Puzzle Creek Restoration Project

Baseline Monitoring Document and As-built Baseline Report

Rutherford County, North Carolina

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EXECUTIVE SUMMARY

The Puzzle Creek site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents baseline, as-built monitoring data for the five-year monitoring period. The goals for the restoration project were as follows:

- Improved hydrologic connectivity between creeks and floodplains;
- The reduction of sediment and nutrient loading through restoration of riparian areas and stream banks;
- To create geomorphically stable conditions on the Puzzle Creek project site; and
- Improved aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Removal of anthropogenic impacts from the stream corridor and rehabilitation of incised and eroding streams by stabilizing stream channels and improving floodplain access;
- Improving impacted buffers to aid in nutrient removal from runoff and stabilizing stream banks to reduce bank erosion and sediment contribution to streams;
- Providing more stable and diverse channel features such as depositional riffles and bars, creating deeper pools and areas of water re-aeration, and providing woody debris to increase instream habitat quality and diversity;
- Establishment of riparian areas characterized by native vegetation, organic debris, and bi-annual flooding which are protected by a permanent conservation easement. The establishment of native streambank and floodplain vegetation are improving bank stability, and will eventually provide shading to decrease water temperature and cover, improving terrestrial wildlife habitat.

Orthophotography maps from the 1930's show residential and agricultural land use altering the Puzzle Creek watershed. Many streams were channelized to help mark property boundaries and to drain low lands for farming. Anthropogenic land use alteration and channelization of streams introduced instabilities from which streams in the region are still recovering. Incision, bank erosion, meander cutoffs, lateral bar formation, debris jams, and other ongoing stream processes typical of adjusting streams were originally found in the project reach. Segments of one unnamed tributary on-site have achieved a degree of relative stability due to the presence of heavily wooded banks, developing floodplains which have been active in recent years, and bedrock that has prevented incision from becoming the driving factor in channel geomorphic development. More recently, sections of Puzzle Creek have been utilized for pasture and are frequently mowed. The remainder of the site is wooded, with acreage being managed for timber production and also as a wildlife sanctuary and hunting grounds. The primary causes of impairment found within the project reaches included previous efforts to channelize the streams, logging activities, an abundance of unstable log jams resulting in erosion, and the presence of non-native vegetation.

This Baseline Monitoring Report presents data on as-built stream geometry, stem count data from vegetation monitoring stations, and crest gauge installation. In addition, this report and subsequent reports will note any deviances relating to stream stability, site planting and the monitoring schedule established for the Puzzle Creek mitigation project. This entailed using a combination Priority I and II restoration approach on Puzzle Creek and UT1. The resulting design should ultimately yield primarily C-type channels with relatively low width-depth ratios but relatively flat bank slopes where site constraints are not present. As an alluvial system, the channels will be free to naturally adjust according to the

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prevailing geomorphologic trends in the system. This report has been delayed due to modifications made following a series of floods through the project post construction. Modifications corrected areas along the channel where the bank elevation was not cut to the bankfull elevation and also included lowering the floodplain to accommodate higher flood flows. Lastly, a cross-vane was also added at the lower end of Reach 2 to align the thalweg in the center of the channel. Based on geomorphic and vegetation data collected, this Site is currently on track to meet the hydrologic, vegetative, and stream success criteria specified in the Puzzle Creek Mitigation Plan.

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1.0 PROJECT GOALS, BACKGROUND, AND ATTRIBUTES

The Puzzle Creek Restoration site is located approximately three miles northeast of Bostic, in Rutherford County, North Carolina (Figure 1). The project site is situated in the Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-02 and United States Geologic Survey (USGS) hydrologic unit 03050105070050. Orthophotography maps from the 1930's show residential and agricultural land use altering the Puzzle Creek watershed. Many streams were channelized to help mark property boundaries and to drain low lands for farming. Anthropogenic land use alteration and channelization of streams introduced instabilities from which the streams are still recovering. Incision, bank erosion, meander cutoffs, lateral bar formation, debris jams, and other ongoing stream processes typical of adjusting streams are found in the project reach. Segments of the unnamed tributary have achieved a degree of relative stability due to the presence of heavily wooded banks, developing floodplains which have been active in recent years, and bedrock that has prevented incision from becoming the driving factor in channel geomorphic development.

Prior to initiation of this project, riparian sections along Puzzle Creek were utilized for pasture and frequently mowed. The remainder of the site is wooded, with acreage being managed for timber production and also as a timberland used for hunting and quite enjoyment. The primary causes of impairment found within the project reaches include previous efforts to channelize the streams, logging activities, an abundance of unstable log jams resulting in erosion, and the presence of non-native vegetation.

The project involved restoration or enhancement of 4,849 linear feet (LF) of two on-site streams: Puzzle Creek and a smaller unnamed tributary (UT) identified in the project as UT1. Puzzle Creek and the unnamed tributary are shown as "blue-line" streams on the USGS topographic quadrangle for the site, and are considered to be perennial, based on field evaluations using NCDWQ stream assessment protocols.

1.1 Restoration Summary

1.1.1 Location and Setting

The Puzzle Creek restoration site is located approximately three miles northeast of Bostic in Rutherford County, NC. To access the site from Interstate 26, take the Hwy 74 East exit, Exit 67, toward NC-108/Columbus/Rutherford. Continue on Hwy 74 East for approximately 23 miles and turn left at the Old Caroleen Road Exit. Continue on Old Caroleen Road and take a right onto Riverside Drive before making another right onto the Hwy 74 Bridge. After crossing the bridge, turn left onto Bostic Sunshine Road which temporarily merges with S Main Street. Continue on Bostic Sunshine Road/S Main Street until reaching Piney Mountain Church Road whereupon a right turn should be made to access the project site, located at 2321 Piney Mountain Church Road.

Unnamed tributary 1(UT 1) flows west then northwest from the upstream end of the Schafer property boundary to a break in the easement. UT1 continues northwest from the break in the easement to its confluence with Puzzle Creek. Reach 1 of Puzzle Creek begins at Piney Mountain Church Rd (SR 1007) and continues southwest to the confluence with UT1. Reach 2 of Puzzle Creek begins at the confluence of with UT1 and continues northwest to the property boundary. The project site is accessible from Piney Mountain Church Rd. and Washburn Rd.

1.1.2 Project Goals and Objectives

The goals for the Puzzle Creek restoration project were as follows:

- Improved hydrologic connectivity between creeks and floodplains in the project corridor;

- The reduction of sediment and nutrient loading through restoration of riparian areas and stream banks;
- To create geomorphically stable conditions at the Puzzle Creek project site; and
- Improved aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Removal of anthropogenic impacts from the stream corridor and rehabilitation of incised and eroding streams by stabilizing stream channels and improving floodplain access;
- Improvements to water quality in the Puzzle Creek watershed through nutrient removal, sediment removal, streambank stability, and erosion control;
- Providing more stable and diverse channel features such as depositional riffles and bars, creating deeper pools and areas of water re-aeration, and providing woody debris to increase instream habitat quality and diversity;
- Establishment of riparian areas characterized by native vegetation, organic debris, and bi-annual flooding which are protected by a permanent conservation easement. The establishment of native streambank and floodplain vegetation are improving bank stability, and will eventually provide shading to decrease water temperature and cover, improving terrestrial wildlife habitat.

In addition to the objectives stated above, the following overarching design objectives were incorporated into the design of the streams on this site:

- Make important design decisions based on hydraulic and sediment modeling in order to solve the issues of concern with process-based, site-specific information with consideration of regional hydrology and restoration design research and information.
- Use constructability as a guiding consideration in order to produce a realistic design that will be possible to build given field constraints and construction tolerances. Design ideas should be discussed with knowledgeable construction personnel to determine the constructability, likely footprint, and severity of impacts to on-site resources.
- Minimize disturbance to ecologically functional and physically stable areas; mimic the character of these areas and borrow materials from them where appropriate to create a more natural design.
- To the utmost extent possible, native, on-site materials will be used to realize design features. Utilizing on-site resources within the project area will aid in re-establishing a contiguous habitat between the project site and surrounding area that favors native flora and fauna. Minimizing construction materials brought onsite also reduces compaction and site disturbance from material transport, and produces an aesthetically pleasing result with the goal being minimal evidence of site disturbance.

1.1.3 Project Structure, Restoration Type, and Approach

1.1.3.1 Project Structure

Please refer to Table 1 in Appendix A for a summarization of the project structure of Puzzle Creek. Figure 2, also in Appendix A, illustrates restoration approaches by project reach.

1.1.3.2 Restoration Type and Approach

Puzzle Creek

The upper reach (reach 1) of the mainstem of Puzzle Creek was severely laterally unstable resulting in the presence of self-perpetuating debris jams. Bank erosion, falling trees, incision, and impingement on the valley wall were considered significant and irreversible trends present in the reach. Based on the pre-existing conditions and design constraints, it was determined that the creation of a new channel through the floodplain on the right side of

the existing channel was the best alignment. This provided an accessible floodplain on both sides of the channel as well as a stable pattern and profile. A combination of Priority I and Priority II Restoration approaches were implemented along Reach 1 based on the need to excavate the floodplain in some areas while elevating the channel in other sections. As was the case with all project reaches, unforested sections of floodplain as well as areas of recently disturbed floodplain were seeded and replanted with trees and shrubs native to the area to provide stability and create an adequate riparian buffer.

The reach of Puzzle Creek downstream of the confluence with UT1 (Reach 2) was suffering from a cycle of debris jams, lateral instability, bank erosion, channel avulsion, and falling trees. This section of Puzzle Creek was incised, although some flood relief was available by the presence of a remnant channel in the left floodplain. A combination of Priority I and Priority II Restoration was applied in Reach 2 to create a meandering pattern with stable riffles and pools. Parts of the existing flow area were incorporated at the first two bends to preserve existing bank vegetation and for the sake of constructability (access and soil removal were significant issues in this reach). Subsequent meander bends were built offline in the vicinity of the meander cutoff. This approach resulted in the channel being moved away from the right valley wall and provided marked improvements in the profile, cross-section, and stability of the channel pattern.

Unnamed Tributary 1

Throughout UT1, a combination of Priority I and II Restoration approaches was implemented. Reach 1 of UT1 flows west then northwest from the upstream end of the Schafer property boundary to a break in the easement above the waterfall. The primary issues addressed on UT1 were connectivity of the stream to the floodplain, localized erosion of streambanks and impingement on valley walls, sub-reaches with bed features that are inconsistent with the plan form of the stream, and non-native vegetation. At the uppermost end of the reach, floodplain connectivity was addressed by changing the bed profile, thereby raising the water surface. By creating backwater in meander bends, naturally-sustainable pools were created. Modification of the water surface below the first 150 linear feet of stream was not possible due to the slope requirements to match natural ground further downstream. Further downstream, a new channel was constructed to bring the stream away from the valley wall and to create a riffle-pool sequence. Below this offline section, banks were graded to improve stream stability while following the existing channel course. A riprap stream crossing was installed in this section for land-owner access and forest fire response access to both sides of the creek. Below the crossing, intact banks and bed diversity minimized the meandering needed and restoration consisted of making minor changes to the channel cross-section, pattern and profile as necessary to improve bank stability and sediment transport continuity.

In other less stable sections where the stream exhibited signs of channelization, the channel was taken offline to restore pattern and profile, creating a more stable channel with a more diverse channel bedform. A significant amount of bedrock is present throughout Reach 1. Consequently, the channel was brought back online where bedrock is present.

In other areas, where bedform is diverse, banks stable, and valley constraints present, modifications to the profile and cross-section were made, but the channel was kept in its existing alignment. For these reasons, an Enhancement Level I approach was taken in this section of Reach 1.

Immediately upstream of the waterfall, a Priority II Restoration approach was implemented as a stable pattern was constructed in this over-wide reach to reduce channel erosion and improve channel stability and habitat through the reach. At the footbridge that marks the downstream end of this reach, a large rock outcrop and waterfall will serve as barriers to any

significant profile changes that could propagate upstream. This footbridge also marks the beginning of a short reach that was excluded from the easement and that ends at the base of the waterfall. Existing channel stability in this section of the reach is acceptable and banks are well vegetated.

A Priority II Restoration approach was also applied to UT1 downstream of the easement break, below the waterfall which drops at an even rate totaling approximately 15 feet over a distance of 150 feet. This lower reach is approximately 400 feet long and transitions from a steep valley type at the waterfall, back to a flatter alluvial valley. A restoration approach was used to change profile and cross-section characteristics from the beginning of the reach to station 36+12 at the confluence. Use of the existing channel minimized grading requirements for this section of UT1; however, minor pattern, dimension and floodplain elevation adjustments were made. Native vegetation was also established in graded areas, providing stability to the confluence of the tributary with Puzzle Creek. Valley constraints and bedrock in this reach did limit the extent of adjustments made; however, bank stability was improved through the use of vegetated geolifts.

Where the valley does not pose serious constraints, the design for Puzzle Creek and UT1 allows stream flows larger than bankfull events to spread onto the floodplain, dissipating flow energies and reducing streambank stress. Where the valley does constrain UT1, existing, mature trees were saved to the extent practical to maintain bank stability and grade control was enhanced where needed. Rootwad structures and coverlogs were used to protect streambanks and promote habitat diversity. Rock and log vanes were also used to promote bedform diversity as well as habitat diversity, and also to provide grade control and bank stabilization where the thalweg alignment changed. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants have provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

Modifications made during construction and consisted of changes in the order of the construction sequence to increase efficiency during wet or high flow conditions. Other modifications involved the location and selection of instream structures and bank stabilization practices as well as the lowering of the bankfull elevation in isolated reaches along Puzzle Creek and UT1. Modifications made during construction also consisted of applying Priority I and II measures on two additional tributaries to Puzzle Creek that are located within the project area. Unnamed Tributary 2 (UT2) is located above the confluence of Puzzle Creek and UT1. The third unnamed tributary to Puzzle Creek, UT3, is located just upstream of the only cross-vane on Puzzle Creek and downstream of the confluence with UT1. These tributaries are included in the total Restoration footage due to the need to reconstruct the confluences of these streams as the mainstem was modified. Invasive vegetation removal and replanting of these areas with native riparian vegetation was carried out along these tributaries. The total linear feet of UT2 and UT3 that Restoration measures were applied on is 52 LF and 48 LF, respectively. Restoration measures applied to UT2 and UT3 actually extend beyond the conservation easement boundary, but were not considered in calculating the mitigation credit provided by this site as the measures fall outside of the project easement area. These changes are documented in the attached as-built drawings. The final as-built stream length for the project as indicated in Table 1, Appendix A is 5,073LF.

1.1.4 Project History, Contacts and Attribute Data

The Puzzle Creek project area drains agricultural and forested land, as well as a small area occupied by residential development. The general area in which the project is located is rural in character, and is not likely to change significantly in the foreseeable future. The largest percentage of land use in the watershed currently is in forested cover for wildlife habitat and hunting as well as timber production. The percentage of land in the watershed available to agriculture is 27% with over 60% of the watershed remaining as forest land.

Anthropogenic alterations include channelization of streams for agricultural purposes and various other stream corridor impairments. Incision, bank erosion, meander cutoffs, lateral bar formation, debris jams, and other ongoing stream processes typical of adjusting streams were found in various reaches of Puzzle Creek and the unnamed tributaries within the project area.

In accordance with the approved mitigation plan for the site, construction activities began in September 2008. Project activity on Puzzle Creek UT1, UT2 and UT3 consisted of making adjustments to channel dimension, pattern, and profile. Project activity also included establishment of a riparian buffer to stabilize the streambanks. A primary design consideration for this project was to allow stream flows larger than bankfull to spread onto a floodplain, dissipating flow energies and reducing streambank stress. The design for most of the restoration reaches involved the construction of new, meandering channels across a floodplain that was excavated to the bankfull elevation of the creek.

Toward the end of construction in October 2008 and shortly thereafter, the project site experienced a series of flood events. Baker evaluated the site to determine the appropriate course of action needed to stabilize the project area. It was determined that damage sustained on Puzzle Creek warranted re-mobilizing a construction crew to the site to repair damage to the site. Minor areas of erosion were stabilized and additional vegetated geolifts were added. Just upstream of the confluence with UT1 one meander was removed to increase the meander length in this area. The last meander on Puzzle was determined to be excessively tight, so the radius was reduced slightly by bringing the meander bend in slightly and a cross-vane was constructed at the head of the riffle to center the thalwag and hold elevation through the upstream pool.

At that time, UT1 had not been completed. During late fall and winter, a number of subsequent flood events impacted UT1, which had been completed by that time. In early 2009, Baker staff visited the site to assess channel and bank stability. Although there were no areas suffering from excessive erosion, there were some indications that the channel, as constructed, was not functioning to the level desired. Initially it appeared that meanders were attempting to elongate downstream and improper pattern was suspected; however, after some time passed and additional high flows passed through the channel it was determined that the pattern of instability was due to the banks not being established at the proper elevation and the floodplain needing to be lower over a wider area. In early 2010 the channel banks were modified by lowering the banks in some areas and lowering the floodplain elevation to accommodate bank flows. The repaired site has been observed for a number of months and appears to be stabilized by the channel modifications. Further site visits have not resulted in any additional design concerns.

Baker went to great lengths in working with the landowners to minimize the number of trees that were removed to increase floodplain connectivity. This, in addition to other site features, created a burden in trying to establish a stable channel and acceptable bankfull elevation. However, after the series of storm events that occurred at the end of 2008 and beginning of 2009, the landowner and Baker were able to reach a consensus regarding additional tree removal necessary to accomplish the greater goal of the project-to create stable stream corridors on Puzzle Creek and UT1.

Rootwads, rock and log vanes and other structures were used to protect streambanks and promote habitat diversity in pool sections. Streambanks were stabilized using a combination of erosion

control matting, bare-root planting, transplants, and geolifts. Transplants provided living root mass quickly to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

The chronology of the Puzzle Creek mitigation project is presented in Table 2, located in Appendix A which also includes Tables 3 and 4. The contact information for designers, contractors and plant material suppliers is presented in Table 3. Relevant project background information is presented in Table 4. Total stream length across the project increased from approximately 4,849 LF to 5,073LF.

2.0 SUCCESS CRITERIA

The five-year monitoring plan for the Puzzle Creek mitigation project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, reference photo stations and crest gauges are shown on the as-built plans.

2.1.1 Morphologic Parameters and Channel Stability

Geomorphic monitoring of restored stream reaches will be conducted over the next five years to evaluate the effectiveness of the restoration practices installed. Monitored stream parameters include bankfull flows, stream dimension (cross-sections), pattern (longitudinal survey), profile (profile survey), and photographic documentation. The methods used and any related success criteria are described below for each parameter. For monitoring stream success criteria, twelve permanent cross-sections, and two crest gauges were installed.

2.1.1.1 Dimension

Twelve permanent cross-sections were installed to help evaluate the success of the mitigation project. Permanent cross-sections were established throughout the project site as follows: five cross-sections were located on Puzzle Creek, and six cross-sections were located on UT1. One cross-section was also located on UT2 to monitor restoration efforts associated with riparian improvements made and pattern and profile adjustments made at the confluence of UT2 and Puzzle Creek. Cross-sections selected for monitoring were located in representative riffle and pool reaches and each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in the as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). At this time, cross-sectional measurements do not indicate any streambank or channel stability issues.

2.1.1.2 Pattern and Longitudinal Profile

A longitudinal profile was completed for the restored streams to provide a baseline for evaluating changes in channel bed conditions over time. A longitudinal profile was

conducted for the entire project length on Puzzle Creek, UT1, UT2 and UT3 (in future monitoring years, the profile surveyed for UT1 will be limited to 3,000 LF). Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, bankfull, and top of low bank, if the features are present. All measurements will be taken at the head of each feature (e.g., riffle, run, pool, glide) and the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. Surveys will be tied to a permanent benchmark. Permanent cross-section and longitudinal profile data are provided in Appendix B.

The longitudinal profiles should show that the bed features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type. Profile data collected reflect stable channel bedform and a diverse range of riffle and pool complexes.

2.1.1.3 Substrate and Sediment Transport

Bed material analysis will consist of a pebble count taken in the same constructed riffle during annual geomorphic surveys of the project site. These samples, combined with evidence provided by changes in cross-sectional and profile data will reveal changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes. As-built surveys do not reveal any significant areas of aggradation or degradation within the project area at this time.

2.1.2 Vegetation

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, eight vegetation monitoring quadrants were installed across the restoration site. The size of individual quadrants varies from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred, or in the fall prior to leaf fall. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between June and November.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of Year 3 of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of Year 5 of the monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided good ground coverage. Live stake, bare root trees, and live brush

in the geolift structures have also begun to grow and are providing streambank stability. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A minimum 30-foot buffer was established along all restored stream reaches. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in the winter of 2009-2010. Species planted are listed below.

Riparian Buffer Plantings (Bare-Root and Live Stake Species)

Trees

Sycamore	*(Platanus occidentalis)*
Willow Oak	*(Quercus phellos)*
River birch	*(Betula nigra)*
Persimmon	*(Diospyros virginiana)*
White Oak	*(Quercus alba)*
Shagbark Hickory	*(Carya ovate)*

Alternate Species

Tulip Poplar	*(Liriodendron tulipifera)*
Green Ash	*(Fraxinus pennsylvanica)*
Swamp Chestnut Oak	*(Quercus michauxii)*
Tag Alder	*(Alnus serrulata)*
Flowering Dogwood	*(Cornus florida)*

Shrubs/small trees

Pawpaw	*(Asimina triloba)*
Witch-hazel	*(Hamamelis virginiana)*
Spicebush	*(Lindera benzoin)*

Alternate Species

Sweet Shrub	*(Calycanthus floridus)*
Redbud	*(Cercis canadensis)*
American Hazelnut	*(Corylus americana)*
Arrowwood Viburnum	*(Viburnum dentatum)*

Woody Vegetation for Live Stakes

Silky willow	*(Salix sericea)*
Ninebark	*(Physocarpus opulifolia)*
Elderberry	*(Sambucus canadensis)*
Silky Dogwood	*(Cephalanthus occidentalis)*

The mitigation plan for the Puzzle Creek Site specifies that the number of quadrants required will be based on the species/area curve method, as described in NCEEP monitoring guidance documents. The size of individual quadrants is 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of eight vegetation plots, each 10 by 10 meters or 5 by 20 meters in size, were established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table 14, Appendix C. The average density of planted bare root stems, based on the data from the eight monitoring plots, is 715 stems per acre which indicates that the Site is on track for meeting the minimum success interim criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5. The locations of the vegetation plots are shown on the as-built plan sheets.

2.1.3 Hydrology

2.1.3.1 Streams

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. Crest gages were installed on the floodplain at bankfull elevation. One crest gauge was placed on UT 1, while another gauge was set up on Puzzle Creek upstream of the confluence with UT1. The gauge on UT 1 was set up near Vegetation Plot 3. The crest gages will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented on each crest gage within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

2.1.4 Photographic Documentation of Site

Photographs will be used to document restoration success visually. Reference stations will be photographed during the as-built survey and for at least five years following construction. Reference photos will be taken once a year, from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) on the site are monitored during each monitoring period. Selected site photographs are shown in Appendix B.

2.1.4.1 Lateral Reference Photos

Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. A survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will be included in each photo. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.4.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored streams are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures subjectively. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.2 Areas of Concern

At this time the only area of concern is the proximity of established kudzu patches to the project area. Although the kudzu originates outside of the easement, small runners were observed entering the project site. Baker will work with the landowner to control this kudzu; what kudzu is located in the easement will be removed.

3.0 MAINTENANCE AND CONTINGENCY PLANS

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels
- Wet weather during construction can make accurate channel and floodplain excavations difficult
- Extreme and/or frequent flooding can cause floodplain and channel erosion
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed
- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in the as-built and monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. NCEEP approval will be obtained prior to any remedial action.

APPENDIX A

GENERAL TABLES AND FIGURES

VICINITY MAP AND PROJECT COMPONENT MAP

TABLES 1-4

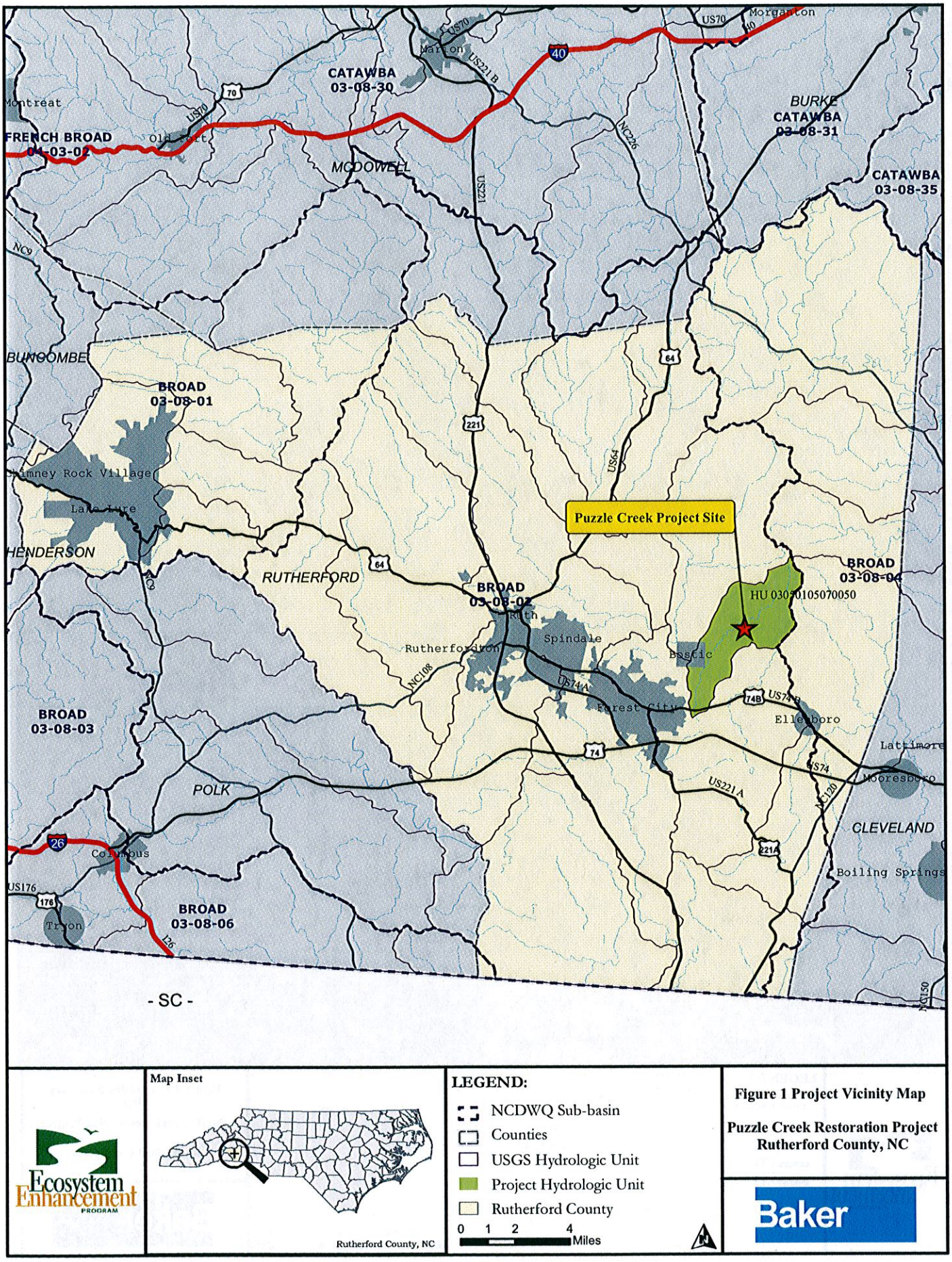
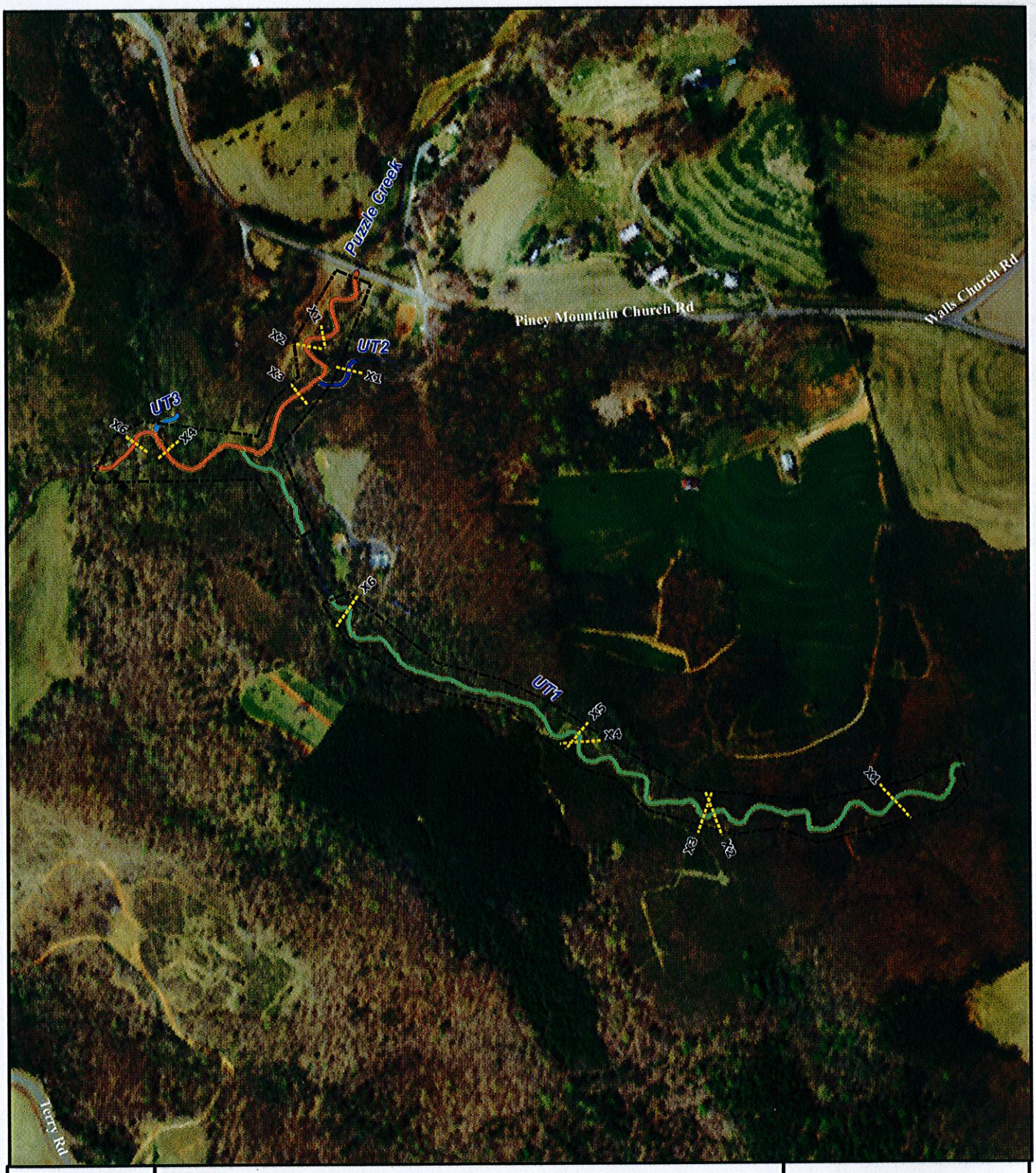


Figure 1 Project Vicinity Map

Puzzle Creek Restoration Project
Rutherford County, NC



LEGEND:

Project Reaches
- Puzzle Creek
- UT2
- UT1
- UT3

Conservation Easement
Cross-sections
Surveyed Profile
Streams

0 100 200 400 Feet

Ecosystem Enhancement Program

Figure 2 Restoration Summary Map

Puzzle Creek Restoration Project

Rutherford County, NC

Baker

Table 1. Project Components

Puzzle Creek Mitigation Project-NCEEP Project#D06027-C

Project Segment or Reach ID	Existing Feet/ Acres	Mitigation Type	Approach	Target Stream Type	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Puzzle Creek									
Reach 1	1,024LF	R	P1	C4/5	1,000 LF	1:1	1,000	0+00-10+00	Reroute channel through middle of valley, improve pattern, dimension and profile
Reach 2	600 LF	R	PII		634 LF	1:1	634	10+00-16+34	Pattern adjustment to address overly sinuous section, profile and dimension adjustments
UT1 (Reach 1)									
Subreach [A]	2,036 LF	R	PII	C4/5	2,150 LF	1:1	2,150	00+00-21+50	Constraints prevented restoration; built bankfull benches
Subreach [A]	320 LF	E	LI		320LF	1.5:1	213	21+50-24+70	Profile and dimension adjustments; improve floodplain access (narrow valley through this reach precluded pattern adjustments)
Subreach [A]	469 LF	R	PII		469 LF	1:1	469	24+70-29+39	Pattern and profile adjustments; improve floodplain benching
Subreach [A]	400LF	R	PII	C4/5	400 LF	1:1	400	32+12-36+12	Slight pattern and profile adjustments, lowering of bankfull elevation on right bank near confluence.
UT 2									
Reach 1	----	R	PII	-	52 LF	1:1	52	1+39-1+91	Bank grading and stabilization; invasives removal and re-planting with native riparian vegetation
UT 3									
Reach 1	----	R	PI	-	48 LF	1:1	48	0+63-1+11	Bank grading and stabilization; invasives removal and re-planting with native riparian vegetation

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
4,966	NA	NA	NA		

Notes: [A] Subreaches are listed as they occur, going in a downstream direction as indicated by the stationing provided.

Table 2. Project Activity and Reporting History Puzzle Creek Mitigation Project-NCEEP Project#D06027-C		
Activity or Report	**Data Collection**	**Completion or Delivery**
Restoration Plan	October 2007	December 2007
Final Design-90%	October 2007	December 2007
Construction	-	October 2008
Temporary S&E mix applied to entire project area	-	October 2008
Permanent seed mix applied to project site	-	October 2008
Containerized and B&B plantings set out	-	October 2008
Flood Events; Site Repairs	-	October-November 2008
Site Evaluation on UT1	January 2009	-
Site Modifications and Repairs	April 2010	-
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2010	January 2011
Year 1 Monitoring		
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

Table 3. Project Contacts Table Puzzle Creek Mitigation Project-NCEEP Project#D06027-C	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200, Cary, NC 27511 Contact: Will Pedersen, Tel. 919.459.9001
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200, Cary, NC 27511 Contact: George Morris, Tel. 919.459.9001
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Carmen McIntyre, Tel. 828.350.1408 x2010

Table 4. Project Attribute Table **Puzzle Creek Mitigation Project-NCEEP Project#D06027-C**	
Project County	Rutherford County, NC
Physiograhic Region	Piedmont Province. Borders Blue Ridge Escarpment
Ecoregion	Southern Inner Piedmont
Project River Basin	Broad
USGS HUC for Project	03050105070050
NCDWQ Sub-basin for Project	03-08-02
Within extent of EEP Watershed Plan?	No
WRC Class	Cool
% of Project Easement Fenced or Demarcated	~5% (goat pasture)
Beaver Activity Observed During Design Phase?	No
Drainage Area (Square Miles or Acres)	
Puzzle Creek Reach 1	2.58 mi^2
Puzzle Creek Reach 2	4.18 mi^2
UT1Reach 1	1.6 mi^2
UT1 Reach2	1.6 mi^2
UT2	<.5 mi^2
Stream Order	Puzzle-3rd Order, UT1-2nd Order, UT2-1st Order
Restored Length	
Puzzle Creek Reach 1	1,000 LF
Puzzle Creek Reach 2	634 LF
UT1Reach 1	3,339 LF
UT 2	52 LF
UT 3	48 LF
Perennial or Intermittent	Perennial (all project streams)
Watershed Type	Rural (Predominantly Forested)
Watershed LULC Distribution (Percent area)	
Forest	61%
Shrub	12%
Pasture	27%
Water	.45%
Drainage Impervious Cover Estimate (%)	<5%
NCDWQ AU/Index #	9-41-19

Table 4. Project Attribute Table **Puzzle Creek Mitigation Project-NCEEP Project#D06027-C**				
303d Listed	No			
Upstream of 303d Listed Segment	No			
Reasons for 303d Listing or Stressor	-			
Total Acreage of Easement	11.64 Acres			
Total Vegetated Acreage w/in Easement	n/a (Easement vegetated with exception of stream channel and access path)			
Total Planted Acreage within the Easement	~10 Acres			
Rosgen Classification (Pre-existing)				
Puzzle Creek Reach 1	C4			
Puzzle Creek Reach 2	E4			
UT1Reach 1	B4c/C4			
UT1 Reach2	B4c			
Rosgen Classification of As-built				
Puzzle Creek Reach 1	E4			
Puzzle Creek Reach 2	E4			
UT1Reach 1	E4/C4			
UT1 Reach2	E4			
Valley Type	VIII			
Valley Slope	.001 to .0106			
Valley Side Slope Range	n/a			
Valley Toe Slope Range	n/a			
Trout Waters Designation	No			
Species of Concern	No			
Dominant Soil Series and Characteristics	Chewacla/ Pacolet/Pacolet-Bethlehem			
	Depth (in.)	% Clay	K Factor	T Factor
Puzzle Creek Reach 1	61"	22.5	.32	5
Puzzle Creek Reach 2	61"	22.5	.32	5
UT1Reach 1	61"	22.5	.32	5
UT1 Reach2	62"	27.5	.2	3

APPENDIX B

MORPHOLOGICAL SUMMARY DATA, PLOTS AND REFERENCE PHOTOGRAPHS

TABLES 5-8

LONGITUDINAL PROFILE PLOTS

CROSS-SECTION PLOTS

REFERENCE PHOTOGRAPH LOGS

Table 5. Categorical Stream Feature Visual Stability Assessment Puzzle Creek Mitigation Project-NCEEP Project#D06027-C						
Features	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%					
B. Pools	100%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Bank Stability	100%					
G. Vanes	100%					
H. Rootwads, Boulders, Geolifts	100%					

Table B5a. Baseline Stream Summary - As-Built Monitoring

Puzzle Creek Restoration Project #D06027-C

Baseline Stream Summary

Puzzle Creek: Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Dimension - Riffle																									
Bankfull Width (ft)	17.90	7.80	11.30	14.80	—	22.00	—	19.82	18.37	21.26															
Floodprone Width (ft)	—	16.70	39.10	61.50	—	100+	—	68.68	74.39	80.09															
Bankfull Mean Depth (ft)	2.03	0.80	1.45	2.10	—	1.90	—	2.10	2.30	2.49															
Bankfull Max Depth (ft)	—	1.30	1.95	2.60	—	2.5	—	3.28	3.38	3.47															
Bankfull Cross Sectional Area (ft2)	40.80	7.50	19.25	31.00	—	42.50	—	44.70	45.20	45.70															
Width/Depth Ratio	—	5.40	8.25	11.10	—	11.60	—	7.39	8.75	10.11															
Entrenchment Ratio	—	1.80	4.85	7.90	—	>4.5	—	3.70	3.75	3.80															
Bank Height Ratio	—	1.33	1.37	1.40	—	1.30	—	1.00	1.00	1.00															
Bankfull Velocity (fps)	—	3.10	9.87	3.30	—	4.47	—	—	4.20	—															
Pattern																									
Channel Beltwidth (ft)	—	—	62.40	—	68.00	—	156.00	75.00	92.00	117.00															
Radius of Curvature (ft)	—	—	12.70	—	35.00	—	68.00	20.00	39.00	81.00															
Meander Wavelength (ft)	—	—	63.60	—	136.00	—	160.00	137.00	155.00	173.00															
Meander Width Ratio	—	6.00	7.00	8.00	3.10	—	7.10	—	5.01	—															
Profile																									
Riffle Length (ft)	—	—	—	—	25.00	—	100.00	31.43	59.59	112.50															
Riffle Slope (ft/ft)	—	0.0006	0.0291	0.0576	—	0.0142	—	0.0051	0.0125	0.0193															
Pool Length (ft)	—	—	—	—	7.00	—	60.00	33.83	56.72	85.62															
Pool Spacing (ft)	—	23.70	33.00	42.30	58.00	—	136.00	54.60	115.09	168.23															
Substrate and Transport Parameters						—			—			—			—			—			—			—	
d16 / d35 / d50 / d84 / d95	—	,5/.35/.92/30.04/56.91																							
Reach Shear Stress (competency) lb/f2	—	—	—	—	—	0.90	—	—	0.90	—															
Stream Power (transport capacity) W/m2	—	—	—	—	—	4.04	—	—	3.80	—															
Additional Reach Parameters																									
Channel length (ft)	—	—	—	—	—	1595.00	—	—	1595.00	—															
Drainage Area (SM)	—	0.20	1.90	2.30	—	2.58	—	—	2.58	—															
Rosgen Classification	—	—	C/E4	—	—	C4-5	—	—	E4	—															
Bankfull Discharge (cfs)	176.56	—	190.00	—	—	190.00	—	—	190.00	—															
Sinuosity	—	—	1.90	—	—	1.30	—	—	1.30	—															
BF slope (ft/ft)	—	—	0.009	—	0.009	0.009	0.009	—	0.009	—															

Table B5a. Baseline Stream Summary - As-Built Monitoring

Puzzle Creek Restoration Project #D06027-C

Baseline Stream Summary
Puzzle Creek: Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	24.70	7.80	11.30	14.80	—	25.00	—	—	25.62	—															
Floodprone Width (ft)	—	16.70	39.10	61.50	—	100+	—	—	82.22	—															
Bankfull Mean Depth (ft)	2.58	0.80	1.45	2.10	—	2.10	—	—	2.48	—															
Bankfull Max Depth (ft)	—	1.30	1.95	2.60	—	2.70	—	—	3.66	—															
Bankfull Cross Sectional Area (ft2)	68.00	7.50	19.25	31.00	—	52.60	—	—	63.40	—															
Width/Depth Ratio	—	5.40	8.25	11.10	—	11.90	—	—	10.35	—															
Entrenchment Ratio	—	1.80	4.85	7.90	—	>4.0	—	—	3.20	—															
Bank Height Ratio	—	1.33	1.37	1.40	1.00	—	1.20	—	1.00	—															
Bankfull Velocity (fps)	—	3.10	9.87	3.30	—	4.75	—	—	3.94	—															
Pattern																									
Channel Beltwidth (ft)	—	—	62.40	—	87.00	—	198.00	62.00	113.00	154.00															
Radius of Curvature (ft)	—	—	12.70	—	45.00	—	62.00	37.00	46.00	53.00															
Meander Wavelength (ft)	—	—	63.60	—	174.00	—	248.00	234.00	256.00	269.00															
Meander Width Ratio	—	6.00	7.00	8.00	3.50	—	8.00	—	4.41	—															
Profile																									
Riffle Length (ft)	—	—	—	—	25.00	—	100.00	32.01	56.32	86.69															
Riffle Slope (ft/ft)	—	0.0006	0.0291	0.0576	—	0.0158	—	0.0051	0.0114	0.0189															
Pool Length (ft)	—	—	—	—	7.00	—	60.00	33.83	53.20	82.65															
Pool Spacing (ft)	—	23.70	33.00	42.30	74.00	—	174.00	85.05	120.81	168.23															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	—	.5/.35/.92/30.04/56.91				—			—			—			—			—			—			—	
Reach Shear Stress (competency) lb/f2	—	—	—	—	—	1.07	—	—	1.07	—															
Stream Power (transport capacity) W/m2	—	—	—	—	—	5.09	—	—	4.22	—															
Additional Reach Parameters																									
Channel length (ft)	—	—	—	—	—	1595.00	—	—	1595.00	—															
Drainage Area (SM)	—	0.20	1.90	2.30	—	4.18	—	—	4.18	—															
Rosgen Classification	—	—	C/E4	—	—	C4-5	—	—	E/C4	—															
Bankfull Discharge (cfs)	250.00	—	190.00	—	—	250.00	—	—	250.00	—															
Sinuosity	—	—	1.90	—	—	1.20	—	—	1.22	—															
BF slope (ft/ft)	—	—	0.009	—	—	0.008	—	—	0.008	—															

Table B5a. Baseline Stream Summary - As-Built Monitoring

Puzzle Creek Restoration Project #D06027-C

Baseline Stream Summary: UT1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Dimension - Riffle																									
Bankfull Width (ft)	14.60	7.80	11.30	14.80	14.00	—	18.00	12.37	17.83	20.39															
Floodprone Width (ft)	—	16.70	39.10	61.50	—	50+	—	44.11	58.15	76.12															
Bankfull Mean Depth (ft)	1.74	0.80	1.45	2.10	1.50	—	1.70	1.53	1.69	1.99															
Bankfull Max Depth (ft)	—	1.30	1.95	2.60	—	—	—	2.33	2.73	3.53															
Bankfull Cross Sectional Area (ft2)	29.50	7.50	19.25	31.00	24.00	—	28.00	24.60	29.46	31.88															
Width/Depth Ratio	—	5.40	8.25	11.10	8.20	—	12.00	6.21	10.85	13.13															
Entrenchment Ratio	—	1.80	4.85	7.90	—	—	—	2.30	3.43	4.80															
Bank Height Ratio	—	1.33	1.37	1.40	1.00	—	1.20	0.90	0.98	1.00															
Bankfull Velocity (fps)	—	3.10	1.34	3.30	—	5.38	—	4.39	4.75	5.69															
Pattern																									
Channel Beltwidth (ft)	—	—	62.40	—	50.00	—	93.00	44.00	66.00	87.00															
Radius of Curvature (ft)	—	—	12.70	—	28.00	—	52.00	23.00	39.00	54.00															
Meander Wavelength (ft)	—	—	63.60	—	130.00	—	213.00	143.00	175.00	220.00															
Meander Width Ratio	—	6.00	7.00	8.00	2.80	—	6.60	3.56	3.70	4.27															
Profile																									
Riffle Length (ft)	—	—	—	—	22.00	—	100.00	0.00	46.04	54.60															
Riffle Slope (ft/ft)	—	0.0006	0.0291	0.0576	0.0120	—	0.0200	0.0060	0.0122	0.0169															
Pool Length (ft)	—	—	—	—	25.00	—	50.00	17.22	33.42	51.80															
Pool Spacing (ft)	—	23.70	33.00	42.30	50.00	—	90.00	55.63	91.41	126.73															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	—	.5/.35/.92/30.04/56.91			na/.35/.92/30.04/56.91			.55/11/21.09/73.77/113.82																	
Reach Shear Stress (competency) lb/f2	—	—	—	—	—	1.24	—	—	1.24	—															
Stream Power (transport capacity) W/m2	—	—	—	—	—	6.66	—	—	5.88	—															
Additional Reach Parameters																									
Channel length (ft)	2975.00	—	—	—	—	3246.00	—	—	3339.00	—															
Drainage Area (SM)	—	0.20	1.25	2.30	—	1.60	—	—	1.60	—															
Rosgen Classification	—	—	E5	—	—	C4-5	—	—	E/C4	—															
Bankfull Discharge (cfs)	—	23.10	25.80	28.50	—	140.00	—	—	140.00	—															
Sinuosity	1.18	—	1.90	—	—	1.27	—	—	1.33	—															
BF slope (ft/ft)	—	—	—	—	—	0.0160	—	—	0.0160	—															

Note: Although UT1 contains alternating restoration approaches, it was decided to leave UT1 as one reach for the purposes of this report as some of the reaches are less than 500 LF.

Table B6. Morphology and Hydraulic Monitoring Summary - Baseline Monitoring
Puzzle Creek Restoration Project #D06027-C

Parameter	Puzzle Creek Reach 1																	
	Cross Section 1 Riffle						Cross Section 2 Pool						Cross Section 3 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	21.26						23.26						18.37					
Floodprone Width (ft)	80.09						94.26						68.68					
BF Cross Sectional Area (ft2)	44.70						56.80						45.70					
BF Mean Depth (ft)	2.10						2.44						2.49					
BF Max Depth (ft)	3.28						4.75						3.47					
Width/Depth Ratio	10.11						9.53						7.39					
Entrenchment Ratio	3.80						4.10						3.70					
Wetted Perimeter (ft)	25.46						28.14						23.35					
Hydraulic Radius (ft)	1.8						2.0						2.0					
Substrate																		
d50 (mm)	-																	
d84 (mm)	-																	

Parameter	Puzzle Creek Reach 2											
	Cross Section 4 Riffle						Cross Section 5 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	25.62						34.56					
Floodprone Width (ft)	82.22						59.51					
BF Cross Sectional Area (ft2)	63.40						99.90					
BF Mean Depth (ft)	2.48						2.89					
BF Max Depth (ft)	3.66						5.34					
Width/Depth Ratio	10.35						11.95					
Entrenchment Ratio	3.20						1.70					
Wetted Perimeter (ft)	30.58						40.34					
Hydraulic Radius (ft)	2.1						2.5					

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	62.00	154.00	103.00															
Radius of Curvature (ft)	20.00	81.00	42.00															
Meander Wavelength (ft)	137.00	269.00	206.00															
Meander Width Ratio	1.79	8.38	5.09															
Profile																		
Riffle length (ft)	31.00	113.00	60.00															
Riffle Slope (ft/ft)	0.01	0.02	0.01															
Pool Length (ft)	34.00	86.00	57.00															
Pool Spacing (ft)	55.00	168.00	115.00															
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)	1281.00																	
Channel Length (ft)	1634.00																	
Sinuosity	1.30																	
Water Surface Slope (ft/ft)	0.008																	
BF Slope (ft/ft)	0.009																	
Rosgen Classification	E/C4																	

UT1

Parameter	Cross Section 1 Riffle						Cross Section 2 Riffle						Cross Section 3 Pool						Cross Section 4 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	12.37						18.99						24.84						20.39					
Floodprone Width (ft)	59.08						76.12						72.14						53.28					
BF Cross Sectional Area (ft2)	24.60						31.88						32.90						31.66					
BF Mean Depth (ft)	1.99						1.68						1.33						1.55					
BF Max Depth (ft)	2.62						2.33						2.47						2.42					
Width/Depth Ratio	6.21						11.31						18.74						13.13					
Entrenchment Ratio	4.80						4.00						2.90						2.60					
Wetted Perimeter (ft)	16.35						22.35						27.50						23.49					
Hydraulic Radius (ft)	1.5						1.4						1.2						1.3					
Substrate																								
d50 (mm)																			----	----	----			
d84 (mm)																			----	----	----			

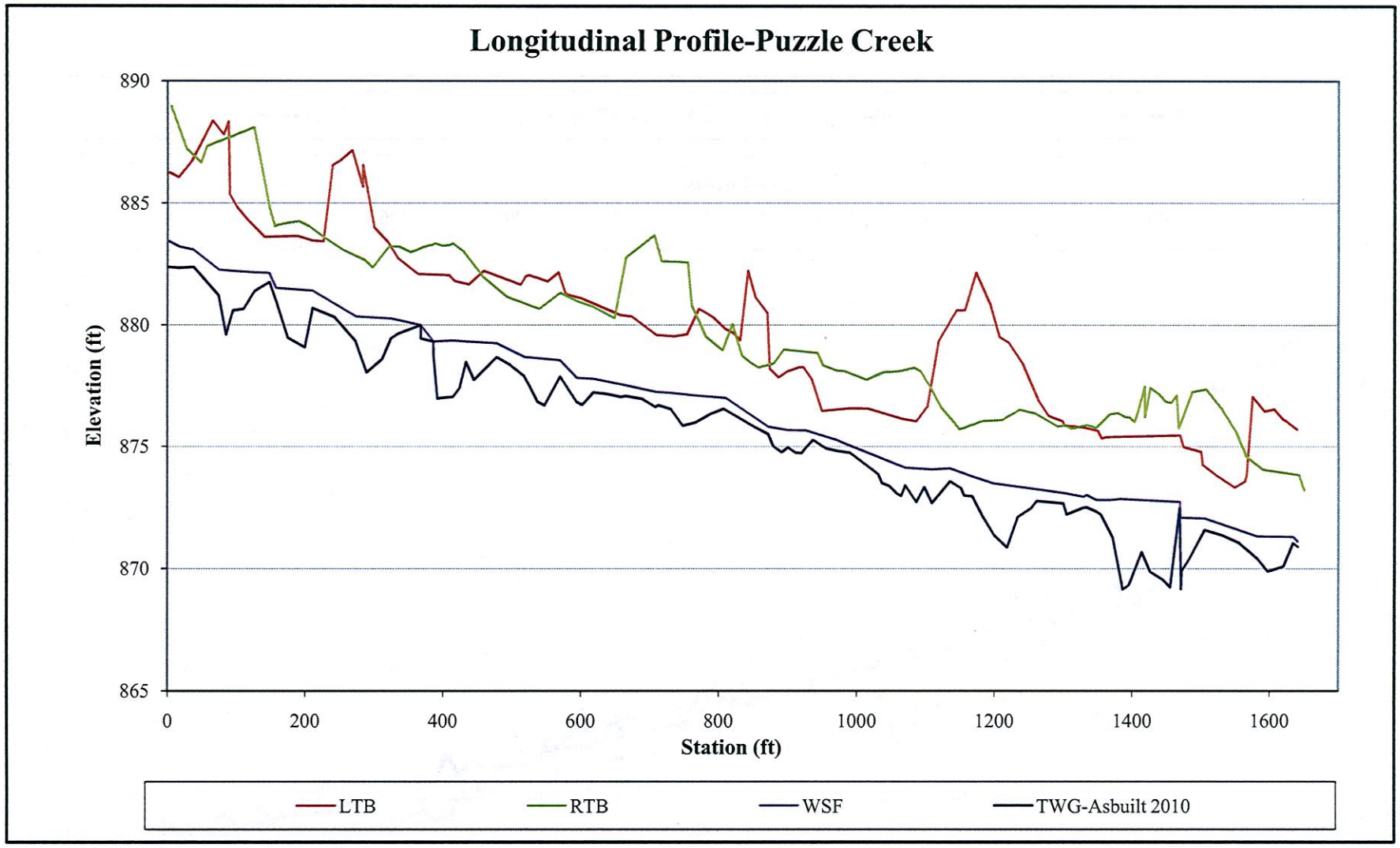
Parameter	Cross Section 5 Pool						Cross Section 6 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	25.46						19.55					
Floodprone Width (ft)	66.25						44.11					
BF Cross Sectional Area (ft2)	53.15						29.96					
BF Mean Depth (ft)	2.09						1.53					
BF Max Depth (ft)	5.39						3.53					
Width/Depth Ratio	12.20						12.76					
Entrenchment Ratio	2.60						2.30					
Wetted Perimeter (ft)	29.64						22.61					
Hydraulic Radius (ft)	1.8						1.3					
Substrate												
d50 (mm)	-						-					
d84 (mm)	-						-					

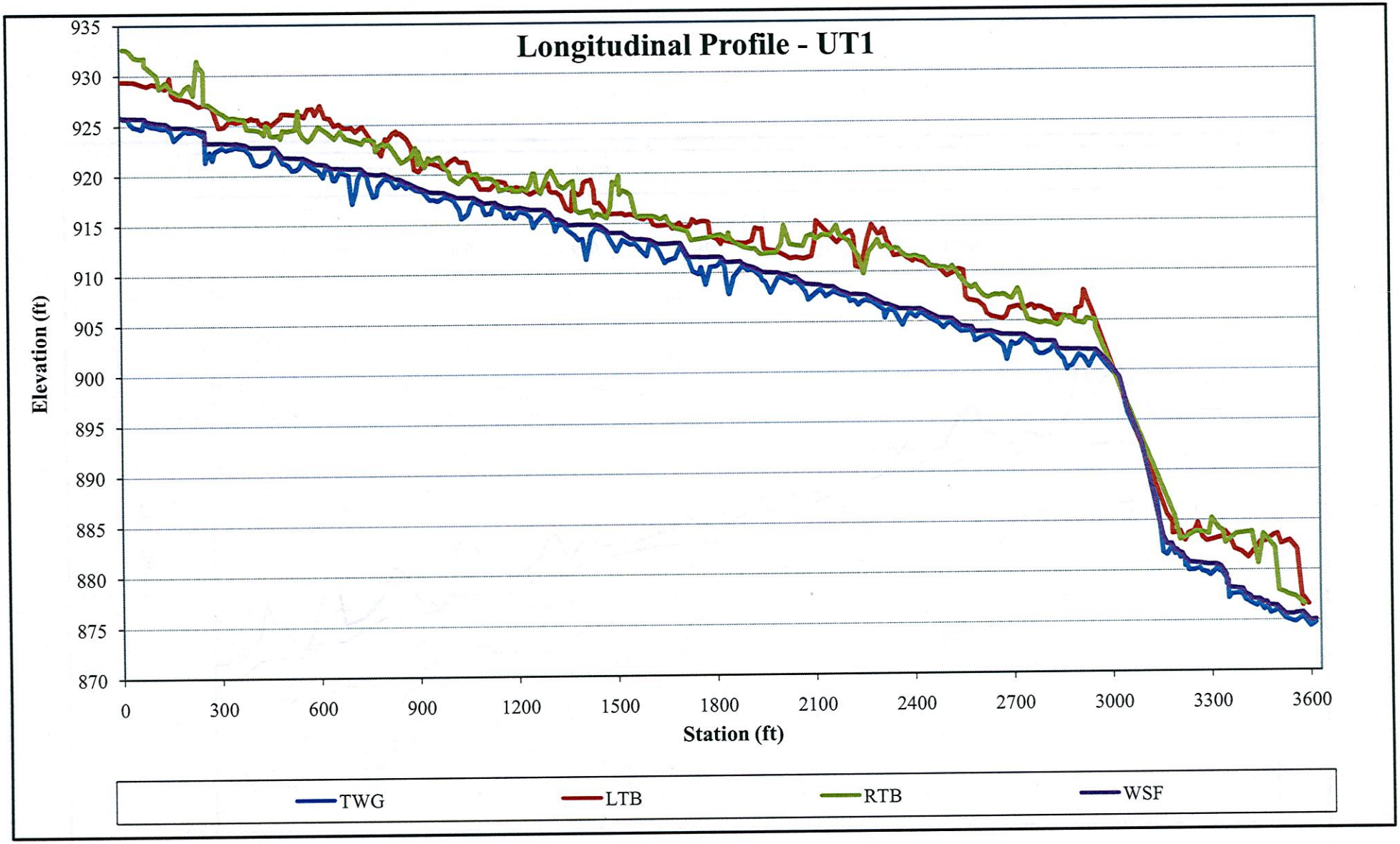
Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	44.00	87.00	66.00															
Radius of Curvature (ft)	23.00	54.00	39.00															
Meander Wavelength (ft)	143.00	220.00	175.00															
Meander Width Ratio	1.73	7.03	4.38															
Profile																		
Riffle length (ft)	0.00	54.60	51.67															
Riffle Slope (ft/ft)	0.01	0.02	0.01															
Pool Length (ft)	17.22	51.80	29.57															
Pool Spacing (ft)	55.63	126.73	94.53															
Substrate																		
d50 (mm)		21.09																
d84 (mm)		73.77																
Additional Reach Parameters																		
Valley Length (ft)		2915.00																
Channel Length (ft)		3339.00																
Sinuosity		1.31																
Water Surface Slope (ft/ft)		0.014																
BF Slope (ft/ft)		0.016																
Rosgen Classification		E/C4																

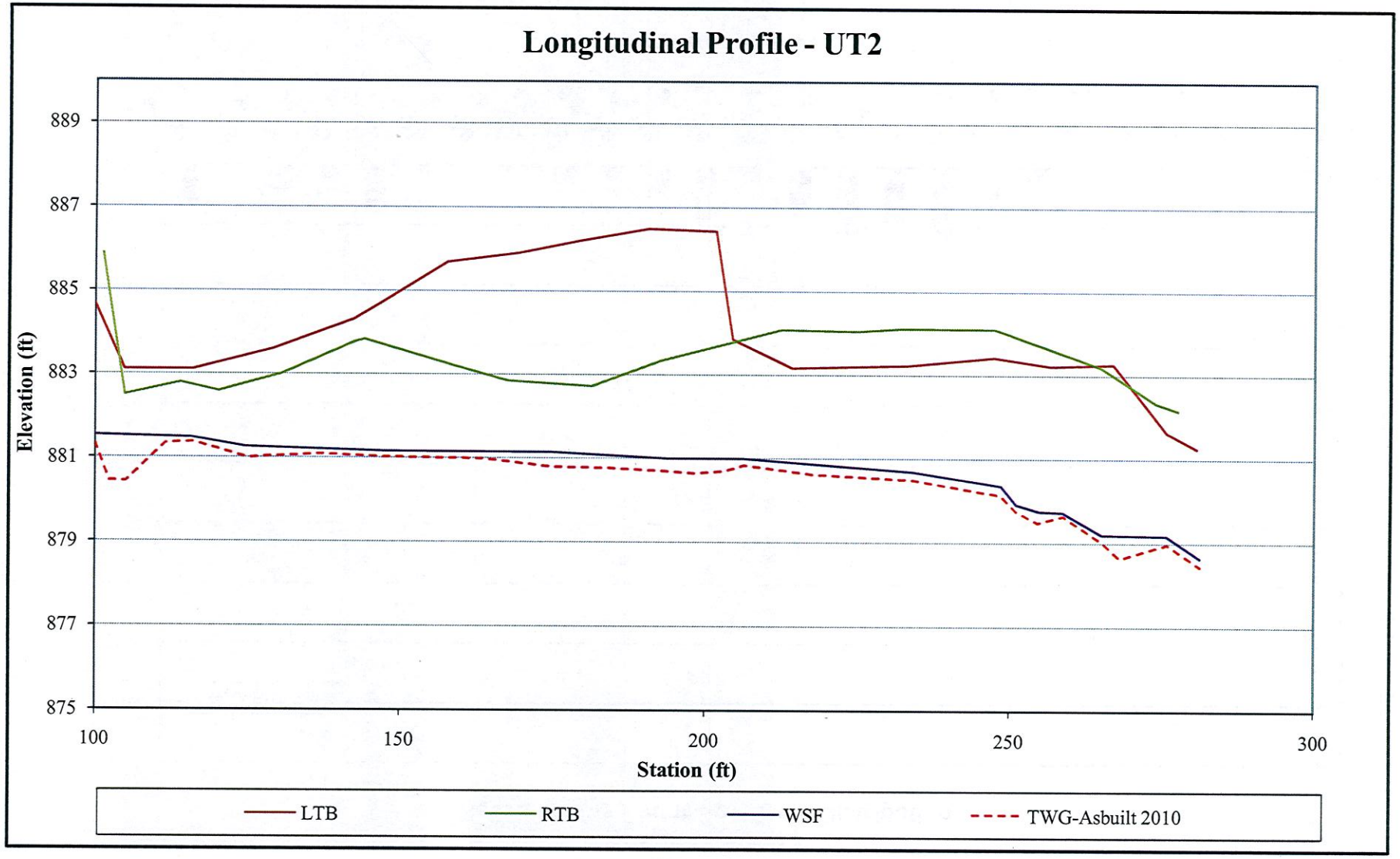
UT2

Parameter	Cross Section 1 Pool					
	AB	MY1	MY2	MY3	MY4	MY5
Dimension						
BF Width (ft)	10.14					
Floodprone Width (ft)	29.41					
BF Cross Sectional Area (ft2)	15.00					
BF Mean Depth (ft)	1.48					
BF Max Depth (ft)	2.89					
Width/Depth Ratio	6.84					
Entrenchment Ratio	2.90					
Wetted Perimeter (ft)	13.10					
Hydraulic Radius (ft)	1.15					
Substrate						
d50 (mm)	----	----	----			
d84 (mm)	----	----	----			

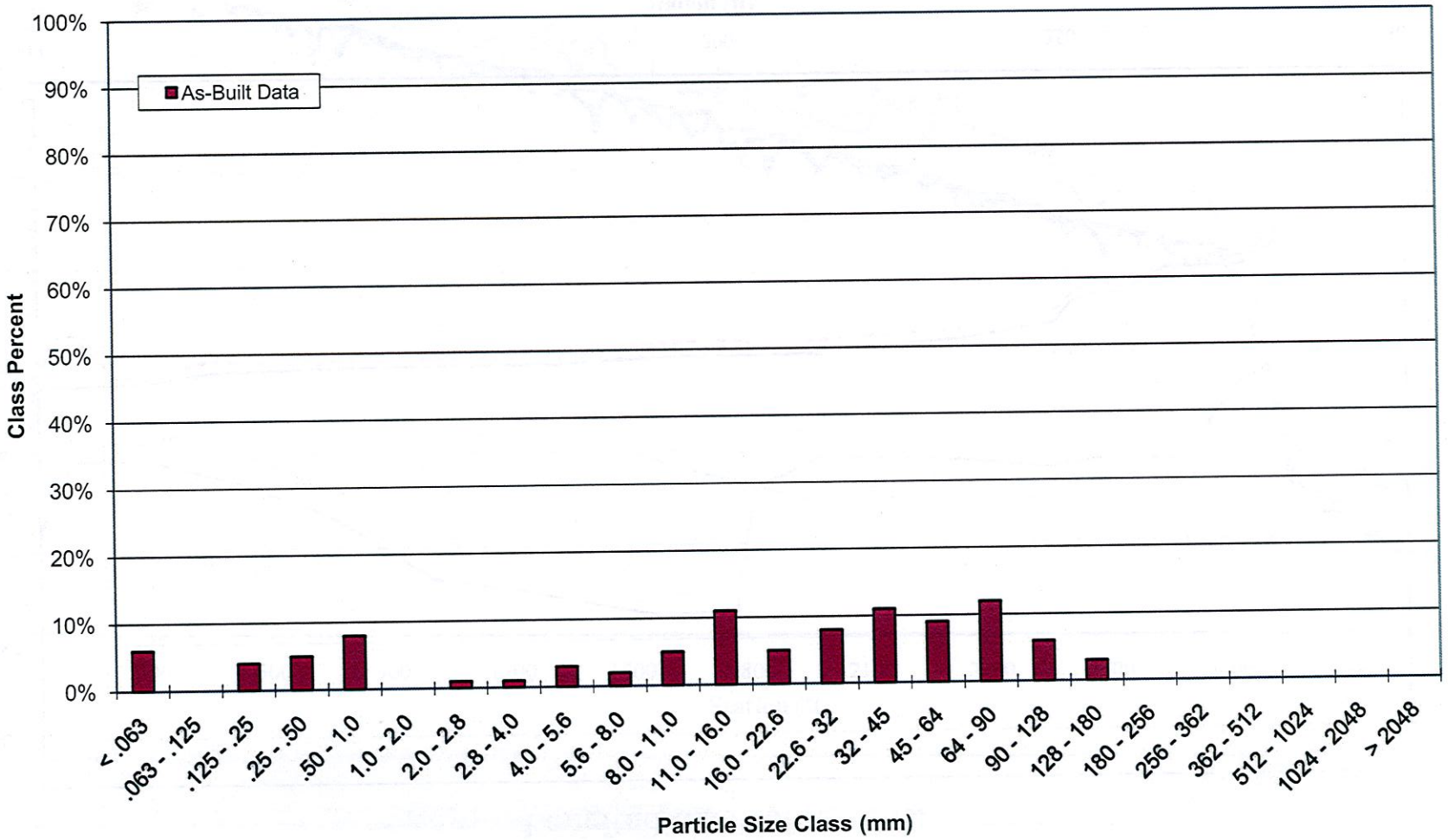
Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	----																	
Radius of Curvature (ft)	----																	
Meander Wavelength (ft)	----																	
Meander Width Ratio	----																	
Profile																		
Riffle length (ft)	----																	
Riffle Slope (ft/ft)	----																	
Pool Length (ft)	----																	
Pool Spacing (ft)	----																	
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)	41.00																	
Channel Length (ft)	52.00																	
Sinuosity	1.28																	
Water Surface Slope (ft/ft)	0.016																	
BF Slope (ft/ft)	0.016																	
Rosgen Classification	E																	


Longitudinal Profile-Puzzle Creek
890
885
880
875
870
865
Elevation (ft)
0
200
400
600
800
1000
1200
1400
1600
Station (ft)
LTB
RTB
WSF
TWG-Asbuilt 2010


Longitudinal Profile - UT1
Elevation (ft)
935
930
925
920
915
910
905
900
895
890
885
880
875
870
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
3300
3600
Station (ft)
TWG
LTB
RTB
WSF


Longitudinal Profile - UT2
Elevation (ft)
889
887
885
883
881
879
877
875
100
150
200
250
300
Station (ft)
LTB
RTB
WSF
TWG-Asbuilt 2010

Puzzle Creek
UT1, at Veg Plot 3
Reach Pebble Count Size Class Distribution



Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	44.7	21.26	2.1	3.28	10.11	0.9	3.8	882.92	882.74

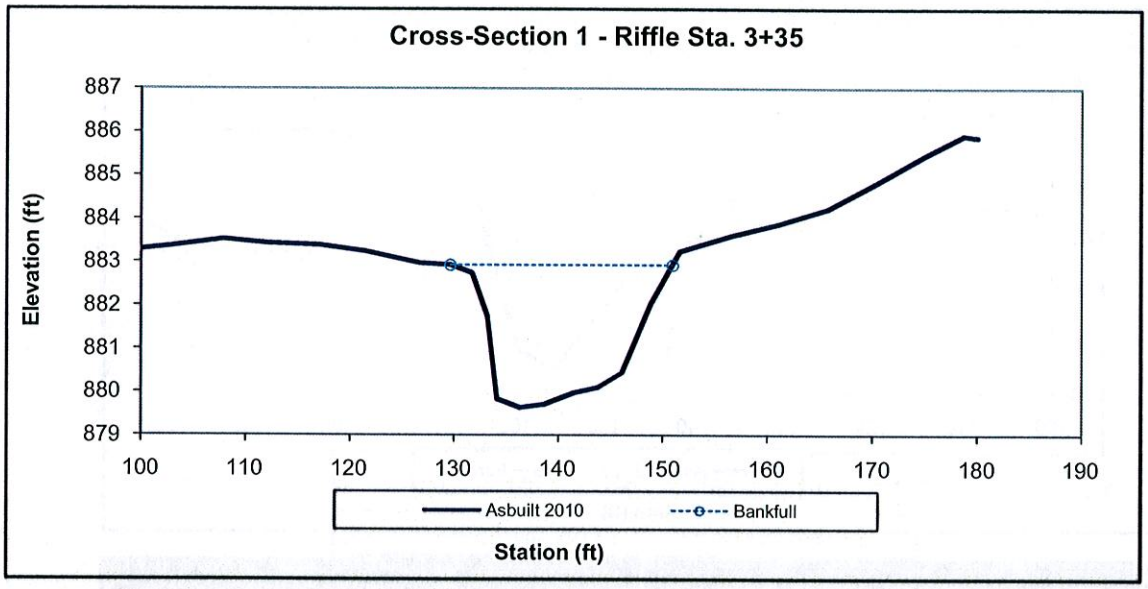


Photo 1: XS-1 facing right bank

Photo2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E	56.8	23.26	2.44	4.75	9.53	1	4.1	881.8	881.8

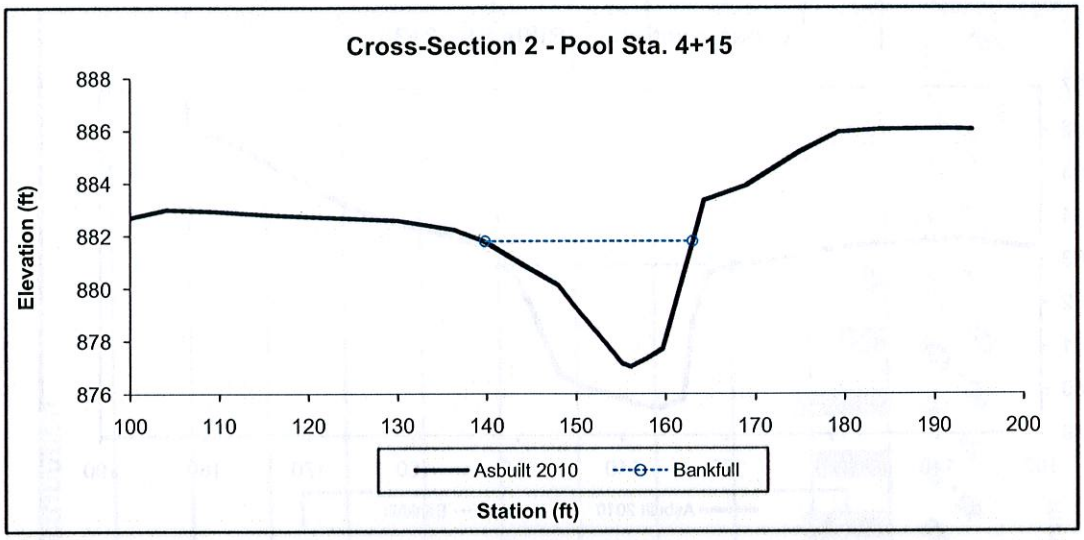


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	45.7	18.37	2.49	3.47	7.39	1	3.7	880.4	880.4

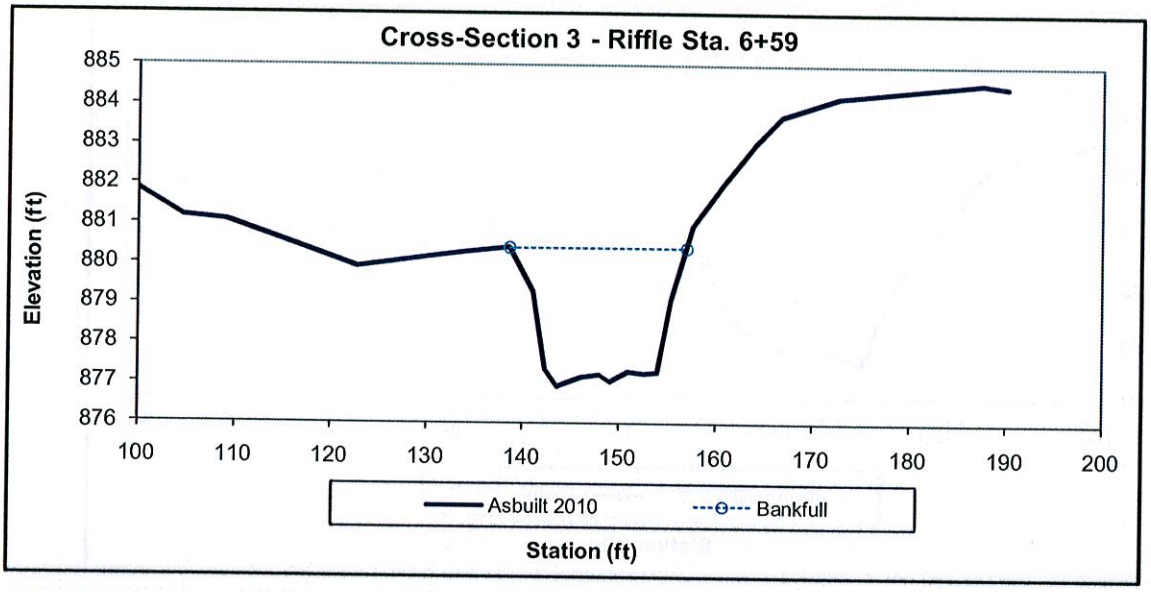


Photo 9: XS-3 facing right bank

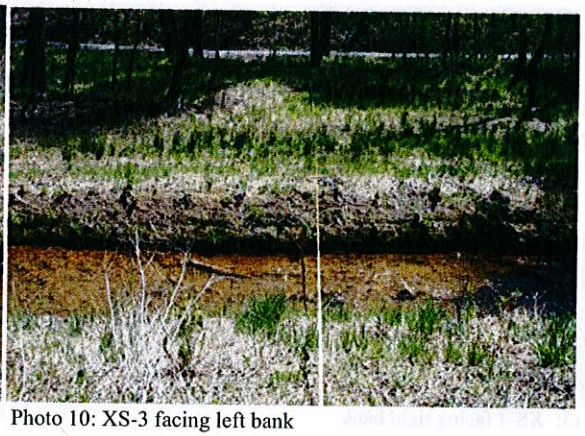


Photo 10: XS-3 facing left bank

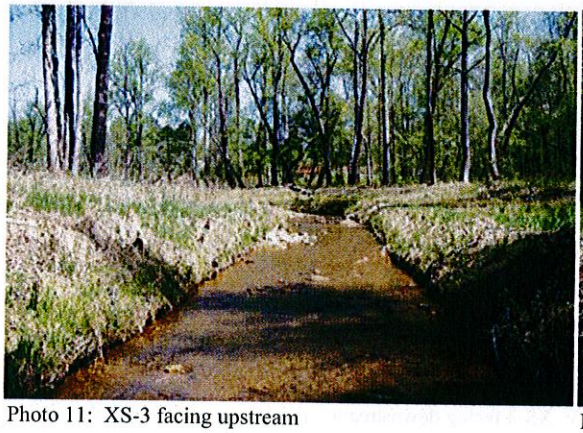


Photo 11: XS-3 facing upstream

Photo 12: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	63.4	25.62	2.48	3.66	10.35	1	3.2	875.88	875.89

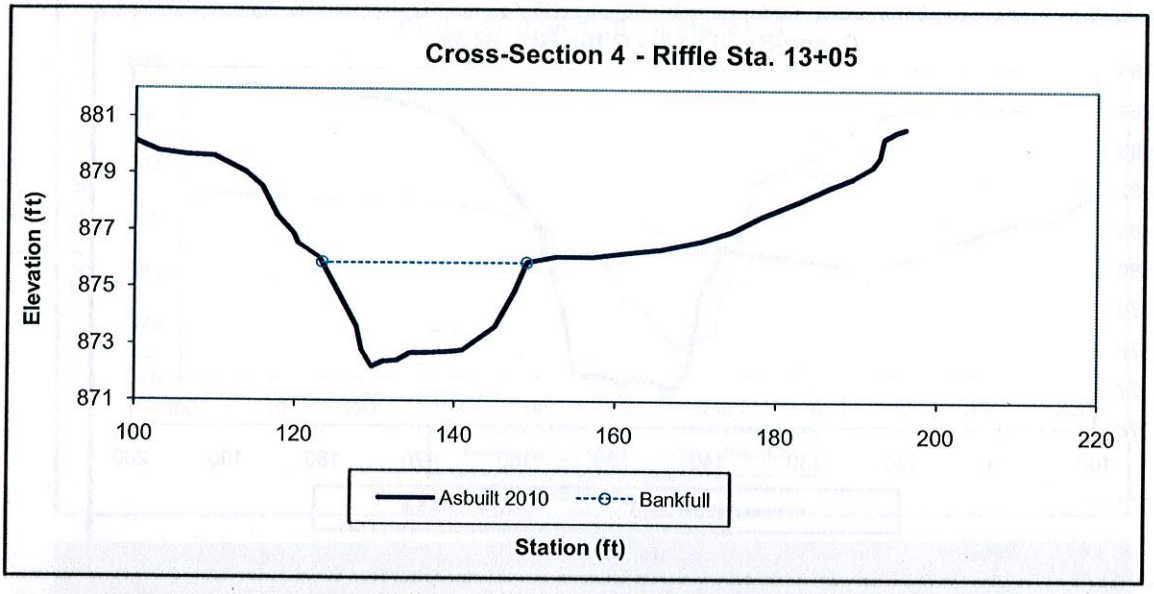


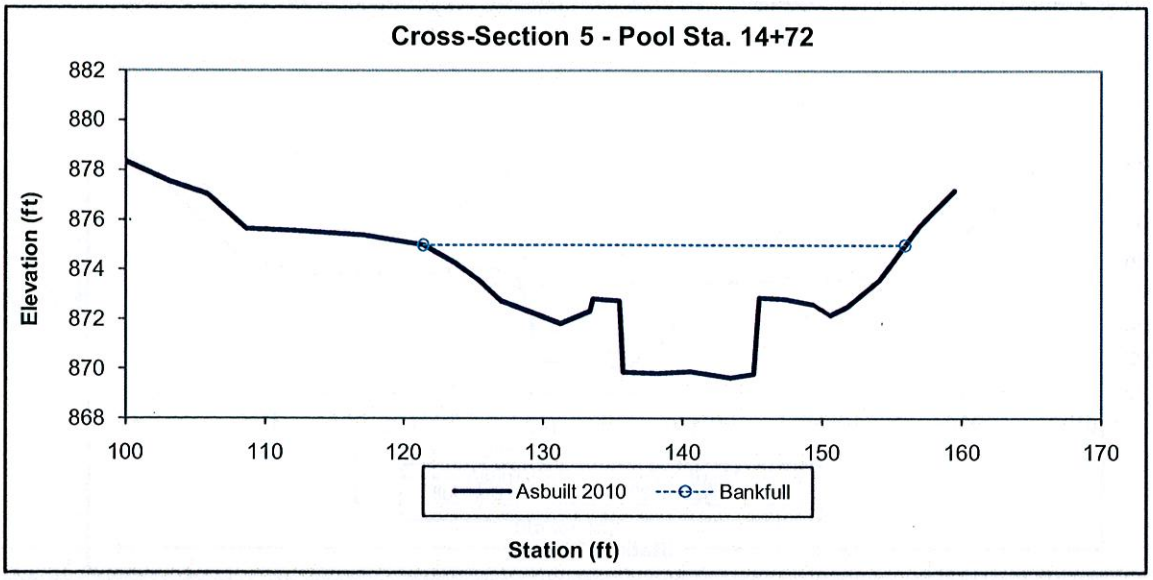
Photo 13: XS-4 facing right bank

Photo 14: XS-4 facing left bank

Photo 15: XS-4 facing upstream

Photo 16: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	99.9	34.56	2.89	5.34	11.95	1	1.7	874.98	874.98



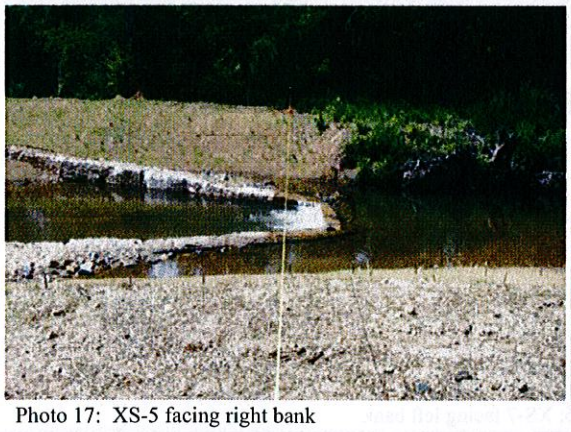


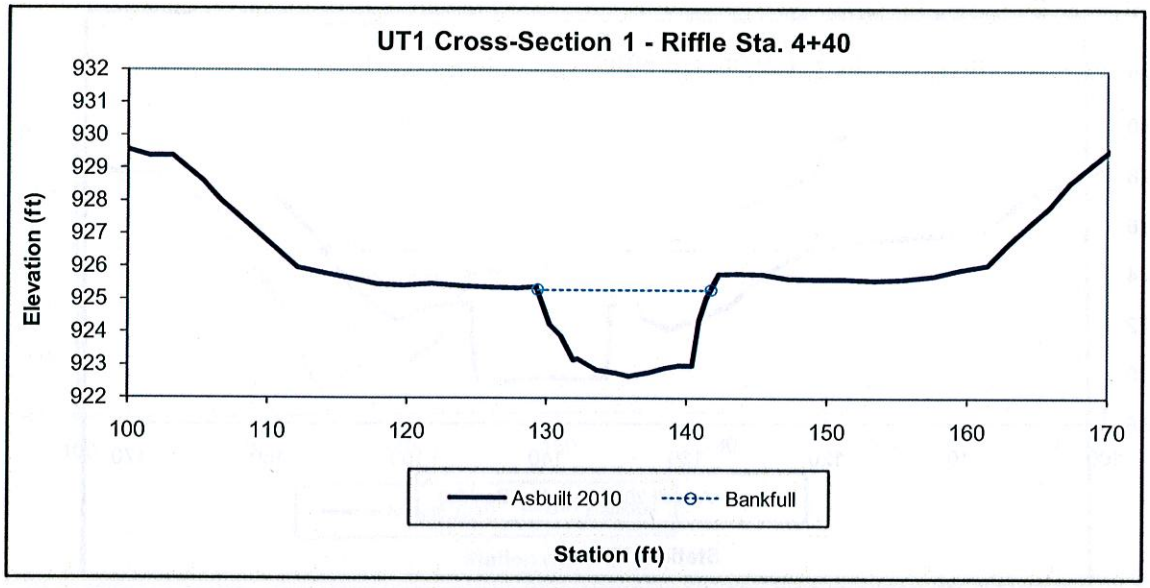
Photo 17: XS-5 facing right bank

Photo 18: XS-5 facing left bank

Photo 19: XS-5 facing upstream

Photo 20: XS-5 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	24.6	12.37	1.99	2.62	6.21	1	4.8	925.3	925.39



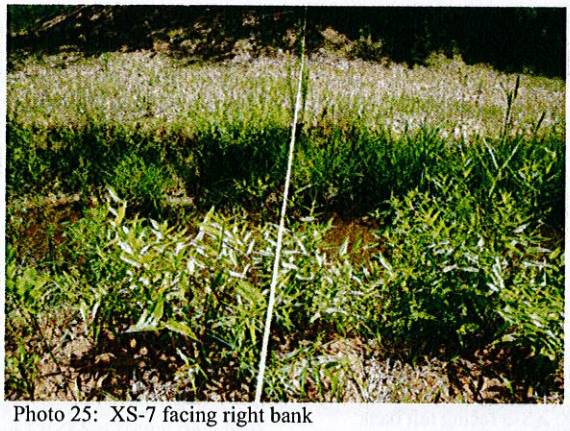


Photo 25: XS-7 facing right bank

Photo 26: XS-7 facing left bank

Photo 27: XS-7 facing upstream

Photo 28: XS-7 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	31.88	18.99	1.68	2.33	11.31	1	4	919.06	919.07

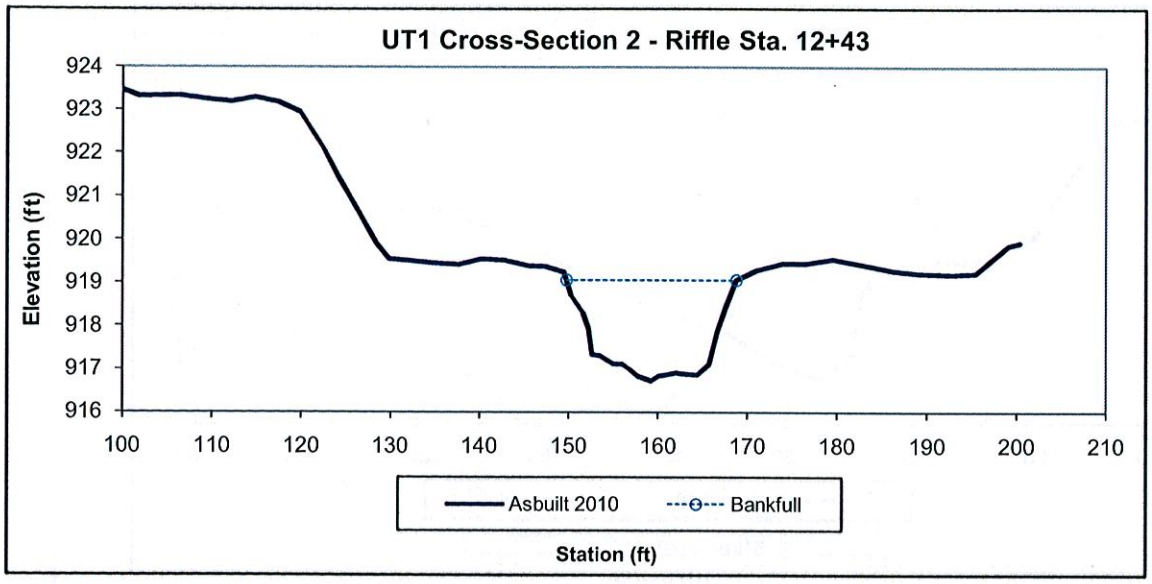


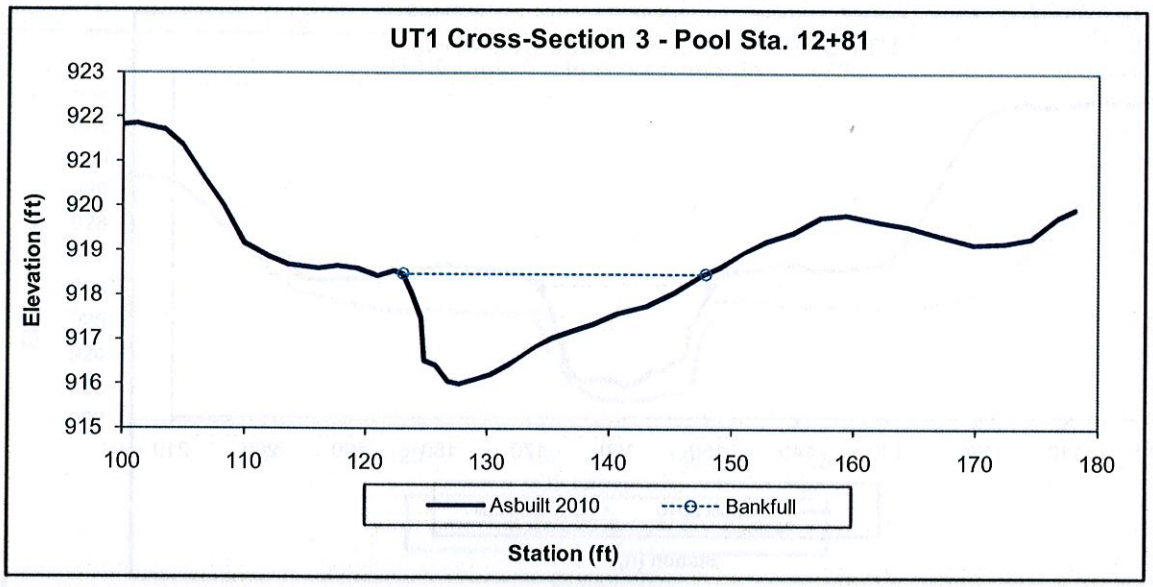
Photo 29: XS-8 facing right bank

Photo 30: XS-8 facing left bank

Photo 31: XS-8 facing downstream

Photo 32: XS-8 facing upstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	32.9	24.84	1.33	2.47	18.74	1	2.9	918.48	918.48



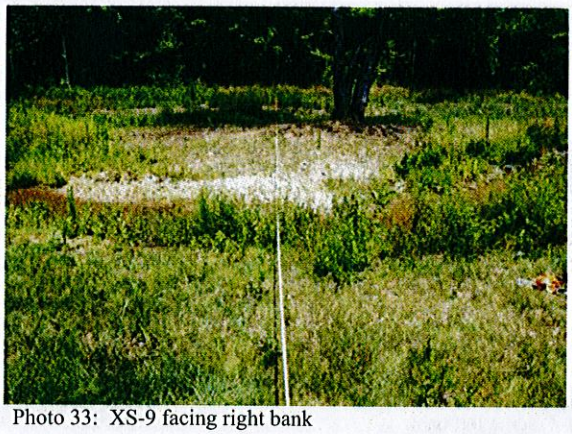


Photo 33: XS-9 facing right bank

Photo 34: XS-9 facing left bank

Photo 35: XS-9 facing upstream

Photo 36: XS-9 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	31.66	20.39	1.55	2.42	13.13	1	2.6	913.25	913.25

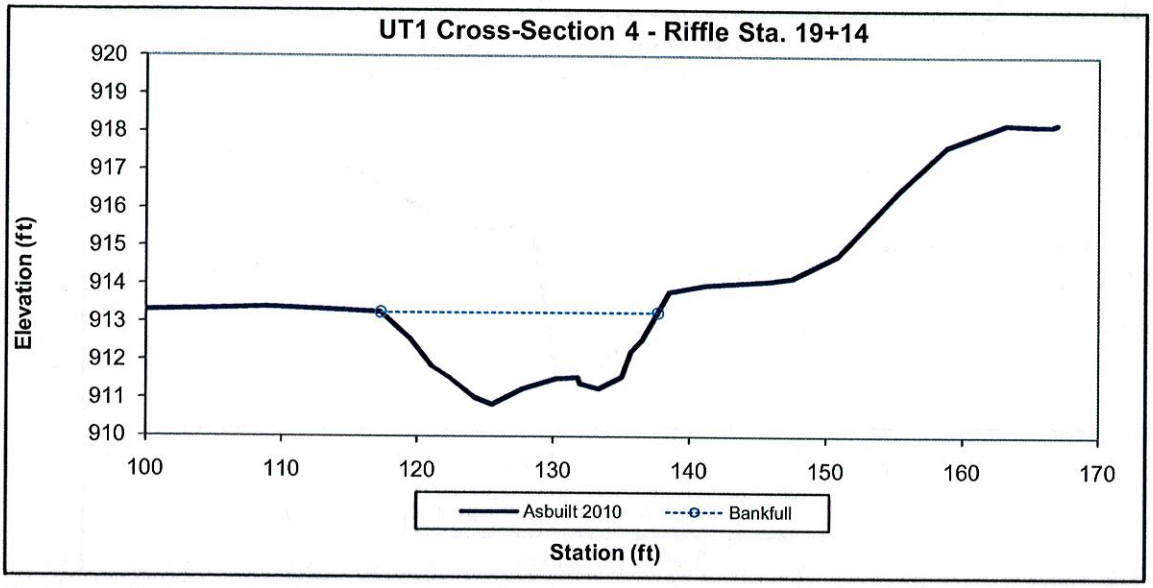


Photo 37: XS-10 facing right bank

Photo 38: XS-10 facing left bank

Photo 39: XS-10 facing upstream

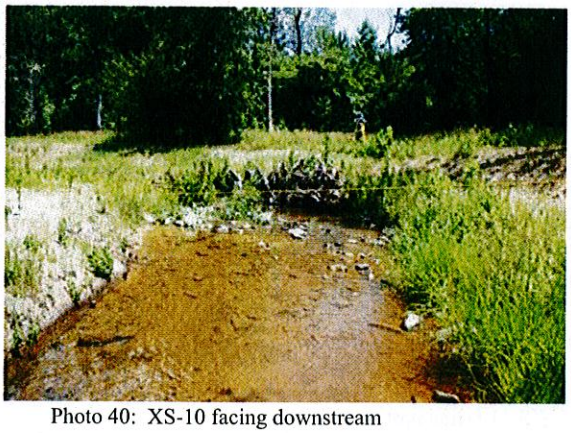


Photo 40: XS-10 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	53.15	25.46	2.09	5.39	12.2	1	2.6	913.25	913.25

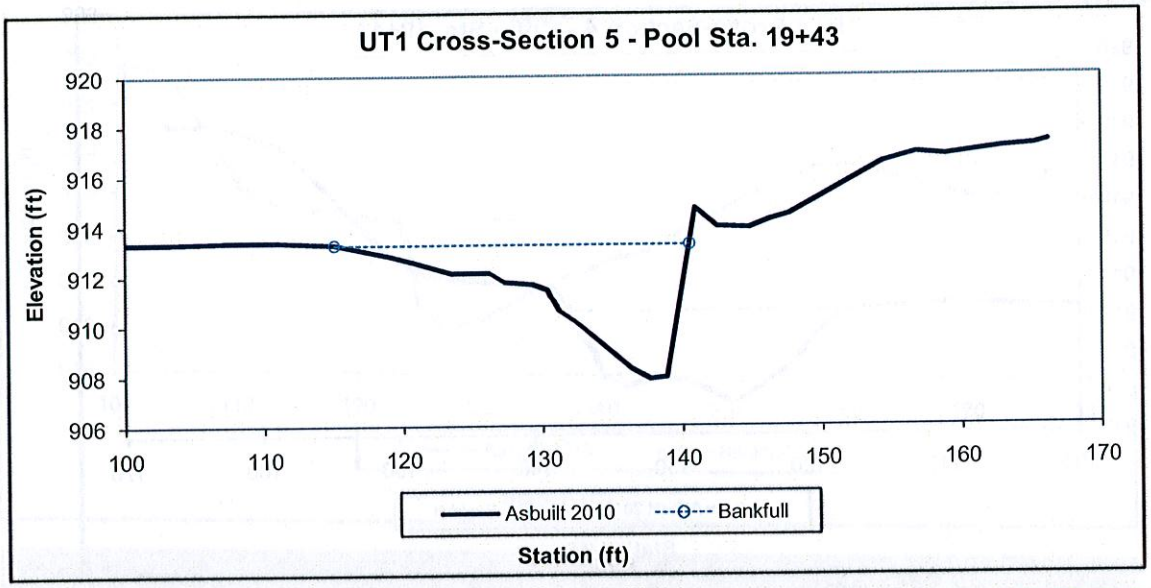


Photo 41: XS-11 facing right bank

Photo 42: XS-11 facing left bank

Photo 43: XS-11 facing upstream

Photo 44: XS-11 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	29.96	19.55	1.53	3.53	12.76	0.9	2.3	903.7	903.39

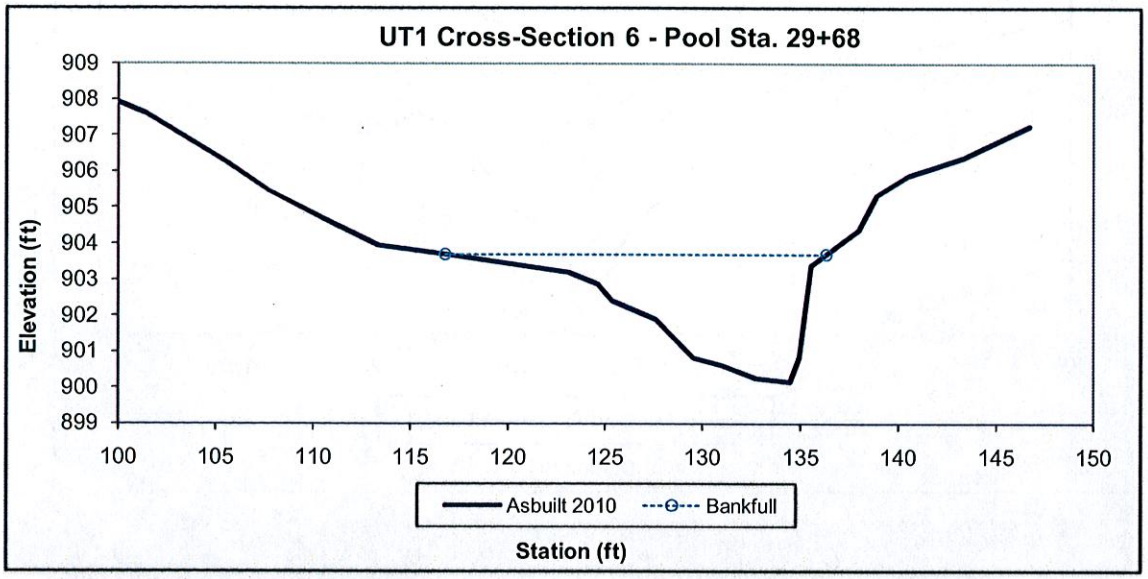


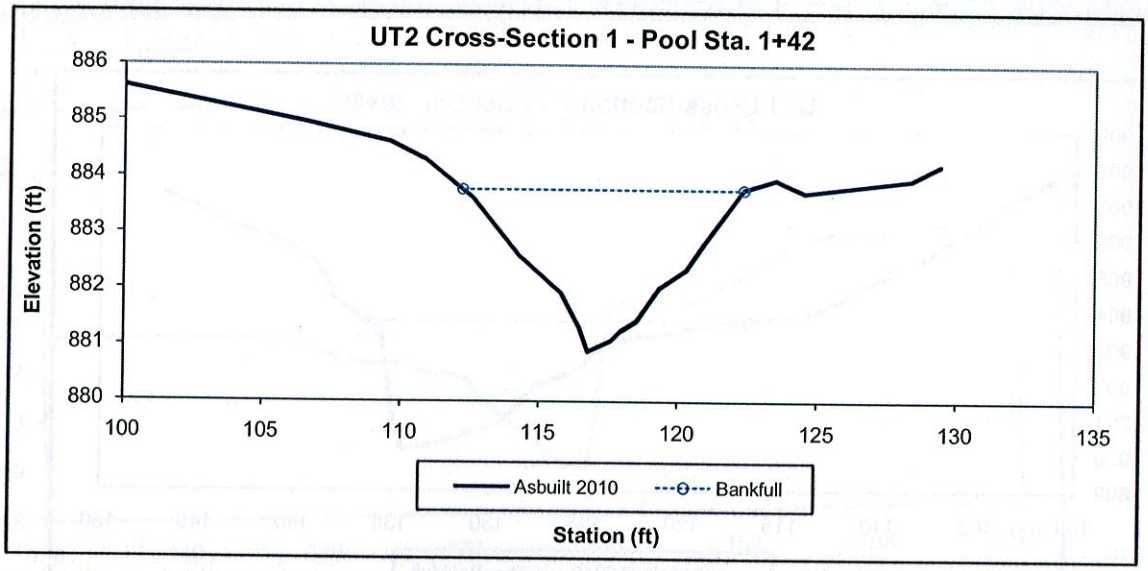
Photo 45: XS-12 facing right bank

Photo 46: XS-12 facing left bank

Photo 47: XS-12 facing upstream

Photo 48: XS-12 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E	15	10.14	1.48	2.89	6.84	1	2.9	883.77	883.77



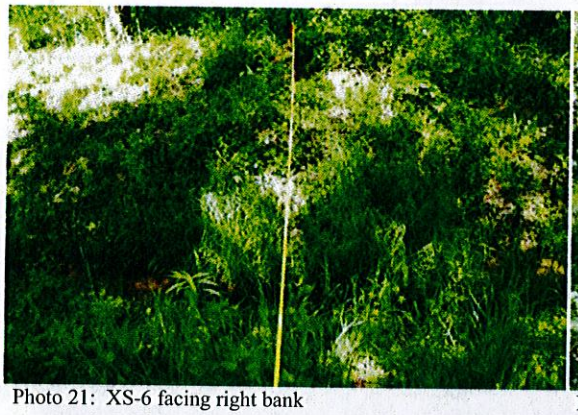


Photo 21: XS-6 facing right bank

Photo 22: XS-6 facing left bank

Photo 23: XS-6 facing upstream

Photo 24: XS-6 facing downstream

Puzzle Creek Mitigation Project
Puzzle Creek Photo Log - Photo Points (July 2010)

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

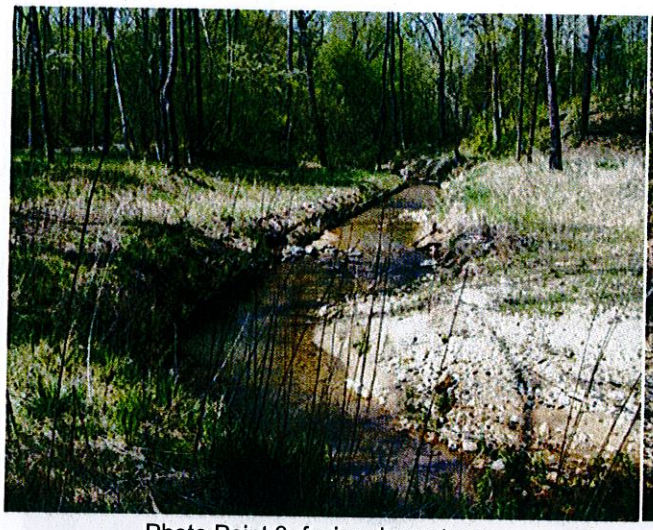


Photo Point 3: facing downstream

Photo Point 4: facing upstream

Photo Point 4: facing downstream

Photo Point 5: facing upstream

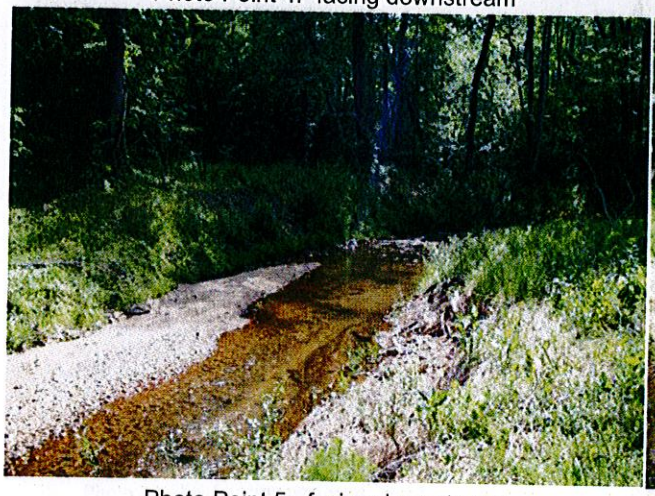


Photo Point 5: facing downstream

Photo Point 6: facing upstream

Photo Point 6: facing downstream

Photo Point 7: facing upstream

Puzzle Creek Mitigation Project
UT1 Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 1: facing upstream

Photo Point 2: facing downstream

Photo Point 2: facing upstream

Photo Point 3: facing downstream

Photo Point 3: facing upstream

Photo Point 4: facing downstream

Photo Point 4: facing upstream

Photo Point 5: facing downstream

Photo Point 5: facing upstream

Photo Point 6: facing downstream

Photo Point 6: facing upstream

Photo Point 7: facing downstream

Photo Point 7: facing upstream

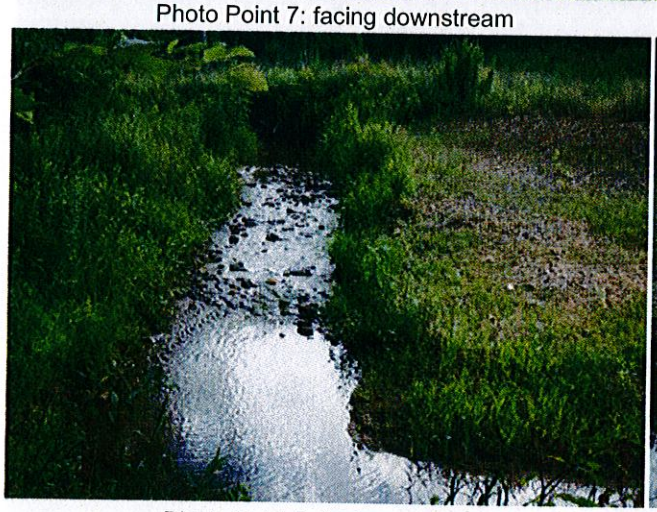


Photo Point 8: facing upstream

Photo Point 9: facing downstream

Photo Point 9: facing upstream

Photo Point 10: facing downstream

Photo Point 10: facing upstream

Photo Point 11: facing downstream

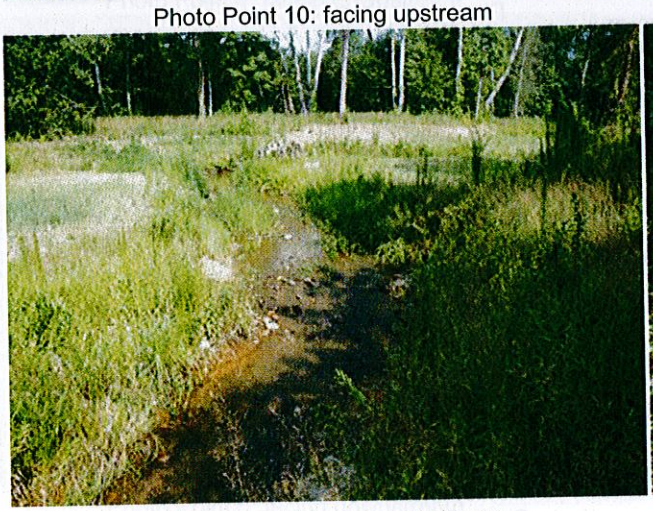


Photo Point 11: facing upstream

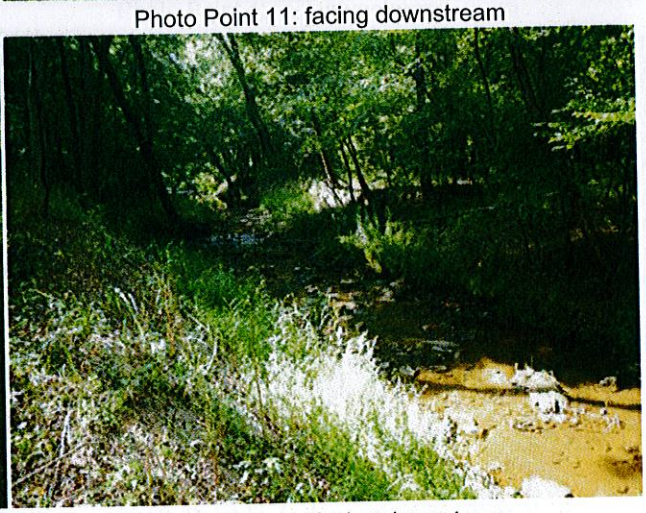


Photo Point 12: facing downstream

Photo Point 12: facing upstream

Photo Point 13: facing downstream

Photo Point 13: facing upstream

Photo Point 14: facing upstream

Photo Point 15: facing downstream

Photo Point 15: facing upstream

Photo Point 16: facing upstream

APPENDIX C

VEGETATION SUMMARY DATA

TABLES 9-14

Table C9. Vegetation Metadata

Puzzle Creek Restoration Project-#D-06027-C

Report Prepared By	Carmen Horne-McIntyre
Date Prepared	8/6/2010 12:49

database name	cvs-eep-entrytool-v2.2.7.mdb
database location	L:\Monitoring\Monitoring Guidance\Vegetation
computer name	ASHEWCMCYINTR
file size	73650176

DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------

Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.

PROJECT SUMMARY----------

Project Code	109277
project Name	Puzzle Creek Restoration Project
Description	Project Label is Baker Proj Code. EEP # D06027-C
River Basin	Broad
length(ft)	4840
stream-to-edge width (ft)	30
area (sq m)	26976.31
Required Plots (calculated)	8
Sampled Plots	8

Table C10. Vegetation Vigor by Species

Puzzle Creek Restoration Project-#D-06027-C

	Species	CommonName	4	3	2	1	0	Missing	Unknown
	Asimina triloba	pawpaw	10	4					
	Betula nigra	river birch	2						
	Cornus florida	flowering dogwood	2				5		
	Diospyros virginiana	common persimmon	14	4			1		
	Fraxinus pennsylvanica	green ash	14	3					
	Prunus serrulata	Japanese flowering cherry	5						
	Quercus coccinea	scarlet oak	1						
	Quercus falcata	southern red oak	2						
	Quercus michauxii	swamp chestnut oak	6	2			2		
	Quercus phellos	willow oak	15	1	1	1			
	Salix nigra	black willow	2	1					
	Cercis canadensis	eastern redbud	2						
	Quercus rubra	northern red oak	4		1				
	Liriodendron tulipifera	tuliptree	10	1					
	Platanus occidentalis	American sycamore	24	2	1				
TOT:	**15**	**15**	**113**	**18**	**3**	**1**	**8**		

Table C11. Vegetation Damage by Species

Puzzle Creek Restoration Project-#D-06027-C

	Species	CommonName	Count of Damage Categories (no damage)
	Asimina triloba	pawpaw	14
	Betula nigra	river birch	2
	Cercis canadensis	eastern redbud	2
	Cornus florida	flowering dogwood	7
	Diospyros virginiana	common persimmon	19
	Fraxinus pennsylvanica	green ash	17
	Liriodendron tulipifera	tuliptree	11
	Platanus occidentalis	American sycamore	27
	Prunus serrulata	Japanese flowering cherry	5
	Quercus coccinea	scarlet oak	1
	Quercus falcata	southern red oak	2
	Quercus michauxii	swamp chestnut oak	10
	Quercus phellos	willow oak	18
	Quercus rubra	northern red oak	5
	Salix nigra	black willow	3
TOT:	**15**	**15**	**143**

Table C12. Vegetation Damage by Plot

Puzzle Creek Restoration Project-#D-06027-C

	Count of Damage Categories	(no damage)
	0	17
	0	17
	0	14
	0	20
	0	13
	0	19
	0	21
	0	22
TOT:	0	143

Table C13. Stem Count by Plot and Species

Puzzle Creek Restoration Project-#D-06027-C

	Species	CommonName	Total Planted Stems	# plots	avg# stems	plot 109277-CHM/MR-0001	plot 109277-CHM/MR-0002	plot 109277-CHM/MR-0003	plot 109277-CHM/MR-0004	plot 109277-CHM/MR-0005	plot 109277-CHM/MR-0006	plot 109277-CHM/MR-0007	plot 109277-CHM/MR-0008
	Asimina triloba	pawpaw	14	6	2.33	3		1	1	2	3	4	
	Betula nigra	river birch	2	1	2								2
	Cercis canadensis	eastern redbud	2	1	2				2				
	Cornus florida	flowering dogwood	2	2	1			1					1
	Diospyros virginiana	common persimmon	18	7	2.57	2	2	2	4	2		2	4
	Fraxinus pennsylvanica	green ash	17	5	3.4		4	7		4	1	1	
	Liriodendron tulipifera	tuliptree	11	4	2.75		4	3	3				1
	Platanus occidentalis	American sycamore	27	7	3.86	1	2		10	3	3	6	2
	Prunus serrulata	Japanese flowering cherry	5	1	5							5	
	Quercus coccinea	scarlet oak	1	1	1						1		
	Quercus falcata	southern red oak	2	1	2		2						
	Quercus michauxii	swamp chestnut oak	8	4	2	1					3	1	3
	Quercus phellos	willow oak	18	6	3	6	2			1	6	1	2
	Quercus rubra	northern red oak	5	4	1.25	2					1	1	1
	Salix nigra	black willow	3	2	1.5		1						2
TOT:	15	15	135	15		15	17	14	20	12	18	21	18

Table C14. Stem Count Arranged by Plot (Baseline)
Puzzle Creek Restoration Site

Tree Species	Plots								As-built Totals	Year 1 Totals	Year 2 Totals	Year 3 Totals	Year 4 Totals	Year 5 Totals	Site Average Stems/acre
	1	2	3	4	5	6	7	8							
Platanus occidentalis	1	2		10	3	3	6	2	27						
Quercus phellos	6	2			1	6	1	2	18						
Diospyros virginiana	2	2	2	4	2	1	2	4	19						
Betula nigra								2	2						
Quercus alba															
Quercus rubra	2					1	1	1	5						
Quercus coccinea						1			1						
Quercus falcata		2							2						
Alnus serrulata	3			1	1	3	4		12						
Salix nigra		1						2	3						
Cornus floridus			1		1			5	7						
Cercis canadensis				2					2						
Alternate Species															
Liriodendron tulipfera		4	3	3				1	11						
Fraxinus pennsylvanica		4	7		4	1	1		17						
Quercus michauxii	3					3	1	3	10						
Prunus serrulata							5		5						
Shrub/Small Tree Species															
Asimina triloba			1		1				2						
Hamamelis virginiana															
Lindera benzoin															
Alternate Species															
Calycanthus floridus															
Rhododendron															
Corylus americana															
Viburnum dentatum															
Volunteers															
Platanus occidentalis						25+			25+						
Liriodendron tulipfera					1+				1+						
Quercus rubra					20+	25+			45+						
Betula nigra			10+	12+	5+	30+	30+		87+						
Stems/plot	17	17	14	20	13	19	21	22							
Stems/acre (Baseline)	680	680	560	800	520	760	840	880							715

Notes: Multiple birch and maple volunteers present. Sycamore seedlings also common. Average stems/plot based on planted stems only.

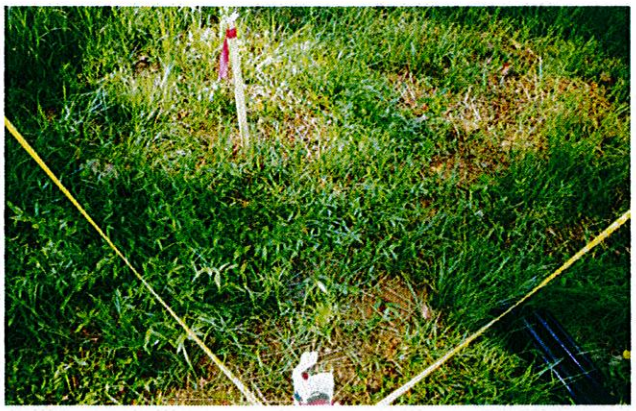
Puzzle Creek Restoration Project
Photo Log - Vegetation Plot Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

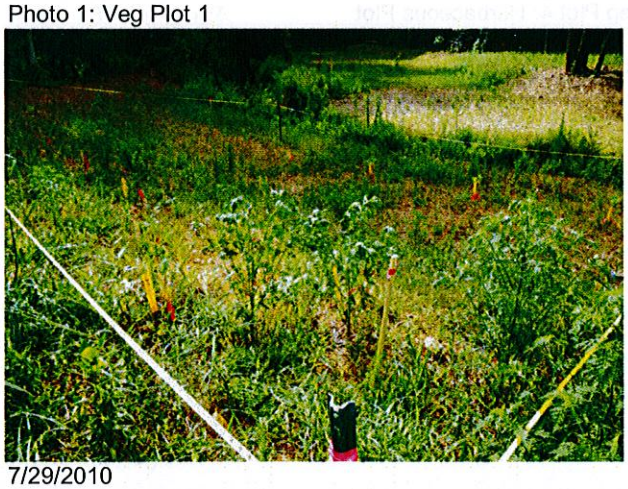
7/29/2010

Photo 1: Veg Plot 1



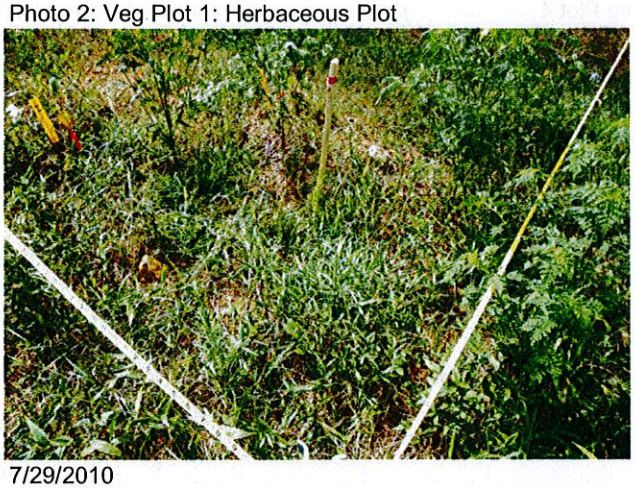
7/29/2010

Photo 2: Veg Plot 1: Herbaceous Plot



7/29/2010

Photo 3: Veg Plot 2



7/29/2010

Photo 4: Veg Plot 2: Herbaceous Plot

7/29/2010

Photo 5: Veg Plot 3

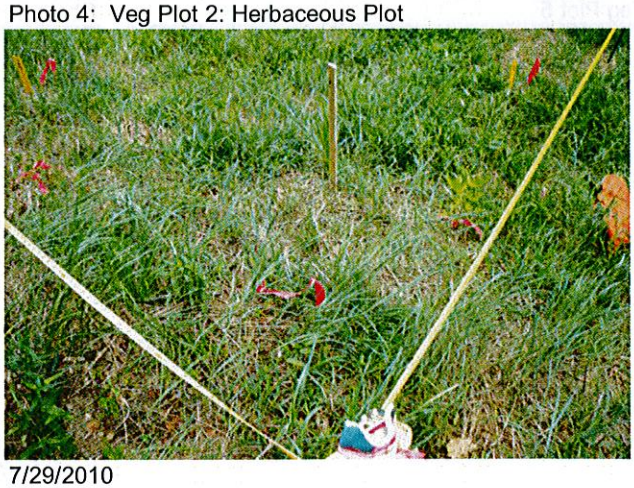


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Photo 6: Veg Plot 3: Herbaceous Plot

Puzzle Creek Restoration Project
Photo Log - Vegetation Plot Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
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Photo 7: Veg Plot 4

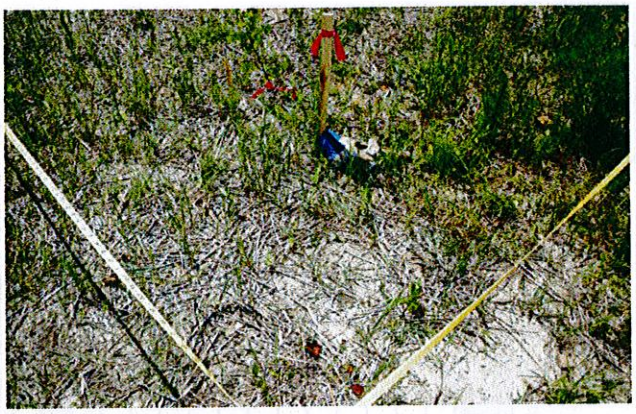

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Photo 8: Veg Plot 4: Herbaceous Plot

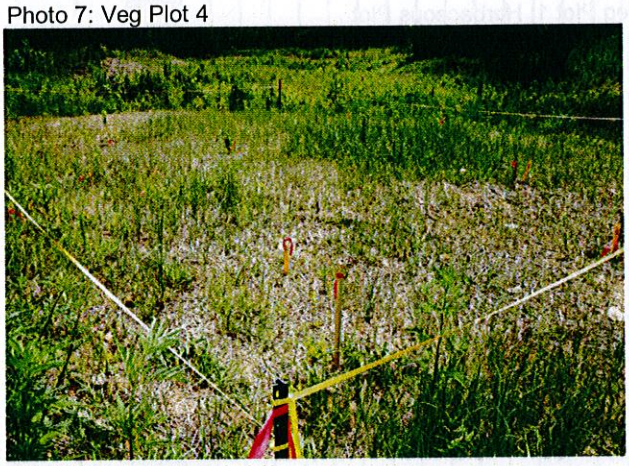

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Photo 9: Veg Plot 5

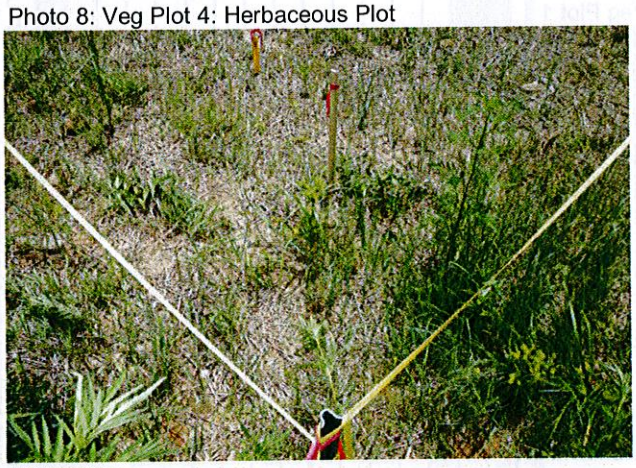

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Photo 10: Veg Plot 5: Herbaceous Plot

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Photo 11: Veg Plot 6

7/29/2010

Photo 12: Veg Plot 6: Herbaceous Plot

Puzzle Creek Restoration Project
Photo Log - Vegetation Plot Photo Points

Notes:

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2. All points are marked with a wooden stake and pink flagging tape.

7/29/2010

Photo 13: Veg Plot 7

7/29/2010

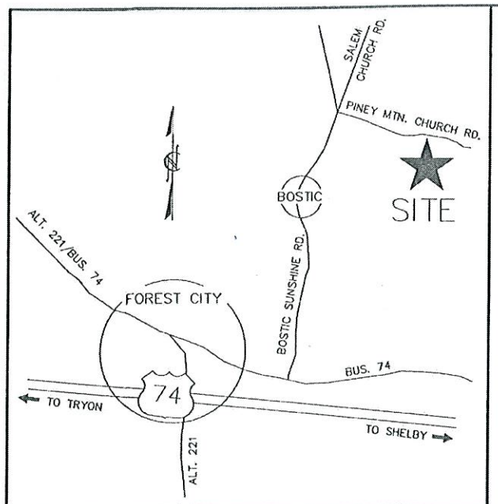
Photo 14: Veg Plot 7: Herbaceous Plot

7/29/2010

Photo 15: Veg Plot 8

7/29/2010

Photo 16: Veg Plot 8: Herbaceous Plot



VICINITY MAP
NOT TO SCALE

NC Ecosystem Enhancement Program

Puzzle Creek Restoration Project

Bostic, North Carolina

INDEX OF SHEETS

Datum Description:

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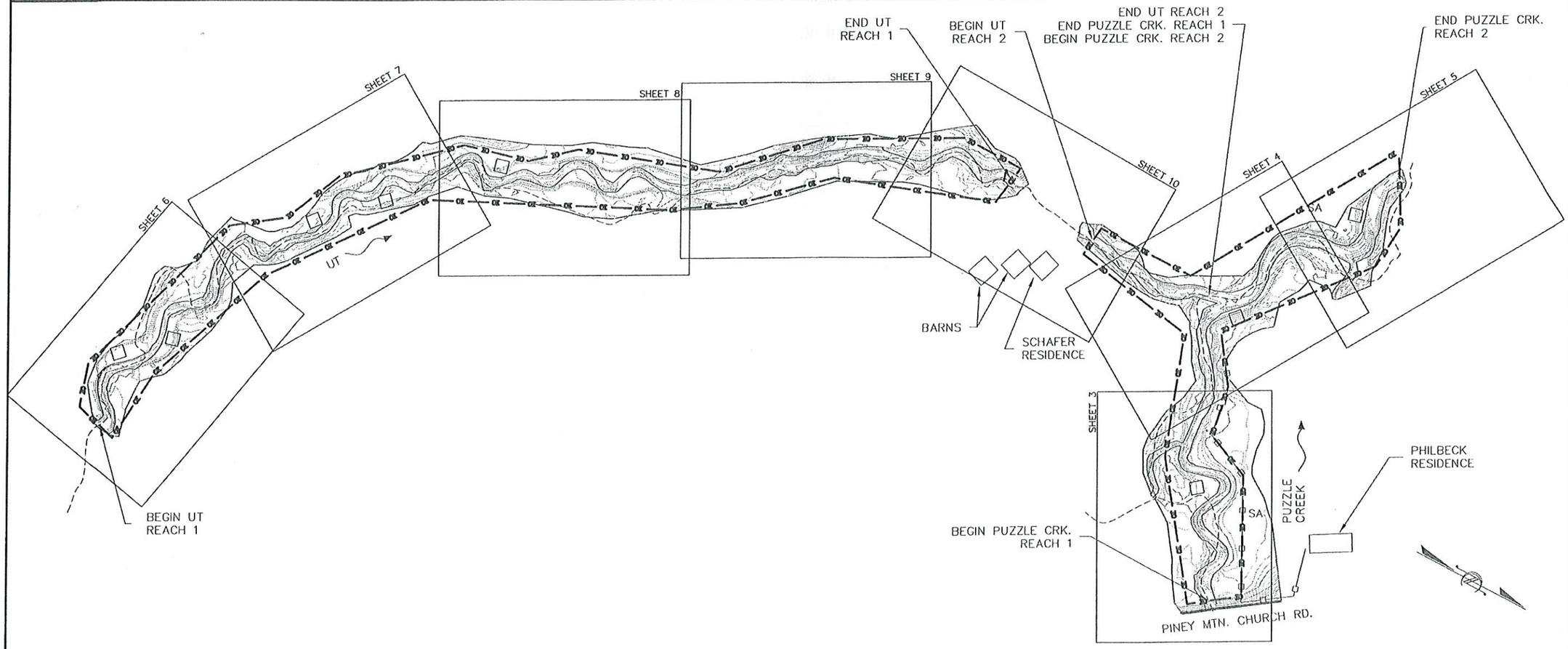

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PUZZLE CREEK RESTORATION PROJECT
BOSTIC, NC

ASBUILT TITLE SHEET

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Fax: 919-715-2219

Baker Project Number
AH-109277
Date: 12/15/10
Drawing Sheet No.
Sheet 1 of 10

LEGEND OF SYMBOLS

TREE

PHOTO POINT

COVER LOG

ROOT WAD

ROCK VANE

LOG VANE

BOULDER TOE

GEO LIFT

FORD CROSSING

DESIGN THALWEG

TOP OF BANK

CHANNEL

EXISTING THALWEG

CE — CONSERVATION EASEMENT

FENCE

CONTOUR–INDEX

CONTOUR–INTERMEDIATE

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LEGEND OF SYMBOLS

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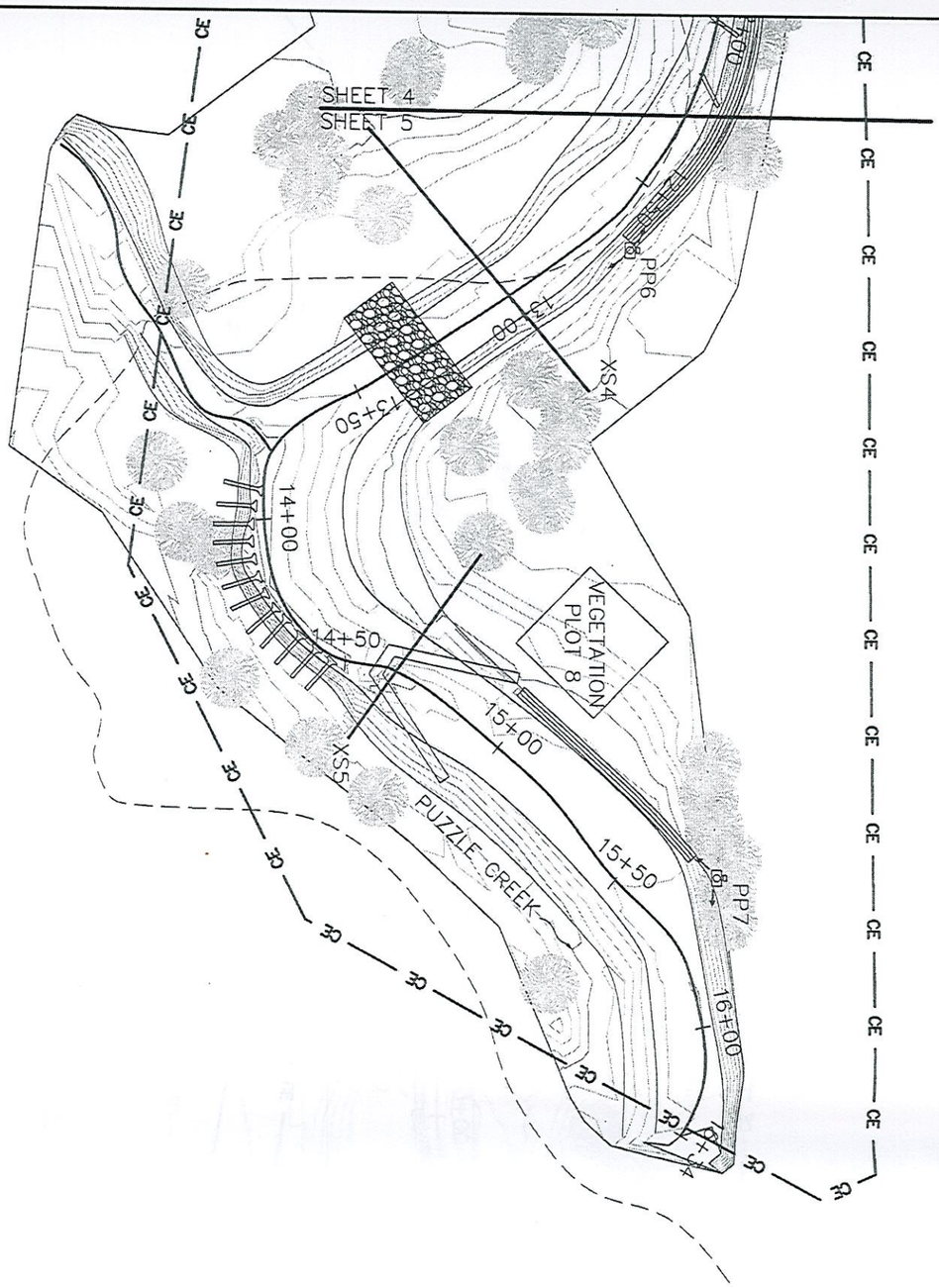

Sheet 5 of 10	Prepared for: Ecosystem Enhancement Program 2728 Capitol Blvd., Suite 1H 103 Raleigh, NC 27604 Phone: 919-715-0476 Fax: 919-715-2219	PUZZLE CREEK RESTORATION PROJECT BOSTIC, NC ASBUILT PLAN	Baker	Michael Baker Engineering Inc. 797 Haywood Road Suite 201 Asheville, North Carolina 28806 Phone: 828.350.1408 Fax: 828.350.1409	DESIGNED: MMC DRAWN: MDB APPROVED: MMC

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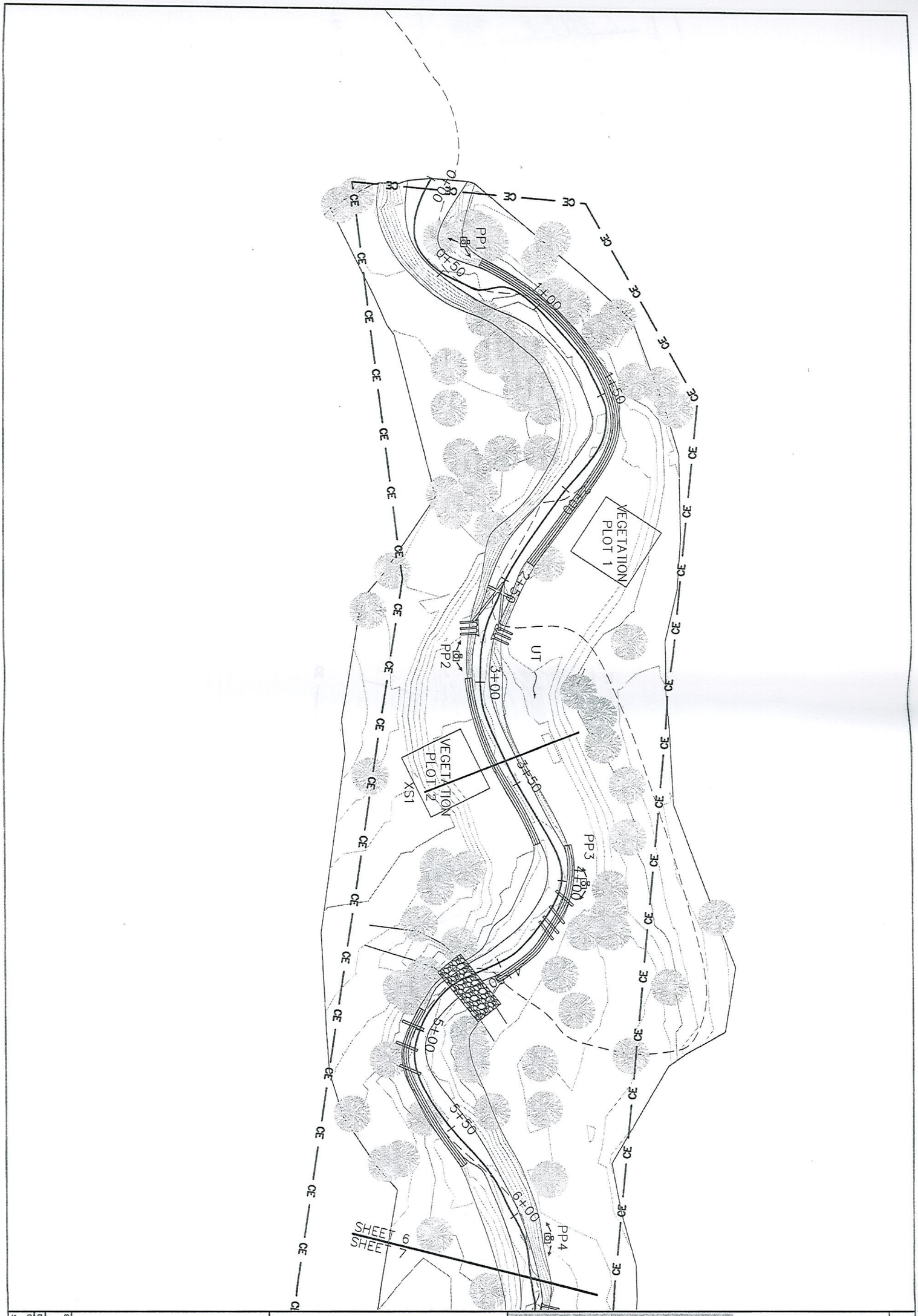

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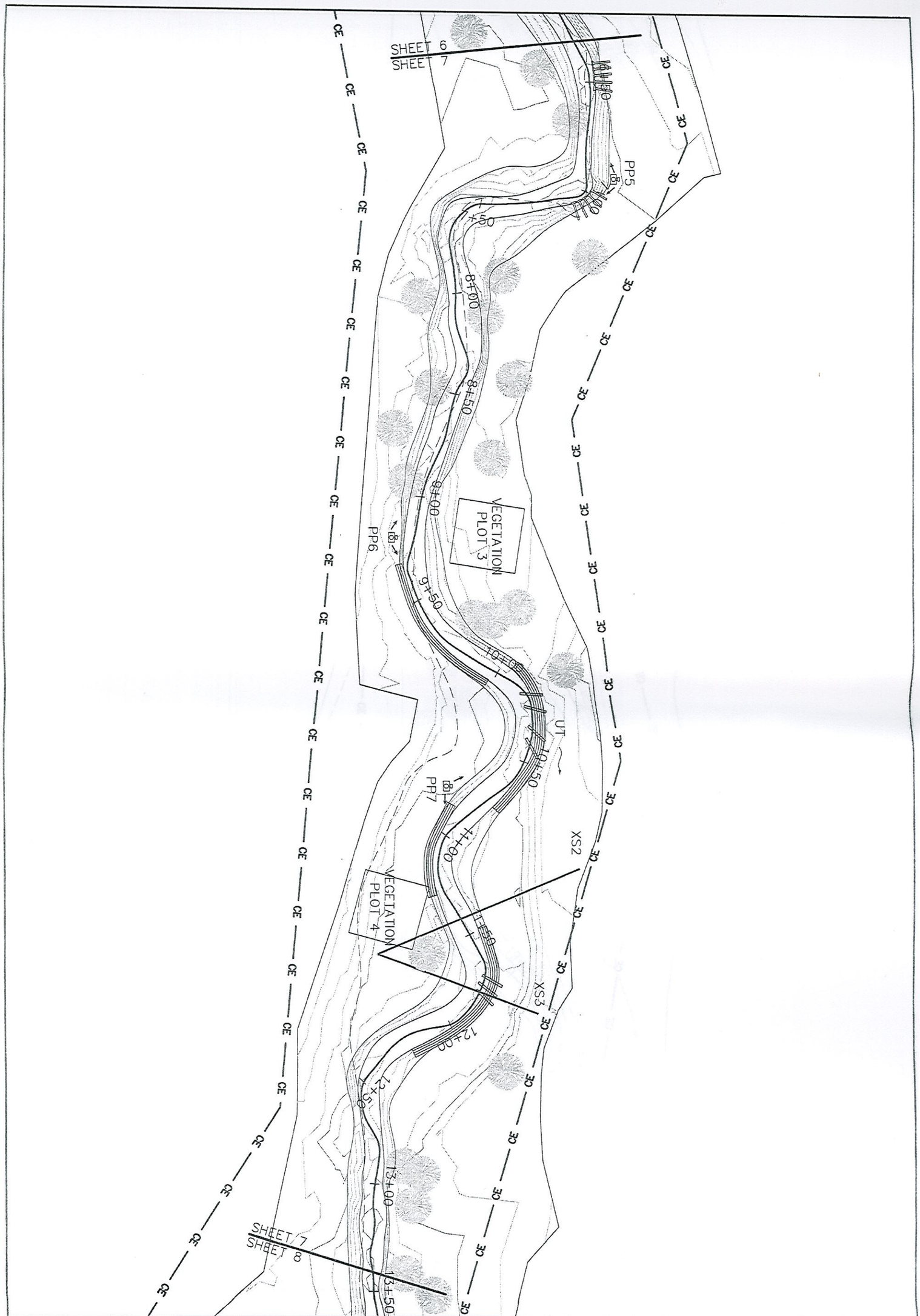

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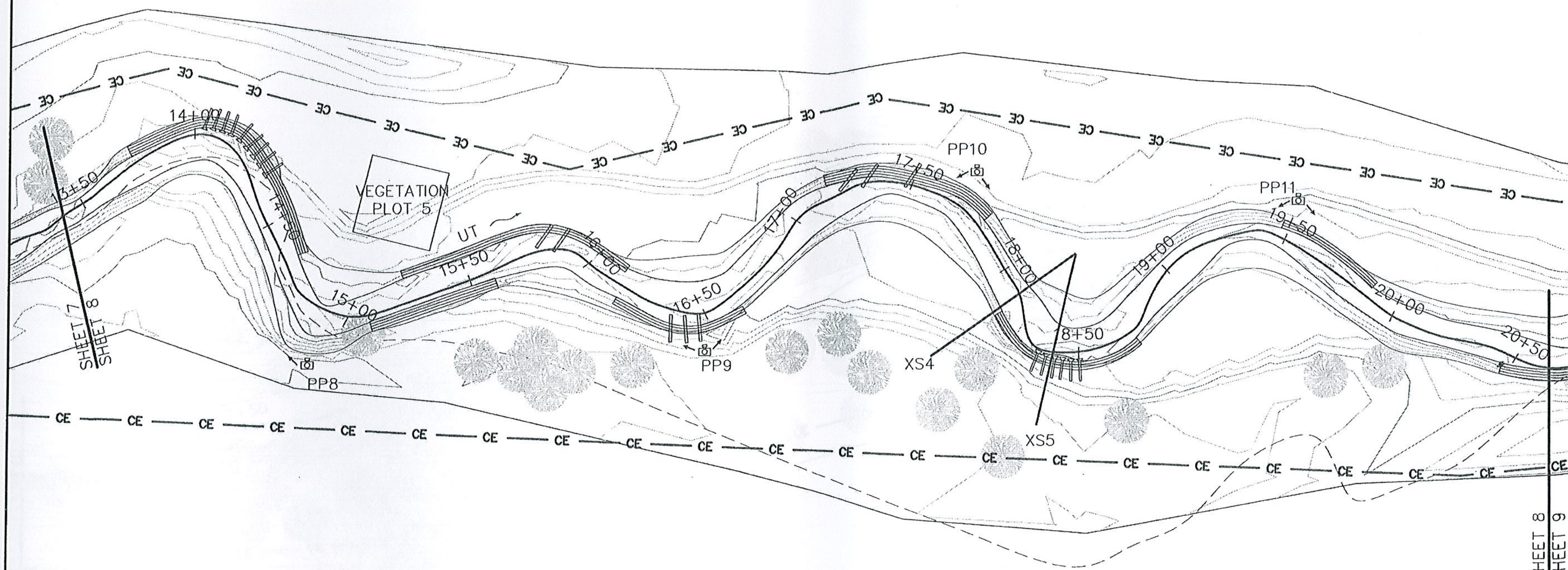

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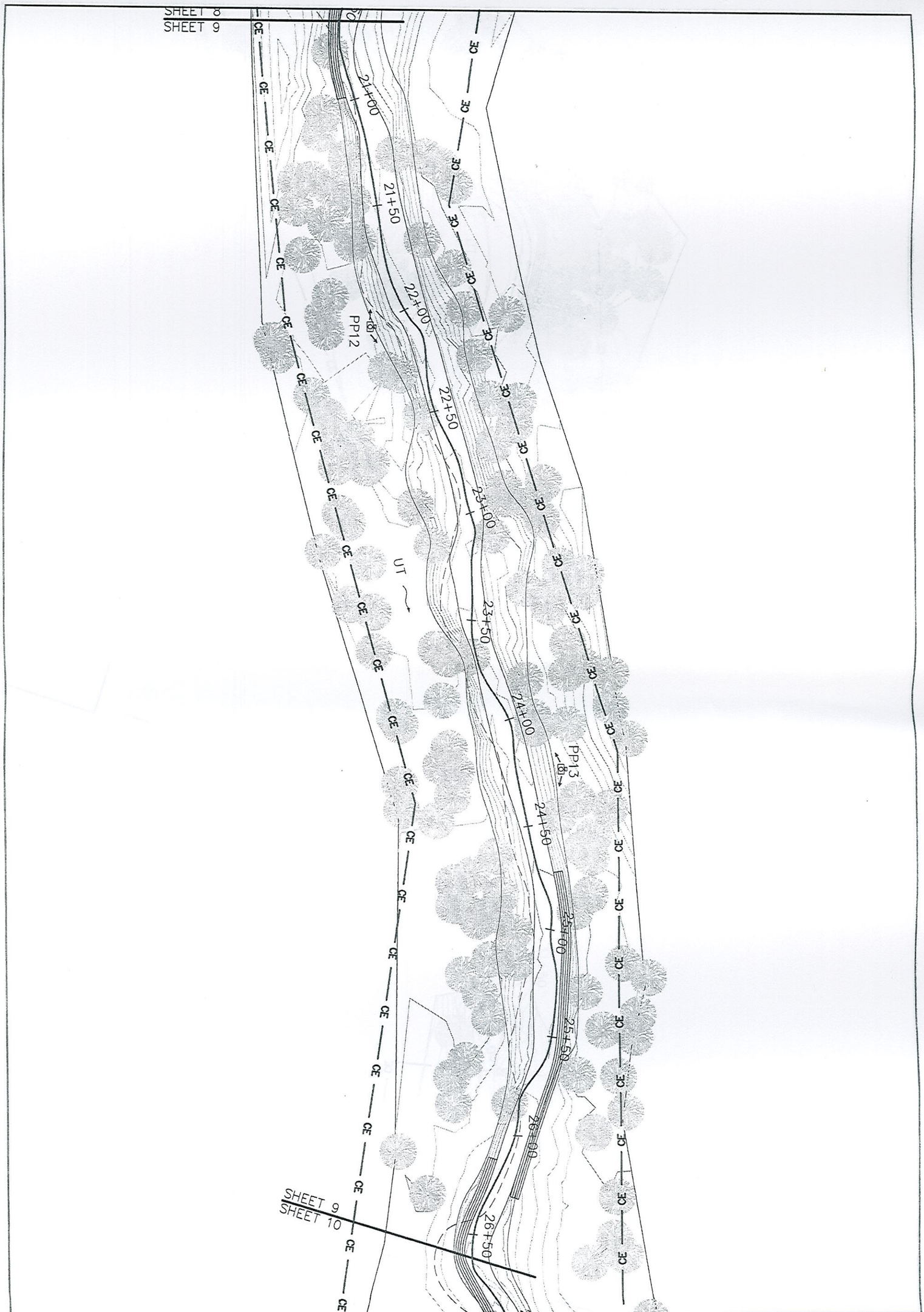

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