Year Two Monitoring Report

FINAL

GROUNDHOG HOLLOW PROJECT

NCDMS Project #100049 (Contract #7417) | RFP 16-007277 (Issued 6/21/2017)

USACE Action ID: SAW-2018-00450 | DWR Project #20180666

Alexander County, North Carolina
Catawba River Basin
HUC 03050101

Provided by:

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For Environmental Banc & Exchange, LLC

Provided for:
NC Department of Environmental Quality
Division of Mitigation Services

February 2022

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RE: Groundhog: Year 2 Monitoring Report (NCDMS ID 100049)

Listed below are comments provided by DMS on January 24, 2023 regarding the Groundhog Mitigation Site: Year 2 Report and RES' responses highlighted in blue.

- Section 1.4 Project Components: "Due to landowner and utility requirements, there are four easement breaks within the project." The CCPV map identifies five (5) project crossings. Please review and revise the report and report text as necessary.
  There are five easement breaks on site, four crossings and one break due to a utility easement. This has been updated in the report.

- Section 1.7 Monitoring Performance (MY2) – Vegetation: Please provide a separate MY2 (2022) supplemental planting list and supplemental planting map in the report appendices. The supplemental planting list should also include the wetland indicator status for the species.
  A supplemental planting figure and summary table have been added to Appendix C.

- Section 1.7 Monitoring Performance (MY1)_Stream Hydrology: In the report text, please review and provide additional discussion regarding the unusual number of bankfull events reported in a normal rainfall year. Are the number of bankfull events reported on the site considered a project concern?
  The large number of out of bank events are not a concern for us at this time. The channels were designed for water to access the floodplain. The reaches containing the gages are stable with established vegetation. The report has been updated to reflect this.

- Table 4 – Project Background Information: Please include the reaches' thermal regime (warm) in the table.
  Done.

- CCPV Map: Please show the stage recorder reported on GF2-B on the CCPV Map. Please update the "Deteriorating Structure" map call out to "Deteriorating Stream Structure" to avoid confusion with a dilapidated building potentially being located within the conservation easement.

The stage recorder is present on the CCPV however is obscured by the XS 18 label and can be hard to see. The gage has been shifted slightly on the figure for clarification. The stream structure callout has been updated.

- Report Text/ Table 6/ CCPV Map: The report text indicates that approximately 0.21 acres of Chinese Privet was "flush cut" in MY1 and will require further invasive treatment in 2023. Chinese privet was also noted along GF1-A, GF1-B, GF2-B, and GF4-A during MY2 and is proposed for treated in 2023. Table 6 shows 0% invasive areas of concern and the CCPV maps provided in the draft report are not consistent with the report text in Section 1.7. Please review the report text, tables and CCPV Map and update them so the invasives reported on the project site are consistent through the final MY2 document.
  The report body and Table 6 has been updated with the correct acreage of Chinese privet of 0.26 acres not 0.21 acres as originally stated. The concentrations of Chinese privet have been noted on the CCPV, however there are scattered stems along GF1-A, GF1-B, GF2-B, and GF4-A.

- Appendix B: Please provide an additional single page georeferenced "Asset Map" in the appendix that clearly identifies the project reaches and stream approaches as specified in Table 1.
  An Asset figure has now been included in Appendix B.

- Appendix B - Groundhog Hollow Crossing Photos: Please also include upstream and downstream photos of the crossing on GF4A/GF4B in the final MY2 report.
  A downstream photo of the culvert crossing on GF4A/GF4B has bow been included in the report. A large hornets nest was located where the monitoring team would take an upstream photo, due to team mates allergies a photo was not taken. Photographs will be taken of the culvert crossing in MY3.

Digital Support File Comments:

- Please note that the reach designations violate DMS attribute rules. Each reach must have a unique segment ID for future submissions.
  This has been noted, thank you.

- The Visual Assessment tables must reflect the problem areas indicated on the CCPV unless established thresholds are not met. The invasives noted on the CCPV exceed the threshold but do not appear in the visual assessment table.
  Table 6 has been updated to include the invasive vegetation polygons and is included in the digital support files.

Table of Contents

1.0 Project Summary

1.1 Project Location and Description

The Groundhog Hollow Project ("Project") is located within a rural watershed in Alexander County, North Carolina approximately three and a half miles northwest of Taylorsville. Water quality stressors affecting the Project included livestock production, agricultural production, and lack of riparian buffer. The Project presents stream restoration and enhancement generating 4,093.95 Warm Stream Mitigation Units (SMU).

The Project's total easement area is 20.58 acres within the overall drainage area of 156 acres. Grazing livestock historically had access to all the stream reaches within the Project. The lack of riparian buffer vegetation, deep-rooted vegetation, and unstable channel characteristics contributed to the degradation of stream banks throughout the Project area.

The stream design approach for the Project was to combine the analog method of natural channel design with analytical methods to evaluate stream flows and hydraulic performance of the channel and floodplain. The analog method involved the use of a reference reach, or "template" stream, adjacent to, nearby, or previously in the same location as the design reach. The template parameters of the analog reach were replicated to create the features of the design reach. The analog approach is useful when watershed and boundary conditions are similar between the design and analog reaches. Hydraulic geometry was developed using analytical methods to identify the design discharge.

The Project has been constructed and planted and will be monitored on a regular basis throughout the seven-year post-construction monitoring period, or until performance standards are met. The Project will be transferred to the NCDEQ Stewardship Program. This party shall serve as conservation easement holder and long-term steward for the property and will conduct periodic inspection of the site to ensure that restrictions required in the conservation easement are upheld.

1.2 Project Goals and Objectives

Through the comprehensive analysis of the Project's maximum functional uplift using the Stream Functions Pyramid Framework, specific, attainable goals will be realized by the Project. These goals clearly address the degraded water quality and nutrient input from farming that were identified as major watershed stressors in the 2009 (amended 2018) Upper Catawba River Basin Restoration Priorities (RBRP). These goals and objectives reflect those stated in the Groundhog Hollow Project Final Mitigation Plan.

The Project goals are:

- Improve water transport from watershed to the channel in a non-erosive manner in a stable channel;
- Improve flood flow attenuation on site and downstream by allowing for overbank flows and connection to the floodplain;
- Improve instream habitat;
- Reduce sediment, nutrient, and fecal coliform inputs into stream system;
- Restore and enhance native floodplain vegetation; and
- Indirectly support the goals of the 2009 Upper Catawba RBRP to improve water quality and to reduce sediment and nutrient loads

The Project goals were addressed through the following project objectives:

- Designed and reconstructed stream channels that convey bankfull flows while maintaining stable dimension, profile, and planform;
- Added in-stream structures and bank stabilization measures to protect restored streams;
- Installed habitat features such as brush toes, constructed riffles, woody materials, and pools of varying depths to restored streams;
- Increased forested riparian buffers to at least 50 feet on both sides of the channel along the Project reaches with a hardwood riparian plant community;
- Installed approximately 12,000 linear feet of livestock exclusion fencing along the easement boundary to ensure livestock will no longer have stream access;
- Treated exotic invasive species; and
- Established a permanent conservation easement on the Project that will exclude future livestock from stream channels and their associated buffers and prevent future land use changes.

Functional uplift, benefits, and improvements within the Project area, as based on the Function Based Framework, are outlined in the Mitigation Plan**.**

1.3 Project Success Criteria

The success criteria for the Project follows the 2016 USACE Wilmington District Stream and Wetland Compensatory Mitigation Update, the Groundhog Hollow Project Final Mitigation Plan, and subsequent agency guidance. Cross section and vegetation plot monitoring takes place in Years 0, 1, 2, 3, 5, and 7. Stream hydrology and visual monitoring takes place annually. Specific success criteria components are presented below.

Stream Restoration Success Criteria

Four bankfull flow events must be documented within the seven-year monitoring period. The bankfull events must occur in separate years. Otherwise, the stream monitoring will continue until four bankfull events have been documented in separate years.

There should be little change in as-built cross sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion) or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross sections shall be classified using the Rosgen stream classification method, and all monitored cross sections should fall within the quantitative parameters defined for channels of the design stream type. Bank height ratio shall not exceed 1.2, and the entrenchment ratio shall be above 1.4 within restored riffle cross sections. Channel stability should be demonstrated through a minimum of four bankfull events documented in the seven-year monitoring period.

Digital images are used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal images should not indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral images should not indicate excessive erosion or continuing degradation of the banks over time. A series of images over time should indicate successional maturation of riparian vegetation.

Specific Project reaches will be monitored to document intermittent or seasonal surface flow. Intermittent reaches must demonstrate a minimum of 30 consecutive days of flow.

Vegetation Success Criteria

Specific and measurable success criteria for plant density within the riparian buffers on the Project follow IRT Guidance. The interim measures of vegetative success for the Project is the survival of at least 320 planted three-year old trees per acre at the end of Year 3, 260 trees per acre with an average height of seven feet at the end of Year 5, and the final vegetative success criteria is 210 trees per acre with an average height of ten feet at the end of Year 7. Volunteer trees are counted, identified to species, and included in the yearly monitoring reports, but are not counted towards the success criteria of total planted stems until present for greater than two seasons. Moreover, any single species can only account for up to 50 percent of the required number of stems within any vegetation plot. Any stems in excess of 50 percent will be shown in the monitoring table but will not be used to demonstrate success.

Level	Treatment	Objective	Monitoring Metric	Performance Standard
1 ***Hydrology***	Convert land-use of Project reaches from pasture to riparian forest	Improve the transport of water from the watershed to the Project reaches in a non-erosive way	NA	NA
2 ***Hydraulic***	Reduce bank height ratios and increase entrenchment ratios by reconstructing channels to mimic reference reach conditions	Improve flood bank connectivity by reducing bank height ratios and increase entrenchment ratios	Stage recorders: Inspected quarterly	Four bankfull events occurring in separate years
			Flow gauge: Inspected quarterly	At least 30 days of continuous flow each year
			Cross sections: Surveyed in Years 1, 2, 3, 5 and 7	Entrenchment ratio shall be no less than 1.4 within restored reaches
				Bank height ratio shall not exceed 1.2
3 ***Geomorphology***	Establish a riparian buffer to reduce erosion and sediment transport into project streams. Establish stable banks with livestakes, erosion control matting, and other in stream structures.	Limit erosion rates and maintain channel stability Improve bedform diversity (pool spacing, percent riffles, etc. Increase buffer width to 50 feet	As-built stream profile	NA
			Cross sections: Surveyed in Years 1, 2, 3, 5 and 7	Entrenchment ratio shall be no less than 1.4 within restored reaches
			Visual monitoring	Bank height ratio shall not exceed 1.2
			Visual monitoring: Performed at least semiannually	Identify and document significant stream problem areas; i.e. erosion, degradation, aggradation, etc.
			Vegetation plots: Surveyed in Years 1, 2, 3, 5 and 7	MY 1-3: 320 trees/acre MY 5: 260 trees/acre (7 ft. tall) MY 7: 210 trees/acre (10 ft. tall)
4 ***Physicochemical***	Exclude livestock from riparian areas with exclusion fence, conservation easement, and plant a riparian buffer	*Unmeasurable Objective/Expected Benefit* Establish native hardwood riparian buffer and exclude livestock.	Vegetation plots: Surveyed in Years 1, 2, 3, 5 and 7 (*indirect measurement*)	MY 1-3: 320 trees/acre MY 5: 260 trees/acre (7 ft. tall) MY 7: 210 trees/acre (10 ft. tall)

			Visual assessment of established fencing and conservation signage: Performed at least semiannually (*indirect measurement*)	Inspect fencing and signage. Identify and document any damaged or missing fencing and/or signs

1.4 Project Components

The Project area is comprised of a 20.58-acre easement involving four unnamed tributaries which drain directly into the Lower Little River which eventually drains into the Catawba River. These four Project streams are split into nine reaches based on treatment type and/or changes in flow: GF1-A, GF1-B, GF2-A, GF2-B, GF3-A, GF3-B, GF4-A, GF4-B, and GF5.

Due to landowner and utility requirements, there are five easement breaks within the project. One break is for an existing utility easement; fencing was installed across the utility easement in order to provide contiguous livestock exclusion to the stream. The other three are locations for current agricultural crossings. These easement breaks will allow landowners to continue current land-use and access throughout the property as needed.

Through stream restoration and enhancement, the Project presents 6,129 LF of stream, generating 4,093.95 Warm Stream Mitigation Units (SMU). The stream mitigation components are summarized below. Mitigation credits presented below are based upon the Approved Mitigation Plan. To account for areas of more or less than minimum 50-foot buffer widths, credits were adjusted using the USACE Wilmington District Stream Buffer Credit Calculator.

Mitigation Approach	Linear Feet	Ratio	Warm SMU
Restoration	2,851	1	2,851.00
Enhancement I	306	1.5	204.00
Enhancement II	2,338	2.5	935.20
Enhancement II	253	5	5060
Enhancement II	381	7.5	50.80
Total	**6,129**		**4,091.60**
		Non-standard Buffer Width Adjustment	**+2.35***
		Total Adjusted SMUs	**4,093.95**

* Credit adjustment for Non-standard Buffer Width calculation using the Wilmington District Stream Buffer Credit Calculator issued by the USACE in January 2018.

1.5 Stream Design/Approach

The Project includes Priority I and II Restoration and Enhancement Levels I and II. Stream restoration incorporates the design of a single-thread meandering channel, with parameters based on data taken from reference sites, published empirical relationships, regional curves developed from existing project streams, and NC Regional Curves. Analytical design techniques were also a crucial element of the project and were used to determine the design discharge and to verify the design as a whole. For livestock exclusion, woven wire fencing with one strand of barbed wire at the top was installed.

The following treatments were performed on the Project reaches:

Reach GF1-A

An Enhancement Level II approach was performed for this reach to address areas of bed instability, bank erosion, and buffer impacts. Enhancement activities included:

- Stabilizing a 2-foot knick-point located near station 00+70 by installing two rock sills,
- Removal and regrading of an existing culvert crossing near station 03+50,
- Bank stabilization beginning near station 05+75 by installing a log vane and brush toe,
- Stabilizing a 5-foot headcut located near station 07+10 by installing a rock step-pool,
- Livestock exclusion,
- Riparian planting,
- Invasive vegetation treatment.

Reach GF1-B

An inline restoration approach was used for the upstream portion of the reach to address eroding banks, channel entrenchment, and buffer impacts. Restoration activities included:

- Raising the channel bed with a mix of log sill, log vanes, riffle grade controls, and clay plugs,
- Normalizing the existing channel alignment to reduce channel stress,
- Establishing a riffle pool sequence throughout the reach,
- Installing brush toe protection on meander bends,
- Transitioning existing vertical channel banks to a minimum 5:1 floodplain slope,
- Livestock exclusion,
- Riparian planting,
- Invasive vegetation treatment.

An offline priority I restoration approach was performed for the middle portion of the reach to address, eroding banks, channel entrenchment, and channel braiding. Restoration activities included:

- Regrading a new single thread channel in the existing floodplain,
- Installing log and rock structures to provide grade control and habitat,
- Establishing a riffle pool sequence throughout the reach,
- Installing brush toe protection on meander bends,
- Filling the existing channel,
- Replacing an existing ford crossing with a culvert crossing,
- Livestock exclusion,
- Riparian planting.

An offline priority II restoration approach was performed for the downstream potion of the reach to address, eroding banks, channel entrenchment, and channel braiding. Restoration activities included:

- Regrading a new single thread channel and floodplain,
- Installing log and rock structures to provide grade control and habitat,
- Establishing a riffle pool sequence throughout the reach,
- Installing brush toe protection on meander bends,
- Filling the existing channel,
- Livestock exclusion,
- Riparian planting.

Enhancement Level II was performed along the portion of the reach that ties into the Lower Little River and is within its non-encroachment area. Enhancement activities included:

- Livestock exclusion,
- Riparian planting,
- Invasive vegetation treatment.

Reach GF2-A

An Enhancement Level II approach was performed for this reach to address areas of bed instability, bank erosion, and buffer impacts. Enhancement activities included:

- Stabilizing a 9-foot headcut located near station 01+30 by installing log sills and a log step pool,
- Bed stabilization beginning near station 05+00 by installing a double log drop,
- Bank stabilization beginning near station 07+50 by installing a log vane and brush toe,
- Livestock exclusion,
- Riparian planting,
- Invasive vegetation treatment.

Reach GF2-B

A mix of offline and inline restoration was performed for this portion of the reach to address eroding banks, channel entrenchment, historic impoundment, and buffer impacts. Restoration activities included:

- Regrading a new single thread channel in the existing floodplain,
- Installing log and rock structures to provide grade control and habitat,
- Establishing a riffle pool sequence throughout the reach,
- Installing brush toe protection on meander bends,
- Removing the relic earthen dam and relic pond,
- Filling the existing channel,
- Replacing an existing ford crossing with a culvert crossing,
- Livestock exclusion,
- Riparian planting.

Reach GF3-A

An Enhancement Level I approach was performed for this reach to address areas of bank erosion, and buffer impacts. Enhancement activities included:

- Stabilizing the left bank near station 08+75 by installing a brush toe,
- Stabilizing the left bank near station 10+25 by installing a brush toe,
- Bank stabilization beginning near station 09+40 and 09+80 by installing a log vane,
- Floodplain grading,
- Livestock exclusion,
- Riparian planting,
- Invasive vegetation treatment.

Reach GF3-B

An offline restoration approach was performed for this portion of the reach to address eroding banks, channel entrenchment, and buffer impacts. Restoration activities included:

- Regrading a new single thread channel in the existing floodplain,
- Installing log and rock structures to provide grade control and habitat,
- Establishing a riffle pool sequence throughout the reach,
- Installing brush toe protection on meander bends,
- Filling the existing channel,
- Replacing an existing ford crossing with a culvert crossing,
- Livestock exclusion,
- Riparian planting.

Reach GF4-A

An Enhancement Level II approach was performed for this reach to address areas of bed instability, bank erosion, and buffer impacts. Enhancement activities included:

- Stabilizing head cut near station 00+50 by grading a vegetated swale,
- Stabilizing banks near station 01+50 by grading back channel banks,

- Bed stabilization beginning near station 03+30 by installing a rock step-pool,
- Removing and replacing the two existing 24" Corrugated Metal Pipes,
- Livestock exclusion,
- Riparian planting,
- Invasive vegetation treatment.

Reach GF4-B
A limited Enhancement Level II approach was performed for this reach at a reduced credit ratio. Enhancement activities included:

- Livestock exclusion,
- Riparian planting,
- Trash removal,
- Invasive vegetation treatment.
    - To ensure bank stability, Chinese privet was flush cut and sprayed; therefore, subsoil was not disturbed. Roots will remain intact while plantings establish roots.

Reach GF5
An Enhancement Level II approach was performed for this reach to address buffer impacts and protect multiple spring heads. Enhancement activities included:

- Livestock exclusion,
- Riparian planting,
- Removal of existing concrete tank,
- Invasive vegetation treatment.

1.6 Construction and As-Built Conditions

Stream construction was completed in September 2020 and planting was completed in December 2020. The Groundhog Hollow Project was built to design plans and guidelines. However, in May 2021, approximately 200 linear feet of channel (three percent of the total stream length) and 10 structures underwent repairs. Generally, the problem areas were step pools, sills, banks, and old channel erosion that failed during extreme high flows that occurred before vegetation could be established. Banks were regraded and matting was added, sills were replaced, repaired, or added to reestablish proposed bed elevations, and check dams were installed in the old channel to discourage concentrated flow. Repair areas were livestaked in May 2021 and will be livestaked again if needed during the following dormant season. Additionally, bareroot supplemental planting was performed in the areas affected by the repairs.

Planting plan changes included the removal of black gum (*Nyssa sylvatica*) and hackberry (*Celtis occidentalis*). Hackberry was replaced with sugarberry (*Celtis laevigata*) and the quantities of the other planted species were increased to compensate for not planting black gum. These changes were based on bare root availability. Minor monitoring device location changes were made during as-built installation; however, the quantities remained as proposed in the Final Mitigation Plan.

1.7 Monitoring Performance (MY2)

The Groundhog Hollow Monitoring activities were performed in July and October 2022. All monitoring year two data is present below and in the appendices. The project fencing previously encroaching into the easement, discussed in the MY1 report, has been relocated out of the easement. There are no known infringements on the easement. The Project is on track to meeting interim success criteria.

Vegetation

Monitoring of the nine fixed vegetation plots and three random vegetation plots was completed on October 25th, 2022. Vegetation data is in **Appendix C**, associated photos are in **Appendix B,** and plot locations are in **Appendix B**. MY2 monitoring data indicates that all plots are exceeding the interim success criteria of 320 planted stems per acre. Planted stem densities ranged from 364 to 688 planted stems per acre with a mean of 513 planted stems per acre across all fixed plots. Stem densities ranged from 526 to 647 planted stems per acre with a mean of 701 planted stems per acre across random plots. Total average stem density across all plots is 526 stems per acre and the average planted stem height in the vegetation plots was 3.1 feet. A total of eight species were documented within the plots. Volunteer species were not noted at monitoring year two but are expected to establish in upcoming years.

Visual assessment of vegetation outside of the monitoring plots indicates that the herbaceous vegetation is becoming well established throughout the project. During MY1 the eastern bank of GF3-A and part of GF4-B was determined to have low stem counts. This area was supplementally planted in March 2022 with 92 3-gallon container trees consisting of white oak (Quercus alba), American sycamore (Platanus occidentalis), northern red oak (Quercus rubra), willow oak (Quercus phellos), and tulip poplar (Liriodendron tulipifera). Chinese privet (Ligustrum sinensis) along GF4-B, approximately 0.26 acres, was flush cut but not excavated to promote bank stability in December, 2021 of MY1. This area will be continue to be monitored for vegetative succession and will be treated again in 2023 to reduce regrowth. Scattered Chinese privet was also noted along GF1-A, GF1-B, GF2-B, and GF4-A during MY2 and is being treated in 2023.

Stream Geomorphology

A total of 22 cross sections were installed on January 27, 2021 and geomorphology data collection for MY2 was conducted on July 5th, 2022. Summary tables and cross section plots are in **Appendix D**. Overall the cross sections and profile relatively match the proposed design. Slight degradation was observed on pool cross section six and pool cross section 13 during MY1 but has remained stable during MY2. Monitoring data shows minor changes in both cross sections and riffle cross sections above and below cross sections six and 13. The MY2 conditions show that channel conditions are stable and functioning as intended. All reaches were designed as gravel bed channels and remain classified as gravel bed channels post-construction.

Visual assessment of the stream channel was performed to document signs of instability, such as eroding banks, structural instability, or excessive sedimentation. A structure on GF4-A is deteriorating where the stream is beginning to add stress to the banks around the log sills. This potential problem structure is still holding grade and shouldn't affect most aquatic passage due to its headwater proximity but will be monitored and addressed if it continues to worsen. Problem areas are cataloged in **Appendix B**. A structure on GF2-a noted in the MY1 monitoring report appears to have stabilized but will continue to be monitored. The channel over all is transporting sediment as designed and will continue to be monitored for aggradation and degradation.

Stream Hydrology

Three stage recorders and one flow gauge were installed on February 4, 2021: one stage recorder on GF1-B, one stage recorder on GF2-B, one stage recorder on GF3-B, and one flow gauge on GF4-A. The stage recorders are in place to document bankfull events and the flow gauge to document at least intermittent flow. The stage recorder on GF1-B had 11 bankfull events with the highest reading being 0.78 feet above the top of bank. The stage recorded on GF2-B recorded 16 bankfull events with the highest reading being 0.67 feet above top of bank. The stage recorded on GF3-B recorded 15 bankfull events with the highest

reading being 0.68 feet above top of bank. Despite the large number of out of bank events, the channels were designed for water to access the floodplain. The reaches the gages are installed in are stable with established vegetation and at this time is not a concern on the project. The flow gauge on GF4-A recorded one flow event lasting 297 consecutive days. Gauge locations can be found on **Figure 2** and photos are in **Appendix B**.

2.0 Methods

Stream cross section monitoring was conducted using a Topcon GTS-312 Total Station. Three-dimensional coordinates associated with cross-section data were collected in the field (NAD83 State Plane feet FIPS 3200). Morphological data were collected at 22 cross-sections. Survey data were imported into CAD, ArcGIS®, and Microsoft Excel® for data processing and analysis. The stage recorders include an automatic pressure transducer placed in PVC casing in a pool. The elevation of the bed and top of bank at each stage recorder are used to detect bankfull events. The flow gauge was also installed in a pool and records flow conditions at an hourly interval. Water level data from the flow gauge is corrected using the height of the downstream riffle to detect stream flow events.

Vegetation success is being monitored at nine fixed monitoring plots and three random monitoring plot. Vegetation plot monitoring follows the CVS-EEP Level 2 Protocol for Recording Vegetation, version 4.2 (Lee et al. 2008) and includes analysis of species composition and density of planted species. Data are processed using the CVS data entry tool. In the field, the four corners of each plot were permanently marked with PVC at the origin and metal conduit at the other corners. Photos of each plot are to be taken from the origin each monitoring year. The random plots are to be collected in locations where there are no permanent vegetation plots. Random plots will most likely be collected in the form of 100 square meter belt transects with variable dimensions. Tree species and height will be recorded for each planted stem and the transects will be mapped and new locations will be monitored in subsequent years.

3.0 References

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Appendix A

Background Tables

Table 1. Groundhog Hollow (100049) - Mitigation Assets and Components

Project Segment	Existing Footage or Acreage	Mitigation Plan Footage or Acreage	Mitigation Category	Restoration Level	Priority Level	Mitigation Ratio (X:1)	Mitigation Plan Credits		As-Built Footage or Acreage	Comments
GF1-A	1,192	1,206	Warm	EII	N/A	2.50000	482.400		1202	Bed and bank stabilization, riparian planting, livestock exclusion (Powerline easement: STA 12+34 to 12+70)
GF1-A	62	62	Warm	EII	N/A	2.50000	24.800		63	Bed and bank stabilization, riparian planting, livestock exclusion
GF1-B	1034	1,020	Warm	R	P1/P2	1.00000	1020.000		1031	Channel restoration, riparian planting, livestock exclusion (Stream crossing: STA 23+52 to STA 24+12)
GF1-B	936	986	Warm	R	P1/P2	1.00000	986.000		994	Channel restoration, riparian planting, livestock exclusion
GF1-B	130	130	Warm	EII	N/A	2.50000	52.000		133	Riparian planting, livestock exclusion
GF2-A	642	642	Warm	EII	N/A	2.50000	256.800		636	Bed and bank stabilization, riparian planting, livestock exclusion
GF2-B	442	451	Warm	R	P1/P2	1.00000	451.000		459	Channel restoration, riparian planting, livestock exclusion (Stream crossing: STA 12+80 to STA 13+10)
GF2-B	167	83	Warm	R	P1/P2	1.00000	83.000		84	Channel restoration, riparian planting, livestock exclusion
GF3-A	311	306	Warm	EI	N/A	1.50000	204.000		306	Bed and bank stabilization, riparian planting, livestock exclusion (Stream crossing: STA 10+75 to STA 11+07)
GF3-B	270	311	Warm	R	P1	1.00000	311.000		311	Channel restoration, riparian planting, livestock exclusion
GF4-A	283*	298	Warm	EII	N/A	2.50000	119.200		283	Bed and bank stabilization, riparian planting, livestock exclusion (Stream crossing: STA 3+54 to STA 3+88)
GF4-B	381	381	Warm	EII	N/A	7.50000	50.800		383	Riparian planting, livestock exclusion
GF5	253	253	Warm	EII	N/A	5.00000	50.600		249	Riparian planting, livestock exclusion

Note: All crossings and utility easements have been removed from credit calculations.

Project Credits

Restoration Level	Stream			Riparian Wetland		Non-Rip Wetland	Coastal Marsh
	Warm	Cool	Cold	Riverine	Non-Riv		
Restoration	2851.000						
Re-establishment							
Rehabilitation							
Enhancement							
Enhancement I	204.000						
Enhancement II	935.200						
Enhancement II (5:1)	50.600						
Enhancement II (7.5:1)	50.800						
Creation							
Preservation							
NSBW	2.350						
Total	**4093.950**						

Table 2. Project Activity and Reporting History
Groundhog Hollow Mitigation Project

Elapsed Time Since grading complete: **26 months**
Elapsed Time Since planting complete: **25 months**
Number of reporting Years[1]: **2**

Activity or Deliverable	Data Collection Complete	Completion or Delivery
Restoration Plan	NA	Dec-19
Final Design – Construction Plans	NA	Jun-20
Stream Construction	NA	Sep-20
Site Planting	NA	Dec-20
As-built (Year 0 Monitoring – baseline)	Feb-21	Jun-21
Stream Channel and Structure Reapirs	NA	May-21
Invasive Plant Treatment	NA	Dec-21
Year 1 Monitoring	Nov-21	Dec-21
Supplemental Planting	NA	Mar-22
Fence Relocation	NA	Aug-22
Year 2 Monitoring	Oct-22	Dec-22
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		
Year 6 Monitoring		
Year 7 Monitoring		

1 = The number of reports or data points produced excluding the baseline

Table 3. Project Contacts Table Groundhog Hollow Mitigation Project	
Designer	RES / 3600 Glenwood Ave., Suite 100, Raleigh, NC 27612
Primary project design POC	Ben Carroll, PE
Construction Contractor	Carolina Environmental Contracting Inc. / PO Box 1905 Mount Airy, NC 27030
Construction contractor POC	James Poe
Survey Contractor	WSP USA / 434 Fayetteville St, Suite 1500, Raleigh, NC 27601
Survey contractor POC	Barry Creed, PLS
Planting Contractor	Shenandoah Habitats
Planting contractor POC	David Coleman
Monitoring Performers	RES / 3600 Glenwood Ave, Suite 100, Raleigh, NC 27612
Monitoring POC	Ryan Medric (919) 741-6268

Table 4. Project Background Information										
Project Name	Groundhog Hollow									
County	Alexander									
Project Area (acres)	20.58									
Project Coordinates (latitude and longitude)	35.937201° N, -81.237783° W									
Planted Acreage (Acres of Woody Stems Planted)	14.42									
Project Watershed Summary Information										
Physiographic Province	Northern Inner Piedmont									
River Basin	Catawba									
USGS Hydrologic Unit 8-digit	3050101	USGS Hydrologic Unit 14-digit	3050101120030							
DWR Sub-basin	03-08-32									
Project Drainage Area (Acres and Square Miles)	156 (0.24)									
Project Drainage Area Percentage of Impervious Area	<1%									
CGIA Land Use Classification	Managed Herbaceous Cover, Mixed Upland Hardwoods									
Reach Summary Information										
Parameters	**Reach GF1-A**	**Reach GF1-B**	**Reach GF2-A**	**Reach GF2-B**	**Reach GF3-A**	**Reach GF3-B**	**Reach GF4-A**	**Reach GF4-B**	**Reach GF5**	
Length of reach (linear feet)	1,254	2,100	642	609	311	270	283	381	253	
Valley confinement (Confined, moderately confined, unconfined)	Moderately confined	Moderately confined/Unconfined	Confined	Moderately confined	Moderately confined	Unconfined	Moderately confined/Unconfined	Confined	Moderately confined	
Drainage area (Acres and Square Miles)	42 (0.07)	156 (0.24)	35 (0.05)	45 (0.07)	36 (0.06)	39 (0.06)	16 (0.02)	23 (0.04)	9 (0.01)	
Perennial, Intermittent, Ephemeral	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Intermittent	Perennial	
Thermal Regime	Warm	Warm	Warm	Warm	Warm	Warm	Warm	Warm	Warm	
NCDWR Water Quality Classification	C	C	C	C	C	C	C	C	C	
Stream Classification (existing)	F4b	G4c/C4	F4b	F4b	G4	G5/6	G4	F4b	C4/5a	
Stream Classification (proposed)	F4b	C4/E4	F4b	C4/E4	G4	C4/E4	G4	F4b	C4/5a	
Evolutionary trend (Simon)	III / IV	II / III	IV	III	III / IV	III	IV / V	IV	I	
FEMA classification	Zone X	Zone X and Zone AE	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	

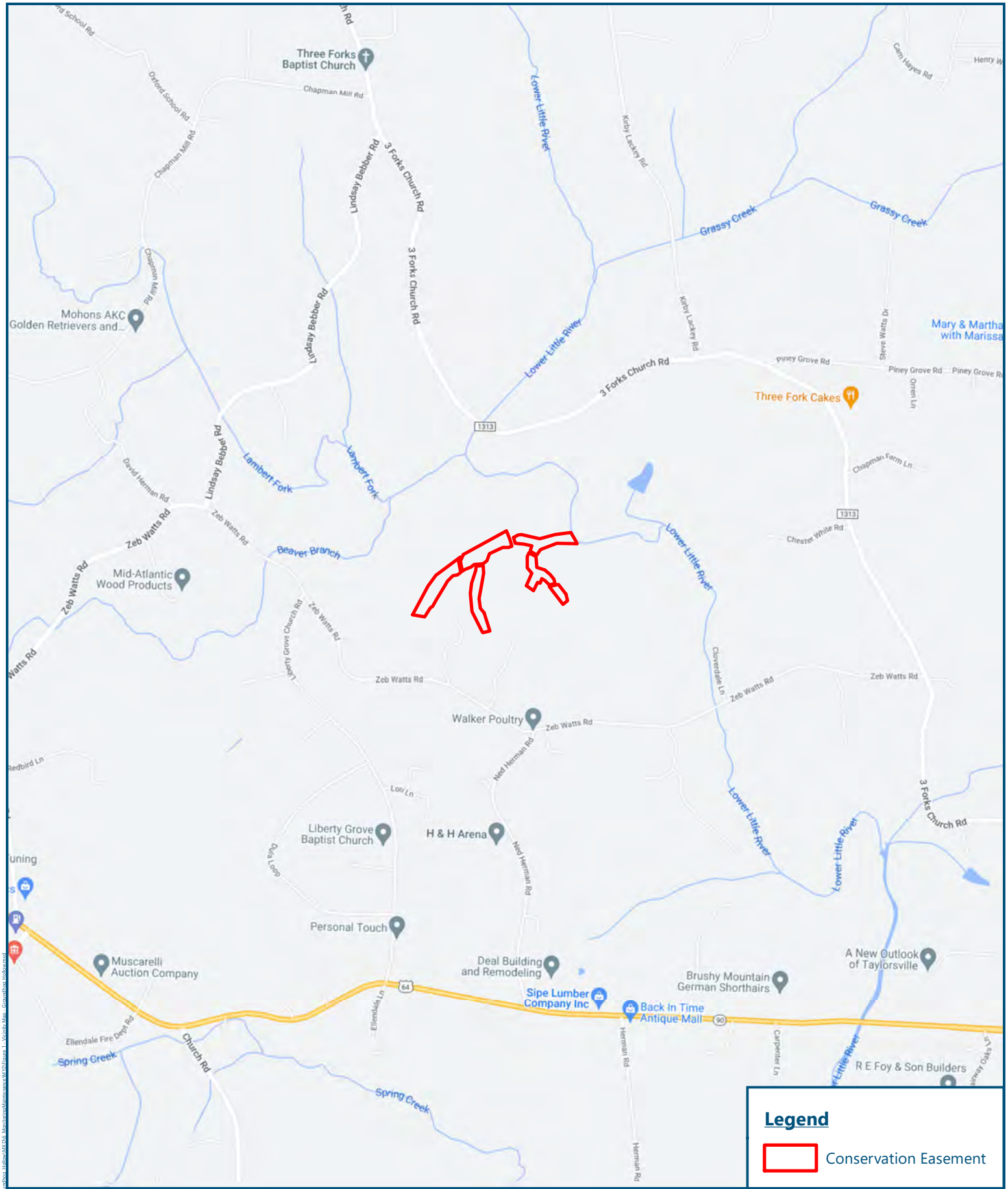

Figure 1 - Site Location Map

Groundhog Hollow Mitigation Project

Alexander County, North Carolina

Date: 10/27/2022

Drawn by: GDS

Checked by: RTM

1 inch = 2,000 feet

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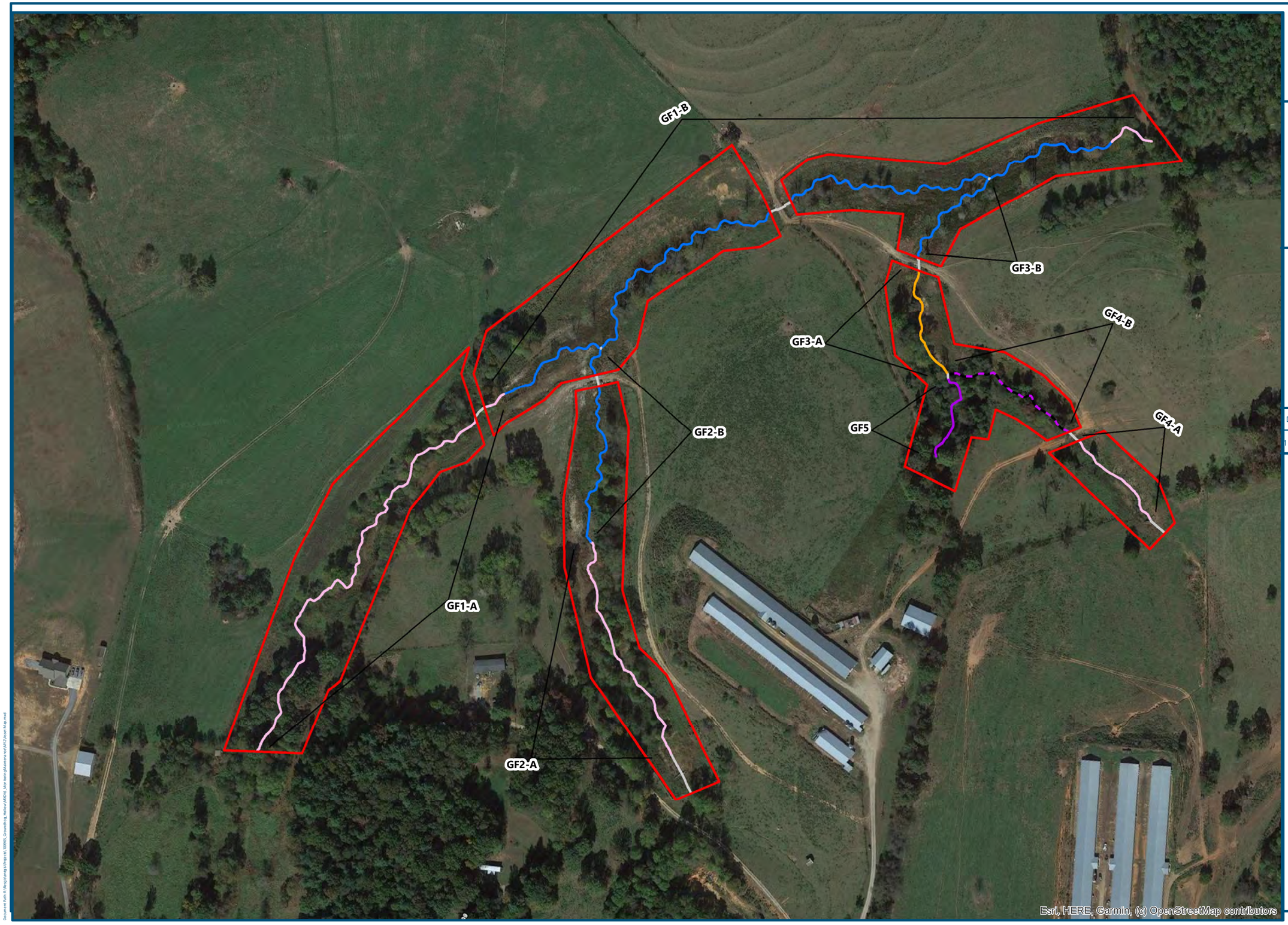
Appendix B

Visual Assessment Data



res

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N
W E
S

0 100 200

Feet

Asset Figure

Groundhog Hollow Mitigation Project

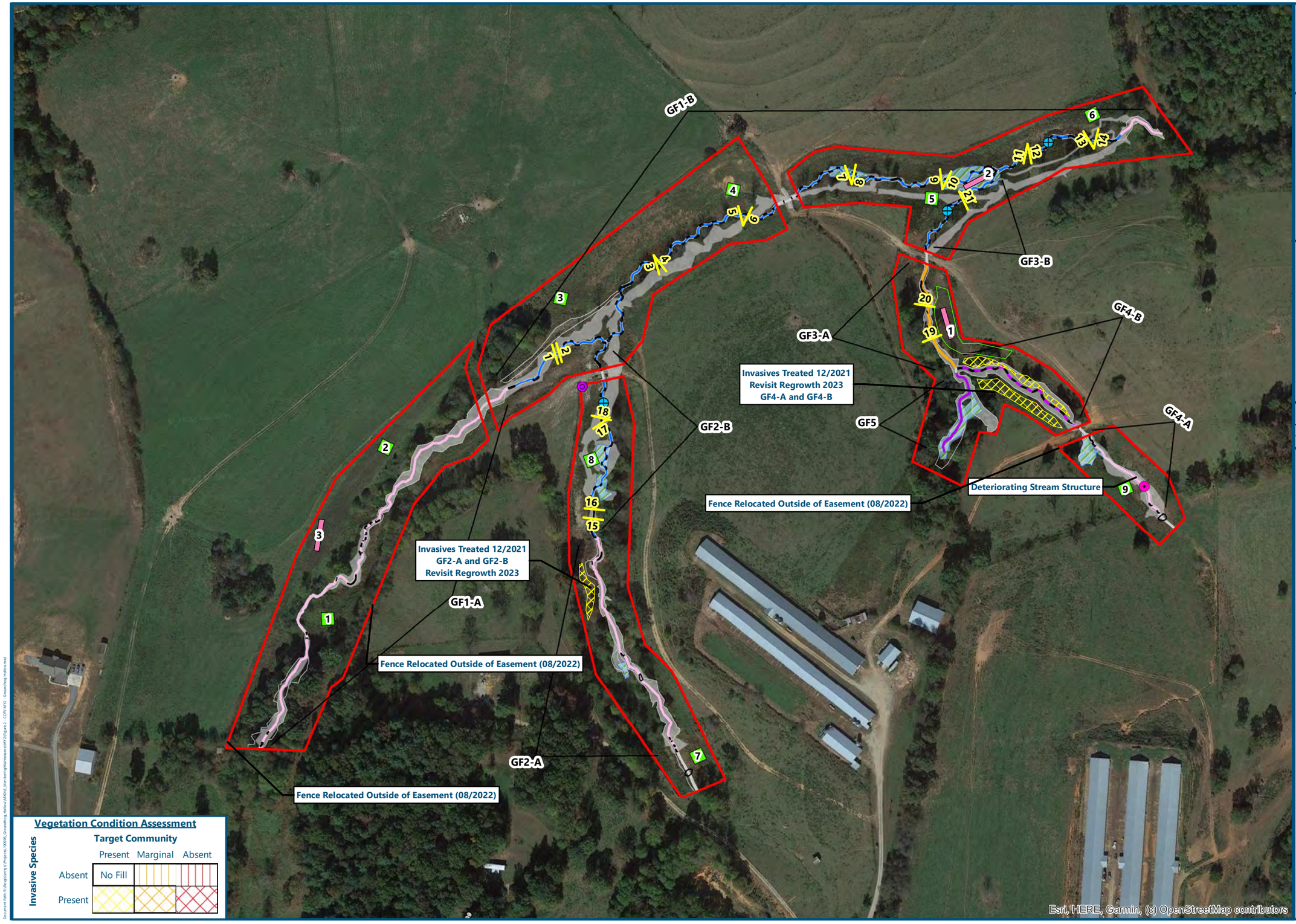
Alexander County, North Carolina

Date: 2/8/2023	Drawn by: DGD
1 in = 235 feet	Checked by: RTM

Legend

- Conservation Easement
- Stream Mitigation Approach
- Restoration
- Enhancement I
- Enhancement II
- Enhancement II (5:1)
- Enhancement II (7.5:1)
- No Credit

Document Path: K:\Projects\NC\Projects 100925_GroundHog_Hollow\MXD\5_Monitoring\Maintenance\MY2\Asset Map.mxd



res

Restoring a resilient earth for a modern world

N
W
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0 100 200
Feet

Figure 2 - CCPV MY2

Groundhog Hollow Mitigation Project

Alexander County, North Carolina

Date: 2/10/2023	Drawn by: DGD
1 in = 235 feet	Checked by: RTM

Legend

- Conservation Easement
- Supplemental Planting MY2
- Invasive Vegetation Regrowth
- Existing Wetland

MY2 Random Veg Plots

- > 320 Stems/Acre

Fixed Vegetation Plot

- >320 stems/acre
- As-Built Top of Bank
- Existing Top of Bank

Stream Mitigation Approach

- Restoration
- Enhancement I
- Enhancement II
- Enhancement II (5:1)
- Enhancement II (7.5:1)
- No Credit
- Stream Structure
- Cross Section

Gauge Type

- Ambient
- Flow Gauge
- Stage Recorder

Document Path: R:\Projects\Projects\100905_GroundHog_Hollow\GMD\9_Monitoring\Maintenance\MY2\Figure 2 - CCPV MY2 - GroundHog Hollow.mxd

Visual Stream Stability Assessment Table 5a

Reach GF1-B
Assessed Stream Length 2006
Assessed Bank Length 4012
Last Site Inspection - Oct 25, 2022

Major Channel Category		Metric	Number Stable, Performing as Intended	Total Number in As-built	Amount of Unstable Footage	% Stable, Performing as Intended
Bank	**Surface Scour/Bare Bank**	Bank lacking vegetative cover resulting simply from poor growth and/or surface scour			0	100%
	Toe Erosion	Bank toe eroding to the extent that bank failure appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	100%
	Bank Failure	Fluvial and geotechnical - rotational, slumping, calving, or collapse			0	100%
Totals					0	100%
Structure	**Grade Control**	Grade control structures exhibiting maintenance of grade across the sill.	32	32		100%
	Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in DMS monitoring guidance document)	60	60		100%

Visual Stream Stability Assessment Table 5b

Reach GF2-B
Assessed Stream Length 534
Assessed Bank Length 1068
Last Site Inspection - Oct 25, 2022

Major Channel Category		Metric	Number Stable, Performing as Intended	Total Number in As-built	Amount of Unstable Footage	% Stable, Performing as Intended
Bank	**Surface Scour/Bare Bank**	Bank lacking vegetative cover resulting simply from poor growth and/or surface scour			0	100%
	Toe Erosion	Bank toe eroding to the extent that bank failure appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	100%
	Bank Failure	Fluvial and geotechnical - rotational, slumping, calving, or collapse			0	100%
Totals					0	100%
Structure	**Grade Control**	Grade control structures exhibiting maintenance of grade across the sill.	15	15		100%
	Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in DMS monitoring guidance document)	18	18		100%

Visual Stream Stability Assessment Table 5c

Reach GF3-B
Assessed Stream Length 311
Assessed Bank Length 622
Last Site Inspection - Oct 25, 2022

Major Channel Category		Metric	Number Stable, Performing as Intended	Total Number in As-built	Amount of Unstable Footage	% Stable, Performing as Intended
Bank	**Surface Scour/Bare Bank**	Bank lacking vegetative cover resulting simply from poor growth and/or surface scour			0	100%
	Toe Erosion	Bank toe eroding to the extent that bank failure appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	100%
	Bank Failure	Fluvial and geotechnical - rotational, slumping, calving, or collapse			0	100%
Totals					0	100%
Structure	**Grade Control**	Grade control structures exhibiting maintenance of grade across the sill.	6	6		100%
	Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in DMS monitoring guidance document)	12	12		100%

Table 6 Vegetation Condition Assessment

Planted Acreage[1] **14.42**

Last Site Inspection - Oct 25, 2022

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres	Red Simple Hatch	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres	Orange Simple Hatch	0	0.00	0.0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres	Orange Simple Hatch	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage[2] **20.66**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern[4]	Areas or points (if too small to render as polygons at map scale).	1000 SF	Yellow Crosshatch	3	0.26	1.3%
5. Easement Encroachment Areas[3]	Areas or points (if too small to render as polygons at map scale).	none	Red Simple Hatch	0	0.00	0.0%

1 = Enter the planted acreage within the easement. This number is calculated as the easement acreage minus any existing mature tree stands that were not subject to supplemental planting of the understory, the channel acreage, crossings or any other elements not directly planted as part of the project effort.

2 = The acreage within the easement boundaries.

3 = Encroachment may occur within or outside of planted areas and will therefore be calculated against the overall easement acreage. In the event a polygon is cataloged into items 1, 2 or 3 in the table and is the result of encroachment, the associated acreage should be tallied in the relevant item (i.e., item 1,2 or 3) as well as a parallel tally in item 5.

4 = Invasives may occur in or out of planted areas, but still within the easement and will therefore be calculated against the overall easement acreage. Invasives of concern/interest are listed below. The list of high concern spcies are those with the potential to directly outcompete native, young, woody stems in the short-term (e.g. monitoring period or shortly thereafter) or affect the community structure for existing, more established tree/shrub stands over timeframes that are slightly longer (e.g. 1-2 decades). The low/moderate concern group are those species that generally do not have this capacity over the timeframes discussed and therefore are not expected to be mapped with regularity, but can be mapped, if in the judgement of the observer their coverage, density or distribution is suppressing the viability, density, or growth of planted woody stems. Decisions as to whether remediation will be needed are based on the integration of risk factors by EEP such as species present, their coverage, distribution relative to native biomass, and the practicality of treatment. For example, even modest amounts of Kudzu or Japanese Knotweed early in the projects history will warrant control, but potentially large coverages of Microstegium in the herb layer will not likley trigger control because of the limited capacities to impact tree/shrub layers within the timeframes discussed and the potential impacts of treating extensive amounts of ground cover. Those species with the "watch list" designator in gray shade are of interest as well, but have yet to be observed across the state with any frequency. Those in *red italics* are of particular interest given their extreme risk/threat level for mapping as points where isolated specimens are found, particularly ealry in a projects monitoring history. However, areas of discreet, dense patches will of course be mapped as polygons. The symbology scheme below was one that was found to be helpful for symbolzing invasives polygons, particulalry for situations where the conditon for an area is somewhere between isolated specimens and dense, discreet patches. In any case, the point or polygon/area feature can be symbolized to describe things like high or low concern and species can be listed as a map inset, in legend items if the number of species are limited or in the narrative section of the executive summary.

Groundhog Hollow MY2 Vegetation Monitoring Plot Photos

Vegetation Plot 1 (10/25/2022)

Vegetation Plot 2 (10/25/2022)

Vegetation Plot 3 (10/25/2022)

Vegetation Plot 4 (10/25/2022)

Vegetation Plot 5 (10/25/2022)

Vegetation Plot 6 (10/25/2022)

Vegetation Plot 7 (10/25/2022)

Vegetation Plot 8 (10/25/2022)

Vegetation Plot 9 (10/25/2022)

Random Vegetation Plot 1 (10/25/2022)

Random Vegetation Plot 2 (10/25/2022)

Random Vegetation Plot 3 (10/25/2022)

Groundhog Hollow Monitoring Device Photos MY2

Stage Recorder GF1-B (10/25/2022)

Stage Recorder GF2-B (7/6/2022)

Stage Recorder GF3-A (10/25/2022)

Flow Gauge GF4-A (10/25/2022)

Groundhog Hollow Crossing Photos

Crossing GF2-B - Upstream (7/5/2022)

Crossing GF2-B – Downstream (7/5/2022)

Crossing GF1-B – Downstream (7/5/2022)

Crossing GF1-B – Upstream (7/5/2022)

Groundhog Hollow Crossing Photos

Crossing GF3 – Downstream (10/25/2022)

Crossing GF3 – Upstream (10/25/2022)

Crossing GF1-A – Downstream (7/5/2022)

Crossing GF1-A - Upstream (7/5/2022)

GF4A Crossing - Downstream

Monitoring Year 2 – 2022 Problem Area Photos

Structure Decline GF4-A

Appendix C

Vegetation Plot Data

Table 7. Planted Species Summary

Common Name	Scientific Name	Mit Plan %	As-Built %	Wetland Indicator Status	Total Stems Planted
White Oak	*Quercus alba*	15	15	FACU	2,100
River Birch	*Betula nigra*	15	15	FACW	2,100
Sycamore	*Platanus occidentalis*	15	15	FACW	2,100
Willow Oak	*Quercus phellos*	15	15	FAC	2,100
Persimmon	*Diospyros virginiana*	5	10	FAC	1,500
Northern Red Oak	*Quercus rubra*	10	10	FAC	1,500
Yellow Poplar	*Liriodendron tulipifera*	10	10	FACU	1,500
Sugarberry	*Celtis laevigata*	0	10	FACW	1,500
Hackberry	*Celtis occidentalis*	10	0	FACU	0
Blackgum	*Nyssa sylvatica*	5	0	FAC	0
				Total	14,400
				Planted Area	14.42
				As-built Planted Stems/Acre	999

Table 8. Vegetation Plot Mitigation Success Summary

Plot #	Planted Stems/Acre	Volunteer Stems/Acre	Total Stems/Acre	Success Criteria Met?	Average Planted Stem Height (ft)
1	405	0	405	Yes	2.0
2	364	0	364	Yes	1.7
3	526	0	526	Yes	2.0
4	486	0	486	Yes	2.6
5	526	0	526	Yes	4.5
6	445	0	445	Yes	2.9
7	607	0	607	Yes	3.7
8	688	0	688	Yes	2.9
9	567	0	567	Yes	3.1
R1	526	0	526	Yes	5.2
R2	647	0	647	Yes	3.5
R3	526	0	526	Yes	2.2
Project Avg	**526**	**0**	**526**	**Yes**	**3.1**

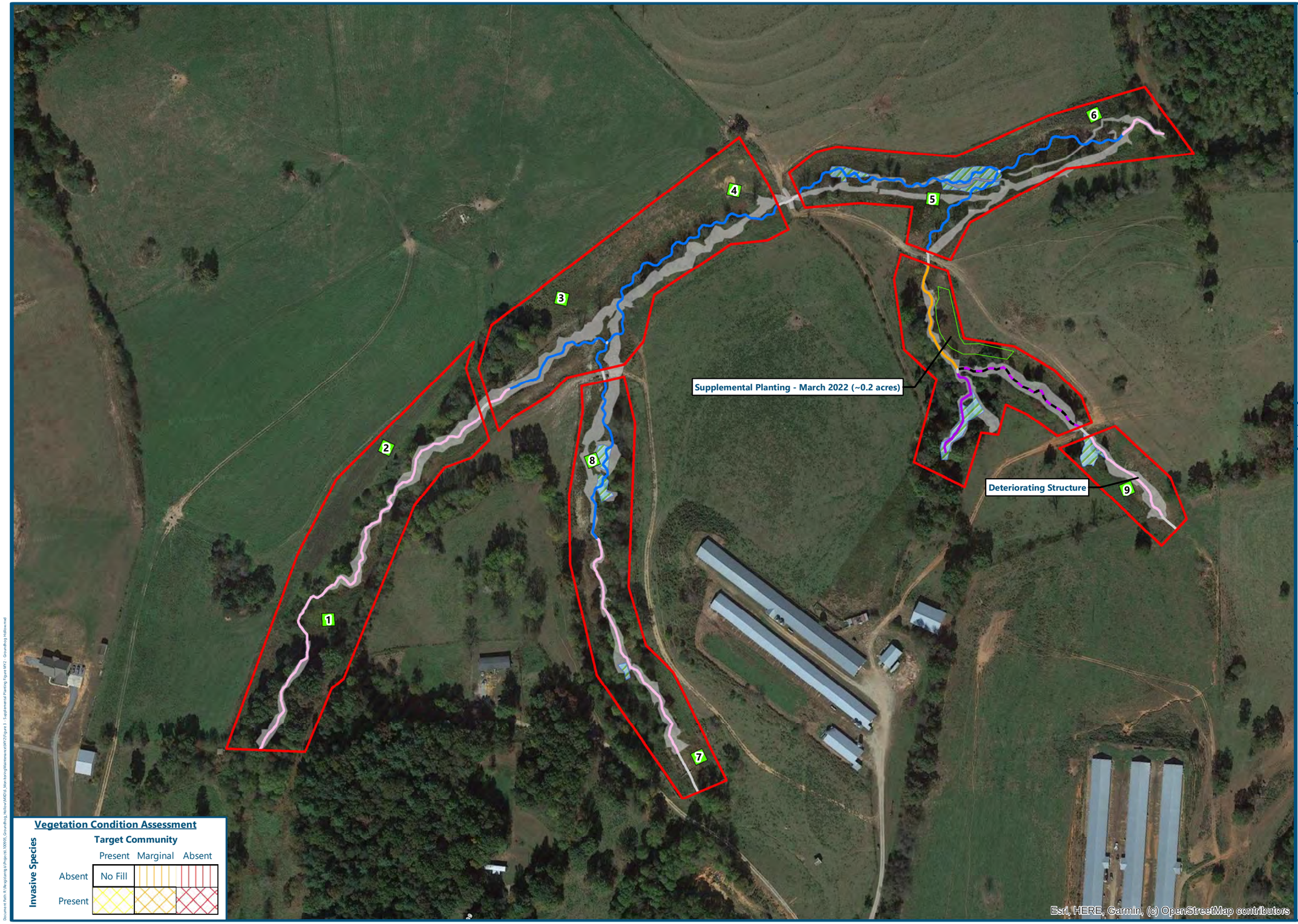
Table 9. Stem Count Total and Planted by Plot Species

EEP Project Code 100049. Project Name: Groundhog Hollow

			Current Plot Data (MY2 2022)																									
			100049-01-0001			100049-01-0002			100049-01-0003			100049-01-0004			100049-01-0005			100049-01-0006			100049-01-0007			100049-01-0008			100049-01-0009		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Betula nigra	river birch	Tree	1	1	1							3	3	3	6	6	6							4	4	4	6	6	6
Celtis laevigata	sugarberry	Tree	2	2	2				2	2	2							4	4	4	8	8	8	1	1	1			
Diospyros virginiana	common persimmon	Tree																											
Liriodendron tulipifera	tulip tree	Tree																											
Platanus occidentalis	American sycamore	Tree							2	2	2	3	3	3	4	4	4				1	1	1	6	6	6	6	6	6
Quercus alba	white oak	Tree				2	2	2	2	2	2							1	1	1	2	2	2	1	1	1			
Quercus phellos	willow oak	Tree	7	7	7							2	2	2	3	3	3							4	4	4			
Quercus rubra	northern red oak	Tree				7	7	7	7	7	7	4	4	4				6	6	6	4	4	4	1	1	1	2	2	2
		Stem count	10	10	10	9	9	9	13	13	13	12	12	12	13	13	13	11	11	11	15	15	15	17	17	17	14	14	14
		size (ares)	1			1			1			1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	3	3	3	2	2	2	4	4	4	4	4	4	3	3	3	3	3	3	4	4	4	6	6	6	3	3	3
		Stems per ACRE	405	405	405	364	364	364	526	526	526	486	486	486	526	526	526	445	445	445	607	607	607	688	688	688	567	567	567

			Current Plot Data (MY2 2022)									Annual Means								
			R1			R2			R3			MY2 (2022)			MY1 (2021)			MY0 (2021)		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Betula nigra	river birch	Tree				6	6	6				26	26	26	22	22	22	33	33	33
Celtis laevigata	sugarberry	Tree	1	1	1				1	1	1	19	19	19	16	16	16	17	17	17
Diospyros virginiana	common persimmon	Tree	1	1	1							1	1	1	1	1	1	1	1	1
Liriodendron tulipifera	tulip tree	Tree	1	1	1							1	1	1						
Platanus occidentalis	American sycamore	Tree	1	1	1	9	9	9				32	32	32	19	19	19	22	22	22
Quercus alba	white oak	Tree							1	1	1	9	9	9	10	10	10	12	12	12
Quercus phellos	willow oak	Tree	4	4	4	1	1	1				21	21	21	18	18	18	26	26	26
Quercus rubra	northern red oak	Tree	5	5	5				11	11	11	47	47	47	34	34	34	41	41	41
		Stem count	13	13	13	16	16	16	13	13	13	156	156	156	120	120	120	152	152	152
		size (ares)	1			1			1			12			9			9		
		size (ACRES)	0.02			0.02			0.02			0.30			0.22			0.22		
		Species count	6	6	6	3	3	3	3	3	3	8	8	8	7	7	7	7	7	7
		Stems per ACRE	526	526	526	647	647	647	526	526	526	526	526	526	540	540	540	683	683	683

Supplemental Planting Summary Table: Groundhog Hollow				
Common Name	**Species**	**Wetland**	**Size**	**Stems Planted**
White Oak	*Quercus alba*	FACU	3 Gallon	2
American Sycamore	*Plantanus occidentalis*	FACW	3 Gallon	7
Northern Red Oak	*Quercus rubra*	FACU	3 Gallon	38
Willow Oak	*Quercus phellos*	FACW	3 Gallon	36
Tulip Poplar	*Liriodendron tulipifera*	FACU	3 Gallon	9
			Total Stems Planted	**91**



Vegetation Condition Assessment

Invasive Species	Target Community: Present	Target Community: Marginal	Target Community: Absent
Absent	No Fill		
Present			

res

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N W E S

0 100 200

Feet

Figure 3 - Supplemental Planting MY2

Groundhog Hollow Mitigation Project

Alexander County, North Carolina

Date: 2/8/2023	Drawn by: DGD
1 in = 235 feet	Checked by: RTM

Legend

- Conservation Easement
- Supplemental Planting MY2
- Existing Wetland

Fixed Vegetation Plot

- >320 stems/acre
- Existing Top of Bank

Stream Mitigation Approach

- Restoration
- Enhancement I
- Enhancement II
- Enhancement II (5:1)
- Enhancement II (7.5:1)
- No Credit

Document Path: R:\Projects\100105_GroundHog_Hollow\MY02\6_Monitoring\Maintenance\MY2\Figure 3 - Supplemental Planting\Figure MY2 - GroundHog Hollow.mxd

Appendix D

Stream Measurement and Geomorphology Data

Table 10. Baseline Stream Data Summary
Groundhog Hollow Mitigation Site - Reach GF1-B

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			Monitoring Baseline					
Dimension and Substrate - Riffle Only		LL	UL	Eq.	Min	Mean	Med	Max	SD[5]	n	Min	Mean	Med	Max	SD[5]	n	Min	Med	Max	Min	Mean	Med	Max	SD[5]	n
Bankfull Width (ft)		---	---	---	4.4	--	6.3	8.3	---	3	4.4	---	---	---	---	1	5.2	5.3	6.8	6.2	6.8	6.4	8.3	0.8	7
Floodprone Width (ft)					6.5	---	8.3	22.5	---	3	12.0	---	---	20.0	---	1	19.2	19.3	20.8	44.8	47.6	47.0	50.6	2.5	7
Bankfull Mean Depth (ft)		---	---	---	0.5	---	0.6	1.1	---	3	0.5	---	---	0.6	---	1	0.5	0.5	0.7	---	---	---	---	---	---
[1]Bankfull Max Depth (ft)					0.9	---	0.9	1.3	---	3	0.8	---	---	0.9	---	1	0.7	0.7	1.0	0.6	1.0	1.0	1.4	0.2	7
Bankfull Cross Sectional Area (ft^2)		---	---	---	2.6	---	4.5	6.8	---	3	2.1	---	---	2.8	---	1	2.5	2.7	5.0	1.9	3.8	3.4	6.2	1.4	7
Width/Depth Ratio					5.9	---	7.6	15.2	---	3	6.9	---	---	9.2	---	1	9.2	10.3	10.7	---	---	---	---	---	---
Entrenchment Ratio					1.3	---	1.5	2.9	---	3	2.7	---	---	4.5	---	1	3.6	3.7	3.9	5.5	7.1	7.3	8.2	1.0	7
[1]Bank Height Ratio					1.3	---	2.3	2.8	---	3	1.0	---	---	2.5	---	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	7
Profile																									
Riffle Length (ft)					---	---	---	---	---	---	4	---	---	18	---	---	3.9	---	19.8	2	8	7	18	3	84
Riffle Slope (ft/ft)					---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.0	3.1	2.5	11.4	2.3	84.0
Pool Length (ft)					---	---	---	---	---	---	3	---	---	8	---	---	3.2	---	9	3	16	14	87	10	83
Pool Max depth (ft)					---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pool Spacing (ft)					---	---	---	---	---	---	12	---	---	35	---	---	13.1	---	38.8	9	24	22	92	11	83
Pattern																									
Channel Beltwidth (ft)					---	---	---	---	---	---	15	---	---	35	---	---	16.7	---	39	16.7	---	---	39	---	---
Radius of Curvature (ft)					---	---	---	---	---	---	6	---	---	17	---	---	6.7	---	18.7	6.7	---	---	18.7	---	---
Rc:Bankfull width (ft/ft)					---	---	---	---	---	---	1.4	---	---	3.9	---	---	1.2	---	3.3	1.2	---	---	3.3	---	---
Meander Wavelength (ft)					---	---	---	---	---	---	23	---	---	43	---	---	25.3	---	47.7	25.3	---	---	47.7	---	---
Meander Width Ratio					---	---	---	---	---	---	3.4	---	---	8	---	---	4.4	---	8.3	4.4	---	---	8.3	---	---
Transport parameters																									
Reach Shear Stress (competency) lb/f^2					---												---			---					
Max part size (mm) mobilized at bankfull					---												---			---					
Stream Power (transport capacity) W/m^2					---												---			---					
Additional Reach Parameters																									
Rosgen Classification					F4b						E4/5						C4/E4			C4/E4					
Bankfull Velocity (fps)		---	---	---	---						---						---			---					
Bankfull Discharge (cfs)		---	---	---	---						---						---			---					
Valley length (ft)					1168						842						1535			1535					
Channel Thalweg length (ft)					1350						995						689			689					
Sinuosity (ft)					1.16						1.18						1.17			1.17					
Water Surface Slope (Channel) (ft/ft)					---						---						---			---					
Channel slope (ft/ft)					0.024						0.0033						0.011			0.011					
[3]Bankfull Floodplain Area (acres)					---						---						---			---					
[4]% of Reach with Eroding Banks					---						---														
Channel Stability or Habitat Metric					---						---														
Biological or Other					---						---														

Shaded cells indicate that these will typically not be filled in.

1 = The distributions for these parameters can include information from both the cross-section measurements and the longitudinal profile. 2 = For projects with a proximal USGS gauge in-line with the project reach (added bankfull verification - rare).

3. Utilizing XS measurement data produce an estimate of the bankfull floodplain area in acres, which should be the area from the top of bank to the toe of the terrace riser/slope.

4 = Proportion of reach exhibiting banks that are eroding based on the visual survey for comparison to monitoring data; 5. Of value/needed only if the n exceeds 3

Table 10. Baseline Stream Data Summary (continued)
Groundhog Hollow Mitigation Site - Reach GF2-B

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			Monitoring Baseline					
Dimension and Substrate - Riffle Only		LL	UL	Eq.	Min	Mean	Med	Max	SD[5]	n	Min	Mean	Med	Max	SD[5]	n	Min	Med	Max	Min	Mean	Med	Max	SD[5]	n
Bankfull Width (ft)		---	---	---	---	---	7.7	---	---	1	---	---	4.4	---	---	1	---	4.9	---	5.5	6.6	6.8	7.5	1.0	3
Floodprone Width (ft)					---	---	8.1	---	---	1	---	---	12.0	20.0	---	1	---	16.9	---	38.6	44.9	45.4	50.8	6.1	3
Bankfull Mean Depth (ft)		---	---	---	---	---	0.5	---	---	1	---	---	0.5	0.6	---	1	---	0.4	---	---	---	---	---	---	---
[1]Bankfull Max Depth (ft)					---	---	0.8	---	---	1	---	---	0.8	0.9	---	1	---	0.6	---	1.0	1.1	1.1	1.2	0.1	3
Bankfull Cross Sectional Area (ft^2)		---	---	---	---	---	4.0	---	---	1	---	---	2.1	2.8	---	1	---	2.2	---	3.0	3.8	3.7	4.8	0.9	3
Width/Depth Ratio					---	---	14.8	---	---	1	---	---	6.9	9.2	---	1	---	11.1	---	---	---	---	---	---	---
Entrenchment Ratio					---	---	1.1	---	---	1	---	---	2.7	4.5	---	1	---	3.4	---	5.7	6.9	6.8	8.3	1.3	3
[1]Bank Height Ratio					---	---	2.1	---	---	1	---	---	1.0	2.5	---	1	---	1.0	---	1.0	1.0	1.0	1.0	0.0	3
Profile																									
Riffle Length (ft)					---	---	---	---	---	---	4	---	---	18	---	---	3.3	---	16.9	3	9	6	48	9	27
Riffle Slope (ft/ft)					---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.5	3.4	2.5	16.3	3.2	27.0
Pool Length (ft)					---	---	---	---	---	---	3	---	---	8	---	---	2.7	---	7.6	6	12	11	22	4	26
Pool Max depth (ft)					---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pool Spacing (ft)					---	---	---	---	---	---	12	---	---	35	---	---	11.1	---	33	12	21	19	65	11	25
Pattern																									
Channel Beltwidth (ft)					---	---	---	---	---	---	15	---	---	35	---	---	14	---	33	14	---	---	33	---	---
Radius of Curvature (ft)					---	---	---	---	---	---	6	---	---	17	---	---	6	---	16	6	---	---	16	---	---
Rc:Bankfull width (ft/ft)					---	---	---	---	---	---	1.4	---	---	3.9	---	---	1.2	---	3.3	1.2	---	---	3.3	---	---
Meander Wavelength (ft)					---	---	---	---	---	---	23	---	---	43	---	---	30	---	56	30	---	---	56	---	---
Meander Width Ratio					---	---	---	---	---	---	3.4	---	---	8	---	---	6.1	---	11.5	6.1	---	---	11.5	---	---
Transport parameters																									
Reach Shear Stress (competency) lb/f^2					---												---			---					
Max part size (mm) mobilized at bankfull					---												---			---					
Stream Power (transport capacity) W/m^2					---												---			---					
Additional Reach Parameters																									
Rosgen Classification					F4b						E4/5						C4/E4			C4/E4					
Bankfull Velocity (fps)		---	---	---	---						---						---			---					
Bankfull Discharge (cfs)		---	---	---	---												---			---					
Valley length (ft)					573						842						492			492					
Channel Thalweg length (ft)					680						995						53			53					
Sinuosity (ft)					1.19						1.18						1.14			1.14					
Water Surface Slope (Channel) (ft/ft)					---						---						---			---					
Channel slope (ft/ft)					0.031						0.0033						0.02			0.02					
[3]Bankfull Floodplain Area (acres)					---						---						---			---					
[4]% of Reach with Eroding Banks					---						---														
Channel Stability or Habitat Metric					---						---														
Biological or Other					---						---														

Shaded cells indicate that these will typically not be filled in.

1 = The distributions for these parameters can include information from both the cross-section measurements and the longitudinal profile. 2 = For projects with a proximal USGS gauge in-line with the project reach (added bankfull verification - rare).

3. Utilizing XS measurement data produce an estimate of the bankfull floodplain area in acres, which should be the area from the top of bank to the toe of the terrace riser/slope.

4 = Proportion of reach exhibiting banks that are eroding based on the visual survey for comparison to monitoring data; 5. Of value/needed only if the n exceeds 3

Table 10. Baseline Stream Data Summary (continued)
Groundhog Hollow Mitigation Site - Reach GF3-B

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			Monitoring Baseline					
		LL	UL	Eq.	Min	Mean	Med	Max	SD[5]	n	Min	Mean	Med	Max	SD[5]	n	Min	Med	Max	Min	Mean	Med	Max	SD[5]	n
Dimension and Substrate - Riffle Only																									
Bankfull Width (ft)		---	---	---	---	---	4.1	---	---	1	---	---	4.4	---	---	1	---	5.3	---	---	---	7.6	---	---	1
Floodprone Width (ft)					---	---	6.2	---	---	1	---	---	12.0	20.0	---	1	---	19.3	---	---	---	25.6	---	---	1
Bankfull Mean Depth (ft)		---	---	---	---	---	0.7	---	---	1	---	---	0.5	0.6	---	1	---	0.5	---	---	---	---	---	---	1
[1]Bankfull Max Depth (ft)					---	---	1.0	---	---	1	---	---	0.8	0.9	---	1	---	0.7	---	---	---	0.9	---	---	1
Bankfull Cross Sectional Area (ft^2)		---	---	---	---	---	2.9	---	---	1	---	---	2.1	2.8	---	1	---	2.7	---	---	---	2.9	---	---	1
Width/Depth Ratio					---	---	5.8	---	---	1	---	---	6.9	9.2	---	1	---	10.3	---	---	---	---	---	---	1
Entrenchment Ratio					---	---	1.5	---	---	1	---	---	2.7	4.5	---	1	---	3.6	---	---	---	3.4	---	---	1
[1]Bank Height Ratio					---	---	1.6	---	---	1	---	---	1.0	2.5	---	1	---	1.0	---	---	---	1.0	---	---	1
Profile																									
Riffle Length (ft)					---	---	---	---	---	---	4	---	---	18	---	---	3.1	---	15.8	3	7	6	12	2	16
Riffle Slope (ft/ft)					---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	0.1	4.6	4.2	11.8	3.2	16.0
Pool Length (ft)					---	---	---	---	---	---	3	---	---	8	---	---	2.6	---	7.2	7	12	11	23	4	15
Pool Max depth (ft)					---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Pool Spacing (ft)					---	---	---	---	---	---	12	---	---	35	---	---	3.8	---	31	10	18	18	27	4	14
Pattern																									
Channel Beltwidth (ft)					---	---	---	---	---	---	15	---	---	35	---	---	13	---	31	13	---	---	31	---	---
Radius of Curvature (ft)					---	---	---	---	---	---	6	---	---	17	---	---	5	---	15	5	---	---	15	---	---
Rc:Bankfull width (ft/ft)					---	---	---	---	---	---	1.4	---	---	3.9	---	---	1	---	2.8	1	---	---	2.8	---	---
Meander Wavelength (ft)					---	---	---	---	---	---	23	---	---	43	---	---	20	---	38	20	---	---	38	---	---
Meander Width Ratio					---	---	---	---	---	---	3.4	---	---	8	---	---	3.8	---	7.2	3.8	---	---	7.2	---	---
Transport parameters																									
Reach Shear Stress (competency) lb/f^2					---												---			---					
Max part size (mm) mobilized at bankfull					---												---			---					
Stream Power (transport capacity) W/m^2					---												---			---					
Additional Reach Parameters																									
Rosgen Classification					G5/6						E4/5						C4/E4			C4/E4					
Bankfull Velocity (fps)		---	---	---	---						---						---			---					
Bankfull Discharge (cfs)		---	---	---	---												---			---					
Valley length (ft)					253						842						294			294					
Channel Thalweg length (ft)					272						995						343			343					
Sinuosity (ft)					1.08						1.18						1.17			1.17					
Water Surface Slope (Channel) (ft/ft)					---						---						---			---					
Channel slope (ft/ft)					0.021						0.0033						0.013			0.013					
[3]Bankfull Floodplain Area (acres)					---						---						---			---					
[4]% of Reach with Eroding Banks					---						---														
Channel Stability or Habitat Metric					---						---														
Biological or Other					---						---														

Shaded cells indicate that these will typically not be filled in.

1 = The distributions for these parameters can include information from both the cross-section measurements and the longitudinal profile. 2 = For projects with a proximal USGS gauge in-line with the project reach (added bankfull verification - rare).

3. Utilizing XS measurement data produce an estimate of the bankfull floodplain area in acres, which should be the area from the top of bank to the toe of the terrace riser/slope.

4 = Proportion of reach exhibiting banks that are eroding based on the visual survey for comparison to monitoring data; 5. Of value/needed only if the n exceeds 3

Appendix D. Table 11 - Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

Project Name/Number: Groundhog Hollow #100049

	Cross Section 1 (Riffle)							Cross Section 2 (Pool)							Cross Section 3 (Pool)							Cross Section 4 (Riffle)							Cross Section 5 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1103.8	1103.8	1103.7					1103.5	1103.5	1103.5					1097.9	1097.9	1098.0					1097.5	1097.5	1097.5					1092.7	1092.7	1092.8				
Bankfull Width (ft)[1]	6.3	5.8	6.7					6.4	6.8	7.2					8.5	9.5	7.9					6.2	6.2	5.7					6.3	5.5	4.7				
Floodprone Width (ft)[1]	50.0	42.7	>42.5					-	-	-					-	-	-					>50.6	>50.7	>50.6					45	>45	>45.9				
Bankfull Max Depth (ft)[2]	0.6	0.6	0.6					0.7	0.7	0.7					1.6	1.4	1.2					1.0	1.1	1.0					0.9	1.0	1.1				
Low Bank Elevation (ft)	1103.77	1103.9	1103.7					1103.5	1103.5	1103.5					1097.9	1097.9	1097.8					1097.5	1097.6	1097.5					1092.7	1092.7	1092.8				
Bankfull Cross Sectional Area (ft^2)[2]	1.9	2.3	1.7					2.3	2.3	2.5					6.1	5.8	4.7					3.3	3.9	3.0					2.6	2.7	2.7				
Bankfull Entrenchment Ratio[1]	7.9	7.4	>6.3					-	-	-					-	-	-					8.2	>8.2	>8.9					7.1	>8.2	>9.8				
Bankfull Bank Height Ratio[1]	1.0	1.1	0.9					-	-	-					-	-	-					1.0	1.1	0.9					1.0	1.0	1.0				

	Cross Section 6 (Pool)							Cross Section 7 (Riffle)							Cross Section 8 (Pool)							Cross Section 9 (Riffle)							Cross Section 10 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1092.2	1091.9	1091.9					1085.5	1085.5	1085.7					1085.2	1085.2	1085.4					1081.3	1081.4	1081.4					1081.0	1080.9	1081.0				
Bankfull Width (ft)[1]	7.9	5.5	5.6					6.4	7.3	7.7					6.5	8.3	5.9					7.6	6.6	7.3					6.6	6.0	6.9				
Floodprone Width (ft)[1]	-	-	-					>49.8	>50	>50.2					-	-	-					>44.8	>45.4	>44.2					-	-	-				
Bankfull Max Depth (ft)[2]	1.2	1.6	1.8					1.0	0.9	0.9					1.0	1.0	0.9					1.1	1.0	1.1					1.2	1.5	1.5				
Low Bank Elevation (ft)	1092.2	1092.2	1092.3					1085.5	1085.5	1085.5					1085.2	1085.2	1085.2					1081.3	1081.3	1081.4					1081.00	1081.0	1081.0				
Bankfull Cross Sectional Area (ft^2)[2]	5.0	7.2	7.8					4.7	4.2	3.7					4.1	4.1	2.9					4.5	3.8	4.4					4.7	5.5	5.0				
Bankfull Entrenchment Ratio[1]	-	-	-					7.8	>6.9	>6.5					-	-	-					5.9	>6.9	>6.1					-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-					1.0	0.9	0.9					-	-	-					1.0	0.9	1.0					-	-	-				

	Cross Section 11 (Riffle)							Cross Section 12 (Pool)							Cross Section 13 (Pool)							Cross Section 14 (Riffle)							Cross Section 15 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1076.2	1076.3	1076.6					1076.3	1076.3	1076.3					1071.6	1071.5	1071.6					1071.0	1071.1	1071.1					1119.1	1119.2	1119.3				
Bankfull Width (ft)[1]	6.4	6.8	6.8					5.5	7.1	5.7					7.8	7.3	7.5					8.3	8.1	8.1					6.8	6.7	7.3				
Floodprone Width (ft)[1]	>47	>49	>50.2					-	-	-					-	-	-					46.1	46.5	46.5					>38.6	>38.6	>38.9				
Bankfull Max Depth (ft)[2]	0.9	0.8	0.9					1.6	1.5	1.7					2.5	3.0	3.1					1.4	1.4	1.4					1.2	1.1	1.1				
Low Bank Elevation (ft)	1076.24	1076.2	1076.4					1076.3	1076.2	1076.2					1071.6	1071.7	1071.7					1071.0	1071.1	1071.3					1119.1	1119.2	1119.2				
Bankfull Cross Sectional Area (ft^2)[2]	3.4	2.9	2.4					5.4	5.4	5.6					9.9	9.9	11.3					6.2	6.2	6.6					4.8	4.5	4.3				
Bankfull Entrenchment Ratio[1]	7.3	>7.2	>7.4					-	-	-					-	-	-					5.5	5.7	5.7					5.7	>5.8	>5.3				
Bankfull Bank Height Ratio[1]	1.0	0.9	0.9					-	-	-					-	-	-					1.0	1.0	0.9					1.0	1.0	0.9				

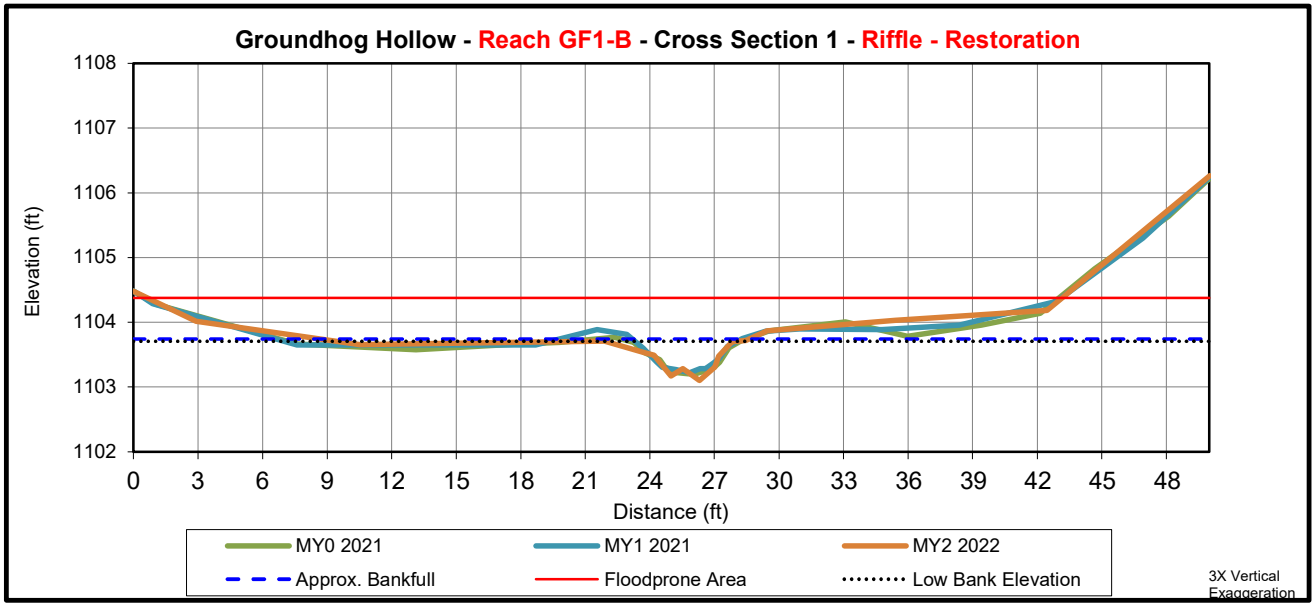
	Cross Section 16 (Pool)							Cross Section 17 (Pool)							Cross Section 18 (Riffle)							Cross Section 19 (Riffle)							Cross Section 20 (Riffle)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1118.6	1119.2	1118.7					1111.0	1111.0	1111.0					1110.6	1110.5	1110.5					1087.0	1087.0	1087.0					1084.8	1084.9	1085.0				
Bankfull Width (ft)[1]	8.0	7.2	8.5					7.5	7.0	6.8					5.5	4.8	5.1					4.9	4.7	4.6					6.2	6.4	6.2				
Floodprone Width (ft)[1]	-	-	-					-	-	-					>45.4	>45.3	>45.5					6.3	6.4	>6					9.6	8.7	>9.3				
Bankfull Max Depth (ft)[2]	2.3	2.4	2.3					1.1	1.3	1.3					1.0	1.0	1.0					0.8	1.0	0.8					0.8	0.7	1.9				
Low Bank Elevation (ft)	1118.63	1119.2	1118.6					1111.0	1111.0	1111.0					1110.6	1110.5	1110.5					1089.2	1088.9	1088.9					1086.2	1086.3	1086.0				
Bankfull Cross Sectional Area (ft^2)[2]	8.3	8.8	7.6					3.7	3.7	3.7					3.0	3.0	2.8					3.0	3.0	2.9					3.0	3.0	11.1				
Bankfull Entrenchment Ratio[1]	-	-	-					-	-	-					8.3	>9.4	>8.8					1.3	1.4	>1.3					1.5	1.4	1.5				
Bankfull Bank Height Ratio[1]	-	-	-					-	-	-					1.0	1.0	1..0					3.6	2.9	3.2					2.9	3.0	>2.2				

	Cross Section 21 (Riffle)							Cross Section 22 (Pool)						
	Base	MY1	MY2	MY3	MY5	MY7	MY+	Base	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1079.8	1079.9	1080.0					1079.6	1079.8	1079.9				
Bankfull Width (ft)[1]	7.6	5.5	7.9					6.2	5.1	4.7				
Floodprone Width (ft)[1]	25.6	27.1	>23.8					-	-	-				
Bankfull Max Depth (ft)[2]	0.9	0.8	0.7					1.0	0.7	1.1				
Low Bank Elevation (ft)	1079.84	1079.8	1079.9					1079.6	1079.5	1079.7				
Bankfull Cross Sectional Area (ft^2)[2]	2.9	2.3	2.2					3.1	1.9	2.5				
Bankfull Entrenchment Ratio[1]	3.4	4.9	>3.0					-	-	-				
Bankfull Bank Height Ratio[1]	1.0	0.9	0.9					-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

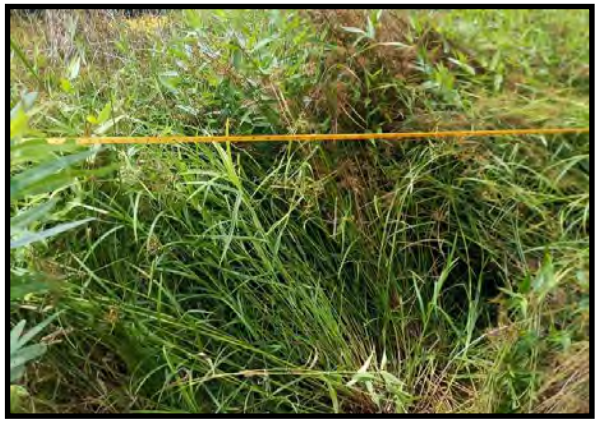
Upstream

Downstream



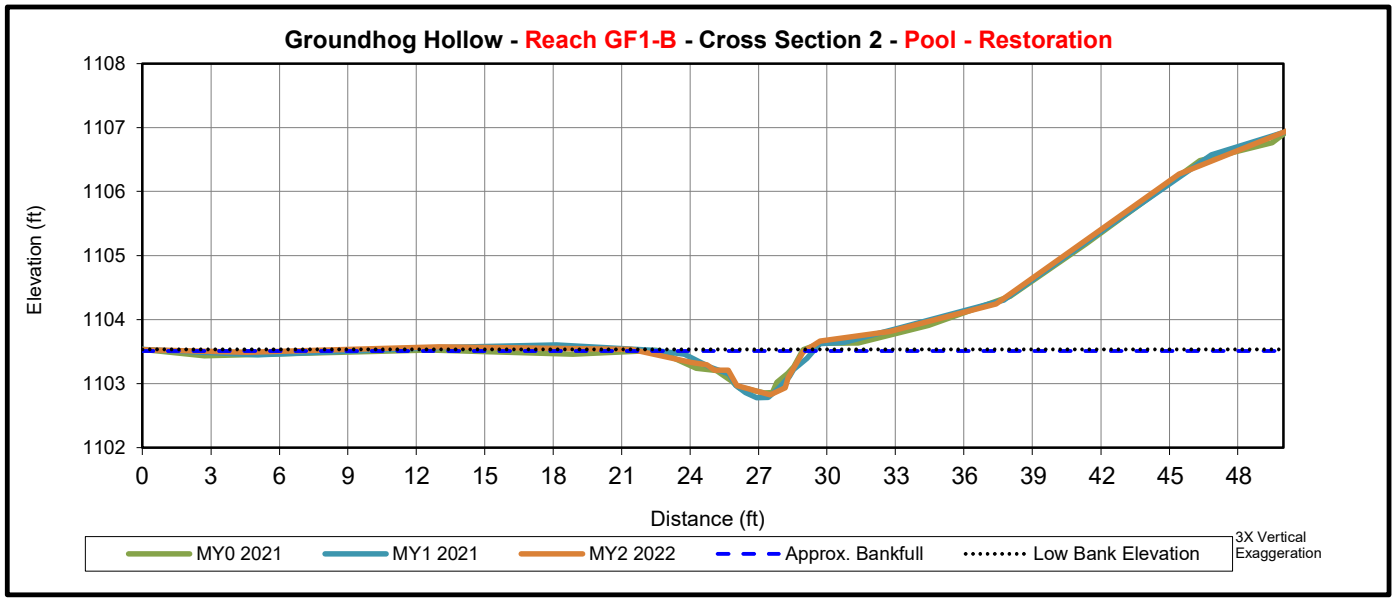
	Cross Section 1 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1103.77	1103.8	1103.7				
Bankfull Width (ft)[1]	6.3	5.8	6.7				
Floodprone Width (ft)[1]	50.0	42.7	>42.5				
Bankfull Max Depth (ft)[2]	0.6	0.6	0.6				
Low Bank Elevation (ft)	1103.77	1103.9	1103.7				
Bankfull Cross Sectional Area (ft^2)[2]	1.9	2.3	1.7				
Bankfull Entrenchment Ratio[1]	7.9	7.4	>6.3				
Bankfull Bank Height Ratio[1]	1.0	1.1	0.9				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation



Upstream

Downstream

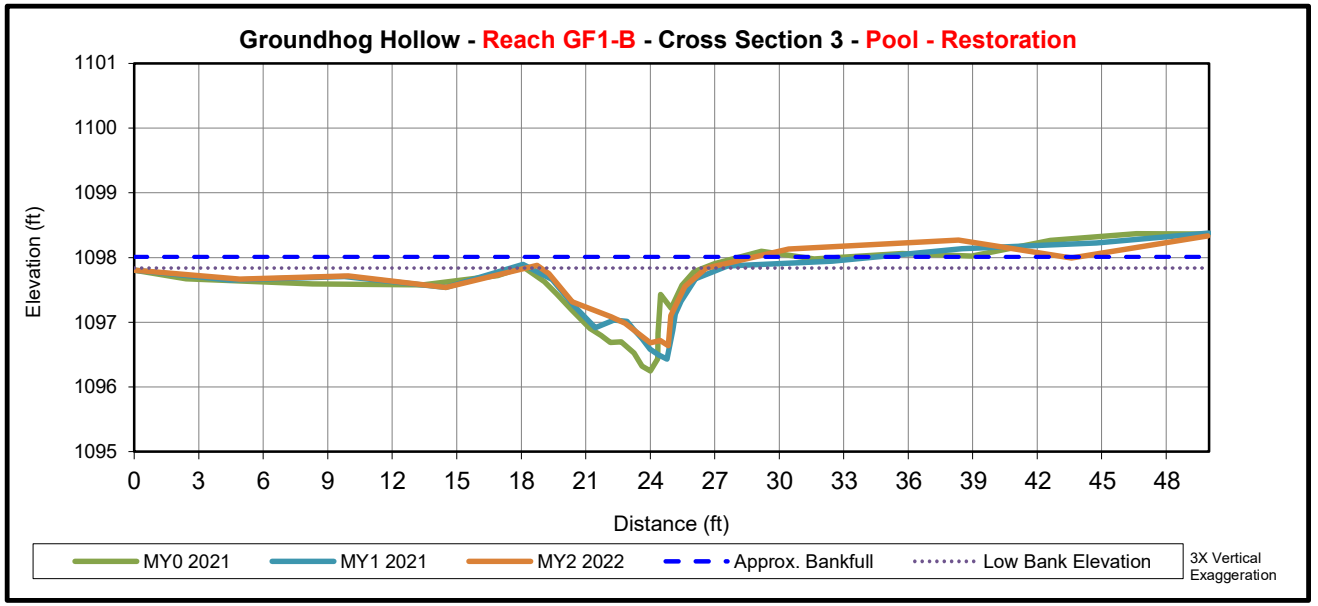


	Cross Section 2 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1103.52	1103.5	1103.5				
Bankfull Width (ft)[1]	6.4	6.8	7.2				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	0.7	0.7	0.7				
Low Bank Elevation (ft)	1103.52	1103.5	1103.5				
Bankfull Cross Sectional Area (ft^2)[2]	2.3	2.3	2.5				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

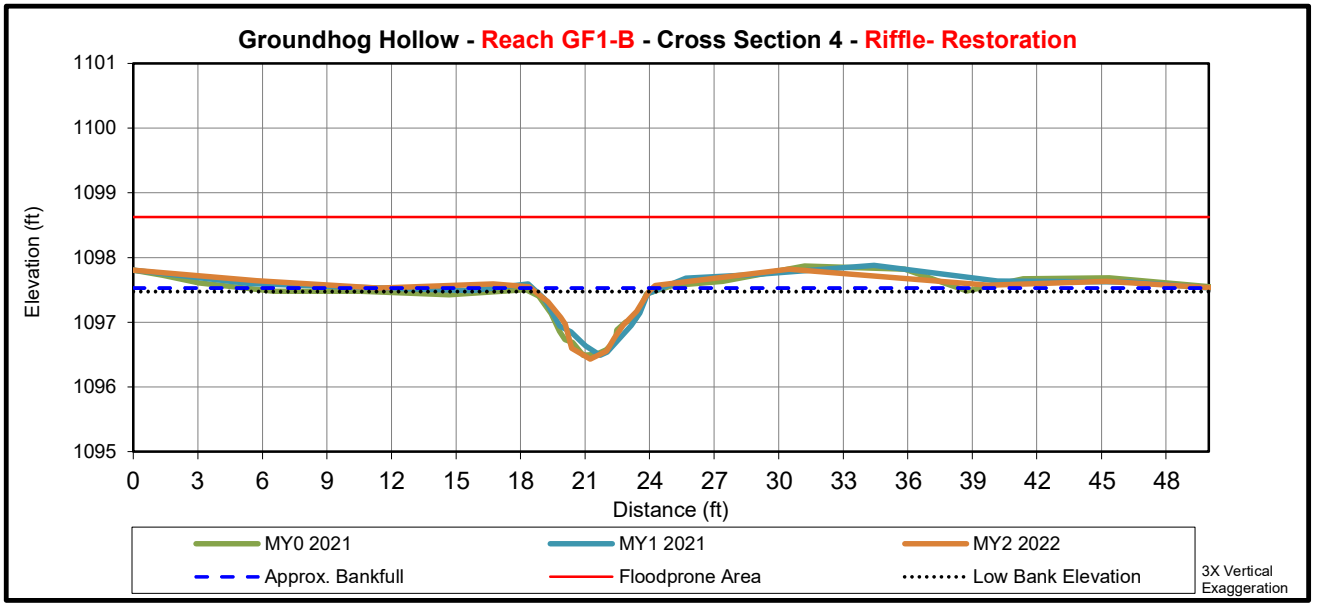


	Cross Section 3 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1097.86	1097.9	1098.0				
Bankfull Width (ft)[1]	8.5	9.5	7.9				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.6	1.4	1.2				
Low Bank Elevation (ft)	1097.86	1097.9	1097.8				
Bankfull Cross Sectional Area (ft^2)[2]	6.1	5.8	4.7				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

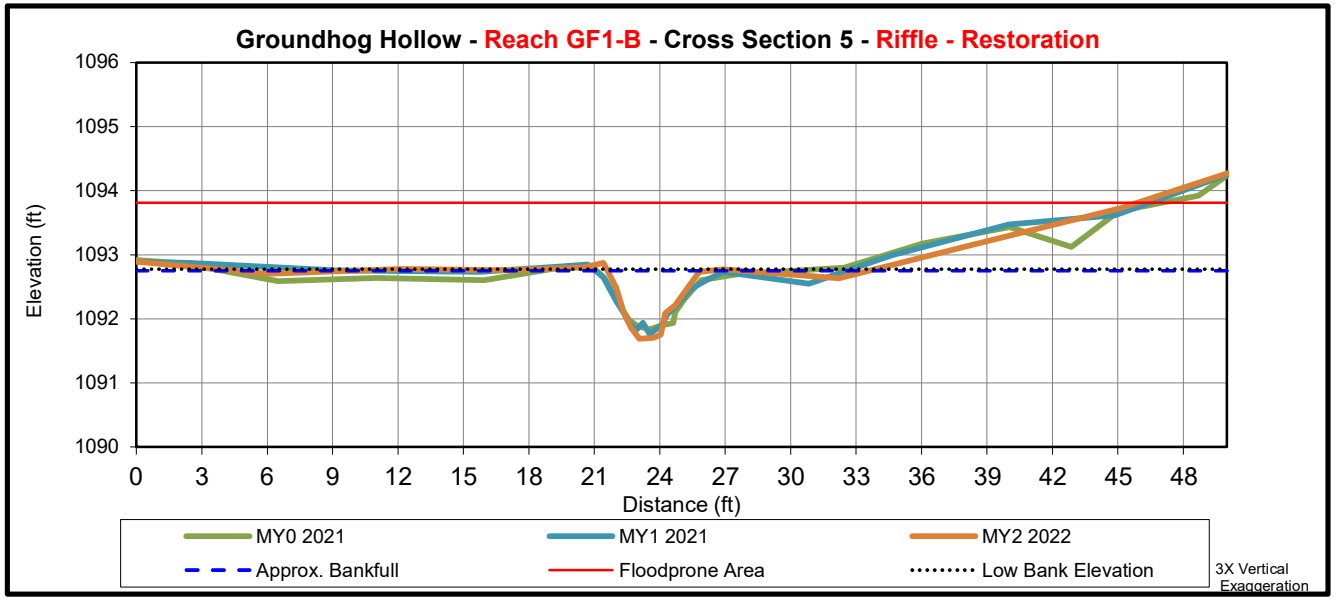


	Cross Section 4 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1097.50	1097.5	1097.5				
Bankfull Width (ft)[1]	6.2	6.2	5.7				
Floodprone Width (ft)[1]	>50.6	>50.7	>50.6				
Bankfull Max Depth (ft)[2]	1.0	1.1	1.0				
Low Bank Elevation (ft)	1097.50	1097.6	1097.5				
Bankfull Cross Sectional Area (ft^2)[2]	3.3	3.9	3.0				
Bankfull Entrenchment Ratio[1]	8.2	>8.2	>8.9				
Bankfull Bank Height Ratio[1]	1.0	1.1	0.9				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

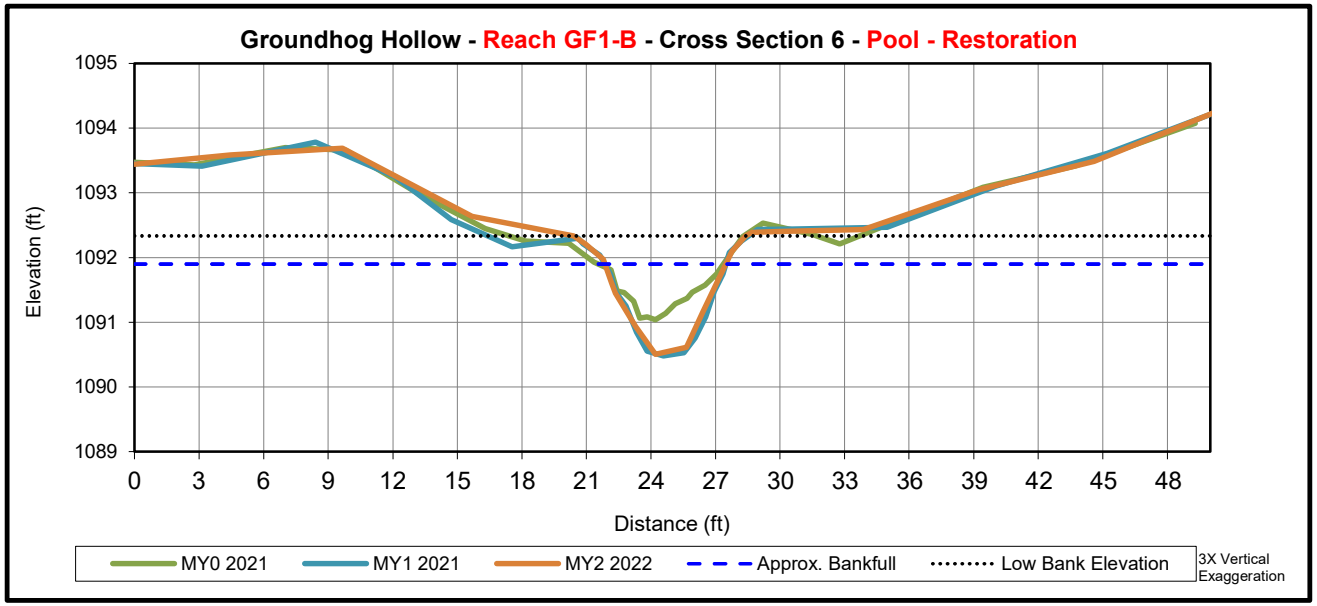


	Cross Section 5 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1092.70	1092.7	1092.8				
Bankfull Width (ft)[1]	6.3	5.5	4.7				
Floodprone Width (ft)[1]	45	>45	>45.9				
Bankfull Max Depth (ft)[2]	0.9	1.0	1.1				
Low Bank Elevation (ft)	1092.70	1092.7	1092.8				
Bankfull Cross Sectional Area (ft^2)[2]	2.6	2.7	2.7				
Bankfull Entrenchment Ratio[1]	7.1	>8.2	>9.8				
Bankfull Bank Height Ratio[1]	1.0	1.0	1.0				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

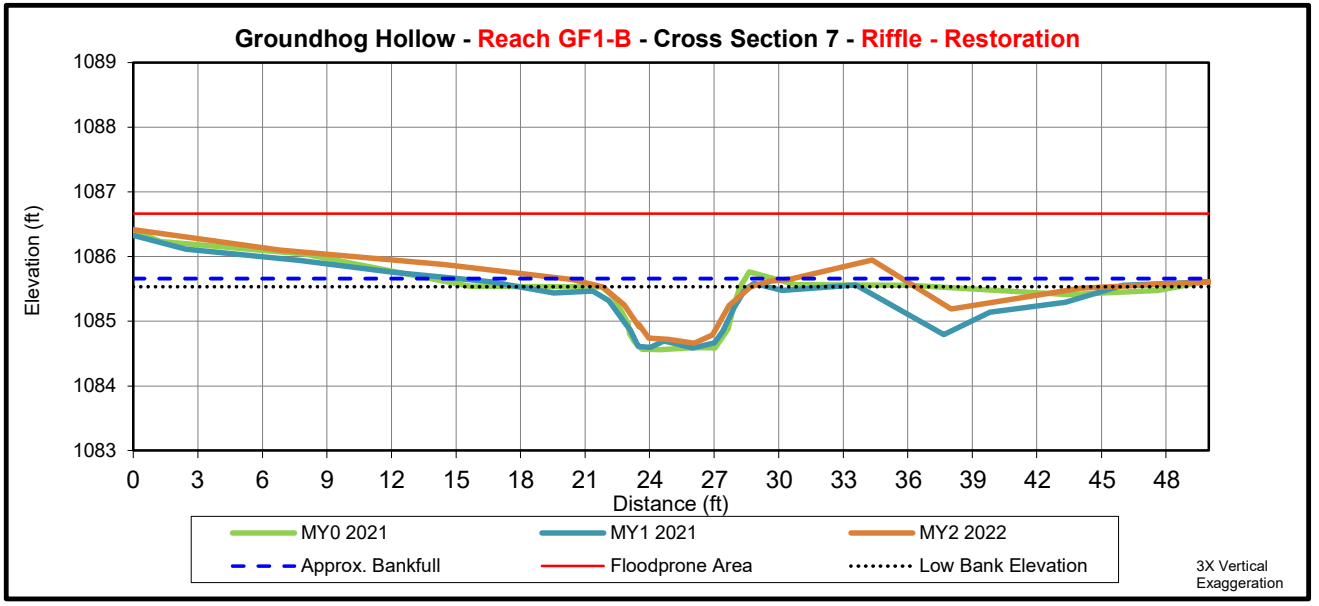


	Cross Section 6 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1092.22	1091.9	1091.9				
Bankfull Width (ft)[1]	7.9	5.5	5.6				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.2	1.6	1.8				
Low Bank Elevation (ft)	1092.22	1092.2	1092.3				
Bankfull Cross Sectional Area (ft^2)[2]	5.0	7.2	7.8				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

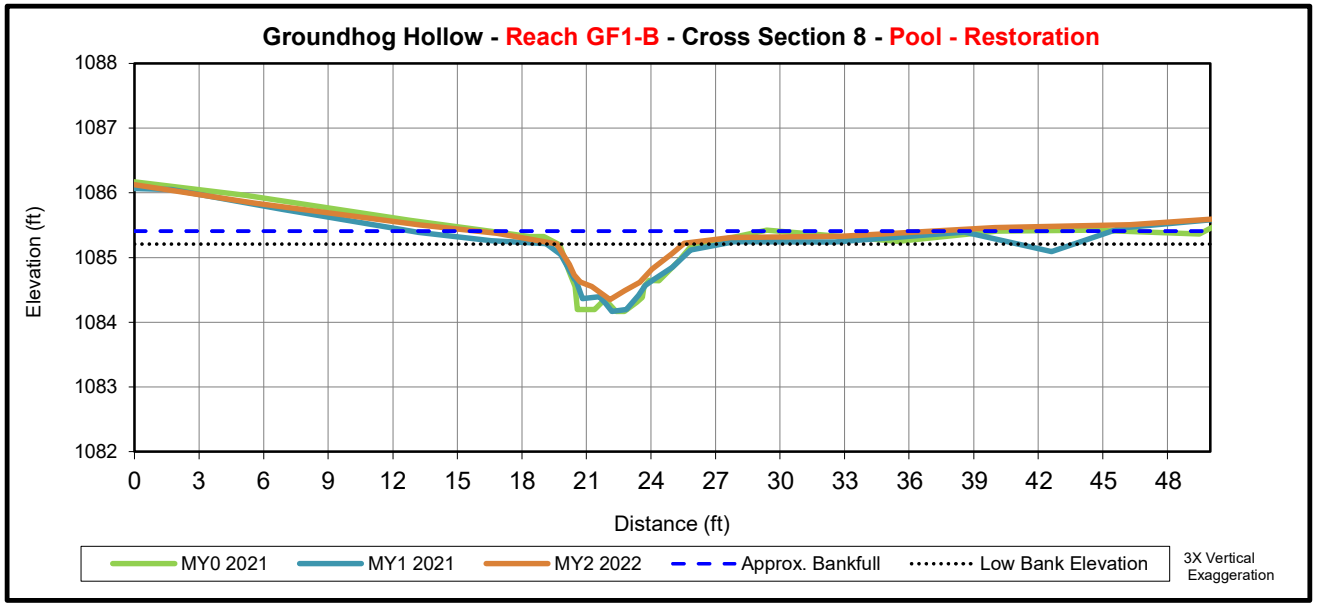


	Cross Section 7 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1085.53	1085.5	1085.7				
Bankfull Width (ft)[1]	6.4	7.3	7.7				
Floodprone Width (ft)[1]	>49.8	>50	>50.2				
Bankfull Max Depth (ft)[2]	1.0	0.9	0.9				
Low Bank Elevation (ft)	1085.53	1085.5	1085.5				
Bankfull Cross Sectional Area (ft^2)[2]	4.7	4.2	3.7				
Bankfull Entrenchment Ratio[1]	7.8	>6.9	>6.5				
Bankfull Bank Height Ratio[1]	1.0	0.9	0.9				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

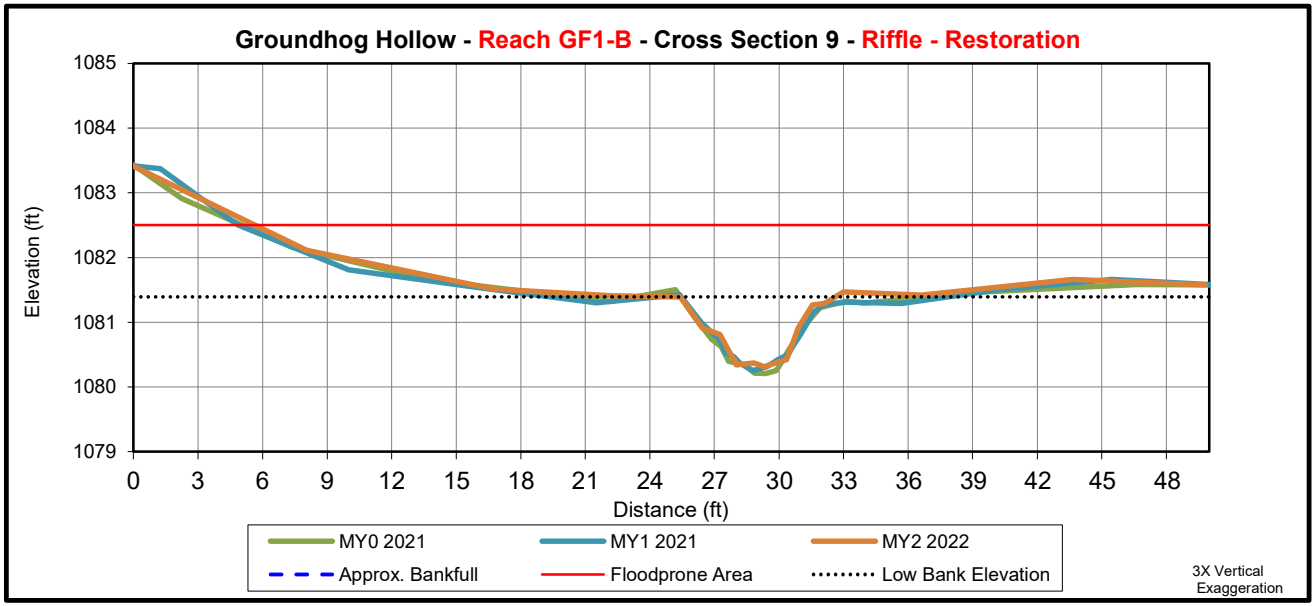


	Cross Section 8 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1085.20	1085.2	1085.4				
Bankfull Width (ft)[1]	6.5	8.3	5.9				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.0	1.0	0.9				
Low Bank Elevation (ft)	1085.20	1085.2	1085.2				
Bankfull Cross Sectional Area (ft^2)[2]	4.1	4.1	2.9				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

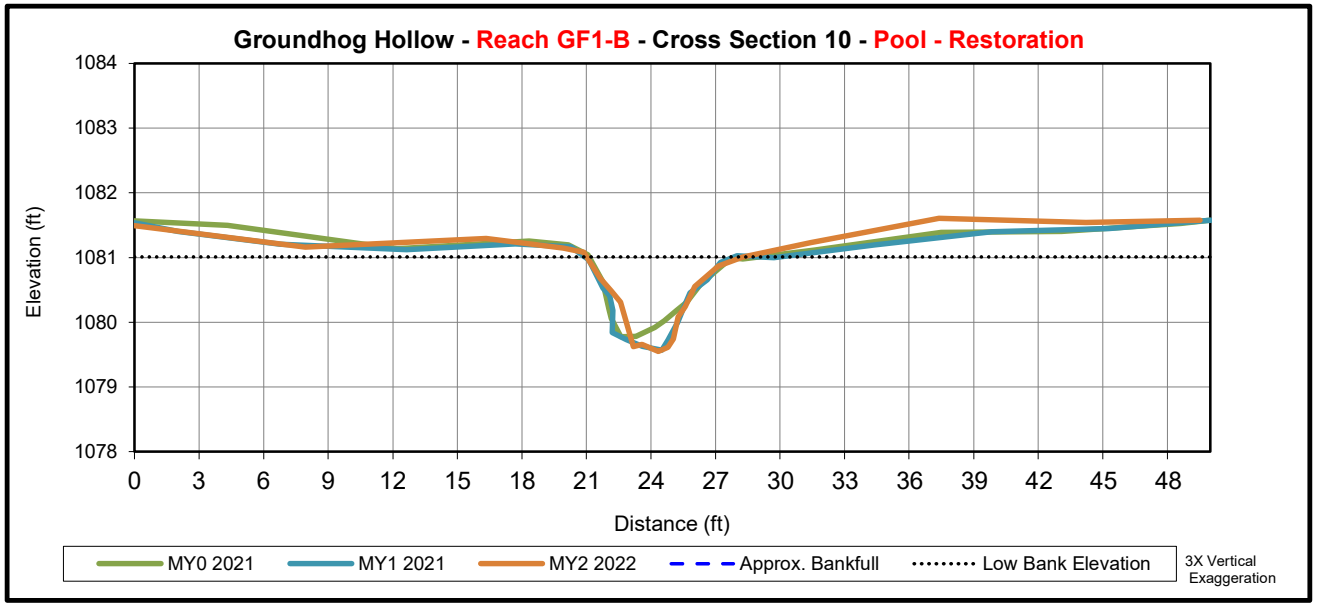


	Cross Section 9 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1081.33	1081.4	1081.4				
Bankfull Width (ft)[1]	7.6	6.6	7.3				
Floodprone Width (ft)[1]	>44.8	>45.4	>44.2				
Bankfull Max Depth (ft)[2]	1.1	1.0	1.1				
Low Bank Elevation (ft)	1081.33	1081.3	1081.4				
Bankfull Cross Sectional Area (ft^2)[2]	4.5	3.8	4.4				
Bankfull Entrenchment Ratio[1]	5.9	>6.9	>6.1				
Bankfull Bank Height Ratio[1]	1.0	0.9	1.0				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

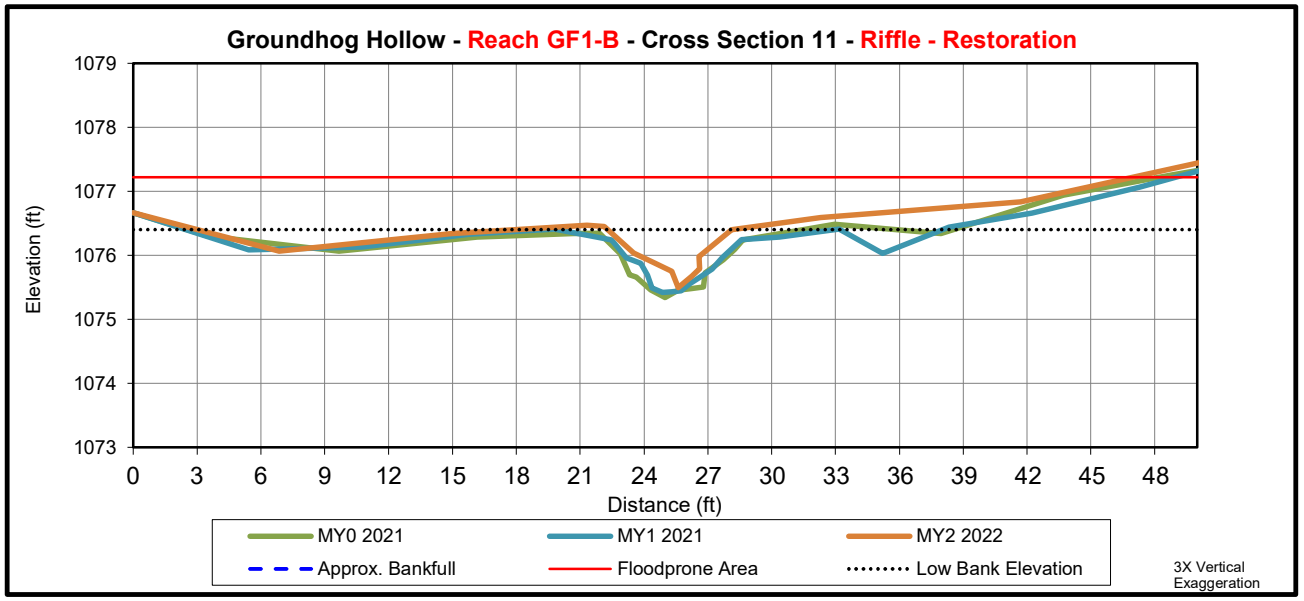


	Cross Section 10 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1081.00	1080.9	1081.0				
Bankfull Width (ft)[1]	6.6	6.0	6.9				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.2	1.5	1.5				
Low Bank Elevation (ft)	1081.00	1081.0	1081.0				
Bankfull Cross Sectional Area (ft^2)[2]	4.7	5.5	5.0				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

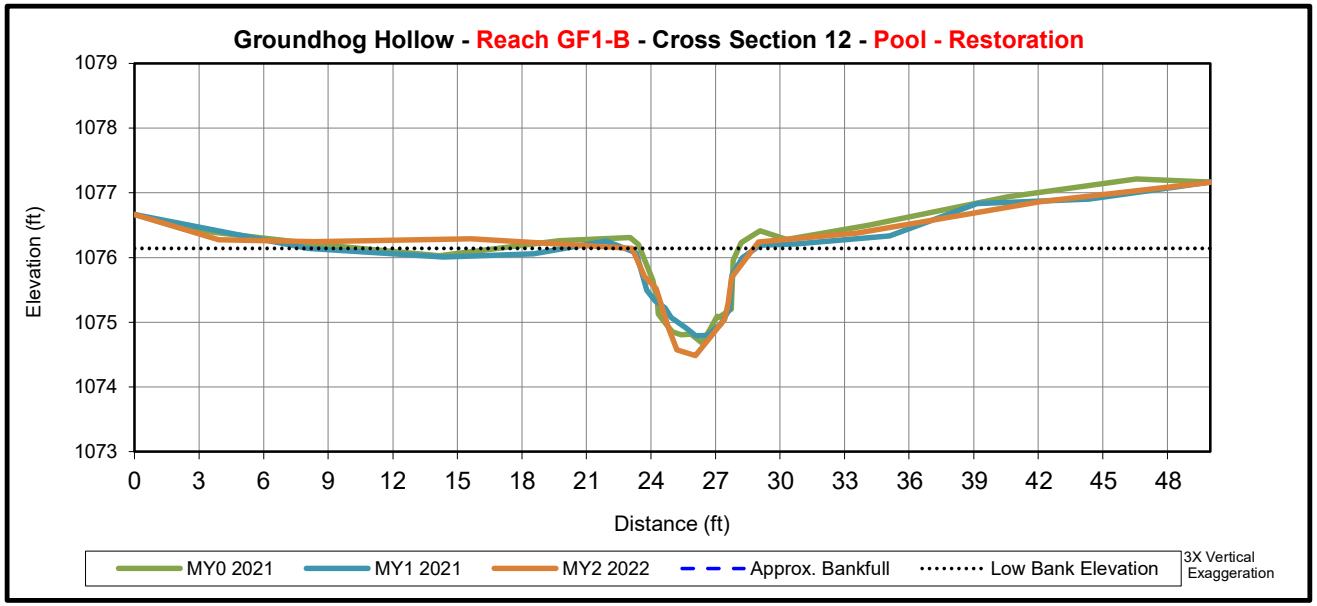


	Cross Section 11 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1076.24	1076.3					
Bankfull Width (ft)[1]	6.4	6.8					
Floodprone Width (ft)[1]	>47	>49					
Bankfull Max Depth (ft)[2]	0.9	0.8					
Low Bank Elevation (ft)	1076.24	1076.2					
Bankfull Cross Sectional Area (ft^2)[2]	3.4	2.9					
Bankfull Entrenchment Ratio[1]	7.3	>7.2					
Bankfull Bank Height Ratio[1]	1.0	0.9					

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream



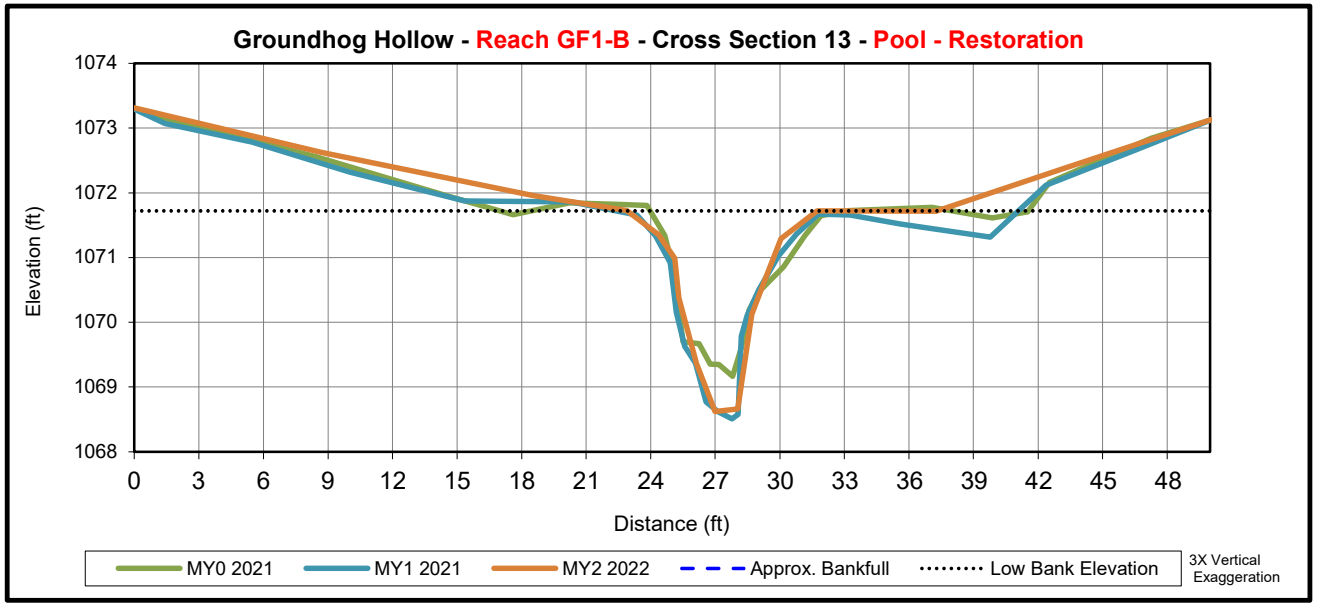
	Cross Section 12 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1076.31	1076.3	1076.3				
Bankfull Width (ft)[1]	5.5	7.1	5.7				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.6	1.5	1.7				
Low Bank Elevation (ft)	1076.31	1076.2	1076.2				
Bankfull Cross Sectional Area (ft^2)[2]	5.4	5.4	5.6				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation

2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

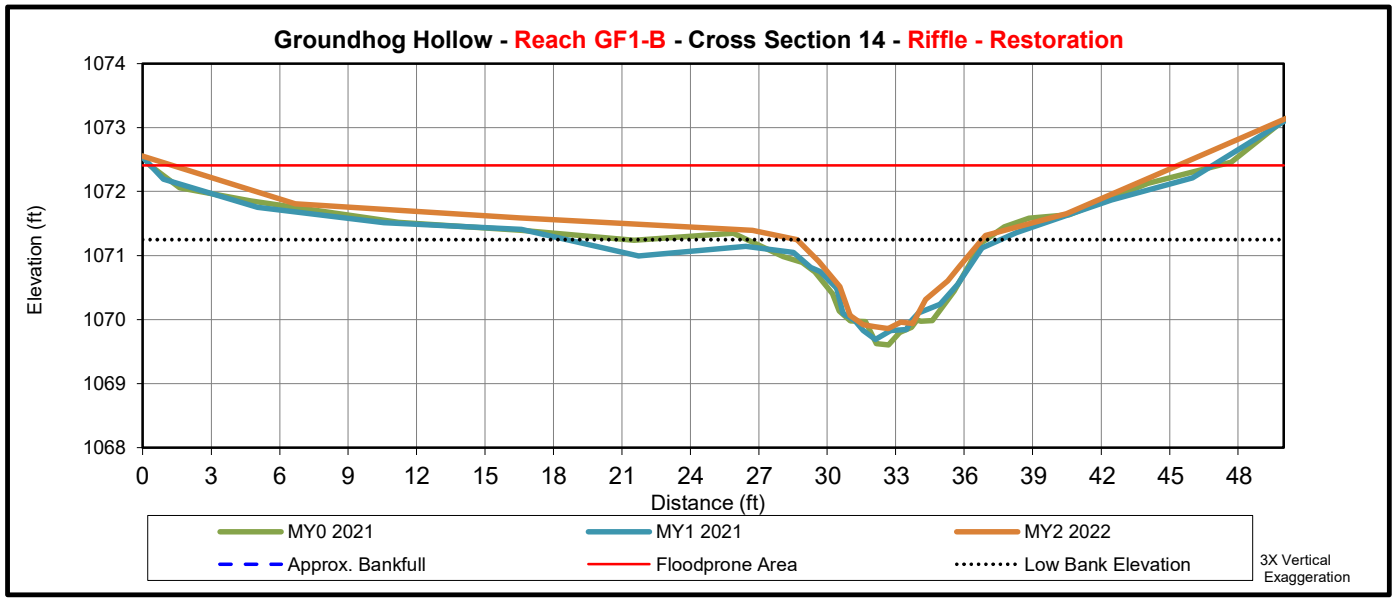


	Cross Section 13 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1071.64	1071.5	1071.6				
Bankfull Width (ft)[1]	7.8	7.3	7.5				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	2.5	3.0	3.1				
Low Bank Elevation (ft)	1071.64	1071.7	1071.7				
Bankfull Cross Sectional Area (ft^2)[2]	9.9	9.9	11.3				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

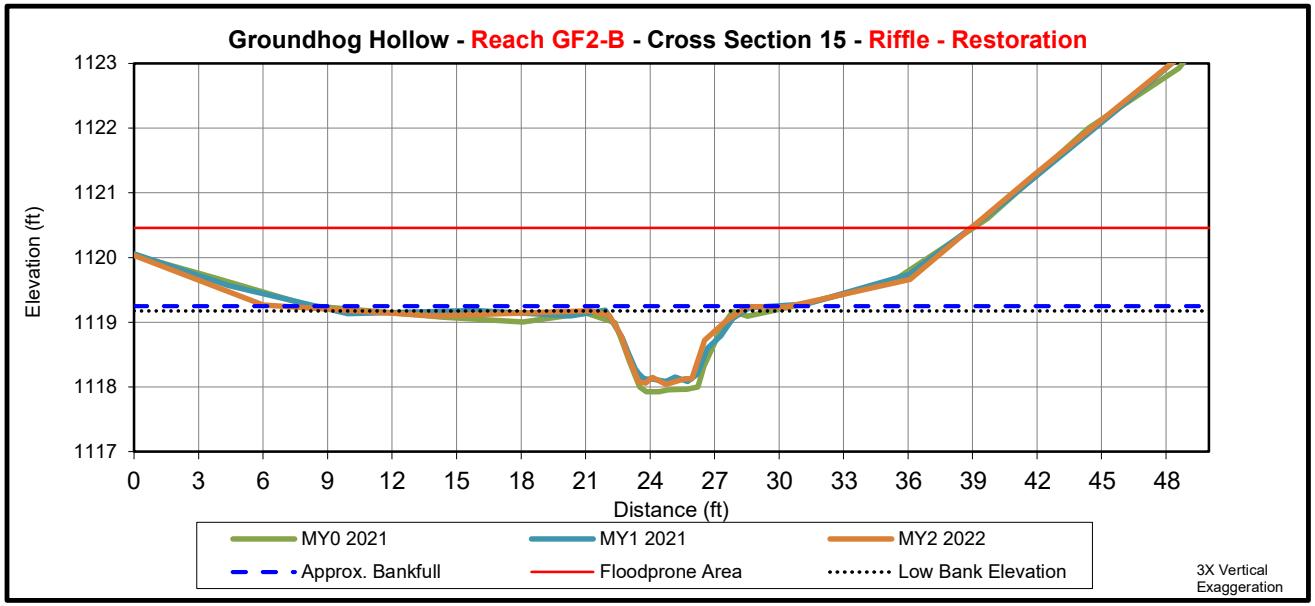


	Cross Section 14 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1070.98	1071.1	1071.1				
Bankfull Width (ft)[1]	8.3	8.1	8.1				
Floodprone Width (ft)[1]	46.1	46.5	46.5				
Bankfull Max Depth (ft)[2]	1.4	1.4	1.4				
Low Bank Elevation (ft)	1070.98	1071.1	1071.3				
Bankfull Cross Sectional Area (ft^2)[2]	6.2	6.2	6.6				
Bankfull Entrenchment Ratio[1]	5.5	5.7	5.7				
Bankfull Bank Height Ratio[1]	1.0	1.0	0.9				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

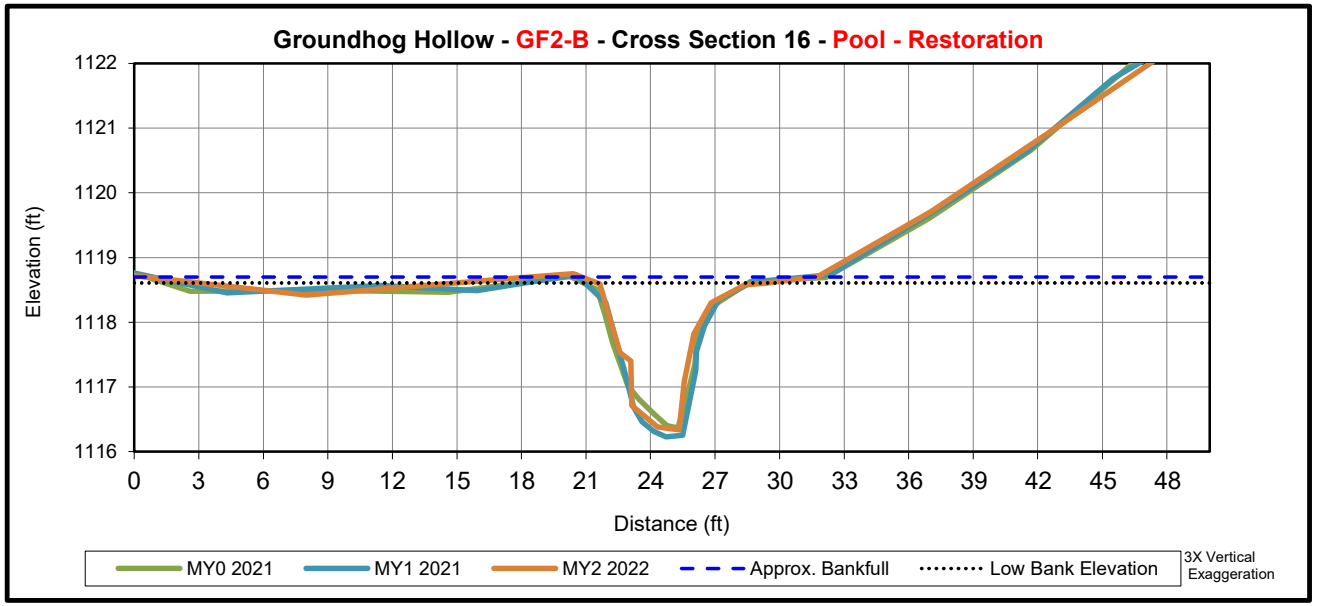


	Cross Section 15 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1119.15	1119.2	1119.3				
Bankfull Width (ft)[1]	6.8	6.7	7.3				
Floodprone Width (ft)[1]	>38.6	>38.6	>38.9				
Bankfull Max Depth (ft)[2]	1.2	1.1	1.1				
Low Bank Elevation (ft)	1119.15	1119.2	1119.2				
Bankfull Cross Sectional Area (ft^2)[2]	4.8	4.5	4.3				
Bankfull Entrenchment Ratio[1]	5.7	>5.8	>5.3				
Bankfull Bank Height Ratio[1]	1.0	1.0	0.9				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

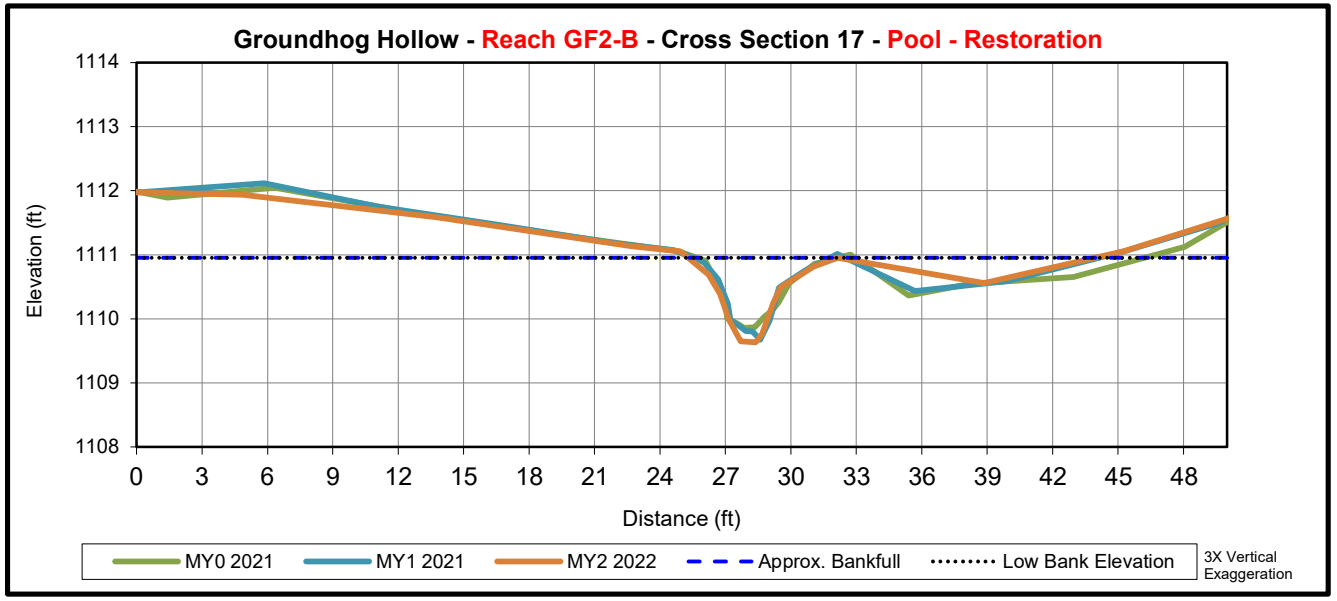


	Cross Section 16 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1118.63	1119.2	1118.7				
Bankfull Width (ft)[1]	8.0	7.2	8.5				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	2.3	2.4	2.3				
Low Bank Elevation (ft)	1118.63	1119.2	1118.6				
Bankfull Cross Sectional Area (ft^2)[2]	8.3	8.8	7.6				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

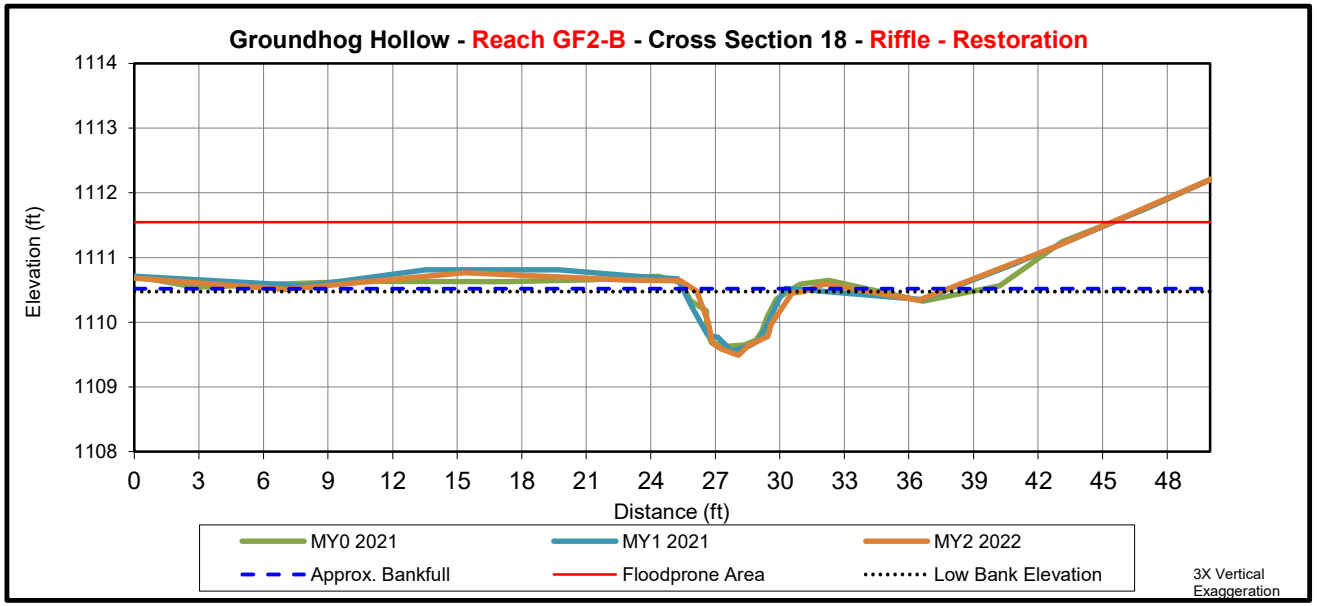


	Cross Section 17 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1111.00	1111.0	1111.0				
Bankfull Width (ft)[1]	7.5	7.0	6.8				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.1	1.3	1.3				
Low Bank Elevation (ft)	1111.00	1111.0	1111.0				
Bankfull Cross Sectional Area (ft^2)[2]	3.7	3.7	3.7				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

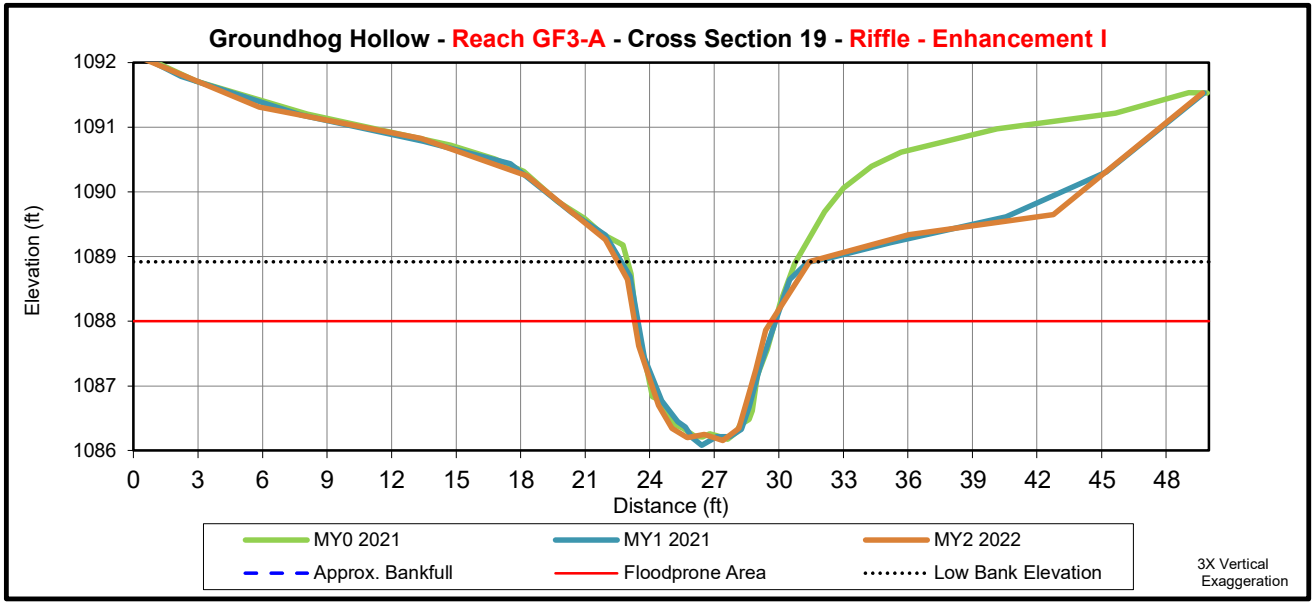


	Cross Section 18 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1110.59	1110.5	1110.5				
Bankfull Width (ft)[1]	5.5	4.8	5.1				
Floodprone Width (ft)[1]	>45.4	>45.3	>45.5				
Bankfull Max Depth (ft)[2]	1.0	1.0	1.0				
Low Bank Elevation (ft)	1110.59	1110.5	1110.5				
Bankfull Cross Sectional Area (ft^2)[2]	3.0	3.0	2.8				
Bankfull Entrenchment Ratio[1]	8.3	>9.4	>8.8				
Bankfull Bank Height Ratio[1]	1.0	1.0	1..0				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

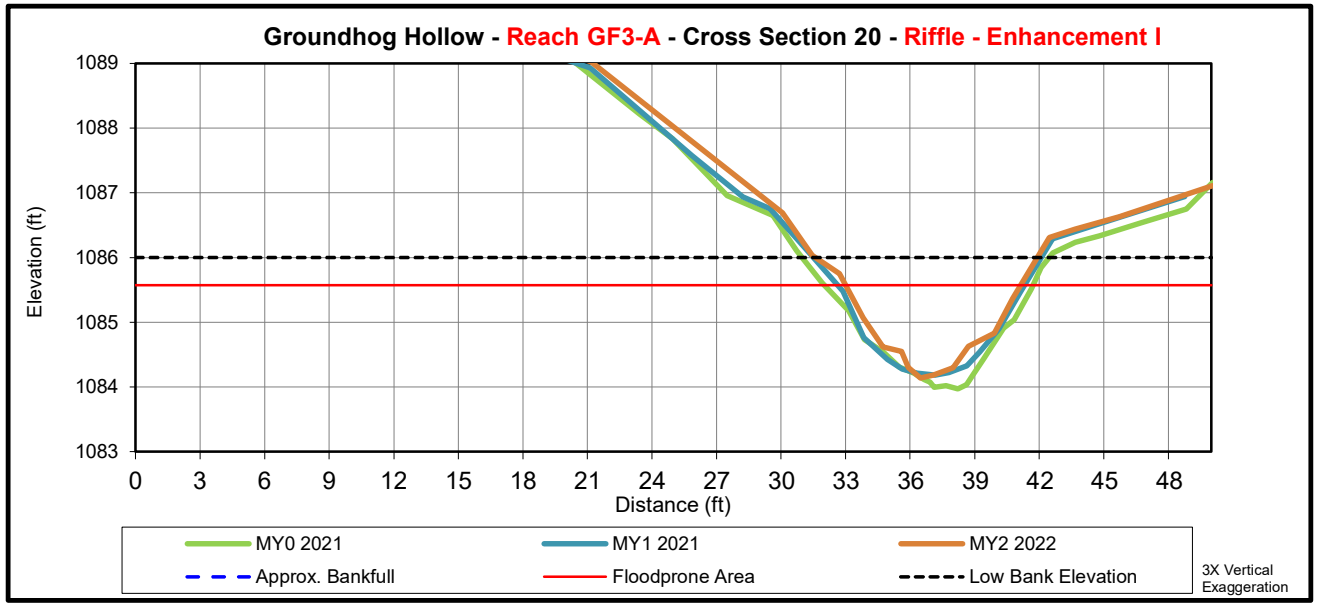


	Cross Section 19 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1087.00	1087.0	1087.0				
Bankfull Width (ft)[1]	4.9	4.7	4.6				
Floodprone Width (ft)[1]	6.3	6.4	>6				
Bankfull Max Depth (ft)[2]	0.8	1.0	0.8				
Low Bank Elevation (ft)	1089.20	1088.9	1088.9				
Bankfull Cross Sectional Area (ft^2)[2]	3.0	3.0	2.9				
Bankfull Entrenchment Ratio[1]	1.3	1.4	>1.3				
Bankfull Bank Height Ratio[1]	3.6	2.9	3.2				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

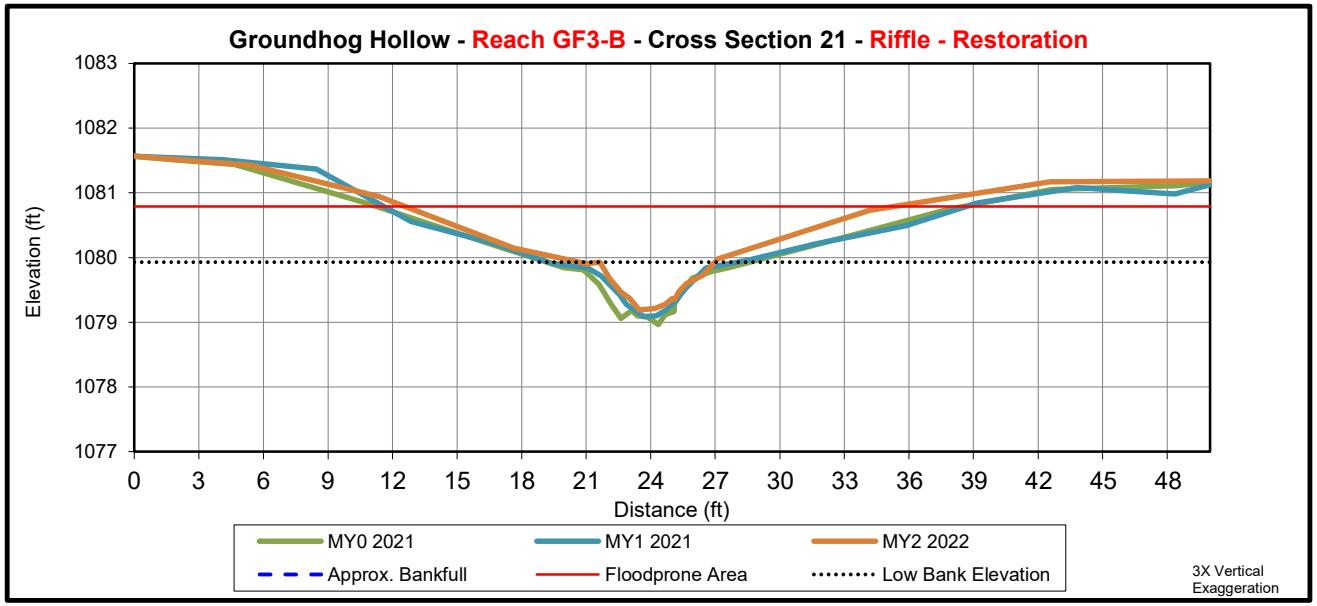


	Cross Section 20 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1084.80	1084.9	1085.0				
Bankfull Width (ft)[1]	6.2	6.4	6.2				
Floodprone Width (ft)[1]	9.6	8.7	>9.3				
Bankfull Max Depth (ft)[2]	0.8	0.7	1.9				
Low Bank Elevation (ft)	1086.20	1086.3	1086.0				
Bankfull Cross Sectional Area (ft^2)[2]	3.0	3.0	11.1				
Bankfull Entrenchment Ratio[1]	1.5	1.4	1.5				
Bankfull Bank Height Ratio[1]	2.9	3.0	>2.2				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream

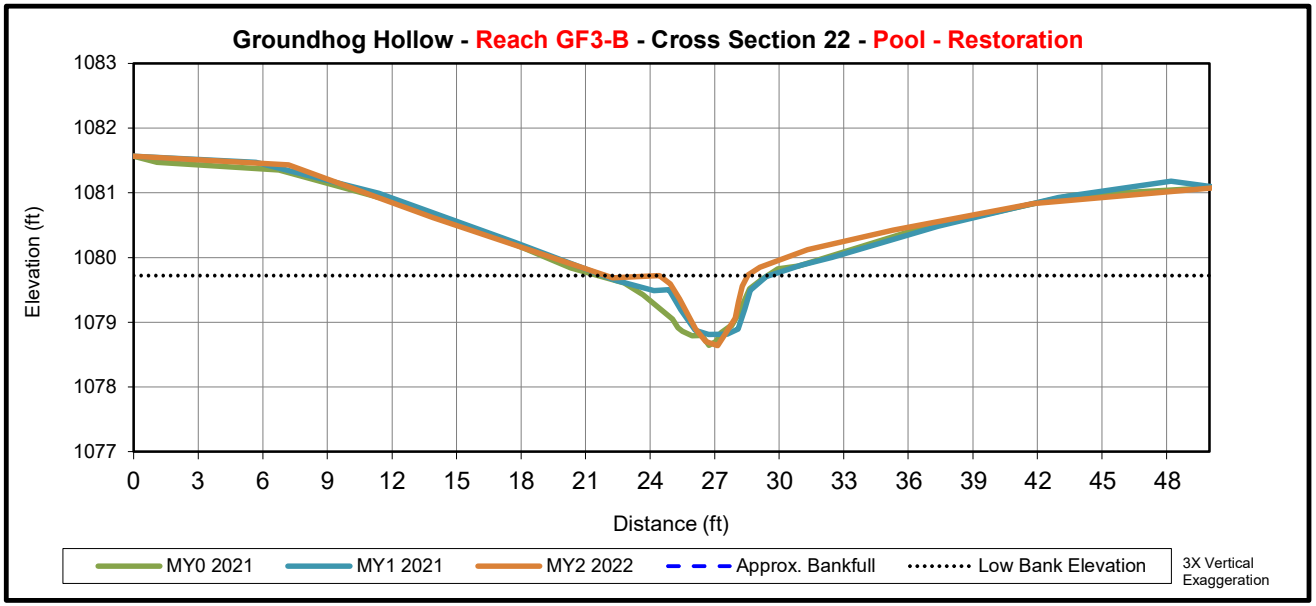


	Cross Section 21 (Riffle)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1079.84	1079.9	1080.0				
Bankfull Width (ft)[1]	7.6	5.5	7.9				
Floodprone Width (ft)[1]	25.6	27.1	>23.8				
Bankfull Max Depth (ft)[2]	0.9	0.8	0.7				
Low Bank Elevation (ft)	1079.84	1079.8	1079.9				
Bankfull Cross Sectional Area (ft^2)[2]	2.9	2.3	2.2				
Bankfull Entrenchment Ratio[1]	3.4	4.9	>3.0				
Bankfull Bank Height Ratio[1]	1.0	0.9	0.9				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Upstream

Downstream



	Cross Section 22 (Pool)						
	MY0	MY1	MY2	MY3	MY5	MY7	MY+
Bankfull Elevation (ft) - Based on AB-XSA[1]	1079.61	1079.8	1079.9				
Bankfull Width (ft)[1]	6.2	5.1	4.7				
Floodprone Width (ft)[1]	-	-	-				
Bankfull Max Depth (ft)[2]	1.0	0.7	1.1				
Low Bank Elevation (ft)	1079.61	1079.5	1079.7				
Bankfull Cross Sectional Area (ft^2)[2]	3.1	1.9	2.5				
Bankfull Entrenchment Ratio[1]	-	-	-				
Bankfull Bank Height Ratio[1]	-	-	-				

1 - Uses the as-built cross sectional area as the basis for adjusting each subsequent years bankfull elevation
2 - Uses the current years low top of bank as the basis for adjusting each subsequent years bankfull elevation

Appendix E

Hydrology Data

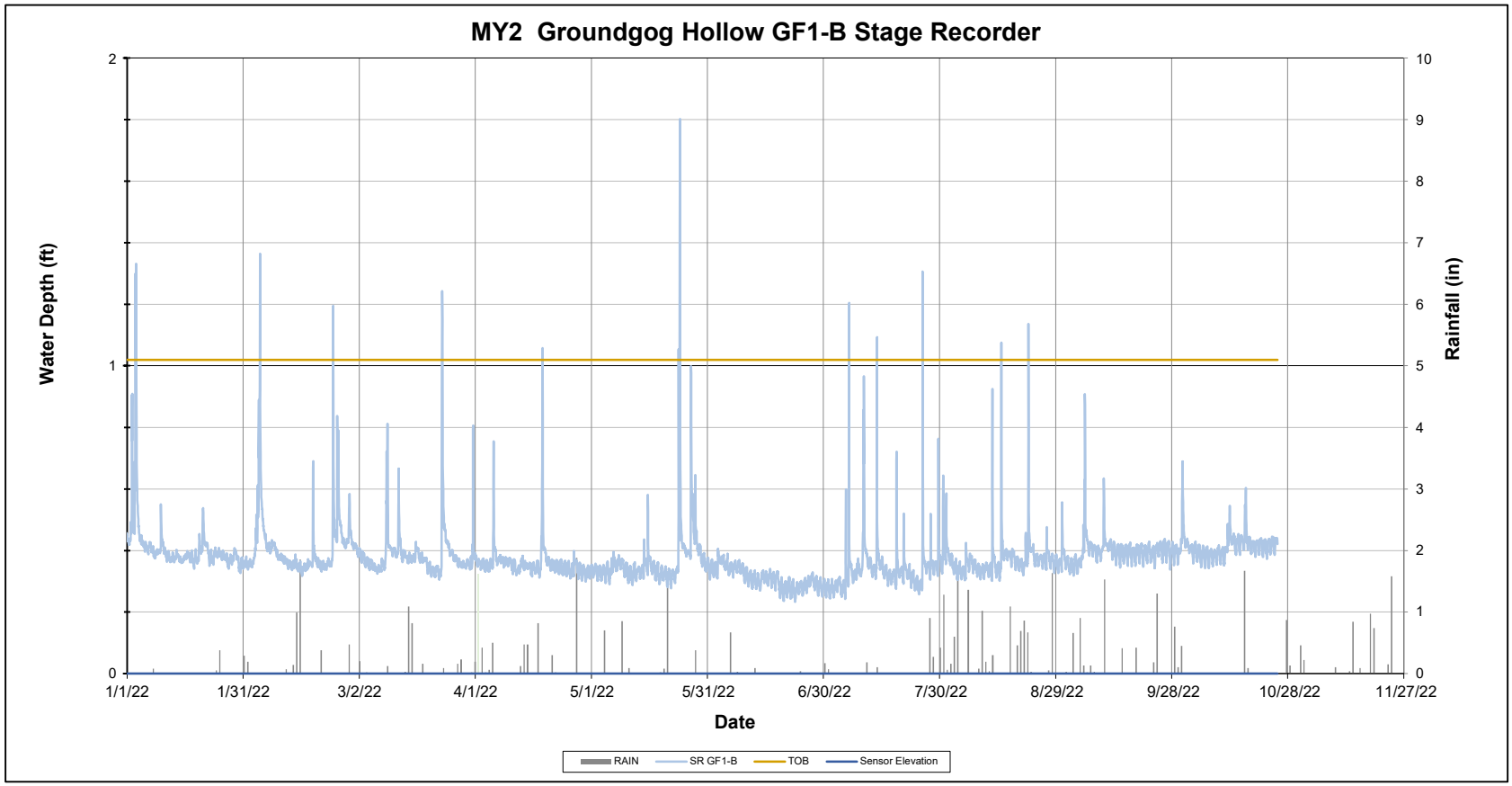
Table 12. Rainfall Summary MY2 2022

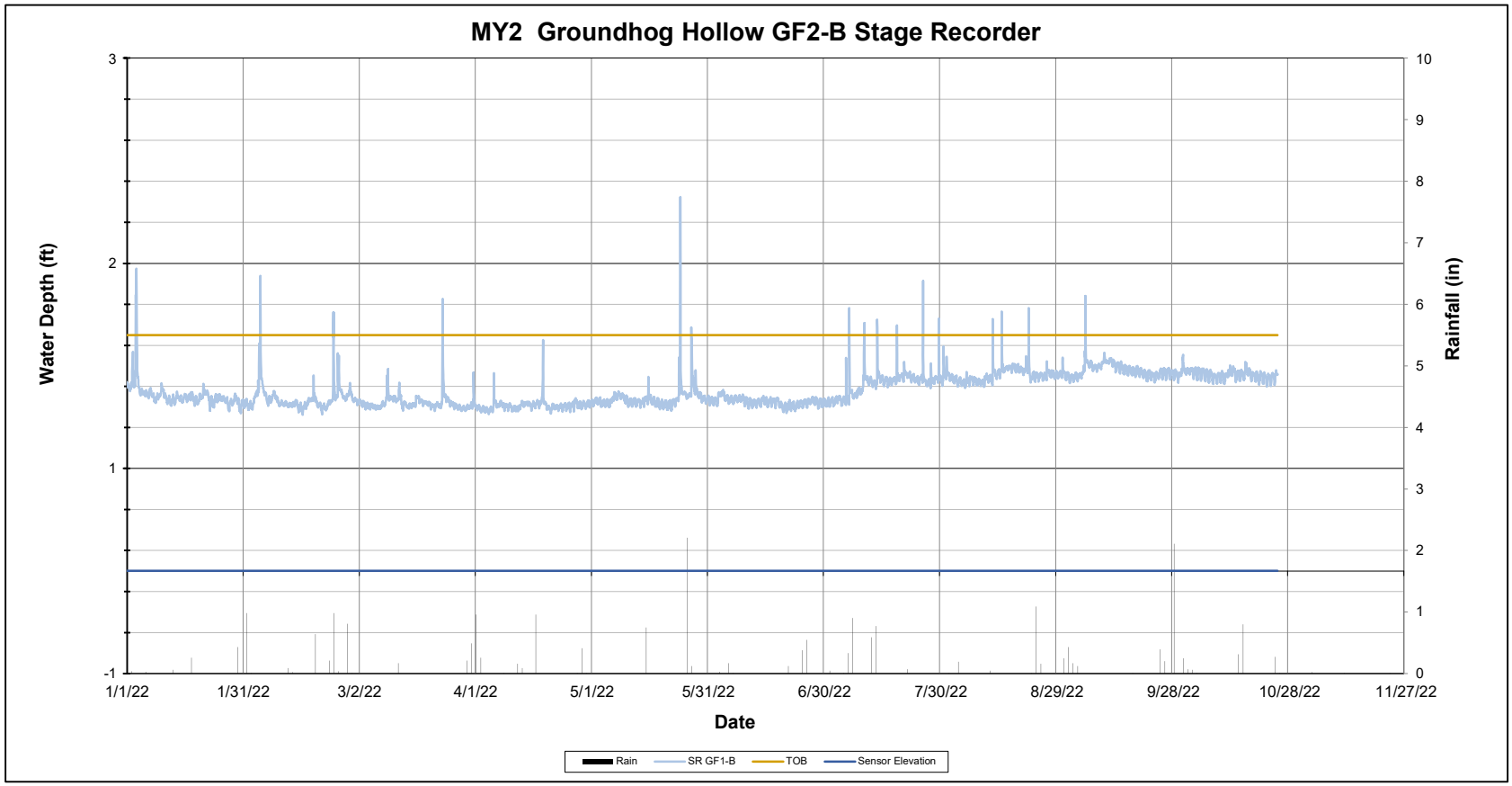
Month	Average	Normal Limits		Taylorsville Station Precipitation
		30 Percent	70 Percent	
January	4.08	2.98	4.80	4.17
February	3.89	2.58	4.66	5.42
March	4.20	3.23	4.88	4.80
April	4.55	2.78	5.51	2.84
May	4.52	2.61	5.49	0.88
June	5.15	3.62	6.11	0.54
July	4.75	3.30	5.65	11.40
August	5.19	3.56	6.19	6.27
September	4.48	2.90	5.38	3.26
October	3.61	2.53	4.31	3.54
November	3.59	1.92	4.39	4.44
December	4.28	3.04	5.07	---
Total	52.29	35.05	62.44	47.56
Above Normal Limits	Below Normal Limits			

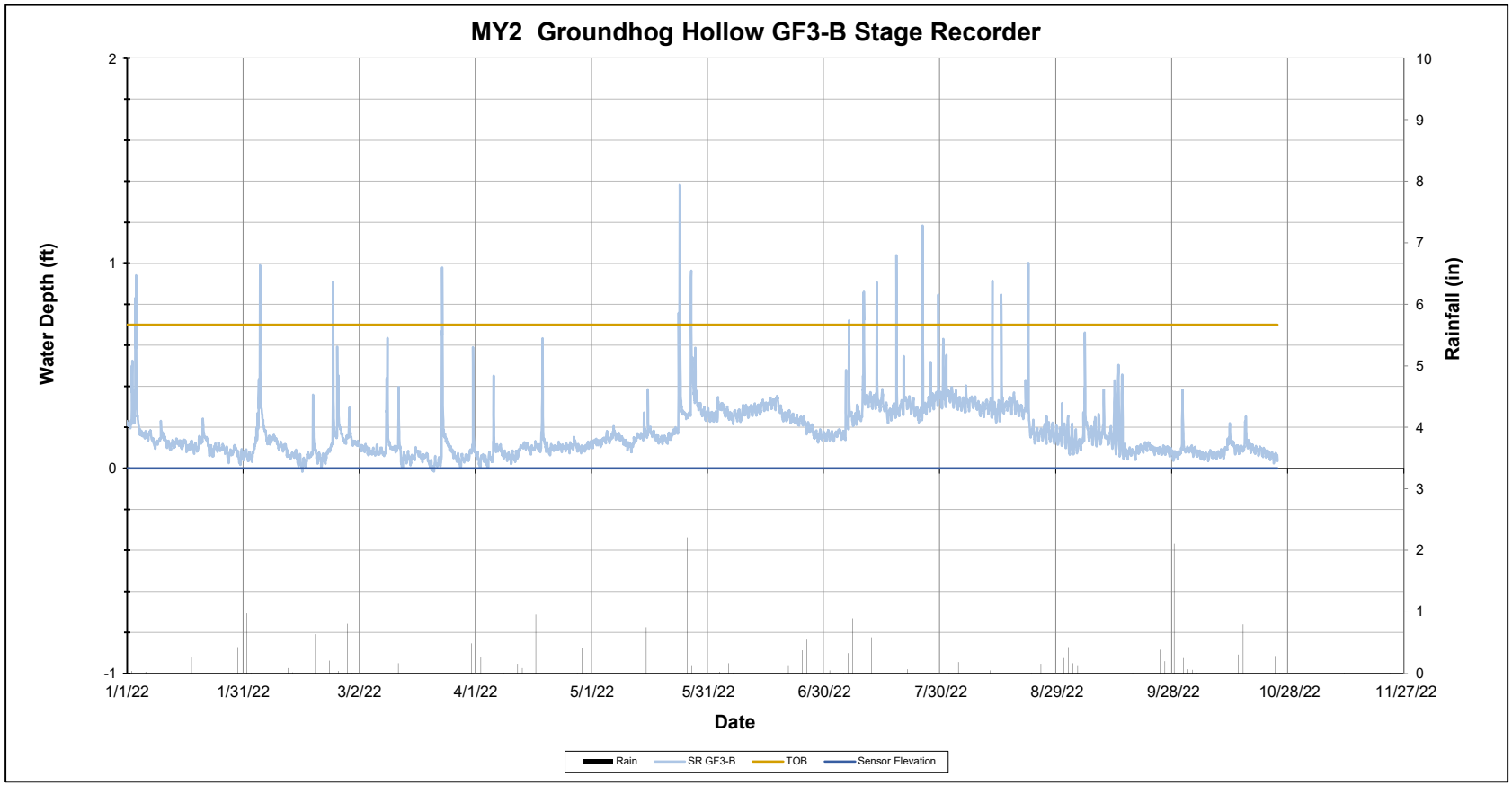
Note: Taylorsville CRONOS Station is approximately 3 miles southeast of the site

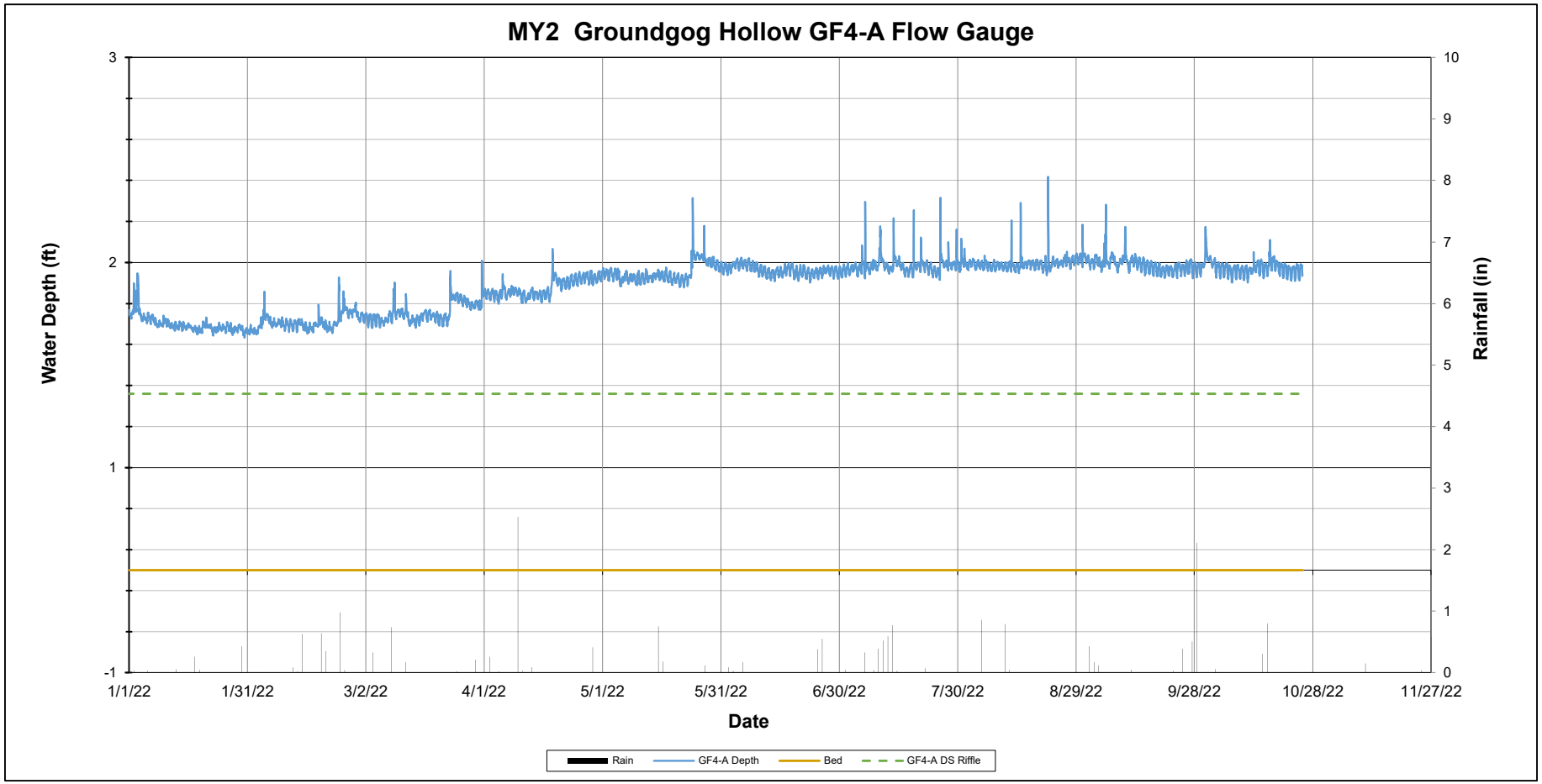
Table 13. Documentation of Geomorphically Significant Flow Events

Year	Number of Bankfull Events	Maximum Bankfull Height (ft)	Date of Maximum Bankfull Event	
Stage Recorder GF1-B				
MY1 2021	15	1.90	8/17/2021	
MY2 2022	11	0.78	5/23/2022	
Stage Recorder GF2-B				
MY1 2021	6	1.58	3/25/2021	
MY2 2022	16	0.67	5/23/2022	
Stage Recorder GF3-B				
MY1 2021	8	1.68	8/17/2021	
MY2 2022	15	0.68	5/23/2022	
Year	**Number of Flow Events**	**Maximum Consecutive Flow Days**	**Maximum Cummlative Flow Days**	**Maximum Consecutive Flow Date Range**
Flow Gauge GF4-A				
MY1 2021	1	235	235	5/10/2021-12/31/2021
MY2 2022	1	297	297	1/1/2021-10/25/2022


MY2 Groundgog Hollow GF1-B Stage Recorder
Water Depth (ft)
Rainfall (in)
Date
2
1
0
10
9
8
7
6
5
4
3
2
1
0
1/1/22
1/31/22
3/2/22
4/1/22
5/1/22
5/31/22
6/30/22
7/30/22
8/29/22
9/28/22
10/28/22
11/27/22
RAIN
SR GF1-B
TOB
Sensor Elevation


MY2 Groundhog Hollow GF2-B Stage Recorder
Water Depth (ft)
Rainfall (in)
3
2
1
-1
10
9
8
7
6
5
4
3
2
1
0
1/1/22
1/31/22
3/2/22
4/1/22
5/1/22
5/31/22
6/30/22
7/30/22
8/29/22
9/28/22
10/28/22
11/27/22
Date
Rain
SR GF1-B
TOB
Sensor Elevation


MY2 Groundhog Hollow GF3-B Stage Recorder
Water Depth (ft)
Rainfall (in)
2
1
0
-1
10
9
8
7
6
5
4
3
2
1
0
1/1/22
1/31/22
3/2/22
4/1/22
5/1/22
5/31/22
6/30/22
7/30/22
8/29/22
9/28/22
10/28/22
11/27/22
Date
Rain
SR GF3-B
TOB
Sensor Elevation


MY2 Groundgog Hollow GF4-A Flow Gauge
Water Depth (ft)
Rainfall (in)
Date
3
2
1
-1
10
9
8
7
6
5
4
3
2
1
0
1/1/22
1/31/22
3/2/22
4/1/22
5/1/22
5/31/22
6/30/22
7/30/22
8/29/22
9/28/22
10/28/22
11/27/22
Rain
GF4-A Depth
Bed
GF4-A DS Riffle