Badin Inn Stream Restoration
Stanly County, NC

Restoration Plan

SCO Project Number D06125-E

Prepared for:

NCDENR Ecosystem Enhancement Program
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EXECUTIVE SUMMARY

The Badin Inn Stream Restoration project involves restoration of a hardened and straightened perennial stream that has been in its altered, concrete lined state for nearly a century. The project encompasses more than 3,700 feet of the concrete channel of an unnamed tributary to Little Mountain Creek (UT to Little Mountain Creek), and its floodplain as it runs through the Badin Inn Resort and Club in the Town of Badin, North Carolina. UT to Little Mountain Creek is located in the Yadkin River Basin 8-digit Catalogue Unit 03040104 and the 14-digit hydrological unit 03040104010010. This watershed has been identified by the NC Ecosystem Enhancement Program (EEP) as a Targeted Local Watershed. The receiving stream of the UT is Little Mountain Creek, a 303(d) listed stream. The project is located in a Water Supply Watershed (WSIV). The Badin Inn stream restoration proposes to restore UT to Little Mountain Creek to 3,994 feet of a perennial channel with a restored riparian ecosystem.

The Badin Inn stream restoration project in Stanly County, North Carolina was identified as part of a North Carolina Ecosystem Enhancement Program (EEP) full-delivery proposal submitted in October of 2006. Upon winning the project, Earth Tech acquired for the State of North Carolina a conservation easement on the golf course property of Badin Inn Resort and Resort Club, to protect in perpetuity the riparian corridor of the restored stream.

The following table presents the restoration activity of the project.

Table 1. Project Restoration Structure and Objectives

Reach ID	Restoration Type	Priority Approach	Existing Linear Footage or Acreage	Designed Linear Footage or Acreage	Comment
UT to Little Mountain Creek	Restoration	I	3,540 feet	3,994 feet	
Tributary	Restoration	II	141 feet	180 feet	Stream is currently piped in culvert.

This project has the following goals:

- Restoring the pre-disturbance ecology and hydrology of a perennial, unnamed tributary to Little Mountain Creek, which was hardened with concrete and relocated to its present location nearly a century ago.
- Improvement of flood attenuation characteristics of a highly urbanized and industrialized watershed.
- Removal of pollutant influx from the adjacent golf course management practices.
- Improve aquatic habitat of the main channel with the use of natural material stabilization structures such as root wads, log vanes, woody debris, and a riparian buffer.

- Provide aesthetic value, wildlife habitat, and bank stability through the creation of a riparian zone.
- Create a contiguous wildlife corridor, with connection of the adjacent natural habitats and state natural heritage areas including Morrow Mountain State Park, Little Mountain Creek riparian corridor and Badin basic forest.
- Provide shading and biomass input to the stream and mast for wildlife when vegetation is mature.
- Provide educational opportunities with information signs along the project and take advantage of the high exposure of the project.

The objectives, which specify how each of the goals will be obtained, are:

1) construct a new stream channel in the valley of the existing stream that:
    a) Possesses plan, profile and cross-section appropriate for streams in the Uwharrie Mountains region of the piedmont, as based on reference reaches.
    b) Will contain changes in stream type that are appropriate for changes in the valley slope along the project.
    c) will have bedload introduced into channel to account for the lack of bedload produced by the watershed, and for any excess shear stress generated by the lack of bedload and to provide instream habitat. The bedload will be sized appropriately based on entrainment calculations, while also ensuring that the bedload will not be mobilized out of the stream completely following restoration.
    d) Will be raised where practical so that bankfull elevation meets the existing floodplain.
    e) Will have structural measures to protect outside meander bends before vegetation becomes established. The structures will contain woody material for habitat, and stone material that is sized appropriately for a stream with a cross sectional area of only approximately 13 square feet.
2) establish a riparian corridor that:
    a) Is planted with local propagules of native vegetation.
    b) Meets the minimum vegetative criteria for survival(outlined below in Section 7.2).
    c) Contains riparian wetland "swales", to improve the quality of water passing through the buffer, to provide floodplain storage for reduction of overbank flood velocities and flooding, to increase the functional diversity of vegetation within the riparian corridor, and to protect the stream channel during flood events.
3) implement educational and aesthetic components:
    a) Install several information kiosks along the edge of the conservation easement with information on stream ecology, hydrology and stream restoration.
    b) Use blue bird boxes as conservation easement boundary markers, along with a barrier/low fence along the easement boundary that will prevent maintenance equipment from entering the easement.

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1.0 PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Directions to Project Site

The Badin Inn Stream Restoration Project is located in the Town of Badin in Stanly County, North Carolina (Figure 1). Directions to the site are as follows:

> If traveling from the north (Raleigh, Greensboro, Winston-Salem), proceed southwest on NC 49 from Asheboro. After passing over the Yadkin River/Badin Lake, head south on NC 8 until reaching New London, where NC 8 merges with US Highway 52. Shortly after the merger, turn left onto NC 740 towards Badin. In Badin, after passing the ALCOA plant, turn left on Nantahala Street, then turn right on Henderson Street (SR 1720), which becomes Valley Drive. The beginning of the project is on the right, where the road passes through the fairways of the golf course.
>
> If coming from the south (Charlotte), take NC 24/27 towards Albemarle, then in Albemarle proceed north on NC 740 towards Badin. In Badin, turn right on Nantahala Street, then right on Henderson Street (SR 1720), which becomes Valley Drive. The beginning of the project is on the right, where the road passes the fairways of the golf course.

The project location is shown on the Badin 7.5 minute United States Geological Service (USGS) Topographic Quadrangle Map at approximately 580331 E and 3917513 N.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The project is located in the Yadkin River Basin USGS 8-digit Catalogue Unit 03040104, 14-digit hydrological unit 03040104010010 and NCDWQ Yadkin-Pee Dee River Subbasin 03-07-08.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area

The watershed of the project stream, UT to Little Mountain Creek, has a drainage area of approximately 0.5 square miles at the end of the project site, where the conservation easement meets with Little Mountain Creek (Figure 2). The upper portions of the watershed are comprised of the western slope of a ridgeline in the Uwharrie Mountains chain. Further down, the watershed contains part of the Town of Badin, and includes residential areas, and the Badin Inn Resort and Club, the golf course property on which the project is located. Although the town is small, it possesses a densely developed area of townhouse complexes and houses that were built as residences for the workers of ALCOA, the large aluminum manufacturer that built the Town of Badin in the early part of the twentieth century. Most of this densely developed area lies within the watershed of UT to Little Mountain Creek.

The primary drainage feature of the watershed is UT to Little Mountain Creek, a completely altered, concrete-lined channel that runs for approximately 7,000 feet from its headwaters to the confluence with Little Mountain Creek. UT to Little Mountain Creek is a 2nd order stream, as several small 1st order tributaries flow into it near the top of the watershed. As it passes through the town, the channel has uniform rectangular dimensions and is lined with concrete. It receives the discharge of numerous stormwater pipes flowing from houses and townhouse complexes. The channelization of this stream occurred during the development of Badin by ALCOA during the early 1920's, and has served ever since as the primary stormwater conveyance system for a portion of the town.

Where the stream enters the Badin Inn and Country Club golf course, the stream is confined to a narrow, stone-lined channel for roughly 700 feet. It continues in this form until reaching the conservation easement and the upstream end of the project reach, after passing through a short, 48" culvert under Henderson Street (State Road 1720). At this point, the stream enters a much larger, concrete lined channel that travels straight down the valley, until its confluence with Little Mountain Creek.

Table 2 shows summary data for the UT to Little Mountain Creek Watershed.

Table 2. Summary Data for UT to Little Mountain Creek Watershed

Stream Order	Drainage Area	%Impervious Surface	Total Length of stream in watershed	% Channel Impact
2nd	0.5 Sq. Miles	5%	7300 ft	100%

2.2 Surface Water Classification/ Water Quality

Surface waters in North Carolina are assigned a classification by the DWQ that is designed to maintain, protect, and enhance water quality within the state. Little Mountain Creek (NCDWQ Assessment Unit – 13-5-1(2)) is classified as a WS-IV water body (NCDENR, 2007a). A WS-IV classification is defined as "Waters used as sources of water supply for drinking, culinary, or food processing purposes for those users where a WS-I, WS-II, or WS-III classification is not feasible" (NCDWQ, 2003). Water supply water bodies are typically located within moderately to highly developed watersheds. UT to Little Mountain Creek has not been classified and therefore, carries the same WS-IV classification as the receiving water body, Little Mountain Creek.

The NCDWQ Basinwide Report for the Yadkin-Pee Dee River Basin- Cycle 2 (hereinafter referred to as the Basinwide Report), released in 2003, contains information on the project watershed and Little Mountain Creek. The major relevant points of the report in regards to the current project are as follows:

- Little Mountain Creek has received a use support rating of impaired.
- A benthic macroinvetebrate sampling station one mile downstream of the project site received a bioclassification rating of Fair.
- Low in-stream dissolved oxygen concentrations have been reported (this is possibly an indication of high levels of nutrients running off into the stream).
- Local efforts to reduce nonpoint source pollution were recommended.

The Basinwide Report provides indications of the impairment of Little Mountain Creek and its watershed, of which the project watershed is a subwatershed. The reach of Little Mountain Creek listed as impaired includes the confluence of the project stream with Little Mountain Creek. This stretch of Little Mountain Creek is also included on the Federal 303(d) list for biological impairment (NCDENR, 2008). The project watershed is located adjacent to several major NPDES discharges, originating from the ALCOA plant. While the ALCOA plant closed in 2002, and thus no longer discharges into Little Mountain Creek, the stream has continued to receive an impaired rating, due to low levels of dissolved oxygen and high conductivity. Less than one mile downstream from the end of the project site, where SR 1720 crosses Little Mountain Creek, the NCDWQ maintains a benthic macroinvertebrate sampling station. Repeated monitoring at this station has given Little Mountain Creek a bioclassification of "Fair".

The Basinwide Report does not include an estimate of percent impervious cover, but does report the overall percentage of urban area in the 03-07-08 subbasin as 0.8 percent (NCDENR, 2007b). The percentage of the project watershed covered in impervious surface has been estimated at approximately 5 percent. Thus it is likely that the project watershed, which consists of portions of the industrial plant of ALCOA and the densely developed residential areas of the Town of Badin, is a significant contributor to the problems of low dissolved oxygen and high conductivity which have been reported in the 303(d) listed section of Little Mountain Creek. Furthermore, the golf course on which the project is situated is also likely a large source of nutrients. During field visits, algal blooms were observed in several areas of the channel where pipes from the golf course ponds discharge into the project stream, and grass clippings were observed being directly dumped in the channel.

2.3 Documentation of Perennial Status of UT to Little Mountain Creek

UT to Little Mountain Creek, although channelized, flows in a very pronounced valley that is readily apparent from examining topography. In addition, the entire valley and floodplain along the project site is composed of Oakboro soils. This soil is a Hydric-B soil, which occur adjacent to streams, indicating that there was historically a well-defined, perennial channel flowing through the valley. Even in the streams current altered state, there are numerous areas of groundwater discharge into the channel where the concrete-lining has cracked. Earth Tech has observed the stream at numerous times over the course of a year, during periods of both drought and heavy rain. Even in the periods of drought, there was a small amount of baseflow in the channel, from groundwater discharge at various points in the channel.

The stream was rated using NCDWQ Identification Methods for the Origin of Intermittent and Perennial Stream v. 3.1 (NCDWQ, 2005). In spite of being a highly modified stream it scored 34.75 points, well above the minimum of 30 points for perennial stream status. Strong indicators include a few depositional bars and benches, a natural valley and drainageway, grade control in the form of bedrock, and an abundance of groundwater flow/discharge. The presence of crayfish, fish, amphibians/reptiles, algae, iron oxidizing bacteria and several wetland plants are all indicators of its perennial status. Finally, while UT to Little Mountain Creek is not shown on the USGS Quadrangle Map, it is shown on the USDA soils map for Stanly County. A copy of the form is included in **Appendix B**.

2.4 Physiography, Geology and Soils

The project site is located in the Carolina Slate Belt ecoregion, which is characterized by mineral-rich metavolcanic and metasedimentary rocks with slatey cleavage. Streams in this ecoregion tend to dry up, as this region contains some of the lowest water-yielding rock units in North Carolina (Griffith et. al. 2002). Field observations confirmed this phenomenon, as several streams observed within the vicinity of the project area had qualities that would classify them as perennial, in accordance with the NCDWQ criteria, but lacked the hydrology that would typically be found in perennial streams in other parts of the piedmont.

The project site is situated within the Uwharrie Mountains, considered by some to be the oldest mountains in North America. The mountains, the tallest of which reaches just above 1000 ft above sea level, stand in stark contrast to the surrounding piedmont plateau. The unique topography of the Uwharrie Mountains has affected design considerations in the restoration of UT to Little Mountain Creek. Both “Mountain” and “Piedmont” regional curves have been considered in the design, while also taking into account the relative scarcity of groundwater input into streams in the region.

According to the Stanly County Soil Survey (USDA NRCS, 1989) several soil types are present in the project area (**Figure 3**). The predominant soils mapped along the floodplain of UT to Little Mountain Creek are Oakboro silt loam, which is a Hydric B soil, and Kirksey silt loam. Hydric B soils are mapped soil units that contain inclusions of hydric soils, and are typically found along the drainage-ways and valleys of stream channels. Soil units mapped by the NRCS along the floodplain at the site are described below.

Oakboro silt loam (Oa) The Oakboro series consists of deep, moderately well drained and somewhat poorly drained soils that formed in loamy alluvium from slates, siltstones, sandstones, and tuffs in the Carolina Slate Belt of the Piedmont. Surface runoff is slow. The seasonal high water table is 1.0 to 2.0 feet below the surface during wet periods. Flooding is common for brief periods when streams overflow in late fall to early spring.

Kirksey silt loam (KkB). The Kirksey series consists of deep, moderately well drained, moderately slowly permeable soils that formed in material mostly weathered from Carolina slate of the Piedmont Uplands. Slopes range from 0 to 10 percent. Surface runoff is moderate. The seasonal high water table is at the surface to 1.5 to 3.0 feet below the surface. Permeability is moderately slow.

2.5 Historical Land Use and Development Trends

The land use throughout the project watershed consists of a mixture of developed areas, including much of the residential areas of the Town of Badin, managed herbaceous areas, the most notable of which is the Badin Inn golf course, and forested areas on the slopes above the town. The Badin plant of ALCOA, a large aluminum manufacturer, is partially located in the watershed, as are most of the housing and commercial areas associated with the town. Badin was founded in 1913 by the French aluminum company, L'Alumnium Français, and named for the company's founder, Adrien Badin. The company began its industrial efforts in Stanly County by constructing a dam across the narrows of the Yadkin River to provide power for a smelter, and thereby creating Badin Lake. The Town of Badin was built on the shores of the newly-created lake to provide housing for the companies workers. The town was modeled after a French mill village, with company houses, apartments and cultural facilities all designed in the French colonial style. In 1915, the town was purchased by ALCOA, and additional housing and infrastructure was completed. The golf course through which UT to Little Mountain Creek flows has been in existence since at least 1925 and was built as part of the overall development of Badin by ALCOA.

While the initial development of Badin led to the modification of the streams and drainages within the project watershed, the town has remained relatively stable in terms of development since then, with little change in land use. Many locals were interviewed during this project and asked about the history of the stream. It was stated that the stream used to carry the towns wastewater and stormwater, and that a wastewater treatment facility was located adjacent to the channel on the golf course. This facility was described as having sprayed treated wastewater onto a pervious pad, allowing it to flow into the stream. The facility is no longer present, but the channel still carries the towns stormwater, and numerous stormwater pipes and culverts discharge into the stream as it passes through housing areas in town.

Table 3 shows land use of the UT to Little Mountain Creek watershed.

Table 3. UT to Little Mountain Creek Watershed Landuse.

Land Use	Acreage	Percentage
Bottomland Forest/Hardwood Swamps	6.8	2.0
Evergreen Shrubland	1.0	0.3
High Intensity Developed	9.9	2.8
Low Intensity Developed	27.3	7.8
Managed Herbaceous Cover	107.2	30.7
Mixed Hardwoods/Conifers	20.9	6.0
Mixed Upland Hardwoods	170.6	48.9
Southern Yellow Pine	5.3	1.5
Total	**349.0**	**100.0**

2.6 Endangered/Threatened Species

Plants and animals with a federal classification of Endangered (E), Threatened (T), Proposed Endangered (PE), and Proposed Threatened (PT) are protected under provisions of Section 7 and Section 9 of the Endangered Species Act of 1973, as amended. The USFWS lists two species under federal protection for Stanly County (USFWS, 2006). These species are listed in **Table 3**.

Table 4. Species under Federal Protection in Stanly County

Common Name	Scientific Name	Federal Status	Biological Conclusion
Schweinitz's sunflower	*Helianthus schweinitzii*	Endangered	No Effect
Bald eagle	*Haliaeetus leucocephalus*	Delisted	No Effect
Notes E Endangered-A species that is threatened with extinction throughout all or a significant portion of its range. T Threatened-A species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.			

Schweinitz's sunflower (*Helianthus schweinitzii*) No Effect

No habitat exists in the project area for Schweinitz's sunflower. Roadsides, power line clearings, old pastures and woodland openings are not present in the project area, which is comprised entirely of a golf course containing maintained grass. A search of the NC Natural Heritage Program (NHP) database found no occurrences of Schweinitz's sunflower in the project vicinity. It can be concluded that the proposed project will not impact this endangered species.

Bald eagle (*Haliaeetus leucocephalus*) No Effect

No nesting or foraging habitat exists in the project area for the Bald eagle. A search of the NHP database found no occurrences of the bald eagle in the project vicinity. It can be concluded that the proposed project will not impact this species.

Records from the North Carolina Natural Heritage Program (NCNHP) were reviewed on July 5th, 2007 to determine the presence of protected species. No records of protected species were found within the project vicinity. However, the records list six occurrences of Schweinitz's Sunflower (*Helianthus schweinitzii*), and three occurrences of the bald eagle (*Haliaeetus leucocephalus*) within 2-miles of the project site. No potential habitat or nesting/foraging sites were found on the project property. The USFWS was contacted, and stated that a determination of "no effect" as to endangered species on the property was sufficient and that no further correspondence was needed.

2.7 Cultural Resources

The State Historic Preservation Office (SHPO) was contacted with a project scoping letter regarding properties listed on or eligible for listing on the National Register of Historic Places in the project area. The SHPO responded with a letter stating that the only area of historical or architectural importance within the project area is the Badin Historic District, which is listed on the National Register of Historic Places. SHPO believes that the Badin Inn Stream Restoration Project will not adversely affect the historic district.

2.8 Potential Constraints

The greatest constraints to the Badin Inn Stream and Restoration project are the lateral constraints posed by the fairways of the golf course and access to the site. While utility crossings are present, they will not pose a major constraint to implementation of the project. A hydraulic analysis has shown that flooding will be reduced and contained within the proposed floodplain (see Section 6.3- HEC-RAS Analysis). Other constraints include the upstream and downstream boundary condition of bed elevations that must be met when leaving the project site. These constraints are not considered significant due to the ample length and moderate slope of the upper section of the reach which allows for enough distance and grade change to bring the bed elevation up and raise the base elevation overall.

2.8.1 Property Ownership and Boundary

The Badin Inn tract is owned by Badin Inn Resort and Club, LLC. The tract will remain in private ownership and a conservation easement has been obtained to protect the restored stream.

Henderson Street (SR 1720) runs adjacent to the property on the northeastern edge of the conservation easement. The southwestern edge of the easement runs along the centerline of Little Mountain Creek. The boundary of the conservation easement has been carefully established to balance the need for adequate buffer width for the restored stream with the interests of the landowner in maintaining sufficient area for the fairways of the golf course. While the conservation easement boundary includes the course of the existing channel for most of its length, it departs from the channel in the final 2000 feet, and travels over the course of the original low point in the valley before meeting Little Mountain Creek (see Figure 4).

2.8.2 Riparian Buffer Widths

The greatest lateral constraints to the restoration of UT to Little Mountain Creek are the golf course fairways which run on either side of the existing stream. Where golf course fairways are already narrow, the easement boundary has been negotiated with the landowner to grant the maximum width possible, in order to balance requirements for buffer width with the landowners need to minimize adverse impacts to the function of the golf course. After having obtained the maximum possible width in light of the physical and landowner constraints, the stream will be protected by a riparian buffer along both banks of approximately 45-50 ft for the majority of its length. Approximately 80 linear feet beginning at station 17+50 has less than 30 ft of buffer width due to lateral constraints that cannot be altered. However, the balance of reach length exceeds a 30 ft buffer width.

The 2003 USACE Stream Mitigation Guidelines provide that restored channels in the mountains should typically be protected by a buffer width of 30 feet “extending landward from the bankfull elevation" (USACE, 2003). UT to Little Mountain Creek exists in the Uwharrie Mountains proper and has a valley type, valley slope, and valley confinement more representative of the western NC mountain counties. The reference reach used for design, UT to Meadow Fork, has valley slopes of about 2%, valley wall slopes of 9-14%, and is moderately confined. Similarly, UT to Little Mountain Creek has valley slopes of 2-5% and valley wall slopes of 12-13%. Due to this similarity to mountainous areas of western NC counties, coupled with the enormous potential for functional uplift which implementation of this project uniquely possesses, it is believed that, despite the lateral constraints, the restored channel will possess adequate buffer width, and the constraints will not pose a detriment to the restoration goals of the project.

The physiographic region of the Uwharrie Mountains, though situated within the general region of the Piedmont, bears greater similarity to the foothills and low mountains of the western counties of North Carolina. The ancient geological formation of the Uwharries is believed to have been part of a volcanic arc of islands which accreted to the North American continent between approximately 450 to 300 million years ago (Hibbard, 1999). As a result, the terrain is comprised of steep hillslopes and peaks reaching elevations of over 1000 feet above mean sea level, while the valleys and floodplains below reach elevations of as low as 300 feet, thus creating large elevation changes and slopes unusually steep for the piedmont, but commonly encountered in the mountains.

The alluvial valleys at the base of these hills also bear resemblance to those of the mountains. Valleys are narrow and are bordered by steep valley "walls" of the adjacent mountainsides, down which steep, first and second order "A" and "B" type streams flow. In fact, there are several 3rd order B streams within a few miles of the project site, and Little Mountain Creek itself is a "Bc" channel. Valley length to width ratios in the mountains and the Uwharries range from 3.0 to more than 10, while piedmont streams consistently have valley length to width ratios of 2.0 to 4.0. The valley on which the project site is located has average slopes of approximately 2.5%., A typical 2nd-order stream in the Piedmont has a valley slope of between .06 to 1.2 %. and would have a much smaller drainage area and a less pronounced valley. It is because of the great similarity to mountainous valleys that one reference reach, UT to Meadow Fork, was chosen from the Blue Ridge Mountains area. Difficulty was encountered in trying to find a stable reference reach nearby the project site, due to the historic effects of agriculture on streams within the Uwharrie Mountains. But after examining topographical maps of many streams, it was only on a stream adjacent to the Blue Ridge Parkway in Allegheny County, in the mountains of NC, that there was found a valley with a very similar type, width and slope.

In spite of the constraints on buffer widths, the restoration of UT to Little Mountain Creek is unique in its potential for functional uplift and benefit to downstream water quality. Currently, the channel of the stream is hardened in concrete, with sheer vertical walls and a bed of concrete. No vegetation grows in the channel, and very little bedload is present, thus creating limiting conditions for macrobenthic organisms and periphyton. Without the presence of stream banks or stream bank vegetation, the channel receives no shading. The channel contains a year-round baseflow, and thus does harbor some fish, amphibians and crayfish during the growing season, but otherwise is ecologically barren.

This functional deficit of the existing stream differs from the common situation of many stream restoration projects, in which the existing channel, while severely impaired, still retains the minimal functions of a natural stream, as it contains stream substrate for macrobenthic and periphyton habitat, some habitat areas in pools and riffles, depositional areas, stream bedload and minimal vegetative growth. In comparison, UT to Little Mountain Creek poses a situation in which a stream doesn't even possess minimal functional value, as it has been completely altered though anthopogenic influence into a streamlined, concrete conveyance of stormwater and groundwater. The restoration of this system will therefore be a complete restoration, in every sense of the word. A natural stream channel and riparian corridor will be restored where none currently exists, but did exist at one time.

In order to document and verify the increase in function due to restoration of UT Little Mountain Creek, Earth Tech plans to monitor variables above the minimum requirements of stream restoration monitoring. Macrobenthic samples will be collected by an experienced and trained benthic ecologist, and water quality samples will be collected and sent off for analysis, with key pollutants, including nutrients, being monitored. Baseline data will be collected before construction, with regular monitoring coinciding with other monitoring efforts in the years following construction (see Section 7.3 for more information regarding the biological monitoring).

As another mitigating factor for the constrained buffer widths, riparian wetland "swales" will be built within the restored floodplain of the stream (See Design Sheets 4-6). These riparian wetlands will not be intended to generate riparian wetland credits. Research has shown that overbank flooding dampens the peak of the hydrograph, and that flows stored within the riparian floodplain typically undergo biochemical processes that improve the quality of water prior to it being retuned to the stream (Evans et al. 2008). Riparian wetland "swales", which will simply be small depressions built into the floodplain, have been incorporated into the design to improve the quality of water passing through the buffer, to provide floodplain storage for reduction of overbank flood velocities and flooding, to increase the functional diversity of vegetation within the riparian corridor, and to protect the stream channel during flood events. It is believed that the incorporation of these highly functional areas into the buffers of the restored stream will offset any loss of function from buffer constrains along the restored channel.

Given the steep slopes, mountainous topography and valley type and other similarities of the project area to the western mountains, coupled with the great potential for functional uplift when compared to other stream restoration projects, and a proposal to intersperse the floodplain with riparian wetland areas for storage and increased water quality benefit, it is believed that the constraints on buffer widths of the restored stream will not affect the goals and success of this restoration project, nor its great potential for benefit to water quality and stream function.

To ensure that the buffer is protected from mowing and other disturbance activities associated with the golf course management, a continuous barrier/low fence will be erected around the perimeter of the conservation easement. The goal of this barrier is to be low enough for golfers to step over to retrieve balls within the conservation easement, but continuous and substantial enough to prevent any maintenance equipment from disturbing the riparian vegetation within the easement.

2.8.3 Site Access

Access to the site will be from the adjacent state road, Henderson Street (SR 1720). While this road will provide easy access to the northern portions of the project, the southern portions will need to be reached via a construction path created on the existing golf cart path within the conservation easement.

2.8.4 Utilities

A power line crosses UT to Little Mountain Creek near the beginning of the project. The utility lines will need to be flagged and equipment working in the area will need to work around the pole and watch the overhanging lines. In addition to the power lines, several stormwater culverts discharge into the existing stream, ranging in size from 6" PVC to 15" reinforced concrete pipes. These are discharges from the ponds located on the golf course. A 6" ductile iron pipe crosses the stream approximately 1020' from the downstream end of the project, and is used for the irrigation system on the golf course. These inputs have been addressed during the design, by routing the stream to below the elevations of the pond outfalls, and providing adequate dissipation for the discharge from the pipes before entering the restored stream.

2.8.5 FEMA/Hydrologic Trespass

According to the Stanly County Flood Insurance Rate Map (37167C0075 D September 21, 2000), the floodplain along UT to Little Mountain Creek has not been mapped by the Federal Emergency Management Administration (FEMA). However, the last several hundred feet of the stream are within the Zone A special flood hazard area (SFHA) of Little Mountain Creek. While the effective study for Little Mountain Creek is a Zone A approximate study, a preliminary detailed study with base flood elevations was released in August of 2007 by the NC Flood Mapping Program as part of their statewide update of flood mapping. Portions of the site are within the 100-year floodplain of both the effective SFHA and the preliminary SFHA. However, since there are no community setbacks and less than 5 acres of grading will occur within this floodplain, no "no-rise" study, CLOMR or LOMR will be required. In addition, the project will not be affecting the cross-sections or discharge inputs of the detailed study model, therefore no rise in base flood elevations is expected due to the grading within the last few hundred feet of the conservation easement. The local floodplain administrator for Stanly County has been notified.

3.0 EXISTING CONDITIONS

3.1 Channel Classification

UT to Little Mountain Creek is a completely modified and concrete lined channel. Despite this, the channel shows all indications of being a perennial stream. The channel has been evaluated with the NCDWQ stream identification form Version 3.1 and scored 34.75 points, which is more than the minimum of 30 points required for a perennial stream. Observations over a period of one year, from July, 2006 to July, 2007, have documented perennial conditions of the stream. Several pools in the channel harbor fish throughout the year, even during drought, and provide refuge during times of stress. Groundwater discharges from cracks in the concrete walls in the stream in various locations along the channel. In addition, the concrete bed of the channel has degraded to reveal slate bedrock beneath what was once likely part of the bed of the original, pre-modified channel (See Appendix A for photos).

A classification of UT to Little Mountain Creek is not possible due to the highly modified state of the channel. UT to Little Mountain Creek is lined with concrete, and has uniform rectangular dimensions for its entire length down the project site. In many places, the vertical concrete walls of the stream are buttressed with timber logs. The stream could therefore not be classified according to the Rosgen system of classification, which is intended for natural, unmodified channels. Based on valley slope, valley type and physiography, a “B” channel would probably have existed in approximately the upper 800 feet of the project site, where the valley slope is approximately 2.9%. The channel would then likely have changed to a “C” or “E” as the valley flattened to a slope of approximately 1.1%, and widened. Low “dips” in the valley indicate that the original stream course deviated greatly from the straight confluence that it is today, and that the stream once possessed much greater sinuosity. Regional curves show that a drainage area of 0.5 square miles in the Piedmont/Mountain region should produce a channel with a bankfull area of approximately 13.1 square feet, a width of approximately 10.1 feet, and a depth of approximately 1.3 feet.

A short, piped tributary, which is approximately 141 feet in length, enters the main channel approximately 500 feet downstream of the beginning of the project. This short stretch of channel is piped underground where it reaches the golf course property, and will be “daylighted” as part of the restoration. The channel has a drainage area of only 0.05 square miles, and would therefore likely be a very small channel, with a cross-sectional area at bankfull of only 2.8 square feet, according to the NC Mountain/Piedmont regional curves. While the piped portion of the channel could not be observed, a short section immediately upstream of the golf course property was incised, with a relatively steep slope (greater than 2%) down the wall of the valley, and then transitioning into a more moderate slope upon reaching the valley floor. A DWQ Stream Identification Form (v. 3.1) was completed at a point on the tributary upstream of the piped reach. The stream scored 28 points, indicating that it is an intermittent stream on the threshold of a perennial stream (which requires 30 points).

Appendix D-Morphological Table presents the dimension of the existing concrete channel, as well as slopes of the existing valley. The bankfull channel values for the existing channel have not been entered, as a natural channel classification was not possible.

3.2 Discharge

Since a field survey of geomorphic features of UT to Little Mountain Creek was not possible due to its concrete-lining, no bankfull area, width, or pebble counts could be obtained. Therefore, calculating a bankfull discharge using the continuity equation, and a resistance equation such as Mannings or Darcy-Weisbach was not possible.

3.3 Channel Morphology

The current concrete-lined state of UT to Little Mountain Creek possesses no sinuosity, a uniform dimension, and a profile which matches the changes in valley slope on the project site. See Appendix D for more detail.

3.4 Channel Stability Assessment

The existing channel of UT to Little Mountain Creek is relatively stable, but only due to the manmade concrete lining present along the entire project reach. Some instability in the concrete walls of the channel is present, but has been mitigated through the use of timber buttresses spread evenly along the channel. In some places, the concrete bed of the channel has been broken over time, revealing slate bedrock beneath the channel. The key issue with UT to Little Mountain Creek does not revolve around typical instability problems such as bank erosion, but with its almost complete lack of natural stream conditions and habitat, and it's functioning as a streamlined confluence of all the watersheds stormwater. Because it is artificially deep, it is unable to access a floodplain, which facilitates complete discharge of the pollutants from the golf course and the runoff of the impervious surfaces of Badin into the 303(d) listed Little Mountain Creek.

3.5 Bankfull Verification

The bankfull area of UT to Little Mountain Creek was verified using the North Carolina Mountain and Piedmont regional curve, as compiled by the Natural Resources Conservation Service, NC Soil and Water Conservation and NC State University, with the known drainage area of 0.5 square miles. The curve shows that a stream with this drainage area should have a cross-sectional area of approximately 13.1 square feet, a width of approximately 10.1 feet and a depth of approximately 0.5 feet. **Table 5** presents a summary of this data.

Table 5. Summary of Regional Curve data for UT to Little Mountain Creek

	DA	**A_{BKF}**	**W_{BKF}**	**D_{BKF}**
UT to Little Mountain Creek	0.5 sq mi	13.1 sq. ft.	10.1 ft	1.2 ft

3.6 Vegetation

The existing vegetation on most of the project site consists of golf course managed grasses mowed to an approximate 2" height on a weekly basis, and sparse areas of planted pine. The grass is mowed up to the stream channel, and on one site visit it was observed that grass clippings are dumped directly into the stream channel. Where the conservation easement reaches the riparian area of Little Mountain Creek, approximately 250 feet from the end of the project, the managed vegetation gives way to an area of mixed bottomland-hardwood forest, with an overstory consisting of willow oak (*Quercus phellos*), pignut hickory (*Carya glabra),* shagbark hickory (*Carya ovata*), American elm (*Ulmus americana*), and red maple (*Acer rubrum*). The understory consists of hornbeam (*Carpinus caroliniana*) and Chinese privet (*Ligustrum sinese*). This riparian area is included in an area classified in the National Wetlands Inventory by the USFWS. Notwithstanding this, no potential jurisdictional wetlands were found on the project property.

4.0 REFERENCE STREAMS

Two streams were used as reference reaches for the Badin Inn stream restoration project. The search for suitable reference reaches involved finding a stream with a similar proposed classification, valley type, drainage area, and within a similar physiographic province as the project stream. In the end, one stream was chosen from nearby Uwharrie National Forest because of its good bankfull indicators and because it represents the typical headwater stream found within the Uwharrie Mountains. A second stream, an unnamed tributary to Meadow Fork, was chosen from the foothills of the Blue Ridge Mountains, and while not within the same physiographic province, possesses a very similar valley and valley slope as the project stream. Dimensionless ratios were developed from these two reference reaches and were used to calculate pattern, profile and dimension for the proposed restored stream.

4.1 Watershed Characterization

Spencer Creek

Spencer Creek is located within the Uwharrie National Forest in Montgomery County, North Carolina off of Tower Road (State Road 1134), and is within the Yadkin-Pee Dee River Basin (Figure 5). The drainage area of Spencer Creek is approximately 0.5 square miles. The watershed consists of mature hardwood forest with some planted pine areas in the upper parts of the watershed. Tower Road passes through a portion of the watershed, but the surveyed reference reach is upstream of this crossing. Similar to the watershed of UT to Little Mountain Creek, the watershed of Spencer Creek is within the unique geology of the Uwharrie and Slate Belt region, has a similar drainage area, and a similar valley type.

Unnamed Tributary to Meadow Fork

UT to Meadow Fork, a third order stream, is located adjacent to the Blue Ridge Parkway in Allegheny County, North Carolina and is within the New River Watershed (**Figure 6**). The watershed consists mainly of forested land, but the surveyed reach is located in a decades-old fallow pasture.

4.2 Channel Classification

Spencer Creek

Based on an existing conditions survey, Spencer Creek can be classified as a Rosgen "C4" channel, with a portion of the reach exhibiting the slope of a "B4" channel.

Unnamed Tributary to Meadow Fork

The surveyed reach is located in a decades-old fallow pasture and has been relieved of active grazing for four years prior to surveying. Relic benches indicate the original channel was an "E" channel, which then downcut and widened with grazing pressure and vegetation removal years ago. A stable "C" channel appears to have existed for several decades and then cessation of grazing allowed the channel to transition to an E in the years prior to being surveyed.

4.3 Discharge (bankfull, trends)

Discharge was calculated for the two reference reaches using the continuity equation for discharge and Mannings equation for resistance. Manning's "n", a required input of the Mannings equation, was calculated using the D_{84} obtained from the pebble count data and the Limerinos data showing a relationship between the relative roughness of a stream and the 84^{th} percentile particle diameter (NRCS, 2007). Velocity was also verified using the Darcy-Weisbach resistance equation, and the U/U* method. The inputs for each of these equations are shown in **Appendix D -Morphology table**. Results and a brief discussion of these calculations follow.

Spencer Creek

Table 6 shows the results of the discharge calculation for Spencer Creek.

Table 6. Dicharge and velocity calculations for Spencer Creek.

	Mannings	Darcy-Weisbach	U/U*
Velocity (fps)	3.42	3.63	3.16
Discharge (cfs)	36.94	39.24	34.17

According to Mountain/Piedmont regional curves, the bankfull discharge for a drainage area of 0.5 square miles should be approximately 50.64 cfs, which is significantly higher than the calculated discharge. However, one of the gage stations used in the development of the regional curves is on Dutchmans Creek, which is nearby Spencer Creek and within the Uwharrie Mountains. The data point collected on Dutchman's Creek shows a discharge that is well below the curve, with a bankfull discharge of only 84 cfs for a drainage area of 3.4 square miles, where the curve would have the discharge at 211 cfs. In addition, the regional curve for North Carolina/Tennesee, which uses datapoints collected in the mountains of North Carolina and Tennessee, indicates that the discharge should be approximately 30 cfs. Thus the bankfull discharge of streams in the Uhwarries may be more similar to that of the western mountains.

Unnamed Tributary to Meadow Fork

Table 7 shows the results of the discharge calculation for UT to Meadow Fork.

Table 7. Dicharge and velocity calculations for UT to Meadow Fork.

	Mannings	**Darcy-Weisbach**	**U/U***
Velocity (fps)	4.84	4.60	4.56
Discharge (cfs)	74.25	70.61	70.01

The Mountain/Piedmont regional curves indicate that a stream with a drainage area of 1.32 square miles should have a discharge of approximately 103.9 cfs. The North Carolina and Tennessee regional curve gives a discharge of 74.31 cfs, which is very close to the calculated discharge using the Mannings equation.

4.4 Channel Morphology (pattern, dimension, profile)

Detailed morphological information for the reference reaches can be found in **Appendix D**.

Spencer Creek

Spencer Creek possesses a dimension, pattern and profile typical of "C" streams. The stream is only slightly sinuous, and possesses relatively small radius of curvature and pool to pool spacing.

Unnamed Tributary to Meadow Fork

Relic benches indicate that UT Meadow Fork's original channel was an "E" channel, which then downcut and widened with grazing pressure and vegetation removal years ago. A stable "C" channel appears to have existed for several decades and then cessation of grazing allowed the channel to transition back to an E in the years prior to being surveyed. The stream possesses very stable pattern, dimension and profile thus making it ideal as a reference reach.

4.5 Channel Stability Assessment

Several indices may be used to determine the stability of a stream, including incision, degree of lateral confinement, bank erosion hazard index (BEHI), near bank stress, sediment competence and sediment capacity. All streams naturally undergo a certain amount of channel adjustment and erosion, but when the indices indicate an increase in magnitude and frequency of adjustment processes when compared to a stable condition, a stream can be labeled as unstable (Rosgen, 2006). In evaluating the overall stability of the reference reaches for this project, the best available data was used to calculate as many indices as possible for each reach. While a comprehensive stability analysis would necessarily require quantitative determinations of sediment capacity, the collection of data required in such an analysis is very intensive and time-consuming, and was beyond the scope of this analysis. RiverMorph® software was used to quickly calculate these indices, and the results follow.

Spencer Creek

Table 8 displays a summary of several stability indices used in evaluating Spencer Creek as a reference reach. The indices were chosen based on the availability of data for this particular reference reach. BEHI data was not collected and therefore does not factor into the stability analysis. Taken as a whole, the indices indicate that Spencer Creek is a stable stream.

Table 8. Stability Indices for Spencer Creek.

Stability Index	Meander Width Ratio	Sediment Competence (Degradation)	Sediment Competence (Aggradation)	Bank Height Ratio (avg.)
Rating	8.0	Largest movable particle = 100.8 mm	Min. Depth needed = 0.33 ft	1.1
		Largest measured particle = 90 mm	Actual stream depth = 1.3 ft	
Comment		Does not indicate excess competence	Sufficient depth to transport largest size available	Not incised

The lateral stability index of meander width ratio falls within the typical values of a type "C" stream, thereby indicating lateral stability (Rosgen, 2006).

Sediment competence indicates if a stream has the ability to move the largest particle in the stream (the D_{100}) by possessing sufficient slope and/or depth. Insufficient slope or depth can indicate that a stream is aggrading. In addition, a dimensional shear stress calculation can be used to determine if a stream can move a larger particle than what was measured, which indicates that a stream has *excess* energy, and is therefore degrading. Bank Height ratio, which is the ratio of low bank height to bankfull maximum depth, is another measure of vertical stability.

On this reach, the largest measured particle is very close to the calculated moveable largest particle which indicates that there is very little excess energy in the stream. Furthermore, the stream has sufficient depth to transport the largest size available. These two results indicate that stream is neither aggrading nor degrading. The bank height ratio value of 1.1 also indicates that the stream is not incised, and is therefore vertically stable.

Visual observations of the stream also indicated that it was stable. No areas of severe bank erosion or undercutting were observed, nor were there any recent signs of channel avulsion, or excess sediment deposition.

Unnamed Tributary to Meadow Fork

Table 9 displays a summary of several stability indices used in evaluating UT to Meadow Fork as a reference reach. Taken as a whole, the indices indicate that UT to Meadow Fork is a stable stream.

Table 9. Stability Indices for UT to Meadow Fork.

Stability Index	Dominant BEHI/NBS	Meander Width Ratio	Sediment Competence (Degradation)	Sediment Competence (Aggradation)	Bank Height Ratio (avg.)	Pfankuch	
						Rating	Condition
Rating	Low/Moderate	4.0	Largest movable particle = 130.7 mm Largest measured particle = 120 mm	Min. Depth needed = 0.83 ft Actual stream depth = 1.3 ft	1.1	56	Good
Comment	Indicates stability		Does not indicate excess competence	Sufficient depth to transport largest size available			

In terms of lateral stability, the meander width ratio is within the low range of an average type "C" stream. While UT Meadow Fork classifies as an "E" stream based on cross-section and profile parameters, the lower belt width is indicative of the evolution of the stream, which has developed into an "E" form after downcutting and widening due to the cattle grazing on the floodplain. Therefore, the stream is likely still laterally constrained within the new, downcut floodplain. The dominant BEHI rating along the stream was "Low", and the dominant near bank stress was moderate. These two values taken together usually indicate a stable stream (Rosgen, 2006).

The vertical stability ratings for the stream, Sediment Competence and Bank Height Ratio, also tend to indicate a stable stream. In this case, the largest measured particle is very close to the calculated moveable largest particle, which indicates that there is very little excess energy in the stream. Furthermore, the stream has sufficient depth to transport the largest size available. These two results indicate that stream is neither aggrading nor degrading. The bank height ratio value of 1.1 shows that the stream is not incised, and is therefore also tends to indicate vertical stability.

Visual observations of the stream also indicated that it was stable. No areas of severe bank erosion or undercutting were observed, nor were there any recent signs of channel avulsion, or excess sediment deposition.

4.6 Bankfull Verification

The bankfull area of each reference reach was verified using the North Carolina Mountain and Piedmont regional curve, as compiled by the Natural Resources Conservation Service, NC Soil and Water Conservation and NC State University, with the known drainage areas for each reference reach watershed.

Spencer Creek

Table 10. NC Mountain/Piedmont Regional Curve Data for Reference Reaches.

	DA	**A_{BKF}**	**W_{BKF}**	**D_{BKF}**
Spencer Creek	0.5 sq mi	13.1 sq. ft.	10.1 ft	1.2 ft
UT to Meadow Fork	0.5 sq mi	13.1 sq. ft.	10.1 ft	1.2 ft

The morphological table (**Appendix D**) shows that Spencer Creek has a bankfull area of approximately 10.8 square feet. This figure is close but slightly under the regional curve, and may indicate a tendency in the slate belt for bankfull to occur at a slightly smaller discharge, and with a slightly smaller area. This was also verified by the discharge calculation (see Section 4.2).

Unnamed Tributary to Meadow Fork

UT to Meadow Fork has a bankfull area of approximately 12.3 feet which is very close to the regional curve value.

4.7 Vegetation

Spencer Creek

The riparian area of Spencer Creek is composed primarily of a mesic mixed hardwood forest (Figure 9) with mixed areas of pine. Common species in this community type include tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), northern red oak (*Quercus rubra*), and sugar maple (*Acer saccharum*). The understory is dominated by flowering dogwood (*Cornus florida*), hop-hornbeam (*Ostrya virginiana*), and American holly (*Ilex opaca*) (Schafale et. al, 1990). Other species that were observed at Spencer Creek include mountain laurel (*Kalmia latifolia*) and a dense mixture of various species of ferns.

Unnamed Tributary to Meadow Fork

The riparian area of UT to Meadow Fork is composed of a fallow cattle pasture containing typical pasture grasses. While the stream has since stabilized through this pasture after relief of grazing, the reference reach did not provide a suitable vegetative reference.

5.0 PROJECT SITE WETLANDS

Earth Tech conducted a survey to determine the presence of potential jurisdictional wetlands. No potential jurisdictional wetlands were found on the project site.

6.0 PROJECT SITE RESTORATION PLAN

6.1 Restoration Project Goals and Objectives

The overarching goals of the Badin Inn stream restoration project are:

- Restoring the pre-disturbance ecology and hydrology of a perennial, unnamed tributary to Little Mountain Creek, which was hardened with concrete and relocated to its present location nearly a century ago.
- Improvement of flood attenuation characteristics of a highly urbanized and industrialized watershed.
- Removal of pollutant influx from the adjacent golf course management practices.
- Improve aquatic habitat of the main channel with the use of natural material stabilization structures such as root wads, log vanes, woody debris, and a riparian buffer.
- Provide aesthetic value, wildlife habitat, and bank stability through the creation of a riparian zone.
- Create a contiguous wildlife corridor, with connection of the adjacent natural habitats and state natural heritage areas including Morrow Mountain State Park, Little Mountain Creek riparian corridor and Badin basic forest.
- Provide shading and biomass input to the stream and mast for wildlife when vegetation is mature.
- Provide educational opportunities with information signs along the project and take advantage of the high exposure of the project.

The objectives, which specify how each of the goals will be obtained, are :

4) construct a new stream channel in the valley of the existing stream that:
    a) possesses plan, profile and cross-section appropriate for streams in the Uwharrie Mountains region of the piedmont, as based on reference reaches.
    b) Will contain changes in stream type that are appropriate for changes in the valley slope along the project.
    c) will have bedload introduced into channel to account for the lack of bedload produced by the watershed, and for any excess shear stress generated by the lack of bedload and to provide instream habitat. The bedload will be sized appropriately based on entrainment calculations, while also ensuring that the bedload will not be mobilized out of the stream completely following restoration.
    d) will be raised where practical so that bankfull elevation meets the existing floodplain.
    e) Will have structural measures to protect outside meander bends before vegetation becomes established. The structures will contain woody material for habitat, and stone material that is sized appropriately for a stream with a cross sectional area of only approximately 13 square feet.
5) establish a riparian corridor that:
    a) is planted with local propagules of native vegetation.

   b) meets the minimum vegetative criteria for survival(outlined below in Section 7.2).
   c) contains riparian wetland "swales", to improve the quality of water passing through the buffer, to provide floodplain storage for reduction of overbank flood velocities and flooding, to increase the functional diversity of vegetation within the riparian corridor, and to protect the stream channel during flood events.
6) implement educational and aesthetic components:
   a) install several information kiosks along the edge of the conservation easement with information on stream ecology, hydrology and stream restoration.
   b) use blue bird boxes as conservation easement boundary markers along with a barrier/low fence along the easement boundary that will prevent maintenance equipment from entering the easement.

The specific strategies for restoring the abiotic and biotic components of the UT to Mountain Creek riparian ecosystem are more fully described below in Sections 6..2 and 6.7. The third objective of abating pollutant input, is expected to occur with the completion of restoration, which will limit nutrient input from the adjacent golf course.

6.2 Designed Channel Classification

The current channel of UT to Little Mountain Creek flows through a relatively narrow valley which widens further downstream, has moderate to gentle slopes, and appears to be formed from alluvial depositional processes. Based on valley slope, the stream type most appropriate for this valley in the Slate Belt ecoregion of North Carolina is a "C" or an "E" channel. Based on reference reach data, and observation of similarly sized streams within similar valley types, the particle sizes most appropriate for this stream type in the Slate Belt are gravel and cobble.

While an "E" channel is the evolutionary endpoint of stream channel succession in the piedmont of North Carolina, it is difficult to construct a stable "E" channel due to lack of vegetative control in the form of rooting mass of streambank trees and shrubs. Therefore, the restored stream will be designed as a "C" channel, which possesses higher width/depth ratios, longer meander lengths, larger radii of curvature and narrower belt width than an "E" channel. Overtime, with the successful growth of tress and shrubs, particularly on outer meanders, vegetation will cause the point bars of the pools to steepen, which will narrow the width of the stream and increase its depth, thereby creating the width/depth ratio characteristic of an "E" channel. With gravel and cobble introduced into the stream, the proposed channel will be classified as a "C4" channel. Morphological criteria for the designed channel is shown in **Appendix 4**.

The restoration of UT to Little Mountain Creek will be a Priority I restoration, in that the bed elevation of the restored stream channel will be raised so that bankfull is at the existing floodplain elevation. In some areas, the bankfull elevation will need to be lowered where certain constraints, such as pipe invert elevations, have to be met. This lowering will not be any greater than 1 foot below the existing ground elevation. In these areas, a floodplain width that is sufficient to provide the necessary floodprone width (width at 2 x maximum bankfull depth) will be established by grading both sides of the stream.

A short, piped intermittent tributary, approximately 141 feet in length, enters the main channel approximately 500 feet downstream of the beginning of the project. This channel will be designed similar to the main channel, however due to the constraint of having to meet the upstream invert elevation where the pipe enters the conservation easement, the tributary will be restored as a Priority II restoration and a type "C" channel. The stream has a much smaller drainage area (approximately 0.05 square miles) than the main channel, and it will be designed with a cross-sectional area of only approximately 2.7 square feet.

6.3 Sediment Transport Analysis

A stable stream has the capacity to move its sediment load without aggrading or degrading, and the competence to move the largest size particle produced by the watershed. UT to Little Mountain Creek poses a unique situation in the calculation of stream competence and stream capacity. From observations, it appears that the watershed of the stream currently produces little to no bed load, and very little suspended sediment. This is because the stream is channelized in concrete from the headwaters of the stream, where flow is first apparent in the channel, downstream to it's' confluence with Little Mountain Creek. As such, no significant amount of particles are entering the stream and thus the bedload typical of streams in the Uwharrie Mountains region is not available. In addition, any suspended sediment traveling through the system is most likely entering from parking lots and yards, rather than from stream banks as it would in a natural stream system.

Due to the lack of bedload in UT to Little Mountain Creek, no pebble counts or bar/subpavement samples could be obtained. Stream competence using critical dimensionless shear stress, which relies on these two sets of empirical data, could therefore not be calculated for the existing channel in order to provide parameters of the required slope and depth of the design channel that would be needed to move the largest particle. Instead, the shear stress of the proposed channel, which was designed based on reference parameters, was calculated to ascertain what the largest particle it could move should be. This was done by using the equation for dimensional shear stress, which is given by:

$$\tau = \gamma R s$$

where, τ=shear stress (lb/ft^2)
γ=specific gravity of water (62.4 lb/ft^3)
R=hydraulic radius (ft)
s=average bankfull slope (ft/ft)

Hydraulic radius is calculated by:

$$R = \frac{A}{P}$$

where, R=hydraulic radius
A=cross-sectional area (ft^2)
P=wetted perimeter (ft)

Wetted perimeter and cross-sectional area were measured off of a CADD file of the proposed typical riffle cross-section, in order to calculate the largest particle that could be mobilized by the proposed stream. Average bankfull slope was calculated from the proposed profile for the stream.

Thus,

$$R = \frac{12.12\,ft^2}{15.04\,ft} = 0.81\,ft$$

Therefore,

$$\tau = (62.4\frac{lb}{ft^3})(0.81\,ft)(0.011\frac{ft}{ft}) = 0.55 lb/ft^2$$

.

Using the Shields curve with revised Colorado data collected by Rosgen (2006), the calculated shear stress is sufficient to move a particle with a diameter from 30.5 mm (Shields curve), to 92.1 mm (Rosgen's Colorado Data for gravel bed streams). The Shields relation generally underestimates particle sizes of heterogeneous bed material in the shear stress range of 0.05 lbs/ft^2 to 1.5 lbs/ft^2 (Rosgen, 2006). Since the calculated shear stress for the proposed channel is 0.55 lbs/ft^2, the actual largest moveable particle is most likely closer to 92.1 mm.

The calculated largest particle size that could be moved by the proposed channel based on the natural channel design of UT to Little Mountain Creek is similar to the largest particle sizes measured in reference reaches and nearby channels in the Uwharrie Mountain region, thus validating that the stream competence of the proposed stream is appropriate for the region. However, due to the lack of bedload from the existing channel and from upstream to match the calculated shear stress, excess shear stress could potentially be produced in the proposed stream with the potential for degradation. Therefore, in order to provide a truly complete restoration of the stream, bedload will be introduced into the new channel.

Introduction of bedload into the proposed stream along the riffle sections is not only necessary to provide the equilibrium of critical shear stress to largest particle size that is indicative of stream stability, but is also necessary to restore biological function for stream organisms such as fish, benthic macroinvetebrates and periphyton. The aggregate placed in the riffle sections will be placed only in the bed, and effort will be made to ensure that crushed slate or other material native to the Uwharries mountain region will be used. To ensure that the aggregate will not mobilize out of the restored channel, the D_{84} of the aggregate will be set to the D_{100} size (92 mm) as calculated above.

6.4 HEC-RAS Analysis

A HEC-RAS analysis was performed by hydrologists at Earth Tech after completion of an initial design of stream plan, profile and cross-section. The analysis was performed to answer two significant questions: 1) will the restored channel cause any increase or decrease in flooding of the surrounding golf course, or neighboring properties, thereby causing hydrological trespass, and 2) will the restored channel affect a FEMA-regulated Special Flood Hazard Area (SFHA) through an increase in water surface elevations during the 100 year flood event? As a result of the analysis, no hydrologic trespass or changes to a FEMA-regulated SFHA requiring a "no-rise" study,CLOMR/LOMR is expected.

The background information, methodology and results of each of these separate analyses follows.

6.4.1 Hydrologic Trespass

While gathering data for the restoration plan, Earth Tech spoke with staff and regular members of the Badin Inn golf course and learned that UT to Little Mountain Creek, in its concrete-lined state, regularly floods out of its hardened banks onto the surrounding fairways of the golf course. A Priority I restoration is proposed for the restored channel, and therefore a HEC-RAS analysis was undertaken to validate the design and determine to what extent flooding will be affected. UT to Little Mountain Creek is an ungaged stream, and therefore, no hydrographical data is available to show the water elevations at various flood recurrence intervals.

Two HEC-RAS models were created to analyze changes in water surface elevations between the existing and restored streams. The existing model used as its primary inputs cross sections cut from surveyed topographical data, flows for the 5-, 10-, 50-, and 100-year recurrence intervals calculated from a Rural Discharges curve (USGS, 2002) and mannings "n" values appropriate for the boundary conditions of the existing channel and floodway: unfinished concrete and mowed golf course grasses.

The proposed model used a modified cross section showing the proposed channel and floodplain as it would appear after final grading. The same flows as the existing model were used as inputs, but mannings "n" values were changed to reflect the graded portion of the floodplain being composed of woody riparian vegetation, the undisturbed portion outside of the conservation easement still being composed of mowed grasses, and a calculated mannings "n" of the restored channel. Mannings "n" for the restored channel was calculated using the Limerinos data, which compares the measured diameter of the 84^{th} percentile particle (D_{84}) with the hydraulic radius of the bankfull channel (NRCS, 2007). A D_{84} of 75 mm was assumed based on introducing bed load of this size and greater into the restored channel (see Section 6.2).

The results of a steady-flow analysis of the existing channel confirm the anecdotal reports given by staff and members of the golf course. The existing channel floods out of its concrete banks and well into the fairways of the golf course during the 5-year flood event. The 100-year flood almost completely covers the valley and fairways of the golf course that lies therein. The proposed model, however, shows that the proposed channel and floodway reduce the flooding of the golf course, but still maintains flooding within the area of the conservation easement during the 5, 50 and 100 year events, thereby helping to restore a natural hydrologic regime within the new floodplain.

As an additional check, a bankfull discharge was calculated for the proposed cross section of the restored channel using the continuity equation (Discharge = Area x Mean Velocity), and this flow was entered in the proposed model. Without any other manipulation of variables, the bankfull water surface elevation was almost exactly at the designed bankfull stage of the proposed channel. This helped to validate the design of the restored channel.

As a result of the HEC-RAS analysis of the existing versus proposed channels, no hydrologic trespass is expected from the restoration of UT to Little Mountain Creek. Flood elevations will be reduced significantly in the existing valley and golf course fairway, thereby meeting the needs of the golf course owner. The new floodplain, however, which is designed to give adequate floodprone width to the restored channel (2 x maximum bankfull depth) will be regularly flooded, thus helping to restore a healthy riparian ecosystem. A summary of the HEC-RAS analysis is included in **Appendix C**.

6.4.2 No-Rise, LOMR, CLOMR

UT to Little Mountain Creek is not within a FEMA Special Flood Hazard Area (SFHA), and therefore no flooding analysis was needed on this channel. However, the receiving stream, Little Mountain Creek, is within a SFHA approximate study (Zone A). Since the conservation easement ends at the confluence of these streams, it was necessary to check for any encroachment into the SFHA of Little Mountain Creek as a result of proposed restoration that would require a no-rise study, a conditional letter of map revision (CLOMR) or letter of map revision (LOMR).

Section 72.2 of the National Flood Insurance Program regulations states that a CLOMR is a "Comment on a proposed project that would, upon construction, affect the hydrologic or hydraulic characteristics of a flooding source and thus result in modification of the existing regulatory floodway, the effective base flood elevations, or the SFHA (44 CFR §72.2)." Furthermore, Section 65.12 requires a CLOMR to be submitted for any encroachment into an existing regulatory floodway that will cause any increases in flood levels (44 CFR §65.12).

The effective Flood Insurance Rate Map (FIRM) that includes the project area shows that Little Mountain Creek is located in an approximate study (SFHA Zone A) (Map Number 37167C0075

D, effective date September 21, 2000). A SFHA designated Zone A does not have determined base-flood elevations (BFEs) and therefore a no-impact study and potential CLOMR/LOMR will only be required if the grading on site will be greater than 5 acres (44 CFR §60.3(b)). In this case, the grading associated with the restoration of UT to Little Mountain Creek within the SFHA of Little Mountain Creek will be less than 5 acres. Therefore, no "no-rise" study will be required, and a CLOMR will not been submitted. The local floodplain administrator, however, has been contacted with this information to verify these assumptions.

At the time of this report, preliminary BFE's and a new, detailed study preliminary SFHA did exist for the portion of Little Mountain Creek at the confluence with UT to Little Mountain Creek, released in August of 2007 by the NC Floodmapping Program. While this study is preliminary and not effective, and therefore at the time of this report does not affect the project, it has been reviewed by Earth Tech in the case that the BFEs do become effective before or after construction. After examining the location of cross-sections and the 100-year flood boundary from this preliminary study, it was concluded that any encroachments to the 100-year floodway from the Badin Stream Restoration will not cause a change in the BFE. The local floodplain administrator has been contacted with this information to verify these assumptions.

6.5 Stormwater Best Management Practices

No Stormwater Best Management Practices are proposed for this project.

6.6 Soil Restoration

No restoration of the soil, through soil amendments or other means, is planned for the Badin Inn stream restoration project. The topsoils on the Badin Inn Stream Restoration site are in fairly fertile condition, having been treated with fertilizers for many decades as part of the golf course management. This topsoil will be reused on the newly graded floodplain. Furthermore, the elevation of the new floodplain will only be 2 feet below the existing grade, and therefore will not likely be deeper than an A horizon soil.

6.7 Natural Plant Community Restoration

Revegetation efforts will emulate natural vegetation communities found along relatively undisturbed stream corridors in the Uwharrie Mountains region. The dominant natural community type within this region along riparian corridors of smaller streams, closely matches the Mesic Mixed Hardwood Forest, as described in *Classification of the Natural Communities of North Carolina* (Schafale et. al., 1990). This forest community is characterized by a canopy of mesic hardwoods, occasional flooding, and a lack of tree species indicating high pH soils.

To quickly establish dense root mass along the channel bank, a permanent native grass mixture will be seeded on the stream bank along with temporary seeding to provide immediate erosion control. Areas around structure installations will be revegetated with live stakes. Live stakes will be installed on the outside of the meander bends to ensure a dense root mass in those areas of high stress. It may be necessary to line key sections of the channel bank with coir matting to provide cover until vegetation can be established. This will be determined further along in the design phase of the project.

Along the tops of the channel banks (riparian area), trees and shrubs will be planted. Live stakes will be utilized to stabilize the banks. In the areas where invasive and exotic species are found during construction and monitoring, control by removal or appropriate herbicides will be implemented to prevent competition with the revegetation efforts. The use of material that is genetically adapted to specific site conditions enhances long-term growth and survival and avoids contaminating the gene pool of the surrounding vegetation with non-adapted ecotypes. Plant material should be native species collected or propagated from material within the Slate Belt ecoregion.

Reforestation plans are provided in **Design Sheets 7-9** and will focus on 3 separate zones having different hydrologic regimes and will include: streambank vegetation, riparian buffer on well-drained floodplain, and wetland swale. Along the streambank, vegetation will be subjected to fluctuating stream flows and stresses. The riparian buffer on the well-drained portions of floodplain will be subjected to occasional flooding, but because of the well-drained nature will be drier much of the year. The wetland swale will be shallow depressions graded into the floodplain and will be subject to occasional flooding, but will temporarily store flood waters, allowing for a wetter hydrological regime than the other two vegetation zones. The following paragraphs describe the vegetation treatments for the 2 individual zones.

Streambank Vegetation

Areas around structure installations on UT to Little Mountain Creek will be revegetated with live stakes. All banks excluding point bars will be reinforced with live stakes. Species that may be proposed for planting in these areas are listed below.

Tag alder	*Alnus serrulata*
Black willow *****	*Salix nigra**
Silky dogwood	*Cornus amomum*

*Use is limited to only in outer meander bends

In addition to the species mentioned above, the streambanks will also be planted with a mixture of herbaceous species. Most notably, soft-rush (*Juncus effusus*) plugs will be installed along the toe of the streambanks. Deer-tongue grass (*Panicum clandestinum*) will be interspersed with the woody vegetation mentioned above.

Woody vegetation will be planted in November or February and March. Care will be taken to make sure that planting occurs in temperatures above freezing to insure maximum seedling survival.

Riparian Buffer - Well-drained Floodplain

The target community to be planted in the riparian buffer and well-drained floodplain zone most closely resembles a Mesic Mixed Hardwood Forest as described in Schafale and Weakley (1990). While this forest community is the desired endpoint of succession for the riparian buffer, the current site conditions do not permit the establishment of some of the species common in this community, which require partial sun to full shade in order to thrive. The site is a south-facing slope on a golf course with no forest canopy and complete exposure to the sun. Therefore, it would be impractical to plant species which require shade or partial shade. Species in this community which are fairly hardy, and can tolerate drought conditions have been chosen, such as Red Oak (*Quercus rubra*) and deerberry (*Vaccineum stamineum*).

Bare root material will be used. Planting a mixture of the species listed below will best reflect the character of stream bank vegetation typically found along small low mountain streams. Species that may be proposed for planting in these areas are listed below.

Flowering dogwood	*Cornus florida*
Patined Buckeye	*Aesculus sylvatica*
Redbud	*Cercis canadensis*
Deerberry	*Vaccinium stamineum*
Serviceberry	*Amelanchier arborea*
Elderberry	*Sambucus Canadensis*
Black gum	*Nyssa sylvatica*
Tulip poplar	*Liriodendron tulipifera*
Northern red oak	*Quercus rubra*
Spicebush	*Lindera benzoin*
Willow oak	*Quercus phellos*
Black oak	*Quercus nigra*
Hawthorne	*Crataegus* spp.

In addition to the species listed above, the riparian buffer zone will also be planted with a herbaceous mixture of warm-season grasses including Indian grass (*Sorghastrum nutans*), big bluestem (*Andropogon gerardii)*, Little bluestem (*Schizachyrium scoparium*), and Switchgrass (*Panicum virgatum*).

Wetland Swales

The target community for the wetland swale zone of the floodplain is a Swamp Forest-Bog Complex as described in Schafale and Weakley (1990). This community is described as occurring in "poorly drained bottomland, generally with visible microtopography of ridges and sloughs or depressions". It is also noted that in addition to being seasonally or intermittently saturated that seepage is sometimes present. Their planting is dependent upon availability. Species that may be proposed for planting in these areas are listed below.

Tag Alder	*Alnus serrulata*	FACW+
Black willow	*Salix nigra*	OBL
Buttonbush	*Cephalanthus occidentalis*	OBL
Elderberry	*Sambucus canadensis*	FACW-
Silky dogwood	*Cornus amomum*	

In order to provide enhanced habitat for amphibious species, the wetland swale zone will also contain "habitat logs". These are logs salvaged from on-site tree removal, which will be placed in various locations with a micro-pool surrounding the root mound.

Areas outside the proposed buffer that are currently vegetated with non-invasive trees or shrubs will remain undisturbed where possible and succession allowed to proceed naturally. The majority of tree removal required in the project will occur in the final several hundred feet of the easement, where the conservation easement is comprised of the riparian area of Little Mountain Creek. Outside of this, the rest of the conservation easement contains golf course grasses and scattered planted pines. Several of the meander bends of the proposed stream alignment have been designed to incorporate the rooting mass of planted trees.

Woody vegetation will be planted between November and March to allow plants to stabilize during the dormant period and set roots during the spring season. A minimum of 680 stems per acre will be planted in portions of the buffer that have been disturbed by construction activities.

The only invasive species found on the project site in great numbers is Chinese privet (*Ligustrum sinese)*. This species is growing in the riparian area of Little Mountain Creek, which comprises the last several hundred feet of the conservation easement. This species will be chemically removed, so as to prevent invasion the restored riparian area following construction.

7.0 PERFORMANCE CRITERIA

The following section outlines the stream monitoring strategy for the proposed restoration. The stream will be monitored to ensure that it is stable. Vegetation will also be monitored. Biological monitoring is also proposed, however, it will not be used to determine project success.

The monitoring report will follow the most recent EEP guidelines at the time monitoring is initiated. The report will discuss the current years' results and will include a discussion of any changes that have occurred on the restoration site. The relative significance of these changes will be discussed in detail and a maintenance plan will be recommended if applicable. The monitoring report will include the current monitoring year's data overlain on the previous monitoring years and design data for the plan, profile and cross-section. In addition, a photo log showing successive conditions at established photo points will also be included.

7.1 Streams

Monitoring of the stability of the channel will occur after the first growing season and will continue annually for a period of 5 years or until two bankfull events have been documented. Bankfull events must be documented during separate monitoring years.

The dimension, pattern, and profile of the stream should show no radical change during the 5-year monitoring period. To determine the presence, magnitude and extent of any changes, the longitudinal profile and cross-sections will be re-surveyed annually. Cross-sections of successive monitoring years will be overlaid to verify no significant change in the dimension from year to year. Similarly, the longitudinal profiles will be overlaid to confirm a stable bed profile, i.e. riffle-pool spacing should remain fairly constant and there should be a general lack of aggradations and degradation.

The criteria for hydrological success will be as follows:

- The restored stream is able to access its floodplain on a regular basis
- The flood attenuation of the stream more closely resembles that of a natural channel, and the reference reach used in design.
- Over time, nothing more than subtle changes in stream dimension and longitudinal profile will occur within the restored stream and the stream can be deemed stable.
- The restored stream does not deviate from the ranges of dimensionless ratios acquired from a reference reach and used to design the restored stream.
- Over time, the stream will constrict slightly and evolve from a “C” channel to an “E”channel as vegetation matures and begins to control the flow of water through the channel.

7.2 Vegetation

Monitoring of vegetation will follow protocols established in the most recent version of the Carolina Vegetative Survey-EEP Protocol. Sample plot distribution will be correlated with the hydrological monitoring locations to help correlate data between vegetation and hydrology parameters. Success will be determined by survival of target species within the sample plots. A minimum of 260 stems/acre must survive for at least five years after initial planting. At least six different representative tree and shrub species should be present on the entire site. If the vegetative success criteria are not met, the cause of failure will be determined and an appropriate corrective action will be taken.

The criteria for vegetative success will be as follows:

- A minimum survival rate of 320 trees per acre in the riparian buffer at the end of 3 years.

- A minimum survival rate of 260 trees per acre in the conservation easement at the end of 5 years.
- The species composition in the riparian buffer meets the diversity criteria established at the beginning of the project.

7.3 Biological Monitoring

In order to document and verify the increase in function from the restoration of UT Little Mountain Creek, Earth Tech will monitor variables above the minimum requirements of stream restoration monitoring. Earth Tech will survey for macroinvertebrates following the NCDENR Standard Operating Procedures for Benthic macroinvertebrates, developed by the Biological Assessment Unit. Because UT Little Mountain Creek is a small 2nd order stream with a 0.5 sq. mi. watershed, the Qual 4 sampling method will be used. Macroinvertebrates will be collected by an Earth Tech biologist with the NC Certification required by the NCDWQ for performing this work. Use of the stream and riparian area by amphibians and other fauna will also be evaluated and documented.

Baseline data will be collected before construction, at Year 3, and at Year 5. This monitoring will help document the anticipated increase in biological functioning of the stream and riparian zone but will not be used in determining the actual success of the stream restoration project. A report of the baseline data will be presented to the DWQ and USACE before construction begins.

7.4 Schedule/Reporting

The following is a proposed project schedule following the completion of this report. This timeline is based upon completing construction and planting of the site by December 31, 2008.

Construction/Planting Completed	December, 2008
Submit Mitigation Report	January, 2009
Submit As-built Plans	February, 2009
Submit Year 1 Monitoring Report	December, 2009
Submit Year 2 Monitoring Report	December, 2010
Submit Year 3 Monitoring Report	December, 2011
Submit Year 4 Monitoring Report	December, 2012
Submit Year 5 Monitoring Report	December, 2013

The mitigation and monitoring reports will follow the most recent EEP methods and templates.

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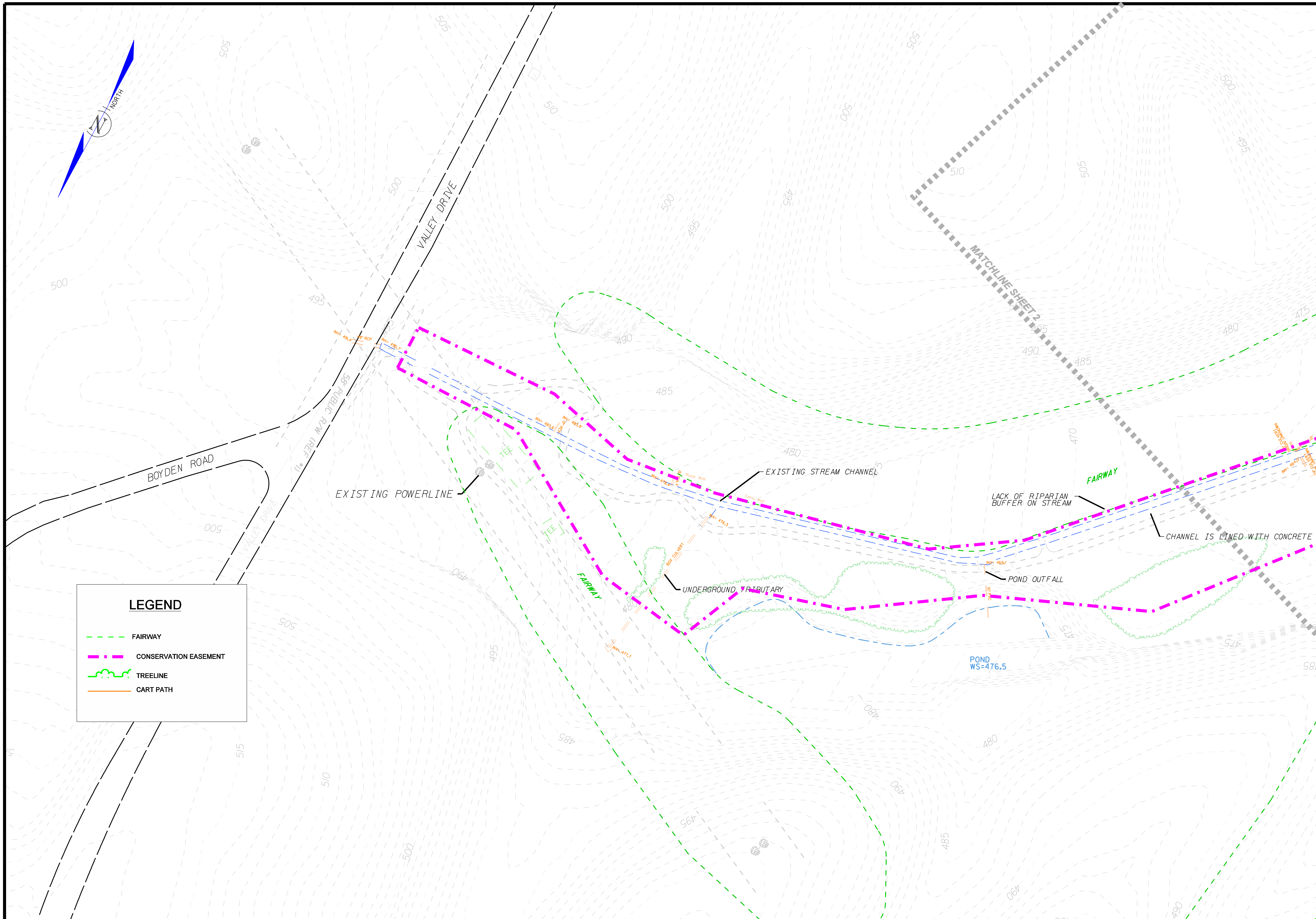

PRELIMINARY PLANS
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HORIZONTAL SCALE
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BADIN INN STREAM RESTORATION
STANLY COUNTY
ECOSYSTEM ENHANCEMENT PROGRAM

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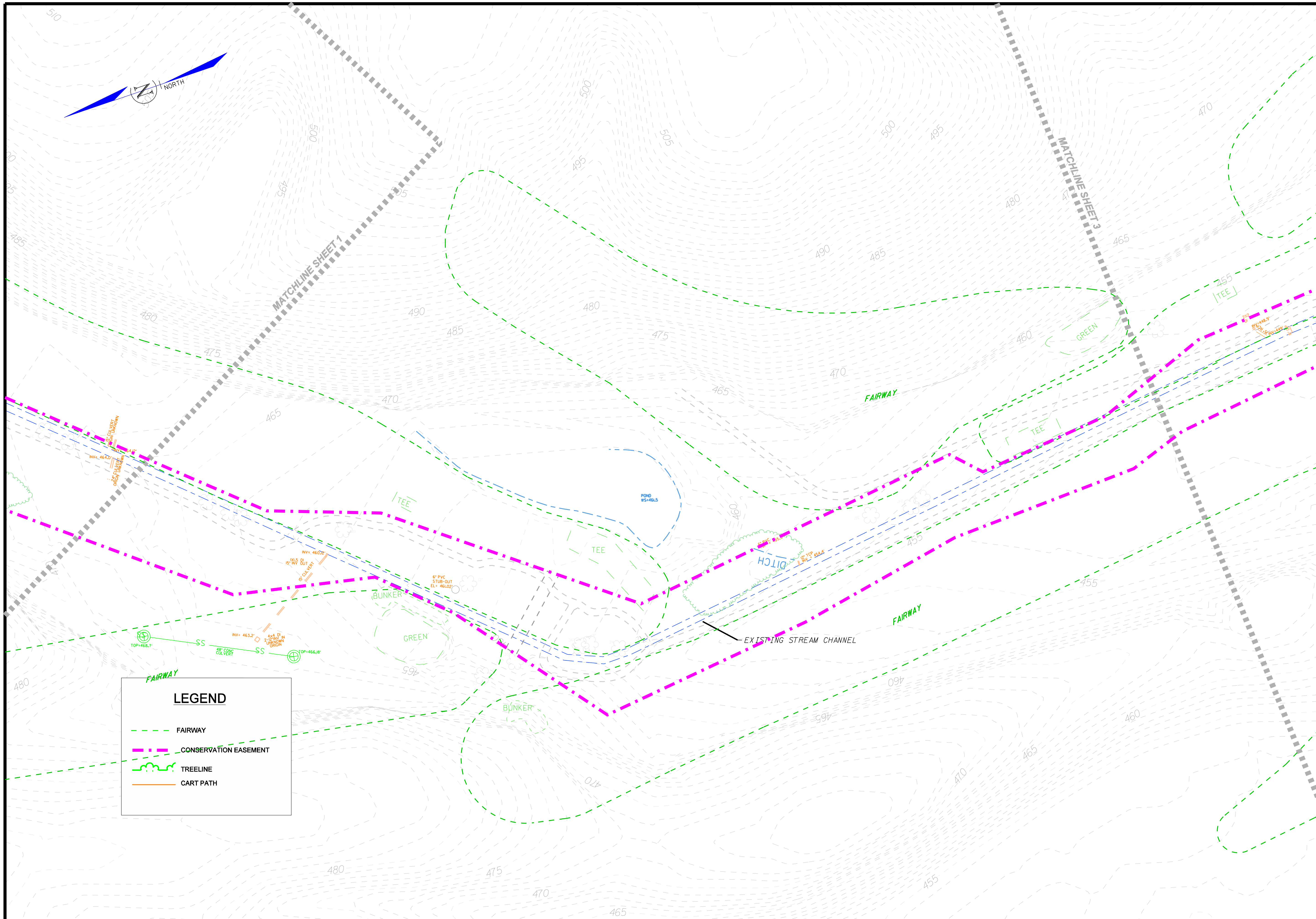

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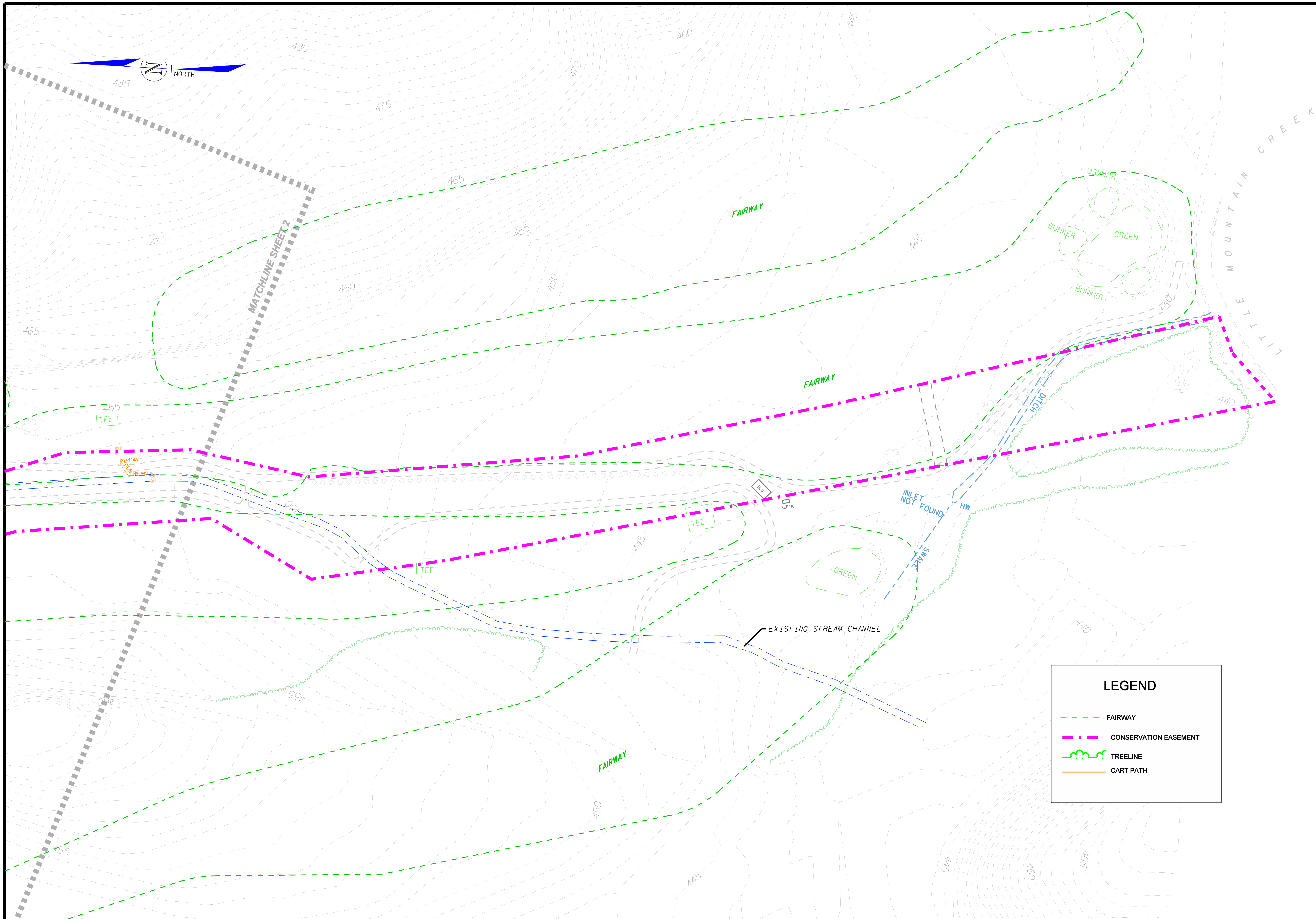

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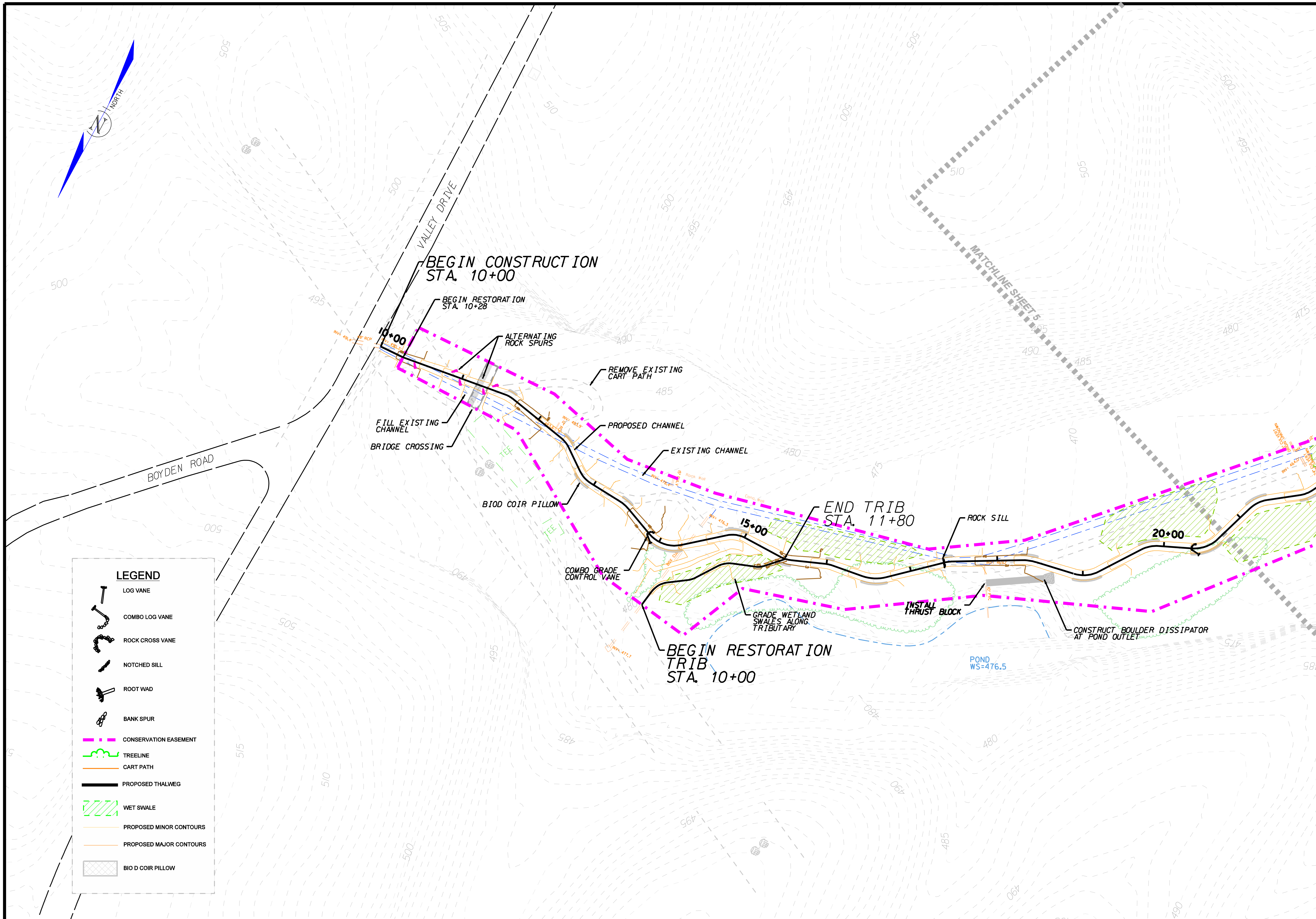

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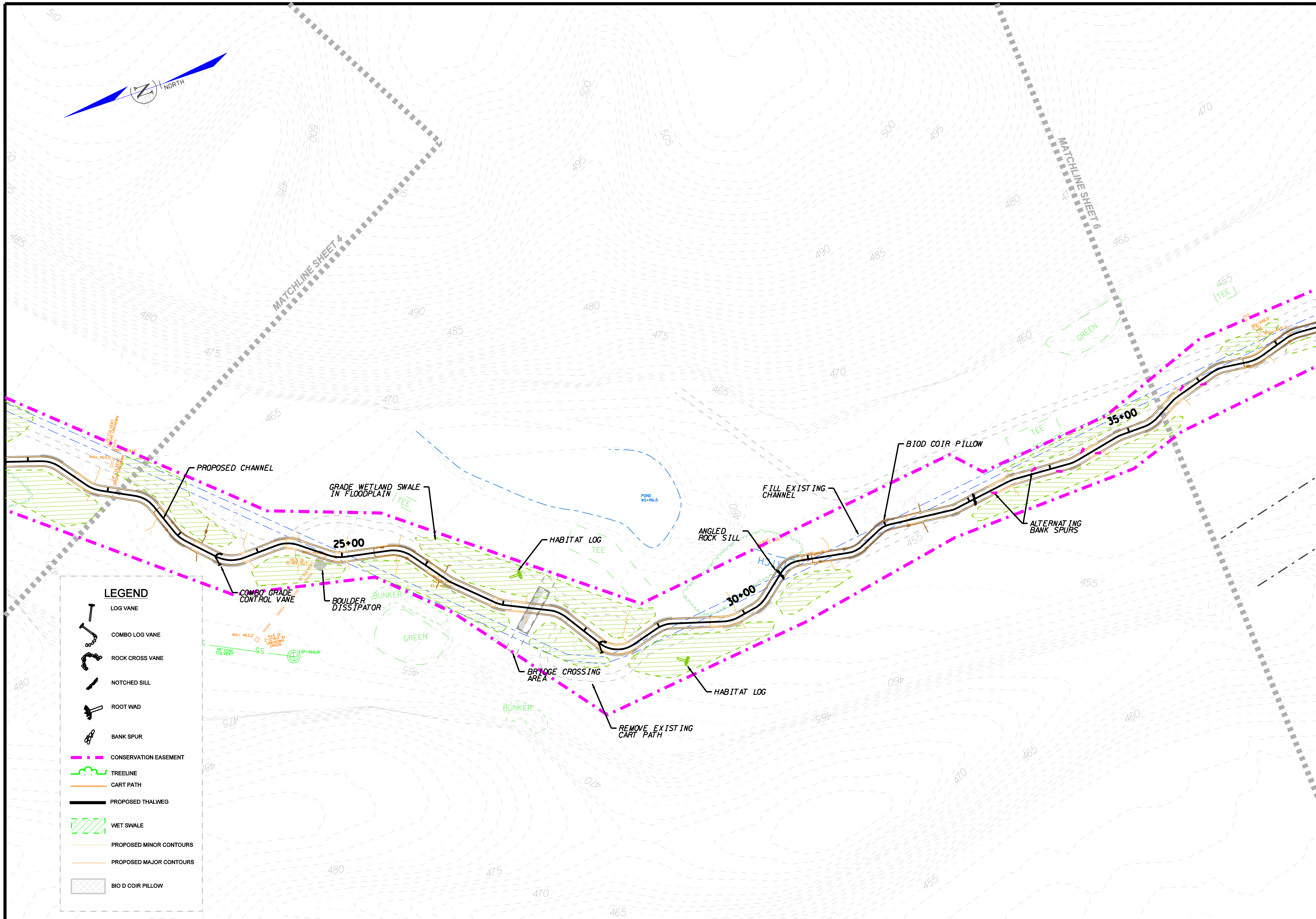

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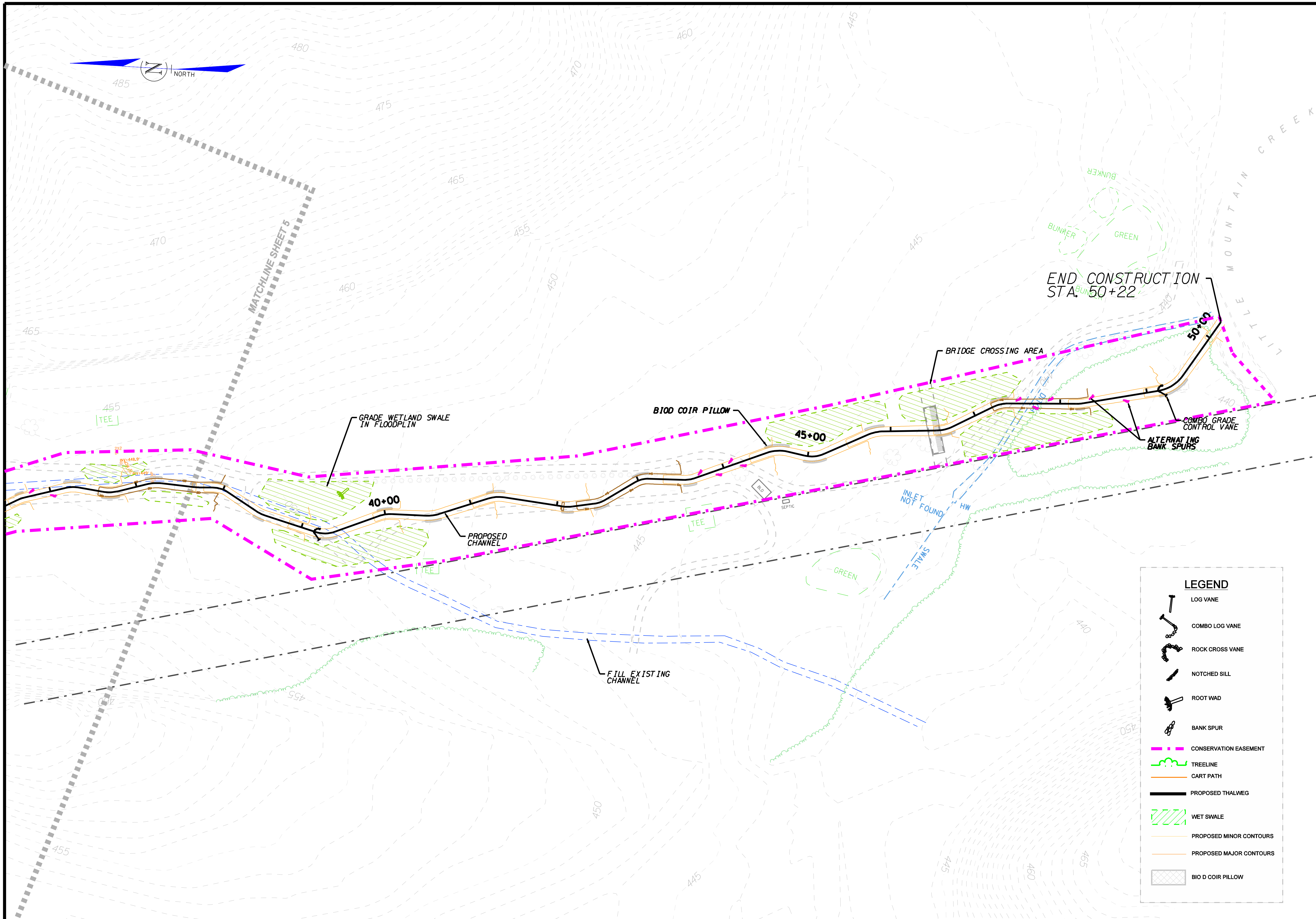

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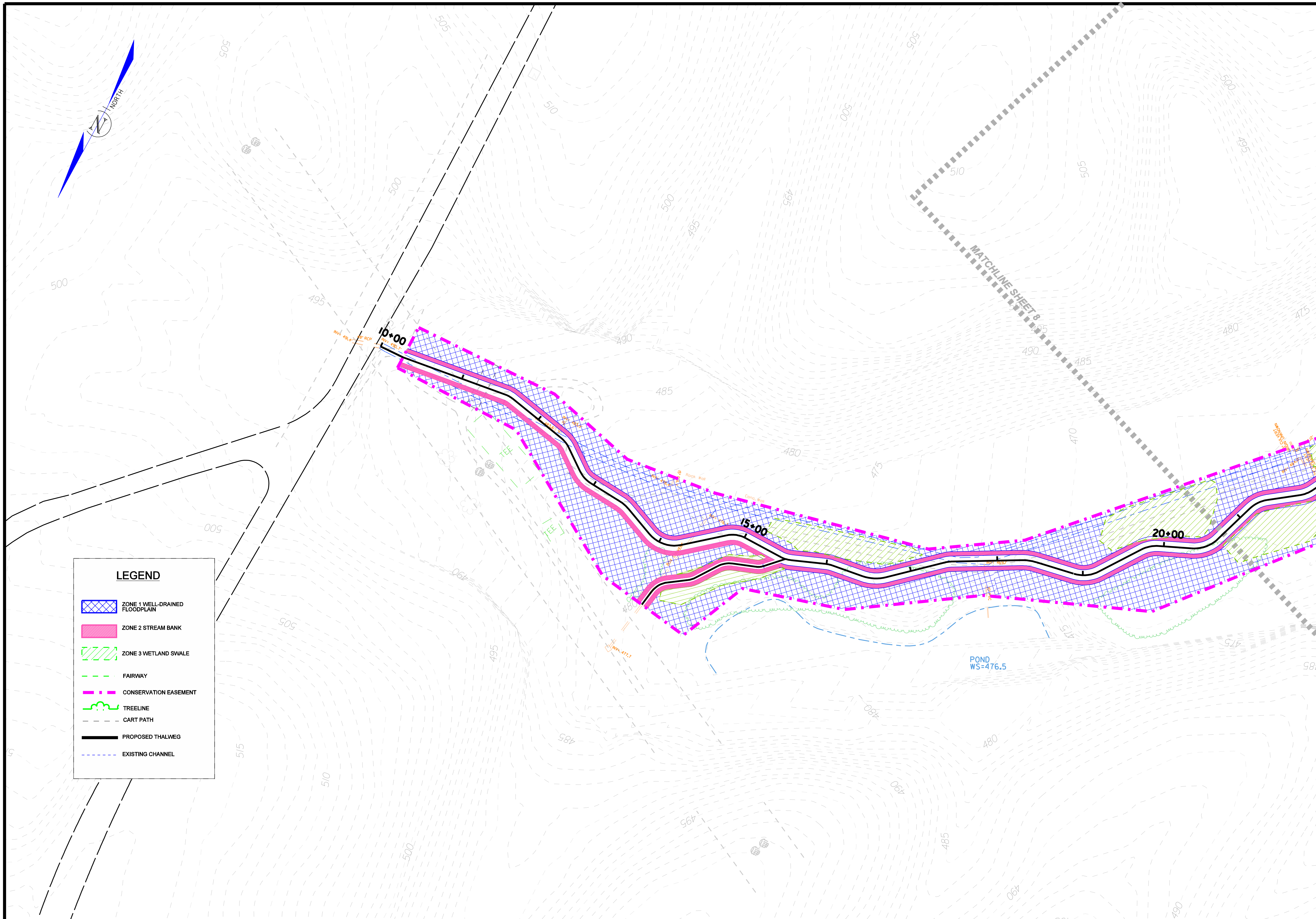

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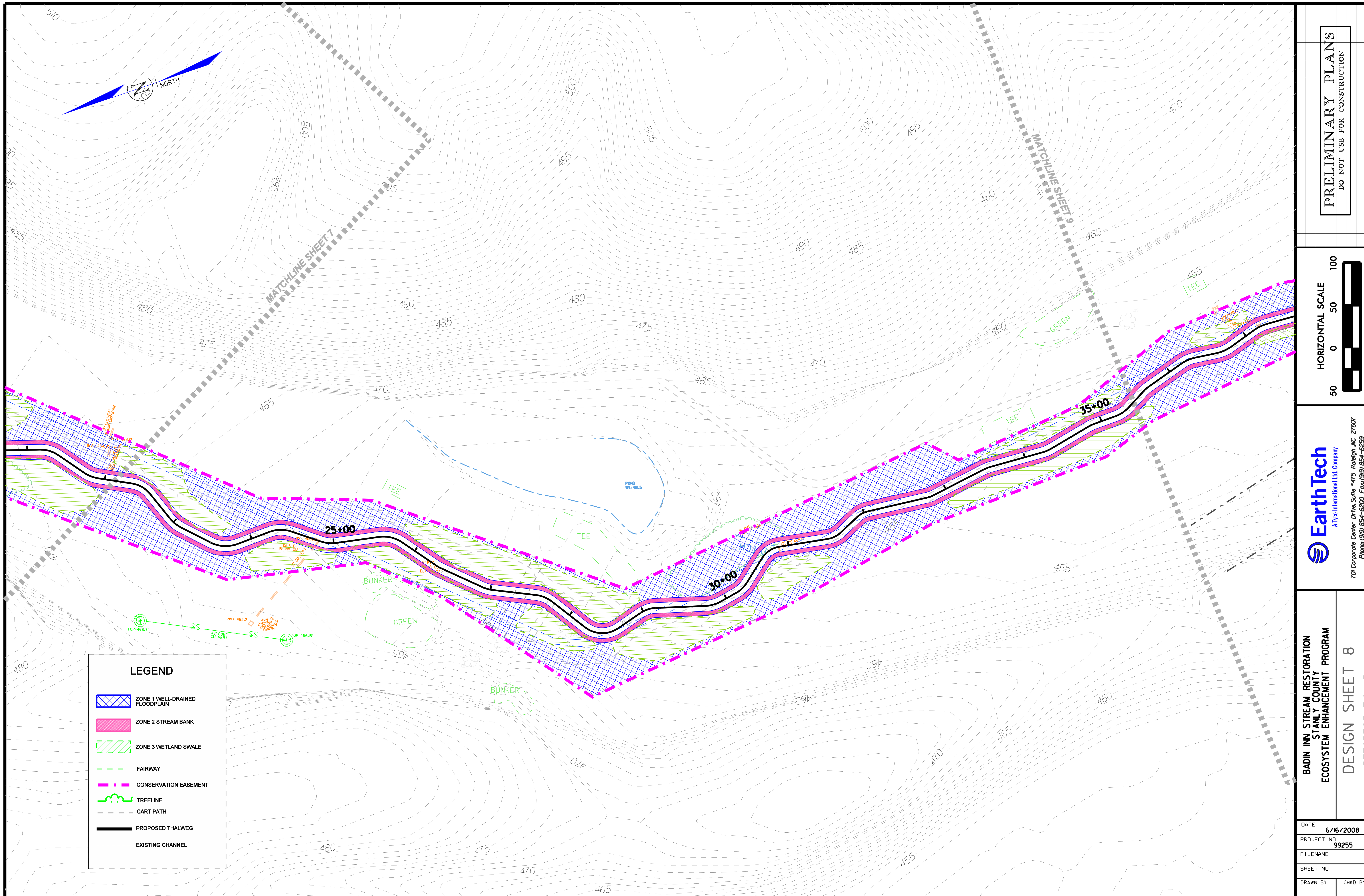

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ZONE 2 STREAM BANK
ZONE 3 WETLAND SWALE
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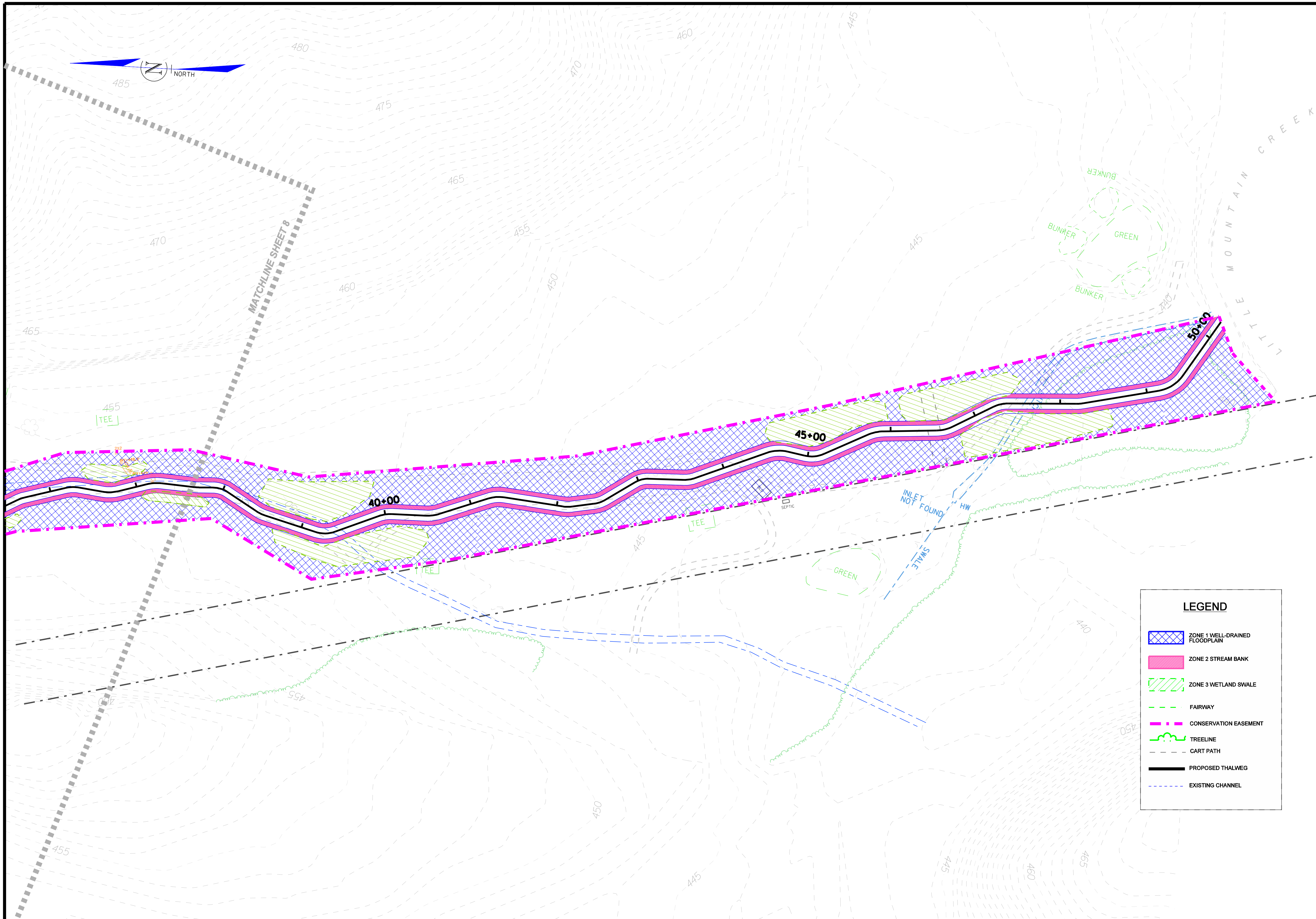

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STANLY COUNTY
ECOSYSTEM ENHANCEMENT PROGRAM

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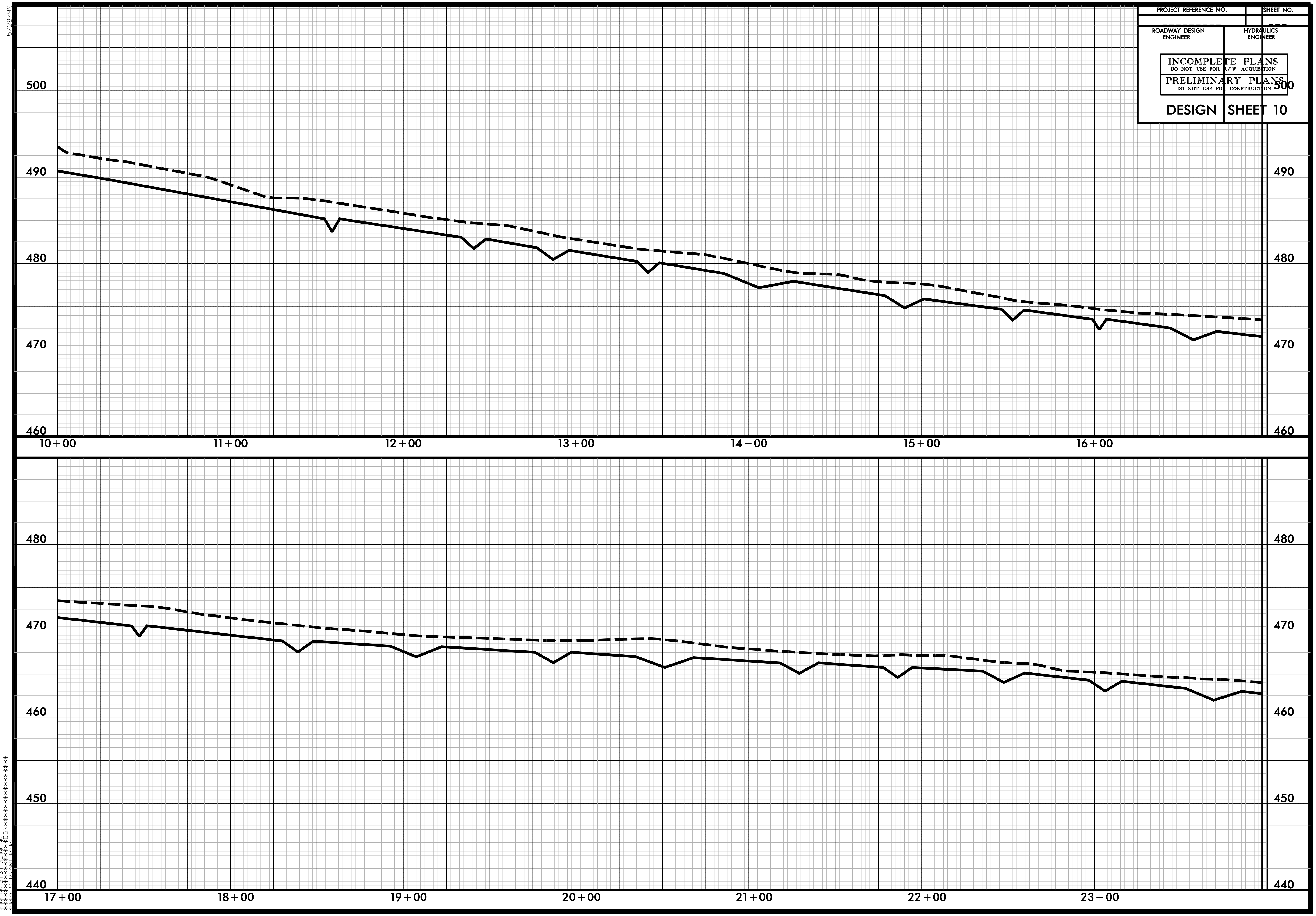
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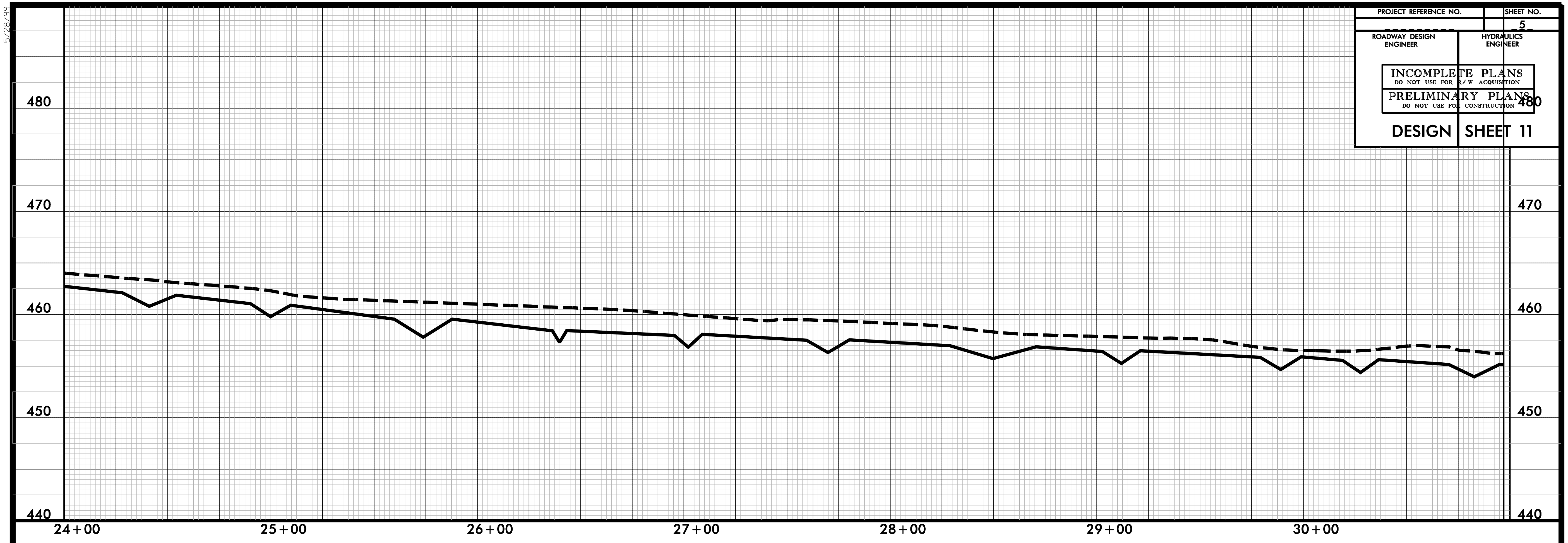

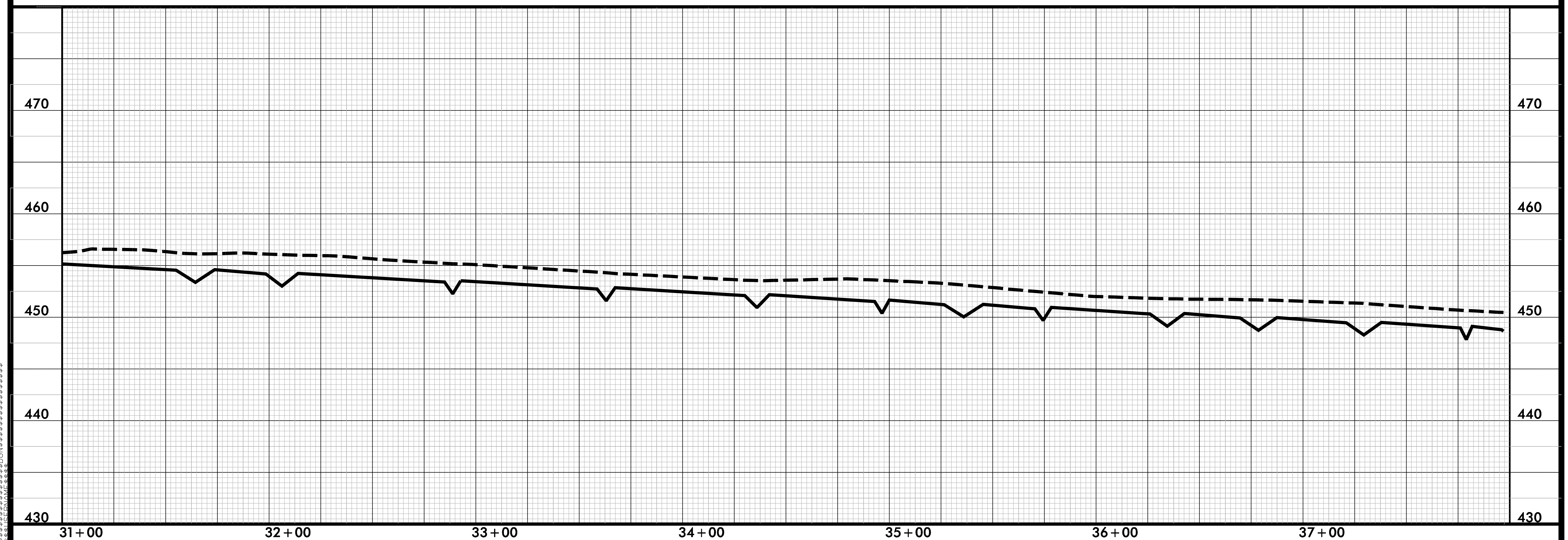

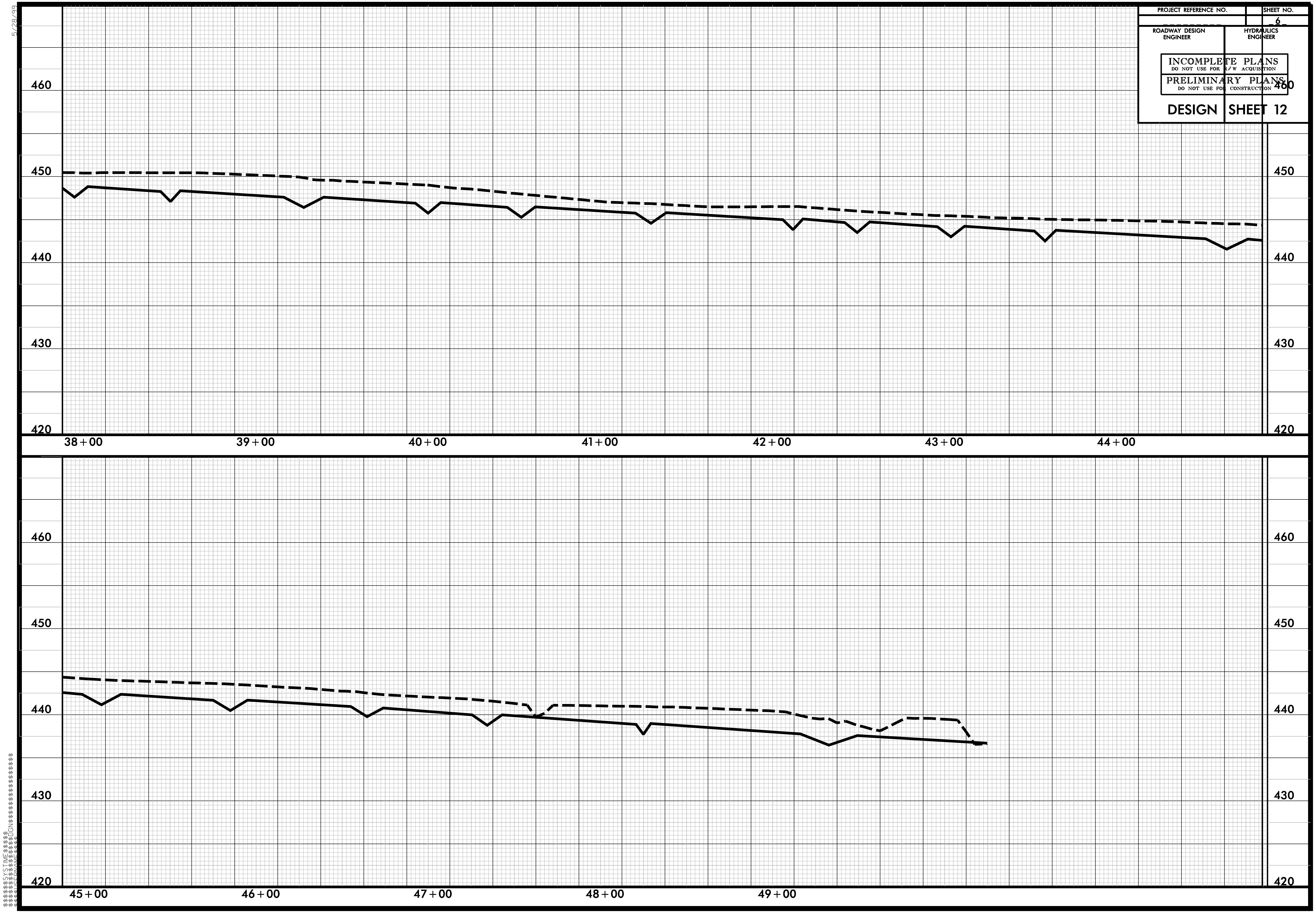

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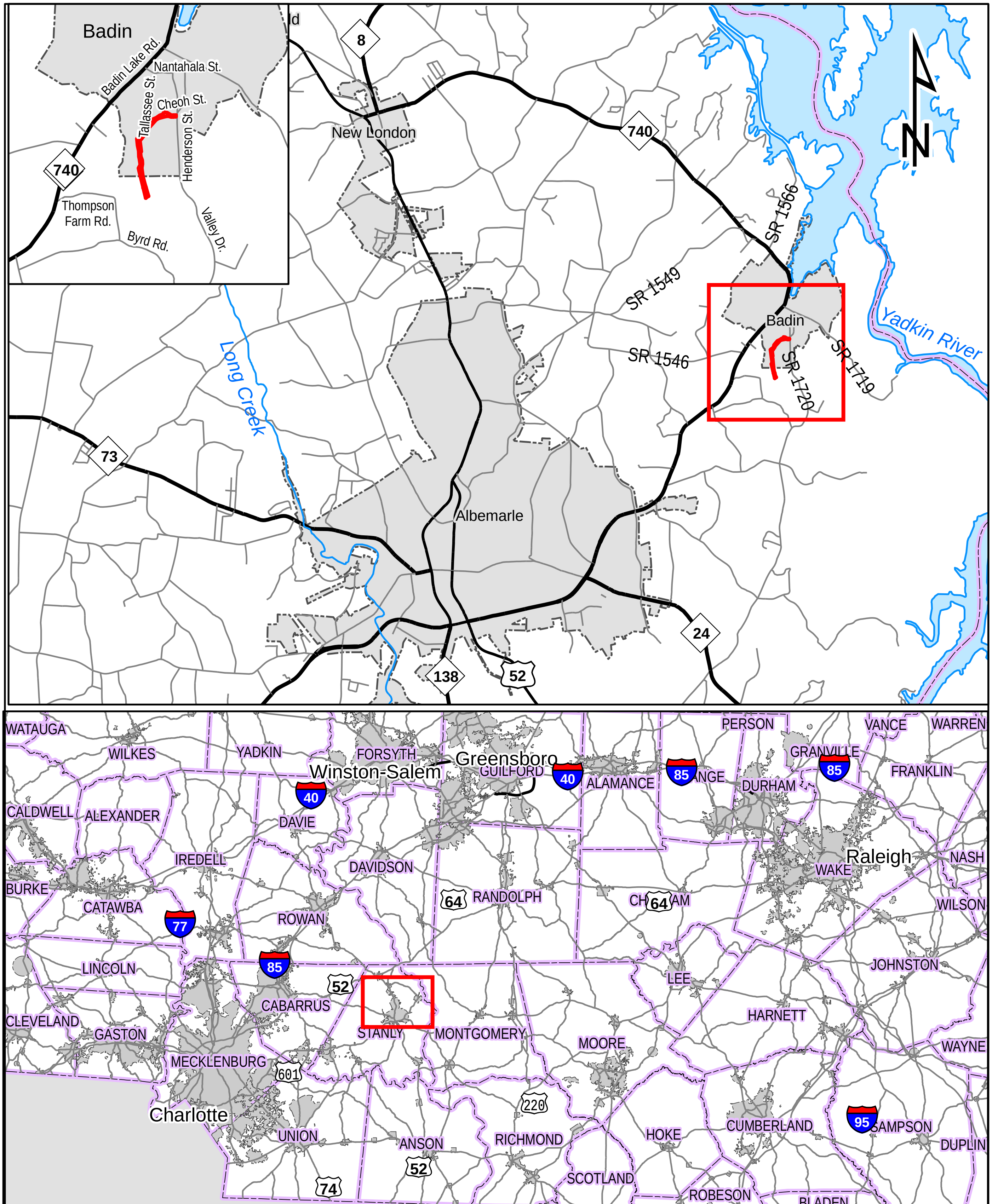
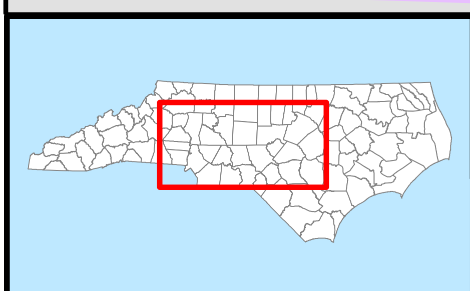




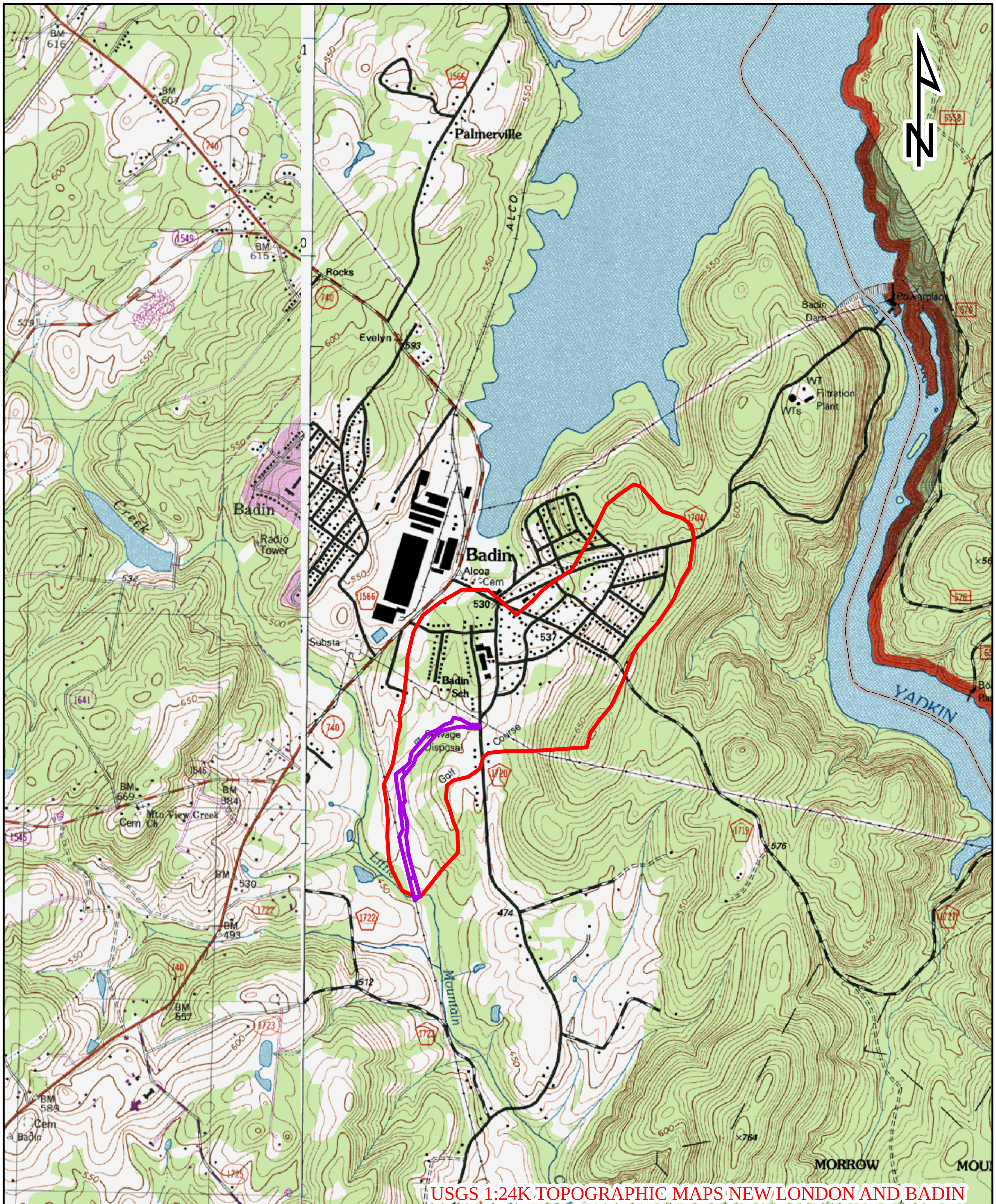
Ecosystem Enhancement Program

EarthTech

A tyco International Ltd. Company

FIGURE 1
PROJECT LOCATION
Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008

Not to Scale



Legend

- Conservation Easement
- Watershed

Ecosystem Enhancement Program

EarthTech

A tyco International Ltd. Company

FIGURE 2

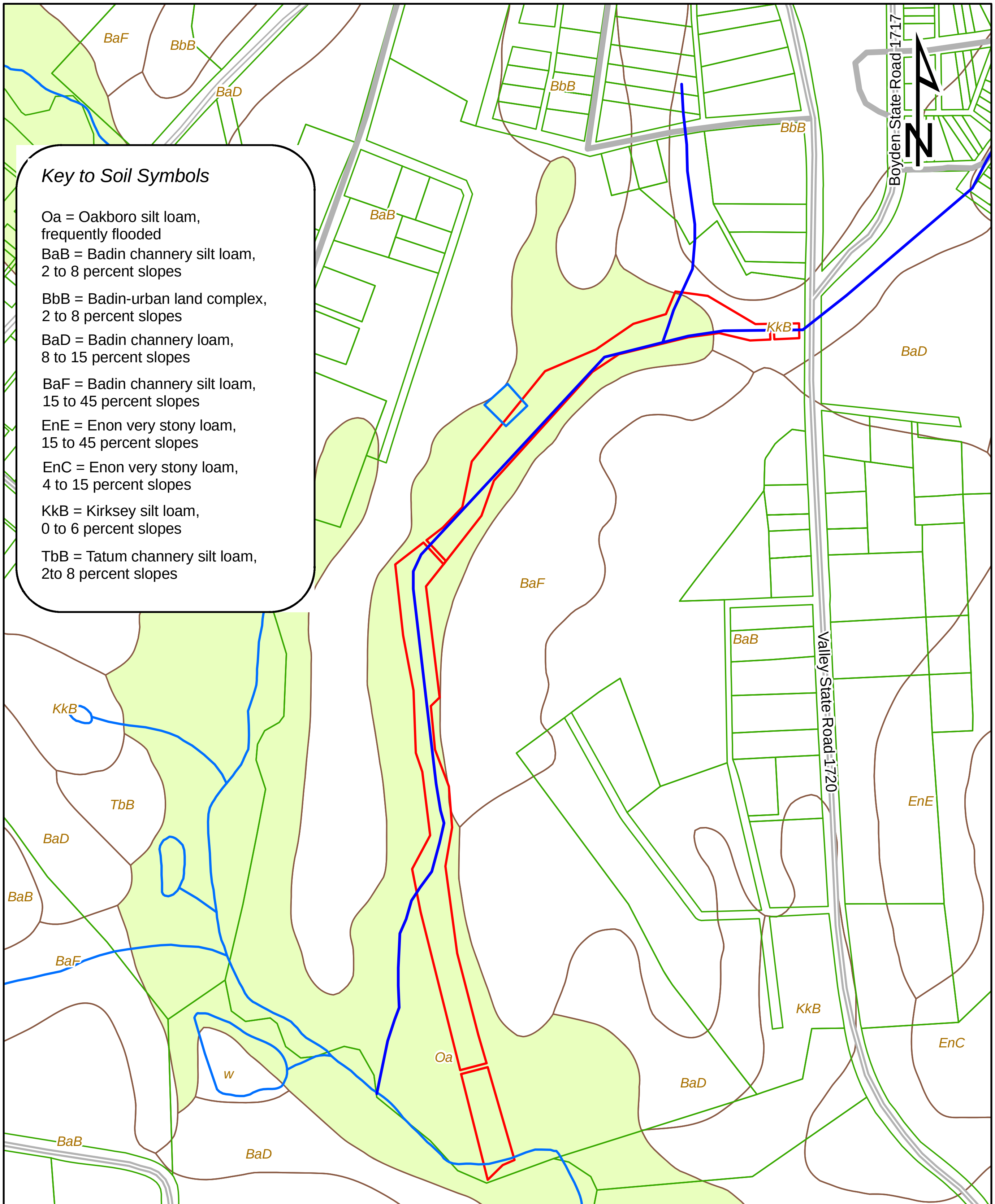
PROJECT WATERSHED

Badin Inn Restoration Plan

Stanly County, North Carolina

January, 2008

0 1,250 2,500 5,000 Feet

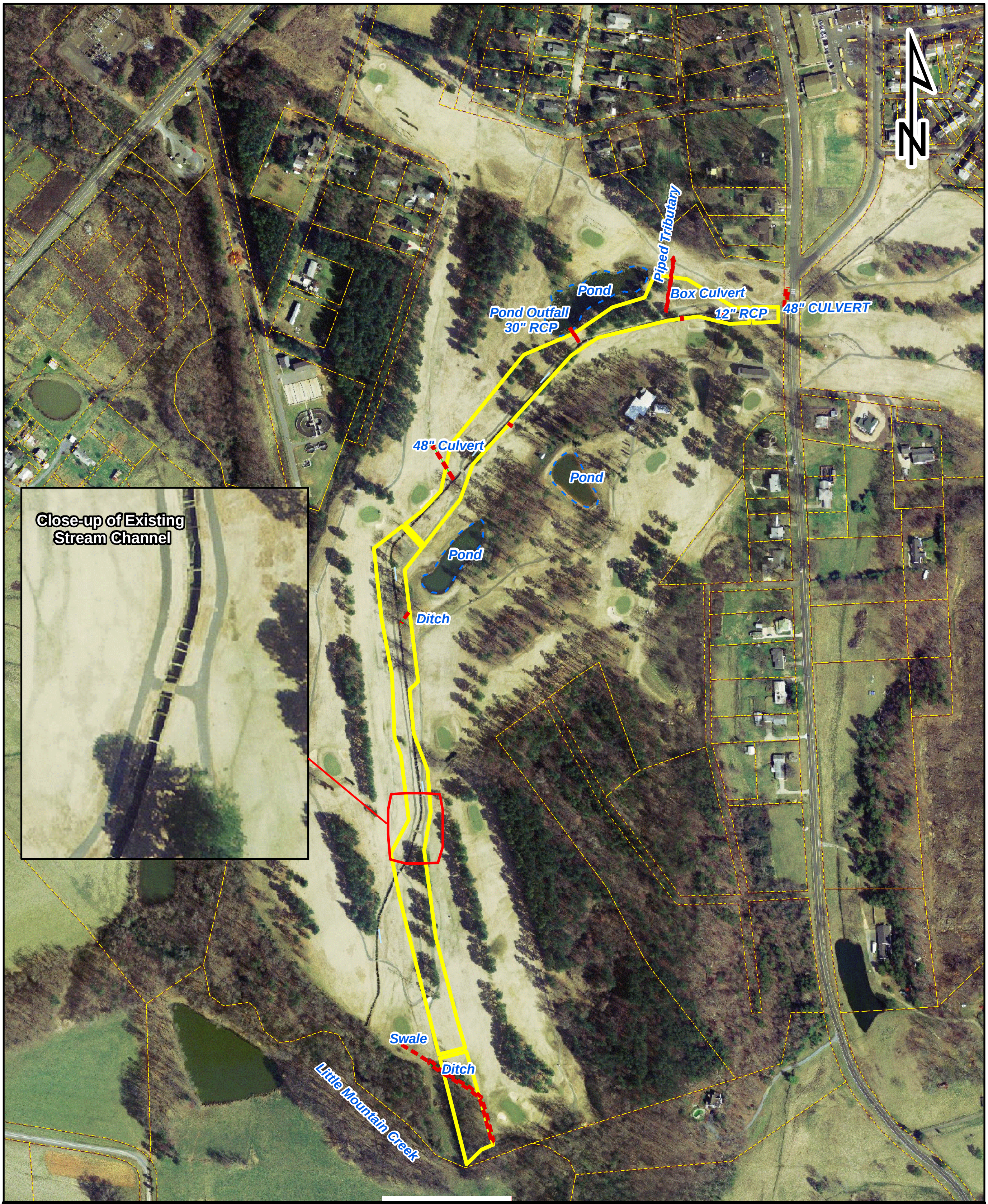


Legend

- Non-hydric
- Hydric B
- Existing Stream
- Conservation Easement
- Parcel Boundaries
- Roads

FIGURE 3
PROJECT SITE SOIL SURVEY MAP
Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008

0 250 500 1,000 Feet



Legend

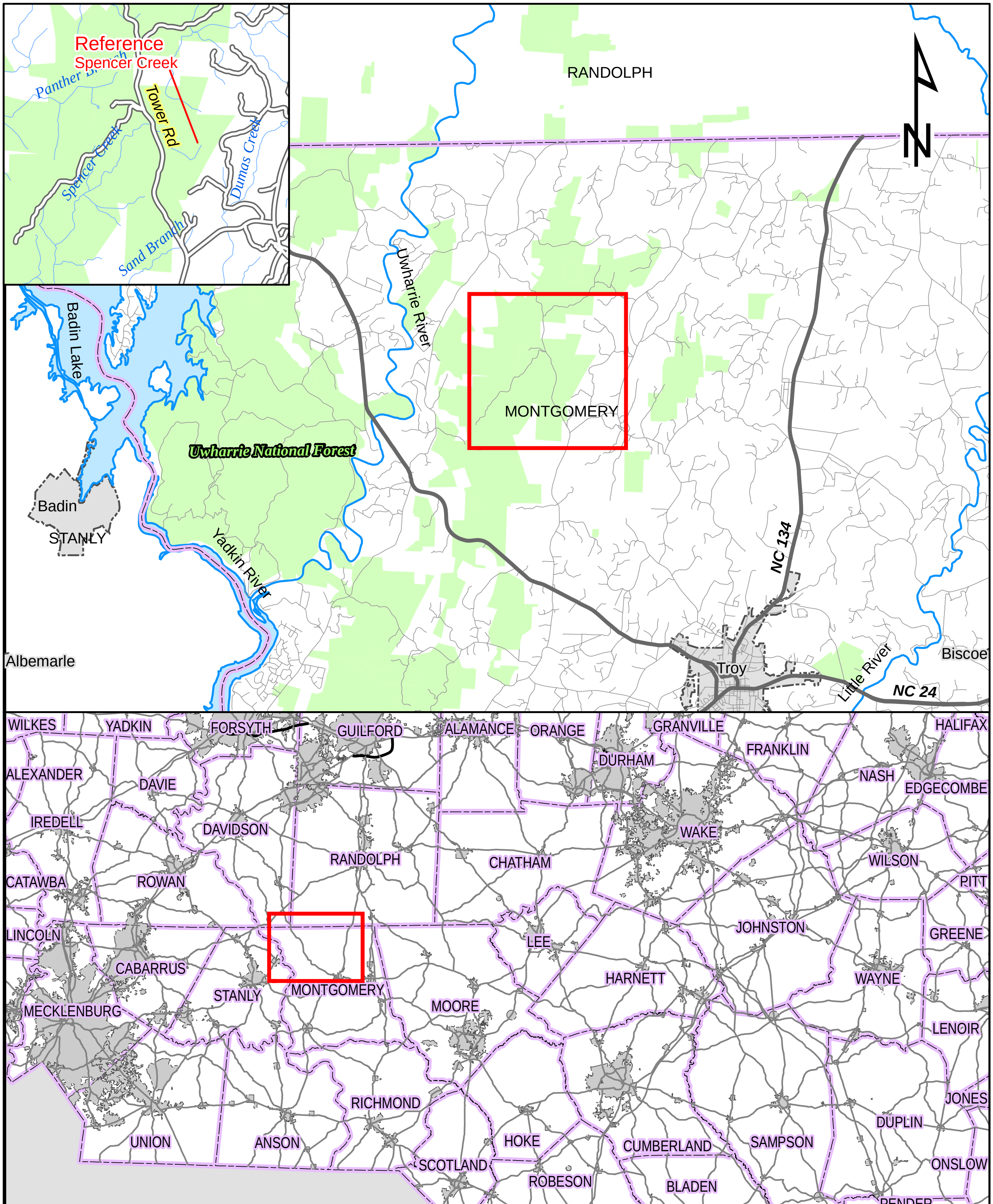
- Hydrological Features
- Ponds
- Parcel Boundaries
- Conservation Easement

Ecosystem Enhancement PROGRAM

EarthTech
A tyco International Ltd. Company

FIGURE 4
HYDROLOGICAL FEATURES
Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008

0 250 500 1,000 Feet



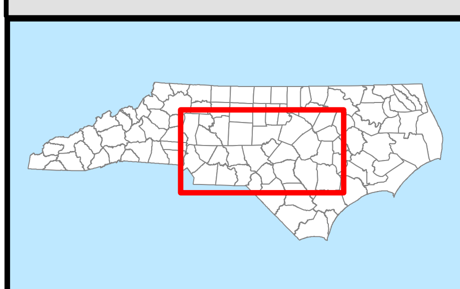
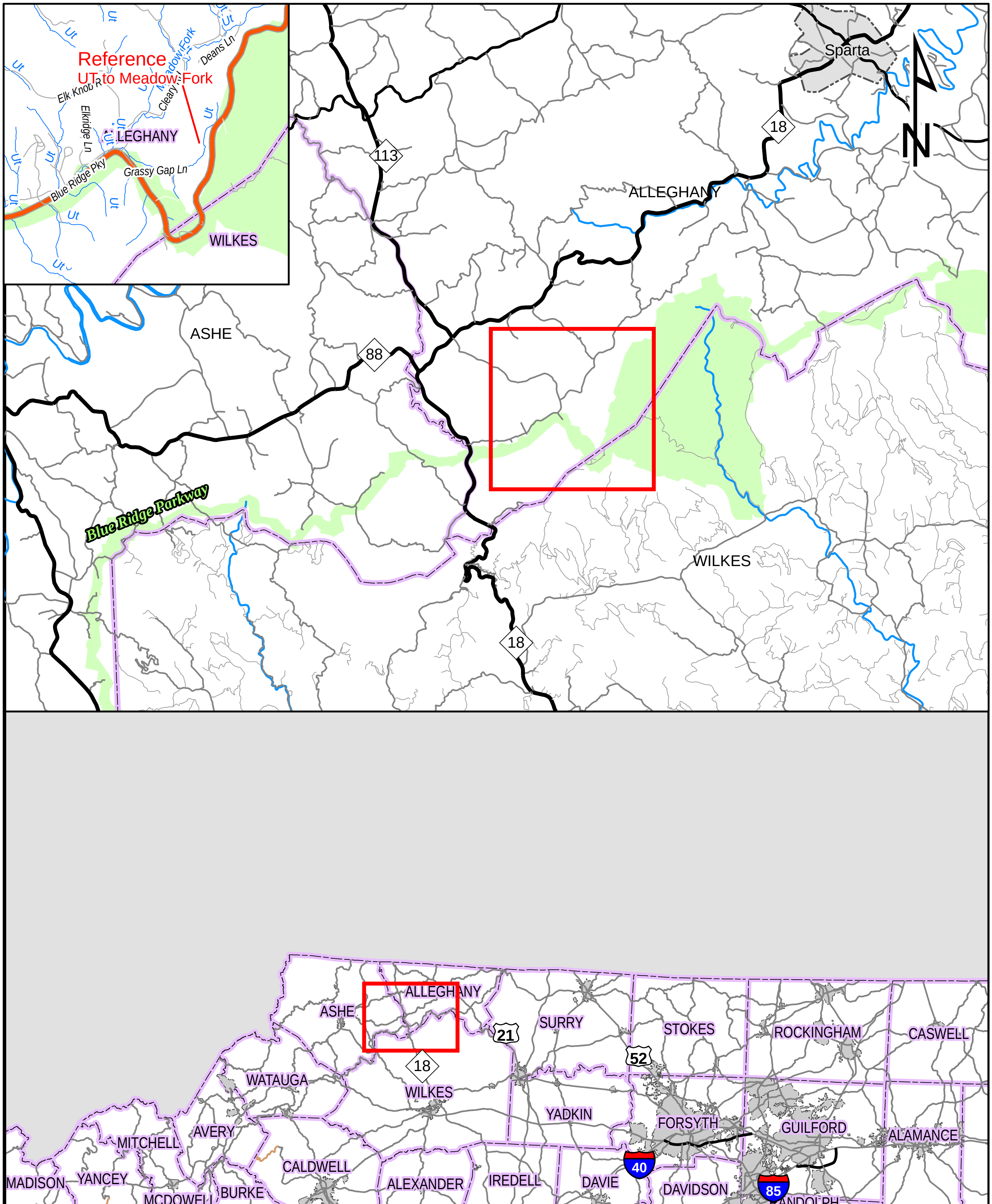
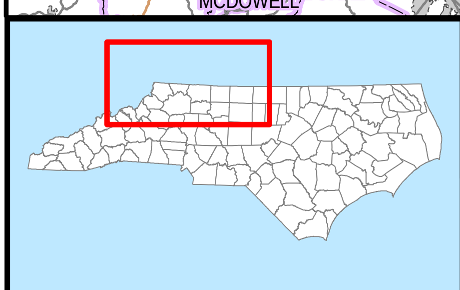


FIGURE 5
REFERENCE REACH VICINITY
SPENCER CREEK

Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008
Not to Scale





Ecosystem Enhancement PROGRAM

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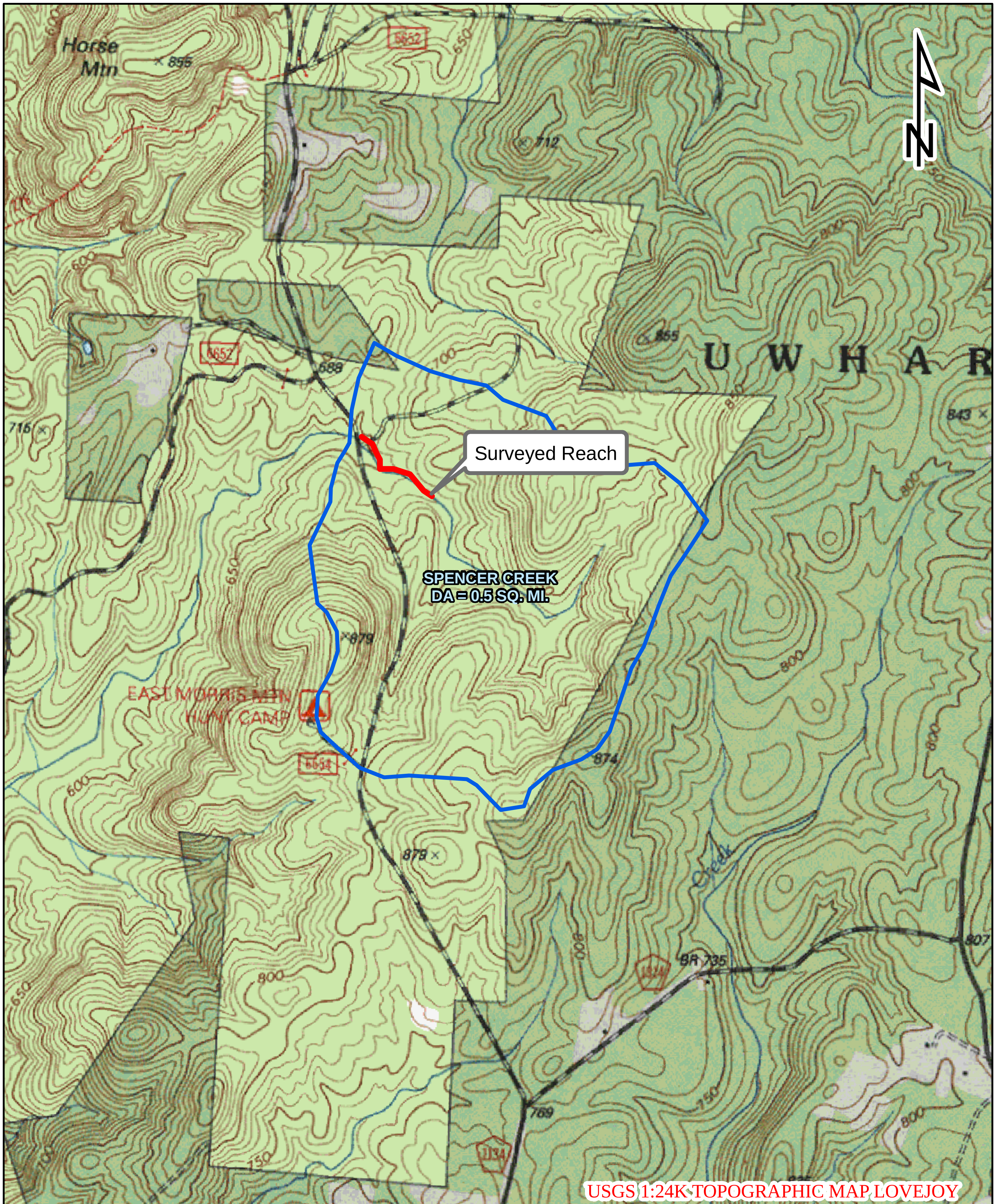
FIGURE 6
UT MEADOW FORK
REFERENCE REACH VICINITY

Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008

Not to Scale



Legend

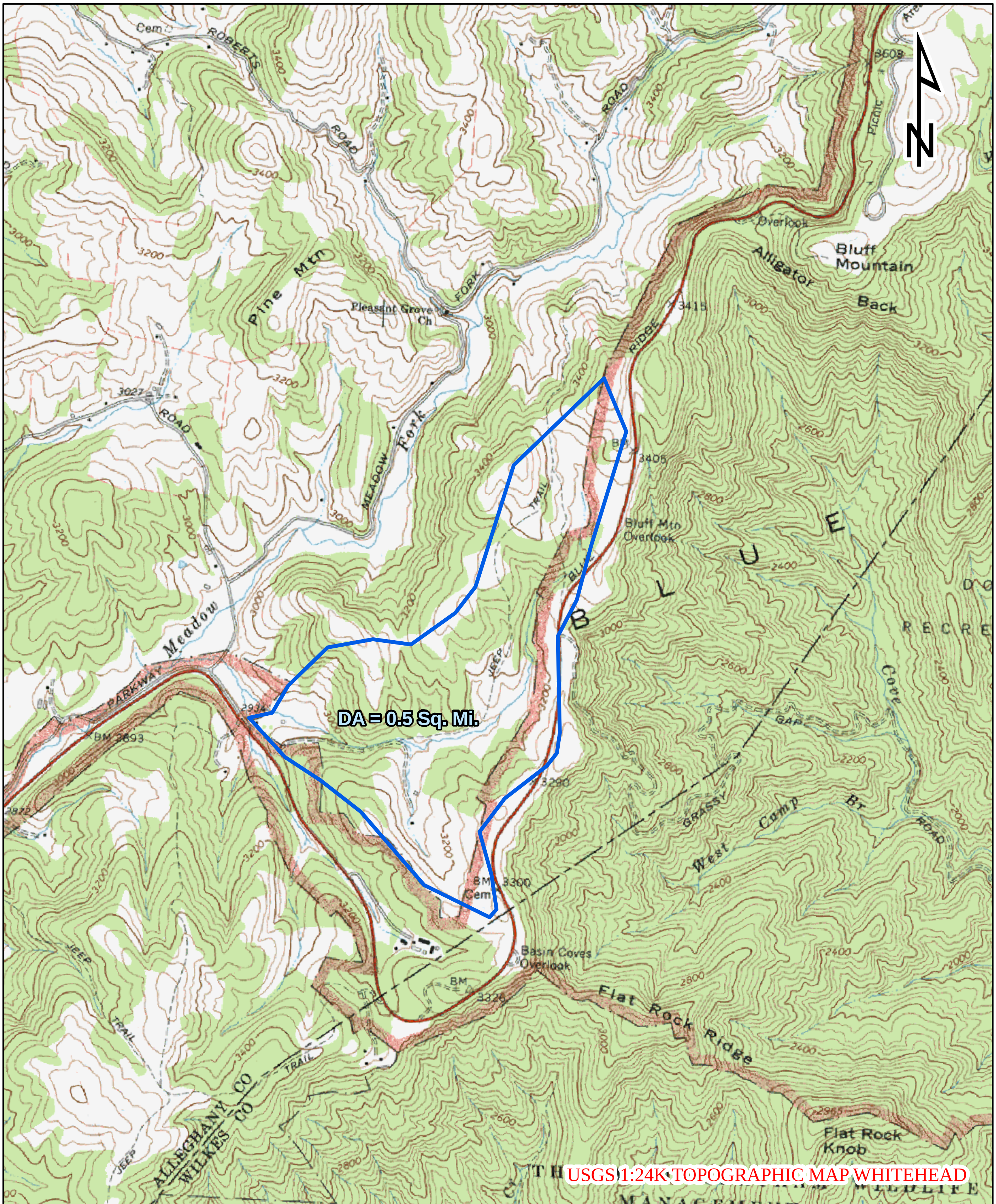
Watershed Boundary

Ecosystem Enhancement PROGRAM

EarthTech
A tyco International Ltd. Company

FIGURE 7
REFERENCE REACH WATERSHEDS
SPENCER CREEK
Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008

0 750 1,500 3,000 Feet



Legend

Watershed Boundary

Ecosystem Enhancement PROGRAM

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FIGURE 8
REFERENCE REACH WATERSHED
UT Meadow Fork
Badin Inn Restoration Plan
Stanly County, North Carolina
January, 2008

0 0.25 0.5 1 Miles

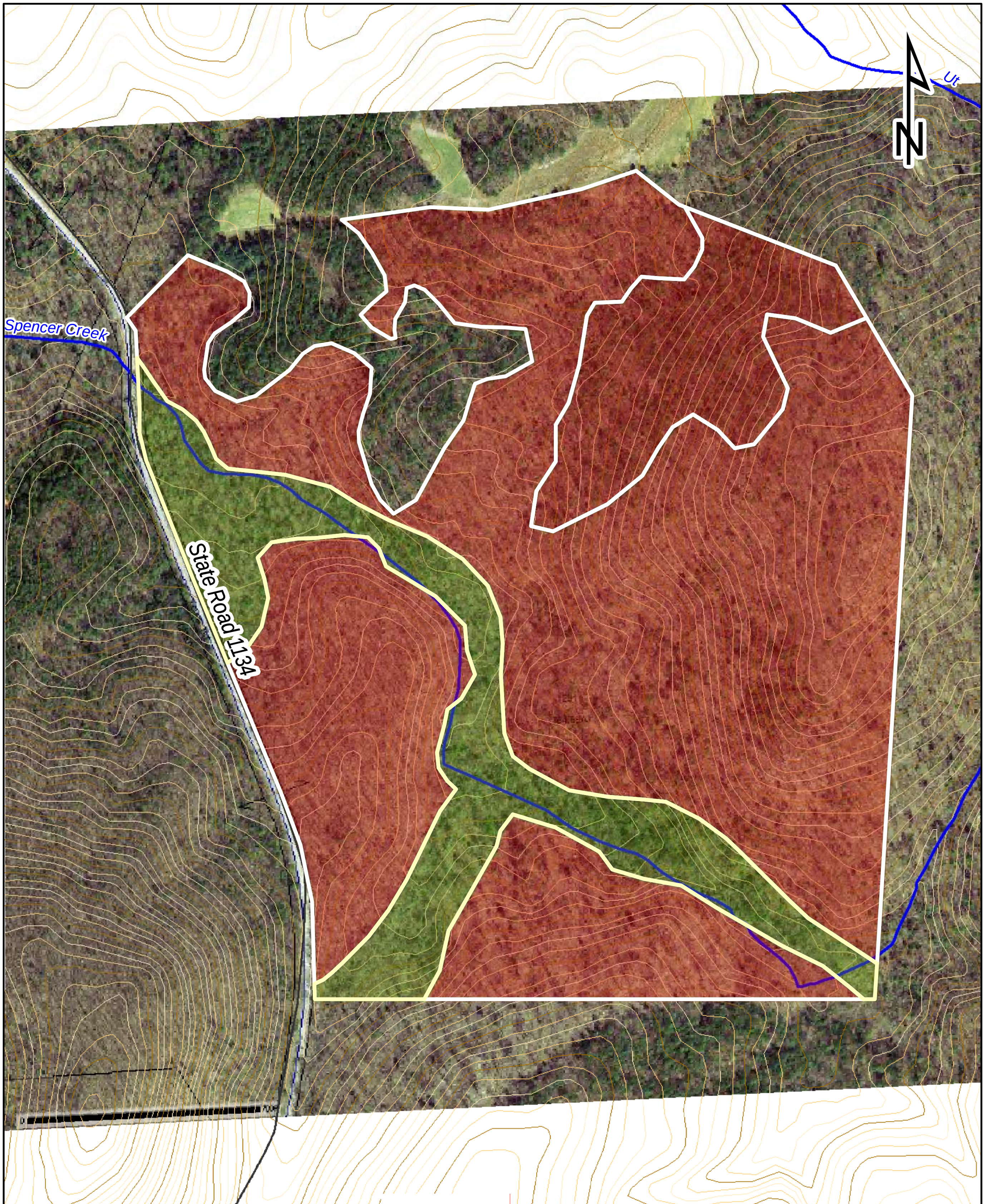


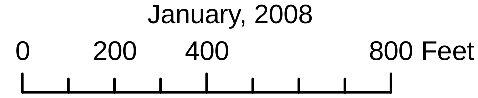
FIGURE 9

Vegetative Communities- Spencer

Badin Inn Restoration Plan

Stanly County, North Carolina

January, 2008

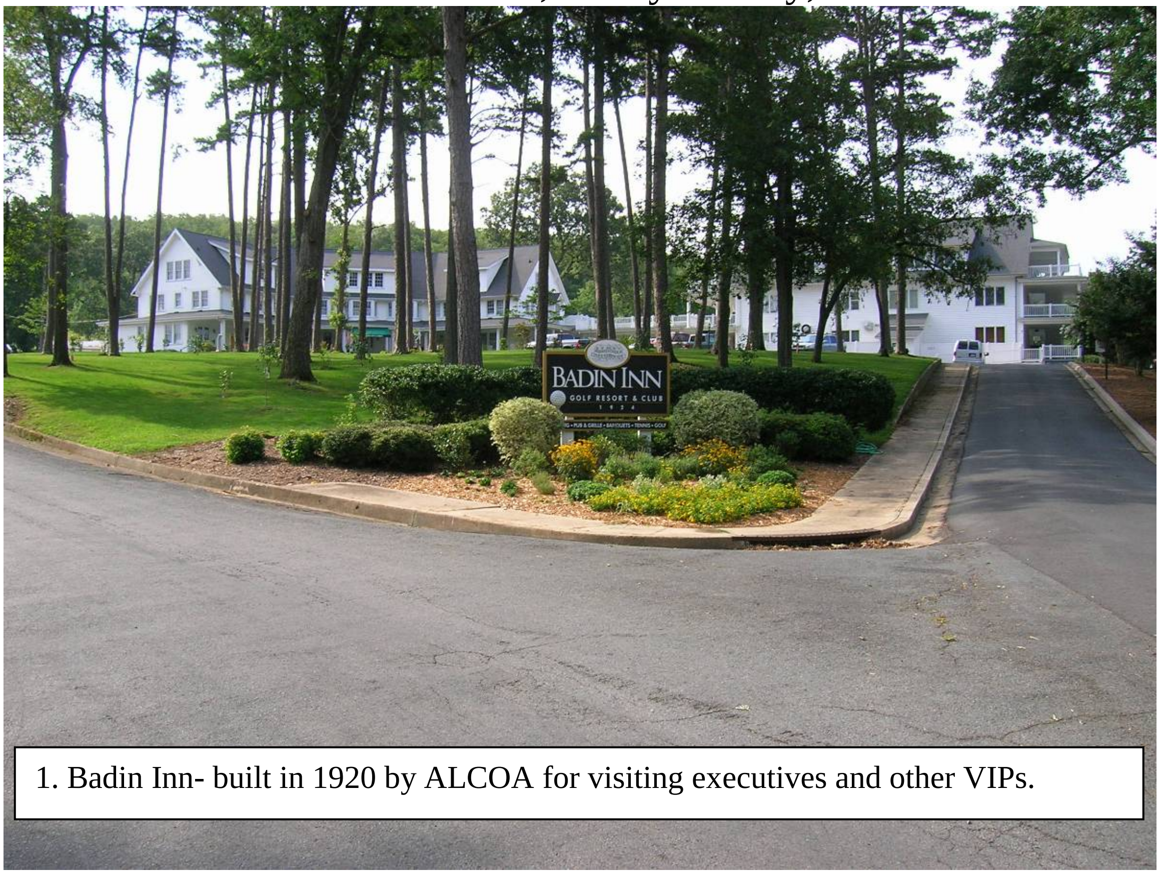


APPENDIX A

PROJECT SITE PHOTOGRAPHS

Photo Log

Badin Inn Restoration Plan, Stanly County, North Carolina



1. Badin Inn- built in 1920 by ALCOA for visiting executives and other VIPs.

2. UT to Little Mountain Creek just above the Badin Inn, facing upstream.

3. Facing upstream, note the groundwater input during a dry time in July.

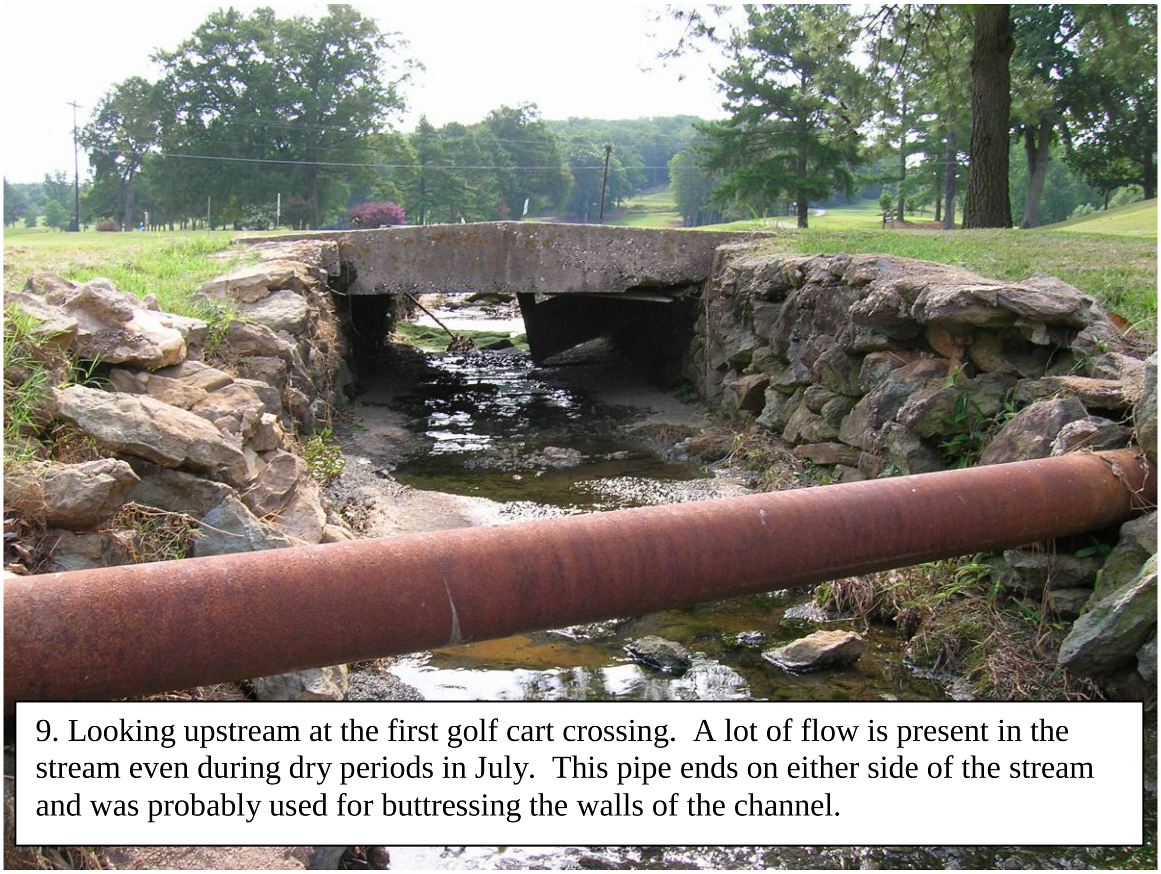
4. Facing downstream, still well upstream of the project site.

5. The head of the project, facing upstream. Two culverts converge at this point.

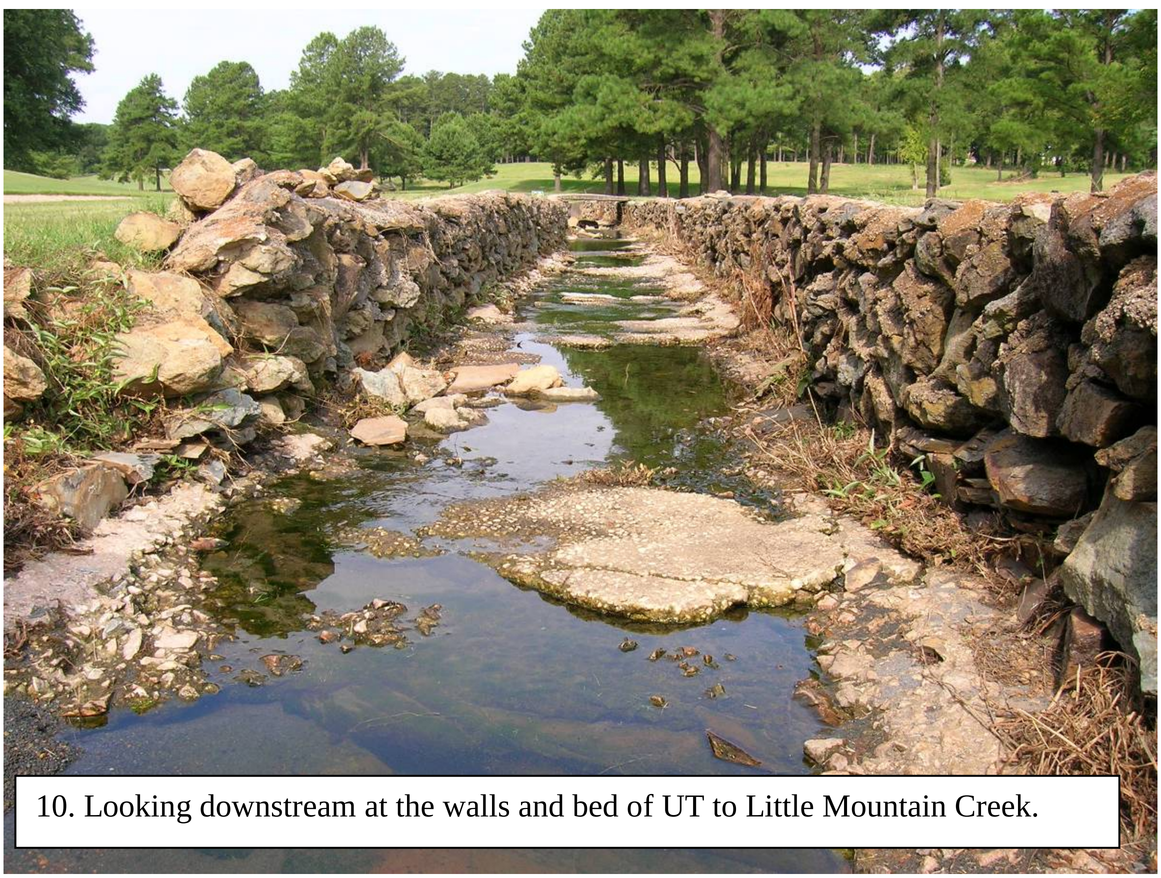
6.Facing downstream at the head of the project. Note the groundwater discharge and broken concrete bed.

7. Looking down the valley of the stream at the head of the project.

8. The bed of UTLMC. The concrete has broken over the years, revealing slate bedrock beneath.



9. Looking upstream at the first golf cart crossing. A lot of flow is present in the stream even during dry periods in July. This pipe ends on either side of the stream and was probably used for buttressing the walls of the channel.



10. Looking downstream at the walls and bed of UT to Little Mountain Creek.

11. A small piped tributary flows into UTLMC. This is facing upstream.

12. The approximate location of the piped tributary, looking upstream. The pipe begins in the woods at the top of the photo.

14. Looking upstream near the middle of the project. The stone walls change to concrete, buttressed walls.

15. Despite the channelization of UTLMC, fish and this snapping turtle were observed in the stream.

16. Much of the existing stream is underlain with slate bedrock such as this.

17. A pipe discharging into the stream from one of the two ponds on the golf course.

18. Another pipe discharging from a pond. Note the algal blooms, indications of high levels of nutrients.

19. Looking downstream. Grass clippings are dumped directly into the stream. Ironically, this has allowed for bankfull formation in the channel, as indicated by the bench on the left side of the stream.

20. This cardinal flower (*Lobelia cardinalis*) and some other wetland plants were observed growing on bars in the stream.

21. Looking upstream, another view of the bankfull formation.

22. Looking upstream. The concrete bed has completely degraded at this point.

23. Looking downstream, note the slate bedrock filling the stream.

23. The conservation easement ends in the wooded riparian area of Little Mountain Creek.

APPENDIX B

PROJECT SITE NCDWQ STREAM CLASSIFICATION FORMS

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 10/3/06	Project: Badin Inn	Latitude:
Evaluator: ICJ, BMD	Site: Badin Inn	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 34.75	County: Stanly	Other *e.g. Quad Name:* Badin

A. Geomorphology (Subtotal = 10)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 9.5)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, or Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 15.25)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 1/11/08	**Project:** Badin Inn	**Latitude:**
Evaluator: ICS	**Site:** Badin Inn	**Longitude:**
Total Points: 28 *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	**County:** Stanly	**Other** *e.g. Quad Name:* Badin

A. Geomorphology (Subtotal = 15)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	3
2. Sinuosity	0	1	2	3
3. In-channel structure: riffle-pool sequence	0	1	2	3
4. Soil texture or stream substrate sorting	0	1	2	3
5. Active/relic floodplain	0	1	2	3
6. Depositional bars or benches	0	1	2	3
7. Braided channel	0	1	2	3
8. Recent alluvial deposits	0	1	2	3
9[a] Natural levees	0	1	2	3
10. Headcuts	0	1	2	3
11. Grade controls	0	0.5	1	1.5
12. Natural valley or drainageway	0	0.5	1	1.5
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 6.5)				
14. Groundwater flow/discharge	0	1	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	3
16. Leaflitter	1.5	1	0.5	0
17. Sediment on plants or debris	0	0.5	1	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		Yes = 1.5	

C. Biology (Subtotal = 6.5)				
20[b]. Fibrous roots in channel	3	2	1	0
21[b]. Rooted plants in channel	3	2	1	0
22. Crayfish	0	0.5	1	1.5
23. Bivalves	0	1	2	3
24. Fish	0	0.5	1	1.5
25. Amphibians	0	0.5	1	1.5
26. Macrobenthos (note diversity and abundance)	0	0.5	1	1.5
27. Filamentous algae; periphyton	0	1	2	3
28. Iron oxidizing bacteria/fungus.	0	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

APPENDIX C

HEC-RAS ANALYSIS

BADIN INN WATER SURFACE ELEVATION DATA- EXISTING STREAM

HEC-RAS Plan: EXISTING River: UT Little Mounta Reach: Existing

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
Existing	4450	Q5	151	488.19	490.58
Existing	4450	Q10	211	488.19	490.86
Existing	4450	Q50	388	488.19	491.23
Existing	4450	Q25	304	488.19	491.08
Existing	4450	BKF	40	488.19	489.29
Existing	4450	Q100	483	488.19	491.35
Existing	3750	Q5	151	468.68	471.57
Existing	3750	Q10	211	468.68	471.79
Existing	3750	Q50	388	468.68	472.09
Existing	3750	Q25	304	468.68	471.98
Existing	3750	BKF	40	468.68	469.79
Existing	3750	Q100	483	468.68	472.23
Existing	3475	Q5	151	464.7	467.87
Existing	3475	Q10	211	464.7	468.05
Existing	3475	Q50	388	464.7	468.37
Existing	3475	Q25	304	464.7	468.25
Existing	3475	BKF	40	464.7	465.81
Existing	3475	Q100	483	464.7	468.45
Existing	3240	Q5	151	461.24	464.47
Existing	3240	Q10	211	461.24	464.68
Existing	3240	Q50	388	461.24	465.06
Existing	3240	Q25	304	461.24	464.91
Existing	3240	BKF	40	461.24	462.34
Existing	3240	Q100	483	461.24	465.19
Existing	2700	Q5	151	454.65	457.59
Existing	2700	Q10	211	454.65	458.08
Existing	2700	Q50	388	454.65	458.49
Existing	2700	Q25	304	454.65	458.31
Existing	2700	BKF	40	454.65	455.76
Existing	2700	Q100	483	454.65	458.64
Existing	2100	Q5	151	449.55	452.26
Existing	2100	Q10	211	449.55	453.38
Existing	2100	Q50	388	449.55	453.71
Existing	2100	Q25	304	449.55	453.58
Existing	2100	BKF	40	449.55	450.66
Existing	2100	Q100	483	449.55	453.83
Existing	1700	Q5	151	446.35	449.22
Existing	1700	Q10	211	446.35	449.39
Existing	1700	Q50	388	446.35	449.66
Existing	1700	Q25	304	446.35	449.53
Existing	1700	BKF	40	446.35	447.46

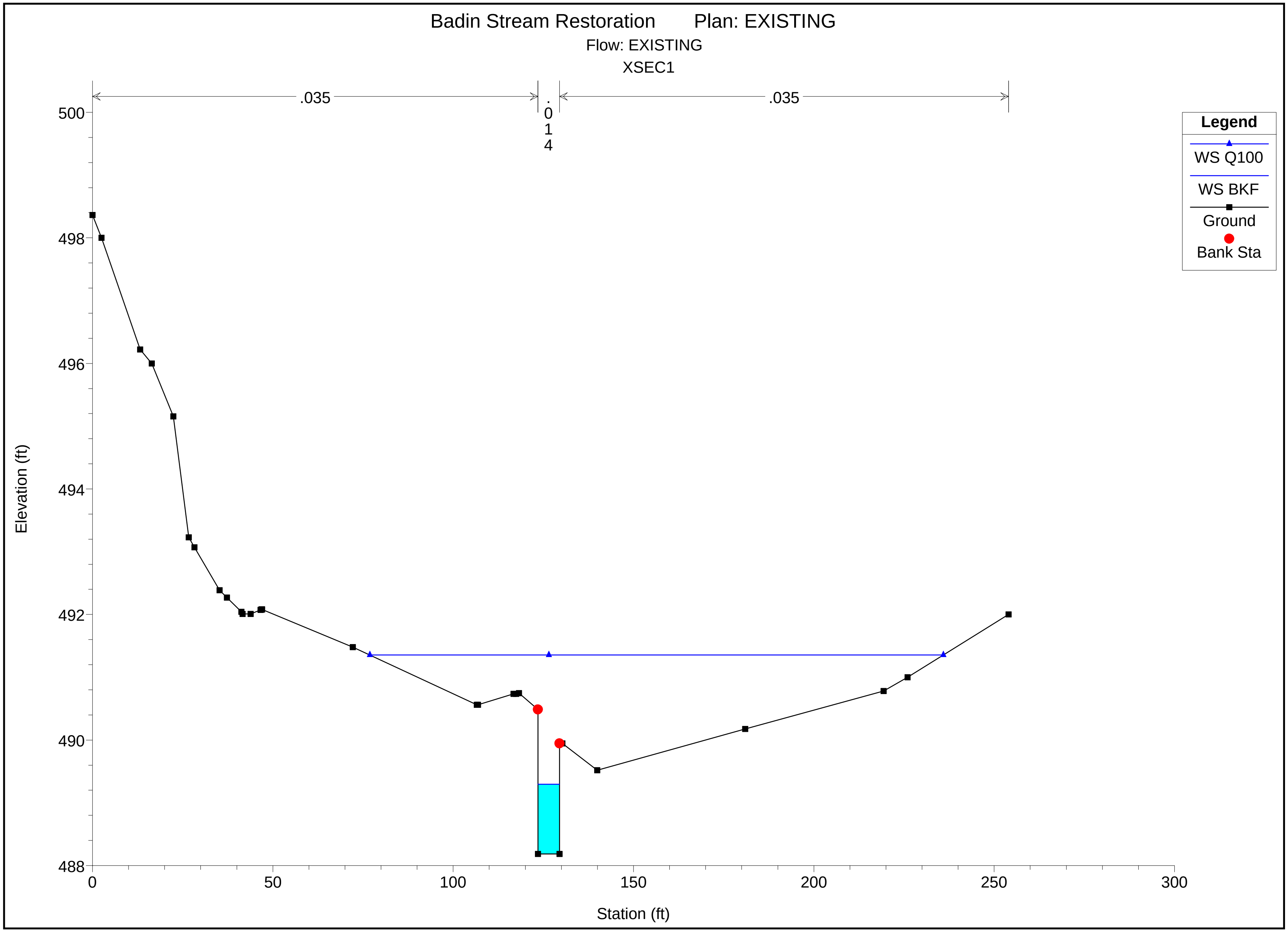
Existing	1700	Q100	483	446.35	449.74
Existing	1200	Q5	151	439.67	443.34
Existing	1200	Q10	211	439.67	443.53
Existing	1200	Q50	388	439.67	443.94
Existing	1200	Q25	304	439.67	443.77
Existing	1200	BKF	40	439.67	441.14
Existing	1200	Q100	483	439.67	444.1
Existing	1000	Q5	151	439.21	443.04
Existing	1000	Q10	211	439.21	443.24
Existing	1000	Q50	388	439.21	443.5
Existing	1000	Q25	304	439.21	443.37
Existing	1000	BKF	40	439.21	440.32
Existing	1000	Q100	483	439.21	443.61

BADIN INN WATER SURFACE ELEVATION DATA- PROPOSED STREAM

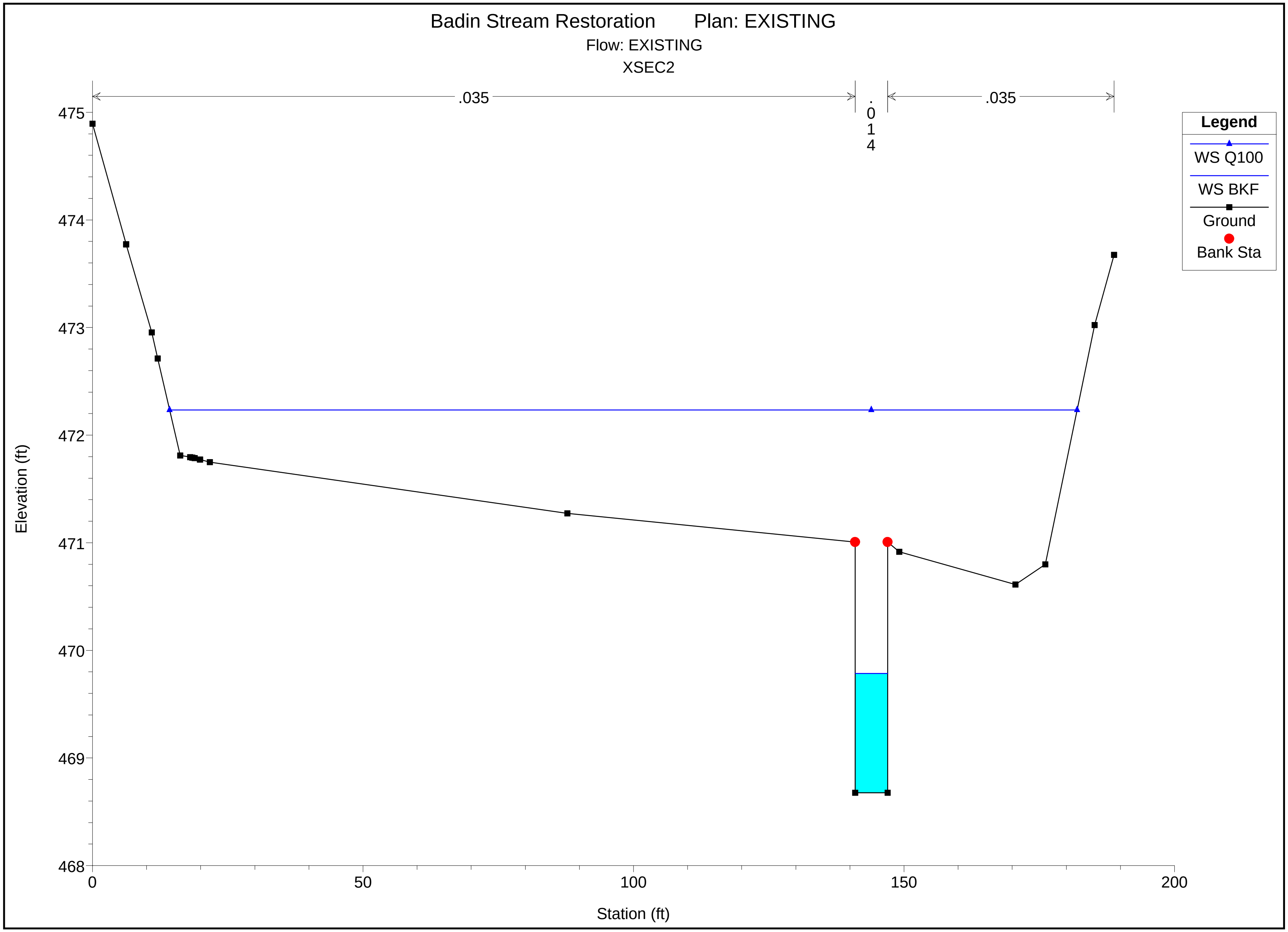
HEC-RAS Plan: PROPOSED River: 255 Reach: BADIN

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)
BADIN	5335.05	Q5	151	486.62	488.67
BADIN	5335.05	Q10	211	486.62	489.02
BADIN	5335.05	Q50	388	486.62	489.77
BADIN	5335.05	Q25	304	486.62	489.45
BADIN	5335.05	BKF	40	486.62	487.76
BADIN	5335.05	Q100	483	486.62	490.06
BADIN	4484.406	Q5	151	468.35	470.4
BADIN	4484.406	Q10	211	468.35	470.76
BADIN	4484.406	Q50	388	468.35	471.41
BADIN	4484.406	Q25	304	468.35	471.18
BADIN	4484.406	BKF	40	468.35	469.35
BADIN	4484.406	Q100	483	468.35	471.8
BADIN	4103.78	Q5	151	463.6	466.05
BADIN	4103.78	Q10	211	463.6	466.36
BADIN	4103.78	Q50	388	463.6	466.61
BADIN	4103.78	Q25	304	463.6	466.35
BADIN	4103.78	BKF	40	463.6	465.06
BADIN	4103.78	Q100	483	463.6	466.94
BADIN	3848.252	Q5	151	461.18	463.23
BADIN	3848.252	Q10	211	461.18	463.58
BADIN	3848.252	Q50	388	461.18	464.34
BADIN	3848.252	Q25	304	461.18	464.2
BADIN	3848.252	BKF	40	461.18	462.22
BADIN	3848.252	Q100	483	461.18	464.48
BADIN	3233.46	Q5	151	454.12	456.56
BADIN	3233.46	Q10	211	454.12	456.87
BADIN	3233.46	Q50	388	454.12	457.5
BADIN	3233.46	Q25	304	454.12	457.23
BADIN	3233.46	BKF	40	454.12	455.55
BADIN	3233.46	Q100	483	454.12	457.78
BADIN	2568.31	Q5	151	449.15	451.48
BADIN	2568.31	Q10	211	449.15	451.84
BADIN	2568.31	Q50	388	449.15	452.61
BADIN	2568.31	Q25	304	449.15	452.28
BADIN	2568.31	BKF	40	449.15	450.45
BADIN	2568.31	Q100	483	449.15	452.91
BADIN	2084.711	Q5	151	445.31	447.71
BADIN	2084.711	Q10	211	445.31	448
BADIN	2084.711	Q50	388	445.31	448.56
BADIN	2084.711	Q25	304	445.31	448.32
BADIN	2084.711	BKF	40	445.31	446.72

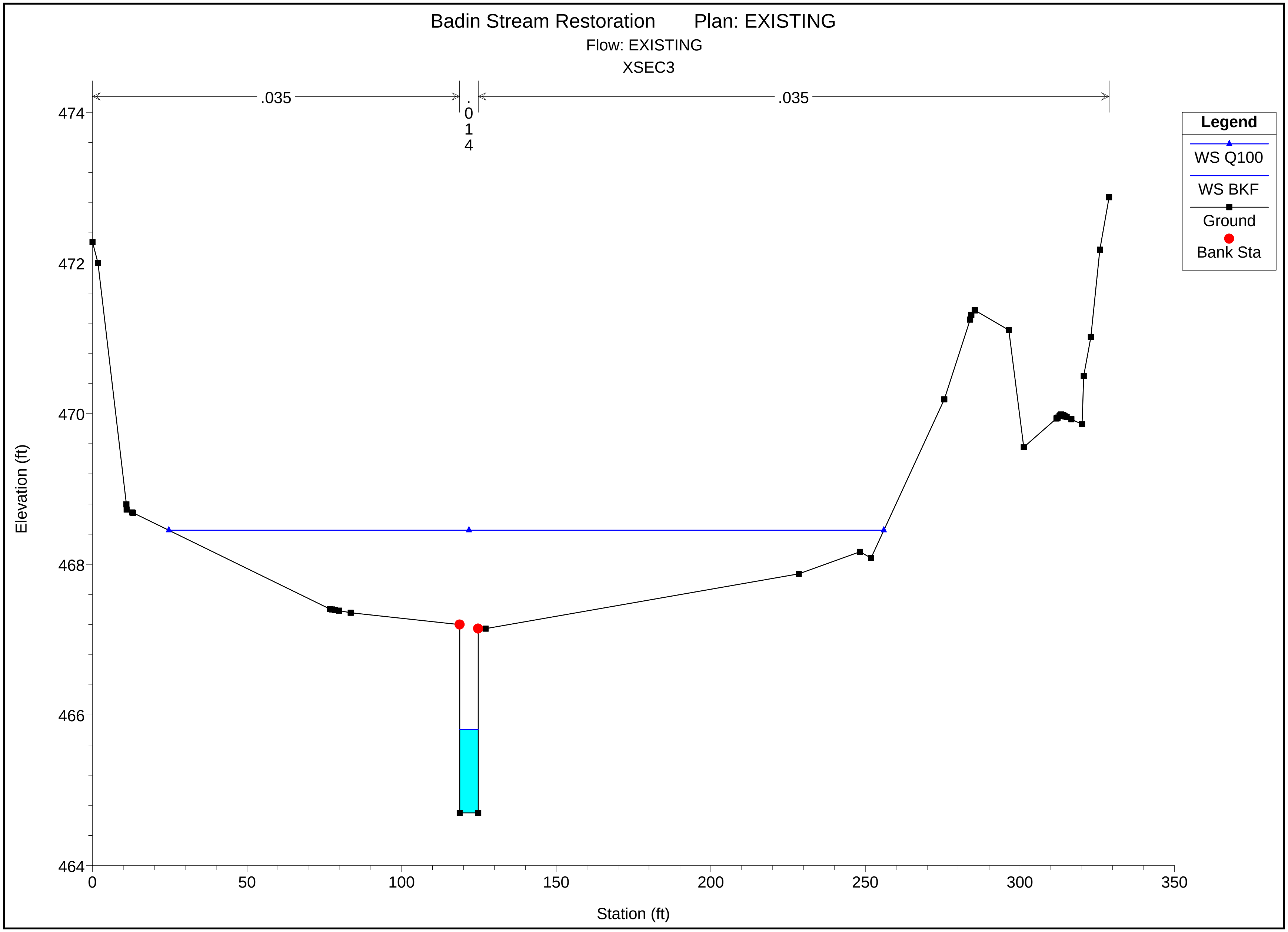
BADIN	2084.711	Q100	483	445.31	448.74
BADIN	1433.706	Q5	151	440.21	442.38
BADIN	1433.706	Q10	211	440.21	442.61
BADIN	1433.706	Q50	388	440.21	443.11
BADIN	1433.706	Q25	304	440.21	442.89
BADIN	1433.706	BKF	40	440.21	441.48
BADIN	1433.706	Q100	483	440.21	443.32
BADIN	1000	Q5	151	435.48	437.7
BADIN	1000	Q10	211	435.48	438.01
BADIN	1000	Q50	388	435.48	438.67
BADIN	1000	Q25	304	435.48	438.39
BADIN	1000	BKF	40	435.48	436.74
BADIN	1000	Q100	483	435.48	438.94



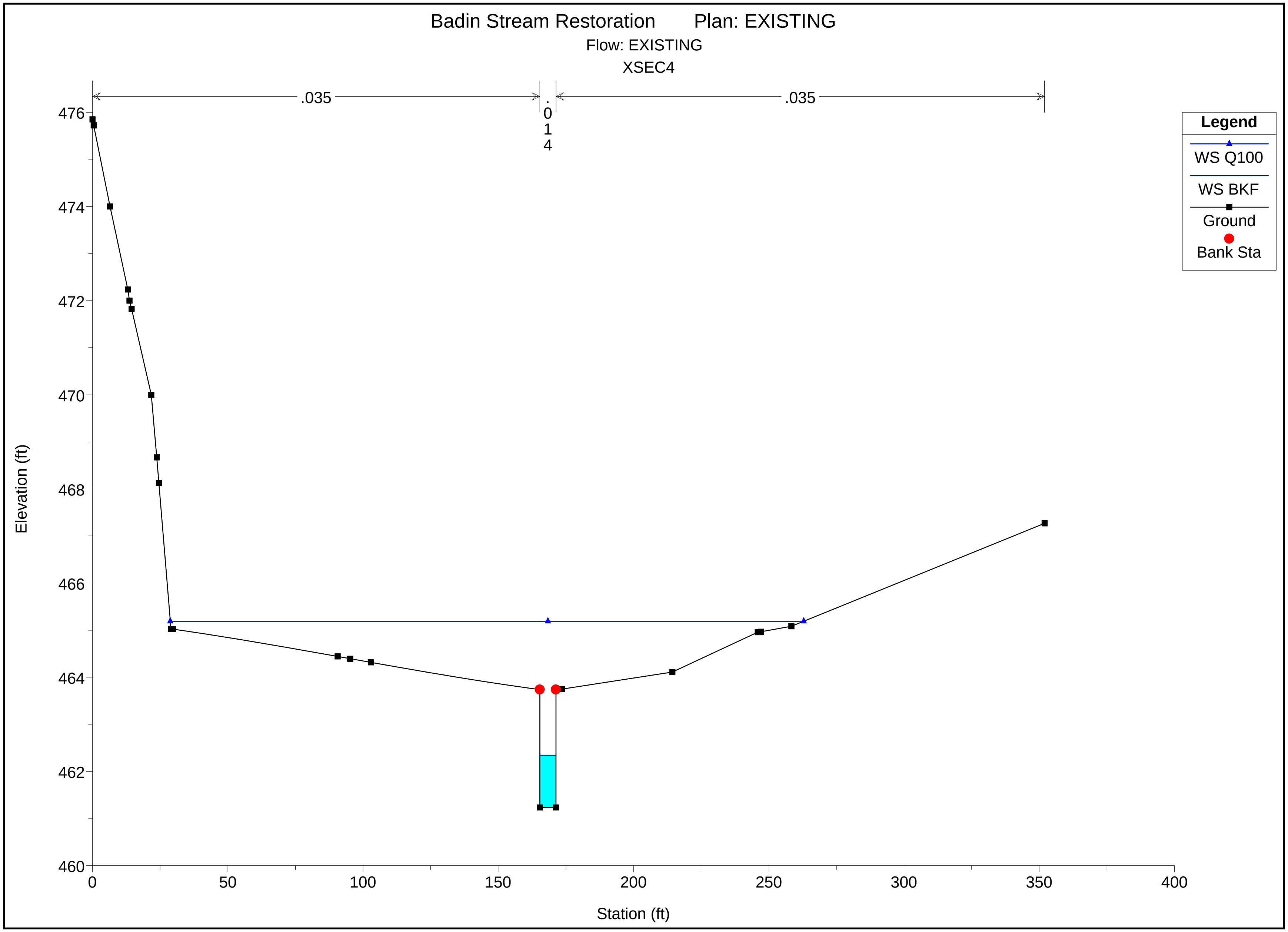
Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC1
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
500
498
496
494
492
490
488
Station (ft)
0
50
100
150
200
250
300



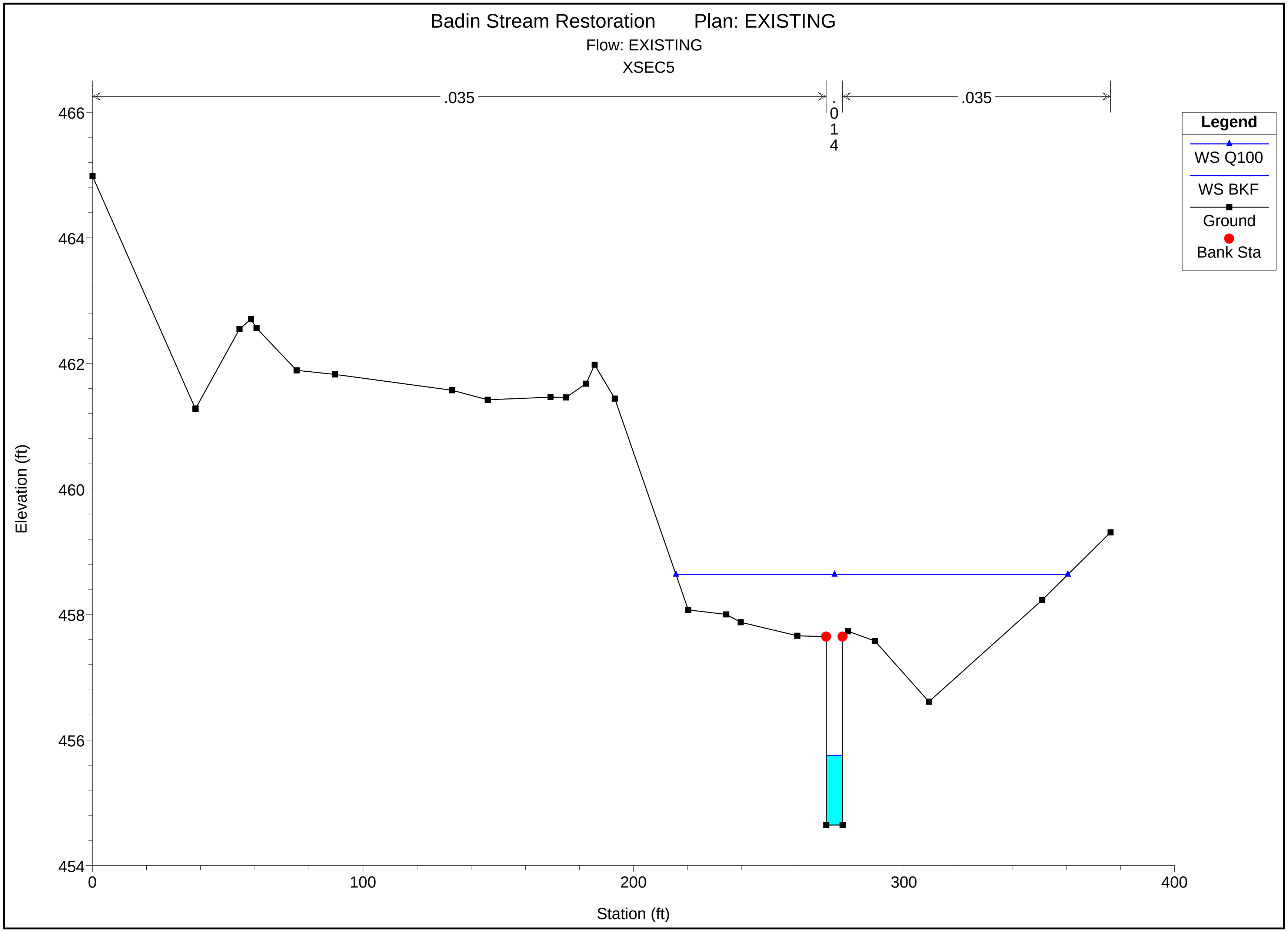
Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC2
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
475
474
473
472
471
470
469
468
0
50
100
150
200
Station (ft)

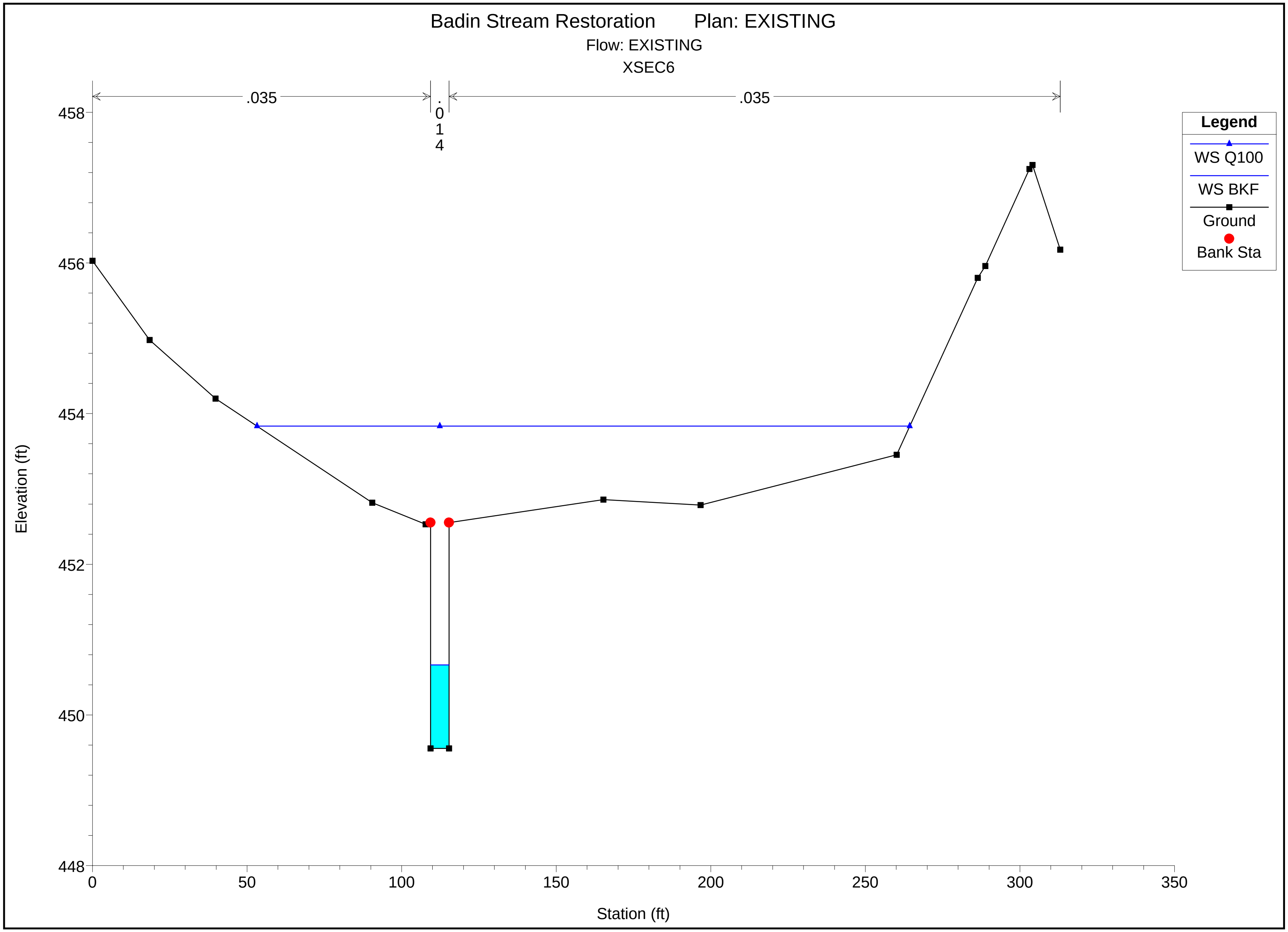


Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC3
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
474
472
470
468
466
464
0
50
100
150
200
250
300
350
Station (ft)

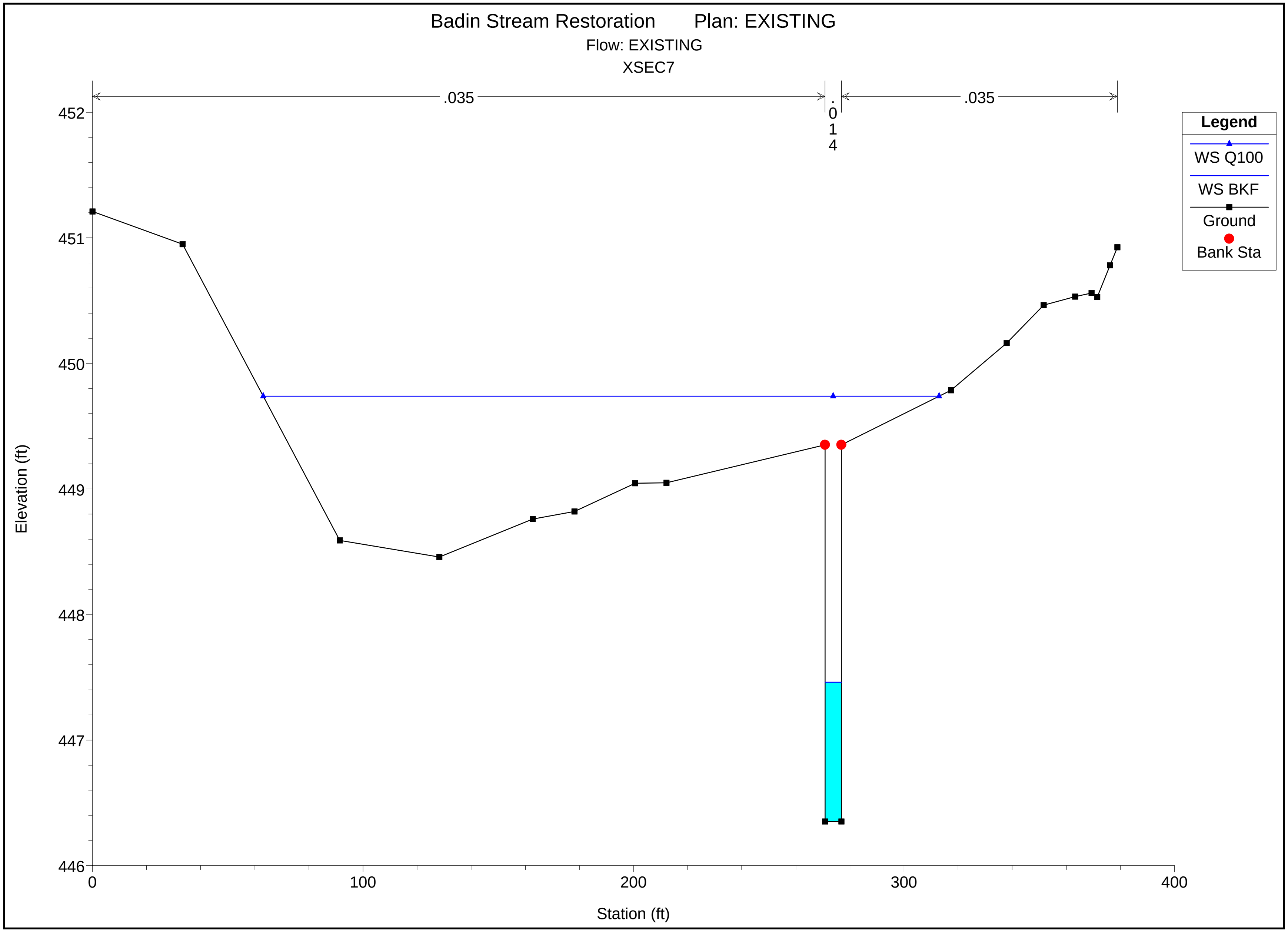


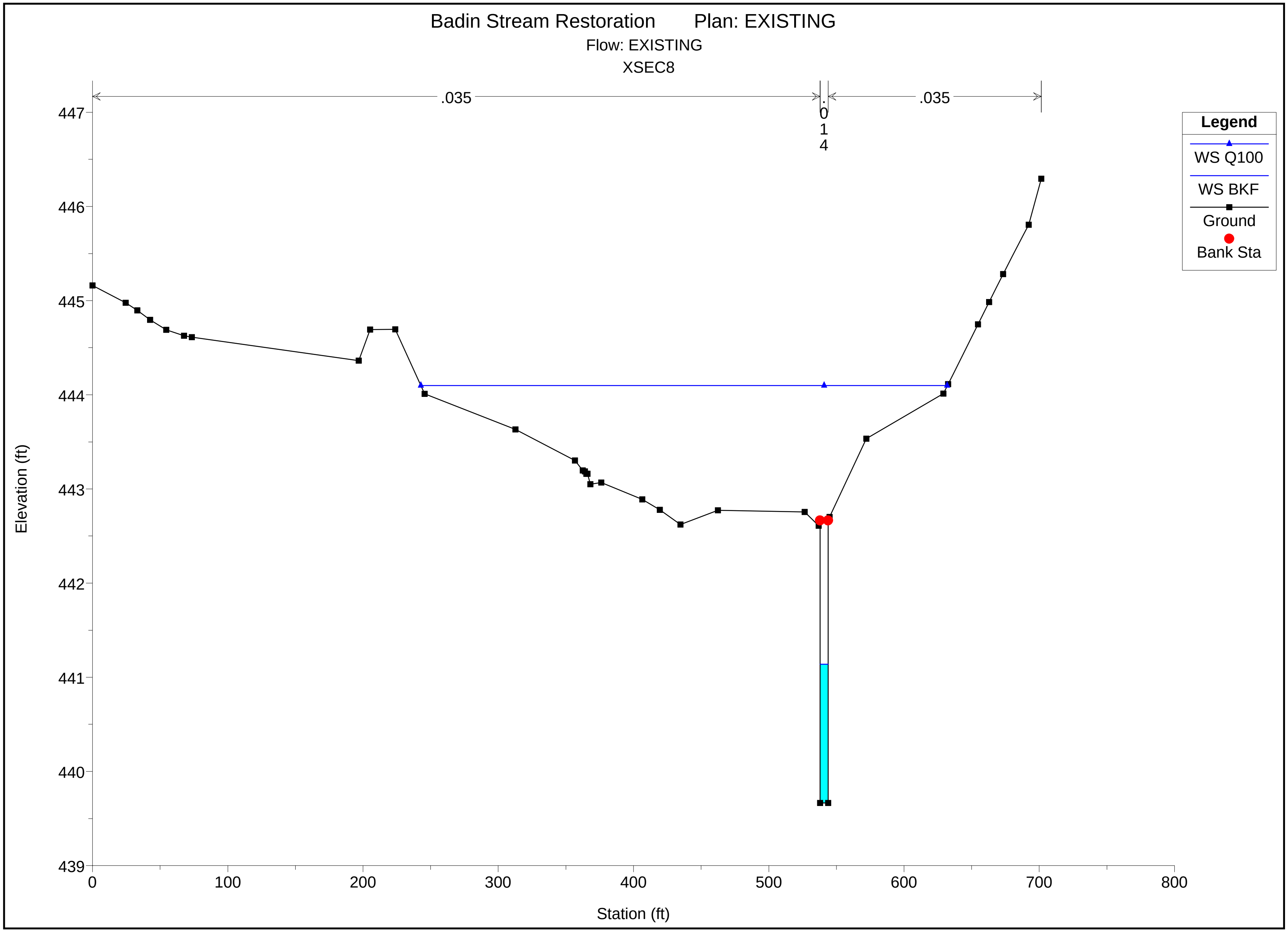
Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC4
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
476
474
472
470
468
466
464
462
460
0
50
100
150
200
250
300
350
400
Station (ft)


Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC5
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
466
464
462
460
458
456
454
0
100
200
300
400
Station (ft)



Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC6
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
Station (ft)
458
456
454
452
450
448
0
50
100
150
200
250
300
350


Badin Stream Restoration Plan: EXISTING
Flow: EXISTING
XSEC7
.035
.014
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
452
451
450
449
448
447
446
0
100
200
300
400
Station (ft)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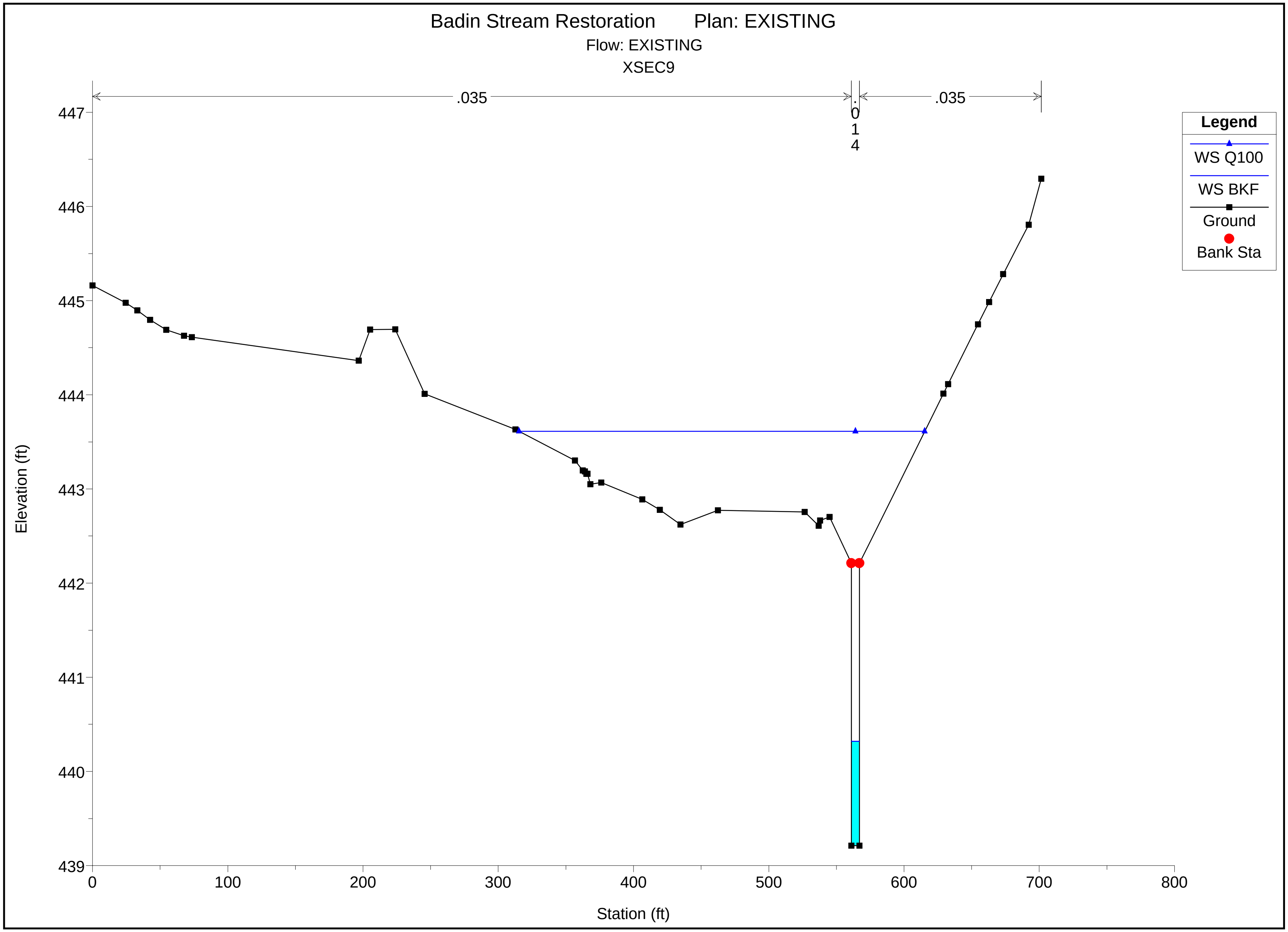
Flow: EXISTING
XSEC8
.035
.
0
1
4
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
447
446
445
444
443
442
441
440
439
0
100
200
300
400
500
600
700
800
Station (ft)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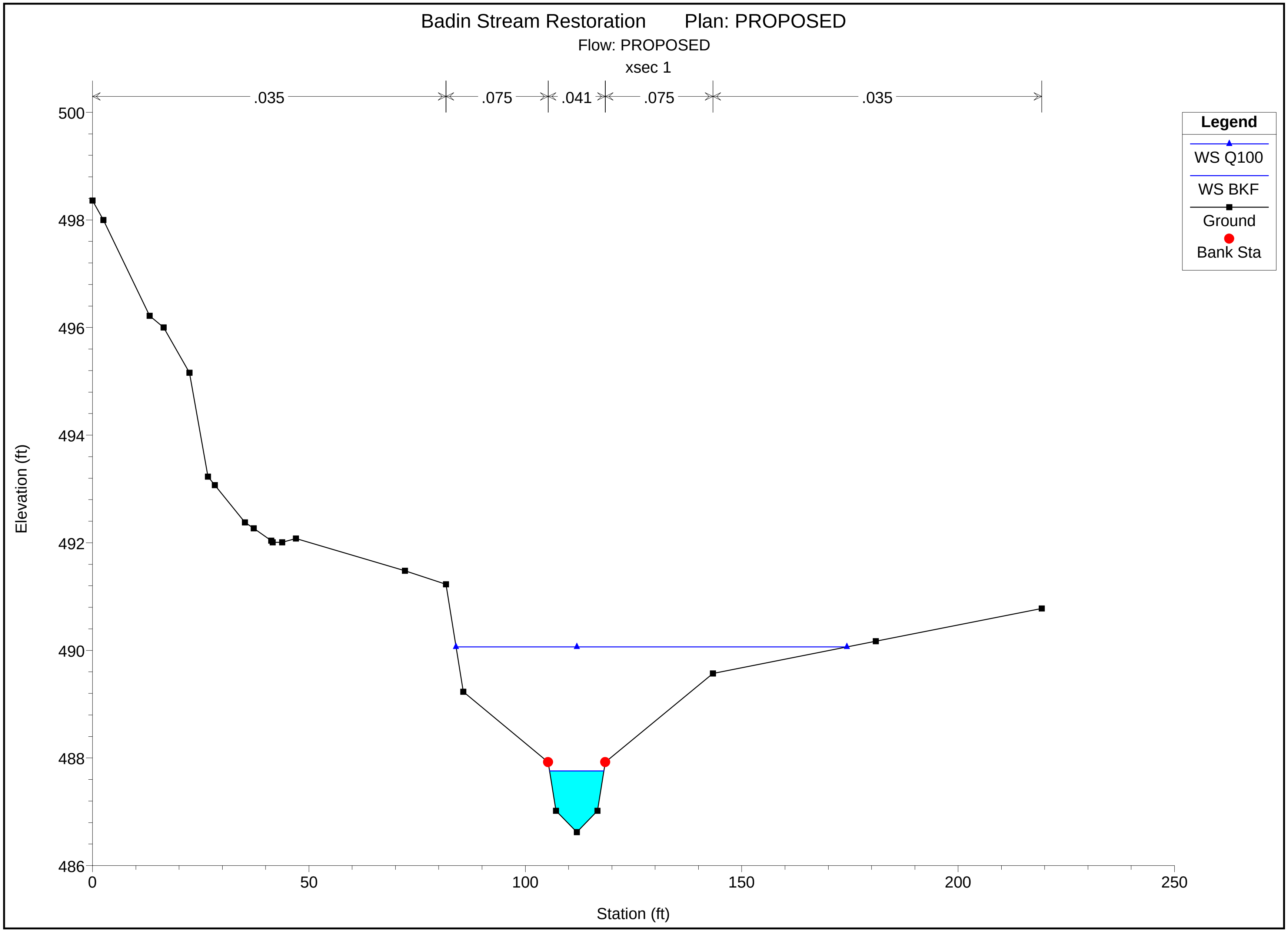
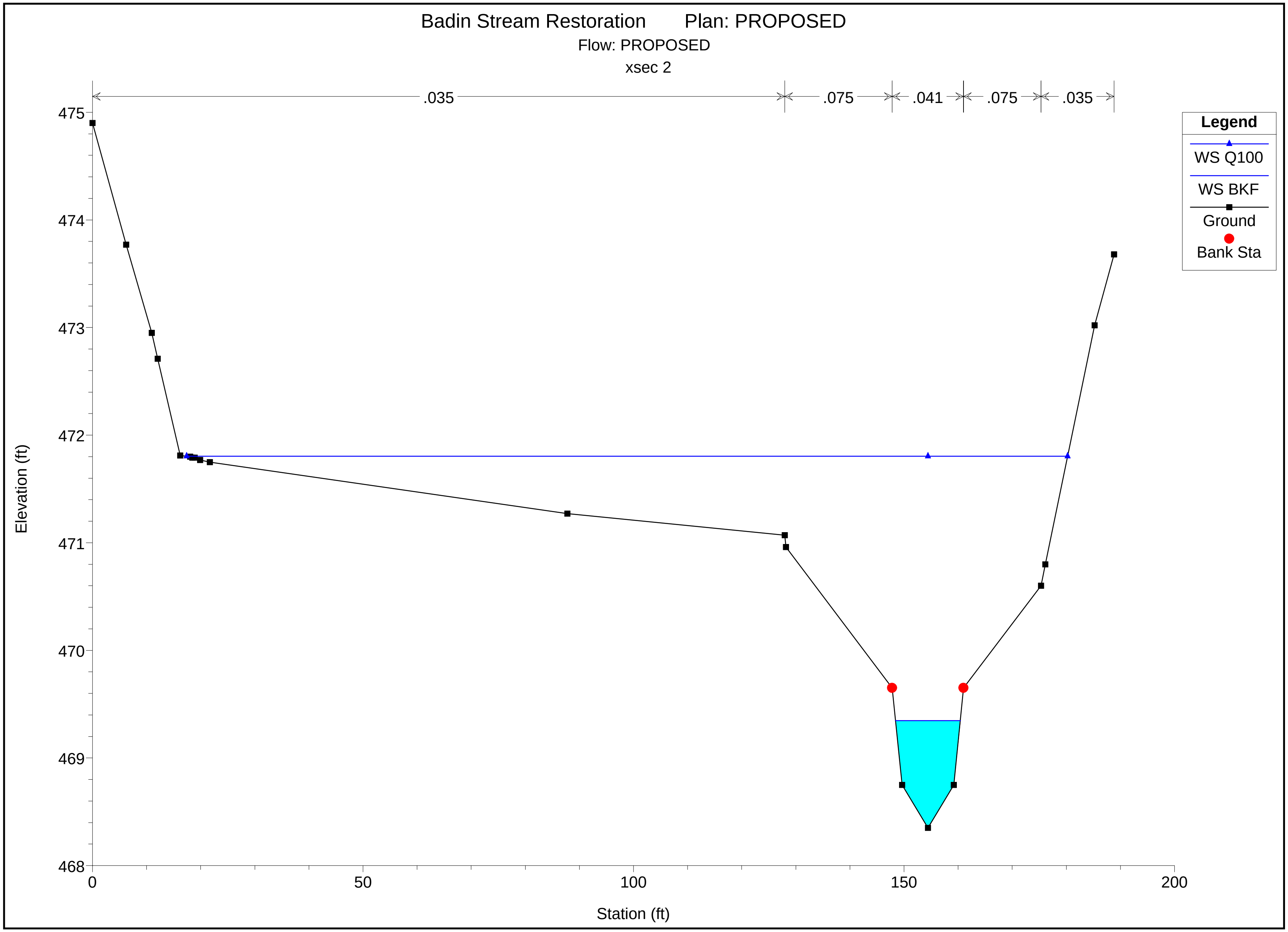
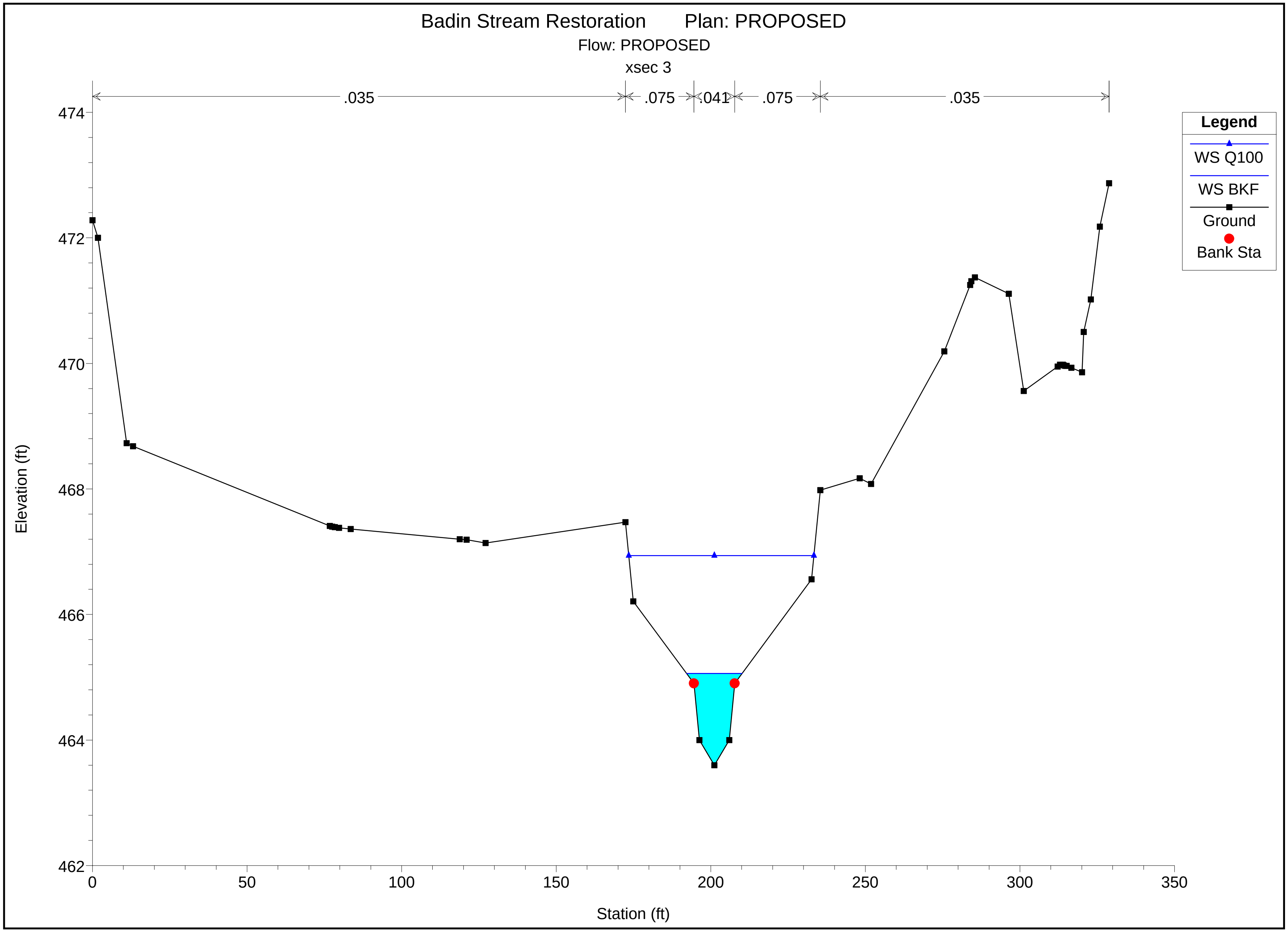
Flow: EXISTING
XSEC9
.035
.035
.014
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
447
446
445
444
443
442
441
440
439
0
100
200
300
400
500
600
700
800
Station (ft)



Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 1
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
Station (ft)
500
498
496
494
492
490
488
486
0
50
100
150
200
250



Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 2
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
475
474
473
472
471
470
469
468
0
50
100
150
200
Station (ft)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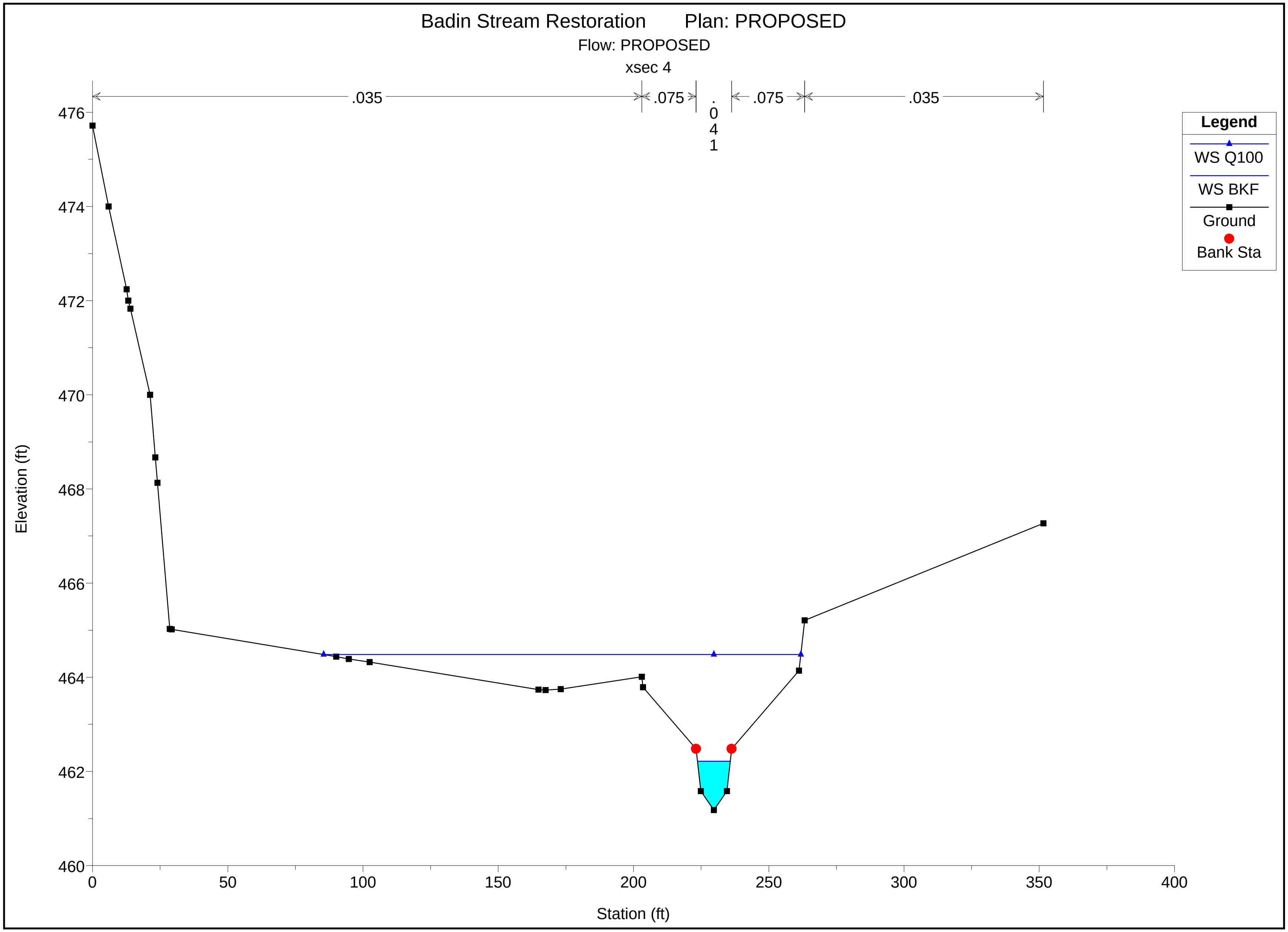
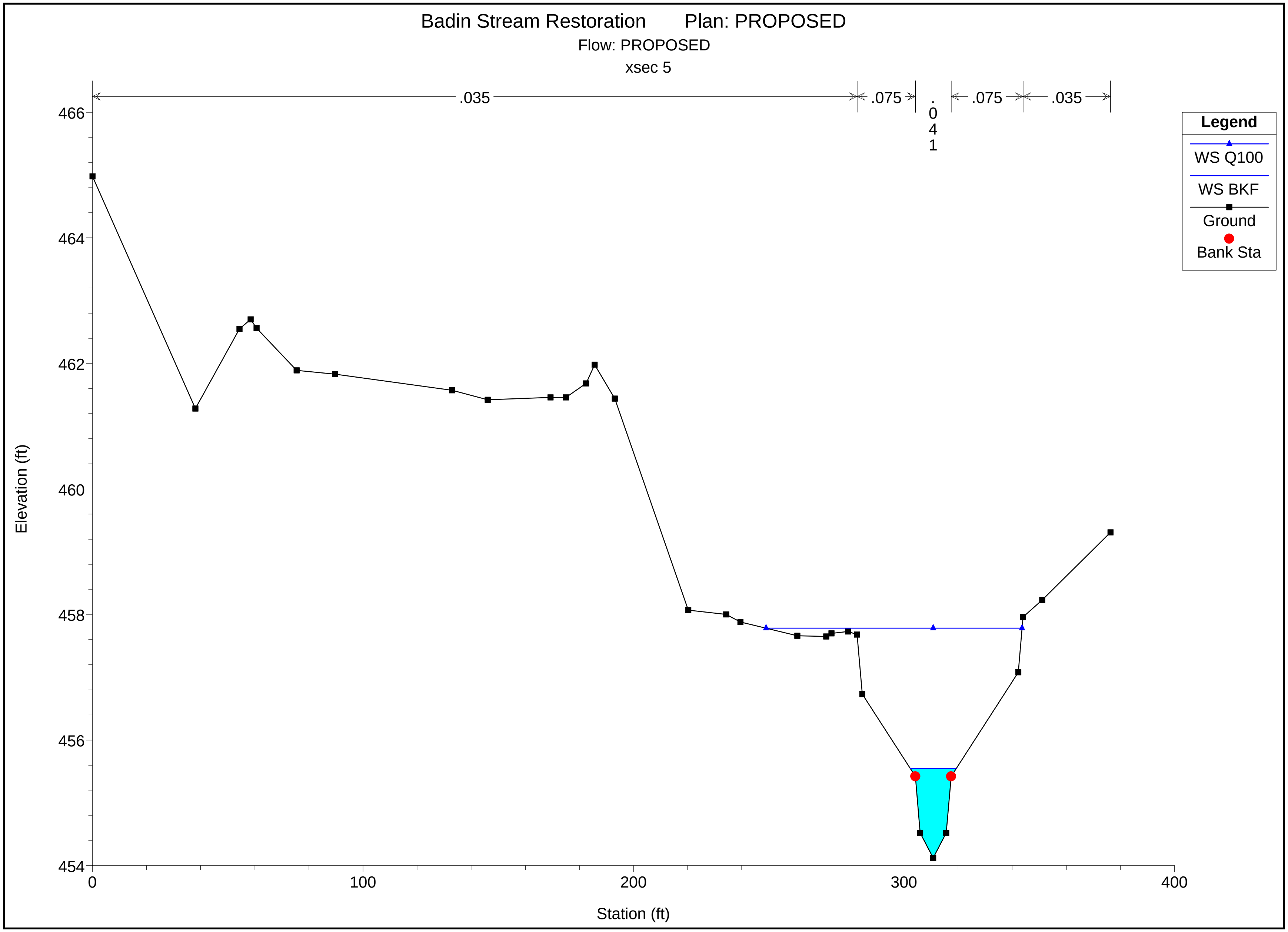
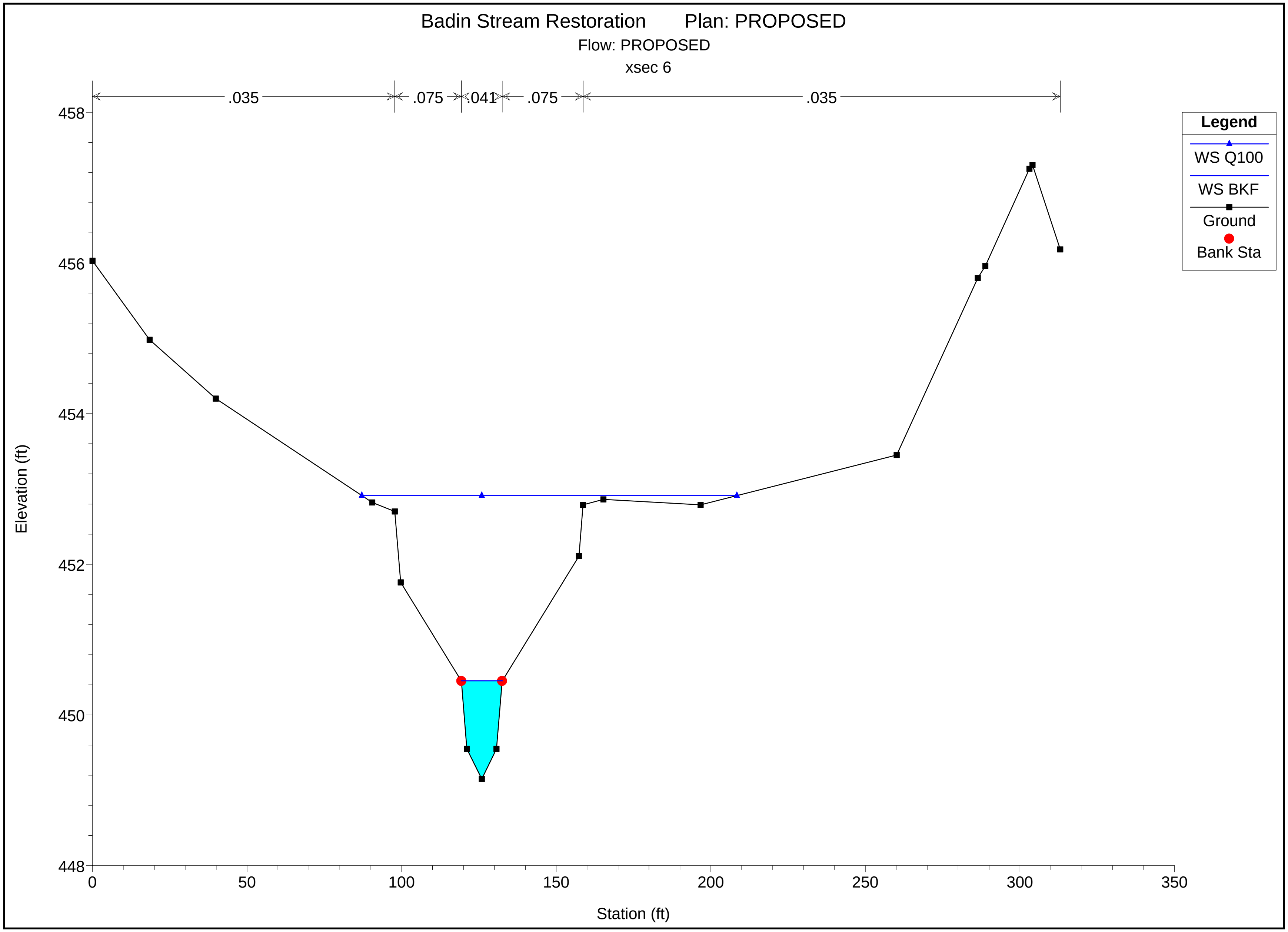
Flow: PROPOSED
xsec 3
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
474
472
470
468
466
464
462
0
50
100
150
200
250
300
350
Station (ft)



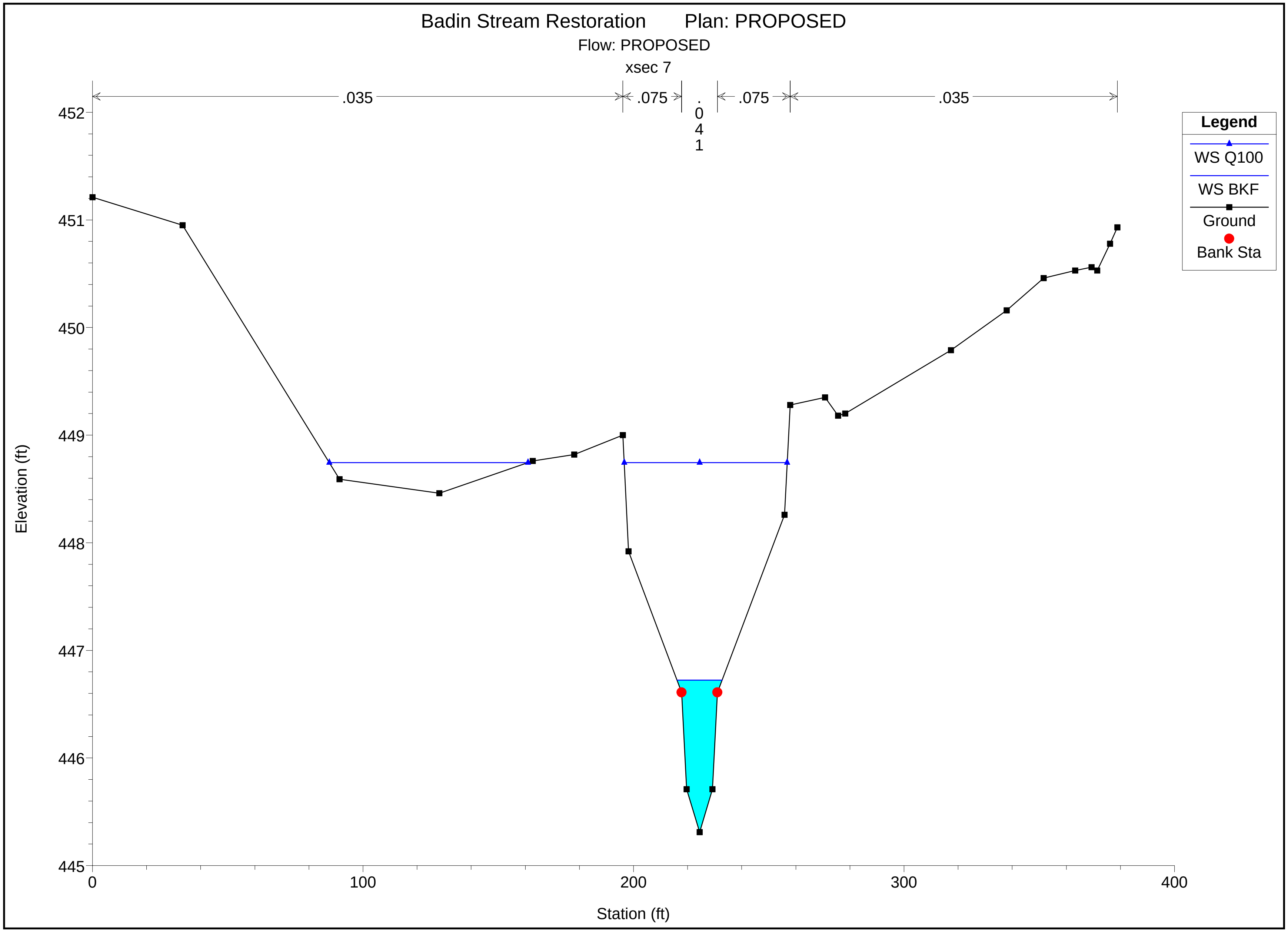
Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 4
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
476
474
472
470
468
466
464
462
460
0
50
100
150
200
250
300
350
400
Station (ft)



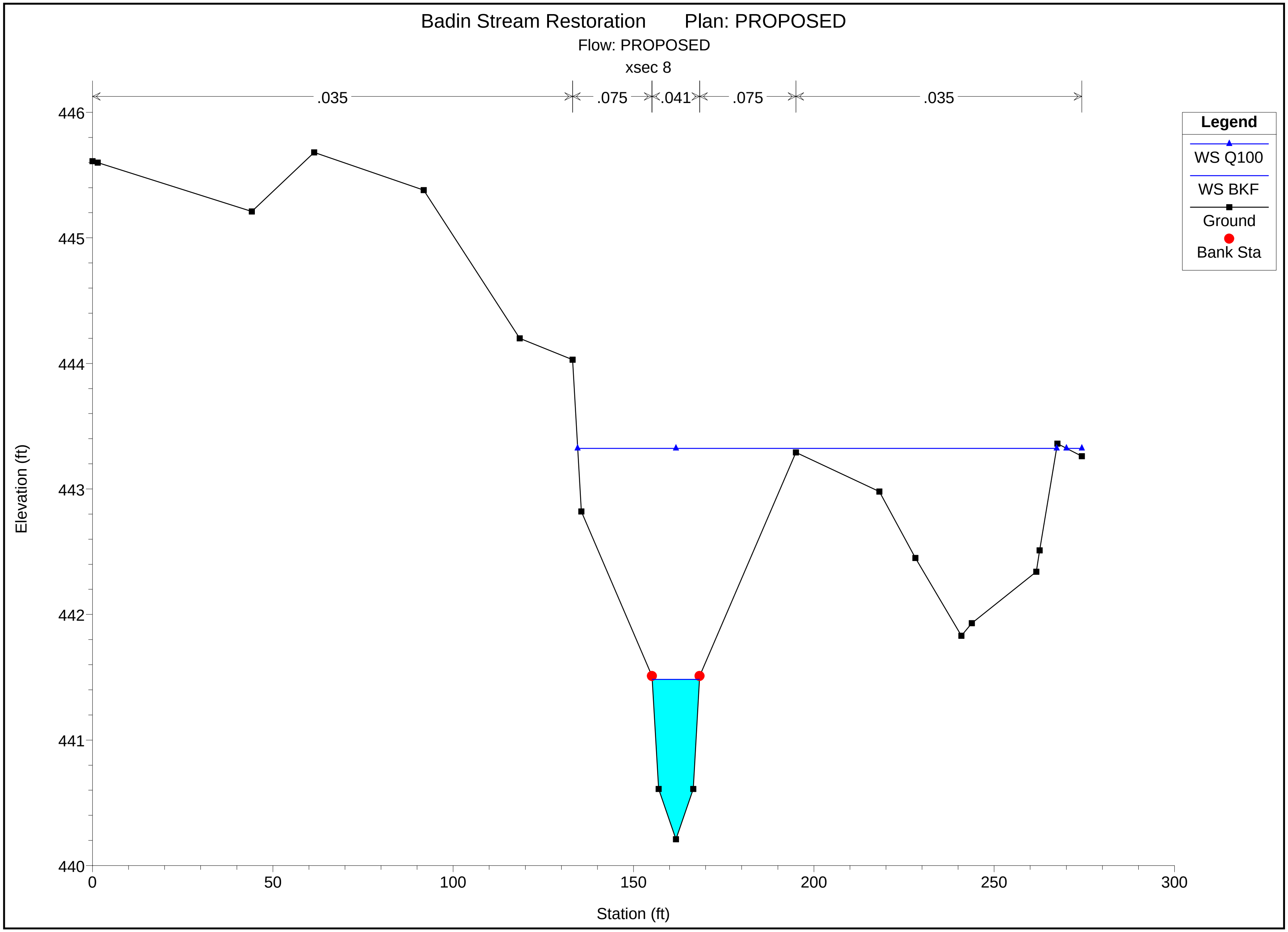
Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 5
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
466
464
462
460
458
456
454
0
100
200
300
400
Station (ft)

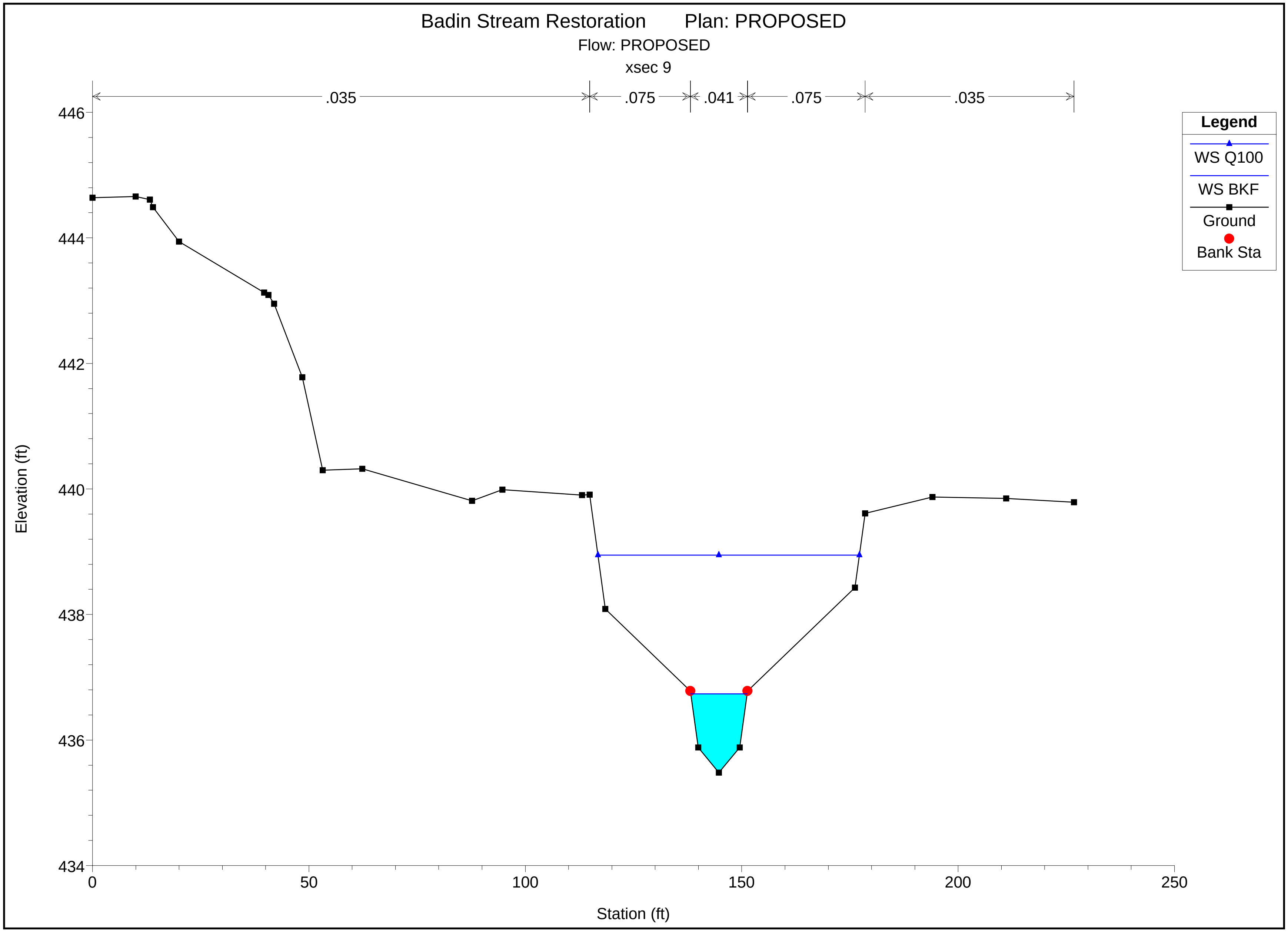


Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 6
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
458
456
454
452
450
448
0
50
100
150
200
250
300
350
Station (ft)



Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 7
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
Station (ft)
452
451
450
449
448
447
446
445
0
100
200
300
400


Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 8
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
446
445
444
443
442
441
440
0
50
100
150
200
250
300
Station (ft)



Badin Stream Restoration Plan: PROPOSED
Flow: PROPOSED
xsec 9
.035
.075
.041
.075
.035
Legend
WS Q100
WS BKF
Ground
Bank Sta
Elevation (ft)
446
444
442
440
438
436
434
0
50
100
150
200
250
Station (ft)

APPENDIX D

MORPHOLOGY TABLE

Parameter	Existing Channel UT to Little Mountain Creek*			Reference Reach- UT to Meadow Fork Creek			Reference Reach- Spencer Creek			Proposed UT to Little Mountain Creek			Proposed Tributary			Dimensions of Existing Concrete Channel		
Stream Type	**NA**			**E4**			**C4**			**C4**			**C4**			**NA**		
Drainage Area	**0.54**			**0.5**			**0.5**			**0.54**			**0.05**			**0.54**		
Dimension	Min	Max	**Avg**	Min	Max	**Avg**	Min	Max	**Avg**	Min	Max	**Avg**	Min	Max	**Avg**		Min	Max
BF Width (ft)						**11.81**			**12.30**			**12.5**			**5.6**	Width	6	6
BF Cross Sectional Area (ft^2)						**15.34**			**10.80**			**13.1**			**2.7**	Depth	2.5	3
BF Mean Depth (ft)						**1.30**			**0.88**			**1.05**			**0.48**			
BF Max Depth (ft)	2.5					**2.11**			**1.80**			**1.2**			**0.53**			
Width/Depth Ratio						**9.08**			**13.98**			**11.90**			**11.67**			
Entrenchment Ratio						**28.11**			**>2.2**			**>2.2**			**>2.2**			
Wetted Perimeter (ft)						**14.34**			**14.13**			**14.6**			**6.56**			
Hydraulic radius (ft)						**1.07**			**0.76**			**0.90**			**0.41**			
Bank Height Ratio				1.03	1.05	**1.04**			**1.10**			**1**			**1**			
Pool Area/Riffle Area						**1.43**			**1.17**			**1.25**			**1.20**			
Max riffle depth/mean riffle depth						**1.62**			**2.05**			**1.14**			**1.10**			
Max pool depth/mean riffle depth						**2.51**			**2.38**			**2.5**			**2.3**			
Pattern																		
Channel Beltwidth (ft)				22.00	57.10	**37.20**	24.00	52.00	**38.00**	23.25	60.38	**41.81**	10.42	27.05	**18.73**			
Radius of Curvature (ft)				18.00	42.80	**25.00**	5.40	22.10	**12.90**	27.63	52.88	**40.25**	12.38	23.69	**18.03**			
Meander Wavelength				78.50	149.90	**107.10**	54.00	196.00	**125.00**	54.88	199.19	**127.03**	24.59	89.24	**56.91**			
Meander Width ratio				1.86	4.83	**3.15**	1.95	4.23	**3.09**	1.86	4.83	**3.35**	1.86	4.83	**3.35**			
Meander Length ratio				6.65	12.69	**9.01**	4.39	15.93	**10.16**	4.39	15.93	**10.16**	4.39	15.93	**10.16**			
Radius of Curvature/Riffle Width (ft)				1.52	3.62	**2.12**	0.44	4.23	**1.05**	2.21	4.23	**3.22**	2.21	4.23	**3.22**			
Pool Length/Riffle Width				1.83	3.10	**2.67**	0.76	1.94	**1.45**	1.83	3.10	**2.67**	1.83	3.10	**2.47**			
Pool to Pool Spacing/ Riffle Width				6.84	8.31	**7.79**	1.06	3.78	**1.97**	6.84	8.31	**7.79**	6.84	8.31	**7.58**			
Profile																		
Pool length (ft)				12.98	20.86	**18.02**	9.29	23.92	**17.78**	22.88	38.75	**30.81**	10.25	17.36	**13.80**			
Pool spacing (ft)				79.48	96.97	**88.23**	13.00	46.5	**24.2**	85.50	103.88	**94.69**	5.92	21.17	**13.54**			
Riffle slope (ft/ft)				0.011	0.021	**0.017**	0.020	0.036	**0.026**	0.012	0.037	**0.019**	0.022	0.040	**0.03**			
Pool slope (ft/ft)				0.003	0.004	**0.003**	0.000	0.005	**0.003**	0.000	0.005	**0.003**	0.000	0.006	**0.00**			
Run slope (ft/ft)				0.012	0.039	**0.029**	0.028	0.059	**0.041**	0.014	0.043	**0.032**	0.031	0.066	**0.05**			
Glide slope (ft/ft)				0.002	0.007	**0.005**	0.000	0.012	**0.003**	0.002	0.007	**0.005**	0.000	0.013	**0.01**			
Riffle Slope/Avg. Water Surface Slope				0.92	1.70	**1.44**	1.52	2.73	**1.97**	0.92	2.73	**1.44**	0.92	2.73	**1.82**			
Run slope/Avg. Water Surface Slope				1.05	3.23	**2.42**	2.12	4.47	**3.11**	1.05	3.23	**2.42**	1.05	3.23	**2.14**			
Pool Slope/Avg. Water Surface Slope				0.20	0.33	**0.26**	0.00	0.38	**0.23**	0.00	0.38	**0.23**	0.00	0.38	**0.19**			
Glide Slope/Avg.Water Surface Slope				0.14	0.56	**0.40**	0.00	0.91	**0.23**	0.14	0.56	**0.40**	0.14	0.56	**0.35**			
Substrate																		
d50 (mm)						**21.4**			**8.6**			**NA**		**NA**				
d84 (mm)						**58.82**			**77**			**92**		**92**				
Additional Reach Parameters																		
Valley Length (ft)			**3540**			**200**			**235**			**3820**			**157**			
Channel Length (ft)			**3540**			**288**			**266**			**3994**			**180**			
Valley Slope (ft/ft)	0.0080	0.0460	**0.0178**			**0.0171**			**0.0139**	0.0080	0.0460	**0.0178**			**0.0152**			
Water Surface Slope (ft/ft)			**0.0178**			**0.0122**			**0.0132**	0.0080	0.0370	**0.0134**			**0.0147**			
Sinuosity			**1**			**1.40**			**1.1**			**1.33**			**1.03**			

NOT APPLICABLE- STREAM IS COMPLETELY MODIFIED

*Channel has been significantly modified through channelization and therefore cannot be classified using Rosgen system of classification for natural channels