Newfound Creek
Stream Restoration Project

Buncombe County, North Carolina
EEP Project Number: 92497
SCO Project Number: 060675001

FINAL

Restoration Plan

Prepared for:
North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

June 2008

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EXECUTIVE SUMMARY

The North Carolina Ecosystem Enhancement Program (NCEEP) has identified a portion of Newfound Creek and six unnamed tributaries to Newfound Creek in Buncombe County, NC for potential stream restoration. The project consists of approximately 10,145 (existing) linear feet of stream and 18 acres of buffer located off of Newfound Road in western Buncombe County, North Carolina (Figure 1 and Figure 2).

The streams in the Project Study Area have been impacted by long-term agricultural activities on the property. Currently, the property is used for raising beef cattle, hay, and row crops (primarily tomatoes and corn). Farming activities typically occur right up to the streambanks, with little to no riparian buffer. Drainage ditches around the row crops discharge directly into Newfound Creek, and appear to carry a large sediment load. In addition, cattle have direct access to Newfound Creek. The proposed project will restore, enhance, and/or preserve stream functions; reforest a natural riparian buffer; exclude cattle from the streams; provide alternative water sources; and be protected in perpetuity by a conservation easement.

The goals of the proposed project include:

- Reducing erosion from within the Project Study Area;
- Restoring a channel that is able to properly transport watershed flows and sediment loads efficiently;
- Improving aquatic habitat;
- Enhancing wildlife habitat;
- Providing ecological corridor with native vegetation;
- Reducing direct nutrient inputs; and
- Improving overall water quality.

The objectives of the proposed project include:

- Restore the stream channels to an appropriate dimension, pattern, and profile;
- Provide grade control in areas of streambed erosion;
- Provide the stream channels with an adequate flood prone area;
- Establish a more diverse bed morphology with riffle-pool sequences supported by in-stream structures;
- Create native riparian buffer and corridors; and
- Exclude cattle from the stream channels (fencing and watering facilities provided by Natural Resources Conservation Service (NRCS).

Of the existing 10,145 linear feet, approximately 4,649 linear feet are designed as Restoration, 1,455 linear feet as Enhancement Level II, and 4,245 linear feet as Enhancement Level I. In addition, a total of approximately 0.85 acres of wetlands will be enhanced through invasive species management and native wetland plantings. Because of the steep terrain and confined valleys, extensive planform adjustments and channel relocation are neither practical nor appropriate in many places. The restored channels will be constructed primarily on-line, with portions on new location where suitable. These adjustments will increase overall reach sinuosity slightly, resulting in a proposed total stream length of approximately 10,349 feet, or an increase of 204 feet. In-stream structures will be incorporated throughout the restored reaches to provide

grade control, enhance stability, promote efficient sediment transport, and produce/enhance in-stream habitat. Buffer reforestation will involve eradication of invasive species and planting of native vegetation to create a native riparian buffer and corridor. Table 1 summarizes the Project Restoration Structure and Objectives.

As an important part of this project, NCEEP contracted with the Buncombe Soil and Water Conservation District (SWCD) to prepare a Farm Conservation Plan that identified and implemented agricultural and livestock Best Management Practices (BMPs) important for improving water quality. The farm plan and associated BMPs are intended to address water quality issues along Newfound Creek and unnamed tributaries through practices such as livestock exclusion, stabilizing heavy use areas, and enabling alternative watering systems, which will all help to ensure the long-term success of the Newfound Creek Stream Restoration Project. This farm plan included BMPs related to livestock watering (21 tanks and 2 drilled wells), fencing (21,000 linear feet), and stock trails (4,000 linear feet). All installed BMPs meet the standards and specifications of either the US Department of Agriculture Natural Resources Conservation Service Technical Guide or the Soil and Water Conservation Commission standards.

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1.0 PROJECT SITE IDENTIFICATION AND LOCATION

The North Carolina Ecosystem Enhancement Program (NCEEP) has identified a portion of Newfound Creek and six unnamed tributaries for stream restoration and enhancement. URS Corporation – North Carolina (URS) is contracted to provide professional assessment, design, and construction management services for this project. The project consists of approximately 10,145 (existing) linear feet of stream and 18 acres of buffer located off of Newfound Road in western Buncombe County, North Carolina (Figure 1 and Figure 2). The proposed project would restore a segment of Newfound Creek and several tributary reaches using the principles of natural channel design and reforest a natural riparian buffer using native vegetation along Newfound Creek.

1.1 Directions to Project Site

The Project Vicinity and Project Study Area are shown on Figures 1 and 2, respectively. The Project Study Area is located in western Buncombe County, North Carolina, in the Newfound Community near the town of Leicester. From Asheville, take I-240 west to Patton Avenue (US19/23). Turn right on NC 63 (Leicester Highway) and go approximately four miles. Turn left on Newfound Road and go approximately three miles. Turn right at the Country Food Stores gas station at Old Newfound Road, and then take an immediate left onto Browntown Road (SR 1297). Browntown Road crosses Newfound Creek near the center of the project.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The Project Study Area is located in the French Broad River Basin. The French Broad River Basin is made up of three major drainage areas referred to as US Geological Survey (USGS) cataloging units. These three units are the French Broad, Pigeon, and Nolichucky river systems. Newfound Creek is part of the Upper French Broad drainage, designated by USGS cataloging unit 06010105. These 8-digit units are further subdivided into smaller watershed units (14-digit hydrologic units). The Newfound Creek watershed is designated as hydrologic unit 06010105090020.

Within North Carolina, the French Broad River Basin is divided up by the North Carolina Division of Water Quality (NCDWQ) into seven subbasins represented by six-digit subbasin codes (04-03-01 through 04-03-07). The Project Reach is located within NCDWQ subbasin 04-03-02, (NCDWQ 2005a).

1.3 Project Vicinity

The Project Vicinity Map is provided as Figure 1 in Section 10.

For the purposes of this document, the following terms are used with regard to the limits of site investigations.

Project Reach – Denotes the sections of stream investigated. The Project Reach includes Newfound Creek and six tributaries. The tributaries identified for this project are designated as: Tributary 3, Tributary 4, Tributary 5, Tributary 6, Tributary 7, and Tributary 8. Tributaries 3 through 6 and 8 flow directly into Newfound Creek. Tributary 7 flows into Round Hill Branch upstream of its confluence with Newfound Creek. The portions of these streams included in the Project Reach are limited to those located within the conservation easement option agreement

between NCEEP and Virgie Brown, Life Estate, Marjorie S. Brown, Life Estate, and Marjorie Lynn Brown, Remainderman, c/o Marjorie Lynn Brown 139 Browntown Road, Leicester, NC 28748. The conservation easement includes an approximate 203.8 acre parcel identified as Buncombe County Parcel Number 8790.00-74-2086.000 and is recorded in Deed Book 4084, page 846-853 of the Buncombe County Registry. The downstream end of Newfound Creek is located on Buncombe County Parcel Number 8790.00-75-5081 and is in negotiation with the above parties as well (Figure 2).

Tributaries 1 and 2 are located on an adjacent property and were initially considered for inclusion in the project. These tributaries were subsequently dropped from the project and do not enter the current Project Study Area. The original numbering of tributaries has been maintained for consistency.

Project Study Area – Denotes the immediate area investigated. The Project Study Area includes the Project Reach plus the adjacent floodplain up to 50 feet on each side from the top of bank (Figure 2). The Project Study Area is approximately 20 acres.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The watershed for the Project Reach is shown in Figure 3. The drainage area at the upstream limit of the Project Reach is approximately 6,400 acres (10 square miles). The drainage area at the downstream limit of the Project reach is approximately 6,620 acres (10.3 square miles). The drainage areas for all the tributaries are given in Table 2.

The watershed is characterized by steep slopes leading to a broad bottomland valley. Much of the watershed can be easily viewed by traveling Newfound Road which follows Newfound Creek along the bottom of the valley.

The dominant land use in the watershed is forest, primarily on the surrounding ridges and steep slopes. As the slopes decrease, agricultural land uses increase. The majority of the valley floor has been cleared and is being used for agricultural and residential practices.

2.2 Surface Water Classification and Water Quality

Best Usage Classifications are ranks assigned to each surface water body by the NCDWQ in accordance with *Procedures for Assignment of Water Quality Standards* (15A NCAC 2B .0100) and *Classifications and Water Quality Standards Applicable to the Surface Waters of North Carolina* (15A NCAC 2B .0200). These classifications serve to protect water quality by governing the uses of the water resource.

The NCDWQ stream index number for Newfound Creek is 6-84 from the source to the French Broad River. It has a Class C water quality classification, meaning it is protected for general uses such as secondary recreation, fishing, wildlife, and aquatic life (NCDWQ 2007).

Newfound Creek is listed as impaired for aquatic life uses on the state 303(d) list. This is based on a fair bioclassification rating during the last assessment period (NCDWQ 2005a). Problems with Newfound Creek cited in the 2005 Basinwide Plan include severe habitat degradation, streambank erosion, embedded substrate, poor riparian buffers, and nutrient and organic enrichment problems. The sources of these impairments are likely associated with agricultural land use (primarily dairy and beef cattle operations) as well as recent urban and residential development. In February 2005, the U.S. Environmental Protection Agency (EPA) approved a Total Maximum Daily Load (TMDL) for fecal coliform in Newfound Creek (NCDWQ 2005a).

2.3 Physiography, Geology, and Soils

The Project Study Area is located in the Blue Ridge Level III Ecoregion (66), and two Level IV Ecoregions (Griffith *et al.* 2002). The majority of the Project Study Area lies within the Broad Basins (66j), with the upstream portions of Tributaries 3, 4, and 7 (to the north and west) extending into the Southern Crystalline Ridges and Mountains Ecoregion (66d). The following Ecoregion descriptions are taken directly from *Ecoregions of North Carolina.*

> The Blue Ridge Ecoregion ranges from narrow ridges to hilly plateaus to more massive mountainous areas with high peaks. The Blue Ridge is part of one of the richest temperate broadleaf forests in the world, with a high diversity of flora and

fauna. The ecoregion within North Carolina is characterized by floristically diverse forested slopes; high gradient, cool, clear streams with rocks and boulders; and rugged terrain on primarily metamorphic bedrock (gneiss, schist, and quartzites). Soils are mostly mesic, udic Dystrudepts and Hapludults. Annual precipitation ranges from 40 inches in the Asheville Basin to more than 100 inches on some of the higher peaks in the wetter areas in the southern part of the state.

The Southern Crystalline Ridges and Mountains occur primarily on Precambrian-age igneous and high-grade metamorphic rocks. The crystalline rock types are mostly gneiss and schist, covered by well-drained, acidic, loamy soils. Some small areas of mafic and ultramafic rocks also occur, producing more basic soils. The heterogeneous region has greater relief and higher elevations than the Broad Basins. This ecoregion is mostly forested, with chestnut oak (*Quercus montana*) and other oaks now dominating on most slopes and ridges. Cove forests are common and northern hardwoods forests are found at higher elevations.

The Broad Basins ecoregion is drier, has lower elevations and less relief than the more mountainous Southern Crystalline Ridges and Mountains ecoregion. It also has less bouldery colluvium and more saprolite. The soils are mostly deep, well-drained, loamy to clayey Ultisols, although there are soil variations between the uplands, the high and low terraces, and the floodplains within the region. The Asheville basin has the lowest annual precipitation amounts in North Carolina, receiving less than 42 inches. Compared to the higher mountainous ecoregions of 66, the Broad Basins have a mix of oaks and pines more similar to the Piedmont, with more shortleaf pine (*Pinus echinata*) and Virginia pine (*P. virginiana*), and white oak (*Quercus alba*), southern red oak (*Q. falcata*), black oak (*Q. velutina*), and scarlet oak (*Q. coccinea*).

The Project Study Area soils are shown in Figure 4. Buncombe County does not have a published soil survey, so the map was obtained from the local office.

According to the US Department of Agriculture, Soil Conservation Service Soil Survey Field Sheet for Buncombe County, five soil series are mapped within the Project Study Area (Figure 4). The floodplain along Newfound Creek is primarily French Loam 0-3% slopes. The tributaries extend into Statler loam 1-5% slopes, Tate Loam 2-8% slopes, Tate loam 8-15% slopes, and Evard-Cowee complex 30-50% slopes. French Loam is a Hydric B soil, or a soil that may contain inclusions of hydric soils or wet spots (Gregory 2004).

The following soil series descriptions are taken from the NRCS, United States Department of Agriculture (USDA) online Soil Series Classification Database (NRCS 2007).

French loam, 0-3% slopes, occasionally flooded:
Fine-loamy over sandy or sandy-skeletal, mixed, active, mesic Fluvaquentic Dystrudepts.
The French series consists of very deep, moderately well to somewhat poorly drained, moderately over rapidly permeable soils with contrasting textures on the flood plains of small

streams in the southern Appalachian and Blue Ridge Mountains. They formed in recent loamy alluvial sediments washed largely from soils weathered from gneiss, schist, phyllite, and other crystalline rocks. Moderately to somewhat poorly drained; runoff is slow and permeability is moderate in the solum and rapid in the stratified sand and gravel. A seasonal high water table fluctuates between 1 and 2 ½ feet below the surface for about 5 months in most years. This soil is flooded for very brief duration mainly in late winter and spring. French loam is classified as a prime farmland soil if drained.

Tate loam, 2-8% slopes:
Fine-loamy, mixed, semiactive, mesic Typic Hapludults.
The Tate series consists of very deep, well drained, moderately permeable soils on benches, fans, and toe slopes in coves in the Blue Ridge. They formed in colluvium weathered from felsic to mafic high-grade metamorphic rocks. Slope ranges from 2 to 50 percent. Depth to bedrock is greater than 60 inches. Tate soils are on colluvial fans, foot slopes, and benches in coves in the Blue Ridge. Slopes are commonly 5 to 15 percent but range from 2 to 50 percent. Elevation ranges from 1,400 to 4,000 feet. The soil formed in colluvium weathered from felsic to mafic high-grade metamorphic rocks such as granite, mica gneiss, hornblende gneiss, and schist. Well drained; saturated hydraulic conductivity is moderately high or high, permeability is moderate in the subsoil and moderately rapid permeability in the underlying material. Index surface runoff is negligible to medium. These soils receive surface and subsurface water from surrounding uplands, and seeps and springs are possible. This map unit is classified as Prime Farmland.

Tate loam, 8-15% slopes:
Fine-loamy, mixed, semiactive, mesic Typic Hapludults.
This map unit is the same as described above, but occurs on steeper slopes. This map unit is not listed as a Prime Farmland, but is a soil of Statewide Importance if drained.

Statler loam, 1-5% slopes, rarely flooded:
Fine-loamy, mixed, active, mesic Humic Hapludults.
The Statler series consists of very deep well drained soils that formed in loamy alluvium. These soils are on low terraces. Slope is dominantly 0 to 5 percent but ranges up to 15 percent on narrow slopes leading down to the adjacent first bottoms. Statler soils are on level to sloping low terraces along streams. Slope gradients most commonly are 0 to 5 percent but range up to 15 percent on the narrow slopes between the low terraces and first bottoms. These soils are formed in loamy alluvium washed from watersheds dominated by granite, gneiss, graywacke, phyllite, and arkosic sandstone. Well drained; slow or medium runoff; moderate permeability. This soil is listed as Prime Farmland.

Evard-Cowee complex, 30-50% slopes, eroded:
Fine-loamy, parasesquic, mesic Typic Hapludults.
The primary distinction between the Evard and Cowee series is depth. Evard soils are very deep, with a depth to weathered bedrock of greater than 60 inches. Cowee soils are moderately deep, and have a paralithic contact with weathered bedrock at 20 to 40 inches.

Both series consists of well drained, moderately permeable soils on ridges and side slopes of the Blue Ridge. They formed in residuum affected by soil creep in the upper part and weathered

from felsic to mafic, igneous and high-grade metamorphic rocks. Elevations are dominantly 1,400 to 4,000 feet. Slopes are typically between15 and 50 percent but range from 2 to 95 percent. Runoff class is low on gentle slopes, medium on strong or moderately steep slopes, and high on steeper slopes. Runoff is much lower where forest litter has little or no disturbance.

This soil complex is not listed as Prime Farmland or of Statewide Importance.

2.4 Historical Land Use and Development Trends

A review of historical site conditions was conducted to evaluate the sequence of land use changes in and adjacent to the Project Study Area. This review was conducted to assist in the assessment of the existing site conditions. Historical aerial photographs of the site were obtained from the Buncombe County NRCS office for 1951, 1963, 1975, and 1988. These photographs indicate that the property has been in agriculture for over 50 years and surrounding land use has changed little in this time. The Project Reach has been impacted by long-term agricultural activities. Until recently, the farm was used for a dairy cattle operation. Currently, it is used for raising beef cattle, hay, and row crops (primarily tomatoes and corn). Farming activities typically occur right up to the streambanks, with little to no riparian buffer. Drainage ditches around the row crops discharge directly into Newfound Creek, and appear to carry a large sediment load. In addition, cattle have direct access to Newfound Creek. Photographs of existing site conditions are located in Appendix 1. A summary of current land use in the watershed is provided in Table 3.

Within the Project Study Area, the impervious surface is less than one percent. The impervious surface area in the watershed has also remained relatively constant. Most of the roads and houses present today were also present in the 1951 aerial photograph. However, new residential development appears to be increasing the impervious surface cover quickly.

The Newfound Creek mainstem was very likely channelized sometime prior to the 1951 aerial photograph. There is some visual evidence between Tributaries 3 and 4 where it appears the stream flowed through the field and has been moved toward the slope to maximize the bottomland for farming.

Currently, Newfound Creek appears to be carving some meanders into the existing channel. In general, the analysis of the historical photographs covering the time period between 1951 and 2006 indicates a long period of relatively static site plan view (horizontal) conditions within the Project Study Area.

2.5 Threatened and Endangered Species

The potential for federally protected species to occur within the Project Study Area was evaluated and documented in the Newfound Creek Environmental Resources Technical Report (ERTR) dated March 2007. A search of the US Fish and Wildlife Service (USFWS) and North Carolina Natural Heritage Program (NCNHP) online databases identified five species currently listed as federally threatened or endangered potentially occurring in Buncombe County (USFWS 2006 and NCNHP 2006). These species were: Bog turtle (*Clemmys muhlenbergii*), Carolina northern flying squirrel (*Glaucomys sabrinus coloratus*), Gray bat (*Myotis grisescens*), Rock gnome lichen (*Gymnoderma lineare*), and Spreading avens (*Geum radiatum*). The Project Study

Area was evaluated for suitable habitat for each of these species. Suitable habitat is not present within the Project Study area. The Biological Conclusion for each of the species listed above is "No Effect." In addition, no federally designated critical habitats were identified within the Project Study Area.

Letters were sent to the USFWS and the North Carolina Wildlife Resources Commission (NCWRC) requesting comments on the project and any potential concerns regarding the species listed above. The NCWRC sent a response letter dated February 7, 2007 stating that the Commission does not anticipate any major resource concerns with the project, provided that sedimentation from construction is minimized. The USFWS did not respond to the scoping letter sent January 25, 2007. The letter stated that if no reply was received within 30 days, it would be assumed that the USFWS had no issues regarding the project. Additional correspondence with USFWS regarding this project is not anticipated. All correspondence with USFWS and NCWRC is located in Appendix 2 of the Newfound Creek ERTR.

2.6 Cultural Resources

2.6.1 Potential for Historic Architectural Resources

The National Park Service's (NPS) online database (NPS 2007) of historic resources listed on the National Register of Historic Places (NRHP) was consulted to determine if any NRHP-listed historic structures or historic districts were located within the Project Study Area, or within one mile of the Project Study Area.

The Project Study Area has been used for agriculture for many decades. It is unlikely that there are any historic structures associated with the property. No historic structures or districts listed on the NRHP are located within one mile of the Project Study Area.

2.6.2 Potential for Archaeological Resources

The potential for archaeological resources to exist within the Project Study Area was initially evaluated and documented in the Newfound Creek ERTR dated March 2007. A records review of site files housed at the North Carolina Office of State Archaeology (NCOSA) was conducted in January 2007. In addition, several arrowhead points were found by the survey crew during their site visits.

A total of five archaeological sites have been previously recorded in close proximity to the Project Study Area. These sites are all prehistoric in nature and have been recorded over time by a variety of sources (rather than as the result of systematic work conducted by a single individual/firm). The data on the five sites are limited due to the nature of who recorded the sites and when they were recorded. The boundaries of these sites have not been delineated. As such, the five sites plotted on the maps at the NCOSA represent approximate center points and the true horizontal extent of the sites is unknown. The sites may or may not extend into the Project Study Area.

In addition to the five previously recorded sites near the Project Study Area, numerous recorded sites are located upstream and downstream. In many instances, these sites are densely clustered along broader stream valley areas along Newfound Creek. Unlike the five sites recorded near the Project Study Area, these dense clusters of sites are known because of the result of systematic compliance work for a variety of projects.

Given the high concentration of known archaeological resources in the immediate vicinity, a comprehensive archaeological survey of the Project Study Area was conducted in July 2007. The resulting report, *Archaeological Survey of the Newfound Creek Stream Restoration Area*, *Buncombe County, North Carolina* by Archaeological Consultants of the Carolinas, Inc. is included in Appendix 2. Three archaeological sites extended into the Project Study Area and were recommended potentially eligible for the NRHP. However, the portions of the sites located in the Project Study Area have been severely disturbed due to erosion and plowing of the agricultural fields. The portions of the sites within the Project Study Area are not considered contributing factors to the NRHP eligibility status of the sites, and the stream restoration project is not expected to impact any significant cultural deposits. Therefore, Archaeological Consultants of the Carolinas, Inc. recommended that the project be given clearance to proceed.

2.6.3 SHPO/THPO Concurrence

Letters were sent to the State Historic Preservation Office (SHPO) and the Tribal Historic Preservation Office (THPO) of the Eastern Band of Cherokee Indians requesting comment on project. A letter received from SHPO dated March 6, 2007 stated that there is a high probability for the presence of archaeological resources within the Project Study Area, and they recommended a comprehensive archaeological survey be conducted. A letter received from THPO dated May 29, 2007 also requested that an archaeological survey be conducted to determine if the area contains cultural resources significant to the tribe. Archaeological Consultants of the Carolinas, Inc. forwarded a copy of the report to SHPO. A response from SHPO is pending. Once received, the SHPO determination and a copy of the report will be forwarded to THPO. SHPO has provided concurrence. THPO has been provided a copy of the archaeological survey and a copy of the SHPO concurrence letter. Correspondence with SHPO and THPO is included in Appendix 2..

2.6.4 Categorical Exclusion Form

The findings of these investigations of existing and potential natural and cultural resources on-site are further documented on the Categorical Exclusion Form for Ecosystem Enhancement Program Projects located in Appendix 2. Agency correspondence and other supporting Categorical Exclusion documentation are located in Appendix 2.

2.7 Potential Constraints

2.7.1 Property Ownership and Boundary

The current Project Study Area is located entirely on properties in the care of Marjorie Lynn Brown (PIN #s 8790.00-74-2086.000 and 8790.00-75-5081). NCEEP and Marjorie Lynn Brown have a conservation easement option agreement.

Browntown Road passes through the Project Study Area and crosses Newfound Creek and Tributaries 3, 4, and 8. Additionally, an ingress-egress easement for neighboring Sprinkle property (PIN# 8790-0054-2023) is located to the west of Tributary 4. It does not appear that this easement will affect the Project Study Area or the conservation easement boundary.

2.7.2 Site Access

Site access is provided by Browntown Road and a series of existing farm roads throughout the property and along the stream channels. Construction access is anticipated to be confined to the Project Study Area in most locations. However a temporary construction access road may be required to access Tributary 7, spanning from the end of the farm road across open pasture to the Project Study Area.

2.7.3 Utilities

An overhead power line traverses the Project Study Area, crossing over Newfound Creek and Tributaries 2, 3, 4, and 6. No underground utilities are known to be present. The area does not have natural gas, sanitary sewer, or drinking water distribution lines. The property owner reported using a well and septic tank, though neither are located within the Project Study Area.

2.7.4 FEMA/Hydrologic Trespass

Newfound Creek is located in a detailed Federal Emergency Management Agency (FEMA) flood zone. A flood study will be conducted to evaluate the need for a No-Rise, Letter of Map Revision (LOMR) and Conditional Letter of Map Revision (CLOMR), and to assure no hydrologic trespass issues onto other properties. The project is expected to require No-Rise and LOMR documentation and produce no hydrologic trespass. Since the project is located within a regulated floodway, the Buncombe County Floodplain Administrator, Cynthia Fox Barcklow, AICP, CFM, will be coordinated with to ensure compliance with floodplain requirements.

2.7.5 Other Constraints

Other site conditions that constrain the design options include:

- Elevations and dimensions of existing culverts and the Browntown Road bridge;
- Existing barns near the confluence of Tributary 8 and Newfound Creek;
- Existing driveway to homes near Tributary 4;
- Existing farm road along south side of Newfound Creek; and
- Multiple bedrock outcrops.

These factors have been taken into consideration during the development of the proposed planform and profile.

If bedrock is encountered during construction, no blasting will occur on-site. Because planform changes in the design are minor, it is expected that the designer and contractor will work around bedrock. Since bedrock is a grade control feature, grade control structures in the area may be removed with approval from the designer if bedrock is encountered.

During the on-site field investigations in early 2007, no beaver activity was observed. However, subsequent site visits have encountered beaver activity on some of the upstream portions of Newfound Creek's mainstem. Beaver dams were not accounted for in the design of Newfound Creek channel dimensions and longitudinal profile, and because of their unpredictable nature are not considered a design constraint. If any beaver dams are present at the time of construction they will be removed.

Additionally, there are severe invasive vegetation populations on Tributary 4. This is not considered a design constraint, but is noted here for planning purposes regarding construction costs.

3.0 PROJECT SITE STREAMS (EXISTING CONDITIONS)

The Project Reach includes Newfound Creek and six unnamed tributaries. The stream locations are shown in Figure 5, and photographs are shown in Appendix 1. NCDWQ stream forms are located in Appendix 3.

All of the Project Site streams appear to have been impacted by human activities. Types of impacts include historical channelization, streambank vegetation removal, and inputs of sediment, nutrients, fecal matter, fertilizers, and pesticides from adjacent agricultural activities. These man made stressors have impacted the stream by changing the stream's ability to transport sediment, maintain stable streambanks, provide habitat, and uphold water quality.

3.1 Channel Classification

Newfound Creek Mainstem

Newfound Creek is a perennial, third-order stream with a drainage area of approximately 10.3 square miles at the downstream limits of the project (USGS 1973). The portion of Newfound Creek in the Project Reach is approximately 4,400 linear feet.

According to the Rosgen classification scheme (Rosgen 1994), Newfound Creek alternates between a C4/1 and B4 stream types, with a high width/depth ratio, low slope, and gravel substrate with bedrock. There are several large bedrock outcrops providing grade control throughout the Project Reach. The stream appears to no longer be down cutting, but is in the process of widening through bank erosion and mass wasting. A few portions of the mainstem are relatively stable with appropriate dimension and access to the floodplain. Other portions are entrenched, over wide and unstable. Due to historical channelization, the channel is much less sinuous than a typical C channel. However, the channel appears to have begun the process of widening and building benches to regain some of its pattern. This is occurring through widespread erosion, slumping of bank material at the expense of a significant amount of sediment being washed downstream. Even though this channel has not experienced massive vertical entrenchment, the lack of horizontal stability and the inconsistency of plan form features (*e.g.* pools) justify the need for restoration.

During recent site visits, EEP noted beaver activity. Beavers will continue to deteriorate the condition of the creek as they build dams and alter sediment transport.

Tributary 3

Tributary 3 is a perennial, first-order stream with a drainage area of approximately 70 acres. The headwaters of Tributary 3 are impounded prior to entering the Project Reach. The tributary enters the Project Reach via a culvert under an old stream crossing, and passes under Browntown Road via another culvert. The 300-foot portion upstream of Browntown Road classifies as a G5 channel, indicating an entrenched low width/depth ratio channel with sand substrate. While the pebble count yielded a median diameter particle of sand, the bed material also contained large amounts of cobble. The 760-foot reach below Browntown Road becomes more wide and flat, and more closely resembles an F5 channel, which is also entrenched.

The portion of Tributary 3 below Browntown Road was dredged in the fall of 2007, after URS's fieldwork was conducted. NCEEP notified the appropriate authorities.

Tributary 4

Tributary 4 is a first-order stream with a drainage area of approximately 70 acres. The tributary is approximately 2,010 linear feet, and changes drastically throughout the Project Reach. The first 250 feet consist of a small wetland. The perennial origin of the stream begins just below the wetland with a series of major headcuts. The first headcut is approximately six feet in height followed by a second four-foot drop into a large pool. This portion most closely resembles an A type channel, but due to its unstable nature does not fit any of the major stream types. The upstream portion of Tributary 4 flows through a relatively steep, confined valley and is fairly incised most of the way to Browntown Road, other than a short stretch near the landowners house where the channel flattens out and becomes very stable. Throughout portions of this reach, the channel resembles a steep, narrow, entrenched G channel, a wide, entrenched B channel, and a flat, narrow un-entrenched E channel. The tributary has a mature stand of the invasive species Chinese privet (*Ligustrum sinense*).

Below Browntown Road, the channel is an entrenched F for a short distance, then it flattens out, widens, and disappears almost completely into a wetland/stream complex until it reaches Newfound Creek. This area most closely resembles an E channel with some braided portions through the wetland.

The portion of Tributary 4 below Browntown Road comprising Wetland D was dredged in the fall of 2007, after URS' fieldwork was conducted. NCEEP has notified the appropriate authorities.

Tributary 5

Tributary 5 is a perennial, first-order stream with a drainage area of approximately 45 acres. It joins Newfound Creek from the south opposite Tributary 4. The upstream portion of the reach is steep, rocky, and relatively stable, with adequate floodplain access and good bed morphology. This portion is classified as a narrow E4b channel, because it is steeper than a typical E. However, there is a large headcut that has caused the downstream portion of the reach to become quite incised and more closely resemble a G channel. As the slope flattens out, this quickly transitions to an E channel, then a B channel, and back to an E channel before joining Newfound Creek.

Tributary 6

Tributary 6 is a perennial, first-order stream with a drainage area of approximately 51 acres. This stream is impounded and piped on adjacent properties prior to entering the Project Reach. The upstream portion is relatively steep and rocky, with some bedrock present. This reach is a stable B4 stream type. The stream passes through a culvert under a dirt farm road and then flattens out into a braided channel followed by a headcut. The channel is somewhat incised below the headcut but is still very narrow. This section classifies as an entrenched E5 channel.

Tributary 7
Tributary 7 is located on the north end of the property and flows north into Round Hill Branch upstream of its confluence with Newfound Creek. The drainage area at the bottom of the Project Reach is approximately 32 acres. Tributary 7 begins as an intermittent channel from a spring at the beginning of the Project Reach and flows through a wetland complex before becoming a perennial channel. An earthen dam impounds a small farm pond within this reach. Above the pond, the channel is narrow, un-entrenched, and flat, resembling a low sinuosity E5 channel. Though the channel is in a narrow valley, the bankfull dimensions are so small that the floodplain width is sufficient to classify as an E. Below the dam, the channel periodically disappears and resurfaces through a wetland/stream complex. A headcut marks the end of the wetland portion and the perennial origin of the stream. The downstream reach of Tributary 7 is a stable E5 channel.

Tributary 8
Tributary 8 is a perennial, first-order stream with a drainage area of approximately 26 acres. It begins with a small springhead about 800 feet from where it joins Newfound Creek. The headwaters have been impounded for many years in a farm pond with an earthen dam. The dam has been breached and the pond is partially drained. Cattle have unrestricted access to the pond and the area below the dam, creating a trampled muddy area and disturbing the defined channel. At the time of the initial natural resources assessment, the intermittent portion of the channel was not evident, and only the perennial origin of the stream was flagged. During subsequent site visits, the upstream portion of the channel has been more clearly defined, depending on the degree of cattle activity at the time. A short distance below the dam, the flow is piped under a barn and a dirt driveway. It surfaces for about 100 feet, and then passes into another culvert under Browntown Road before joining Newfound Creek. The 100-foot portion is classified as a G5 stream type, and the remainder below Browntown Road is a stable E5.

The portion of Tributary 8 above the barn was not included in the original Project Study Area, but was subsequently added via a supplemental agreement with NCEEP.

3.2 Discharge

Equation 1, Manning's equation, was utilized to estimate discharge (Chow, 1959) for the mainstem and the tributaries. The mainstem's bankfull discharge ranges between 550 and 600 cubic feet per second (ft^3/s). Discharge rates for the bankfull event on Newfound Creek are comparable to those shown on the North Carolina Rural Mountain Regional Curve (Harman *et al.* 1999). The drainage areas for the tributaries are all less than one square mile, and so discharge cannot be accurately estimated from the regional curve.

$$Q = (1.49AR^{2/3}S^{1/2}/n) \text{ Equation 1}$$

Where:
Q = Discharge (cfs)
A = Cross-Sectional Area of the riffle at bankfull stage (sq. ft)
R = Hydraulic Radius of the riffle cross-section at bankfull stage (ft)
S = Average Channel Slope (ft/ft)
n = Manning's Roughness Coefficient

Existing flood elevations will be obtained from the Hydrologic Engineering Center (HEC) model provided by Federal Emergency Management Agency (FEMA). The model provided to Salam Murtada by John Gerber on January 24, 2008 was utilized as the base model for all modeling efforts.

3.3 Channel Morphology

Morphological data are located in Table 4.

Newfound Creek Mainstem

The pattern of Newfound Creek appears to have been historically channelized. The channel was likely moved to the base of the slope to maximize the floodplain available for agriculture. One area, between Tributaries 3 and 4, shows evidence of the original channel, with lower topography and a marked vegetation line. However the total reach still has an overall sinuosity of approximately 1.2, attributed primarily to a few large bends. The straight-line valley length is 3,980 feet compared to a total thalweg length of 4,400 feet.

The cross-sectional dimensions of Newfound Creek vary somewhat across the Project Reach. The upstream portion has a bankfull width of 30 to 40 feet and a mean depth of two to three feet. Bankfull is near the top of bank with sufficient access to the broad floodplain. Several hundred feet downstream, the channel is confined on the right side by a steep hill and farm road and has access only to the left floodplain. Below the bridge, the channel becomes over wide (approximately 60 feet wide) with much lower banks. The downstream reaches more closely resemble the top of the Project Reach, though the channel has less riparian vegetation and the banks are less stable. The dimensions of the channel have been altered in many areas by erosion processes as well as the construction of berms in an effort to protect the adjacent agricultural fields from flooding. The construction of berms has altered the streambanks, dimension, and entrenchment. The stream appears to no longer be down cutting, but is in the process of widening through bank erosion and mass wasting.

The profile of the mainstem is dominated by riffle habitat. There are multiple long, stable riffles with course substrate. There are also three major bedrock waterfall features where the stream loses much of its slope. The overall reach slope is 0.64 percent. There is a lack of adequate pool habitat, largely due to the dominance of straight reaches. The channel is in the process of trying to build meanders and lateral scour pools are evident in numerous locations.

Tributary 3

The pattern of Tributary 3 is virtually straight with only a few small meanders. The portion upstream of Browntown Road is in a very confined valley and the lack of sinuosity is more than likely its natural condition and not a result of channelization. The portion below Browntown Road is also very straight, but less confined, so more pattern may be appropriate in this reach.

The bankfull dimensions of Tributary 3 vary between about seven to 10 feet wide and one to 1.5 feet deep. Upstream of Browntown Road, the channel is very entrenched and has no access to its floodplain. Below Browntown Road, the channel is less entrenched, but is confined by

agricultural berming along the banks. The channel also becomes overly wide and is not transporting its sediment efficiently.

The bed profile of Tributary 3 is relatively homogeneous with few true riffles or pools. The overall reach slope is 2.4 percent, with a fairly constant gradient and very little diversity of morphological features and habitat. Excessive sediment accumulation has filled in many of these features.

UPDATE: The portion of Tributary 3 below Browntown Road was dredged in the fall of 2007, after fieldwork was conducted.

Tributary 4

The upstream portion of Tributary 4 follows the curve of the hillside and is then fairly straight the remainder of the way to Newfound Creek. The portion upstream of Browntown Road is in a very confined valley and the lack of sinuosity is more than likely its natural condition and not a result of channelization. The portion below Browntown Road is also very straight, but less confined, so more pattern may be appropriate in this reach.

The bankfull dimensions of Tributary 4 vary significantly, since the Project Reach contains the headwaters and the stream type changes multiple times. The headcuts at the stream origin do not have a defined thalweg and drop into one large pool. Once the channel leaves this actively eroding area and becomes more defined, it is approximately four feet wide. It has no clear bankfull indicators and the banks are extremely high due to excessive down cutting in the past. As the channel continues downstream, it becomes less incised and stable, before becoming incised again as it approaches Browntown Road. The dimensions below Browntown Road are approximately 11 feet wide and 0.5 feet deep.

The profile of Tributary 4 also varies greatly throughout the Project Reach. The upstream portion has several large scour pools induced by headcuts or bedrock nick points. In several locations the stream flow becomes subterranean and then resurfaces. Below Browntown Road, there is virtually no diversity of bed facets, as the reach has filled in with sediment and becomes more of a wetland/stream complex. In many places, there is no defined thalweg, and the stream flow is subterranean. This reach has experienced excessive sediment inputs from upstream, both within the channel and out of the channel. The upstream reaches show evidence of severe bed erosion in the multiple headcuts and incised channel. There is also a very steep farm road with large ruts that direct sediment-laden run-off to flow directly into this channel.

UPDATE: The portion of Tributary 4 below Browntown Road comprising Wetland D was dredged in the fall of 2007, after our fieldwork was conducted. NCEEP has notified the proper authorities.

Tributary 5

The pattern of Tributary 5 appears to be unaltered. Due to the steep slope and confined valley, it is a naturally low sinuosity channel, but it does have small natural meanders within the reach.

The dimension of Tributary 5 varies from seven to nine feet wide and 0.7 to 1.1 feet deep. The majority of the reach is un-entrenched with good floodplain access and low bank height ratios. However, there are two short sections where the channel becomes very entrenched.

Tributary 5 has an overall slope over six percent, with a highly varied profile transitioning between short stretches of channel. The upstream portion is a stable step-pool system with good grade control. There is one headcut several feet high that has created a very incised reach. This is followed by a flat, stable reach with good floodplain access. The channel then loses a substantial amount of slope over a stable bedrock feature. Downstream of the bedrock feature the channel becomes more entrenched. As it approaches Newfound Creek, it becomes un-entrenched once again.

Tributary 6

The upstream portion of Tributary 6 also appears to have a largely unaltered pattern. The reach above the farm road flows through a confined valley and follows the natural curve of the slope, giving it a higher sinuosity. The section below the farm road is less confined and has likely been channelized, making it much straighter.

The dimensions vary from six to eight feet wide and 0.5 to 1 feet deep. The upstream reach is somewhat entrenched, though the banks are stable and bank angles are low. The downstream reach is also entrenched, but with steep, eroding banks.

The bed profile in the upstream reach is a stable step-pool system with substantial grade control. It displays good diversity of bed morphology and habitat features. The profile downstream of the farm road is varied. There is a short section where the channel is braided and loses a defined thalweg. A large headcut concentrates the flow downstream, creating an incised channel to its confluence with Newfound Creek.

Tributary 7

Tributary 7 is located in a confined valley and has a naturally low sinuosity. The portion upstream of the pond is quite straight, but downstream of the pond the channel exhibits some small meanders.

At the intermittent origin of the channel, the dimensions are one to three feet wide and a few inches deep. Near the bottom of the reach, after the stream becomes perennial, the bankfull width is approximately five to six feet wide and 0.5-0.7 feet deep. It is not entrenched and has stable banks.

The channel develops a distinct profile from the spring flow at its intermittent origin. Even though the flow is minimal, very small riffle and pool features are evident before the flow disperses into the wetland created by the earthen dam. Below the dam, the channel flows through a wetland/stream complex, often flowing subterranean for short distances before resurfacing. A large headcut is present at the perennial origin of the channel and the end of the wetland feature. Below this headcut, the channel bed is stable with good substrate sorting and diversity of riffle and pool habitats.

Tributary 8

Since the upstream portion of Tributary 8 was not included in the original Project Study Area, assessments of these reaches have not been conducted. If these reaches are added to the project, this information will be included in the Final Restoration Plan.

The portion of Tributary 8 currently included in the Project Study Area begins at the culvert below the barns. This short stretch of stream has very little pattern. The portion above Browntown Road is confined to a small triangle of land surrounded by buildings and roads. Below Browntown Road, the channel has a few small meanders but is fairly straight to its confluence with Newfound Creek.

The dimensions of Tributary 8 are four to five feet wide and 0.5 to 0.8 feet deep. The section above Browntown Road is quite entrenched due to the built-up road elevations adjacent to the channel. The reach downstream of Browntown Road is less entrenched as it flows through the floodplain of Newfound Creek.

The bed profile above Browntown Road has two small headcuts that are actively eroding. The channel loses a lot of slope in the culvert carrying the stream under Browntown Road. The overall slope of the reach is approximately 5 percent.

3.4 Channel Stability Assessment

While portions of the Project Reach are fairly stable, there are multiple areas that are unstable and are likely to threaten the stable reaches. Sources of instability are primarily historical channelization, removal of streamside vegetation, and sediment inputs from agricultural activities in the watershed. This is evident in the active erosion of the bed and banks, lack of diversity of bed morphology, lack of woody debris, and excessive fine-grained sediment deposition within the active flow area.

The initial straightening of the channel likely resulted in channel incision. After a channel becomes incised, the stress on the banks increases, causing bank erosion and channel widening. The lack of sufficient stabilizing vegetation further contributes to a high rate of bank erosion and collapse. The large amount of fine-grained particles contributed by the eroding banks causes excessive sediment accumulation and channel aggradation. This sediment buildup is also a significant factor in limiting aquatic habitat, as it clogs the substrate and creates conditions unsuitable to support diverse bivalve, benthic macroinvertebrate, and fish habitat.

It is important to consider this process of channel evolution where incision, widening, and aggrading have occurred when evaluating the potential of the existing degraded channel to naturally stabilize over time. Without intervention, it is expected that bank materials will continue to erode at an accelerated rate, resulting in a loss of usable property as well as water quality impacts downstream.

Bank Erosion Hazard Index (BEHI) scores for the Project Reach ranged from Very Low to Very High, with the majority of reaches falling in the Moderate range. These scores reflect the high degree of variability within the project site. BEHI scores for each reach are located in Table 5.

BEHI sediment yield values were derived from streambank study results on the Mitchell River, North Carolina (Rosgen 2001).

Newfound Creek Mainstem
The bed of Newfound Creek appears stable throughout the majority of the Project Reach. There is no evidence of continued down cutting or degradation, and several large bedrock outcrops provide grade control. However, aggradation is occurring in several locations where the channel is over wide, particularly around the Browntown Road Bridge and at the downstream end of the Project Reach.

The banks are much less stable and are experiencing active erosion and mass wasting in a majority of the reaches. The channel appears to be in the process of widening and developing point bars to regain some of its sinuosity. In some areas, the banks are slumping into the channel and being washed downstream.

Tributary 3
The portion of Tributary 3 upstream of Browntown Road also has a fairly stable bed, and is bounded by culverts on each end that provide grade control. The channel also has a significant amount of cobble substrate. It is severely entrenched, but does not appear to be actively down cutting. Since very large flows are contained entirely within the channel, the banks are eroding. The channel is in the process of developing a new floodplain at its current elevation since it cannot access its historic floodplain.

The reach downstream of Browntown Road is less entrenched, but has experienced a high degree of bed aggradation due to over wide dimensions that are not able to transport sediment efficiently.

Tributary 4
The headwaters of Tributary 4 represent a state of great instability. A series of severe headcuts has been working up the channel and eroding the bed, sending large volumes of sediment downstream. These headcuts result in a drop of approximately ten feet over a distance of 35 linear feet. As these headcuts progress, they threaten to cut into a small wetland at the headwaters of the tributary and continue to provide a source of high sediment load to the downstream reaches of Tributary 4 and, eventually, Newfound Creek. This high volume of sediment has resulted in aggradation of the bed in the lower reaches of Tributary 4 where the slope flattens out and the channel becomes too wide to move the sediment through.

Tributary 5
Tributary 5 is very stable in some of its reaches. It has more intact riparian vegetation than any of the other reaches on the project, including some very large red maple (*Acer rubrum*) and tulip poplar (*Liriodendron tulipifera*) trees on the edge of the banks. These trees are providing essential root mass to stabilize the banks in this reach. There is one severe four-foot headcut that is migrating up into a stable step-pool reach.

Tributary 6
The portion of Tributary 6 from the top of the Project Reach to the farm road crossing is stable. This portion of the tributary has several natural grade control features and a significant amount of rock and cobble substrate. Below the crossing, a headcut is present and the confluence of the tributary with Newfound Creek is unstable.

Tributary 7
Tributary 7 is very instable in the upstream portion. The earthen dam creating the open water impoundment is old and failing. The piped outlet for the dam is no longer functional, forcing the water to seep through the dam. Animal burrows and woody vegetation have also impacted the stability of the dam. Below the dam, the tributary is fairly stable, with several large trees holding the banks in place. A headcut has formed within the channel, but does not pose major issues.

Tributary 8
The upstream portion of Tributary 8 is highly confined by surrounding roads and buildings, encouraging bank failures and down cutting. Two small headcuts are actively eroding the bed. Below Browntown Road, Tributary 8 is stable.

3.5 Bankfull Verification

Several consistent features were present on Newfound Creek to indicate possible bankfull stages. A low depositional bench was found at a consistent elevation. This also corresponded to the elevation at the back of several new point bars that are in the process of forming. However, field observations suspect this is an inner berm feature. Other features included a high scour line near the top of bank and the top of bank.

The channel dimensions resulting from different bankfull indicators were compared to the NC Mountain Rural Regional Curve (Harman et al. 1999). Selecting the lower bench/back of point bar feature resulted in a cross-sectional area less than half that shown on the regional curve. Selecting the highest scour line/top of bank elevation resulted in cross-sectional areas of 70 to 90 square feet, which was much more consistent with the value indicated by the regional curve (approximately 110 square feet median value). Anecdotal reports from the landowners also indicate that Newfound Creek floods the surrounding fields every year or two. These factors indicated that the true bankfull stage is actually the top of bank in some locations or the highest scour line in other locations, and that the lower bench is an inner berm feature rather than bankfull. Because this feature is so consistent and important during low flows, it will be replicated in the designed dimensions of the new channel.

Two stream gages were installed on Newfound Creek and were used to further verify the bankfull stage. Data collection began in April 2007 and is currently presented through March 2008. During this time, the water level exceeded the inner berm feature on eleven dates (in October and November 2007 and in March 2008). The bankfull elevation has not been reached as of the submittal of this report. There are several gaps in the data due to equipment malfunction. No data were recorded during August or September of 2007; however, these were extremely dry months so it is unlikely that a bankfull event was missed during this time period. Gage data will continue to be collected and analyzed throughout the project and may yield additional information. Monthly gage data are presented in Appendix 4.

All of the tributaries within the Project Study Area have a drainage area of less than one square mile. The data set used to develop the NC Mountain Rural Regional Curve did not include any points within this range, so it is not appropriate to extrapolate to these much smaller drainages. Therefore, the bankfull stage for all the tributaries was determined based solely on field indicators. These indicators included the top of depositional benches and scour lines.

3.6 Vegetation

Plant communities within the state of North Carolina are typically classified using *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990). However, this publication restricts its scope to those communities that are considered 'natural' and without the overriding influence of human activities. The project site has been heavily impacted by invasive species and no longer resembles any natural community type.

The dominant canopy species include black locust (*Robinia psuedoacacia*), black walnut (*Juglans nigra*), red maple, American sycamore (*Platanus occidentalis*), tulip poplar, and black cherry (*Prunus serotina*). Midstory species include Chinese privet, red maple, flowering dogwood (*Cornus florida*), American holly (*Ilex opaca*), tree of heaven (*Ailanthus altissima*), and black willow (*Salix nigra*). The understory contains early successional/invasive species such as Japanese honeysuckle (*Lonicera japonica*), Chinese privet, multiflora rose (*Rosa multiflora*), greenbrier (*Smilax* sp.), Virginia creeper (*Parthenocissus quinquefolia*), and blackberry (*Rubus occidentalis*).

Newfound Creek Mainstem

There is very little riparian buffer along most of Newfound Creek, with agricultural activities occurring along both banks. Riparian vegetation consists of a single row of trees along the top of bank, primarily black locust, black walnut, and red maple.

Tributary 3

This reach is heavily infested with invasive species, including Chinese privet, multiflora rose, blackberry, and Japanese honeysuckle. Other species include black walnut, black cherry, and pokeweed (*Phytolacca americana*). Both sides of the floodplain are plowed for row crops.

Tributary 4

Above Browntown Road, the Project Study Area is uncultivated, with a farm road on the left side; below the road both sides of the floodplain are cropland. The reach above the road is heavily infested with invasive species, including dense thickets of Chinese privet, multiflora rose, blackberry, and Japanese honeysuckle. Wetlands A and D occur alongside Tributary 4 and are dominated by black willow, common rush (*Juncus effusus*), woolgrass (*Scirpus cyperinus*), and rice cutgrass (*Leersia oryzoides*).

Tributary 5

The majority of this reach is wooded, with several very large trees on the streambanks. Dominant vegetation includes Chinese privet, Japanese honeysuckle, Christmas fern (*Polystichum acrostichoides*), blackberry, flowering dogwood, ironwood (*Carpinus caroliniana*), black walnut, American sycamore, red maple, and Virginia pine.

Tributary 6

Above the farm road this reach is uncultivated. Below the farm road, the right floodplain is cropland and the left floodplain contains a closed waste lagoon. Dominant vegetation includes American sycamore, Virginia pine, Chinese privet, and Japanese honeysuckle.

Tributary 7

The reach is heavily infested with invasive species, including multiflora rose, Chinese privet, Japanese honeysuckle, tree of heaven, and blackberry. Other species include ironwood, red maple, woolgrass, common rush, and hazel alder (*Alnus serrulata*). The land surrounding Tributary 7 is currently hay fields, which the landowner anticipates converting to pasture for beef cattle. Wetland B/C is located adjacent to Tributary 7 and is dominated by rice cutgrass, woolgrass, cattail (*Typha latifolia)*, and hazel alder.

Tributary 8

There is very little riparian vegetation on Tributary 8. There is a small clump of trees above the old farm pond consisting primarily of red maple and tulip poplar. The dam below the farm pond is overgrown with Chinese privet. The portion below Browntown Road is primarily fescue with scattered tree of heaven.

4.0 REFERENCE CONDITIONS

An extensive search was conducted to locate appropriate reference reaches for the Project Reach. The reference reach criteria for the mainstem of Newfound Creek were to find a C4 or E4 channel in the Broad Basins Ecoregion with a wide, unconfined valley, and a slope of less than one percent. It was discovered that most of the streams that meet these criteria have been heavily impacted, due to the scarcity of flat land in the mountains. The neighboring watersheds of Sandymush and Turkey Creek were searched, particularly on streams identified for preservation by a NCEEP watershed assessment project. Other areas investigated include the Bent Creek and Mills River drainages. Stream professionals and agency personnel in the area were contacted regarding ideas for potential sites, but without success. Therefore, URS requested permission from NCEEP to utilize stable portions of on-site stream reaches for reference material to develop design parameters. This approach has the advantage of using reference reaches with the same hydrological and geological conditions as are experienced by the Project Reach. We believe that these measurements will be very appropriate for developing design parameters on the site. Morphological data for the reference reaches are presented in Table 4. Representative cross-section photos are shown in Appendix 5.

The same approach will work well for the six tributaries on-site. The vast majority of the site is designated for enhancement activities rather than restoration, and there are multiple reaches on site that are stable and will provide the best reference parameters for what is appropriate in the design.

On-site vegetation was not suitable for reference community development, so appropriate communities were selected from Schafale and Weakley's *Classification of the Natural Communities of North Carolina* (1990).

5.0 PROJECT SITE WETLANDS (EXISTING CONDITIONS)

USFWS National Wetlands Inventory (NWI) maps showed no mapped wetlands within the Project Study Area (USFWS 2007). The existing on-site wetlands were field-delineated by URS wetland scientists, according to the 1987 U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual. For an area to be considered a "wetland", the following three criteria must be met: (1) presence of hydric soils (low soil chroma values), (2) prevalence of hydrophytic vegetation, and (3) sufficient hydrology (inundation or saturation). Evidence of hydrology includes saturated soils, drift lines, sediment deposits, water stained leaves, oxidized rhizospheres, matted vegetation, high water marks on trees, buttressed tree bases, or surface roots (Environmental Laboratory 1987). These parameters were observed during the field delineation performed in January 2007. Three wetlands were delineated – Wetland A, Wetland B/Wetland C, and Wetland D. Their locations are shown on Figure 6 and their Cowardin classifications (Cowardin *et. al* 1979) are given below. Photographs of the wetlands are located in Appendix 1. USACE wetland data forms are located in Appendix 6. A jurisdictional determination was not included in the project scope. Wetland descriptions are provided below.

Wetland A begins at a seep and forms the headwaters of Tributary 4. It is approximately 0.26 acres in size and is classified as palustrine emergent (PEM)/palustrine scrub-shrub (PSS). The dominant vegetation includes rice cutgrass, common rush, and black willow. The soils in Wetland A are mapped as Tate Loam, 8-15% slopes, as shown on Figure 4. A large headcut forms the boundary between Wetland A and Tributary 4.

Wetland B and Wetland C are located along Tributary 7 and are formed largely by an on-line farm pond (Figure 6). Together they comprise approximately 0.44 acres (0.30 acres for Wetland B and 0.14 acres for Wetland C). The earthen dam for the pond is an upland area and separates Wetland B and Wetland C. These wetlands are a combination of palustrine emergent, scrub-shrub, and open water (POW). The dominant vegetation includes rice cutgrass, woolgrass, cattail, and hazel alder. The soils in Wetland B/C are mapped as Tate Loam, 8-15% slopes (Figure 4). The intermittent origin of Tributary 7 begins at a seep and flows into Wetland B, including the open water portion. Flow exits the impoundment via an outlet structure and seepage through the dam to form Wetland C. The stream flow is largely subterranean through the wetland, until a headcut forms the perennial origin of the tributary and the delineated wetland ends.

Wetland D is located along Tributary 4, between Browntown Road and the confluence with Newfound Creek (Figure 6). It is classified as palustrine emergent and is approximately 0.15 acres in size. The dominant vegetation includes rice cutgrass, woolgrass, common rush, and arrowleaf tearthumb (*Polygonum sagittatum*). The soils in Wetland D are mapped as French loam 0-3% slopes, which are listed on the Buncombe County Hydric Soils List (Figure 4).

UPDATE: In late November 2007, URS was notified that Wetland D had been ditched and drained by one of the farmers leasing the property. A field visit verified that the channel had been completely ditched and Wetland D no longer exists. NCEEP notified the appropriate authorities. Tributary 3 had also been ditched.

Enhancement will be performed on Wetlands A and B/C. They will be treated with Invasive Species Management and Native Wetland Plantings. As the wetlands are in the riparian zone, stream activities have the potential to affect the wetland's hydrology. The proposed stream designs in the vicinity of the wetlands have been evaluated to minimize changes to the wetlands. The proposed stream design does extend further upstream into Wetland A than the existing condition due to a massive headcut currently in place. Without extending slightly into the wetland area a stable stream origin will be difficult to construct and without restoring the channel the headcut will continue upwards through the wetland. For the other wetlands, the existing max and bankfull depth ranges are being held in the proposed design. By not substantially altering the channel depth or the alignment, the wetland should continue to maintain hydrology. Design plans will take into account this is a stream and wetland complex.

6.0 PROJECT SITE RESTORATION PLAN

6.1 Restoration Project Goals and Objectives

The goals of the proposed project include:

- Reducing erosion from within the Project Study Area;
- Restoring a channel that is able to properly transport watershed flows and sediment loads efficiently;
- Improving aquatic habitat;
- Enhancing wildlife habitat, and
- Improving overall water quality.

The objectives of the proposed project include:

- Stabilization of eroding streambanks and headcuts;
- Restoring the stream channels to a proper dimension, pattern, and profile;
- Providing the stream channels with adequate flood prone area;
- Establishing a more diverse bed morphology with riffle-pool sequences supported by in-stream structures, and by providing a source for woody debris and leaf litter by planting a native riparian buffer;
- Creating riparian corridors;
- Reducing direct inputs of nutrients and fecal coliform by excluding cattle from the stream channels and providing them with alternative sources for drinking water, and
- Reducing nutrient and sediment inputs to the stream from the agricultural fields by providing a native riparian buffer.

6.1.1 Designed Channel Classification

The existing channel and designed channel alignments are shown on Plan Set 1 (Proposed Restoration Plan Sheets Main Channel, 0-17) in Section 11.0. Table 4 presents the Morphological Data for the Existing Reaches, Proposed Design Reaches, and Reference Reaches. The dimensionless ratios developed from the Reference Reaches were used to build the design parameters for the Project Reach. The proposed longitudinal profiles are shown on Plan Set 2 (Longitudinal Profile). For the purpose of Restoration Type, the Project Reach has been divided into smaller reaches (Table 1 and Figure 5).

Newfound Creek Mainstem

The upstream limit of the Project Reach begins at Station 12+00, where Ms. Brown's property line crosses the stream. The property owner has requested a stabilized cattle crossing near the upstream end of the Project Reach, below the confluence with Tributary 2. There is an existing point of access where the farmer pumps irrigation water. Enhancement Level I is proposed from Station 12+00 to Station 16+50. Throughout this reach, the existing pattern will be kept, and the dimension and profile will be enhanced in select locations. Some areas of this reach are stable and will be used as reference conditions for the other reaches. In some areas, the right bank is very steep and will be sloped back to a more stable gradient. The left bank is stable through most of this reach. At Station 14+00 the stream makes a sharp 90-degree bend where a steep hill rises on the left side. The flow is scouring behind a large willow tree in the bend. A vane will be

added to help turn the water around the bend and save the willow tree. There is bedrock visible below the bend. The bed profile is dominated by long riffles. Pool habitat is lacking and will be enhanced with the addition of structures. The pattern will not be changed. Recent beaver activity has been noted in this section. All beaver dams will be eliminated during construction. Beaver removal is recommended.

Restoration will occur from Station 16+50 to 20+75, where the stream ties into Tributary 3. After the channel passes the steep hill on the left bank, the left floodplain opens up and the right side becomes very steep. It appears that the channel was moved from its original location in the floodplain to the base of the slope. Meanders will be added to restore pattern to the channel and provide floodplain relief on the right side of the channel. Since the channel is incised in this reach, its cross-section will be adjusted to the appropriate bankfull dimension. Any eroding and undercut banks will be sloped and stabilized. The profile in this section is lacking in pool habitat, so pools will be constructed in the new meander bends. The riffles contain appropriate, coarse bed material that will be transplanted to any new sections of channel that are constructed. There are several large trees around the confluence of Tributary 3 that are proposed for preservation. If able to be preserved, the trees will help stabilize the channel. There is some bedrock visible in the farm road on right terrace at Station 17+00 that may be encountered during construction. The landowner will need access to the farm road paralleling the creek upstream of Browntown Road, which may prevent the easement from extending to a full 30 feet in some locations. The road is ten to fifty feet from the existing channel.

After tying in with Tributary 3, the same restoration approach will continue to Tributary 4, extending from Station 20+75 to 27+00. The left floodplain between Tributary 3 and Tributary 4 is very wet and is not cultivated. An especially wet meander in the floodplain appears to be the location of the channel prior to straightening activities. This section of restoration will pull the channel away from the steep slope on the right bank to allow for more gently sloped banks and increase the floodprone width. This section, like most, is dominated by riffles. Adding more meanders will provide the opportunity to increase pool habitat. Several structures will also be added to encourage pool development. A small drainage ditch enters Newfound Creek at Station 25+50. The ditch will be incorporated into the new channel location. There are several stretches of raw banks in this reach that will be repaired when the channel dimensions are adjusted. Several large trees around the confluence with Tributary 4 will be preserved, if possible.

Below Tributary 4, Newfound Creek becomes more entrenched as it approaches the Browntown Road bridge. The right bank is confined by a steep slope and existing farm road, and berms have been built up on the left side in an effort to prevent the fields from flooding. This reach extends from Station 27+00 to 32+00, to a bedrock outcrop just upstream of the Browntown Road bridge. The pattern will not be altered, but the dimension will be enhanced by cutting a bankfull bench and removing the berms. Between Stations 27+25 and 28+50 the stream is incised. A bench will be cut on both sides. The landowner has requested that all cut material be kept on-site and spread in low spots in the agricultural fields. The existing bedrock outcrop occurs from Station 31+50 to 32+00. This bedrock feature is directing water to the left side of bridge rather than the middle. Several mid-channel bars have formed in the vicinity of the bridge (upstream, downstream, and directly beneath). A structure will be added to center the thalweg between the bridge pilings. At Station 32+00, a drainage ditch enters from the fields on the left. From

Station 31+00 to 33+25, the right bank is extremely steep and high, and is reinforced with concrete and other debris. This material may be remnants of a former bridge. Several small outfalls drain from the barn roads on the right from Station 31+50 to 32+25.

The next reach will consist of Enhancement Level I and will extend from Station 32+00 to 45+00. It will begin at the bedrock feature above the bridge to the second bedrock feature below the bridge. Throughout this reach the existing pattern will be kept, and the dimension and profile will be enhanced in select locations. Some areas of this reach are stable and will be used as reference conditions for the other reaches. Immediately below the bridge, the channel will receive major adjustments to its dimension and profile. It has become over wide and cattle have access to the stream at this point. The cattle will be excluded and the dimension and profile will be restored. An island has formed in the channel which will be filled in behind it. A small pocket wetland will be constructed on the right floodplain between the road and Tributary 8, from Station 35+00 to 36+00. A structure will be added below the bridge to center the thalweg and turn the flow away from the left bank. From Station 35+00 to 40+00, agricultural berms will be removed on the left side of the channel and the banks will be graded down where necessary to adjust the dimensions for bankfull flow and to increase floodprone width. Several structures will be added at key locations. The structure at Station 34+00 is anticipated to tighten up the channel and center flow ahead of a long riffle. Other structures will be installed to enhance pool development. At Station 36+00 there is a large clump of maple trees on left bank that will be preserved, if possible. At Station 38+00, a large bedrock waterfall is pushing flow into left bank and causing scour. We propose to encourage the alignment to follow this natural path and will cut a small meander in this location to pull the channel out into left floodplain. At Station 38+50, the remnants of an old beaver dam have formed a small island. The channel needs to be filled to the right to concentrate flow to left. There are also remnants of old concrete bridge material around Station 39+00 that need to be removed. As a result of all these issues, a massive bank scour has occurred on the right bank around Station 38+75. This stretch will need extensive adjustment to both dimension and profile in order to be stabilized.

From Station 39+00 to 43+00, the channel becomes uniform and flat. A few structures will be added in select locations to promote profile diversity and pool development. The dimension will also be corrected and steep, unstable banks will be graded back to a more stable angle. Some small meanders will be enhanced. A large, stable bedrock waterfall feature is located at Station 43+75.

The downstream end of the project, from Station 45+00 to 56+00 is designated for Restoration. In this reach, the channel becomes over wide and very flat. The bed is relatively homogeneous with few good riffles or pools. The bed material becomes much finer, dominated by sand with some gravel. The low slope and over wide dimensions are causing aggradation of the bed, evidenced by mid-channel bars. The left floodplain is topographically lower than the right floodplain, so several small meanders will be constructed out in the left floodplain at select locations. For the most part, the thalweg will meander gently within the existing channel, taking advantage of bank failures to increase sinuosity slightly and create habitat diversity without significantly increasing stream length. Structures will be added at key locations to develop pools and promote sediment transport. A structure will also be placed at the end of the project (Station 56+00) to provide grade control protection.

Multiple drainage ditches enter the channel carrying discharge from the adjacent tomato fields. All of these discharge points will be diffused through the riparian buffer.

Tributary 3

The portion of Tributary 3 upstream of Browntown Road, (Station 200+35 to 203+35) is designated for Enhancement I. This reach is in a very confined valley. It is not feasible to make changes to the pattern of the channel. However, the banks will be graded back to a gentler slope to reduce erosion potential and to maximize the floodprone width.

The reach below Browntown Road (Station 204+15 to 211+75) is designated for Restoration. This reach is experiencing aggradation of the bed and is not transporting its sediment load efficiently. The dimension will be restored by removing berms from both sides of the channel. The profile will be enhanced with small structures to concentrate the thalweg and promote sediment transport. Logs may be used in these structures. Sinuosity will be increased in the lower portion of the reach by developing meanders on the right floodplain.

Tributary 4

Tributary 4 begins as a seep that forms a small wetland before it develops a defined channel. This seep and wetland area, from Station 300+00 to 302+50 will be treated as Enhancement. Proposed activities consist of invasive species management and the planting of native wetland species.

Restoration will be performed from Station 302+50 to 304+75. The restoration approach in this reach will be to build a step-pool system to stabilize the massive series of headcuts forming the origin of the stream channel. The first structures will extend slightly into the wetland area in order to step the slope down as gradually as possible. Currently, the channel is head cutting into the wetland, without extending slightly into the wetland area a stable stream origin will be very difficult to achieve. Without restoring the channel, the massive headcut is anticipated to continue further upward into the wetland and over some time drain the wetland. The channel is extremely confined due to long-term erosion processes. The left banks can be cut back slightly to reduce the bank angle and erosion potential. The right side is a steep hillside and is not practical to alter.

At Station 304+75 the bed becomes more stable, and has several bedrock nick points. However, the channel is still somewhat entrenched and has little floodplain relief due to the confined valley. Enhancement Level I is proposed from Station 304+75 to 308+25. No pattern adjustments are appropriate in this reach, and cutting a true floodplain bench is not feasible because of the bedrock in the banks and steep slopes. Bedrock was visible from Station 306+50 to 307+25. There is a sharp 90-degree bend in the channel at Station 306+00 which is very confined. However, there are areas where the banks can be sloped back, matted, and planted to provide a more stable slope and reduce erosion potential. Along this reach, the banks are heavily infested with invasive species, including some large privet specimens. Beneath the privet are bare banks. Since much of the woody root mass on the banks is attributed to privet, a successful planting plan will be very important to stability after the invasive species are removed. There is also some debris in the channel that will be removed, including scrap metal, cinder blocks, and a

metal cylinder. There is a farm road running along the left floodplain within the 30-foot easement area throughout much of this reach. The landowner is agreeable to losing this road as long as access to the upstream reach is provided by other means. This will allow for a fully forested 30-foot buffer along the reach. At Station 304+60 a 12" Corrugated Metal Pipe (CMP) enters the channel from under the farm road that should be removed.

At Station 308+25, the valley becomes much wider, the channel becomes relatively flat, and the bed and banks are stable with adequate floodplain access. This reach (Station 308+25 to 312+50) is designated for Enhancement Level II. The primary treatment needed is invasive species management and buffer reforestation.

At Station 312+50 the channel quickly becomes incised again. There are several small headcuts in this area that will be stabilized with grade control structures to keep them from moving upstream into the stable reach. As the channel approaches Browntown Road, it becomes more incised and is very confined by an existing driveway on the left and a steep hill on the right. This reach is designated for Enhancement Level I and extends to the culvert inlet under Browntown Road at Station 315+00. Pattern adjustments are not possible due to the confines mentioned above, but the bed profile will be improved with a series of small step-pool structures to dissipate energy, provide grade control, and move sediment through the culvert. The riparian buffer will be less than 30 feet on the left because of the driveway, but will extend beyond 30 feet on the right. A large amount of sediment is entering the channel near the top of this reach from a steep farm road nearby.

Restoration is proposed for the remainder of Tributary 4, from the culvert below Browntown Road to the confluence with Newfound Creek (Station 315+80 to 320+90). The channel exits the culvert into a large scour hole filled with deep deposits of fine-grained sediment. The slope becomes very flat and the bed profile has little variability. The channel dimensions are also very wide and somewhat entrenched. A berm is maintained along most of the left bank. At STA 317+50 the channel becomes a wetland/stream complex and continues to the confluence. This reach is very flat and straight. The channel is wide and lacks a concentrated point of flow, often disappearing underground. Wetland vegetation is growing within the channel. This wetland has been created by a large supply of sediment from upstream that is unable to move through the over wide and flat channel. It is suspected that Newfound Creek was historically moved toward the southeast, which would have increased the length of Tributary 4, thereby further decreasing its slope. Restoration is proposed on this reach to create a defined channel with proper dimension and profile to transport sediment. The channel will be allowed to meander through the existing wetland area, without significantly increasing stream length. Small, long structures will be utilized to concentrate the thalweg flow and provide grade control. A headcut at the confluence with Newfound Creek will be stabilized with a rock structure.

Tributary 5

The upstream portion of Tributary 5 from Station 400+00 to 402+25 is a stable step-pool system that is being used as a reference reach for other reaches. This segment is designated for Enhancement Level II consisting of invasive species removal and planting of native vegetation.

Further downstream, from Station 402+25 to 404+25, the channel becomes very unstable, as evidenced by a 3-foot headcut at Station 402+75. The segment will be restored to stabilize the headcut and diffuse the elevation drop through a series of step-pools modeled after the upstream reach.

The stream becomes stable again from Station 404+25 to 405+00, where the slope becomes less steep and the banks are no longer incised. This reach is designated for Enhancement Level II consisting of invasive species removal, planting, and debris removal. There is extensive debris within the easement area, including sheds, household appliances, etc.
The channel becomes entrenched again at Station 405+00. The segment from 405+00 to the confluence with Newfound Creek at Station 406+75 is designated for Enhancement Level I. At Station 405+10 the bed falls over a large stable bedrock drop, and becomes very incised below. There are several very large tulip poplar and maple trees on the banks that are helping to hold the banks in place. The banks will be sloped back where possible with minimal disturbance to the mature trees. There is also significant debris removal needed in this reach, including a large number of old tires, appliances, and an old spring house. At Station 406+50 the stream crosses a farm road. This road will need to remain and will also need to be stabilized for a cattle crossing. Below the farm road a grade control structure will be installed to tie into Newfound Creek.

Tributary 6
The portion of Tributary 6 from the top of the Project Reach to the farm road crossing is fairly stable and is designated for Enhancement Level II. This reach extends from Station 500+00 to 503+00. The reach has several natural grade control features, particularly in the upstream section, and a significant amount of rock. A groundwater seep enters the channel around Station 502+00. There are a few areas where the banks will be graded back to a gentler slope at the time of planting. Invasive species management and riparian buffer planting will be the primary treatment types on this reach. There is also some cinder block debris near the top of the reach that will be removed. The culvert under the farm road crossing will be replaced during the construction of the project.

The portion of Tributary 6 from below the crossing to Newfound Creek is designated for Restoration. This reach extends from Station 503+50 to 506+50 and will be reconstructed to correct its dimension and profile and improve the pattern. There is a small dam at Station 504+90 that will be removed, and a headcut at Station 505+35 that will be stabilized. A small shed and old tires on the left bank will be removed, and a closed waste lagoon on the left bank will be excluded from the easement. The pattern adjustments will consist of constructing small meanders, primarily within the current alignment. The confluence with Newfound Creek will also need to be realigned and stabilized. The channel makes a sharp turn downstream but is dry, while the flow is actually seeping through the bank.

Tributary 7
The upstream portion of Tributary 7, from the intermittent origin to the dam, is designated for Enhancement Level II. The stationing for this reach extends from Station 600+00 to 603+85. The treatment in this reach will consist primarily of managing the heavily infested invasive species and planting a native riparian buffer. The entire tributary will also be fenced to exclude cattle.

The earthen dam creating the open water impoundment is quite old and has several stability issues. There is one outlet on the left side of the dam with a broken 12-inch pipe spillway that is not functional. On the right side of the dam, there is no defined outlet, but the water seeps through and forms a channel at the bottom of dam. These two channels converge at Station 604+50. A stabilized outlet and v-ditch will be constructed from the left spillway to carry flow to the main channel. Other sources of instability include animal burrows and woody vegetation that has been allowed to grow on the dam. The vegetation will be removed and burrows in the dam will be plugged.

The reach from the bottom of the dam to the end of the Project Reach at the property line extends from Station 603+85 to 607+85. This portion of the channel will receive Enhancement Level I, consisting of a few minor adjustments to dimension and profile, and stabilization of headcuts with structures. One structure will be located at STA 605+75 to stabilize a headcut and concentrate the flow. A second structure will be placed at STA 606+75 to stabilize a headcut marking the perennial origin of the channel. Logs will be incorporated into these structures. There are several large trees on both sides of the channel at STA 607+25 that will be protected during construction, if possible. The downstream end of the reach from STA 607+50 to 608+00 is stable and will be planted with a native riparian buffer.

Tributary 8

The headwaters of Tributary 8 are currently being considered for addition to the Project Reach. If the headwaters are added to the project, restoration will be performed. The headwater spring area will be enhanced with riparian plantings. The soils in this reach are heavily compacted by cattle and will need to be amended prior to planting. A large pile of trash and debris above the pond will need to be removed. The debris includes an old hay trailer, tires, automotive battery, watering trough, and a metal cylinder. The remainder of the reach will be restoration, consisting of removal of the old earthen dam and restoration of a channel through the old pond bed. The entire reach will be fenced to exclude cattle and an existing pipe will be extended to provide a dry cattle crossing.

The portion of Tributary 8 currently included in the Project Reach extends from the pipe outlet near the barns to the pipe under Browntown Road. This reach is only 100 feet long, and is designated for Enhancement Level I. The perennial origin of the stream was flagged within this reach. The channel is highly confined by the surrounding roads and buildings. A barn and paved parking area are approximately ten feet from the left top of bank. The left bank will be sloped back as much as possible to provide a more stable slope and maximize the floodplain. The right floodplain is lower and will be used to create a small pocket wetland to add habitat diversity and aid in nutrient removal. The channel is entrenched and two small headcuts are eroding the bed. Two small step-pool structures will be installed to stabilize the headcuts and drop the grade. The substrate is primarily silt with some small gravel. Because this reach is located in a high traffic area, it will be planted with small attractive shrubs and flowering plants, with no large trees.

The remainder of Tributary 8, from below the road to Newfound Creek, is stable and designated for Enhancement Level II. There is a large pile of trash and debris near the road that will need to

be removed, including tires, a 55-gal drum, farm equipment, gas tank, and a metal cylinder. The buffer will be planted with a native riparian buffer. The buffer is currently planted in fescue, which will be treated prior to planting but left in place to provide soil stability.

6.2 Sediment Transport Analysis

6.2.1 Methodology

A stream's ability to transport sediment load without aggrading or degrading is the threshold of a stream's stability. The stream's critical dimensionless shear stress, the force required to initiate the general movement of particles in a streambed, and the overall stream's power are evaluated to determine if the proposed design is able to transport the bedload without aggrading or degrading. Stream power is a measure of the rate a stream can do work, or transport its load. As a function of channel slope and discharge, the rate is expressed as power. The bankfull discharge variable of the stream power equation was computed utilizing Manning's Equation (Chow, 1959) for both existing and proposed on the tributaries. The methodology utilizes a comparison between existing conditions, Reference Reach conditions, proposed conditions, and the Shields' curve. Additionally, shear stress is evaluated to verify the stream design does not mobilize too large of a particle.

Critical Shear Stress
$\tau = \gamma R S$
τ = bankfull shear stress lb/ft^2
γ = specific weight of water = 62.4 lb/ft^3
R = hydraulic radius of riffle cross section (ft)
S = average water surface slope (ft/ft)

Unit Stream Power
$\omega = \gamma Q S$
ω = unit stream power (lb/ft/s)
γ = specific weight of water = 62.4 lb/ft^3
Q = discharge ft^3/s
S = average water surface slope (ft/ft)

Bankfull Discharge by Manning's Equation
$Q = (1.49 A R^{2/3} S^{1/2}) / n$
Q = discharge ft^3/s
A = area ft^2
R = hydraulic radius of riffle cross section (ft)
S = average water surface slope (ft/ft)
n = Manning's roughness coefficient ($n = n_b + n_1 = n_2 = n_3 + n_4$)m

6.2.2 Calculations and Discussion

The design provides floodplain relief for above-bankfull flow, while allowing sufficient stream power such that the stream's sediment supply will be properly transported. Additionally, grade

control structures (rock cross vanes) will provide profile stability by controlling sediment transport locally and maintaining bed elevations.

The gravel bed systems were evaluated mainly by critical shear stress values. Ensuring these systems can move the sediment load through the Project Site is essential to stability. All of Newfound Creek, Tributary 5, and Tributary 6 are gravel-dominated systems. Two mainstem pavement/sub-pavement samples were taken, both taken near the installed gages. The upstream sample was taken from a bar feature and the downstream sample was taken from a riffle feature per methodology taught in Rosgen's stream courses. The largest particle of 98 mm (upstream sample) and 75 mm (downstream sample) will be moved by the calculated design critical shear stress of 1.11 lb/ft^2 (upstream sample) and 0.89 lb/ft^2 (downstream sample) according to Shields relations between grain diameter for entrainment and shear stress. Thus, the mainstem calculations show the design will be able to mobilize the largest particle from the sediment samples (pavement and bar sample).

For the smaller tributaries, the critical shear stress is comparable with the reference section on-site within Tributary 5. The critical shear stress equation computes 3.51 lb/ft^2 for the reference. The design criteria for Tributary 5 matches the reference reach (width-to-depth and bankfull depth, width and area). The minor difference is the natural undulation of existing cross-section verses the smooth lines of a proposed cross-section altering the hydraulic radius. Thus with time, these cross-sections are expected to appear very similar. The reference and design shear stress are within range of one another. The design variables produce a value of 4.4 lb/ft^2 for Tributary 5. Although this initially appears significantly higher, these values are actually in close range according to the shape of Shield's curve.

For Tributary 6, the shear stress of 3.19 lb/ft^2 is slightly below but within range of the reference portion of Tributary 5. As these are similar channels, and the designed shear stress can move the sediment load, this reach is anticipated to be stable.

The sand bed systems were evaluated utilizing stream power estimates as critical shear stress equations do not apply. Tributaries 3, 4, 7, and 8 are sand bed systems. These systems do have gravel, cobble, and even boulders within their systems; however, upon execution of pebble counts the majority of the channel was determined to be sand bed. During field pebble counts, the bed was probed to determine if a thin layer of sand deposition was covering a gravel bed, but this was not found to be the case. While the fine material may be in part a result of sedimentation, this is currently the substrate of these channels. In general, Tributary 3 is experiencing degradation processes. Stream power was decreased from the existing condition for Tributary 3 to 29 $lb/ft^2/s$. There is a drop in stream power proposed for Tributary 3 as the existing condition is down cutting and becoming further entrenched. This value is within range of the stable downstream reach of Tributary 8 as well (27.6 $lb/ft^2/s$).

The proposed design for Tributary 4 drops stream power to 29 $lb/ft^2/s$. The existing condition calculation is averaging the extreme ranges (severe degradation upstream to aggrading in the downstream) within this tributary.

For Tributary 8, the stable downstream was compared with the design for the reach. The existing power (67.6 lb/ft^2/s) was reduced to 22.7 lb/ft^2/s which is within an acceptable range of the stable downstream portion (27.6 lb/ft^2/s).

Considering gravel, cobble, and boulders are sporadically throughout each of the Tributaries and the design recommends reducing slope angles, providing grade control structures, and introducing a continuously vegetated bank, all designs are anticipated to be stable.

6.3 HEC Analysis

Newfound Creek is located in a detailed Federal Emergency Management Agency (FEMA) flood zone. A flood study has been conducted to evaluate the need for a No-Rise, Letter of Map Revision (LOMR) and/or Conditional Letter of Map Revision (CLOMR), and to assure no hydrologic trespass issues. The project, as modeled, requires No-Rise and LOMR documentation and produces no hydrologic trespass onto another property.

In order to model the proposed restoration, the current effective FEMA Flood Insurance Study (FIS) hydraulic model was combined with more recent survey data of Newfound Creek. The original FEMA backup data used for the current FIS on Newfound Creek was obtained from Mr. Salam Murtada of NCEEP and utilized in Hydrologic Engineering Center (HEC) program, HEC-2. The more recent survey data for Newfound Creek was obtained from survey work done by ESP Associates and input into HEC-2. The data was combined to create three HEC-2 models: current effective, revised effective, and proposed effective.

The effective FEMA FIS model served as the current effective model. This model was utilized as a starting model for the restoration site. The current effective model was used to compare the model water surface elevations of the model to the water surface elevations posted in the FIS in order to verify model agreement with published data. It was also used to determine cross section locations within the site so that model cross section stations would match cross section stations of the current FIS.

Recently surveyed cross sections within the restoration site were added to the current effective model in order to produce the revised effective model. The addition of cross sections into the current effective model resulted in a surcharge of over 1.0 foot for a portion of the site. Where a surcharge of over 1.0 foot was observed, the floodway was widened, by modifying encroachment stations, until a surcharge to 1.0 foot or less resulted. The floodway was widened between five and 70 feet along approximately 1,700 feet of Newfound Creek.

Cross sections within the restoration site were then modified to reflect the geometry from the restoration design in the proposed effective model. The proposed effective model resulted in a decrease from the revised effective model 100-year flood water surface elevations within the restoration site.

The proposed effective model results in a No-Rise situation, but because the 100-year water surface elevation decreases more than 0.1 feet between the revised effective and proposed effective model, a LOMR will be required.

The proposed changes in the floodway effect property owned by Virgie and Marjorie Brown. Notification of the proposed floodway changes will be sent to the property owners and the Buncombe County Floodplain Administrator, Cynthia Fox Barcklow, AICP, CFM. Since the project is located within a regulated floodway, the Buncombe County Floodplain Administrator will be coordinated with to ensure compliance with floodplain requirements.

6.4 Soil Restoration

6.4.1 Narrative and Soil Preparation and Amendment

The soil along the Project Reach has been significantly impacted by agricultural practices and the presence of cattle. Cattle trampling and usage of farm equipment has compacted the ground within the proposed conservation easement. The compaction is so severe in some areas that the ground is not supporting vegetative cover, particularly around the headwaters of Tributary 8.

Soil amendment will be required within the entirety of the conservation easement, and will occur prior to permanent seeding. Upon the completion of grading and stream excavation/channel filling related work, the areas to be planted will be ripped and disked. Ripping will be required on the floodplain and will be restricted from within the channel and slopes. Restoration activities should be sufficient to loosen soils within the top of bank. Ripping shall be conducted utilizing a "v" ripper tillage tool. Disking will be performed in all areas that have been ripped.

In areas where ripping and disking are not feasible due to space and/or slope constraints (i.e., between existing trees or on steep slopes along tributaries), other mechanical or manual means will be used to properly prepare the ground surface.

Upon completion of ripping and disking, soil tests will be conducted to determine the need, if any, of limestone and/or fertilizer prior to planting. At a minimum, the test must provide the acidity of the soil and availability of major nutrients (N, P, and K). Limestone and/or fertilizer rates should be determined based on the results.

6.5 Natural Plant Community Restoration

Re-establishing a riparian buffer composed of native woody and herbaceous vegetation is critical to the success of a stream restoration design. Vegetated buffers provide shade, input of woody debris and organic matter, and a soil stabilizing root mass for the streambanks.

Native woody and herbaceous species will be used to establish a 30-foot wide riparian buffer on both sides of the Project Reach, where possible. In some areas, existing land uses will prohibit a fully vegetated buffer, so other areas will be extended beyond 30 feet to compensate for the difference.

Species selected for planting will be dependent upon availability of local seedling sources; however, species will all be native and appropriate to Project Study Area soils. The proposed plantings will cover the constructed streambanks, floodplain (where applicable), and adjacent slope within the 30-foot buffer.

In some areas, remnants of the target natural communities currently exist with mature individuals of the desired species. As much as possible in these areas, the zone of construction activity will be limited to lessen damage to individual stems. Maintaining existing trees in place with intact root masses will contribute to post-construction slope stability and streambank retention. Areas with existing tree canopy will receive primarily herbaceous and shrub plantings.

6.5.1 Narrative and Plant Community Restoration

The designed vegetative communities are presented in Table 7 and in Section 11.0, Restoration Planting Zones, and Plan Sheet 19. Four planting zones are proposed for the Project Site. The Streamside zone will occur along all reaches of the project and will consist of live stake plantings. The Floodplain zone will occur outside the Streamside zone. The target natural community for the Floodplain zone will be a mixture of Piedmont/Mountain Bottomland Forest and Piedmont/Mountain Levee Forest (Schafale and Weakley 1990). Although Levee Forests typically occur along river systems, once the project reach has been restored, an active floodplain will be present and alluvial deposits will occur. This zone will be present along the entirety of the mainstem of Newfound Creek, but will be limited along the tributaries that occur on steeper valley slopes. In such steep areas where an active floodplain will not be created, a Mountain Slope zone will be planted. The Mountain Slope zone is a mixture of Montane Alluvial Forest and Piedmont/Mountain Bottomland Forest. The Wetland zone will be planted in the three small wetland areas delineated along tributaries 4 and 7. The Wetland zone will consist of a mixture of Piedmont/Swamp Forest and Piedmont/Mountain Bottomland Forest and will require a different permanent seed mixture than the remainder of the site, to include wetland herbs and ferns.

6.5.2 On-site Invasive Species Management

Prior to the re-vegetation phase of the project, removal of non-native species will be necessary. Exotic species currently occurring at the Project Site include Chinese privet, multiflora rose, Japanese honeysuckle, and tree of heaven. Invasive species eradication and management shall commence in conjunction with site preparation and will continue through the one-year monitoring period at a minimum. Proposed management procedures described below are based upon recommendations taken from the Southeast Exotic Pest Plant Council Invasive Plant Manual (SE-EPPC 2003). Personnel applying herbicide will be licensed to do so, as required by the North Carolina Pesticide Board and all work will comply with the North Carolina Pesticide Law of 1971 and applicable federal laws (G.S. 143-434, Article 52). Environmental conditions including weather, wind, temperature, and period of the growing season will be evaluated prior to initiation of management efforts. The sequence of removal procedures will be coordinated with planned seeding and planting tasks such that treatment methods do not affect planted species.

The first step of the invasive species removal process will consist of an application of Rodeo®, Accord®, AquaMaster®, or equal herbicide (glyphosate – aquatic label) designated as suitable for extermination of trees and shrubs in riparian and wetland areas. Ideally, application will occur late in the growing season, but prior to dormancy. Ambient air temperature at the time of application will be above 40°F. The herbicide will be applied at the recommended rate in

accordance with label instructions. This application will be completed a minimum of two weeks prior to planting activities. The herbicide will be applied on all identified invasive plants using appropriate application methods to prevent drift into adjacent areas.

Two weeks after spraying, all woody vegetation will be removed by cutting stems and stumps to a maximum height of two inches above ground. A 25 percent glyphosate herbicide solution approved for aquatic applications shall be immediately applied to completely cover the cut surface of each individual stem or stump. After an additional two-week period, woody remnants will be removed, separated from the soil, and disposed of properly (*e.g.* burning).

The Project Study Area shall be observed throughout the monitoring period to evaluate invasive management effectiveness. If required, additional control steps may be implemented.

6.6 Farm Conservation Plan

As an important part of this project, NCEEP contracted with the Buncombe SWCD to prepare a farm conservation plan that identified and implemented agricultural and livestock BMPs important for improving water quality. Buncombe SWCD has considerable expertise and experience working with private landowners to develop and install these conservation practices and in providing long-term management strategies for landowners.

The farm plan and associated BMPs are intended to address water quality issues along Newfound Creek and unnamed tributaries through practices such as livestock exclusion, stabilizing heavy use areas, and enabling alternative watering systems, which will all help to ensure the long-term success of the Newfound Creek Stream Restoration Project while improving watershed conditions. This farm plan included the following BMPs:

- Watering – 21 watering tanks and 2 drilled wells and related materials;
- Fencing – Approximately 21,000 linear feet of livestock exclusion and easement fencing; and
- Stock Trails – 4,000 linear feet of cloth and stone trails with fencing to reduce erosion and sediment input to stream.

All installed BMPs meet the standards and specifications of either the US Department of Agriculture Natural Resources Conservation Service Technical Guide or the Soil and Water Conservation Commission standards.

7.0 PERFORMANCE CRITERIA

7.1 Streams

Performance criteria and monitoring protocol will follow that outlined within the NCEEP Site Specific Mitigation Plan and detailed in the USACE Stream Mitigation Guidelines (USACE *et al.* 2003). Monitoring shall consist of the collection and analysis of stream stability and riparian vegetation survivability data to support the evaluation of the project in meeting established restoration objectives. Data collection will include measurements of stream dimension, profile, pattern, and bed materials; photo documentation; vegetation survivability sampling; and stream bankfull return interval. Monitoring will be performed each year for a five-year period, with no less than two bankfull flow events documented through the monitoring period. If less than two events occur during the first five years, monitoring will continue until the second bankfull event is documented.

7.2 Vegetation

Evaluation of planted vegetation survival will be measured based upon the survival of 320 stems per acre at the end of three years of monitoring. A tolerance of ten percent mortality rate will be acceptable for years four and five. The final vegetated success criteria will be survival of 260 stems per acre through year five (USACE *et al.* 2003). In addition, survival percentages will also be monitored on a species by species basis**.**

7.3 Schedule and Reporting

URS will prepare a Mitigation Plan in accordance with NCEEP standards (September 20, 2005) that will include the following sections: introduction, summary, success criteria, monitoring schedule, mitigation type and extent, maintenance/contingency plans, and references. Revisions to the NCEEP standards (since September 20, 2005) may be incorporated into the Mitigation Plan in consultation with NCEEP. Existing data developed during the assessment and design phases of the project will be used to the extent possible.

Following construction, permanent stream monitoring cross-sections, vegetation plots, and photo reference points will be established on the project site, marked using rebar and cap, for use during subsequent monitoring phases of the project. The selected construction contractor will survey these points during the execution of the as-built field survey. The contractor shall supply URS with a complete and properly sealed Project As-built Survey for inclusion in the Mitigation Plan (11" x 17" format). The Mitigation Plan will be formatted and submitted in a three-ring binder format to allow the latter inclusion of yearly project monitoring reports.

Yearly project monitoring reports will be prepared and submitted each year after monitoring tasks are completed. The report will provide the new monitoring data and compare the new data against previously existing conditions. Data, cross-sections, profiles, photographs, and other graphics will be included in the report as necessary. The report will include a discussion of any significant deviations from the as-built survey, as well as evaluations as to whether the changes indicate stabilizing or de-stabilizing conditions.

Establishment of permanent monitoring cross-sections, vegetation plots, photo reference points, and all subsequent monitoring will be conducted by a firm chosen by NCEEP. URS is not scoped to conduct any monitoring for this project.

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9.0 TABLES

Table 1: Project Restoration Structure and Objectives
Project Number 92497 Newfound Creek

Reach		Existing Station Range	Restoration Type	Priority Approach	Existing Linear Feet	Designed Linear Feet	Comment
MAINSTEM	A	12+00 – 16+50	Enhancement I	P3	450	450	Grade right bank, add a few structures to develop pools and direct flow around sharp bend.
	B	16+50 – 20+75	Restoration	P2	425	455	Increase sinuosity and floodprone width by pulling meander bends out into left floodplain and away from steep bank on right.
	C	20+75 – 27+00	Restoration	P2	625	640	Increase sinuosity and floodprone width by pulling meander bends out into left floodplain and away from steep bank on right.
	D	27+00 – 32+00	Enhancement I	P2	500	500	Cut bankfull bench and remove berms on left floodplain. Add cross vane to direct flow correctly under bridge.
	E	32+00 – 45+00	Enhancement I	P2	1,300	1,300	Adjust to proper dimension, some small alignment corrections, and some structures to direct flow and develop pool habitat. Enhance meanders in select locations.
	F	45+00 – 56+00	Restoration	P2	1,100	1,145	Adjust dimension pattern and profile, primarily in place with the addition of small meander bends.
TRIB 3	3A	200+35 – 203+35	Enhancement I	P2	300	300	Adjust dimension and profile in confined valley.
	3B	204+15 – 211+75	Restoration	P2	760	778	Adjust dimension, profile and pattern.

Reach		Existing Station Range	Restoration Type	Priority Approach	Existing Linear Feet	Designed Linear Feet	Comment
TRIBUTARY 4	4A	300+00 – 302+50	Enhancement Wetland A	N/A	250 (0.26 ac)	250 (0.26 ac)	Buffer reforestation and wetland enhancement
	4B	302+50 – 304+75	Restoration	P2	225	225	Build step-pool system to stabilize series of severe headcuts
	4C	304+75 – 308+25	Enhancement I	P2	350	350	Adjust dimension and profile.
	4D	308+25 – 312+50	Enhancement I	P2	425	425	Adjust dimension and add structure to stabilize headcuts below.
	4E	312+50 – 315+00	Enhancement I	P3	250	250	Step-pool system, stabilize headcuts.
	4F	315+80 – 317+50	Restoration	P2	170	190	Correct dimension and profile, stabilize culvert outlet.
	4G	317+50 – 320+90	Restoration	P2	340	340	Restore dimension pattern and profile and improve sediment transport.
	4G	317+50 – 320+90	Enhancement Wetland D	N/A	340 (0.15 ac)	340 (0.15 ac)	Buffer reforestation and wetland enhancement
TRIBUTARY 5	5A	400+00 – 402+25	Enhancement II	N/A	225	225	Buffer reforestation
	5B	402+25 – 404+25	Restoration	P2	200	200	Mimic step-pool in 5A and stabilize large headcut.
	5C	404+25 – 405+00	Enhancement II	N/A	75	75	Buffer reforestation, extensive debris removal.
	5D	405+00 – 406+75	Enhancement I	P3	175	175	Slope back banks, add grade control.
TRIB 6	6A	500+00 – 503+00	Enhancement II	N/A	300	300	Bank grading in select areas during buffer reforestation.
	6B	503+50 – 506+50	Restoration	P2	300	326	Restore to stable dimension, pattern, and profile.
TRIB 7	7A	600+00 – 603+85	Enhancement Wetland B/C	N/A	385 (0.46 ac)	385 (0.46 ac)	Dam stabilization, Buffer reforestation, cattle exclusion
	7B	603+85 – 607+85	Enhancement I	P2	400	400	Adjust dimension and profile, add grade control and stabilize headcuts.
TRIBUTARY 8	8A*	693+40 – 698+40	Enhancement II	N/A	100	100	Buffer reforestation, cattle exclusion
	8A*		Restoration	N/A	460	500	Dam removal and new channel construction
	8B	700+00 – 700+95	Enhancement I	P3	95	95	Adjust dimension and increase floodprone width. Create pocket wetland BMP.

Reach		Existing Station Range	Restoration Type	Priority Approach	Existing Linear Feet	Designed Linear Feet	Comment
	8C	701+45 – 702+65	Enhancement II	N/A	120	120	Buffer reforestation

Table 2: Drainage Areas
Project Number 92497 Newfound Creek

Reach	Drainage Area (Acres)	Drainage Area (Sq. Miles)
Newfound Creek	6620	10.3
Tributary 3	70	0.11
Tributary 4	70	0.11
Tributary 5	45	0.07
Tributary 6	51	0.08
Tributary 7	32	0.05
Tributary 8	26	0.04

Table 3: Land Use of Watershed
Project Number 92497 Newfound Creek

Land Use	Area (acres)	Percentage
Evergreen Forest	1,655	25
Mixed Forest	1,324	20
Deciduous Forest	331	5
Agriculture/Pasture/Hay	1,655	25
Row Crops	993	15
Rural Residential	662	10

Table 4. Morphological Characteristics Table
Project Number 92497 Newfound Creek

URS

Site Name: **Newfound Creek, Buncombe County, NC**
Watershed: **French Broad**
Design by: **Melissa Bauguess**
Checked by: **Kathleen McKeithan, PE, CPESC, CPSWQ**

		EXISTING CONDITIONS								DESIGN CONDITIONS								REFERENCE CONDITIONS		
SITE NAME	UNITS	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek	Newfound Creek
WATERSHED		French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad	French Broad
REACH DESCRIPTION		Mainsteam upstream Browntown Rd.	Mainsteam downstream Browntown Rd.	Tributary 3	Tributary 4	Tributary 5	Tributary 6	Tributary 7	Tributary 8	Mainsteam upstream Browntown Rd.	Mainsteam downstream Browntown Rd.	Tributary 3	Tributary 4	Tributary 5	Tributary 6	Tributary 7	Tributary 8	Mainsteam near Sta 16+00	Mainstream near Sta 45+00	Tributary 5
STREAM TYPE		C4/1	B4/1	G5/F5	A5/G5/B5/E5	E4b/G4/B4/E4	B4/E5	E5	G5/E5	C4/1	C4/1	B5	E5	E4b	E4b	E5	E5	C4	C4	E4b
DRAINAGE AREA (DA)	Ac	6400	6620	70	70	45	51	32	26	6400	6620	70	70	45	51	70	26	6208	6528	45
BANKFULL WIDTH (W_{bkf})	ft	33.8	86.6	10.5	6.9	9.4	9.5	5.8	7.4	32.0	35.0	8.4	6.0	8.2	9.0	5.8	5.8	39.6	32.6	8.2
BANKFULL MEAN DEPTH (d_{bkf})	ft	2.3	1.2	0.9	0.9	1.0	1.0	0.6	0.6	1.7	2.3	0.8	0.7	1.0	1.0	0.6	0.4	1.9	2.6	1.0
LOWEST BANK HEIGHT RATIO		1.3	0.8	2.1	2.5	1.2	2.1	1.6	2.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
WIDTH/DEPTH RATIO (W_{bkf}/d_{bkf})		14.8	69.8	11.4	8.0	9.2	9.5	9.7	12.9	19.0	15.0	10.0	8.5	8.6	8.6	9.7	16.0	21.0	12.5	8.6
BANKFULL X-SECTION AREA (A_{bkf})	ft^2	69.70	114.30	9.52	5.73	9.55	9.50	3.40	4.48	80.00	90.00	8.30	4.00	8.30	8.50	5.83	2.42	74.90	85.10	8.30
BANKFULL MEAN VELOCITY, ft/s	f/s	8.3	5.2	3.7	4.1	6.2	5.1	3.5	4.8	7.2	6.6	2.3	6.4	6.3	5.3	3.6	3.0	7.6	6.9	7.2
BANKFULL DISCHARGE, cfs	ft^3/s	579	594	36	24	59	48	12	22	579	594	19	26	52	45	21	7	566	588	59
BANKFULL MAX DEPTH (d_{max})	ft	4.3	4.0	1.5	1.2	2.2	1.7	1.1	1.1	3.4	4.0	1.7	1.1	1.6	1.7	1.1	0.5	4.7	4.4	1.6
WIDTH Flood-Prone Area (W_{fpa})	ft	183	175	30	10	41	15	14	50	182.5	175.0	18.0	14.0	21.1	23.2	13.8	100.0	164	200	21
ENTRENCHMENT RATIO (ER)		5.4	2.0	2.8	1.4	4.4	1.6	2.4	6.7	5.7	5.0	2.1	2.3	2.6	2.6	2.4	17.2	4.1	6.1	2.6
MEANDER LENGTH (Lm)	ft	250 - 420	1100 - 1600	20 - 270	800 - 1250	100 - 240	100 - 200	130 - 175	100 - 100	90 - 350	100 - 300	40 - 200	40 - 250	50 - 230	40 - 200	150 - 175	40 - 130	200 - 420	500 - 1650	100 - 240
RATIO OF Lm TO W_{bkf}		7.4 - 12.4	12.7 - 18.5	1.9 - 25.7	115.9 - 181.2	10.7 - 25.6	10.5 - 21.1	22.3 - 30.0	13.5 - 13.5	2.8 - 10.9	2.9 - 8.6	4.8 - 23.8	6.7 - 41.7	6.1 - 28.0	4.4 - 22.2	25.7 - 30.0	6.9 - 22.4	5.1 - 10.6	15.3 - 50.6	12.2 - 29.3
RADIUS OF CURVATURE	ft	25.0 - 130.0	91.0 - 150.0	180.0 - 180.0	109.0 - 180.0	51.0 - 255.0	110.3 - 181.7	175.0 - 175.0	0.0 - 0.0	32 - 140	35 - 140	22 - 65	25 - 40	10 - 55	60 - 60	30 - 30	15 - 15	137.7 - 211.1	283.3 - 283.3	51.0 - 255.0
RATIO OF Rc TO W_{bkf}		0.7 - 3.8	1.1 - 1.7	17.1 - 17.1	15.8 - 26.1	5.4 - 27.2	11.6 - 19.1	30.0 - 30.0	0.0 - 0.0	1.0 - 4.4	1.0 - 4.0	2.6 - 7.7	4.2 - 6.7	1.2 - 6.7	6.7 - 6.7	5.1 - 5.1	2.6 - 2.6	3.5 - 5.3	8.7 - 8.7	6.2 - 31.1
BELT WIDTH	ft	60 - 150	50 - 200	20 - 40	25 - 40	10 - 70	20 - 30	20 - 20	20 - 20	80 - 150	30 - 130	25 - 40	25 - 40	25 - 80	30 - 45	20 - 30	20 - 50	120 - 250	60 - 370	20 - 70
MEANDER WIDTH RATIO		1.8 - 4.4	0.6 - 2.3	1.9 - 3.8	3.6 - 5.8	1.1 - 7.5	2.1 - 3.2	3.4 - 3.4	2.7 - 2.7	2.5 - 4.7	0.9 - 3.7	3.0 - 4.8	4.2 - 6.7	3.0 - 9.8	3.3 - 5.0	3.4 - 5.1	3.4 - 8.6	3.0 - 6.3	1.8 - 11.3	2.4 - 8.5
SINUOSITY (K)		1.03	1.14	1.01	1.01	1.07	1.02	1.07	1.00	1.05	1.16	1.00	1.01	1.04	1.00	1.08	1.00	1.03	1.14	1.07
VALLEY SLOPE	ft/ft	0.0078	0.0062	0.0242	0.0376	0.0670	0.0394	0.0446	0.0499	0.0078	0.0062	0.0242	0.0376	0.0670	0.0397	0.0446	0.0499	0.0001	0.0062	0.0670
AVERAGE SLOPE (S)	ft/ft	0.0076	0.0054	0.0240	0.0373	0.0625	0.0387	0.0416	0.0499	0.0075	0.0053	0.0242	0.0371	0.0642	0.0397	0.0414	0.0499	0.0001	0.0054	0.0625
RIFFLE SLOPE	ft/ft	0.0076	0.0054	0.0240	0.0373	0.0625	0.0387	0.0416	0.0499	0.0230	0.0165	0.0484	0.0742	0.0963	0.0595	0.0414	0.0499	0.0002	0.0001	0.0001
POOL SLOPE	ft/ft	0.0050	0.0037	0.0250	NA	NA	NA	NA	NA	0.0011	0.0008	0.0001	0.0002	0.0003	0.0002	0.0002	0.0003	0.0000	0.0003	0.0003
RATIO OF POOL SLOPE TO AVERAGE SLOPE	ft/ft	0.01	0.00	0.03	NA	NA	NA	NA	NA	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0
MAX POOL DEPTH	ft	5.02	2.26	1.14	NA	NA	NA	NA	NA	4.21	5.83	1.68	1.41	2.94	3.23	1.20	0.73	3.05	3.77	2.94
RATIO OF POOL DEPTH TO AVERAGE BANKFULL DEPTH		2.19	1.82	1.23	NA	NA	NA	NA	NA	2.50	2.50	2.00	2.00	3.09	3.09	2.00	2.00	1.61	1.44	3.09
POOL WIDTH	ft	34.1	24.0	27.5	NA	NA	NA	NA	NA	38.4	42.0	10.9	7.8	10.7	11.7	7.6	7.5	47.8	108.0	8.8
RATIO OF POOL WIDTH TO BANKFULL WIDTH		1.01	0.28	2.6	NA	NA	NA	NA	NA	1.20	1.20	1.30	1.30	1.30	1.30	1.30	1.30	1.21	3.31	1.07
POOL TO POOL SPACING	ft	50.0 - 585.0	205.0 - 900.0	175.0 - 600.0	NA	NA	NA	NA	NA	40.4 - 185.9	44.2 - 203.3	10.6 - 168.4	7.6 - 120.0	100.0 - 164.0	109.8 - 180.0	36.7 - 116.7	36.5 - 116.0	50.0 - 230.0	205.0 - 900.0	100.0 - 200.0
RATIO OF POOL TO POOL SPACING TO BANKFULL WIDTH		1.5 - 17.3	2.4 - 10.4	16.7 - 57.1	NA	NA	NA	NA	NA	1.3 - 5.8	1.3 - 5.8	1.3 - 20.0	1.3 - 20.0	12.2 - 20.0	12.2 - 20.0	6.3 - 20.0	6.3 - 20.0	1.3 - 5.8	6.3 - 27.6	12.2 - 24.4

Note average slope of existing conditions were taken over a specific reach surveyed, thus they may not coorespond with valley slopes taken over the entire reach. Proposed average slopes may exclude controlled grade drops (average slope between niche points). Stream type considers data as well as professional judgement/field calls. Multiple points were utilized to get ranges.

Table 5: BEHI/NBS and Sediment Export Estimates for Project Site Streams
Project Number 92497 Newfound Creek

Time Point	Reach	Linear Feet	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export*
Pre-Construction			ft	%	ft	%	ft	%	ft	%	ft	%	%	ft	Ton/y
	A	450							150		300				26.6
	B	425							425						51.7
	C	625							625						74.9
	D	500							500						59.9
	E	1,300							1,300						121.7
	F	1100					1100								615
	3A	300							300						23.6
	3B	760							760						52.6
	4A	250							250						2.34
	4B	225			225										648.6
	4C	350							350						19.7
	4D	425							425						23.9
	4E	250							250						11.7
	4F	170							170						11.5
	4G	340							340						22.9
	5A	225									225				3.7

Table 5: BEHI/NBS and Sediment Export Estimates for Project Site Streams (cont.)
Project Number 92497 Newfound Creek

Time Point	Reach	Linear Feet	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export*
Pre-Construction			ft	%	ft	%	ft	%	ft	%	ft	%	%	ft	Ton/y
	5B	200							200						9.0
	5C	75											75		1.7
	5D	175									175				5.2
	6A	300									300				13.9
	6B	300							300						21.3
	7A	385											385		10.1
	7B	400					400								195.7
	8A	100									100				N/A
	8A	300					300								N/A
	8B	95					95								51.5
	8C	120							120						7.0

Table 6: BEHI/NBS and Sediment Export Estimates for Reference Streams
Project Number 92497 Newfound Creek

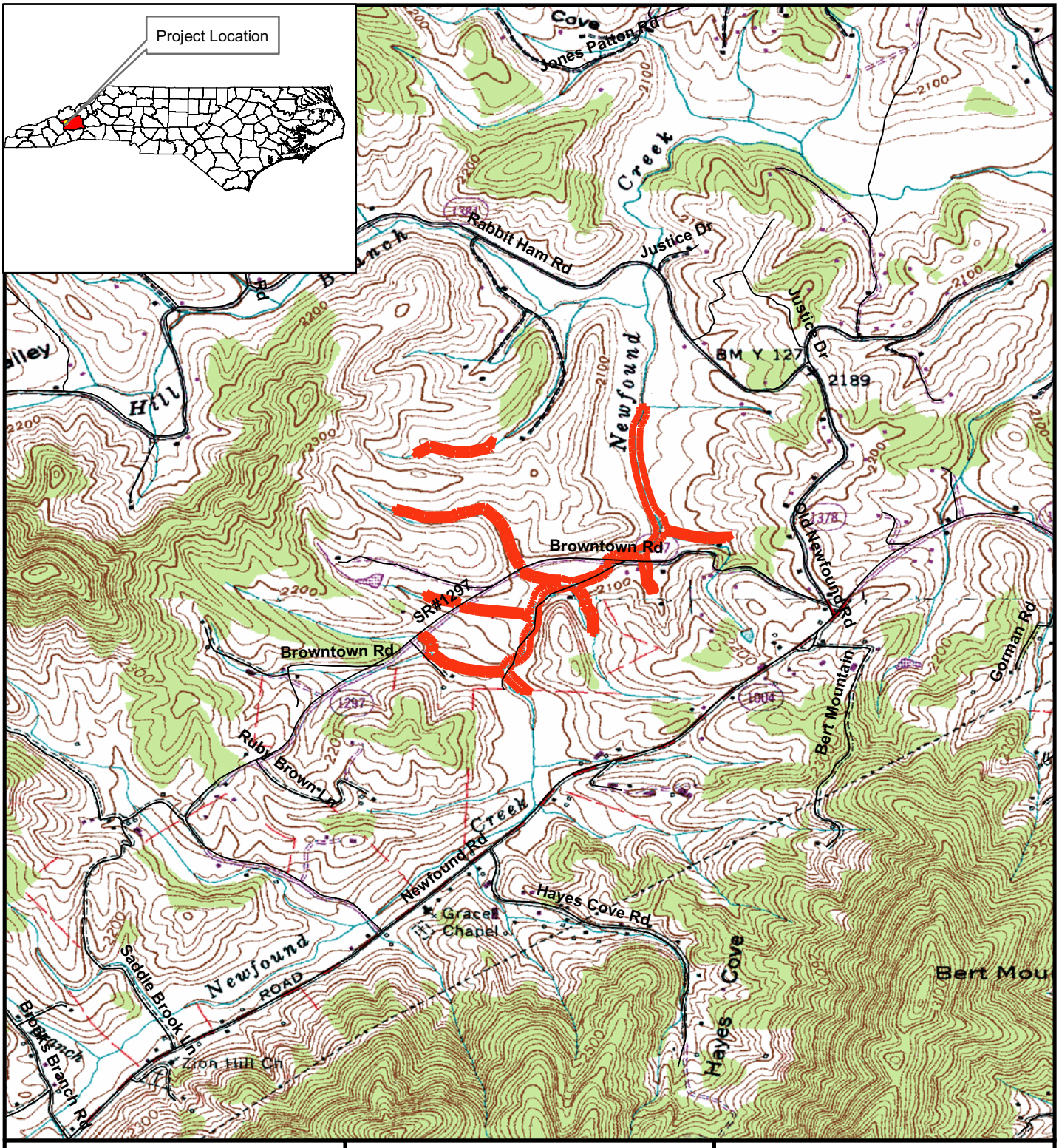
Time Point	Reach	Linear Feet	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
Pre-Construction			**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**%**	**ft**	**Ton/y**
	A	287									287				19.3
	E	234							134		100				18.7
	5A	225									225				5.1
	5C	100											100		1.7

Table 7. Designed Vegetative Communities (by zone)
Project Number 92497 Newfound Creek

Common Name	Scientific Name	Wetland Indicator
ZONE 1: STREAMSIDE LIVESTAKES		
Elderberry	*Sambucus canadensis*	FACW-
Black willow	*Salix nigra*	OBL
ZONE 2: FLOODPLAIN		
River birch	*Betula nigra*	FACW
Smooth alder	*Alnus serrulata*	FACW+
Sugarberry	*Celtis laevigata*	FACW
Cherrybark oak	*Quercus pagoda (falcata var. pagadaefolia)*	FAC+
Swamp chestnut oak	*Quercus michauxii*	FACW-
American elm	*Ulmus americana*	FACW
Green ash	*Fraxinus pennsylvanica*	FACW
Ironwood	*Carpinus caroliniana*	FAC
Spicebush	*Lindera benzoin*	FACW
Yellow root	*Xanthorhiza simplicissima*	FACW-
ZONE 3: MOUNTAIN SLOPE		
American sycamore	*Platanus occidentalis*	FACW-
Boxelder	*Acer negundo*	FACW
Yellow birch	*Betula lutea*	FACU+
Black walnut	*Juglans nigra*	FACU
Flowering dogwood	*Cornus florida*	FACU
Bitternut hickory	*Carya cordiformis*	FAC
Shagbark hickory	*Carya ovata*	FACU
American holly	*Ilex opaca*	FAC-
Pawpaw	*Asimina triloba*	FAC
Southern sugar maple	*Acer floridanum*	N/A
American witchhazel	*Hamamelis virginiana*	FACU
Great laurel	*Rhododendron maximum*	FAC-

ZONE 4: WETLAND		
Black willow	*Salix nigra*	OBL
Smooth alder	*Alnus serrulata*	FACW+
Possumhaw	*Ilex decidua*	FACW-
Mountain holly	*Ilex ambigua*	N/A

10.0 FIGURES



North Carolina
Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM

Newfound Creek Stream Restoration
Buncombe County

EEP Project No. 92497

Legend

Project Study Area

N
W E
S

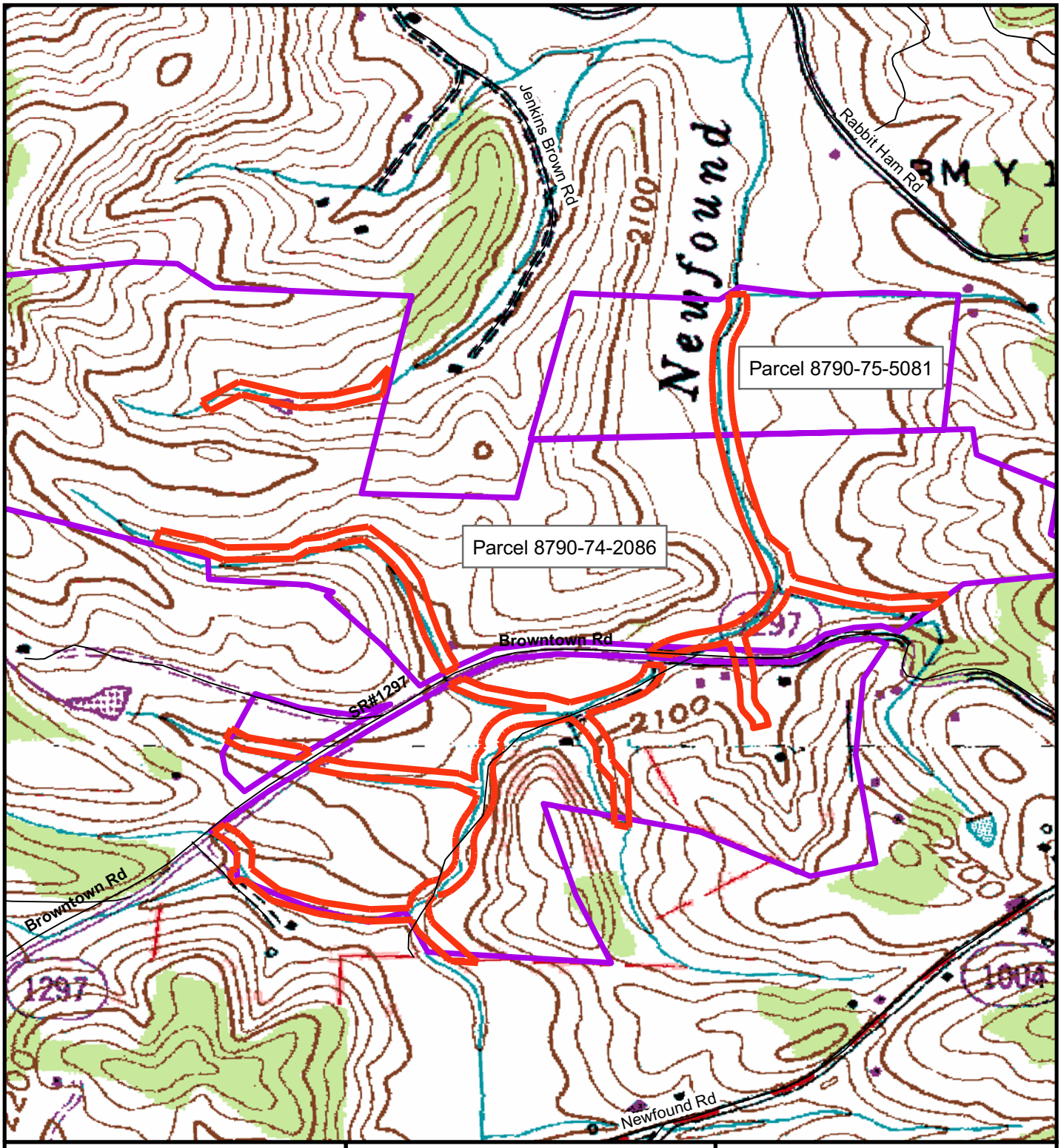
0 0.25 0.5 Miles

URS

Figure 1

Project Site Vicinity Map

Date: July 2007



North Carolina
Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM

Newfound Creek Stream Restoration
Buncombe County

EEP Project No. 92497

Legend

Project Study Area

Property Boundary

N
W E
S

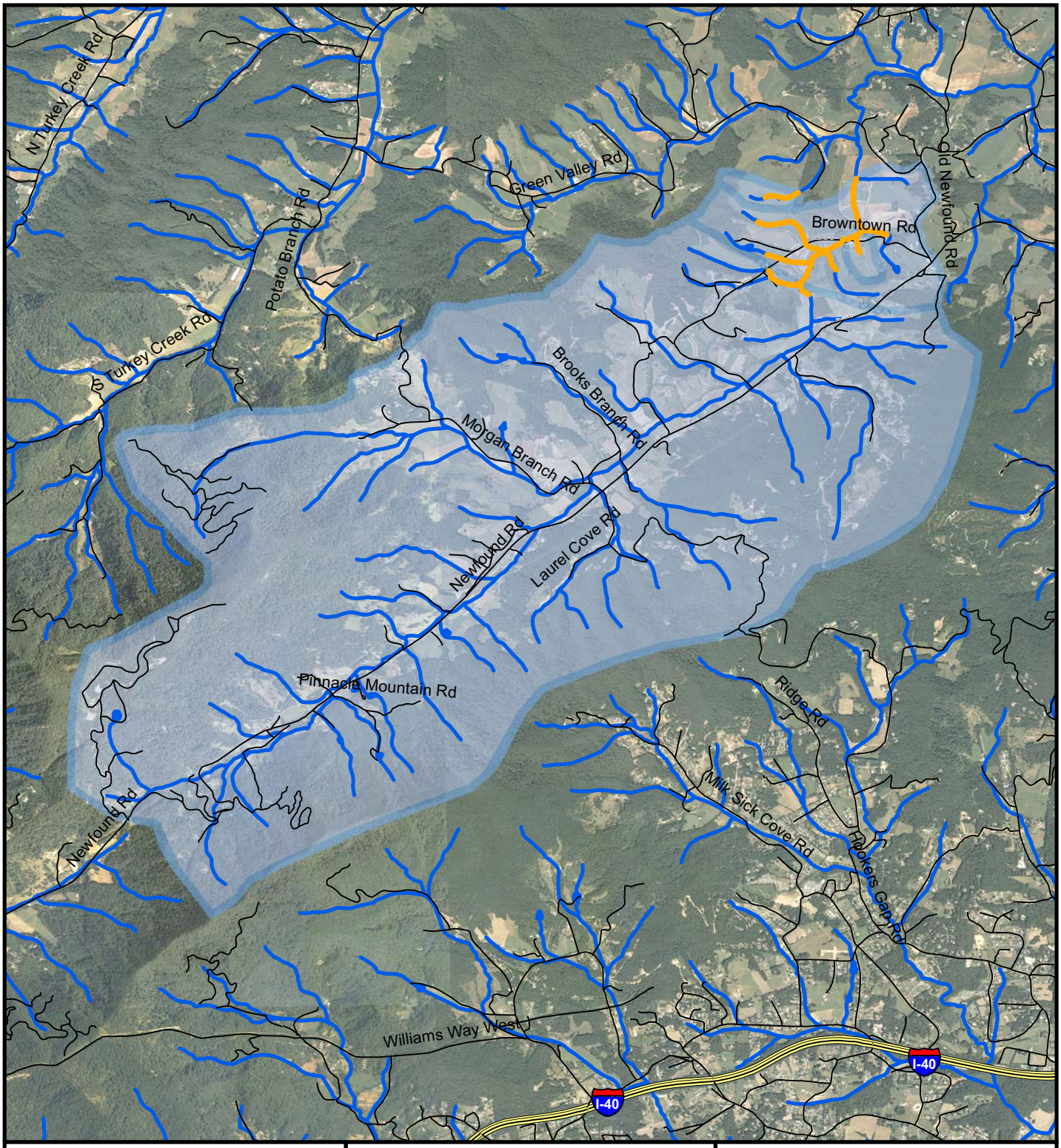
0 500 1,000 Feet

URS

Figure 2

Project Site Location Map

Date: July 2007



North Carolina Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM

Newfound Creek Stream Restoration
Buncombe County

EEP Project No. 92497

Legend

- Project Reach
- Streams
- Watershed
- Interstate
- Local Road

0 0.5 1 Miles

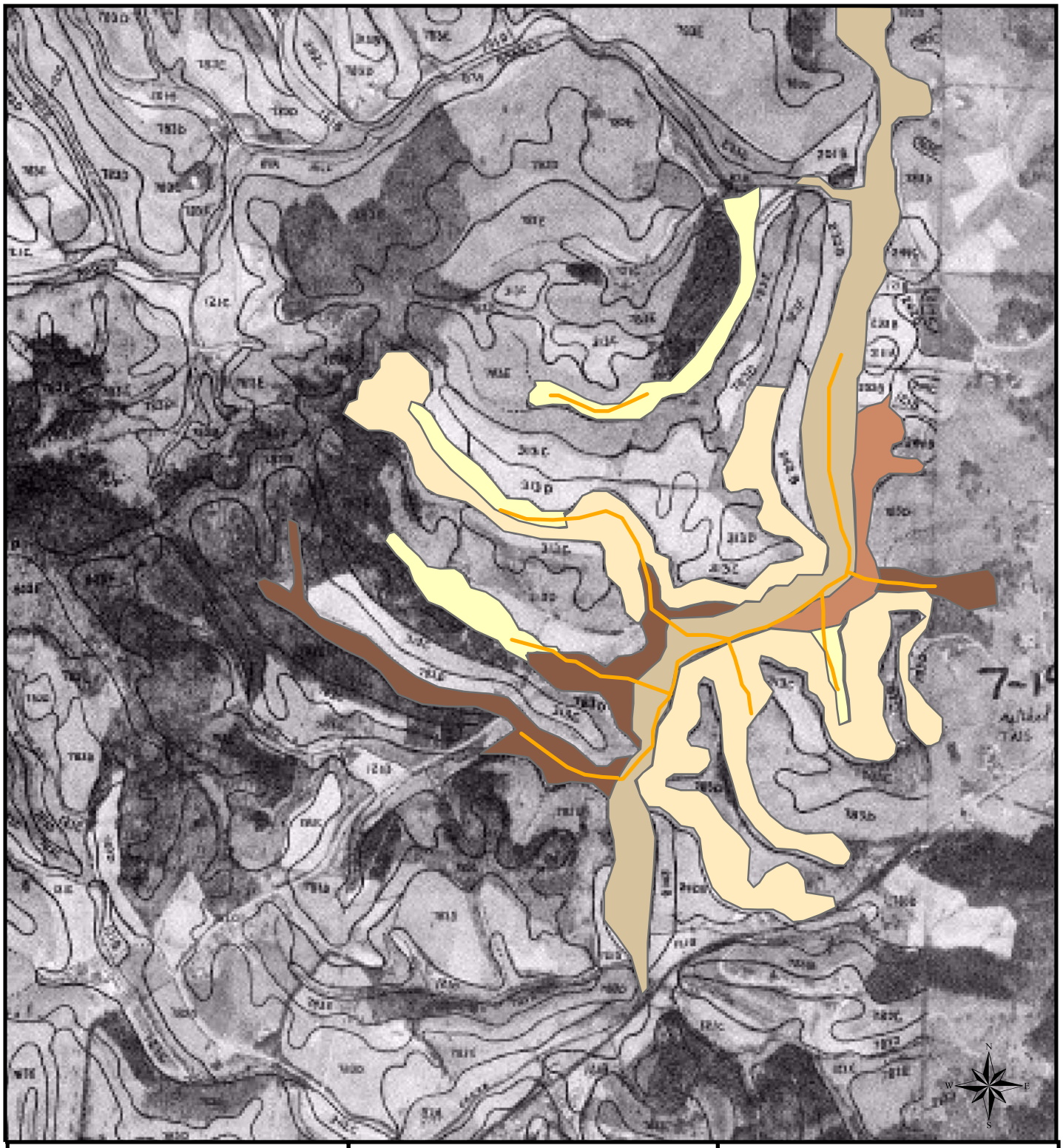
URS

Figure 3

Project Site Watershed Map

N W E S

Date: July 2007



North Carolina
Ecosystem Enhancement Program

Newfound Creek Stream Restoration
Buncombe County

EEP Project No. 92497

Legend

- Project Reach
- Tate Loam, 8-15% slopes
- French Loam, 0-3% slopes
- Tate Loam, 2-8% slopes
- Statler Loam, 1-5% slopes
- Evard-Cowee Complex, 30-50% slopes

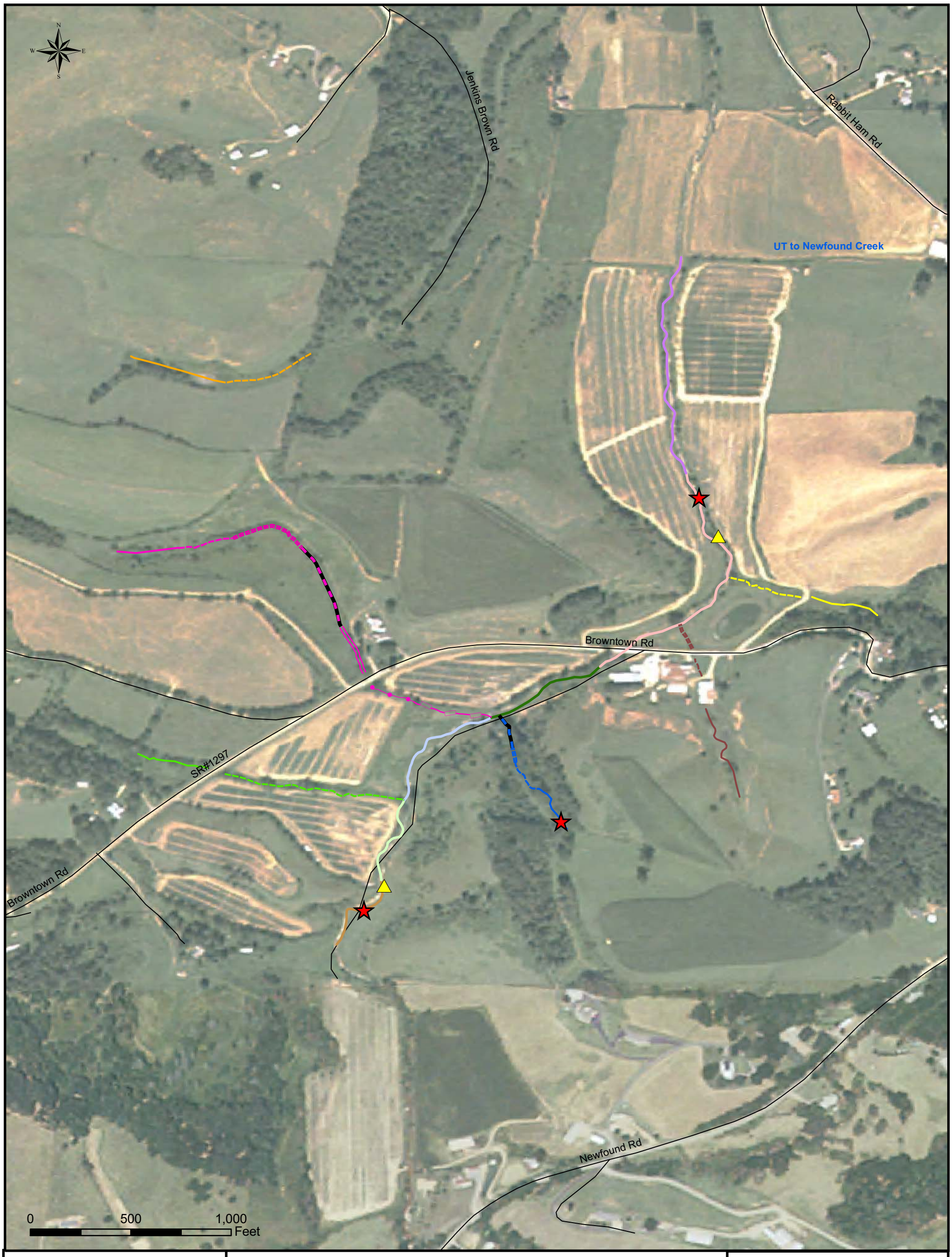
Not to Scale

URS

Figure 4

Project Site NRCS Soil Survey Map

Date: July 2007



North Carolina
Ecosystem Enhancement Program

Newfound Creek Stream Restoration
Buncombe County

EEP Project No. 92497

Legend

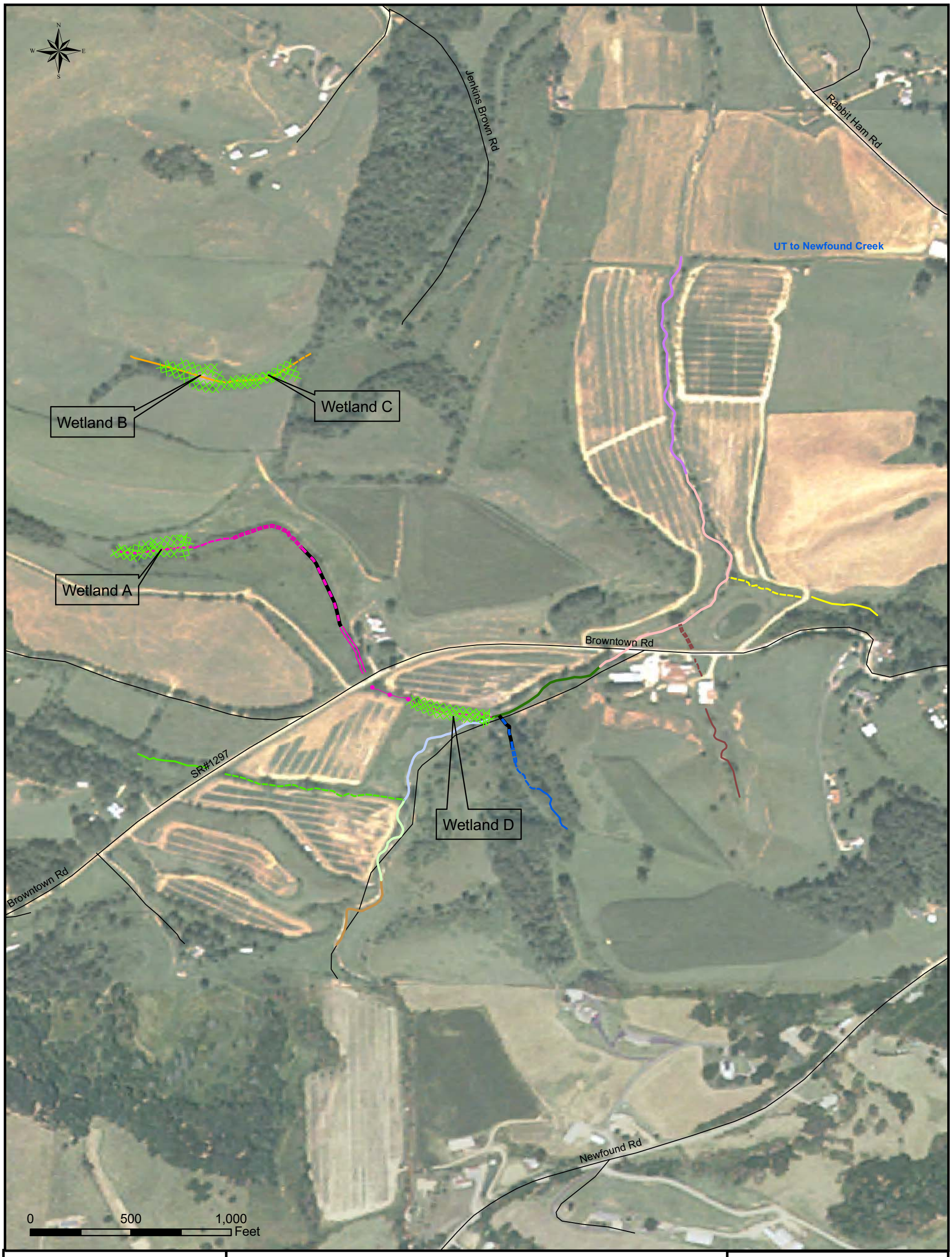
- Reach 3A
- Reach 3B
- Reach 4A
- Reach 4B
- Reach 4C
- Reach 4D
- Reach 4E
- Reach 4F
- Reach 4G
- Reach 5A
- Reach 5B
- Reach 5C
- Reach 5D
- Reach 6A
- Reach 6B
- Reach 7A
- Reach 7B
- Reach 8A
- Reach 8B
- Reach 8C
- Reach A
- Reach B
- Reach C
- Reach D
- Reach E
- Reach F
- Local Road
- Reference Reach Survey Point
- Gauge Location

URS

Figure 5

Project Site Hydrologic Features Map with Gauge Locations

Date: July 2007



North Carolina Ecosystem Enhancement Program

Newfound Creek Stream Restoration
Buncombe County

EEP Project No. 92497

Legend

- Reach 3A
- Reach 3B
- Reach 4A
- Reach 4B
- Reach 4C
- Reach 4D
- Reach 4E
- Reach 4F
- Reach 4G
- Reach 5A
- Reach 5B
- Reach 5C
- Reach 5D
- Reach 6A
- Reach 6B
- Reach 7A
- Reach 7B
- Reach 8A
- Reach 8B
- Reach 8C
- Reach A
- Reach B
- Reach C
- Reach D
- Reach E
- Reach F
- Wetland
- Local Road

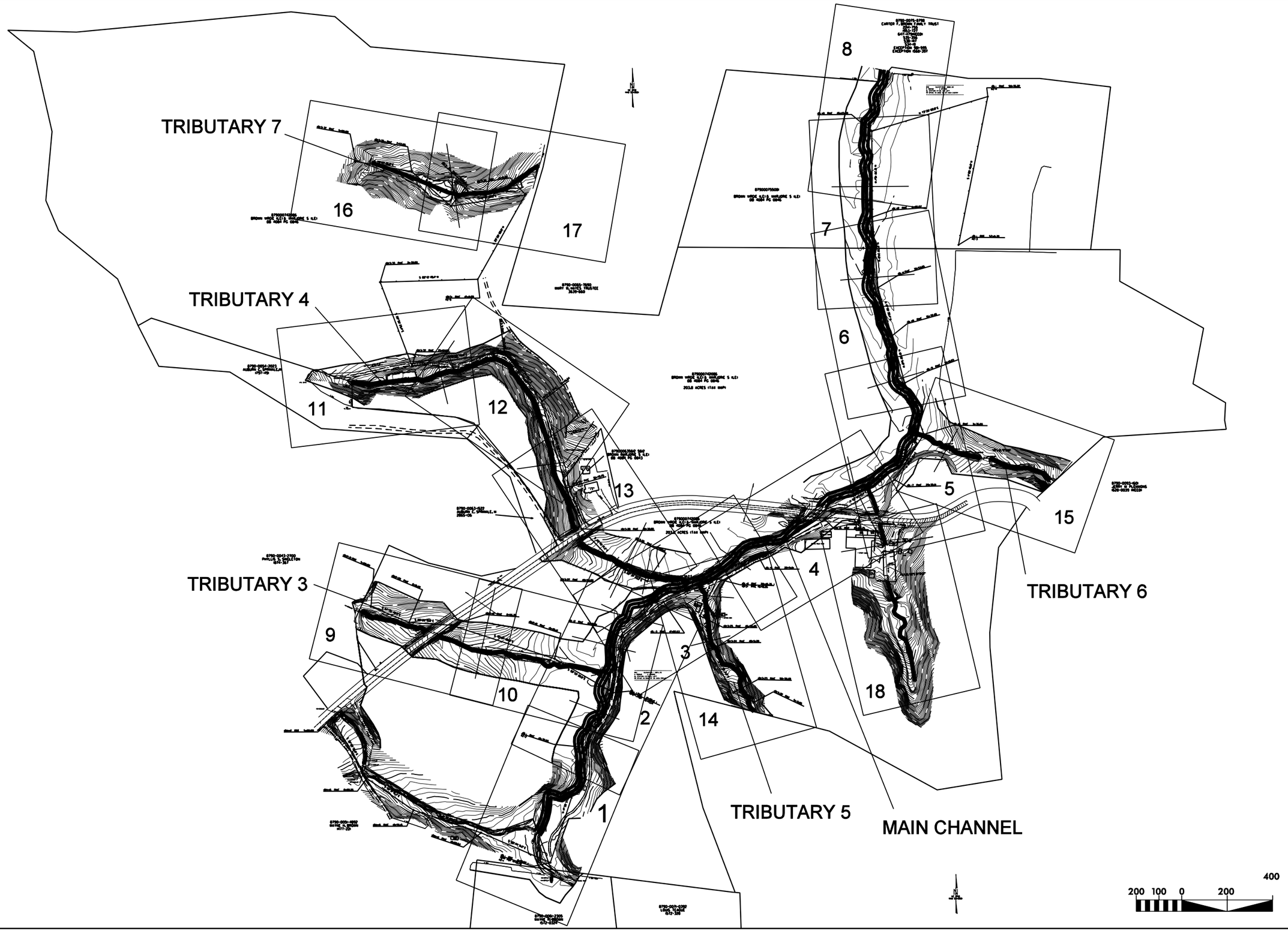
URS

Figure 6

Project Site
Wetland Delineation Map

Date: July 2007

11.0 DESIGNED SHEETS



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PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: PLAN SHEET KEY MAP

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

SEAL: PRELIMINARY PLANS NOT FOR BIDDING OR CONSTRUCTION

DATE: JULY 2007

TECHNICIAN: EHJ

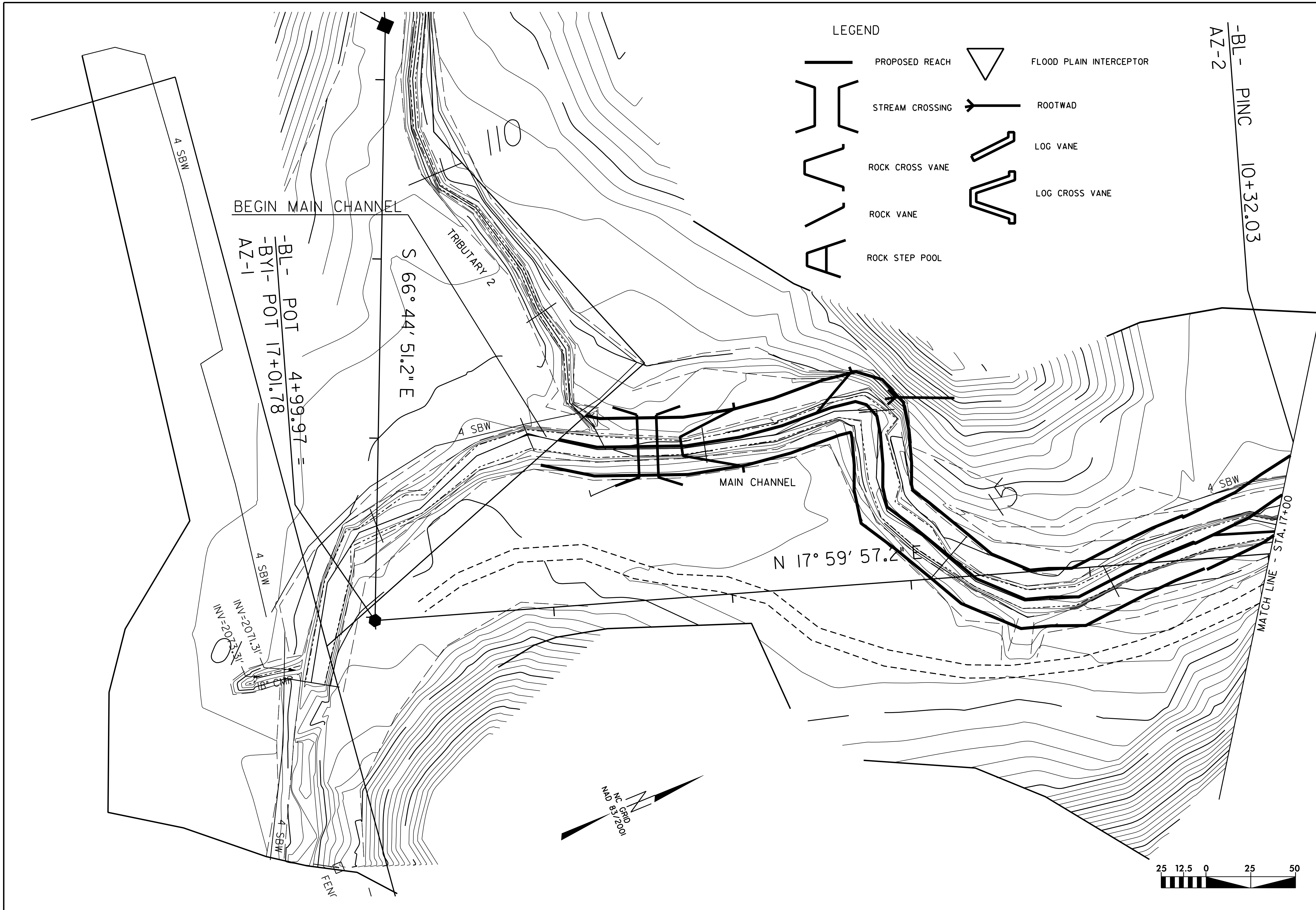
CHECKED BY: KMM

EEP PROJ. NO.
92497

35.6268° N, 82.7104° W

0

...\Proposed Plans\plansheet00.dgn 4/30/2008 2:13:37 PM



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TITLE: PROPOSED RESTORATION PLAN SHEET MAIN CHANNEL

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Ecosystem Enhancement PROGRAM

SEAL: PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

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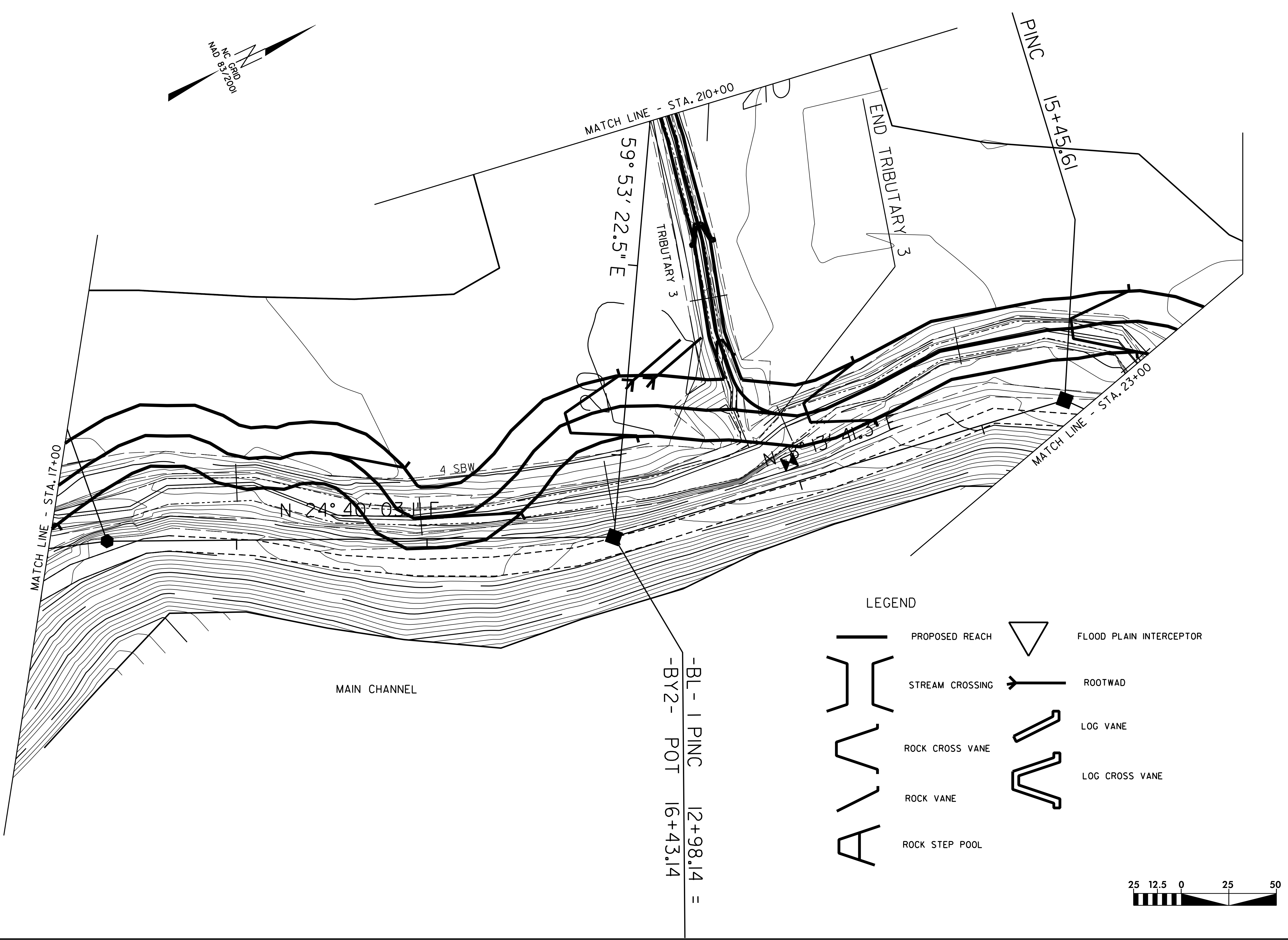
TECHNICIAN: EHJ

CHECKED BY: KMM

EEP PROJ. NO. 92497

1



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CHECKED BY: KMM

EEP PROJ. NO. 92497

NC GRID
NAD 83/2001

MATCH LINE - STA. 39+00

42+09.14

END TRIBUTARY 4

320

25

TRIBUTARY 4

WETLAND AREA

N 88° 02' 58.3" E

MAIN CHANNEL

4 SBW

MATCH LINE - STA. 29+00

MATCH LINE - STA. 23+00

N 49° 55' 47.2" E

N 67° 03' 49.8" E

N 62° 51' 29" E

MAIN CHANNEL

-BL-3 PINC 17+87.63

I.S.F.S. DWELLING ABANDONED

25° 53.4" W

190A

S 13° 39' 45" W

TRIBUTARY 5

1 STORY FRAME SHED (RUINS)

SPRING BOX

END TRIBUTARY 5

-BL-4 PINC 20+45.
-BY3- PINC 45+18.26

-BY3-25 PINC

MATCH LINE - STA. 404+00

LEGEND

- PROPOSED REACH
- STREAM CROSSING
- ROCK CROSS VANE
- ROCK VANE
- ROCK STEP POOL
- FLOOD PLAIN INTERCEPTOR
- ROOTWAD
- LOG VANE
- LOG CROSS VANE

25 12.5 0 25 50

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92497

3

NC GRID
NAD 83/2001

MATCH LINE - STA. 22+00.00

-BL-5 PINC 22+51.61

MAIN CHANNEL

N 60° 00' 57.0" E

ROCK OUTCROP

ELEV=2064.83'

ELEV=2064.80'

ELEV=2064.84'

ELEV=2064.83'

PDE

MID AND CONS BRIDGE

PDE

PDE

ELEV=2064.83'

MAIN CHANNEL

N 60° 10'

MATCH LINE - STA. 35+50

FRAME BARN

FRAME POLE SHED

-BL-6 PINC 25+86.75

INV=2063.30'

BROWNTOWN ROA

FEED BARN

BLOCK BARN

MATCH LINE - STA. 700+00

MTE

30

35

LEGEND

- PROPOSED REACH
- STREAM CROSSING
- ROCK CROSS VANE
- ROCK VANE
- ROCK STEP POOL
- FLOOD PLAIN INTERCEPTOR
- ROOTWAD
- LOG VANE
- LOG CROSS VANE
- EXISTING UTILITIES - POWER POLE

25 12.5 0 25 50

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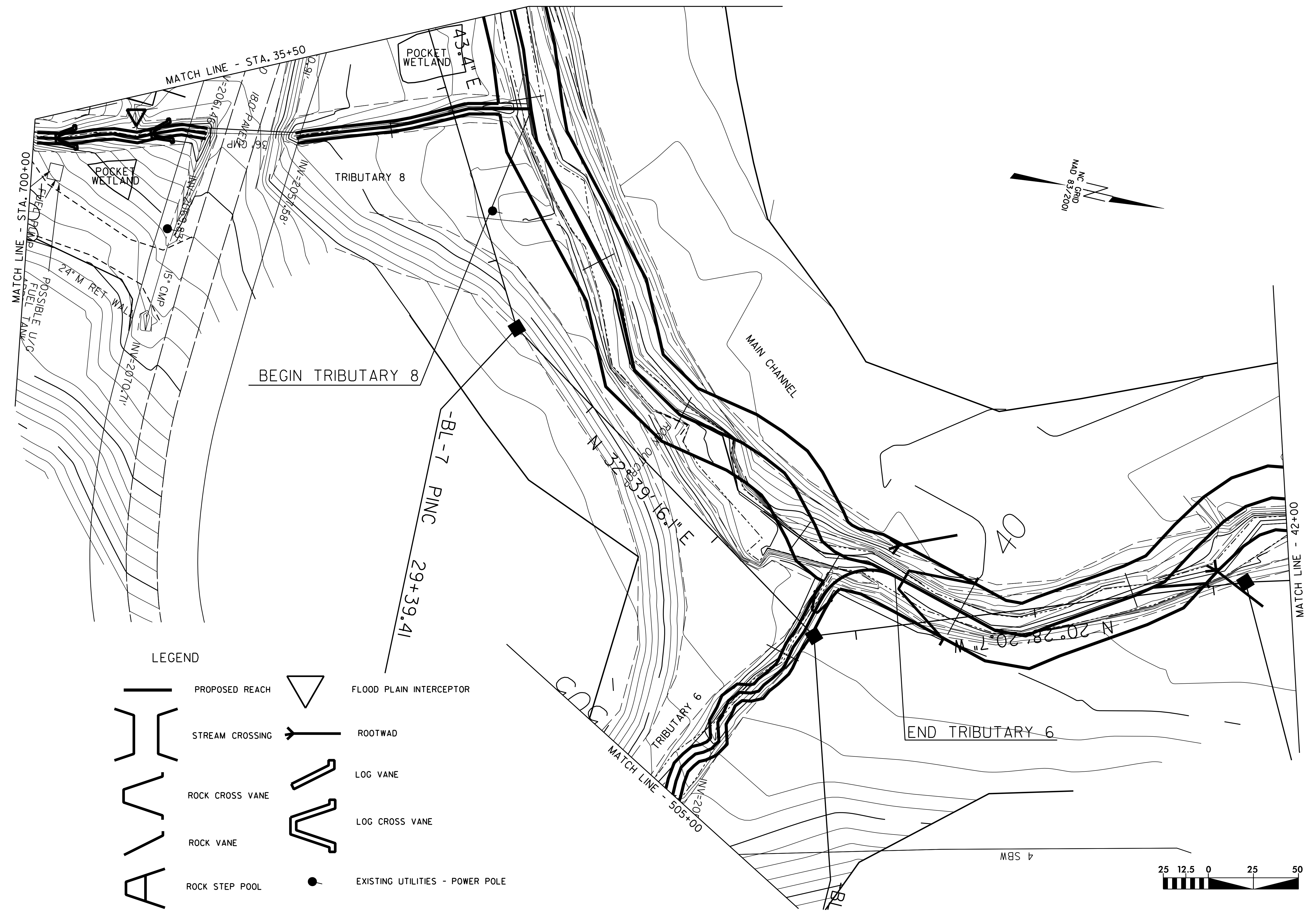
4



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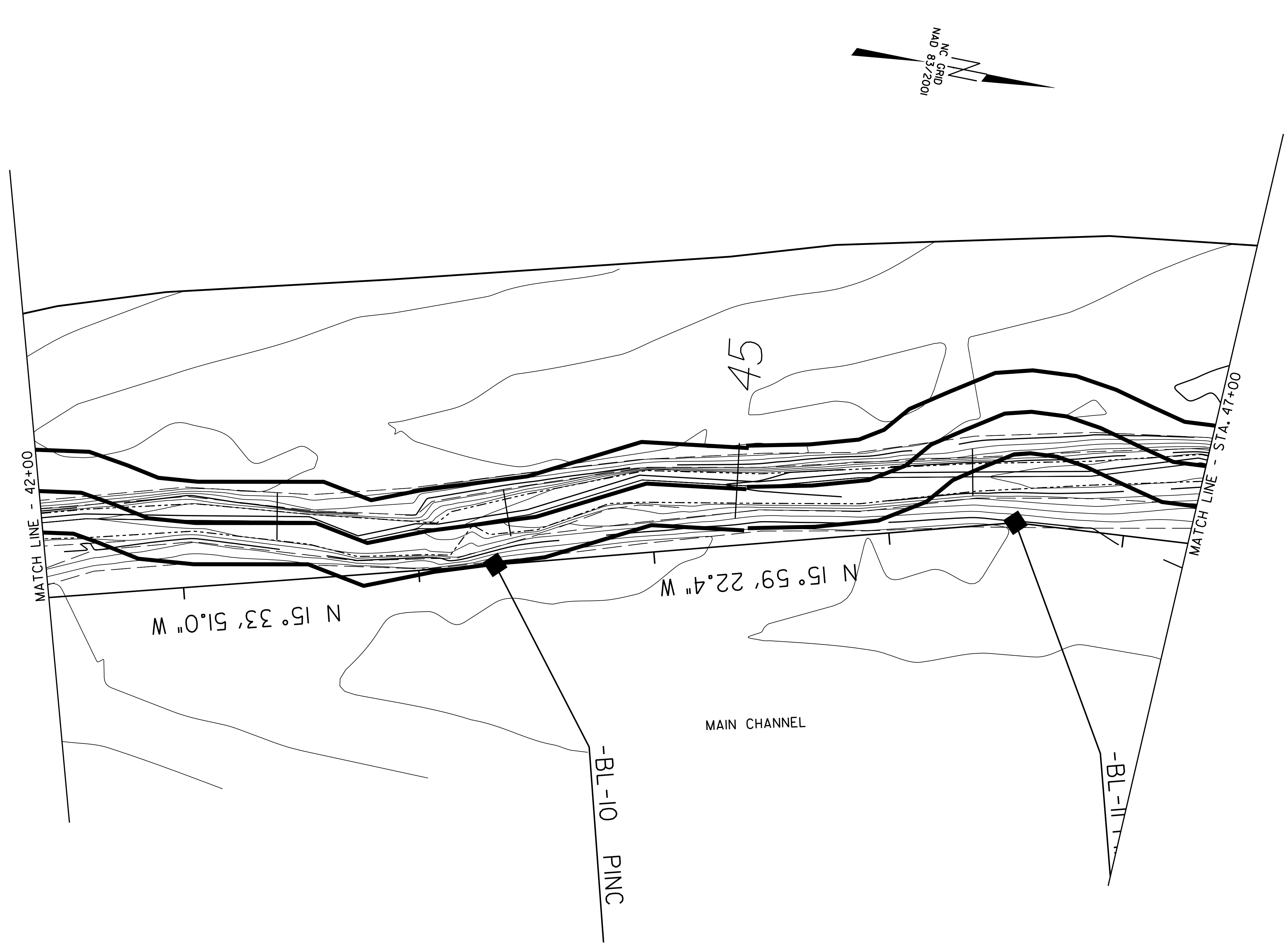

PROPOSED REACH

25 12.5 0 25 50

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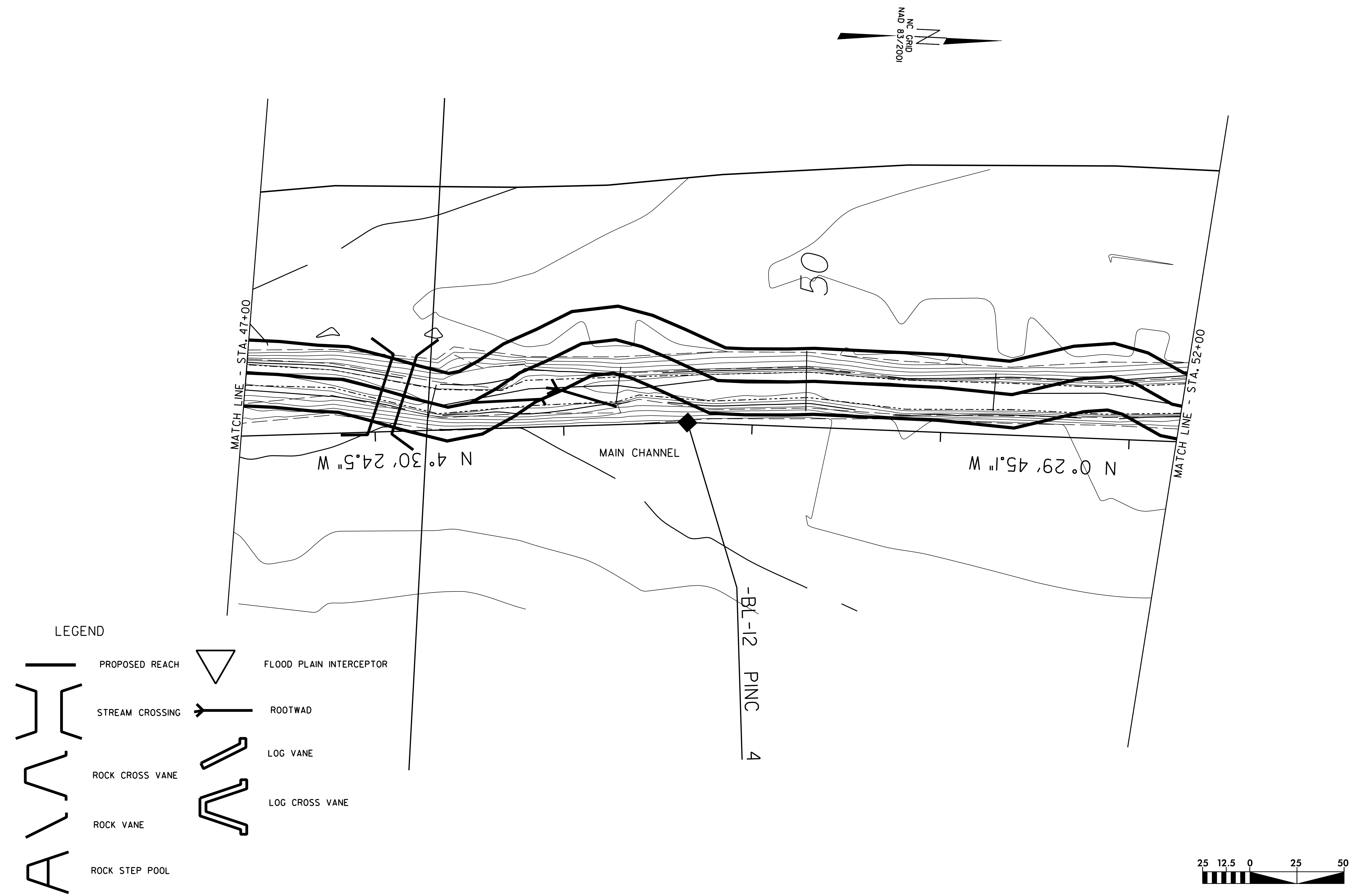

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EEP PROJ. NO. 92497

25 12.5 0 25 50

LEGEND

PROPOSED REACH	FLOOD PLAIN INTERCEPTOR
STREAM CROSSING	ROOTWAD
ROCK CROSS VANE	LOG VANE
ROCK VANE	LOG CROSS VANE
ROCK STEP POOL	

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Ecosystem Enhancement

SEAL: PRELIMINARY PLANS

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TECHNICIAN: EHJ

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EEP PROJ. NO. 92497

-BY2-21 POT 5+00.00

-BY2-20 PINC 6+81.44

BEGIN TRIBUTARY 3

200

S 67° 26' 42.8" E

S 86° 20' 18.6" E

INV=2090.96'

48" RCP

INV=2090.02'

TRIBUTARY 3

48" CMP

INV=2082.11'

INV=2080.02'

MATCH LINE - STA. 206+00

-BY

NC GRID
NAD 83/2001

LEGEND

PROPOSED REACH

STREAM CROSSING

ROCK CROSS VANE

ROCK VANE

ROCK STEP POOL

FLOOD PLAIN INTERCEPTOR

ROOTWAD

LOG VANE

LOG CROSS VANE

5023

25 12.5 0 25 50

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TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 3

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

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SEAL: PRELIMINARY PLANS NOT FOR BIDDING OR CONSTRUCTION

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TECHNICIAN: EHJ

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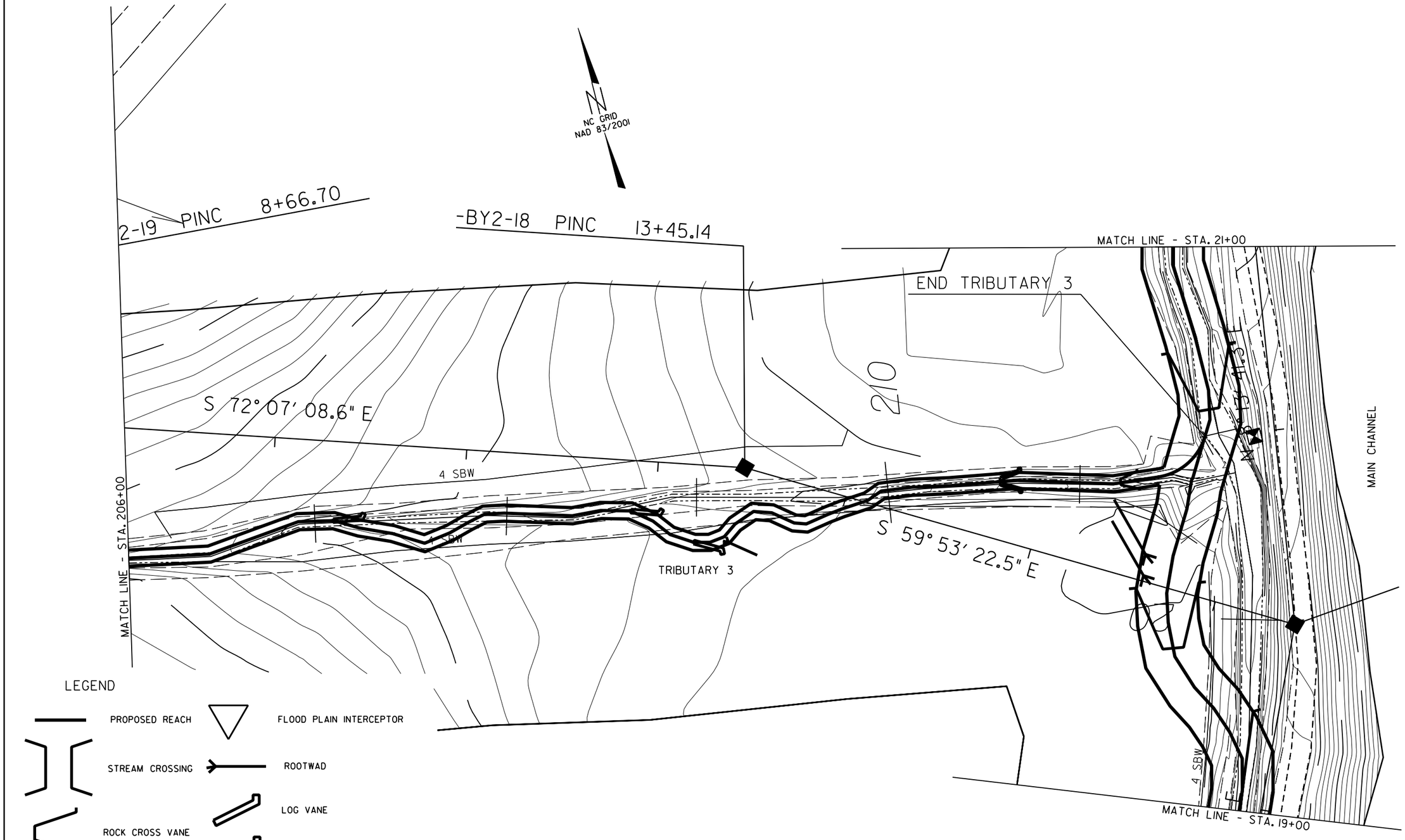
92497



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CHECKED BY: KMM

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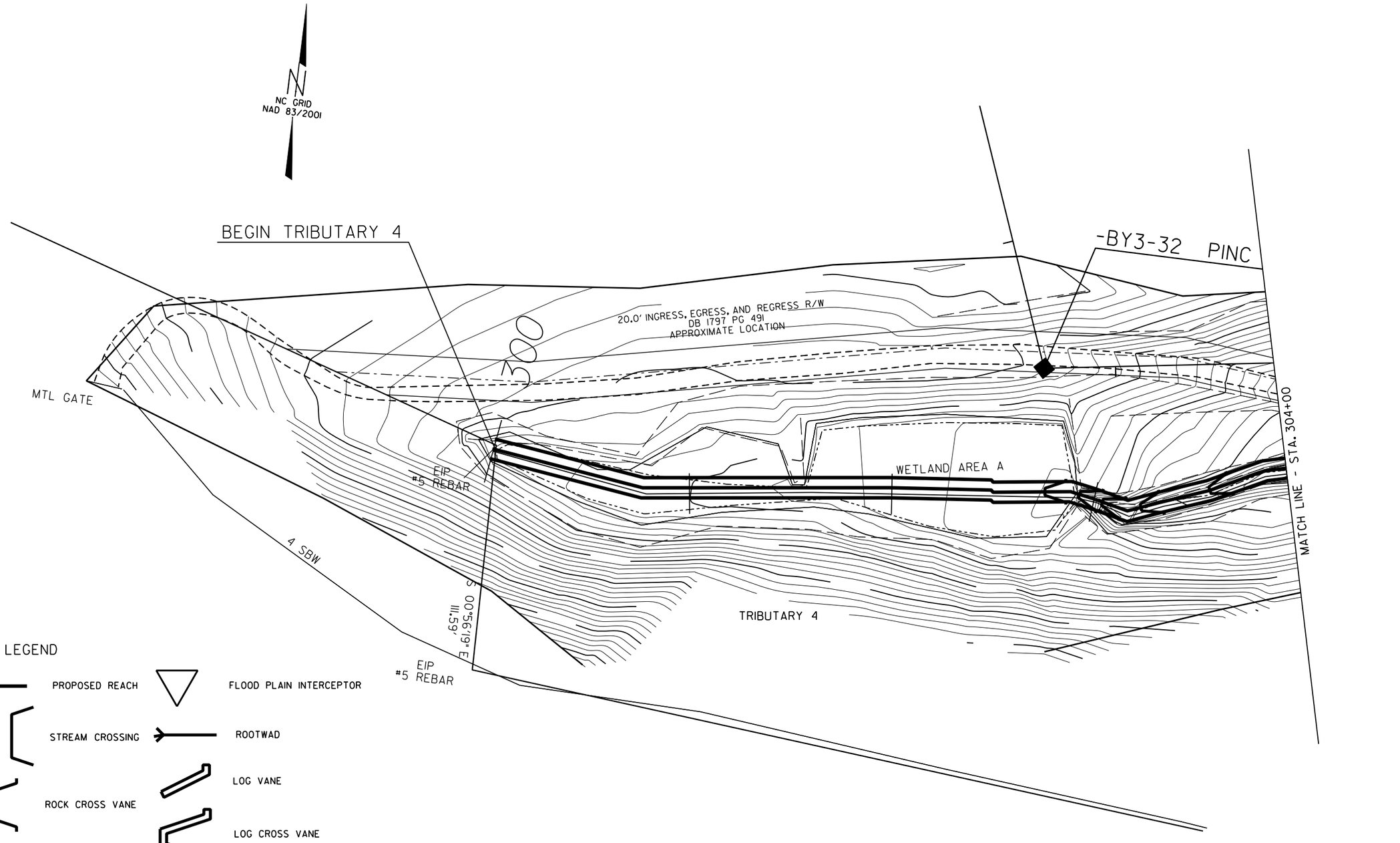
10



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PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 4

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

Ecosystem Enhancement Program

SEAL: PRELIMINARY PLANS NOT FOR BIDDING OR CONSTRUCTION

DATE: JULY 2007

TECHNICIAN: EHJ

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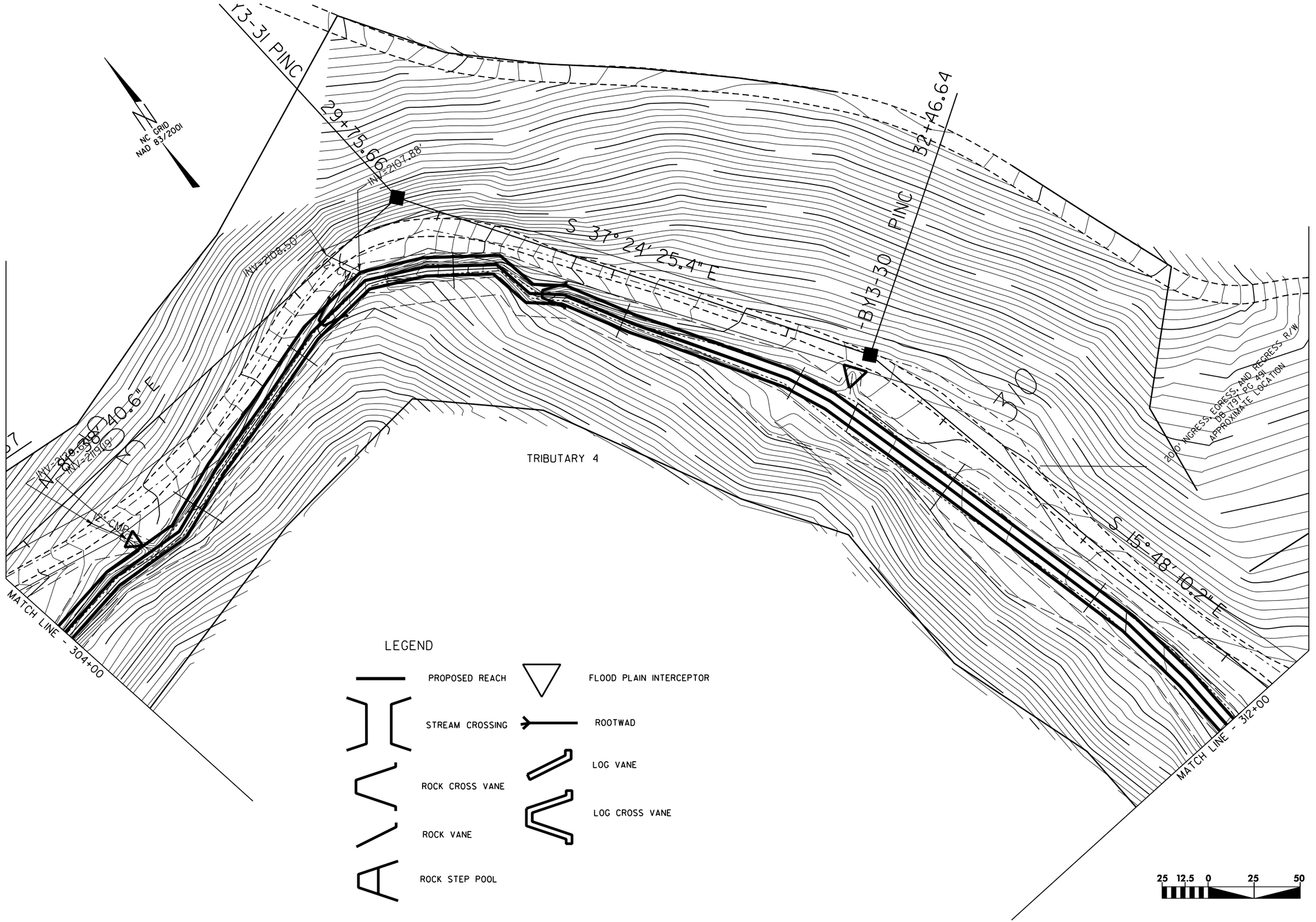

LEGEND

- PROPOSED REACH
- STREAM CROSSING
- ROCK CROSS VANE
- ROCK VANE
- ROCK STEP POOL
- FLOOD PLAIN INTERCEPTOR
- ROOTWAD
- LOG VANE
- LOG CROSS VANE

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TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 4

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

SEAL: PRELIMINARY PLANS Not to be used for construction

DATE: JULY 2007

TECHNICIAN: EHJ

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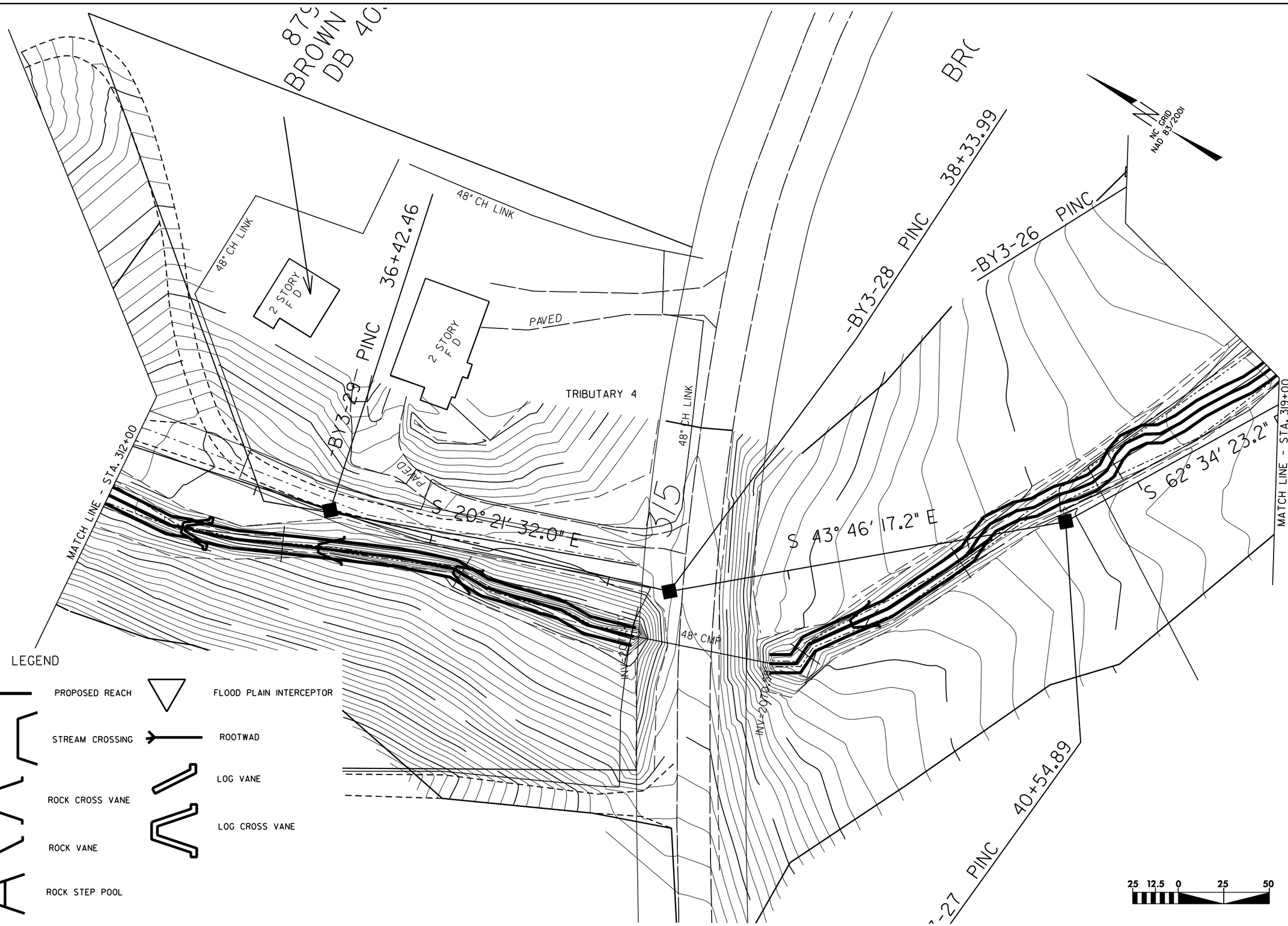
12



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TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 4

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM
Ecosystem Enhancement Program

SEAL: PRELIMINARY PLANS NOT TO BE USED FOR CONSTRUCTION

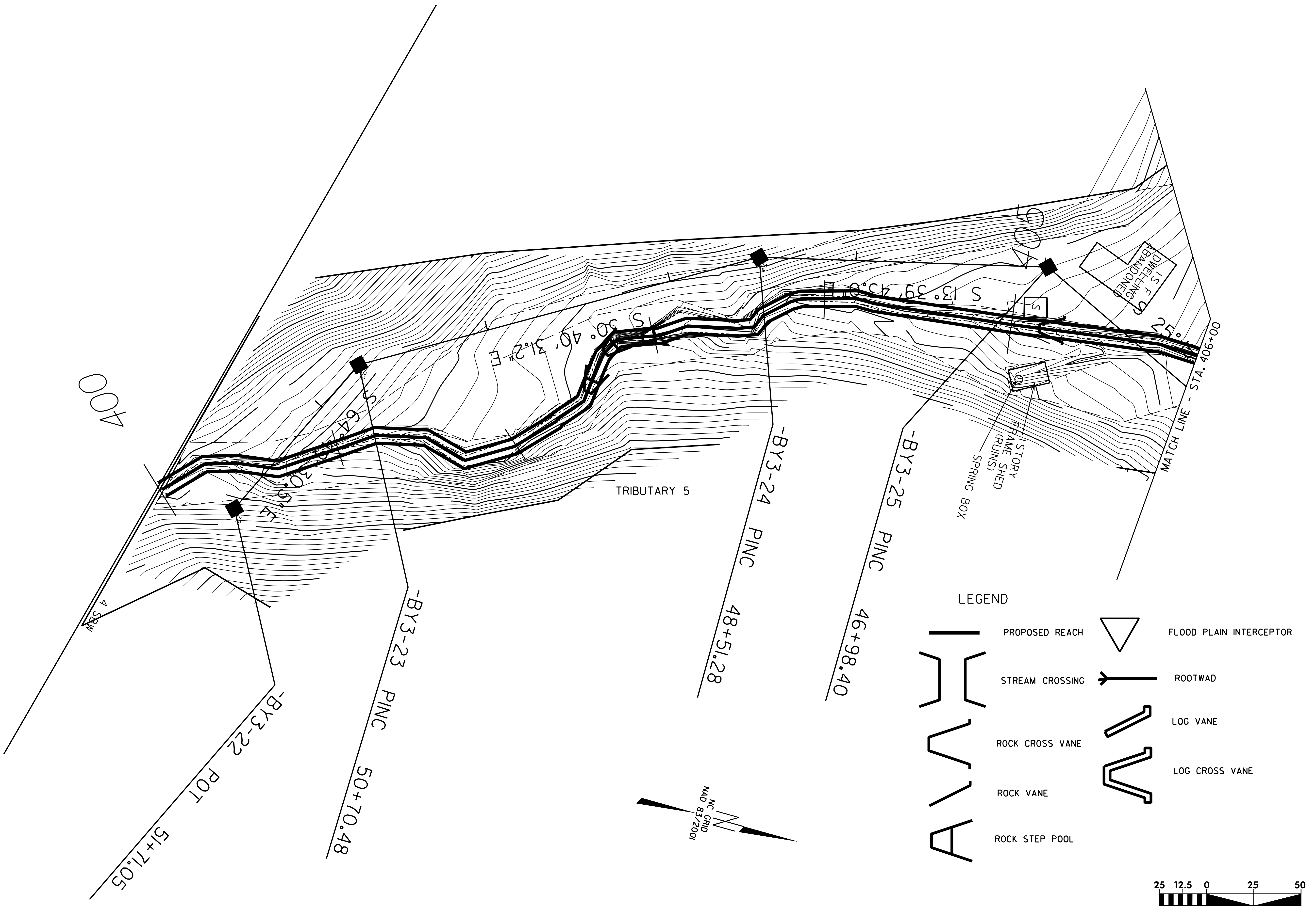
DATE: JULY 2007

TECHNICIAN: EHJ

CHECKED BY: KMM

EEP PROJ. NO.
92497

13



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PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 5

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

SEAL

PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

DATE: JULY 2007

TECHNICIAN: EHJ

CHECKED BY: KMM

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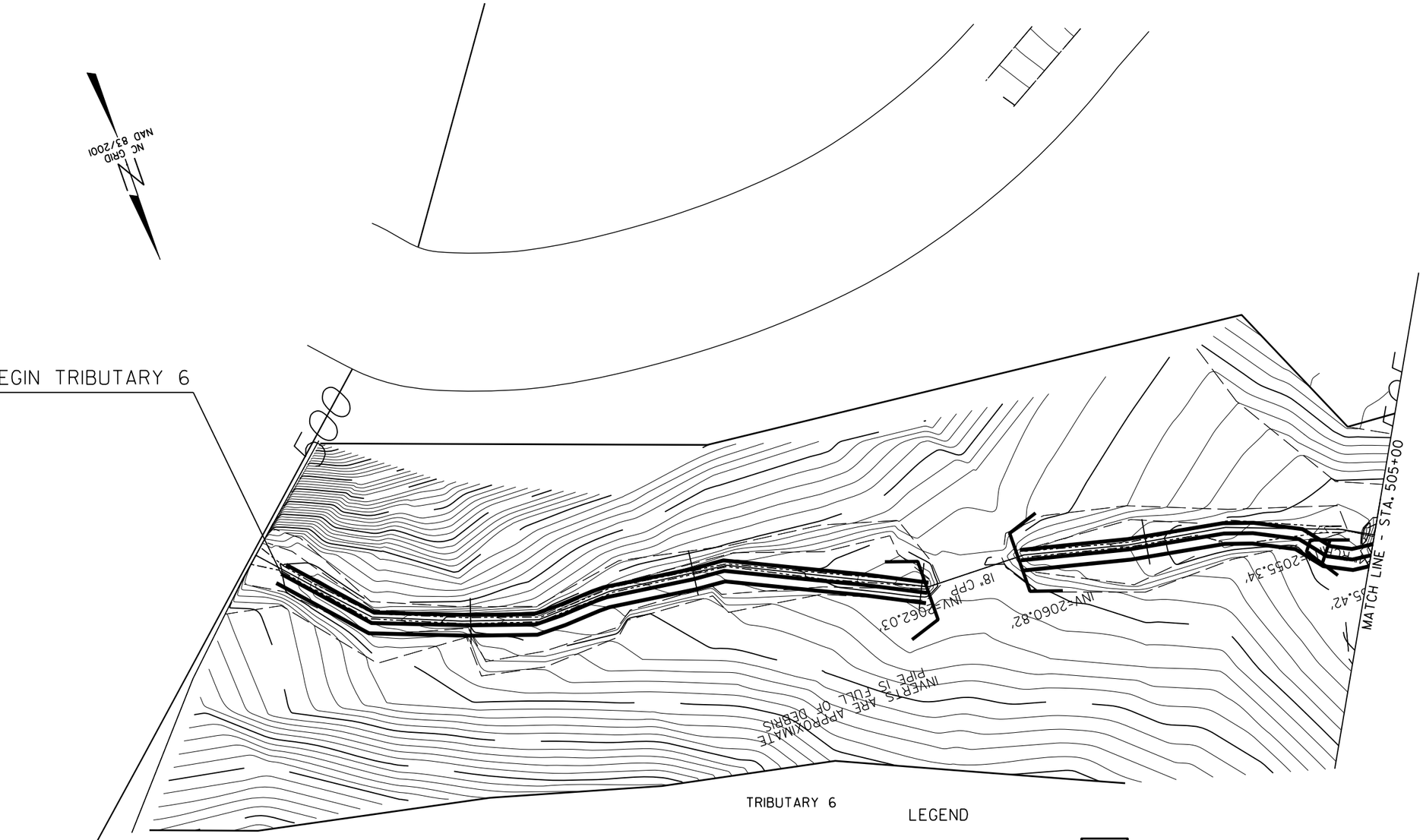

LEGEND

- PROPOSED REACH
- STREAM CROSSING
- ROCK CROSS VANE
- ROCK VANE
- ROCK STEP POOL
- FLOOD PLAIN INTERCEPTOR
- ROOTWAD
- LOG VANE
- LOG CROSS VANE

25 12.5 0 25 50

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PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 6

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

Ecosystem Enhancement

SEAL: PRELIMINARY PLANS NOT TO BE USED FOR CONSTRUCTION

DATE: JULY 2007

TECHNICIAN: EHJ

CHECKED BY: KMM

EEP PROJ. NO. 92497

BEGIN TRIBUTARY 7

-BY3-37 PINC 5+00.00

-BY3-36 PINC 7+53.86

-BY3-35 PINC

S 79° 52' 45.9" E

S 48° 16' 45.8" E

INV-2120.61'

18" CMP

WETLAND AREA

MATCH LINE - 605+00

TRIBUTARY 7

NC GRID NAD 83/2001

LEGEND

PROPOSED REACH

STREAM CROSSING

ROCK CROSS VANE

ROCK VANE

ROCK STEP POOL

FLOOD PLAIN INTERCEPTOR

ROOTWAD

LOG VANE

LOG CROSS VANE

25 12.5 0 25 50

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URS Corporation - North Carolina
1600 Perimeter Park Drive
Morrisville, North Carolina 27560
TELEPHONE (919) 461-1100 FAX (919) 461-1415

PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 7

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

Ecosystem Enhancement

SEAL

PRELIMINARY PLANS Not for bid or construction

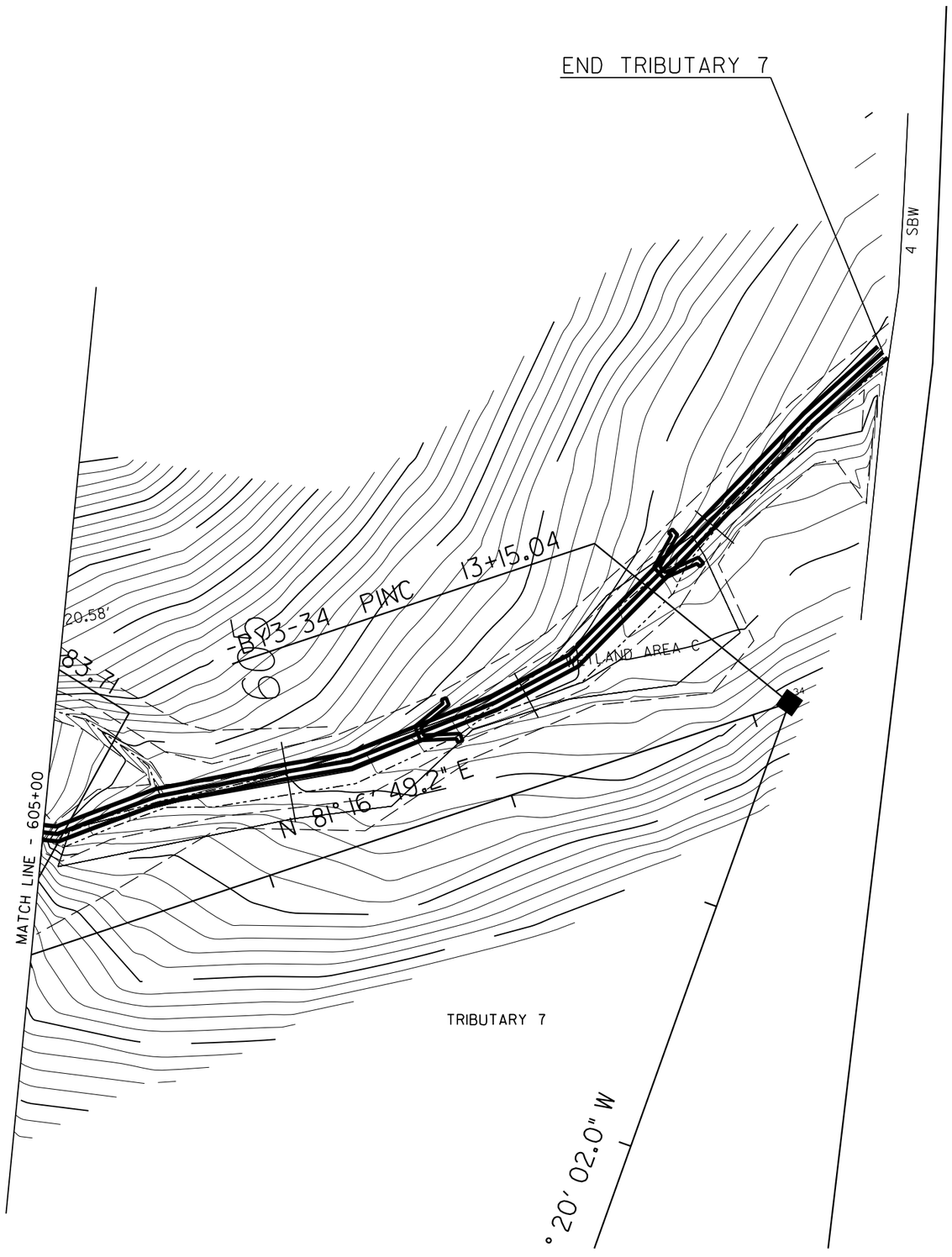
DATE: JULY 2007

TECHNICIAN: EHJ

CHECKED BY: KMM

EEP PROJ. NO.
92497

16



LEGEND

- PROPOSED REACH
- STREAM CROSSING
- ROCK CROSS VANE
- ROCK VANE
- ROCK STEP POOL
- FLOOD PLAIN INTERCEPTOR
- ROOTWAD
- LOG VANE
- LOG CROSS VANE

25 12.5 0 25 50

REVISIONS

NO.	DATE

Prepared by
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Morrisville, North Carolina 27560
TELEPHONE (919) 461-1100 FAX (919) 461-1415

PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

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Ecosystem Enhancement Program

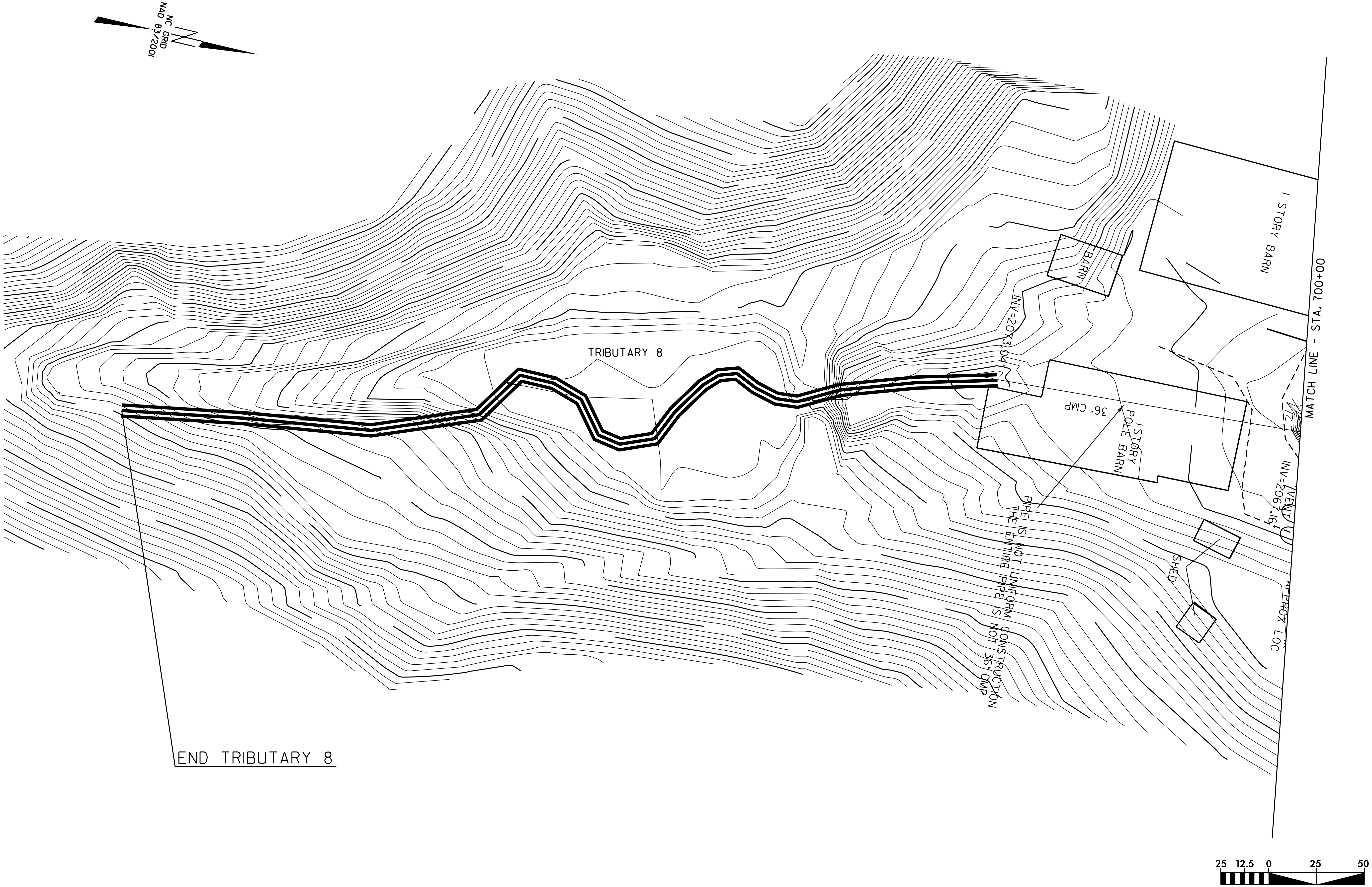
SEAL: PRELIMINARY PLANS NOT FOR BIDDING OR CONSTRUCTION

DATE: JULY 2007

TECHNICIAN: EHJ

CHECKED BY: KMM

EEP PROJ. NO. 92497



REVISIONS

NO.	DATE	

Prepared by URS
URS Corporation - North Carolina
1600 Perimeter Park Drive
Morrisville, North Carolina 27560
TELEPHONE (919) 461-1100 FAX (919) 461-1415

PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: PROPOSED RESTORATION PLAN SHEET TRIBUTARY 5

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

Ecosystem Enhancement PROGRAM

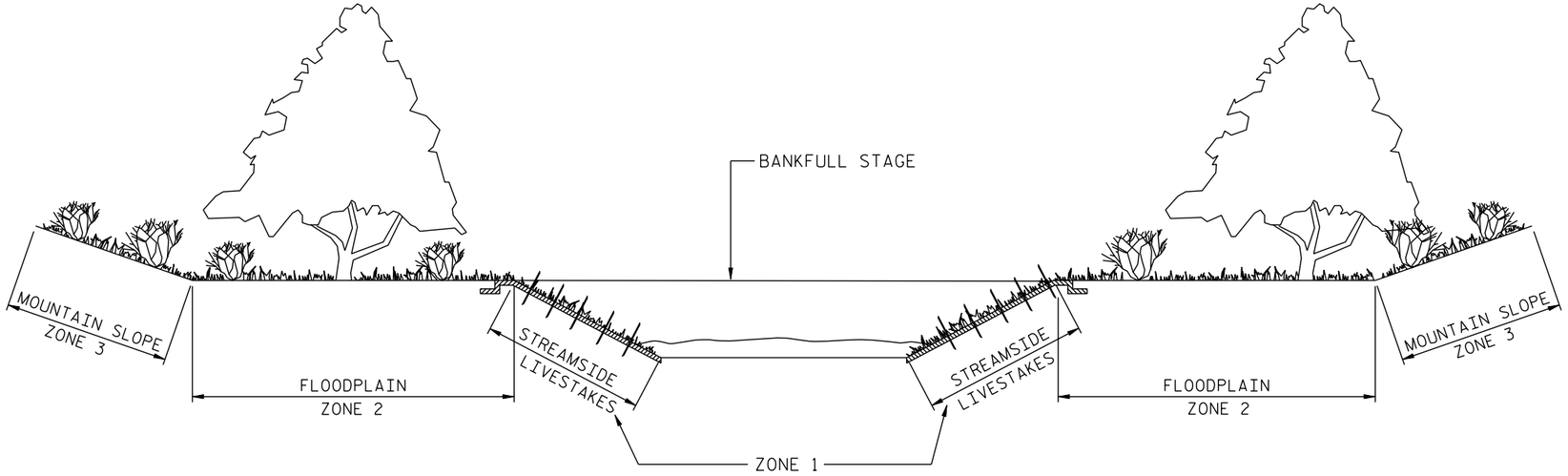
SEAL: PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

DATE: JULY 2007

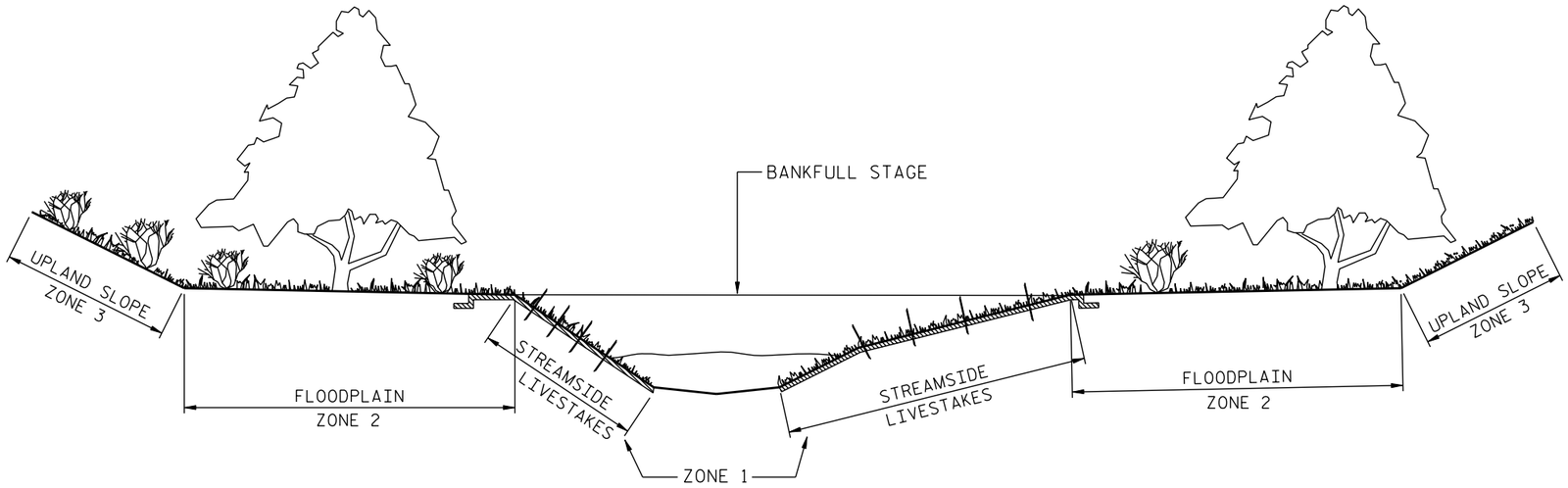
TECHNICIAN: EHJ

CHECKED BY: KMM

EEP PROJ. NO. 92497



RIFFLE PLANTING ZONES



POOL PLANTING ZONES

NOTE: ZONE 4 (WETLAND) WILL BE PLANTED IN DESIGNATED WETLAND AREAS.

REVISIONS

NO.	DATE

Prepared by
URS
URS Corporation - North Carolina
1600 Perimeter Park Drive
Morrisville, North Carolina 27560
TELEPHONE (919) 461-1100 FAX (919) 461-1415

PROJECT: NEWFOUND CREEK STREAM RESTORATION PROJECT

TITLE: RESTORATION PLAN PLANTING ZONES

CLIENT: NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

Ecosystem Enhancement Program

SEAL: PRELIMINARY PLANS NOT FOR BIDDING OR CONSTRUCTION

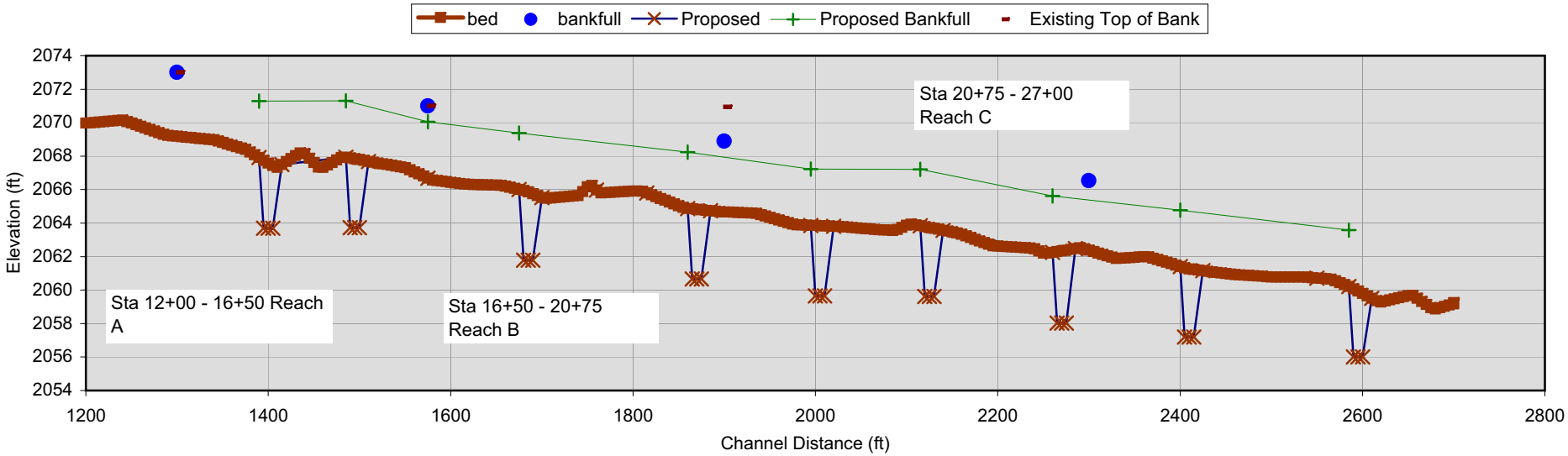
DATE: JULY 2007

TECHNICIAN: EHJ

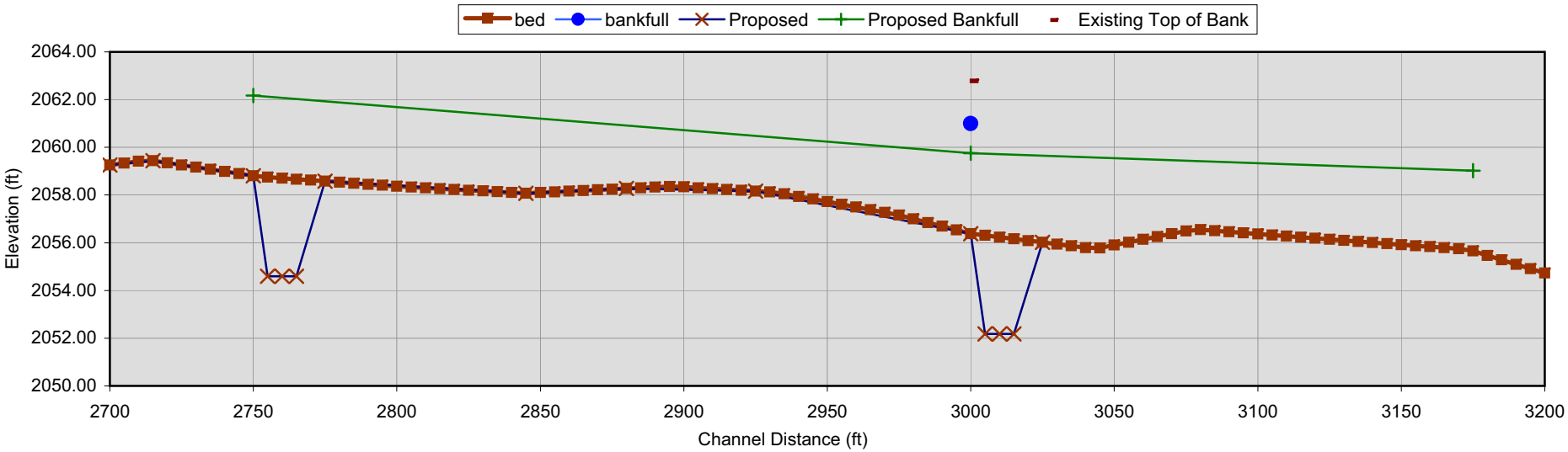
CHECKED BY: KMM

EEP PROJ. NO. 92497

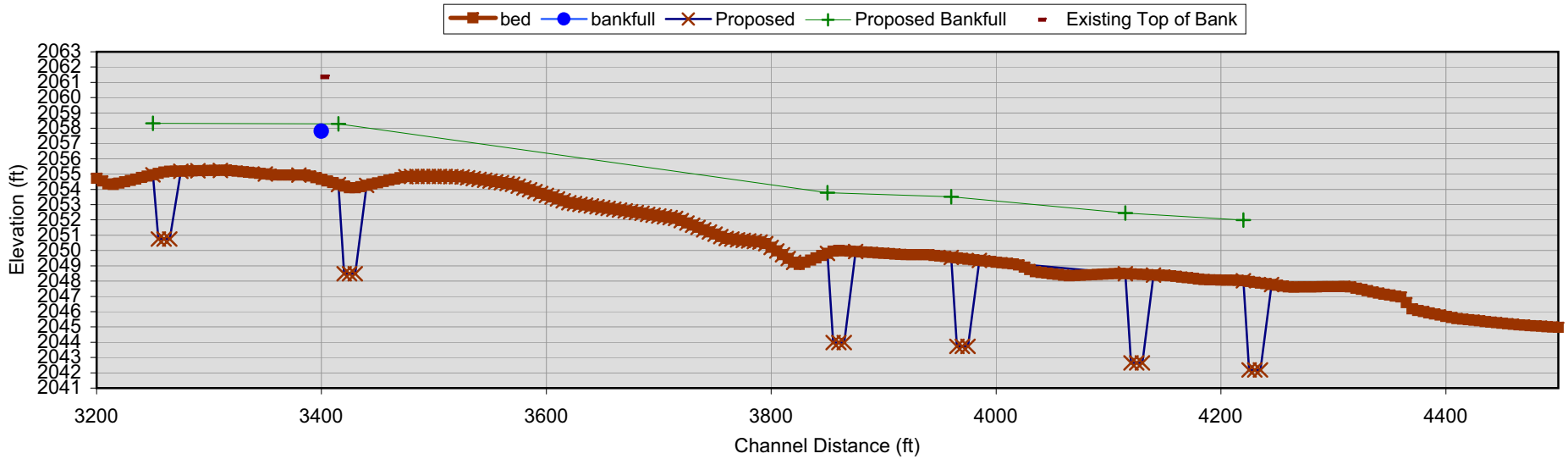
Newfound Creek Stream Restoration
EEP Project No. 92494
Mainstem Reach A - C
Existing and Proposed Longitudinal Profile



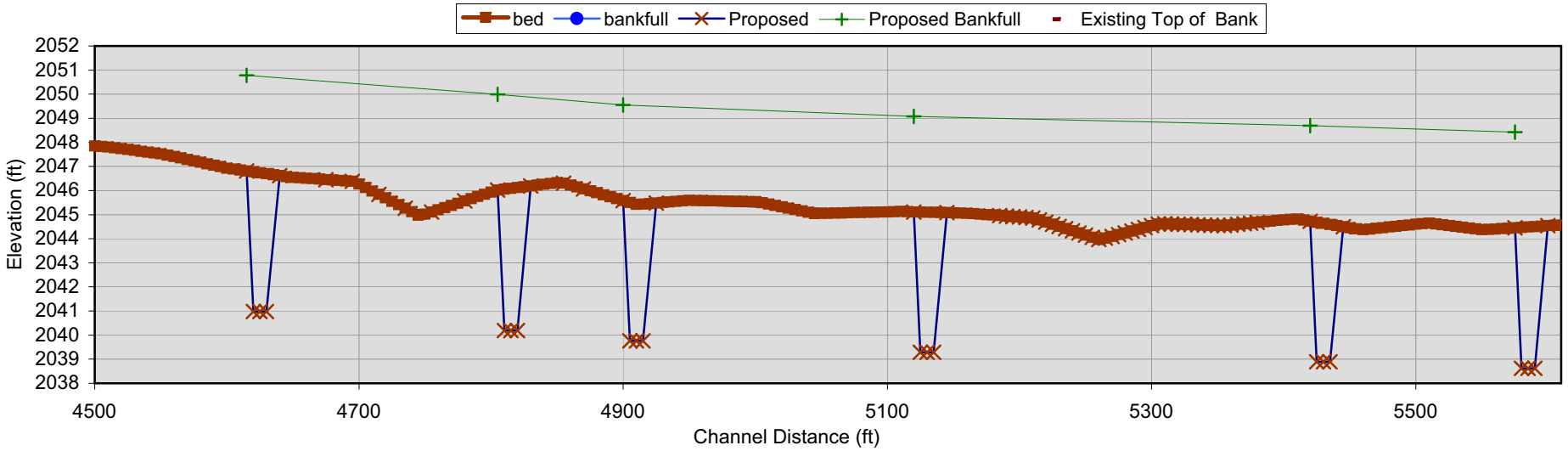
Newfound Creek Stream Restoration
EEP Project No. 92494
Mainstem Reach D
Existing and Proposed Longitudinal Profile



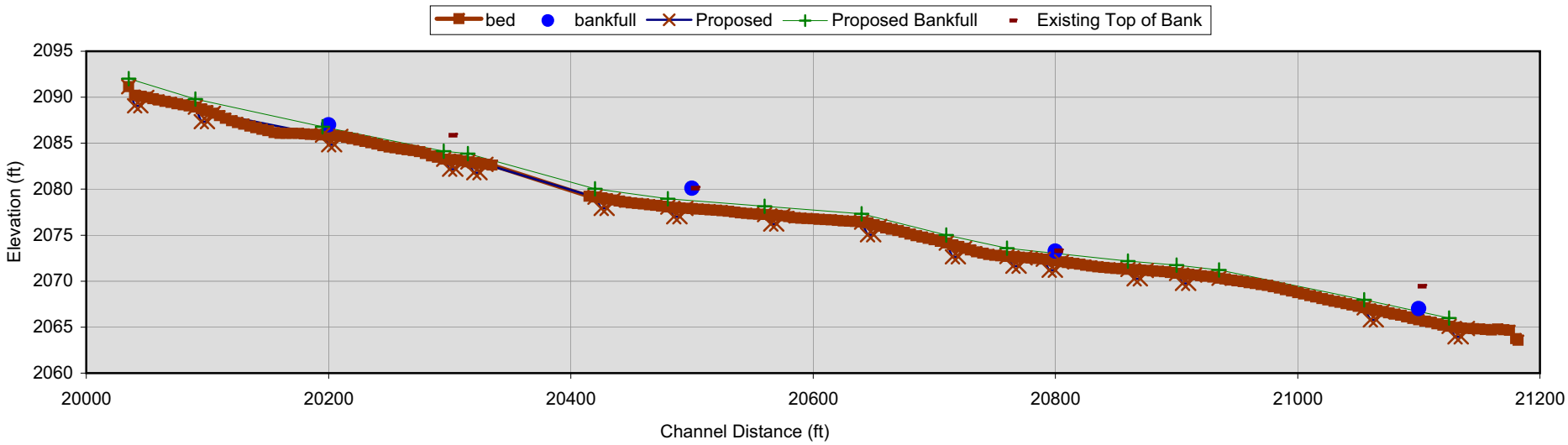
Newfound Creek Stream Restoration
EEP Project No. 92494
Mainstem Reach E
Existing and Proposed Longitudinal Profile



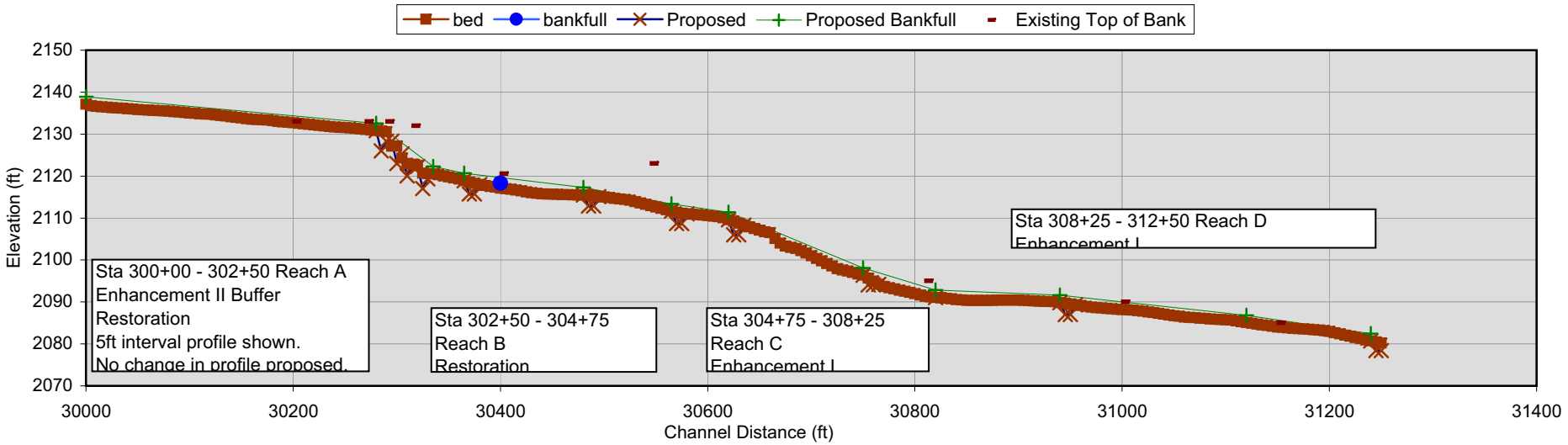
Newfound Creek Stream Restoration
EEP Project No. 92494
Mainstem Reach F
Existing and Proposed Longitudinal Profile



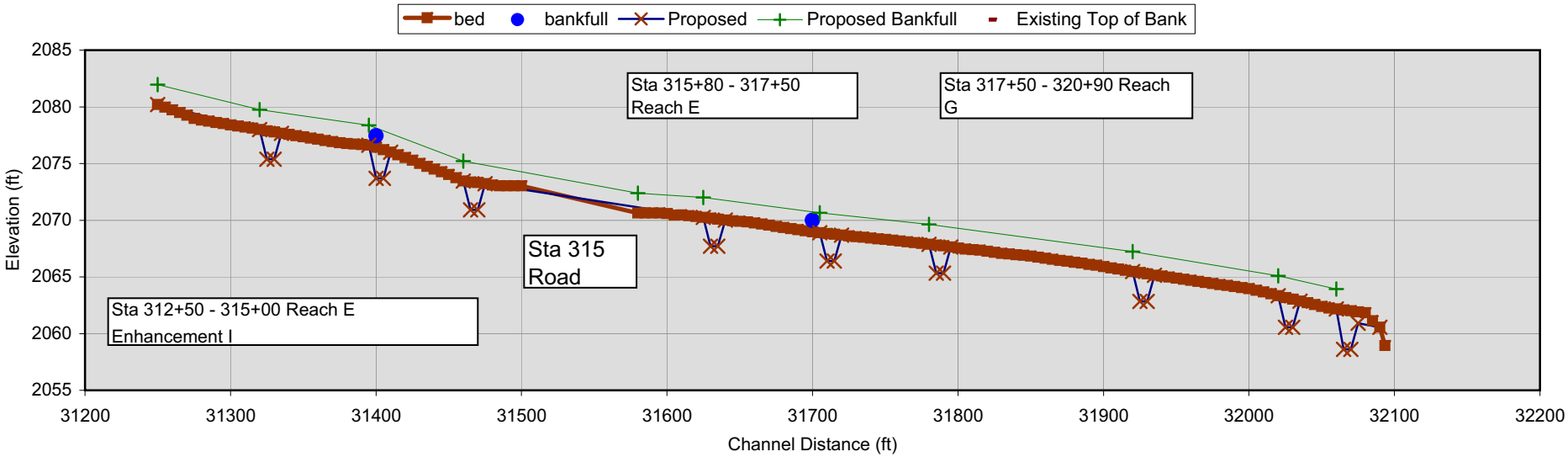
Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 3
Existing and Proposed Longitudinal Profile



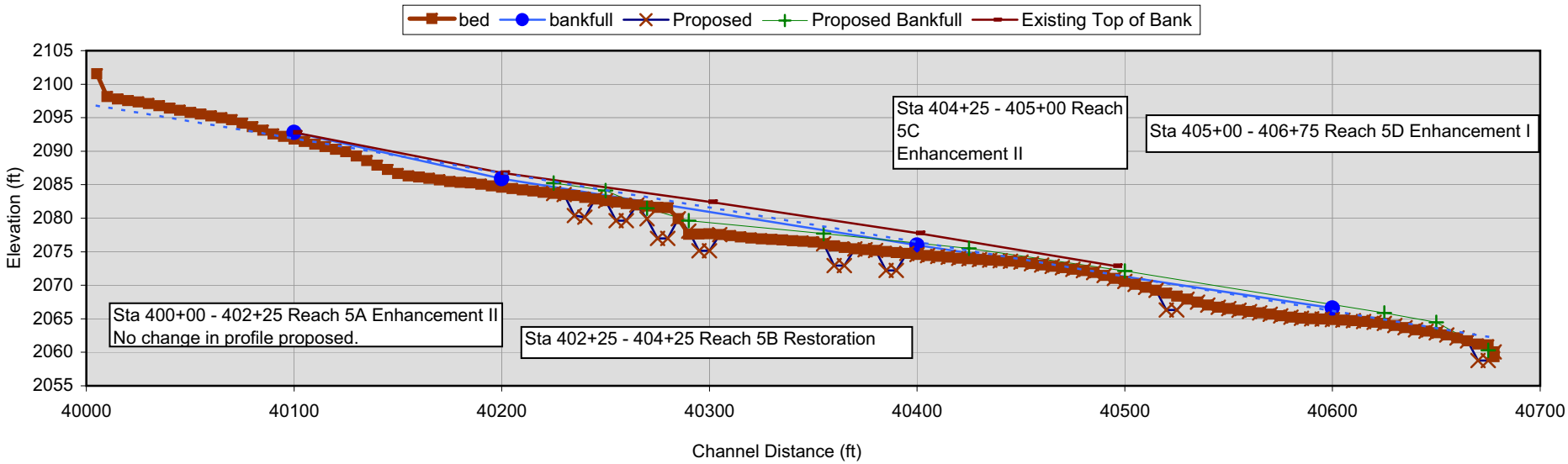
Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 4A - D
Existing and Proposed Longitudinal Profile



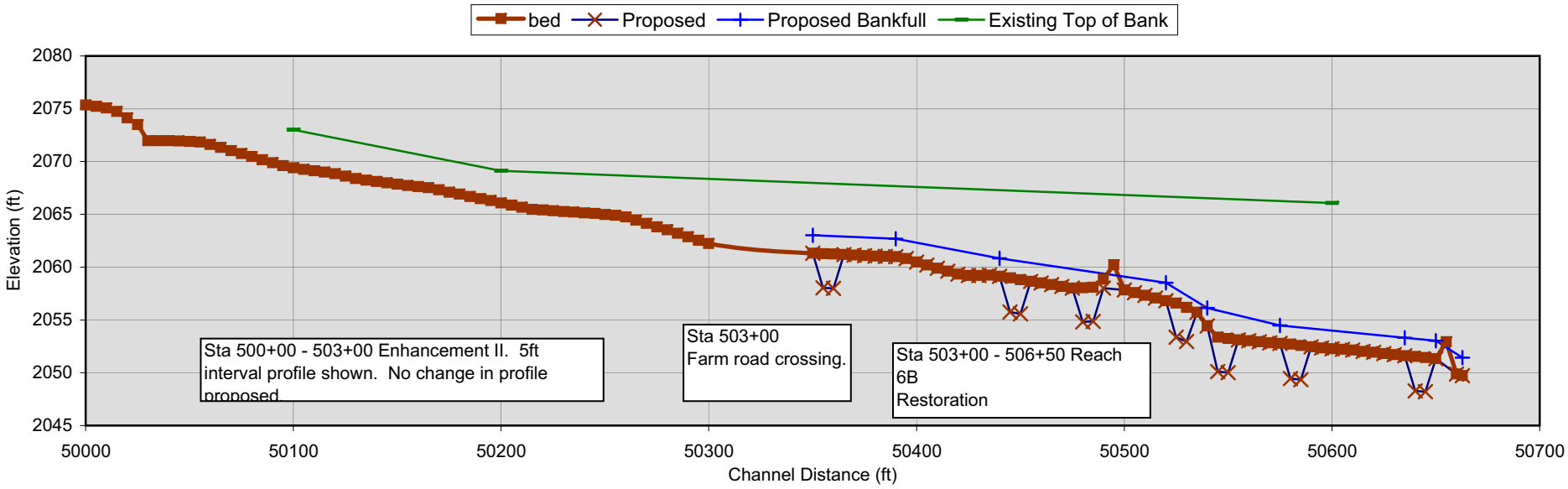
Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 4E - G
Existing and Proposed Longitudinal Profile



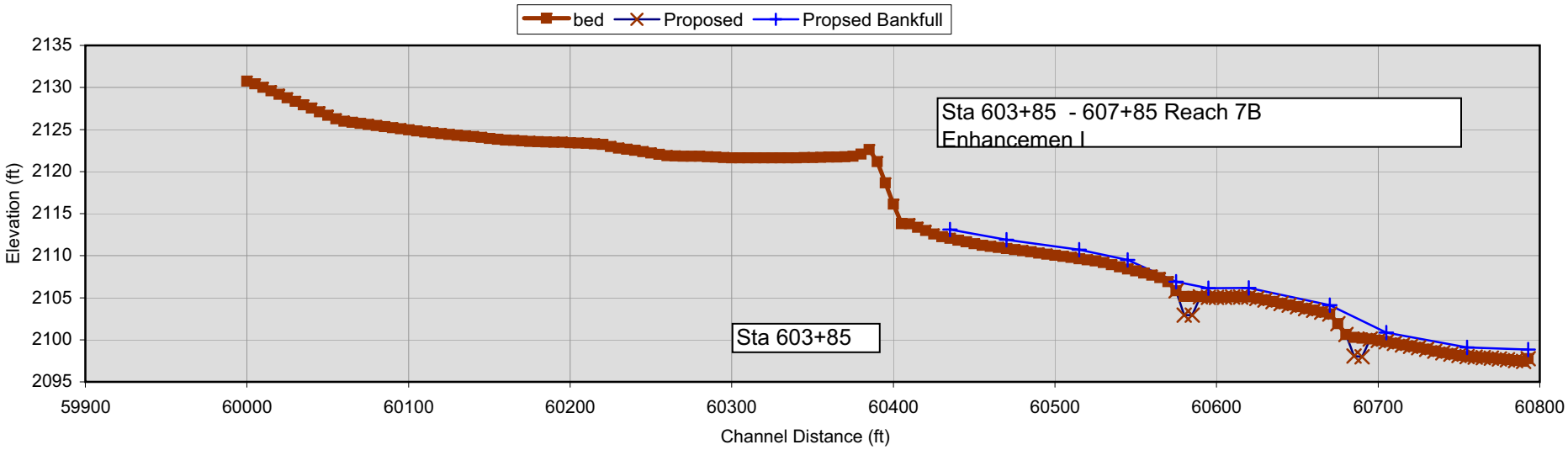
Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 5
Existing and Proposed Longitudinal Profile



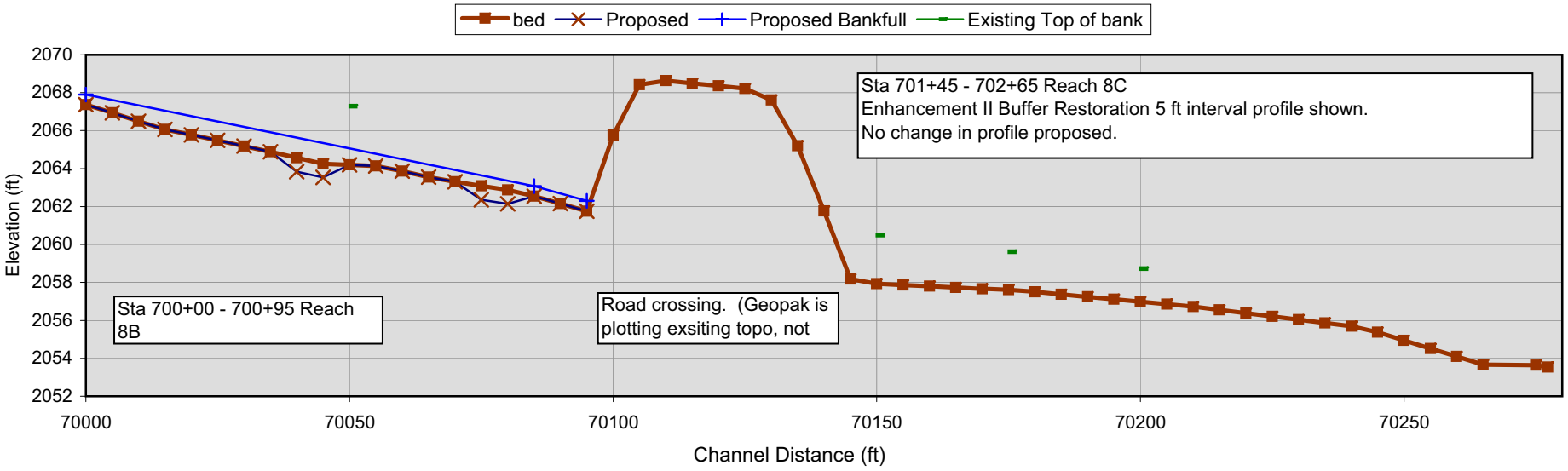
Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 6
Existing and Proposed Longitudinal Profile



Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 7
Existing and Proposed Longitudinal Profile



Newfound Creek Stream Restoration
EEP Project No. 92494
Tributary 8
Existing and Proposed Longitudinal Profile



Click on the Desired Link Below

Appendices