**FINAL**

# North Muddy Creek Mitigation Report

## McDowell and Burke Counties, North Carolina

## USGS HUC: 03050101040020

### Project ID No. 16-D06115

*Before*

*After*

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# Executive Summary

The North Muddy Creek site consists of five separate stream reaches and three wetland areas. Unnamed Tributary 1 (UT1) and its associated wetland areas are located just north of Interstate 40 on the McDowell/Burke County line on property owned by J. David and Betty Jean Connolly. UT2, UT4, and UT5 and their associated wetland areas are located immediately south of Interstate 40 in McDowell County on property owned by James G. Benfield. UT6 and its associated wetland area is located south of Interstate 40 in McDowell County on property owned by Robert E. Price (see **Figure 1**). The project streams lie within the Catawba River Basin (Hydrologic Unit Code **03050101040020**) and the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-30.

UT1 flows east to west and drains into Muddy Creek. UT1 is a perennial stream that begins at an off-site pond and is divided into two reaches (Upper UT1 and Lower UT1). The stream enters the project site in a steep valley setting and flows into the flat floodplain of Muddy Creek (see **Figure 2**). Prior to restoration, cattle had open access to both stream reaches, which actively degraded the buffer, banks, bed, and water quality. Lower UT1 also had been historically straightened and dredged. The spoils of the dredging that had been deposited on the banks formed berms that acted like hydrologic barriers, preventing frequent flood flows from inundating the adjacent wetland areas. UT1 contains two on-site jurisdictional wetlands, which have been enhanced.

UT5 is a perennial stream that had been historically straightened (see **Figure 3**) prior to restoration. The lower reach of UT5 was incised, lacked in-stream habitat, and was not connected to its floodplain. There was minimal to no woody buffer along this section of UT5. UT5 contains a jurisdictional wetland at the toe of the valley slope. Prior to its enhancement/preservation, the wetland area had been degraded along its outer boundary due to periodic tilling and open cattle access.

UT6 is a perennial stream that had been historically straightened and cleared (see **Figure 4**). Prior to restoration, the wetland hydrology had been removed because of the ditching, channelization of the associated stream, and severely limited infiltration of ponded waters. The land surface of this area had been smoothed, crowned, ditched, altered by cattle access, and stripped of forest cover.

The restoration reaches included all of UT1 and UT6 and the lower section of UT5. Prior to construction, these reaches had minimal woody riparian buffers, failed culvert crossings, and livestock access. In addition, the reaches had been physically altered (straightened) in the past. These impairments created unstable bed and banks and excess sediment, nutrients, and biochemical demand (BOD). These problems combined with the lack of sufficient re-oxygenating riffle features, reduced dissolved oxygen within the water column. Water quality also was diminished due to raised turbidity from bank erosion and elevated water temperatures caused by the lack of tree shading. Habitat potential was reduced by the diminished water quality and loss of physical habitat such as bed features, woody debris, and a well developed vegetative community.

The enhancement reach was located amidst two preservation reaches along UT5. Prior to construction, this reach was mainly affected by incision, livestock access, and adjacent eroding dirt roads. The enhancement reach was aggrading, causing a lack of diversity, habitat, and degraded water quality. This reach was enhanced (enhancement level I and II) through livestock exclusion fencing and was reattached to its floodplain through the addition of log sills for grade control. The log sills also added riffles and pools to help diversify the bed form and add habitat.

The preservation reaches included UT2, UT4, and UT5, which are headwater streams that flow into Muddy Creek (see **Figures 3** and **5**). These reaches were stable, had a mature woody riparian buffer, and were not incised. Steep slopes prevented livestock from accessing the reaches. These reaches were protected with a recorded permanent conservation easement.

Wetland enhancement areas located in UT1 and UT5 are hydrated by their connection to the groundwater table, hill slope seepage, runoff, and over-bank flooding from the nearby streams. Modifications to these enhancement areas included livestock exclusion and supplemental plantings.

Wetland restoration areas located in UT1 and UT6 were modified by grading (a maximum of 6 inches) to bring the ground elevation within a foot of the mean growing season water table. The land surface was reshaped to allow over-bank flows to route though the wetland. The grading also created microtopography to increase ponded water detention and infiltration times. The areas that were open fields were revegetated with woody species, thereby increasing hydraulic roughness of the floodplain, leading to an increase in the duration of flooding in these areas. Restoring the streams and backfilling the ditches will restore the local ground water table and increase the frequency and duration of flooding from smaller storm events.

## Goals and Objectives

Based on the site conditions described above, the goals and objectives achieved by this project include:

**Goals achieved:**

- Provided an ecological uplift by re-establishing and improving terrestrial and aquatic habitat and diversity.

**Objectives achieved:**

- Removed excess nutrients and sediment through the use of vegetative buffers;
- Increased dissolved oxygen concentrations through the use of in-stream structures and the turbulence they produce in pools;

- Stabilized stream banks using bioengineering and/or natural channel design techniques;
- Improved substrate through the use of structures and the elimination of major on-site sediment sources;
- Created habitat diversity by introducing woody structures such as log vanes and rootwads;
- Reduced temperature by restoring canopy in the buffer areas;
- Reconnected streams to their adjacent floodplains and wetlands;
- Raised groundwater levels in adjacent wetlands by raising channel bed elevations;
- Removed and/or plugged ditches that previously drained historic wetlands;
- Created micro-topography by regarding and ripping wetlands;
- Broke up historically compacted soils to allow groundwater to reach the surface and wetland vegetation to flourish;
- Controlled the invasive exotics by removing them during construction;
- Preserved stable on-site streams and riparian buffers draining into the enhancement/restoration reaches;
- Excluded livestock through fencing;
- Improved crossings by replacing pipes and/or stabilizing outfalls; and
- Protected site assets through the recordation of a conservation easement.

The streams were restored using either Rosgen Priority 1 or Priority 2 methodologies. Priority 1 was employed along the wetland restoration areas to restore the groundwater table and increase over-bank flooding in small storm events. The wetland and riparian areas were ripped to remove compaction from the livestock and create microtopography. The riparian buffer and wetlands were replanted or planted with supplemental, native woody species to restore ecological function to the buffer and wetlands.

All stream reaches (restoration, enhancement, and preservation) are protected with a recorded permanent conservation easement. As shown in **Tables 1** and **2** below, the mitigation work at the site resulted in the restoration, enhancement, and/or preservation of 7,960 linear feet of stream for a total of 4,996 stream mitigation units (SMUs) and 20.2 acres of riparian/non-riparian wetlands for a total of 16.4 wetland mitigation units (WMUs).

**Table 1: Stream Mitigation Summary**

| Project Stream | Stream Restoration (linear feet) | Stream Enhancement Level I (linear feet) | Stream Enhancement Level II (linear feet) | Stream Preservation (linear feet) | Total |
|---|---|---|---|---|---|
| **Total Site** | 3,974 | 337 | 336 | 3,313 | 7,960 |
| **Total SMUs** | 3,974 | 225 | 134 | 663 | 4.996 |

**Table 2: Wetland Mitigation Summary**

| Project Wetlands | Riparian Wetland Restoration (acres) | Riparian Wetland Enhancement (acres) | Riparian Wetland Preservation (acres) | Riparian Total (acres) | Non-Riparian Wetland Restoration (acres) | Total |
|---|---|---|---|---|---|---|
| **Total Site** | 11.4 | 3.7 | 2.5 | 17.6 | 2.6 | 20.2 |
| **Total WMUs** | 11.4 | 1.9 | 0.5 | 13.8 | 2.6 | 16.4 |

Monitoring in 2008 through 2012 will assess the site's streams to determine restoration success. The monitoring plan has been established based on guidance provided by *Stream Mitigation Guidelines* disseminated by the United States Army Corps of Engineers – Wilmington District (McLendon, Scott, Fox, St. John et al. 2003) and the most current version of the North Carolina Ecosystem Enhancement Program (EEP) documents entitled "Content, Format, and Data Requirements for EEP Monitoring Reports." Streams will be monitored for stability using cross section and longitudinal profile surveys and photo documentation.

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# Narrative

The North Muddy Creek site consists of five separate project reaches. The first reach, Unnamed Tributary 1 (UT1), is located just north of Interstate 40 on the McDowell/Burke County line. UT5 and UT6 are both located south of Interstate 40 in McDowell County (see **Figure 1**). The project streams lie within the Catawba River Basin (Hydrologic Unit Code **03050101040020**) and the North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-30. The site is defined by the conservation easement surrounding the stream and riparian buffers that cover approximately 34.8 acres.

Prior to construction, the site consisted of five unnamed tributaries and associated wetlands (UT1, UT2, UT4, UT5, and UT6), which included approximately 7,960 linear feet of unnamed tributaries to Muddy Creek. The land adjacent to the site (outside of the conservation easement) is being used for cattle grazing and hay production. It also included portions of undisturbed forest. All five systems drain a watershed consisting of predominately forest and agricultural land.

The pasture land surrounding the streams, wetlands, and wetland restoration areas lacked strong rooted vegetation (e.g., woody or deep-rooted herbaceous vegetation). Pasture grasses dominated most of the riparian buffer with isolated specimens of hardwoods. These areas were highly impacted by livestock access and historical ditching and channelization. Most of the stream banks were actively failing predominantly due to hoof shear. Stream features were obliterated by continuous livestock access.

Based on the above site conditions, the goals and objectives achieved by this project include:

Goals achieved:

- Re-established and improved terrestrial and aquatic habitat and diversity.

Objectives achieved:

- Removed excess nutrients and sediment through the use of vegetative buffers;
- Increased dissolved oxygen concentrations through the use of in-stream structures and the turbulence they produce in pools;
- Stabilized stream banks using bioengineering and/or natural channel design techniques;
- Improved substrate through the use of structures and the elimination of major on-site sediment sources;
- Created habitat diversity by introducing woody structures such as log vanes and rootwads;
- Reduced temperature by restoring canopy in the buffer areas;

- Controlled the invasive exotics by removing them during construction;
- Preserved stable on-site streams and riparian buffers draining into the enhancement/restoration reaches;
- Excluded livestock through fencing;
- Improved crossings by replacing pipes and/or stabilizing outfalls,
- Created vernal pools and oxbow lakes; and
- Protected site assets through the recordation of a conservation easement.

Applying Rosgen Priority 1 and 2 methodologies, natural channel design techniques were used to adjust the channel dimension, pattern, and profile to a stable configuration for each restoration reach. The configuration was based on reference reach morphology, values from regional curves, regime equations, experience from other restoration projects, and the existing channel morphology (see **Figures 2-5)**.

Upper UT1 was designed as a Rosgen B stream because of its setting in a steep valley. Lower UT1, UT5, and UT6 were designed as Rosgen C streams with high width-to-depth ratios and point bars. The wetlands on UT1 and UT5 were designed to be riparian bottomland hardwood areas. The wetlands on UT6 were designed to be mostly riparian bottomland hardwood areas with some non-riparian areas at the toe of slope away from the streams.

The middle section of UT5 was enhanced (enhancement levels I and II) through livestock exclusion fencing and woody structure placement. This reattached the stream to its historic floodplain, diversified the bed form, and added additional habitat areas.

UT2, UT4, and stable reaches of UT5 and their riparian buffers were preserved. All stream reaches (restoration, enhancement, and preservation) are protected with a recorded permanent conservation easement (see **Figures 2-5**).

Wetland enhancement areas located in UT1 and UT5 are hydrated by their connection to the groundwater table, hill slope seepage, runoff, and over-bank flooding from the nearby streams. Modifications to these enhancement areas included livestock exclusion and supplemental plantings.

Wetland restoration areas located in UT1 and UT6 were modified by grading (a maximum of 6 inches) to bring the ground elevation within a foot of the mean growing season water table. The land surface was reshaped to allow over-bank flows to route though the wetland. The grading also created microtopography to increase ponded water detention and infiltration times. The areas that were open fields were revegetated with woody species, thereby increasing hydraulic roughness of the floodplain, leading to an increase in the duration of flooding in these areas. Restoring the streams and backfilling the ditches will restore the local ground water table and increase the frequency and duration of flooding from smaller storm events.

The riparian buffer of the entire easement was planted in five zones. Zone 1, the stream bank zone, consisted of planted tree and shrub species and seeded native herbaceous species typically found along stream banks in the region. Zone 2, a forested riparian area, consisted of selected tree and shrub species that are tolerant of inundation and saturation. Zone 3 was a transitional zone between the other zones and the conservation easement. It included a mixture of light-tolerant, canopy, and understory species. Zone 4, a wetland/bottomland hardwood zone, covered planting zones in the wetland restoration areas where the inundation or saturation occurs for a long enough period of time during the growing season to select species more adapted to hydric conditions. Zone 5 included areas that already had appropriate native forest vegetation. In these areas, supplemental tree and shrub species were planted as needed. Zone 1 was planted with live stakes, and Zones 2 through 5 were planted with bare root seedlings. Plant spacing was determined according to planting type.

Inspection of the vegetation plots during the baseline monitoring phase showed that the planting density matched the density prescribed in the planting plan. It should be noted that Zone 5 plantings in currently forested areas are supplemental. As a result, the actual densities may reflect the spacing of mature forested areas.

**Table 3: Stream Mitigation Summary by Reach**

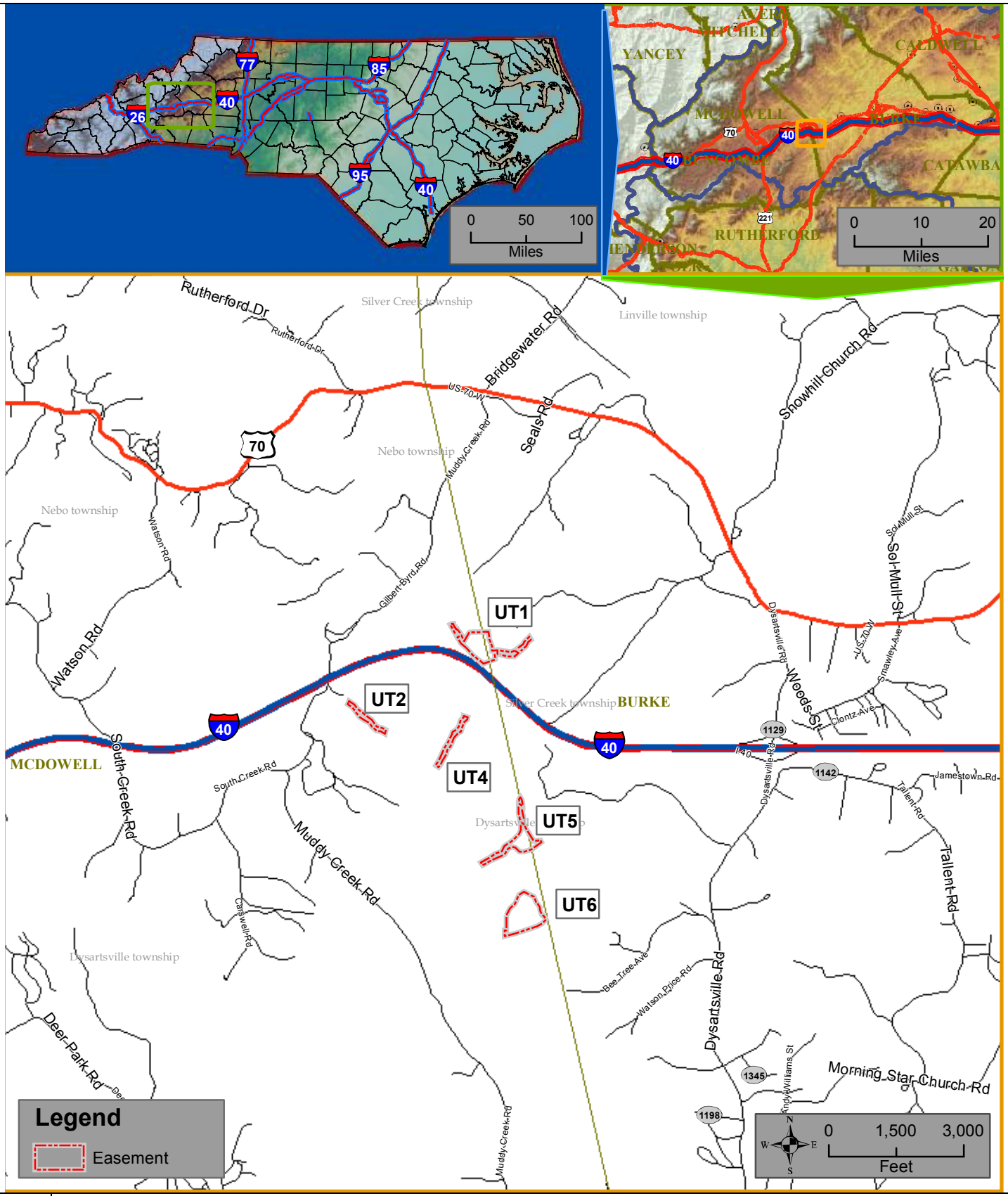
| Project Stream | Stream Restoration (linear feet) | Stream Enhancement Level I (linear feet) | Stream Enhancement Level II (linear feet) | Preservation (linear feet) | Total |
|---|---|---|---|---|---|
| UT1 | 2,257 | 0 | 0 | 0 | 2,257 |
| UT2 | 0 | 0 | 0 | 1,172 | 1,172 |
| UT4 | 0 | 0 | 0 | 1,421 | 1,421 |
| UT5 | 550 | 337 | 336 | 720 | 1,943 |
| UT6 | 1,167 | 0 | 0 | 0 | 1,167 |
| **Total Site** | **3,974** | **337** | **336** | **3,313** | **7,960** |
| **Total SMUs** | **3,974** | **225** | **134** | **663** | **4,996** |

**Table 4: Wetland Mitigation Summary by Reach**

| Project Wetlands | Riparian Wetland Restoration (Acres) | Riparian Wetland Enhancement (Acres) | Riparian Wetland Preservation (Acres) | Riparian Total (Acres) | Non-Riparian Wetland Restoration (Acres) | Total (Acres) |
|---|---|---|---|---|---|---|
| UT1 | 3.3 | 3.0 | 0.3 | 6.6 | 0 | 6.6 |
| UT2 | - | - | - | - | - | - |
| UT4 | - | - | - | - | - | - |
| UT5 | 0 | 0.7 | 2.2 | 2.9 | 0 | 2.9 |
| UT6 | 8.1 | 0 | 0 | 8.1 | 2.6 | 10.7 |
| **Total Site** | **11.4** | **3.7** | **2.5** | **17.6** | **2.6** | **20.2** |
| **Total WMUs** | **11.4** | **1.9** | **0.5** | **13.8** | **2.6** | **16.4** |

**Table 5: Mitigation Units Summary**

| Contract Stream Mitigation Units (SMUs) | As-built Stream Mitigation Units (SMUs) | Contract Riparian Wetland Mitigation Units (WMUs) | As-built Riparian Wetland Mitigation Units (WMUs) | Contract Non-Riparian Wetland Mitigation Units (WMUs) | As-built Non-Riparian Wetland Mitigation Units (WMUs) |
|---|---|---|---|---|---|
| 5,014 | 4,996 | 12 | 13.8 | 2.4 | 2.6 |

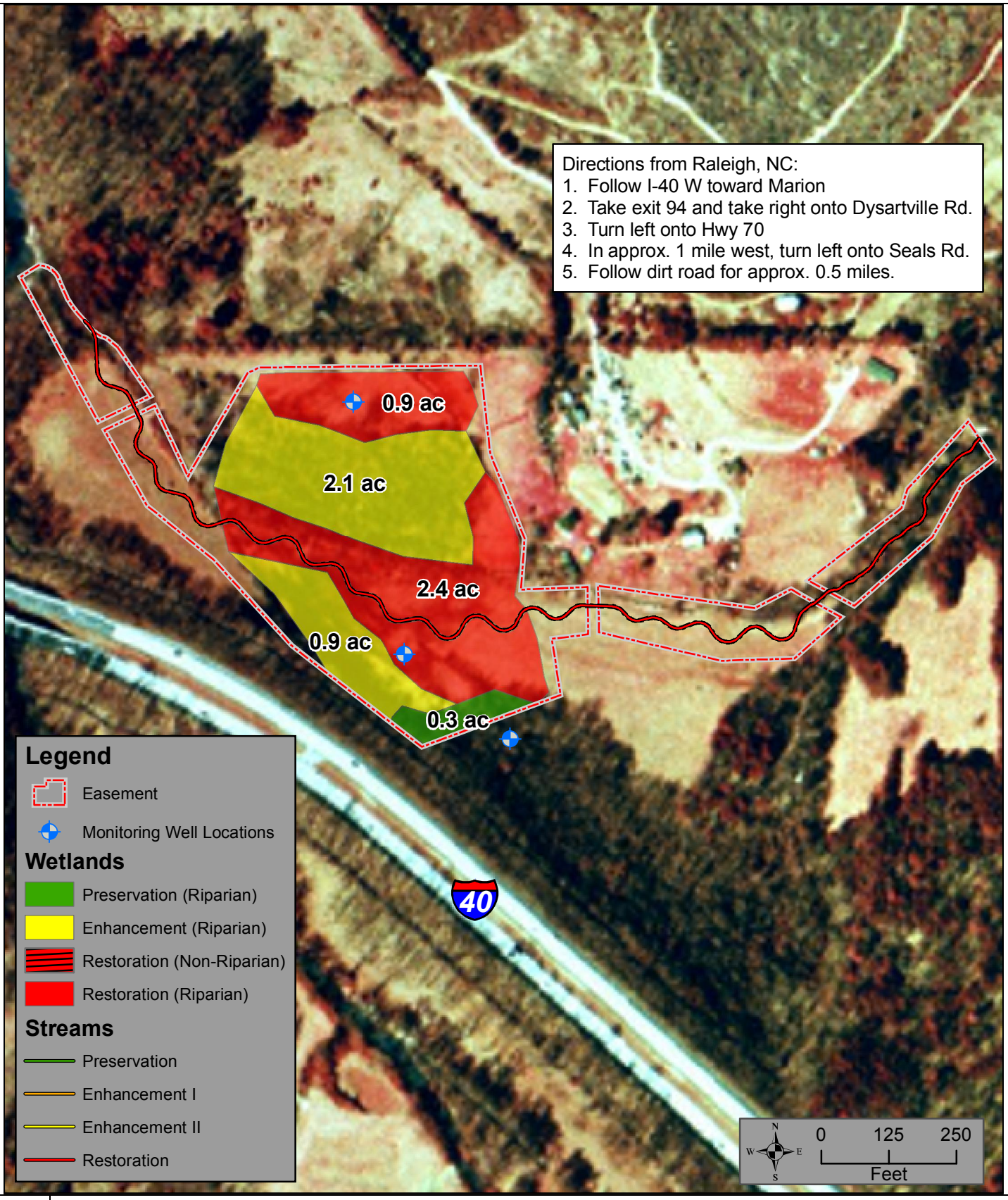



| Title | Vicinity Map |
|---|---|

Submitted to:

Ecosystem Enhancement Program

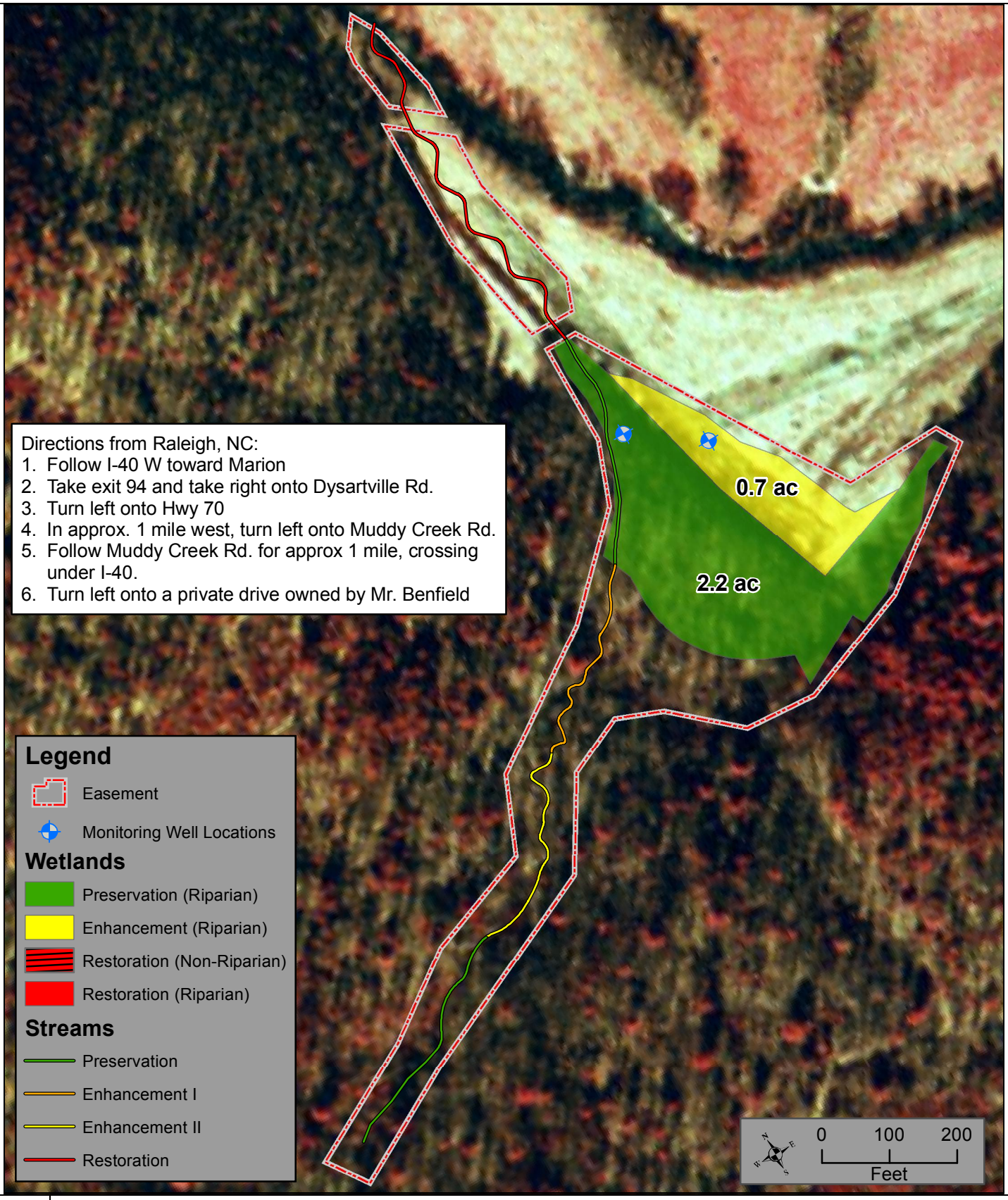
| Project | North Muddy Creek Site<br>McDowell and Burke Counties, North Carolina | | |
|---|---|---|---|
| | **Date** | **Project Number** | **Figure** |
| | 4/20/09 | 16-D06115 | 1 |




| | |
|---|---|
| **Title** | Project Component/Asset Map – UT1 |

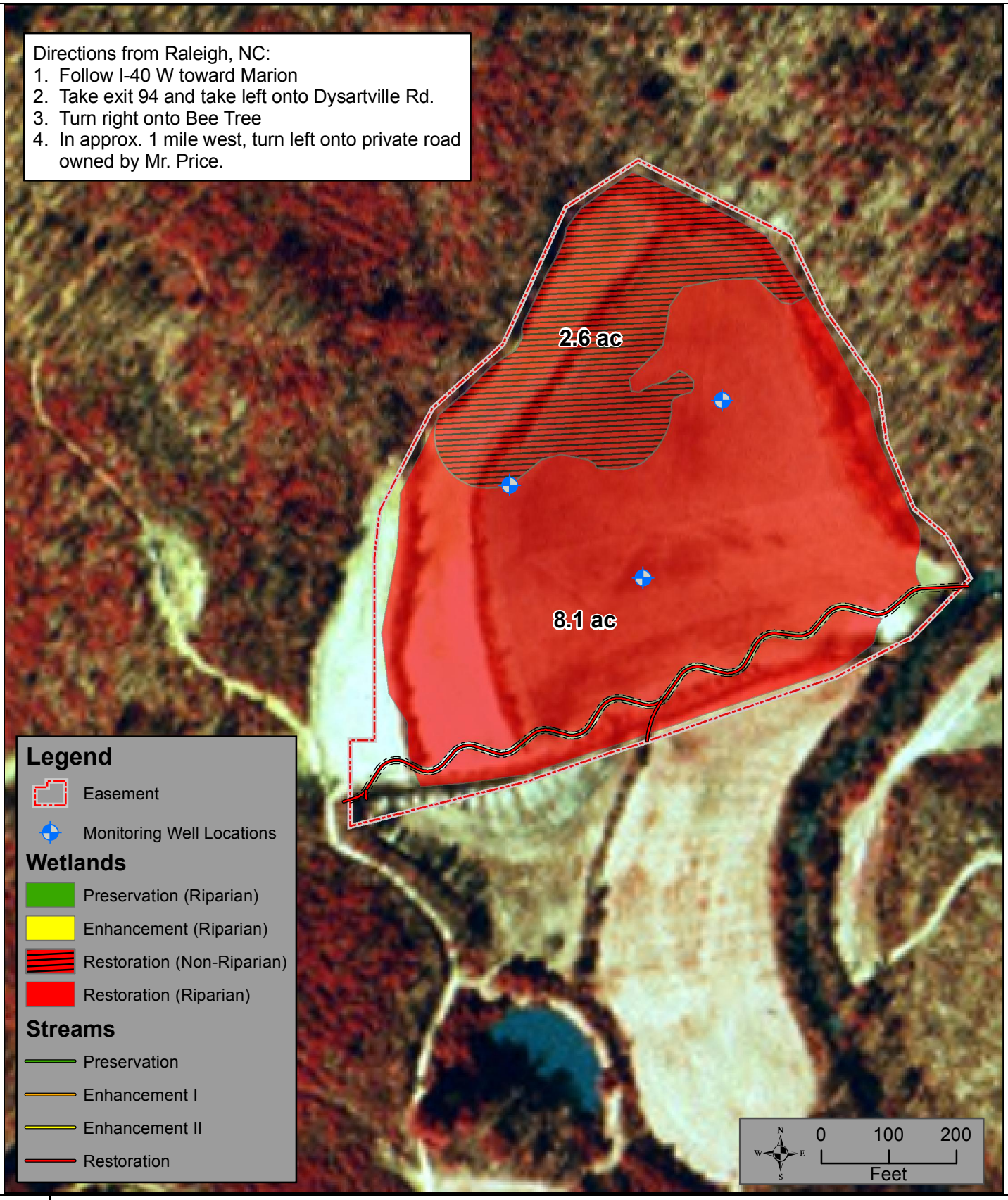
Submitted to: Ecosystem Enhancement Program

| **Project** | North Muddy Creek Site<br>McDowell and Burke Counties, North Carolina | |
|---|---|---|
| **Date** | **Project Number** | **Figure** |
| 4/20/09 | 16-D06115 | 2 |




| | |
|---|---|
| **Title** | Project Component/Asset Map – UT5 |
| Submitted to: Ecosystem Enhancement Program | **Project**: North Muddy Creek Site<br>McDowell and Burke Counties, North Carolina |

| Date | Project Number | Figure |
|---|---|---|
| 4/20/09 | 16-D06115 | 3 |




| Title | Project Component/Asset Map – UT6 | | |
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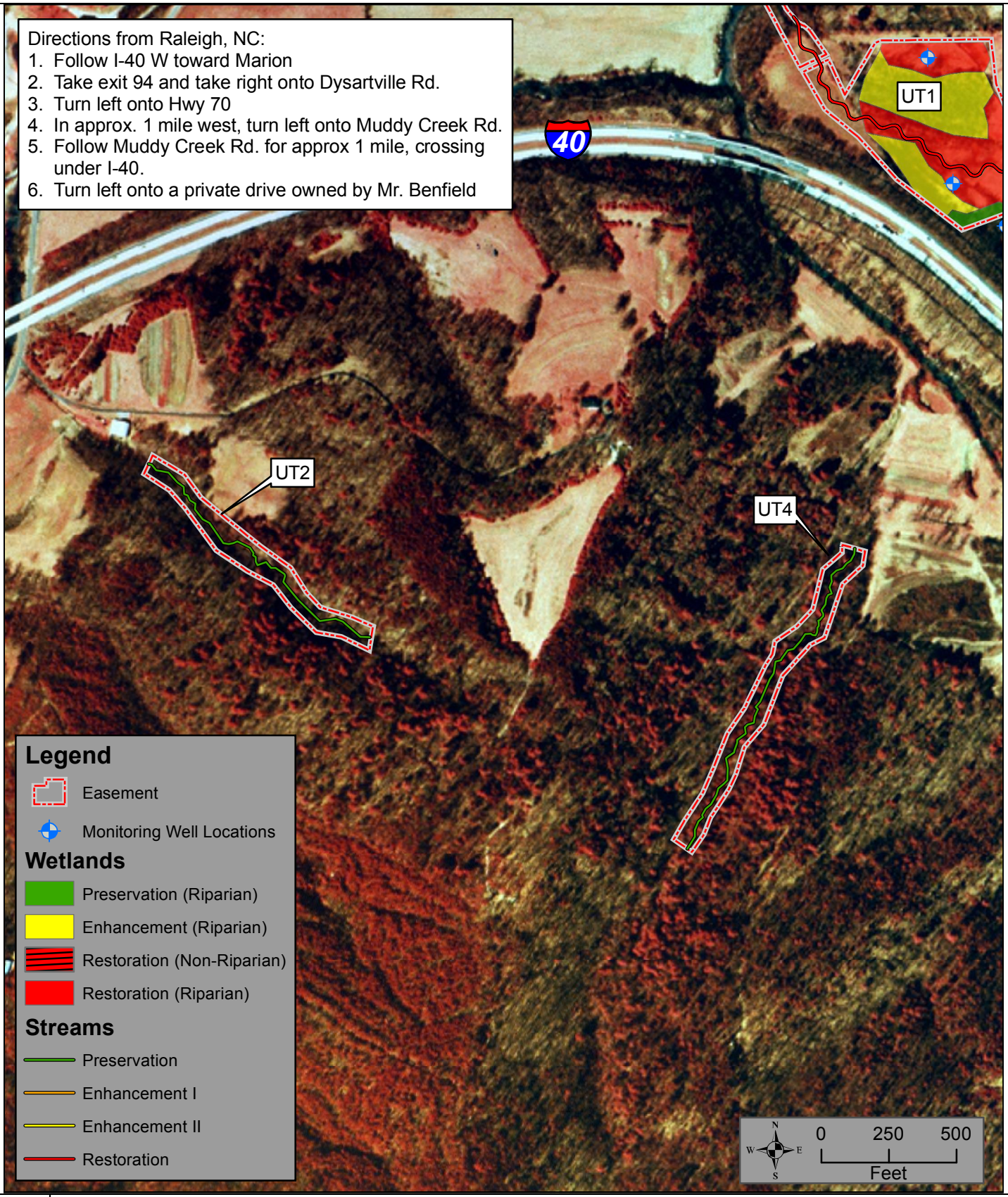
| Submitted to: Ecosystem Enhancement Program | Project | North Muddy Creek Site<br>McDowell and Burke Counties, North Carolina | |
| | Date | Project Number | Figure |
| | 4/20/09 | 16-D06115 | 4 |




| Title | Project Component/Asset Map – UT2 and UT4 | | |
|---|---|---|---|
| Submitted to: Ecosystem Enhancement Program | **Project** | North Muddy Creek Site<br>McDowell and Burke Counties, North Carolina | |
| | **Date** | **Project Number** | **Figure** |
| | 4/20/09 | 16-D06115 | 5 |

# Monitoring Plan

The monitoring plan to evaluate the success of the stream restoration project is based on guidance provided by *Stream Mitigation Guidelines* disseminated by the United States Army Corps of Engineers (USACE) – Wilmington District and recommendations from the North Carolina Ecosystem Enhancement Program (EEP). The collection and summarization of monitoring data will be conducted in accordance with the most current version of the EEP documents entitled "Content, Format, and Data Requirements for EEP Monitoring Reports."

Monitoring will occur annually for five years and include reference photographs, materials sampling, site survey, visual assessment, and mapping of significant features. The success criteria and assessment methods for the site's streams and riparian buffer are provided below.

## Stream Monitoring

### Success Criteria

The stream geometry will be considered successful if the cross-section geometry, profile, and sinuosity are stable or reach a dynamic equilibrium. It is expected that there will be changes in the designed cross sections, profile, and/or substrate composition. Changes that may occur during the monitoring period will be evaluated to determine whether they represent a movement toward a more unstable condition (e.g., down cutting or bank erosion) or an increase in stability (e.g., settling, vegetative changes, coarsening of bed material, braiding in areas of flatter slopes, etc.).

Deviation from the design ratios will not necessarily denote failure, as it is possible to maintain stability and not stay within the design geometry. Changes to the as-built hydraulic geometry may occur due to natural processes of channel adjustment.

### Assessment Methods

Nine permanent cross sections have been installed at unique stream segments throughout the project site. The cross sections represent five riffles and four pools. Annual photographs showing both banks will be taken for each cross section.

Four longitudinal profile sections have been installed totaling 4,090 linear feet of survey. UT1-Upper consists of 386 linear feet, UT1-Lower consists of 2,054 linear feet, UT5 consists of 578 linear feet, and UT6 consists of 1,072 linear feet of surveyed profile.

Thirty-three permanent photo stations have been established to capture the condition of the channel and vegetation plots. Eleven vegetation plot photos have been established.

The restored and enhanced stream reaches will be investigated for channel stability and in-stream structure functionality. Evidence of channel instability (if found) will be identified, mapped, and photographed. Structures will be inventoried for functionality.

## Riparian Buffer and Wetlands Vegetation

### Success Criteria

The success of riparian and wetland vegetation planting will be gauged by stem counts of planted species. Riparian and wetland vegetation will be considered successful with the survival of 260 planted stems per acre at the end of the fifth year of monitoring. Survival of 320 planted stems per acre at the end of the third year of monitoring will be used as an interim measure of success. Photos taken at established photo points should indicate maturation of riparian vegetation community.

### Assessment Methods

The success of vegetation plantings will be measured through stem counts. Eleven (11) permanent plots will be used to sample the riparian buffer and restoration wetlands. Each quadrant covers 100 square meters. During the counts, the health of the vegetation will be noted. The vegetation survey will occur during the growing season. Permanent photo stations have been set up for each plot.

## Wetland Hydrology

### Success Criteria

The success of wetland hydrology will be based on a comparison the monitoring gauge data from the restoration sites to that of the enhancement sites. The groundwater hydrology of the enhancement areas will serve as the site's hydrology reference for target groundwater hydrology because the enhancement areas (pre-construction) exhibited wetland groundwater hydrology but lacked appropriate vegetation. The enhancement sites are considered to have already met wetland hydrology criteria because they are considered to be jurisdictional by the USACE. They also are in similar landscape positions and should have hydrological responses similar to the restored wetlands. The hydrological success also will be based on saturation of the upper surface of the soils for 7% of the growing season.

### Assessment Methods

Wetland groundwater hydrology will be monitored using shallow continuous monitoring gauges. Monitoring gauges have been placed in the proposed restoration and enhancement areas. This data will be used to confirm that the success criteria have been met.

## References

McLendon, Scott, Becky Fox, Todd St. John, et al. (2003). Stream Mitigation Guidelines. United States Army Corps of Engineers - Wilmington District, United States Environmental Protection Agency, North Carolina Wildlife Resources Commission, and North Carolina Department of Natural Resources - Division of Water Quality.

Rosgen, David L. (1995). A Geomorphic Approach to Restoration of Incised Rivers. Management of Landscapes Disturbed by Channel Incision.

Mathis Jr., Roy L. (1995). Soil Survey of McDowell County, North Carolina. Natural Resources Conservation Service, United States Department of Agriculture.