browning <Kimberly.D.Browning@usace.army.mil>; Kayne Van Stell <kayne@waterlandsolutions.com>; Worth Creech <worth@restorationsystems.com>; Jason Lorch <jlorch@wildlandseng.com>
Cc: Crocker, Lindsay <Lindsay.Crocker@ncdenr.gov>; Wiesner, Paul <paul.wiesner@ncdenr.gov>; Tsomides, Harry <harry.tsomides@ncdenr.gov>; Reid, Matthew <matthew.reid@ncdenr.gov>; Dow, Jeremiah J <jeremiah.dow@ncdenr.gov>; Horton, Jeffrey <jeffrey.horton@ncdenr.gov>; Ullman, Kirsten J <Kirsten.Ullman@NCDENR.gov>; Ackerman, Anjie <anjie.ackerman@ncdenr.gov>; Blackwell, Jamie D <james.blackwell@ncdenr.gov>; Xu, Lin <lin.xu@ncdenr.gov>; Mir, Danielle <Danielle.Mir@ncdenr.gov>; Corson, Kristie <kristie.corson@ncdenr.gov>; Russell, Periann <periann.russell@ncdenr.gov>; Sparks, Kimberly L <Kim.sparks@ncdenr.gov>
Subject: Pebble Count Data Requirements

Please review the attached memo documenting the agreed upon policy for pebble count data requirements.
Please reply (me only) to this email if accept that this memo represents (or misrepresents) our discussion on Sept 29.
Thank you.

Periann Russell
Geomorphologist
Division of Mitigation Services, Science and Analysis
NC Department of Environmental Quality

919 707 8306 office
919 208 1426 mobile
periann.russell@ncdenr.gov

Mailing: 1652 Mail Service Center Raleigh, NC 27699-1652
Physical: 217 West Jones Street Raleigh, NC 27603

APPENDIX 5. Hydrology Summary Data and Plots

Table 14. Verification of Bankfull Events

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Reach	MY	Date of Occurrence	Date of Data Collection	Method
UT1 Reach 2	MY1	2/13/2020	2/13/2020	Crest Gage
		4/13/2020	4/13/2020	
	MY2	7/19/2021	7/19/2021	
		8/18/2021	8/18/2021	
	MY3	7/10/2022	7/10/2022	
UT2 Reach 2	MY1	2/6/2020	2/6/2020	
	MY2	7/19/2021	7/19/2021	
		8/13/2021	8/13/2021	
		8/17/2021	8/17/2021	
		10/8/2021	10/8/2021	
	MY3	5/27/2022	5/27/2022	
		6/15/2022	6/15/2022	
		7/10/2022	7/10/2022	
		9/12/2022	9/12/2022	
UT3 Reach 2	MY2	7/19/2021	8/9/2021	Debris Wracklines[1]
UT4	MY2	7/19/2021	7/19/2021	Crest Gage
		8/7/2021	8/7/2021	
		8/17/2021	8/17/2021	
		10/8/2021	10/8/2021	
	MY3	5/27/2022	5/27/2022	
		7/10/2022	7/10/2022	
Shake Rag Branch Reach 5	MY2	7/19/2021	8/9/2021	Debris Wracklines[1]
	MY3	7/10/2022	7/10/2022	Crest Gage

[1]Photo documentation of debris wracklines are included in the electronic support files

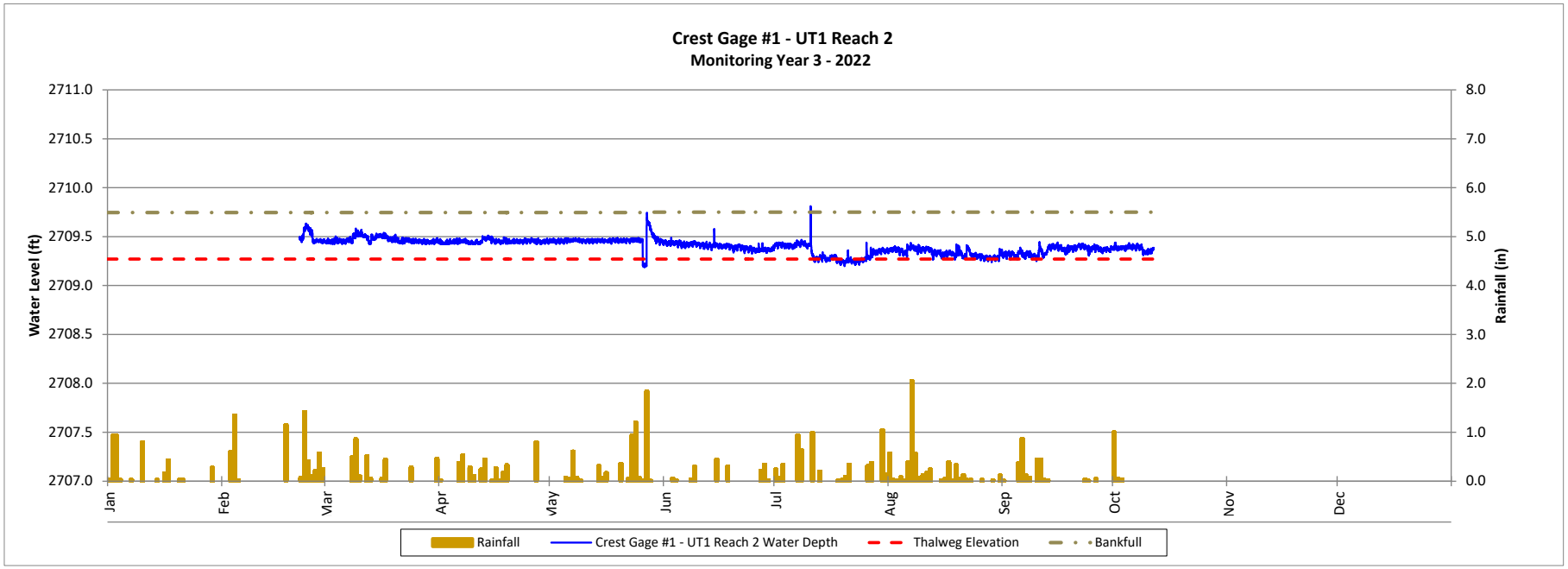
Table 15. Verification of Consecutive Flow Days

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Reach	MY	Date of Occurrence	Maximum Consecutive Days of Stream Flow	Method
UT8	MY1	1/1/2020 - 10/16/2020	289 days	Stream Gage
	MY2	1/1/2021 - 10/20/2021	292 days	
	MY3	1/1/2022 - 10/11/2022	284 days	

Stream and Crest Gage Plots

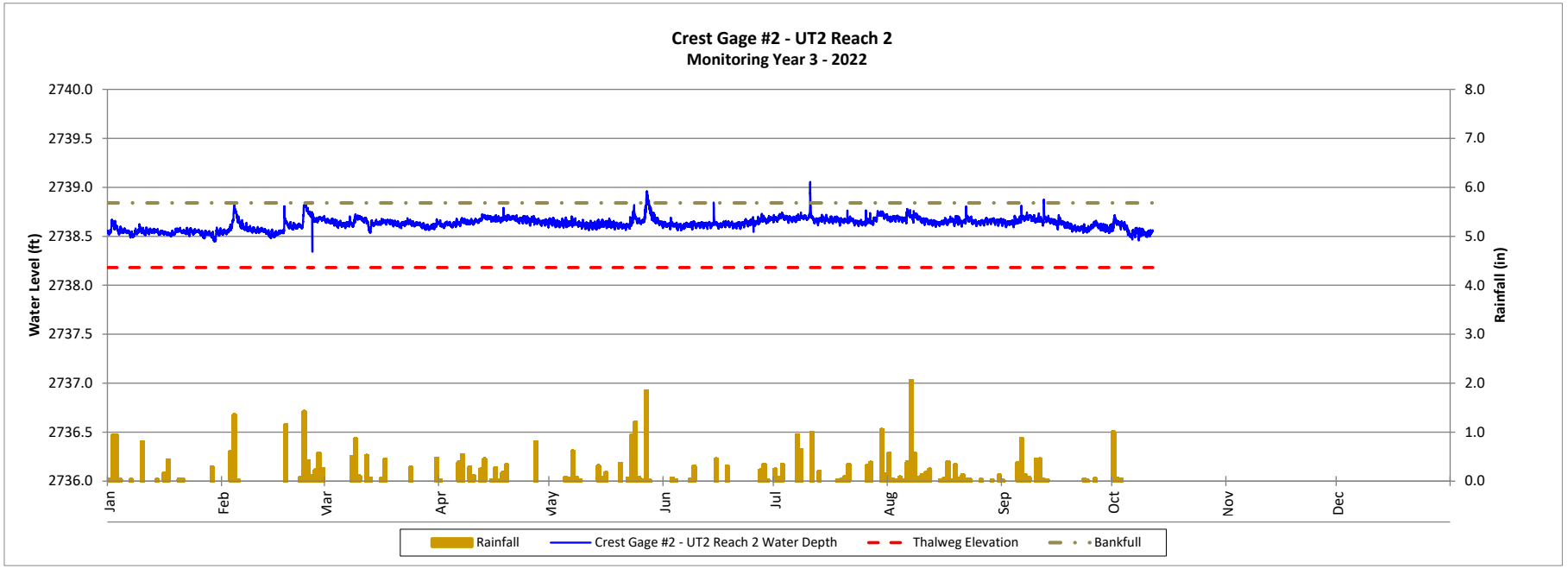
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



- Data omitted from 1/1/2022 to 2/22/2022 due to gage malfunction.

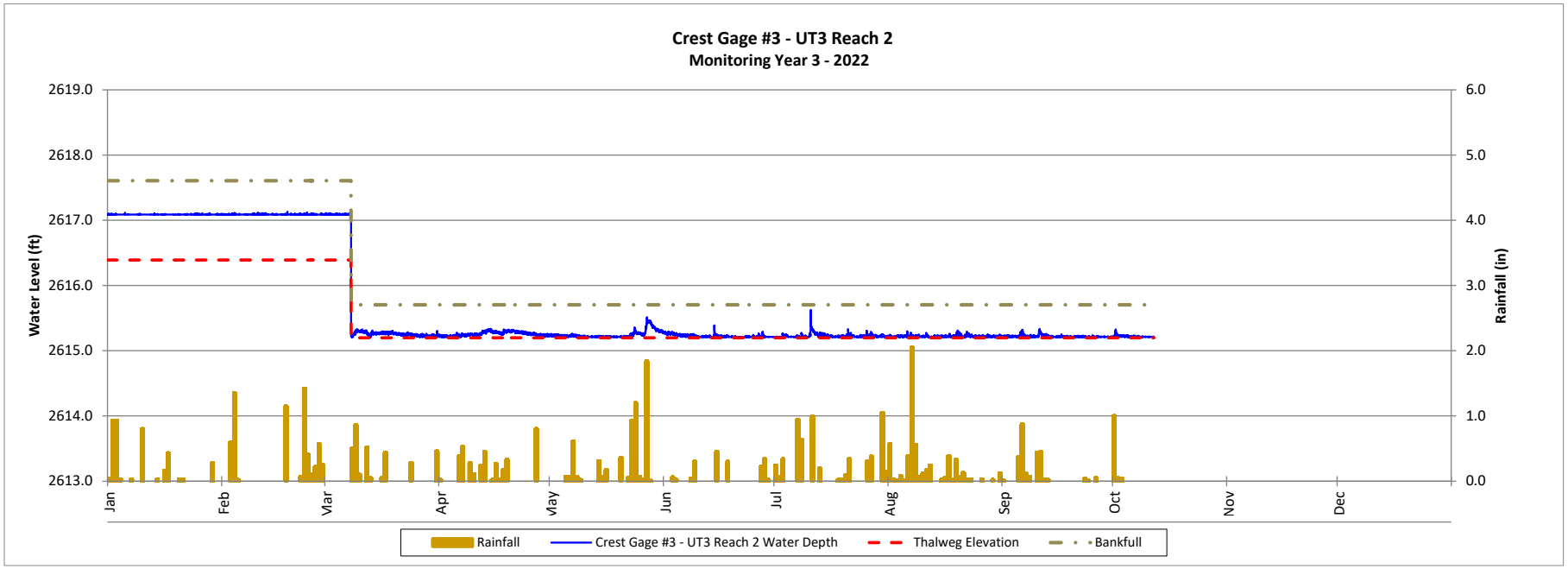
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



Stream and Crest Gage Plots

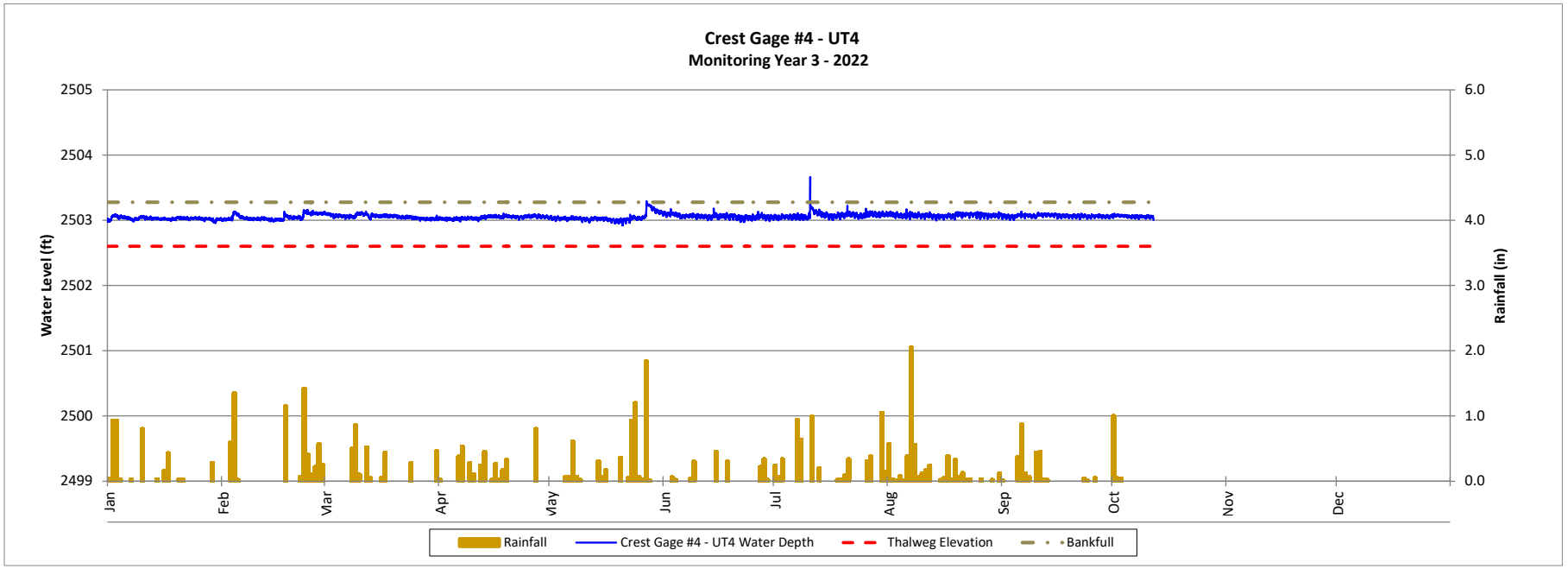
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



- CG3 reinstalled in a downstream riffle along UT3 Reach 2 on 3/8/2022.

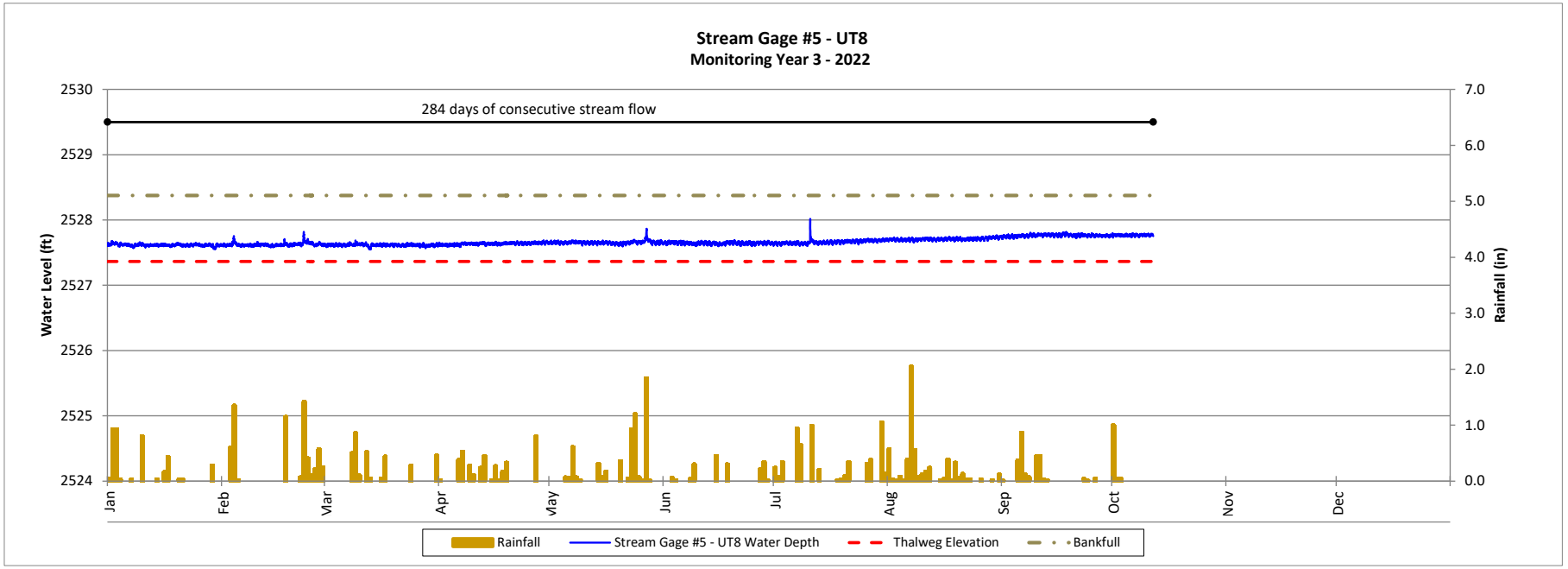
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



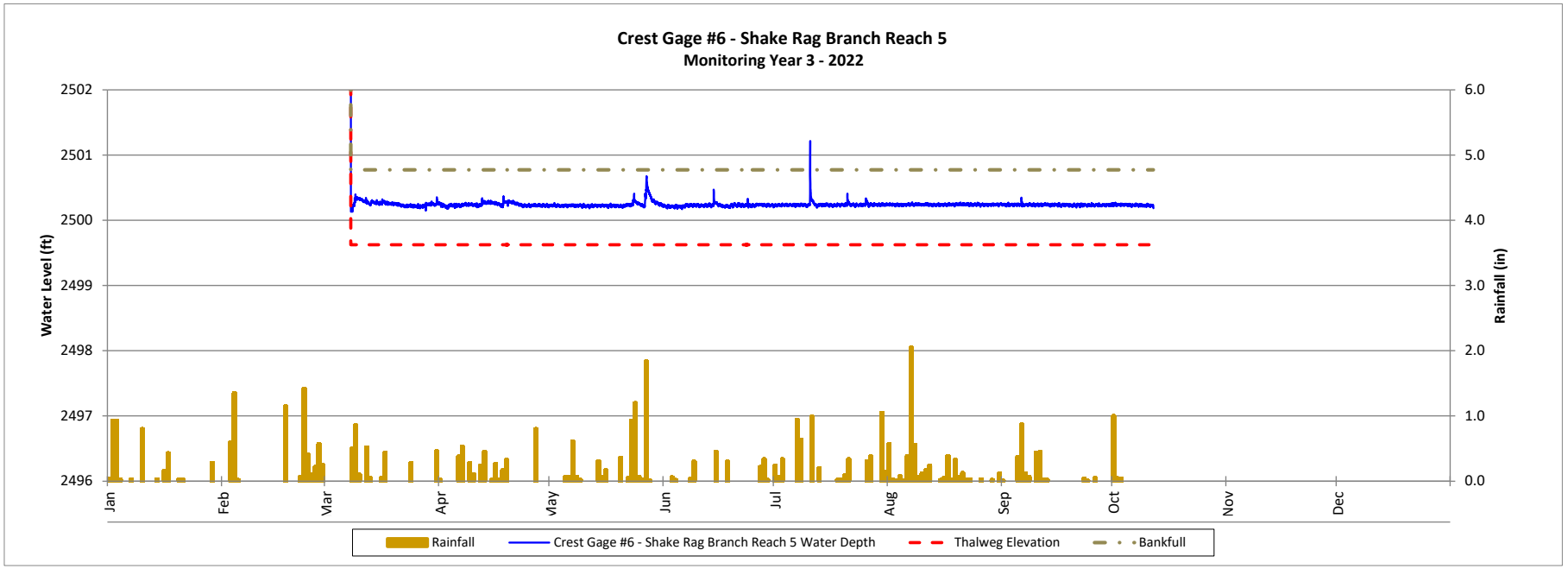
Stream and Crest Gage Plots

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



Stream and Crest Gage Plots

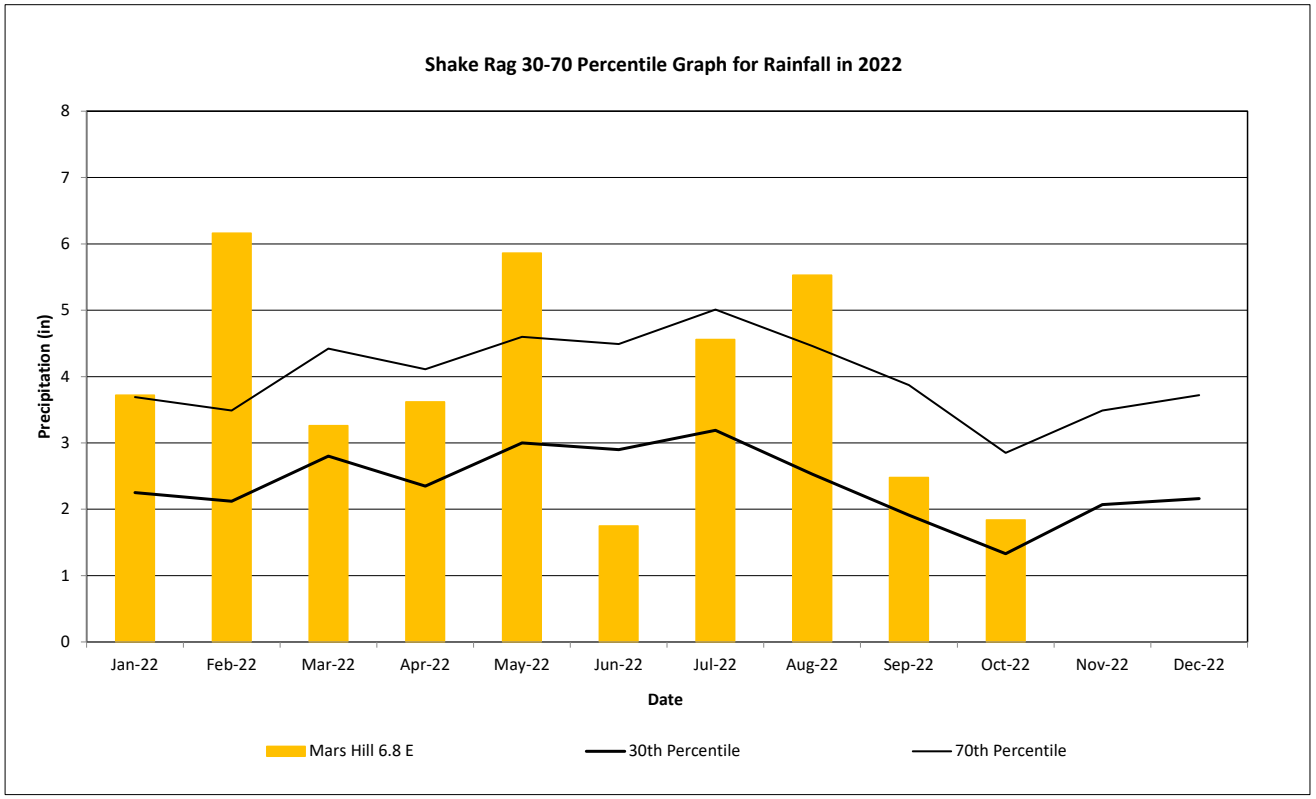
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



- CG6 reinstalled at XS12 along Shake Rag Branch Reach 5 on 3/8/2022

Monthly Rainfall Data

Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022



2022 rainfall collected by NC CRONOS Station, Mars Hill 6.8 E
30th and 70th percentile rainfall data collected from WETS station Marshall, NC

APPENDIX 6. Adaptive Management

Table 16. Adaptive Management Actions
Shake Rag Mitigation Site
DMS Project No. 100018
Monitoring Year 3 - 2022

Reach	Station	Length (LF)	Issue mapped on MY2 CCPV	Description	2022 Management Action
UT1 Reach 2	112+00	N/A	Headcut/downcutting	Structure[1] dislodged	Reset structure boulder
UT3 Reach 2	306+00	N/A	Headcut/downcutting	Structure[1] piping	Reset downstream structure
	307+75	10	Bank instability	Flow on side of riffle	Regrade bank, recompact riffle material against bank
	309+90	N/A	Headcut/downcutting	Riffle/structure[1] piping at head	Reset head of riffle
	310+85	5	Bank instability	Minor scour	Stabilize isolated bank scour
	311+25	N/A	Headcut/downcutting	Riffle material shift	Reset head of riffle, regrade bank
	311+75	N/A	Headcut/downcutting	Riffle material shift	Build new drop to replace eroded riffle
	312+00	20	Bed instability	Flow under stone	Repair head of riffle and add substrate material
	312+30	N/A	Headcut/downcutting	Riffle material shift	Add boulder footer to drop
	312+70	N/A	Headcut/downcutting	Structure[1] piping	Reconstruct downstream structure, stabilize bank
	313+25	5	Bank instability	Minor erosion	Hand work, monitor
	314+60	N/A	Headcut/downcutting	Riffle eroded	Drop ok, add splash rock by hand, monitor
Shake Rag Reach 3	921+50	25	Bed instability	Structure[1] piping with bank erosion	Rebuild structures, stabilize bank
	921+75	10	Bank instability		
	922+15	10	Bank instability	Minor piping right side of structure	Plug pipping structure, stabilize bank
	922+50	N/A	Headcut/downcutting	Riffle material shift	Add splash rock/footer stone, regrade bank
	922+90	N/A	Headcut/downcutting	Riffle material shift	Add splash rock/footer stone, regrade bank
Shake Rag Reach 4	923+75	20	Deposition	Sediment deposition – natural valley slope break	Monitor
	924+00	20	Bank instability	Minor toe erosion	Stabilize bank
Shake Rag Reach 5	937+75	N/A	Structure issue	Structure dislodged	Hand work, monitor
UT4	400+25	N/A	Structure issue	Structure pipping	Plug pipping structure
	404+25	N/A	Headcut/downcutting	Piping under repair	Plug with handwork/monitor

[1] Encompassed within a cascading riffle feature, as displayed on the Shake Rag Record Drawings from as-built (4/3/2020).

Not applicable (N/A): Lengths not associated with instances (points)

Repair Areas Photolog
MY3

	
UT1 Reach 2 STA 112+00: pre-repair downcutting behind dislodged structure, 3/8/2022	**UT1 Reach 2 STA 112+00**: post-repair, 4/19/2022
	
UT3 Reach 2 STA 306+00: pre-repair, downcutting/structure piping, 3/8/2022	**UT3 Reach 2 STA 306+00:** post-repair, 4/19/2022
	
UT3 Reach 2 STA 307+75: pre-repair, bank instability, 3/8/2022	**UT3 Reach 2 STA 307+75**: post-repair, 4/19/2022

	
UT3 Reach 2 STA 309+90: pre-repair, downcutting, riffle/structure piping at head, 3/8/2022	**UT3 Reach 2 STA 309+90**: post-repair, 4/19/2022
	
UT3 Reach 2 STA 310+85: pre-repair, bank instability, 3/8/2022	**UT3 Reach 2 STA 310+85**: post-repair, 4/19/2022
	
UT3 Reach 2 STA 311+25: pre-repair, downcutting and shifting riffle material, 3/8/2022	**UT3 Reach 2 STA 311+25**: post-repair, 4/19/2022

	
UT3 Reach 2 STA 311+75: pre-repair, downcutting and shifting riffle material, 3/8/2022	**UT3 Reach 2 STA 311+75**: post-repair, 4/19/2022
	
UT3 Reach 2 STA 312+00: pre-repair, bed instability, 3/8/2022	**UT3 Reach 2 STA 312+00**: post-repair, 4/19/2022
	
UT3 Reach 2 STA 312+30: pre-repair, downcutting riffle material shift, 3/8/2022	**UT3 Reach 2 STA 312+30**: post-repair, 4/19/2022

	
UT3 Reach 2 STA 312+70: pre-repair, downcutting structure piping, 3/8/2022	**UT3 Reach 2 STA 312+70**: post-repair, 4/19/2022
	
UT3 Reach 2 STA 313+25: pre-repair, bed instability, 3/8/2022	**UT3 Reach 2 STA 313+25**: post-repair, 4/19/2022
	
Shake Rag Branch Reach 3 STA 921+50: pre-repair, bed instability, 3/8/2022	**Shake Rag Branch Reach 3 STA 921+50**: post-repair, 4/19/2022

	
Shake Rag Branch Reach 3 STA 921+75: pre-repair, bank instability, 3/8/2022	**Shake Rag Branch Reach 3 STA 921+75**: post-repair, 4/19/2022
	
Shake Rag Branch Reach 3 STA 922+15: pre-repair, bank instability, 3/8/2022	**Shake Rag Branch Reach 3 STA 922+15**: post-repair, 4/19/2022
	
Shake Rag Branch Reach 4 STA 924+00: pre-repair, bank instability, 3/8/2022	**Shake Rag Branch Reach 4 STA 924+00**: post-repair, 10/11/2022

	
Shake Rag Branch Reach 5 STA 937+75: pre-repair, structure dislodged, 3/8/2022	**Shake Rag Branch Reach 5 STA 937+75**: post-repair, 4/19/2022
	
UT4 STA 404+25: pre-repair, piping under structure, 3/8/2022	**UT4 STA 404+25**: post-repair, 4/19/2022
	
UT4 STA 400+25: pre-repair, piping under structure, 3/8/2022	**UT4 STA 400+25**: post-repair, 4/19/2022