



# MONITORING YEAR 5 ANNUAL REPORT

Final

## GLADE CREEK II RESTORATION PROJECT

Alleghany County, NC  
DEQ Contract 6843  
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### PREPARED FOR:



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

PREPARED BY:

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**Wildlands Engineering, Inc.**  
1430 South Mint Street, Suite 104  
Charlotte, NC 28203  
Phone: 704.332.7754  
Fax: 704.332.3306

## EXECUTIVE SUMMARY

Wildlands Engineering, Inc. (Wildlands) completed design and construction management on a design-bid-build project at the Glade Creek II Restoration Site (Site) for the North Carolina Division of Mitigation Services (DMS) in Alleghany County, NC. The project components included restoring and enhancing 2,579 linear feet (LF) and preserving 129 LF of perennial stream, restoring 0.16 acre of wetlands, and preserving 0.84 acre of existing wetland. Riparian buffers were also established by removing exotic invasive plants and installing a variety of native vegetation. The Site is expected to generate 2,166.467 stream mitigation units (SMUs) and 0.328 wetland mitigation units (WMUs) for the Glade Creek watershed (Table 1). The Site is located off US Highway 21 in the northern portion of Alleghany County, NC in the New River Basin, eight-digit Hydrologic Unit Code (HUC) 05050001 and the 14-digit HUC 05050001030020 (Figure 1). The project streams consist of one unnamed tributary, UT to Glade Creek, and two reaches along Glade Creek mainstem (Reach 1 and Reach 2) (Figure 2). Glade Creek flows into the Little River four miles northeast of the Site near Fox Trot Lane in the Town of Hooker, North Carolina. The land adjacent to the streams and wetlands is primarily maintained for forestry production of White Pine trees.

The Glade Creek II Restoration Project is located within a DMS Targeted Local Watershed (TLW) (Brush Creek, HUC 05050001030020), as documented within the 2009 River Basin Restoration Priorities (RBRP) for the New River Basin. Furthermore, the project site is located within Middle Glade Creek, a priority subwatershed for stream and wetland restoration (and habitat protection), as identified within 2006 Local Watershed Plan and Preliminary Project Atlas for Little River and Brush Creek. Primary stressors within the Brush Creek TLW and the Middle Glade Creek subwatershed include stream channelization, livestock access, degraded riparian buffers, and Christmas tree farming. Glade Creek is also classified as a trout water and the project will help improve trout habitat in the watershed.

The project goals established in the mitigation plan addendum (Confluence, 2013) were completed with careful consideration of goals and objectives described in the RBRP and to address stressors identified in the LWP. The following project goals established include:

- Improve water quality by repairing eroding stream banks and establishing riparian buffers;
- Improve the community structure of the buffers;
- Improve stream function and habitat by re-establishing stream-to-floodplain connections;
- Restore long-term stability through the restoration of channel dimension, pattern and profile;
- Improve in-stream habitat using in-stream structures; and
- Remove exotic invasive plant species.

The Site construction was completed between December 2015 and April 2016. Planting was completed in February 2016. The as-built survey was completed in January 2016 with Monitoring Year (MY) 0 beginning in May 2016. MY5 activities occurred between March and November 2020. An additional year of monitoring (MY6) will occur in 2021 and the Site is anticipated to be presented for closeout in 2022.

The MY5 morphological surveys and visual assessments indicate that the majority of Glade Creek appears stable and functioning as designed; however, sediment deposition has continued to cause a loss of channel function along a portion of UT to Glade Creek. The vegetation assessment resulted in an average planted stem density of 465 stems per acre and is exceeding the final success criterion of 260 stems per acre. In addition, all six plots individually exceeding this requirement. The Site's groundwater gage met the performance standard for MY5. The bankfull performance standard was met for the project in MY2. The visual assessment also revealed that adaptive management activities have nearly eradicated many invasive species on the Site, alleviated areas of bank instability, and benefited the long-term ecological function of the Site.



**GLADE CREEK II RESTORATION PROJECT**  
Monitoring Year 5 Annual Report

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## Section 1: PROJECT OVERVIEW

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The Site is a design-bid-build contract with DMS in Alleghany County, NC. The Site is located in the New River Basin, eight-digit Hydrologic Unit Code (HUC) 05050001 and the 14-digit HUC 05050001030020 (Figure 1). Located in the Blue Ridge Belt (USGS,2016), Blue Ridge physiographic province, the project watershed includes primarily agricultural and forest land uses, with a drainage area of 8.0 square miles.

The project stream reaches consist of Glade Creek and UT to Glade Creek (stream restoration). The project wetland areas consist of restoration and preservation (Wetlands A-D). Mitigation work within the Site included restoring and enhancing 2,579 LF and preserving 129 LF of perennial stream, restoring 0.16 acre of wetlands, and preserving 0.84 acre of existing wetland and proposes the generation of 2,166.467 SMUs and 0.328 WMUs. The stream and wetland areas were planted with native vegetation to improve habitat and protect water quality. Construction activities were completed by Carolina Environmental, Inc. in December 2015. Turner Land Surveying completed the as-built survey in January 2016. Storm repairs prior to end of the construction phase were completed in April 2016 and the repairs were judged to have not resulted in changes that would warrant a revised as-built survey. A 12.8-acre conservation easement was purchased in 2008 by the State of North Carolina and was recorded with Alleghany County Register of Deeds. The conservation easement protects the project area in perpetuity.

Appendix 1 includes detailed project activity, history, contact information, and watershed/site background information. Directions and a map of the Site are provided in Figure 1. Project components are illustrated in Figure 2 while Table 1 outlines the project component and mitigation credit information for the Site.

### 1.1 Project Goals and Objectives

Prior to construction, the streams had been impacted by historic agricultural practices, silviculture and valley filling. In addition, there was widespread bank erosion, especially along the outside meander bends, and mid-channel deposition. The wetlands had been impacted by vegetation clearing, the establishment of exotic invasive plant species, and the burial of the hydric soils layer from historic valley fill. Table 4 in Appendix 1 and Tables 6a and 6b in Appendix 2 present the pre- and post-restoration conditions in detail.

This mitigation site is intended to provide numerous ecological benefits within the New River Basin and addresses habitat degradation, which is the primary water quality stressor described in the New River RBRP (2009). While many of the benefits are limited to the immediate project area, others, such as pollutant removal, reduced sediment loading, and improved aquatic and terrestrial habitat, have farther-reaching effects. Expected improvements to water quality and ecological processes are outlined below as project goals and objectives. These project goals were met by giving careful consideration to the goals and objectives described in the RBRP.

The project specific goals of the Glade Creek II Restoration Site included the following:

- Improve water quality by repairing eroding stream banks and establishing riparian buffers;
- Improve the community structure of the buffers;
- Improve stream function and habitat by re-establishing stream-to-floodplain connections;
- Restore long-term stability through the restoration of channel dimension, pattern and profile;
- Improve in-stream habitat using in-stream structures; and
- Remove exotic invasive plant species.

The project objectives have been defined as follows:



- Restoration and enhancement of approximately 2,260 LF of Glade Creek;
- Restoration of 319 LF of the UT to Glade Creek;
- Preservation of 129 LF of UT to Glade Creek;
- Restoration of 0.16 acre of wetland by improving hydrologic connections;
- Preservation of 0.84 acre of existing jurisdictional wetland; and
- Establishment of riparian buffers by removing exotic invasive plants and installing a variety of native vegetation.

The stream and wetland performance criteria for the Site follow approved performance standards presented in the Glade Creek II Restoration Plan (Ward, 2008). Annual monitoring and semi-annual site visits will be conducted to assess the condition of the finished project. The stream restoration and enhancement reaches (Glade Creek and UT to Glade Creek) of the project were assigned specific performance standards for stream morphology, hydrology, and vegetation. Wetland restoration areas were assigned specific performance standards for wetland hydrology and vegetation. The Glade Creek Stream Restoration Project was instituted prior to 7/28/2010; therefore, the Site will be monitored for a minimum of five years post-construction. An additional year of monitoring (MY6) will occur in 2021 to further assess repairs, with the Site anticipated to be presented for closeout in 2022.

## 1.2 Monitoring Year 5 Data Assessment

Annual monitoring was conducted between March and November 2020 to assess the condition of the project. The stream restoration success criteria for the Site follows the approved monitoring plan presented in the Glade Creek II Restoration Plan (Ward, 2008).

### 1.2.1 Vegetation Assessment

A total of six vegetation monitoring plots were established during baseline monitoring within the project easement areas using a standard 10 by 10 meter or 5 by 20 meter plots. Please refer to the Current Condition Plan View (CCPV) Figure 3 in Appendix 2 for the vegetation monitoring plot locations. The final vegetation success criterion is the survival of 260 planted stems per acre in the riparian corridor along restored and enhanced reaches at the end of year five of the monitoring period.

The MY5 vegetation survey was completed in August 2020, resulting in an average planted stem density of 465 stems per acre. The Site is exceeding the MY5 density requirement of 260 planted stems, with all six plots (100%) individually exceeding this requirement. Vegetation plot 1 has an increased stem density compared to last year due to tag alder (*Alnus serrulata*) trees that have been present for at least two growing seasons and are counted towards the final performance standard. In addition, the number of volunteer woody stems have steadily increased each year with desired species including tag alder, nine bark (*Physocarpus opulifolius*), and red maple (*Acer rubrum*). Approximately 50% of the monitored stems have a health score (vigor) of 3 or greater, indicating that they are very likely to survive. Moreover, about 28% of the monitored stems have a vigor of 2 indicating that they have fair plant health with some damage present. Stems with a vigor of 1 that are unlikely to survive next year accounted for roughly 2% of the monitored stems. These lower vigor ratings were due to damage from deer, suffocation from dense herbaceous cover, and other unknown factors. Some of the tag alders that were planted from bare root at as-built have low vigor or have died for reasons unknown. However, the volunteer and transplant tag alders are numerous and thriving throughout the Site. Please refer to Appendix 2 for vegetation plot photographs and Appendix 3 for vegetation data tables.

### 1.2.2 Vegetation Areas of Concern and Adaptive Management Activity

The MY5 vegetation monitoring and visual assessments revealed that very few areas of concern persist on the Site. DMS contracted with a provider for invasive species treatment beginning in October 2019



and continuing throughout 2020. Previously noted areas of invasive species were treated and observed to have very few resprouts with less than 0.1% of the easement acreage currently affected by invasive species. In addition, supplemental planting occurred within the wetland preservation area consisting of 350 tubling plants in April 2020. A visual assessment in November 2020 revealed that many planted wooded stems in Wetland B had survived the growing season. Please refer to the CCPV Figure 3 in Appendix 2 for vegetation areas of concern and Appendix 6 for adaptive management details.

### **1.2.3 Stream Assessment**

Morphological surveys for MY5 were conducted in May and June 2020. Along Glade Creek, the surveyed longitudinal profile illustrates that bedform features are maintaining vertical stability for the majority of the surveyed reaches. Profile dimensions for Glade Creek are showing little change between MY4 and MY5. The longitudinal profile plot for UT to Glade Creek demonstrates the extent of aggradation that has altered the channel profile, which is further discussed below in Section 1.2.4. Please refer to Appendix 4 for longitudinal profiles with annual overlays and Table 13a-b for stream reach data summaries.

Cross-section survey results indicate that channel dimensions are stable and continuing to function on Glade Creek with minimal adjustments. As woody vegetation has become well established along the banks, there is additional floodplain deposition from bankfull events thus slightly raising low bank elevation and increasing the low bank height ratio (XS2). As observed in previous MYs, cross-sections along UT to Glade Creek are representative of the significant sediment deposition and decreasing pool depths occurring throughout the reach. The surveyed riffle cross-section along UT to Glade (XS5) has maintained bed and bank elevations compared to MY4 and dimensions compared to MY0. Please refer to Appendix 4 for cross-section plots with annual overlays and Table 12 for morphology summaries.

Along Glade Creek, the reachwide pebble counts show coarser materials in the riffles and fines in the pools. The UT to Glade Creek reachwide channel materials resulted in a  $D_{50}$  of 0.4 mm (sand) during MY5. This fining of sediment materials observed in MY3 has continued through MY5 for UT to Glade Creek. Please refer to Appendix 4 for pebble count plots with annual overlays.

### **1.2.4 Stream Areas of Concern and Adaptive Management Activity**

UT to Glade Creek has continued to experience an increase in fine sediment throughout MY5. Large bankfull events along Glade Creek are depositing sediment along the floodplain and within the channel of UT to Glade Creek. In addition, land management activities upstream of the project are contributing excessive sedimentation on UT to Glade Creek. At the start of UT to Glade Creek Reach 2, sediment deposition has directed flow through Wetland D on the right floodplain of the channel resulting in active braiding. However downstream of Wetland D, willows and alders have become more established along the banks and have helped maintain channel form and function.

Along Glade Creek, areas of concern previously noted included an undercut brush mattress (station 22+95 to 23+50) and left bank hillslope erosion (station 24+25 to 24+75). DMS contracted with a provider to complete repairs which included brush toe geolift, point bar regrading, and stabilization of the hillslope. The repairs were completed in April 2020 and appear to be stable. Other small areas of scour that were not addressed by the repair remain along Glade Creek. However, woody vegetation has become well established in these areas causing them to be of minor concern to the ecological integrity of the project. The remaining areas of concern are depicted on the CCPV Figure 3 in Appendix 2 and the stream repair as-built plans are included in Appendix 6.



### **1.2.5 Hydrology Assessment**

A bankfull event was documented for Glade Creek and UT to Glade Creek on June 8, 2020 based on crest gage measurements and wracklines found throughout the floodplain. In MY1 through MY5, there has been at least five bankfull events for each reach documented in separate years. The performance standard was met in MY2 with two bankfull flow events documented on restoration reaches and occurring in separate years during the five-year monitoring period. Refer to Appendix 5 for hydrologic data and graphs.

### **1.2.6 Wetland Assessment**

One groundwater monitoring gage (GWG 1) was established during baseline monitoring within the wetland restoration area using a logging hydrology pressure transducer. The gage was installed at an appropriate location so that the data collected will provide an indication of groundwater levels throughout the wetland restoration area. The target performance standard for wetland hydrology success consists of the presence of groundwater within 12 inches of the ground's surface for 21 consecutive days (12.5%) of the defined growing season for Alleghany County (April 26<sup>th</sup> to October 11<sup>th</sup>) under typical precipitation conditions. The Site does not contain a rainfall gage; therefore, the daily precipitation data was collected from closest NC CRONOS Station, Sparta 3.5 SSW.

The GWG 1 recorded 169 consecutive days or 100% of the growing season; thereby exceeding the performance standard for MY5. Each time that the groundwater gage was downloaded in MY5, standing water was observed in the area surrounding the gage in Wetland D. This is corroborated by the groundwater gage data which plots water levels above the ground's surface for a majority of the growing season. Monthly rainfall data in 2020 indicated higher than normal rainfall amounts occurred during the months of April, May, August, and October and lower than normal rainfall amounts occurred during March 2020. Please refer Figure 3 in Appendix 2 for the groundwater gage location, and Appendix 5 for hydrology data and plots.

### **1.2.7 Wetland Areas of Concern and Adaptive Management Activity**

One headcut was previously noted beginning in MY3 at the outflow of Wetland B where it meets Glade Creek Reach 2 (near station 22+75). DMS contracted with a provider to complete repairs in April 2020 which included the installation of log sills for grade control at the wetland outflow. As discussed in section 1.2.2, Wetland B had previously been noted to have poor woody stem growth and therefore supplemental planting occurred in April 2020 with appropriate wetland tree and shrub species. Please refer to the repair as-built plan in Appendix 6.

## **1.3 Monitoring Year 5 Summary**

The MY5 morphological surveys and visual assessments indicate that the majority of Glade Creek appears stable and functioning as designed; however, sediment deposition has continued to cause a loss of channel function along a portion of UT to Glade Creek. The MY5 vegetation assessment resulted in an average planted stem density of 465 stems per acre and is exceeding the final success criterion of 260 stems per acre. In addition, all six plots individually met this requirement. The Site's groundwater gage met the performance standard for MY5. The bankfull performance standard was met for the project in MY2. The MY5 visual assessment revealed that treatments have nearly eradicated many invasive species on the Site. In addition, wetland adaptive management activities and stream repairs that occurred in Spring 2020 have alleviated previously noted areas of bank instability and have benefited the long-term ecological function of the Site. An additional year of monitoring (MY6) will occur in 2021.

Summary information and data related to the performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these annual monitoring reports can be found in the Mitigation Plan



documents available on DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.



## Section 2: METHODOLOGY

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Geomorphic data was 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). Longitudinal and cross-sectional data were collected using a total station and were georeferenced. All Integrated Current Condition Plan View mapping was recorded using a Trimble handheld GPS with sub-meter accuracy and processed using Pathfinder and ArcView. Crest gages were installed in surveyed riffle cross-sections and monitored semi-annually. Hydrology attainment installation and monitoring methods are in accordance with the USACE (2003) standards. Vegetation monitoring protocols followed the Carolina Vegetation Survey-NCEEP Level 2 Protocol (Lee et al., 2008).



## Section 3: REFERENCES

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- Confluence Engineering, P.C. (2013). Glade Creek II Restoration Project Final Mitigation Plan Addendum. NCEEP, Raleigh, NC.
- 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-eeep-protocol-v4.2-lev1-2.pdf>
- North Carolina Climate Retrieval and Observations Network of the Southeast Database (NCCRONOS). 2020. State Climate Office of North Carolina. Version 2.7.2. Station ID Sparta 3.5 SSW. Accessed November 2020.
- North Carolina Division of Mitigation Services and Interagency Review Team Technical Workgroup. 2018. Standard Measurement of the BHR Monitoring Parameter. Raleigh, NC.
- North Carolina Ecosystem Enhancement Program (NCEEP), 2009. New River Basin Restoration Priorities. Accessed from: [https://ncdenr.s3.amazonaws.com/s3fs-public/Mitigation%20Services/PublicFolder/Work%20With/Watershed%20Planners/New\\_RBRP\\_2009.pdf](https://ncdenr.s3.amazonaws.com/s3fs-public/Mitigation%20Services/PublicFolder/Work%20With/Watershed%20Planners/New_RBRP_2009.pdf)
- North Carolina Ecosystem Enhancement Program (NCEEP). Little River and Brush Creek Local Watershed Plan. Accessed from: <https://ncdenr.s3.amazonaws.com/s3fs-public/documents/files/LittleRiver-BrushCrk%20LWP%20FactSheet.pdf>
- Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.
- United States Army Corps of Engineers (USACE), 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.
- United States Geological Survey (USGS), 2016. North Carolina Geology. Accessed from: <http://ngmdb.usgs.gov/maps/mapview/>
- Ward Consulting Engineers, P.C. (2008). Glade Creek II Restoration Project Restoration Plan. NCEEP, Raleigh, NC.

