Beaverdam Creek Stream Restoration Plan
Mecklenburg County, North Carolina

Submitted by:

Riverworks, Inc.
8000 Regency Parkway
Suite 200
Cary, NC 27511

This document printed on Recycled Paper

February 2006

Beaverdam Creek Stream Restoration Plan
Mecklenburg County, North Carolina

Design Report Prepared by Buck Engineering PC

1447 S. Tryon Street
Suite 200
Charlotte, NC 28203
www.buckengineering.com

Shawn Wilkerson
Project Manager

Joshua Gilman
Project Engineer

Aaron Earley
Project Engineer

February 2006

EXECUTIVE SUMMARY

In this Beaverdam Creek Stream Restoration Plan, Riverworks, Inc., proposes to restore and enhance 12,869 linear feet (LF) of perennial stream channel along two unnamed tributaries of Beaverdam Creek (UT1 and UT2) and several of their tributaries. Additionally, this plan proposes to preserve a combined total of 2,603 LF along Beaverdam Creek mainstem and UT2 within the proposed restoration and enhancement area. The entire restoration plan site is located within the Extraterritorial Jurisdiction (ETJ) of the City of Charlotte, Mecklenburg County, NC (Figure 1.1) and lies in the Catawba River Basin within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-34 and United States Geologic Survey (USGS) hydrologic unit 03050101170040.

The goals for the restoration project are as follows:

- To create geomorphically stable stream channel and floodplain conditions along UT1, UT2 and their associated tributaries within the Beaverdam Creek watershed
- Improve the local hydrology through increased groundwater recharge, groundwater storage, and hydrologic connectivity between the channel and the adjacent floodplain
- Improve the water quality in the Beaverdam Creek watershed by increasing dissolved oxygen concentrations, and by reducing nutrient and sediment load
- Improve aquatic and riparian terrestrial habitat through improved hydraulic and biologic diversity.

To accomplish these goals, Buck Engineering recommends the following:

- Restore the existing incised, eroding, and channelized streams by creating channels that possess characteristics (pattern, profile and dimension) of a natural channel with access to an active floodplain
- Raise the existing streambed to provide access to the adjacent floodplain in the form of incipient flooding at bankfull stage (Priority 1), where possible, or excavate a bankfull bench (Priority 2) where required
- Restore hydrologic and vegetative function of the floodplain and stream channel by removing invasive non-native species, protecting the existing stable riparian forest, and establishing native vegetation within a permanent conservation easement. This will allow for increased filtration of storm water runoff, improved bank stability, and reduced water temperature
- Establish variation in bedform by including riffles, steps and pool features using cobbles, boulders, logs and other woody debris where appropriate.

Table ES.1
Mitigation Overview

Project Feature	Existing Condition (LF)	Design Condition (LF)	Type of Mitigation	Priority Approach	Credit Ratio	Mitigation Credits (SMUs)
UT1 (Reach 1)	542	555	Enhancement	P3	1.5:1	370
UT1 (Reaches 2-5)	5,796	6,155	Restoration	P1	1:1	6,155
UT1B	743	790	Restoration	P2	1:1	790
UT1C	744	628	Restoration	P1	1:1	628
UT1D	323	352	Restoration	P1	1:1	352
UT2	3,130	3,290	Restoration	P1	1:1	3,290
UT2A	886	1,099	Restoration	P1	1:1	1,099
Beaverdam Creek	1,641	1,641	Preservation	-	5:1	328
UT2	962	962	Preservation	-	5:1	192
Total	**14,767**	**15,472**	**Various**	**Various**	**Various**	**13,204**

Table of Contents

List of Tables

List of Tables (continued)

List of Figures

List of Appendices

1.0 INTRODUCTION AND BACKGROUND

1.1 Project Location and Description

The Beaverdam Creek site is located approximately 3 miles southwest of the Charlotte-Douglas International Airport in the western portion of an extraterritorial jurisdiction (ETJ) of the City of Charlotte, Mecklenburg County, and lies within the Catawba River Basin (Figure 1.1). The project site is part of highly degraded system that was included in the *2003 Beaverdam Creek Watershed Geomorphic Assessment* (Buck, 2004) completed by Buck Engineering for Charlotte Storm Water Services. The City of Charlotte Storm Water Services supports this project as part of the watershed improvements to improve and protect the water quality of a rapidly developing watershed. The site extends from the newly constructed Interstate 485 corridor to Brown's Cove of Lake Wylie, an impounded reservoir on the Catawba River. The site lies within North Carolina Department of Water Quality (NCDWQ) sub-basin 03-08-34 and U.S. Geologic Survey (USGS) hydrologic unit 03050101170040. Historically, this site was likely heavily timbered and subsequently farmed aggressively. More recent land use of the site consists of reforested areas actively farmed and grazed. The proposed land use varies from managed parkland to medium density residential development. The combined historic and current land used has contributed to the degraded nature of this site while the proposed land use presents a substantial opportunity for water quality and ecosystem improvements.

Riverworks, Inc. proposes to restore and enhance 15,472 linear feet (LF) of channelized stream on two unnamed tributaries of Beaverdam Creek (UT1 and UT2). The project also includes the preservation of an additional 1,641 LF of Beaverdam Creek and 962 LF of UT2 (Figure 4.1).

All surface waters in North Carolina are assigned a primary classification by the NCDWQ. All waters must at least meet the standards for Class C (fishable / swimmable) waters. Class C waters are protected for secondary recreation, fishing, wildlife, agriculture, and fish and aquatic life propagation and survival. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. NCDWQ (source: http://h2o.enr.state.nc.us/bims/reports/basinsandwaterbodies/Mecklenburg.pdf) lists Beaverdam Creek as Class C. Based on North Carolina's tributary rule, its tributaries are also considered Class C waters.

Restoration of the site would reduce the amount of sediment flowing from the site, improving the overall water quality of the downstream receiving inlet, Brown's Cove. Restoration of this site will support the ongoing effort by the City of Charlotte and Mecklenburg County to limit the impact of development in the Beaverdam Creek Watershed occurring due to the construction of I-485.

1.2 Project Goals and Objectives

This project site has been selected by the North Carolina Ecosystem Enhancement Program (NCEEP) due to its highly degraded state and potential for restoration and enhancement. Most of the existing stream systems proposed for restoration are incised and have banks that are actively eroding. These reaches have lost connection with their natural floodplain and only through a slow process of subsequent bank erosion, channel widening and floodplain development will the channel achieve equilibrium in the form of new floodplain development at lower elevations.

The goals for the restoration project are as follows:

- To create geomorphically stable stream channel and floodplain conditions along UT1, UT2 and their associated tributaries within the Beaverdam Creek watershed
- Improve the local hydrology through increased groundwater recharge, groundwater storage, and hydrologic connectivity between the channel and the adjacent floodplain

- Improve the water quality in the Beaverdam Creek watershed by increasing dissolved oxygen concentrations, reducing nutrient and sediment load
- Improve aquatic and riparian terrestrial habitat through improved hydraulic and biologic diversity.

To accomplish these goals, we recommend the following:

- Restore the existing incised, eroding, and channelized streams by creating channels that possess characteristics (pattern, profile and dimension) of a natural channel with access to an active floodplain
- Raise the existing streambed to provide access to the adjacent floodplain in the form of incipient flooding at bankfull stage (Priority 1), where possible, or excavate a bankfull bench (Priority 2) where existing topography dictates
- Restore hydrologic and vegetative function of the floodplain and stream channel by removing invasive non-native species, protecting the existing stable riparian forest, and establishing native vegetation within a permanent conservation easement. This will allow for increased filtration of storm water runoff, improved bank stability, and reduced water temperature
- Establish variation in bedform by including riffles, steps and pool features using cobbles, boulders, logs and other woody debris where appropriate.

1.3 Report Overview

This report has been arranged and formatted to maximize its utility. Section 2 provides new readers with a review of the background science methodologies applied by Buck Engineering in the practice of natural channel design and wetland restoration. Sections 3, 4, 5, and 6 are specific to the project site. These sections cover the site assessment findings, selection and application of design criteria, and site design. Section 7 presents a post-construction monitoring and evaluation procedures.

2.0 BACKGROUND SCIENCE AND METHODS

A stream and its wetland floodplain (referred to here as the riparian area) comprise a dynamic environment where the floodplain, wetland areas, channel, and bedform evolve through natural processes. Weather and hydraulic processes erode, transport, sort, and deposit alluvial materials throughout the riparian system. The flow regime and associated hydraulic geometry of a stream are primarily a function of independent variables including watershed properties (area and topography), land use, parent geology, and climate. The morphology, or size and shape, of the stream channel reflects a complex interrelationship of all of these factors (Leopold et al., 1992; Knighton, 1998). Given that these independent variables remain constant, over time the channel may adjust longitudinally and laterally (i.e. migrating meanders) while maintaining a relatively constant dimension, pattern, and profile. Similarly, other valley features, such as adjacent wetlands and their characteristics (size, location and function) reflect this dynamic equilibrium of the stream channel. However, changes to the independent variables such as changes in land use (increased imperviousness) may yield dramatic changes in the flow regime, including increased peak flow and reduced time of concentration, which can upset this balance. A new equilibrium may eventually result, but not until after large adjustments in channel form, including extreme bank erosion in the form of down cutting, or incision, and over-widening can occur (Lane, 1955; Schumm, 1960). These adjustments in channel form often have negative effects on associated wetland areas, as channel incision dewaters of adjacent floodplains and wetlands. By understanding and applying the processes of riparian form and function to stream and wetland restoration projects, a self-maintaining riparian system can be designed and constructed to maximize natural ecosystem form and function.

In riparian systems, wetland functions cannot be restored without also addressing the restoration of stream functions; therefore, it is crucial that the degraded stream system be restored to the appropriate dimension, pattern, and profile while allowing the stream to access the abandoned floodplain and associated wetland areas. In this way, the stream returns to serving one of the primary sources of water and nutrient inputs to the wetland system. The following sections describe the processes, which Buck Engineering uses when developing stream and wetland restoration projects using natural channel design concepts.

2.1 General Stream Morphology

In addition to transporting water and sediment, natural streams provide the habitat for many aquatic organisms, including fish, amphibians, insects, mollusks, and plants. Trees and shrubs along the banks provide a food source and regulate water temperatures. Channel features such as pools, riffles, steps, and undercut banks provide diversity of habitat, oxygenation, and cover (Dunne and Leopold, 1978). Stream restoration projects can repair these features in concert with the return of a stable dimension, pattern, and profile. The following sections provide an overview of the primary channel-forming process and typical stream morphology.

2.1.1 Channel-Forming Discharge

The channel-forming discharge, also referred to as bankfull discharge, effective discharge, or dominant discharge, creates a natural and predictable channel size and shape (Leopold et al., 1992; Leopold, 1994). Channel-forming discharge theory states that there is a unique flow that would, over time, yield the same channel morphology as that shaped by the natural sequence of flows. At this discharge, equilibrium is most closely approached, and the tendency to change is the least (Inglis, 1947). Uses of the channel-forming discharge include channel stability assessment, river management using hydraulic geometry relationships, and natural channel design (Soar and Thorne, 2001).

Proper determination of bankfull stage in the field is vital to stream classification and the natural channel design process. The bankfull discharge is the point at which flooding occurs on the floodplain (Leopold, 1994). This flood stage may or may not be the top of the stream bank. With the exception of some urban streams, bankfull discharge occurs at a frequency of approximately 1.5 years (Leopold, 1994; Harman et al., 1999; McCandless, 2003). If the stream has incised due to changes in the watershed or streamside vegetation, the bankfull stage may be indicated by a small, depositional bench or scour line on the stream bank (Harman et al., 1999). In this case, the top of the bank, which was formerly the floodplain, is called a terrace. A stream with terraces at the top of its banks is considered to be incised.

2.1.2 Bedform Diversity and Channel Substrate

The profile of a stream bed and its bed materials is largely dependent on valley slope and geology. In simple terms, steep, straight streams are found in steep, colluvial valleys, while flat, meandering streams are found in flat, alluvial valleys. Colluvial valleys have slopes between two and four percent, while alluvial channels have slopes less than two percent. A colluvial valley forms through hillslope processes. Sediment supply in colluvial valleys is controlled by hillslope erosion and mass wasting; i.e., the sediments in the stream bed originated from the hillslopes. Sediments reaching the channel in a colluvial valley are typically poorly-sorted mixtures of fine- and coarse-grained materials, ranging in size from sand to boulders. In contrast, an alluvial valley forms through stream and floodplain processes. Sediments in alluvial valleys include some coarse gravel and cobble transported from steeper upland areas but are predominantly fine-grained particles, such as gravel and sand. Grain size generally decreases with valley slope (Leopold et al., 1992).

2.1.2.1 Step/Pool Streams

A step/pool bed profile is characteristic of steep streams formed within colluvial valleys. Steep mountain streams demonstrate step/pool morphology as a result of episodic sediment transport mechanisms. Because of the high energy associated with the steep channel slope, the substrate in step/pool streams contains significantly larger particles than streams in flatter alluvial valleys. Steps form from accumulations of boulders and cobbles that span the channel, resulting in a backwater pool upstream and plunge pool downstream. Smaller particles collect in the interstices of steps, creating stable, interlocking structures (Knighton, 1998).

In contrast to meandering streams that dissipate energy through meander bends, step/pool streams dissipate energy through drops and turbulence. Step/pool streams have relatively low sinuosity. Pattern variations are commonly the result of debris jams, topographic features, and bedrock outcrops.

2.1.2.2 Gravel Bed Streams

Meandering gravel bed streams in alluvial valleys have sequences of riffles and pools that maintain channel slope and bed stability. The riffle is a bed feature composed of gravel-size or larger particles. During low flow periods, the water depth at a riffle is relatively shallow and the slope is steeper than the average slope of the channel. At low flows, water moves faster over riffles, increasing the interphase between water and air, providing oxygen to the stream. Riffles control the stream bed elevation and are usually found entering and exiting meander bends. The inside of the meander bend is a depositional feature called a point bar, which also helps maintain channel form (Knighton, 1998). Pools are typically located on the outside bends of meanders, between riffles. Pools have a flat slope and are much deeper than the average depth of the channel. At low flows, pools are depositional features and riffles are scour features.

At high flows, the water surface becomes more uniform: the water surface slope decreases at the riffles and increases at the pools. The increase in pool slope coupled with the greater water depth at the pools causes an increase in shear stress at the bed elevation. The opposite is true at riffles. With a relative increase in shear stress, pools scour. The relative decrease in shear stress at riffles causes bed material deposits at these features during the falling limb of the hydrograph.

2.1.2.3 Sand Bed Streams

While gravel bed streams have riffle/pool sequences with riffles composed of gravel-size particles, sand bed channels are characterized by median bed material sizes less than two millimeters (Bunte and Abt, 2001). Bed material features called ripples, dunes, planebeds, and antidunes characterize the sand bedform. Although sand bed streams technically do not have riffles, the term is often used to describe the crossover reach between pools. We use "riffle" in this report to mean the same as "the crossover section."

The size, stage, and variation of sand bedforms are formed by changes in unit stream power, as described below. These bedforms are symptomatic of local variations in the sediment transport rate and cause minor to major variations in aggradation and degradation (Gomez, 1991). Sand bedforms can be divided between low- flow regimes and high-flow regimes, with a transitional zone between the two. Ripples occur at low flows where the unit stream power is just high enough to entrain sand-size particles. This entrainment creates small wavelets from random accumulation of sediment that are triangular in profile, with gentle upstream and steep downstream slopes. The ripple dimensions are independent of flow depth, and heights are less than 0.02 meter.

As unit stream power increases, dunes eventually replace ripples. Dunes are the most common type of sand bedform and have a larger height and wavelength than ripples. Unlike ripples, dune height and wavelength are proportional to flow depth. The movement of dunes is the major cause of variability in bed-load transport rates in sand bed streams. Dunes are eventually washed out to leave an upper-flow plane bed characterized by intense bedload transport. This plane bed prevents the patterns of erosion and deposition required for dune development. This stage of bedform development is called the transitional flow regime, between the low-flow and high-flow regime features (Knighton, 1998).

As flow continues to increase, standing waves develop at the water surface, and the bed develops a train of sediment waves (antidunes) which mirror the surface forms. Antidunes migrate upstream by way of scour on the downstream face and deposition on the upstream face, a process that is opposite of ripples and dunes. Antidunes can also move downstream or remain stationary for short periods (Knighton, 1998).

2.1.3 Stream Classification

The Rosgen Stream Classification System categorizes essentially all types of channels based on measured morphological features (Rosgen, 1994, 1996). The system presents several stream types based on a hierarchical system. The classification system is illustrated in Figure 2.1. The first level of classification distinguishes between single and multiple-thread channels. Streams are then separated based on degrees of entrenchment, width/depth ratio, and sinuosity. Slope range and channel materials are also evaluated to subdivide the streams. Stream types are further described according to average riparian vegetation, organic debris, blockages, flow regimes, stream size, depositional features, and meander pattern.

Bankfull stage is the basis for measuring the width/depth and entrenchment ratios, two of the most important delineative criteria; therefore, it is critical to correctly identify bankfull stage when classifying streams and designing stream restoration measures. A detailed discussion of bankfull stage was provided in Section 2.1.1.

2.1.4 Stream Stability

A naturally stable stream must be able to transport the sediment load supplied by its watershed while maintaining dimension, pattern, and profile over time so that it does not degrade or aggrade (Rosgen, 1994). Stable streams migrate across alluvial landscapes slowly, over long periods, while maintaining their form and function. Instability occurs when scouring causes the channel to incise (degrade) or excessive deposition causes the channel bed to rise (aggrade). A generalized relationship of stream stability proposed by Lane (1955) is shown as a schematic drawing in Figure 2.2. The drawing shows that the product of sediment load and sediment size is proportional to the product of stream slope and discharge, or stream power. A change in any one of these variables causes a rapid physical adjustment in the stream channel.

2.1.5 Channel Evolution

A common sequence of physical adjustments has been observed in many streams following disturbance. This adjustment process is often referred to as channel evolution. Disturbance can result from channelization, increase in runoff due to build-out in the watershed, removal of streamside vegetation, and other changes that negatively affect stream stability. All of these disturbances occur in both urban and rural environments. Several models have been used to describe this process of physical adjustment for a stream. The Simon (1989) Channel Evolution Model characterizes evolution in six steps, including

1. sinuous, pre-modified
2. channelized
3. degradation
4. degradation and widening
5. aggradation and widening
6. quasi-equilibrium.

Figure 2.3 illustrates the six steps of the Simon Channel Evolution Model.

The channel evolution process is initiated once a stable, well-vegetated stream that interacts frequently with its floodplain is disturbed. Disturbance commonly results in an increase in stream power that causes degradation, often referred to as channel incision (Lane, 1955). Incision eventually leads to over-steepening of the banks and, when critical bank heights are exceeded, the banks begin to fail and mass wasting of soil and rock leads to channel widening. Incision and widening continue moving upstream in the form of a head-cut. Eventually the mass wasting slows, and the stream begins to aggrade. A new, low-flow channel begins to form in the sediment deposits. By the end of the evolutionary process, a stable stream with dimension, pattern, and profile similar to those of undisturbed channels forms in the deposited alluvium. The new channel is at a lower elevation than its original form, with a new floodplain constructed of alluvial material (FISRWG, 1998).

2.1.6 Priority Levels of Restoring Incised Rivers

Though incised streams can occur naturally in certain landforms, they are often the product of disturbance. High, steep stream banks, poor or absent in-stream or riparian habitat, increased erosion and sedimentation, and low sinuosity are all characteristics of incised streams. Ideally, complete restoration of the stream, wherein the incised channel's grade is raised so that an abandoned floodplain terrace is reclaimed, is the overriding project objective. In some scenarios, such an objective is impractical due to encroachment into the abandoned floodplain terrace by homes, roadways, utilities, or other obstructions. A priority system for the restoration of incised streams, developed and used by Rosgen (1997), considers a range of options to provide the best level of stream restoration possible for a given setting. Figure 2.4 illustrates various restoration/stabilization options for incised channels within the framework of the Rosgen's priority system. Generally:

- Priority 1 – Re-establishes the channel on a previous floodplain (i.e., raises channel elevation); meanders a new channel to achieve the dimension, pattern, and profile characteristic of a stable stream for the particular valley type; and fills or isolates existing, incised channel. This option requires that the upstream start point of the project not be incised.

- Priority 2 – Establishes a new floodplain at the existing bankfull elevation (i.e., excavates a new floodplain); meanders channel to achieve the dimension, pattern, and profile characteristic of a stable stream for the particular valley type; and fills or isolates existing, incised channel.
- Priority 3 – Converts a straight channel to a different stream type while leaving the existing channel in place by excavating bankfull benches at the existing bankfull elevation. Effectively, the valley for the stream is made more bowl-shaped. This approach uses in-stream structures to dissipate energy through a step/pool channel type.
- Priority 4 – Stabilizes the channel in place using in-stream structures and bioengineering to decrease stream bed and stream bank erosion. This approach is typically used in highly-constrained environments.

2.2 Natural Channel Design Overview

Restoration design of degraded stream reaches first involves accurately diagnosing their current condition. Understanding valley type, stream type, channel stability, bedform diversity, and potential for restoration is essential to developing adequate restoration measures (Rosgen, 1996). This combination of assessment and design is often referred to as natural channel design.

The first step in a stream restoration design is to assess the reach, its valley, and its watershed, to understand the relationship between the stream and its drainage basin and to evaluate the causes of stream impairment. Bankfull discharge is estimated for the watershed. After sources of stream impairment are identified and channel geometry is assessed, a plan for restoration can be formulated.

Design commences at the completion of the assessment stage. A series of iterative calculations are performed using data from reference reaches, pertinent literature, and evaluation of past projects to develop an appropriate stable cross-section, profile, and plan form dimensions for the design reach. A thorough discussion of design parameter selection is provided in Section 2.5. The alignment should avoid an entirely symmetrical layout to mimic natural variability, create a diversity of aquatic habitats, and improve aesthetics.

Once a dimension, pattern, and profile have been developed for the project reach, the design is tested to ensure that the new channel will not aggrade or degrade. A discussion of sediment transport methodology is provided in Section 2.6.

After the sediment transport assessment, additional structural elements are added to the design to provide grade control, protect stream banks, and enhance habitat. Section 2.7 describes these in-stream structures in detail.

Once the design is finalized, detailed drawings are prepared showing dimension, pattern, profile, and location of additional structures. These drawings are used in the construction of the project.

Following the implementation of the design, a monitoring plan is established to:

- Ensure that stabilization structures are functioning properly
- Monitor channel response in dimension, pattern and profile, channel stability (aggradation/degradation), particle size distribution of channel materials, and sediment transport and stream bank erosion rates
- Determine biological response (food chains, standing crop, species diversity, etc.)
- Determine the extent to which the restoration objectives have been met.

2.3 Geomorphic Characterization Methodology

Geomorphic characterization of stream features includes the bankfull identification, bed material characterization and analysis, and stream classification.

2.3.1 Bankfull Identification

Correct identification of bankfull is important to the determination of geomorphic criteria such as stream type, bank height ratios, width/depth ratios, and entrenchment ratios. Buck Engineering uses the following field techniques for bankfull identification:

- Identify the most consistent bankfull indicators along the reach that have obviously been formed by the stream, such as a point bar or lateral bar. Bankfull is usually the back of this feature, unless sediment supply is high. In that case, the bar may flatten and bankfull will be the front of the feature at the break in slope. The indicator is rarely the top of the bank or lowest scour mark.
- Measure the difference in height between the water surface and the bankfull indicator; for example, the indicator may be 2.2 feet above water surface. Bankfull stage corresponds to a flow depth. It should not vary by more than a few tenths of a foot throughout the reach, unless a tributary enters the reach and increases the size of the watershed.
- Go to a stable riffle. If a bankfull indicator is not present, use the height measured in the previous step to establish the indicator; for example, measure 2.2 feet above water surface, and place a flag in both the right and left banks.
- Measure the distance from the left bank to the right bank between the indicators. Calculate the cross-sectional area.
- Obtain the appropriate regional curve (e.g., rural Piedmont, urban Piedmont, Mountain, or Coastal Plain) and determine the cross-sectional area associated with the drainage area of the reach.
- Compare the measured cross-sectional area to the regional curve cross-sectional area. If the measured cross-sectional area is not a close fit, look for other bankfull indicators, and test them. If there are none, look for reasons to explain the difference between the two areas; for example, if the cross-sectional area of the stable riffle is lower than that of the regional curve area, look for upstream impoundments, wetlands, or a mature, forested watershed. If the cross-sectional area is higher than that of the regional curve area, look for stormwater drains, parking lots, or signs of channelization.

It is important to perform the bankfull verification at a stable riffle, using indicators from depositional features. The cross-sectional area will change with decreasing stability. In some streams, bankfull indicators will not be present due to incision or maintenance. In such cases, it is important to verify bankfull through other means, such as a gage station survey or reference bankfull information that is specific to the geographic location. The gage information can be used, along with regional curve information, to estimate bankfull elevation in the project reach that contains no bankfull indicators.

2.3.2 Bed Material Characterization

Buck Engineering performs bed material characterization using a modified Wolman procedure (Wolman, 1954; Rosgen, 1996). A 100-count pebble count is performed in transects across the streambed, with the number of riffle and pool transects being proportional to the percentage of riffles and pools within the longitudinal distance of a given stream type. As stream type changes, a separate pebble count is performed. The median particle size of the modified Wolman procedure is known as the d_{50}. The d_{50} describes the bed material classification for that reach. The bed material classification is shown in Figure 2.1 and ranges from a classification of 1 for a channel d_{50} of bedrock to a classification of 6 for a channel d_{50} in the silt/clay particle size range.

2.3.3 Stream Classification

Cross-sections are surveyed along stable riffles for the purpose of stream classification. Values for entrenchment ratio and width/depth ratio, along with sinuosity and slope, are used to classify the stream. The entrenchment ratio (ER) is calculated by dividing the flood-prone width (width measured at twice the maximum bankfull depth) by the bankfull width. The width/depth ratio (w/d ratio) is calculated by dividing bankfull width by mean bankfull depth). Figure 2.5 shows examples of the channel dimension measurements used in the Rosgen Stream Classification System.

Finally, the numbers that coincide with each bed material classification are to further classify the stream type; for example, a Rosgen "E3" stream type is a narrow and deep, cobble-dominated channel with access to a floodplain that is greater than two times its bankfull width.

2.4 Channel Stability Assessment Methodology

Buck Engineering uses a modified version of stream channel stability assessment methodology developed by Rosgen (2001). The Rosgen method is a field assessment of the following stream channel characteristics:

- Stream Channel Condition
- Vertical Stability
- Lateral Stability
- Channel Pattern
- River Profile and Bed Features
- Channel Dimension Relations
- Channel Evolution.

This field exercise is followed by the evaluation of various channel dimension relationships.

Evaluation of the above categories and ratios leads to a determination of a channel's current state, potential for restoration, and appropriate restoration activities. A description of each category is provided in the following sections.

2.4.1 Stream Channel Condition Observations

Stream channel conditions are observed during initial field inspection (stream walk). Buck Engineering notes the follow characteristics:

- Riparian vegetation – concentration, composition, and rooting depth and density
- Sediment depositional patterns – mid-channel bars and other depositional features that indicate aggradation and can lead to negative geomorphic channel adjustments
- Debris occurrence – presence or absence of woody debris
- Meander patterns – general observations with regard to the type of adjustments a stream will make to reach equilibrium
- Altered states due to direct disturbance – such as channelization, berm construction, and floodplain alterations.

These qualitative observations are useful in the assessment of channel stability. They provide a consistent method of documenting stream conditions that allows comparison across different sets of conditions. The observations also help explain the quantitative measurements described below.

2.4.2 Vertical Stability – Degradation/Aggradation

The bank height and entrenchment ratios are measured in the field to assess vertical stability. The bank height ratio is measured as the ratio of the lowest bank height to a maximum bankfull depth. Table 2.1 shows the relationship between bank height ratio (BHR) and vertical stability developed by Rosgen (2001).

Table 2.1
Conversion of Bank Height Ratios (Degree of Incision) to Adjective Rankings of Stability (Rosgen, 2001a)

Adjective Stability Rating	Bank Height Ratio
Stable (low risk of degradation)	1.0 – 1.05
Moderately unstable	1.06 – 1.3
Unstable (high risk of degradation)	1.3 – 1.5
Highly unstable	> 1.5

The entrenchment ratio is measured as the width of the floodplain at twice the maximum bankfull depth. If the entrenchment ratio is less than 1.4 (+/- 0.2), the stream is considered entrenched (Rosgen, 1996).

2.4.3 Lateral Stability

The degree of lateral containment (confinement) and potential lateral erosion are assessed in the field by measuring the meander width ratio (MWR) and the Bank Erosion Hazard Index (BEHI) (Rosgen, 2001a). The MWR is the meander belt width divided by the bankfull channel width, and provides insight into lateral channel adjustment processes, depending on stream type and degree of confinement. For example, an MWR of 3.0 often corresponds to a sinuosity of 1.2, which is the minimum value for a stream to be classified as meandering. If the MWR is less than 3.0, lateral adjustment is probable. BEHI ratings along with near bank shear stress estimates can be compared to data from monitored sites and used to estimate the annual, lateral stream bank erosion rate.

2.4.4 Channel Pattern

Channel pattern is assessed in the field by measuring the plan features of the stream, including radius of curvature, meander wavelength, meander belt width, stream length, and valley length. Results are used to compute the MWR (described above), ratio of radius of curvature to bankfull width, sinuosity, and meander wavelength ratio (meander wavelength divided by bankfull width). These dimensionless ratios are compared to reference reach data for the same valley and stream type to assess whether channel pattern has been impacted.

2.4.5 River Profile and Bed Features

A longitudinal profile is created by measuring and plotting elevations of the channel bed, water surface, bankfull, and low bank height. Profile points are surveyed at prescribed intervals and at significant breaks in slope, such as the head of a riffle or the head of a pool. This profile can be used to assess changes in river slope compared to valley slope, which affect sediment transport, stream competence, and the balance of energy; for example, the removal of large woody debris may increase the step/pool spacing and result in excess energy and subsequent channel degradation. Facet (e.g., riffle, run, pool) slopes of each individual feature are important for stability assessment and design.

2.4.6 Channel Dimension Relations

The bankfull width/depth ratio provides an indication of departure from reference reach conditions and relates to channel instability. A greater width/depth ratio compared to reference conditions may indicate accelerated stream bank erosion, excessive sediment deposition, stream flow changes, and alteration of channel shape (e.g., from channelization). A smaller width/depth ratio compared to reference conditions may indicate channel incision and downcutting. Both increases and decreases in width/depth ratio can indicate evolutionary shifts in stream type (i.e., transition of one stream type to another). Table 2.2 shows the relationship between the degree of width/depth ratio increase and channel stability developed by Rosgen (2001).

Table 2.2
Conversion of Width/Depth Ratios to Adjective Ranking of Stability from Stability (Rosgen, 2001a)

Stability Rating	Ratio of Project to Reference Width/Depth
Very stable	1.0
Stable	1.0 – 1.2
Moderately unstable	1.21 – 1.4
Unstable	> 1.4

While an *increase* in width/depth ratio is associated with channel *widening*, a *decrease* in width/depth ratio is associated with channel *incision*. Hence, for incised channels, the ratio of channel width/depth ratio to reference reach width/depth ratio will be less than 1.0. The reduction in width/depth ratio indicates excess shear stress and movement of the channel toward an unstable condition.

2.4.7 Channel Evolution

Simon's channel evolution model (introduced in Section 2.1.5) relies on a qualitative, visual assessment of the existing stream channel characteristics, such as bank height, evidence of degradation/aggradation, presence of bank slumping, and direction of bed and bank movement. Establishing the evolutionary stage of the channel helps ascertain whether the system is moving towards greater stability or instability. The model also provides a better understanding of the cause and effect of channel change. This information, combined with Rosgen's (1994) priority levels of restoration, aids in determining the restoration potential of unstable reaches.

2.5 Design Parameter Selection Methodology

Buck Engineering uses a combination of approaches to develop design criteria for channel dimension, pattern, and profile. These approaches are described in the following sections. A flow chart for selecting design criteria is shown in Figure 2.6.

2.5.1 Upstream Reference Reaches

The best option for developing design criteria is to locate a reference reach upstream of the project site. A reference reach is a channel segment that is stable – neither aggrading nor degrading – and of the same morphological type as the channel under consideration for restoration. The reference reach should also have a valley slope similar to that of the project reach. The reference reach is then used as the blueprint for the channel design (Rosgen, 1998). To account for differences in drainage area and discharge between a reference site and a project site, data on channel characteristics (dimension, pattern, and profile) in the form of dimensionless ratios are developed for the reference reach. If the reach upstream of the project does not have sufficient pattern but does have a stable riffle cross-section, only dimension ratios are calculated. It is ideal to measure a reference bankfull dimension that was formed under the same environmental influences as the project reach.

2.5.2 Reference Reach Searches

If a reference reach cannot be located upstream of the project reach, a review of a reference reach database is performed to locate reaches with the same stream type and valley slope in close proximity to the project site. In general, the search is limited to subwatersheds within or adjacent to the project watershed. In certain cases, a reference reach may be identified farther away; if so, care is taken to ensure that the potential reference reach lies within the same physiographic region as the project reach.

Potential reference sites are identified using USGS topographic quadrangles and aerial photography; if a reference reach meeting the criteria is found, it is field-surveyed for validation and comparison with the database values (that may have been originally collected and provided by a third party). When potential sites are located on private property, landowner permission is acquired prior to any survey work being conducted. If no reference reach meeting the criteria is found, a field search is performed locally to identify a reference reach that has not yet been surveyed.

2.5.3 Reference Reach Databases

If a reference reach is not found in close proximity to the project site, a reference reach database is consulted, and summary ratios are acquired for all streams with the same valley and stream type within the project's physiographic region. These ratios are then compared to literature values and regime equations along with ratios developed through the evaluation of successful projects.

2.5.4 Regime Equations

Buck Engineering uses a variety of published journals, books, and design manuals to cross-reference North Carolina database values with peer-reviewed regime equations. Examples include *Fluvial Forms and Processes,* by David Knighton (1998), *Mountain Rivers,* by Ellen Wohl (2000), and the *Hydraulic Design of Stream Restoration Projects,* by the US Army Corps of Engineers (USACE) Copeland et al., 2001). The most common regime equations used in our designs are for pattern. For example, most reference reach surveys in the eastern United States show radius of curvature divided by bankfull width ratios much less than 1.5; however, the USACE manual recommends a ratio greater than 2.0 to maintain stability in free-forming systems. Since most stream restoration projects are constructed on floodplains denude of woody vegetation, we often use the USACE-recommended value rather than reference reach data. Meander wavelength and pool-to-pool spacing ratios are examples of other parameters that are sometimes designed with higher ratios than those observed on reference reaches, for reasons similar to those described for radius of curvature.

2.5.5 Comparison to Past Projects

All of the above techniques for developing ratios and/or regime equations are compared to past projects built under similar conditions. Ultimately, these sites provide the best pattern and profile ratios because they reflect site conditions after construction. While most reference reaches are in mature forests, restoration sites are in floodplains with little or no mature woody vegetation. This lack of mature woody vegetation severely alters floodplain processes and stream bank conditions. If past ratios did not provide adequate stability or bedform diversity, they are not used; conversely, if past project ratios created stable channels with optimal bedform diversity, they will be incorporated into the design.

Ultimately, the design criteria are selections of ratios and equations made upon thorough evaluation of the above tasks. Combinations of approaches may be used to optimize the design. The final selection of design criteria for the restoration site is discussed in Section 5.

2.5.6 Considerations Regarding Wetland Hydrology

Special considerations must be used during the stream restoration design process if there is also a goal of restoring wetland hydrology to adjacent hydric soil areas; specifically, stream dimension and pattern will have a significant effect on wetland hydrology. Collected data have shown that the water table of wetland areas adjacent to the stream channel is directly influenced by the baseflow water level in the stream. Higher width-to-depth channels are more conducive to supporting wetland hydrology, because the baseflow water level is at a higher elevation. Surveys of sand-bed streams in existing wetland areas have shown that high width-to-depth ratios (typically 10 to 14) are common.

Stream pattern is also an important consideration for wetland restoration. The location of the restored stream channel will have a direct effect on which areas of the restoration site are flooded, and how frequently. While stream pattern is primarily controlled by the topography of the site, minor adjustments to stream pattern can be used to provide additional hydrologic inputs to crucial wetland restoration areas.

2.6 Sediment Transport Competency and Capacity Methodology

Stream restoration designs must be tested to ensure that the new channel dimensions (in particular, the design bankfull mean depth) create a stream that has the ability to move its sediment load without aggrading or degrading over long periods of time. The ability of the stream to transport its total sediment load is quantified through two measures: sediment transport competency and sediment transport capacity. Competency is the ability of a stream to move particles of a given size and is a measurement of force, often expressed as units of pounds per square foot (lbs_f/ft^2). Sediment transport capacity is the ability of a stream to move a quantity of sediment and is a measurement of stream power per area, often expressed in units of watts/square meter. Sediment transport capacity is also calculated as a sediment transport rating curve, which provides an estimate of the quantity of total sediment load transported through a cross-section per unit of time. The curve is provided as a sediment transport rate in pounds per second (lbs_m/sec) versus discharge or stream power.

The total volume of sediment transported through a cross-section consists of bedload plus suspended load fractions. Suspended load is normally composed of fine sand, silt, and clay particles transported in the water column. Bedload is generally composed of larger particles, such as course sand, gravels, and cobbles, which are transported by rolling, sliding, or hopping (saltation) along the bed.

2.6.1 Competency Analysis

Median substrate size has an important influence on the mobility of particles in stream beds. Critical dimensionless shear stress (τ_{ci}) is the measure of force required to initiate general movement of particles in a bed of a given composition. At shear stresses exceeding this critical value, essentially all grain sizes are transported at rates in proportion to their presence in the bed (Wohl, 2000). Critical dimensionless shear stress can be calculated for gravel-bed stream reaches using surface and subsurface particle samples from a stable, representative riffle in the reach (Andrews, 1983). The following equations are used to determine the critical dimensionless shear stress required to mobilize and transport the largest particle from the bar sample (or subpavement sample) (Rosgen, 2001a).

a) Calculate the ratio d_{50}/ds_{50}

where: d_{50} = median diameter of the riffle bed (from 100 count in riffle or pavement sample)
ds_{50} = median diameter of the bar sample (or subpavement)

If the ratio d_{50}/ds_{50} is between the values of 3.0 and 7.0, then calculate the critical dimensionless shear stress using Equation 1.

$$\tau_{ci} = 0.0834(d_{50}/ds_{50})^{-0.872} \qquad \textbf{(Equation 1)}$$

b) If the ratio d_{50}/ds_{50} is not between the values of 3.0 and 7.0, then calculate the ratio of D_i/d_{50}

where: D_i = largest particle from the bar sample (or subpavement)
d_{50} = median diameter of the riffle bed (from 100 count in the riffle or pavement sample)

If the ratio D_i/d_{50} is between the values of 1.3 and 3.0, then calculate the critical dimensionless shear stress using Equation 2.

$$\tau_{ci} = 0.0384(D_i/d_{50})^{-0.887} \qquad \textbf{(Equation 2)}$$

2.6.2 Aggradational Analysis

The aggradation analysis is based on calculations of the required depth and slope needed to transport large sediment particles, in this case defined as the largest particle of the riffle subpavement sample. Required depth can be compared with the existing/design mean riffle depth, and required slope can be compared to the existing and design slopes to verify that the stream has sufficient competency to move large particles (and thus prevent thalweg aggradation). The required depth and slope are calculated by:

$$d_r = \frac{1.65\tau_{ci}D_i}{S_e}$$ **(Equation 3)**

$$s_r = \frac{1.65\tau_{ci}D_i}{d_e}$$ **(Equation 4)**

where: d_r = required bankfull mean depth (ft)
d_e= design bankfull mean depth (ft)
1.65 = sediment density (submerged specific weight)
= density of sediment (2.65) – density of water (1.0)
τ_{ci} = critical dimensionless shear stress
D_i = largest particle from bar sample (or subpavement) (ft)
s_r = required bankfull water surface slope (ft/ft)
S_e = design bankfull water surface slope (ft/ft)

The aggradation analysis is used to assess both existing and design conditions; for example, if the calculated value for the existing critical depth is significantly larger than the measured maximum bankfull depth, this indicates that the stream is aggrading. Alternately, if the proposed design depth significantly differs from the calculated critical depth, and the analysis is deemed appropriate for the site conditions, the design dimensions should be revised accordingly.

2.6.3 Competency Analysis using Shields Curve

As a complement to the required depth and slope calculations, boundary shear stresses for a design riffle cross-section can be compared with a modified Shields curve to predict sediment transport competency. The shear stress placed on the sediment particles is the force that entrains and moves the particles and is given by:

$$\tau = \gamma R s$$ **(Equation 5)**

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

The boundary shear stress can be estimated for the design cross-section and plotted on a modified Shields curve, as shown in Figure 2.7. The particle size that Shields curve predicts will be moved is compared to the D_i of the site subpavement. Shields curve predicts whether the design conditions will have enough shear stress to move a particle larger than the largest subpavement particle found in the creek and prevent aggradation.

2.6.4 Degradation Analysis

A degradation analysis is performed in order to assess whether the design cross-sections will result in scour and bed downcutting. The potential for degradation may be evaluated by examining the upper competency limits for design cross-sections and by reviewing existing and design grade control at the site. The calculated shear stress discussed in Section 2.7.3 can be used to describe the upper competency limits for the design channel. The calculated shear stress is compared to the Modified Shields Curve, as illustrated in Figure 2.7, to determine the largest particle size that stress value will move. This value should be comparable to the D_{84} to D_{95} values from the reach-wide pebble count.

2.6.5 Sediment Transport Capacity

For sand bed streams, sediment transport capacity is much more important than competency. Sediment transport capacity refers to the ability of a stream to move a mass of sediment past a cross-section per unit of time in pounds/second or tons/year. Sediment transport capacity can be assessed directly using actual monitored data from bankfull events if a sediment transport rating curve has been developed for the project site. Since this curve development is extremely difficult, other empirical relationships are used to assess sediment transport capacity. The most common capacity equation is stream power. Stream power can be calculated a number of ways, but the most common is:

$$\omega = QS/W_{bkf}$$

(Equation 6)

where: w = mean stream power (W/m^2)
γ = specific weight of water 9,810 N/m^3); $\gamma = \rho g$, where ρ is the density of the water-sediment mixture (1,000 kg/m^3) and g is the acceleration due to gravity 9.81 m/s^2)
Q = bankfull discharge (m^3/s)
S = design channel slope (m/m)
Wbkf = bankfull channel width (m)
Note: 1 ft-lb/sec/ft^2 = 14.56 W/m^2

Equation 6 does not provide a sediment transport rating curve; however, it does describe the ability of the stream to accomplish work, i.e., move sediment. Calculated stream power values are compared to reference and published values. If deviations from known stable values for similar stream types and slopes are observed, the design should be reassessed to confirm that sediment will be adequately transported through the system without containing excess energy in the channel.

2.7 In-Stream Structures

There are a variety of in-stream structural elements used in restoration. Figure 2.8 illustrates a few typical structures. These elements are composed of natural materials such as stone, wood, and live vegetation. Their shape and location work with the flow dynamics to reinforce, stabilize, and enhance the function of the stream channel. In-stream structures serve three primary functions: grade control, stream bank protection, and habitat enhancement.

2.7.1 Grade Control

Grade control pertains mainly to the design bed profile. A newly-excavated gravel stream bed with a slope greater than 0.5 percent is seldom able to maintain the desired slopes and bed features (riffles, runs, pools and glides) until a pavement/subpavement layer has been established. Stone and/or log structures installed at the bed elevation and at critical locations in the plan view help to set up the new stream bed for long-term vertical stability. Over time, as the new channel adjusts to its sediment transport regime and vegetative root mass establishes on the banks, the need for grade control diminishes.

2.7.2 Bank Protection

Bank protection is critical during and after construction, as bank and floodplain vegetation is establishing a reinforcing root mass. This vegetation establishment takes several years, but vegetation is typically providing meaningful bank protection after two to four growing seasons. Bank protection structures generally provide both reinforcement to the stream banks and re-direction of flow away from the banks and toward the center of the channel.

2.7.3 Habitat Enhancement

Habitat enhancement can take several forms and is often a secondary function of grade control and bank protection structures. Flow over vanes and wing deflectors create scour pools, which provide diversity of in-stream habitat. Boulder clusters form eddies that provide resting places for aquatic species. Constructed riffles and vane structures encourage oxygenation of the water. Root wads provide cover and shade and encourage the formation of deep pools at the outside of meander bends.

2.7.4 Selection of Structure Types

Table 2.3 summarizes the names and functions of several in-stream structures.

Table 2.3
Functions of In-Stream Structures

Structure	Function (Primary = 1, Secondary = 2)		
	Grade Control	Bank Protection	Habitat Enhancement
Cross Vane	1	1	2
Rock or Log Vane		1	2
J-Hook Vane	2	1	2
Constructed Riffle	1	1	2
Rock or Log Weir	1		2
Wing Deflector	2	1	1
Boulder Cluster			1
Root Wad		1	1
Cover Log			1
Brush Mattress		1	2
Log/Boulder Sill	1		2
Boulder Step Pool	1		1
Log Step Pool	2	2	1

The selection of structure types and locations typically follows dimension, pattern, and profile design. In some situations, structures comprise the main, or possibly only, effort to restore a stream. More often, structures are used in conjunction with grading, realignment, and planting in an effort to improve channel stability and aquatic habitat.

2.8 Vegetation

The planting of additional and/or more desirable vegetation is an important aspect of the restoration plan. Vegetation helps stabilize stream banks, creates habitat and a food source for wildlife, lowers water temperature by providing shade for the strea, improves water quality by filtering overland flows, and improves the aesthetics of the site.

The reforestation component of a restoration project typically includes live dormant staking of the stream banks, riparian buffer plantings, invasive species removal, and seeding for erosion control. The stream banks and the riparian area are typically planted with both woody and herbaceous vegetation to establish a diverse streamside buffer. Planting on the stream banks is a very desirable means of erosion control because of the dynamic, adaptive, and self-repairing qualities of vegetation. Vegetative root systems stabilize channel banks by holding soil together, increasing porosity and infiltration, and reducing soil saturation through transpiration. During high flows, plants lie flat and stems and leaves shield and protect the soil surface from erosion. In most settings, vegetation is more aesthetically appropriate than engineered stabilization structures.

Stream banks are delineated into four zones when considering a planting scheme:

1. Channel bottom – extending up to the low-flow stage. Emergent, aquatic plants dominate bank range, extending from the low-flow stage to the bankfull stage.
2. Lower bank – frequently flooded, extending from the low-flow stage to the bankfull stage. A mix of herbaceous and woody plants including sedges, grasses, shrubs and trees.
3. Upper bank – occasionally flooded, but most often above water. Dominated by shrubs and small trees.
4. Riparian area – infrequently flooded, terrestrial, and naturally forested with canopy-forming trees.

The most appropriate source of plant material for any project is the site itself. Desirable plants that must be removed during the course of construction should be salvaged and transplanted as part of the restoration plan. The next best alternative is to obtain permission to collect and transplant native plants from areas nearby. This transplant process ensures that the plants are native and adapted to the locale. Finally, plants may need to be purchased. They should be obtained from a nearby reputable nursery that guarantees that the plants are native and appropriate for the locale and climate of the project site.

2.8.1 Live Staking

Live staking is a method of re-vegetation that utilizes live, dormant cuttings from appropriate species to establish vegetation cheaply and effectively. The installation of live stakes on stream banks serves to protect the banks from erosion and at the same time provide habitat, shade and improved aesthetics. Live staking must take place during the dormant season (November through March in the Southeast US). Live stakes can be gathered locally or purchased from a reputable, commercial supplier. Stakes should be at least one half inch in diameter and no more than two inches in diameter, between two and three feet in length, and living (based on the presence of young buds and green bark). Stakes are cut at an angle on the bottom end and driven into the ground with a rubber mallet.

2.8.2 Riparian Buffer Re-Vegetation

Riparian buffers are naturally occurring ecosystems adjacent to rivers and streams and are associated with a number of benefits. Buffers are important for nutrient and pollutant removal in overland flow and may provide additional, subsurface water-quality improvement in the shallow groundwater flow. Buffers also provide habitat and travel corridors for wildlife populations and are an important recreational resource. Riparian buffer areas help to moderate the quantity and timing of runoff from the upland landscape and contribute to the groundwater recharge process.

Buffers are most valuable and effective when composed of a combination of trees, shrubs, and herbaceous plants. Although width generally increases the capacity of riparian buffers to improve water quality and provide greater habitat value, even buffers less than 85 feet wide have been shown to improve water quality and habitat (Budd et al., 1987). An estimated minimum width of 30 feet is required for creating beneficial forest structure and riparian habitat.

In stream and wetland restoration, where buffer width is often limited, the following design principles apply:

- Design for sheet flow into and across the riparian buffer area.
- If possible, the width of the riparian buffer area should be proportional to the watershed area, the slope of the terrain, and the velocity of the flow through the buffer.
- Forest structure should include understory and canopy species. Canopy species are particularly important adjacent to waterways to moderate stream temperatures and to create habitat.
- Use native plants that are adapted to the site conditions (e.g., climate, soils, and hydrology). In suburban and urban settings riparian forested buffers do not need to resemble natural ecosystems to improve water quality and habitat.

2.9 Risk Recognition

It is important to recognize the risks inherent in the assessment, design, and construction of environmental restoration projects. Such endeavors involve the interpretation of existing conditions to deduce appropriate design criteria, the application of those criteria to design, and most importantly, the execution of the construction phase. There are many factors that ultimately determine the success of these projects, and many of the factors are beyond the influence of a designer. To compile all of the factors is beyond the scope of this report. Further, it is impossible to consider and to design for all of them; however, it is important to acknowledge those factors, such as daily temperature, amount and frequency of rainfall, subsurface conditions, and changes in watershed characteristics that are beyond the control of the designer.

Many restoration sites will require some post-construction maintenance, primarily because newly-planted vegetation plays a large role in channel and floodplain stability. Stream restoration projects are most vulnerable to adjustment and erosion immediately after construction, before vegetation has had a chance to fully establish. Risk of instability diminishes with each growing season. Streams and floodplains usually become self-maintaining after the second year of growth; however, unusually heavy floods often cause erosion, deposition and/or loss of vegetation in even the most stable channels and forested floodplains.

3.0 WATERSHED ASSESSMENT RESULTS

3.1 Watershed Delineation

The Beaverdam Creek Stream Restoration site is located in Mecklenburg County, just southwest of the Charlotte-Douglas International Airport and is generally bounded by Rock Island Road on the south, Shopton Road on the east, and Dixie River Road on the north and west. The site lies within NCDWQ sub-basin 03-08-34 and hydrologic unit 03050101170040 (Figure 1.1). The entire Beaverdam Creek watershed is approximately 4.69 square-miles (3,000 acres), and discharges to Brown's Cove of Lake Wylie, while the tributary watersheds for UT1 and UT2 are 1.73 square-miles (1,105 acres) and 0.31 square miles (199 acres), respectively (Figure 1.2).

3.2 Geology

The Beaverdam Creek watershed is situated in the Charlotte Belt of the Piedmont physiographic province on the eastern shore of Lake Wylie. The watershed is a typical Piedmont watershed with gently sloping uplands and steep-walled valleys produced by streams that cut down in places to bedrock. The watershed has a dendritic pattern and is predominantly drained by four major tributaries, which converge in the last mile of the main stem. Elevations within the watershed range from about 560 feet to about 760 feet above sea level.

According to the one-degree by two-degree geologic map for the Charlotte region prepared by USGS (Goldsmith, Milton and Horton, 1988, Map I-1251-E) watershed is underlain by five rock types described in Table 3.1.

Table 3.1
Beaverdam Creek Watershed Geology [1] (source: 2003 Beaverdam Creek Watershed Geomorphic Assessment)

Abbreviation	Rock Type	Description
DScgb	Silurian and Devonian gabbro of the Concord plutonic suite	This rock type is composed of gabbro, norite, gabbronorite, and hornblende gabbro. Major minerals are plagioclase, both clinopyroxene and orthopyroxene, and hornblende, biotite and olivine or quartz. Upland soils developed on this rock type are medium acid to neutral (MeB – Mecklenburg fine sand loam on 2 to 8 percent slopes).0.1
DOgd	Late Ordovician to Early Devonian granodiorite and related granitoids	This rock type is gray, medium-grained, massive to weakly foliated. It is composed mostly of plagioclase and quartz with lesser amounts of potassium feldspar and biotite, with or without minor hornblende. Upland soils developed on this substrate are strongly acid to very strongly acid (CeB2 and CeD2 – Cecil sandy clay loam, 2 to 15 percent slopes).
DOgp	Late Ordovician to Early Devonian porphorytic granodiorite	This rock type is similar in composition to DOgd but inequigranular with large phenocrysts of plagioclase and smaller phenocrysts of biotite. The upland soils are similar to those developed on DOgd.
c	Contact metamorphic rocks	This rock type is composed dominantly of albite or sodic oligoclase and hedenbergite, with or without amphibole, andradite, orthoclase and sphene, probably originally metagranodiorite and related metagranitoids (mgd) metasomatized in aureole of gabbro (DScgb) and perhaps of granodiorite and related granitoids (DOgd). There are acidic upland soils developed on this rock type (e.g. CeB2 and Ce D2 – Cecil sandy loams) but there are also patches of slightly acid to alkaline soils on valley walls. These soils belong to the Wilkes loam and slopes can vary from 4 up to 45 percent.
Mqd	Metamorphosed quartz diorite and tonalite	This lithology is a gray, usually medium- to coarse-grained, generally foliated rock composed dominantly of plagioclase, quartz, biotite, hornblende, and epidote. Biotite, hornblende, and epidote are commonly associated in clots replacing original mafic phenocrysts. The clots may be smeared out, thus defining foliation. The upland soils developed on this lithology are typically acid (e.g. Cecil sandy loams, Enon sandy loam) and there are a few patches of alkaline soils belonging to the Wilkes loam on valley walls.

1 Source: USGS Map I-1252, Goldsmith, Milton and Horton, 1988

Table 3.2
Project Soil Types and Descriptions

Soil Name	Location	Description
Cecil	Main channel and floodplain	The Cecil series consists of well-drained soils with moderate permeability on and near floodplains. They formed in residuum weathered felsic igneous and metamorphic rock, such as granite. Slopes range from 8 to 15 percent.
Monacan	Main channel and floodplain	Soils of the Monacan series are deep, moderately well and somewhat poorly drained with moderate permeability. They formed in recent alluvial sediments of the Piedmont and Coastal Plain. Slopes are commonly less than 2 percent. Mean annual temperature is about 61 degrees F and mean annual precipitation is about 42 inches.
Pacolet	Adjacent to floodplain	The Pacolet series consists of very deep, well drained, moderately permeable soils that formed in material weathered mostly from acid crystalline rocks of the Piedmont uplands. Slopes commonly are 15 to 25 percent but range from 2 to 60 percent.
Davidson	Adjacent to floodplain	The Davidson series consists of very deep, well drained, moderately permeable soils that formed in materials weathered from dark colored rocks high in ferromagnesian minerals. These soils are on gently sloping to moderately steep uplands in the Piedmont. Slopes are commonly 2 to 15 percent but range up to 25 percent.

NRCS, USDA. Official Soil Series Descriptions (http://soils.usda.gov/technical/classification/osd/index.html)

Table 3.3
Project Soil Type Characteristics (NRCS, USDA. Official Soil Series Descriptions.)

Series	Max Depth (in)	% Clay on Surface	K[(1)]	T[(2)]	OM %[(3)]
Cecil Sandy Clay Loam (CeD2)	80	20-35	0.28	5	0.5-1
Monacan Loam (MO)	80	7-27	0.43	5	2-3
Davidson sandy clay loam (DaD)	75	20-35	0.28	5	0.5-2
Pacolet sandy loam (PaE)	62	8-20	0.20	5	0.5-2
Pacolet sandy loam (PaF)	62	8-20	0.20	5	0.5-2

NRCS, USDA. Official Soil Series Descriptions (http://soils.usda.gov/technical/classification/osd/index.html)

[(1)] **K** = erosion factor (Universal Soil Loss Equation, USLW, and Revised USLE) indicating sheet and rill erosion susceptibility (dimensionless). Higher values indicate greater susceptibility.

[(2)] **T** = estimate of maximum average annual rate of soil erosion that can occur without affecting crop productivity (tons/acre/year)

[(3)] **OM%** = percent organic matter

3.3 Soils

Soil types and profiles at the site were researched using the Natural Resources Conservation Service (NRCS) soil survey data for Mecklenburg County, along with preliminary on-site evaluations to locate potentially hydric soils (NRCS, 1975). Tables 3.1 and 3.2 list, identify and characterize the five soil-types most commonly found within the project boundaries.

The predominant soil series within the floodplain area of the site is mapped as Monacan loam series. The Monacan series are deep, moderately-well to somewhat-poorly drained having moderate permeability. This soil type is considered a hydric "B" soil type in Mecklenburg County, indicating that some areas of mapped Monacan soils may consist (up to 20 percent) of inclusions of hydric soils.

3.4 Land Use

Presently, the watershed is primarily undeveloped (young forest and pasture land) with scattered, single family residential and recently constructed sections of I-485. The few roads in the area tend to follow the drainage divides. Forestry and agricultural activities have clearly impacted watershed streams in the past while recent clear cuts have continued a land use pattern that has degraded many stream reaches in the watershed. Road building, utility right-of-way cuts and some minor development have also likely contributed to stream degradation. Construction of mixed residential communities is expected to change land use types in the future. The present land use for the Beaverdam Creek watershed is detailed in Table 3.4.

Table 3.4
Land Uses in Beaverdam Creek Watershed (source: 2003 Beaverdam Creek Watershed Geomorphic Assessment)

Land Use	Area (ac)	Percent
Commercial	0.6	0.1
Forest-Mixed	1,980.5	63.7
Industrial	26.9	0.9
Institutional	7.3	0.2
Residential-Low Density	545.2	17.5
Residential-Med/Low Density	322.6	10.4
Residential-Medium Density	22.7	0.7
Residential-High Density	144.8	4.7
Transportation	41.7	1.3
Water	17.7	0.6

3.5 Habitat Descriptions

The plant communities were very similar between UT1 and UT2. The tributaries all exhibited riparian areas ranging from relatively undisturbed to very disturbed. The undisturbed riparian areas were not considered fully mature forests but had diverse age-class distribution among species present. Riparian buffers were partially intact for most of the stream reaches. Examples of major disturbance include power-line corridor maintenance, recent logging, residential clearing, and I-485 construction.

The communities described within the project area primarily consist of a Piedmont/Mountain Bottomland Forest transitioning upslope to a Dry/Mesic Oak-Hickory Forest community as described by Schafale and Weakely (1990). Native trees species were dominant in the overstory while invasive exotic species were prevalent in the mid-canopy and herbaceous layers. A general description of each community follows.

3.5.1 Piedmont/ Mountain Bottomland Forest

This ecological community is located adjacent to both UT1 and UT2 within the floodplain for the majority of the project area. The dominant species in the overstory of these bottomland hardwood/floodplain areas include southern sugar maple (*Acer barbatum*), ironwood (*Carpinus caroliniana*), American elm (*Ulmus americana*), sycamore (*Platanus occidentalis*), American beech (*Fagus grandifolia*), loblolly pine (*Pinus taeda*), green ash (*Fraxinus pennsylvanica*), tulip poplar (*Liriodendron tulipifera*), hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), hickory (*Carya* spp.), sugarberry (*Celtis laevigata*), sweetgum (*Liquidambar styraciflua*), box elder (*Acer negundo*), and swamp chestnut oak (*Quercus michauxii*). Mid-canopy species include ironwood (*Carpinus caroliniana*), pawpaw (*Asimina triloba*), winged sumac (*Rhus copallina*), honey locust (*Gleditsia triacanthos*), flowering dogwood (*Cornus florida*), silky dogwood (*Cornus amomum*), sweetgum, tulip poplar, winged elm (*Ulmus alata*), red mulberry (*Morus rubra*), green ash, cucumber tree (*Magnolia acuminate*), buckeye (*Aesculus sylvatica*), black willow (*Salix nigra*), and American holly (*Ilex opaca*). Invasive exotic shrub species, which were dominant along many of the reaches include Russian olive (*Elaeagnus umbellata*) and Chinese privet (*Ligustrum sinense*). Herbaceous and vine species consisted of Nepal grass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), Christmas fern (*Polystichum acrostichoides*), poison ivy (*Toxicodendron radicans*), false nettle (*Boehmeria cylindrical*), grape (*Vitis* spp.), jack-in-the-pulpit (*Arisaema triphyllum*), greenbrier (*Smilax* spp.), Virginia creeper (*Parthenocissus quinquefolia*), jewelweed (*Impatiens capensis*), and trumpet creeper (*Campsis radicans*). Also present were isolated populations of river cane (*Arundinaria gigantean*).

3.5.2 Dry-Mesic Oak-Hickory Forest

This ecological community is located on the hillsides of the project area, and is an upland transition from the Piedmont/Mountain Bottomland Forest. The dominant overstory species of this upslope area include American beech (*Fagus grandifolia*), sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), loblolly pine (*Pinus taeda*), sourwood (*Oxydendrum arboreum*), southern sugar maple (*Acer barbatum*), mockernut hickory (*Carya tomentosa*), sycamore (*Plantanus occidentalis*), black walnut (*Juglans nigra*), sourwood (*Oxydendrum arboretum*), and red cedar (*Juniperus virginiana*). Mid-canopy species include red bud (*Cercis canadensis*), red mulberry (*Morus rubra*), sourwood, service berry (*Amelanchier arborea*), and buckeye (*Aesculus sylvatica*). Herbaceous and vine species consisted of Nepal grass (*Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), Christmas fern (*Polystichum acrostichoides*), poison ivy (*Toxicodendron radicans*), grape (*Vitis* spp.), Virginia creeper (*Parthenocissus quinquefolia*), yellow root (*Xanthorhiza simplicissima*), buttercup (*Oxalis* spp.), and trumpet creeper (*Campsis radicans*).

3.5.3 Disturbed

The disturbed areas include power line easements, recently harvested forests, areas adjacent to the recent home construction and I-485 construction.

The power line easement was periodically maintained either through mowing or herbicide application. Therefore, no overstory forest species were present. Species found within this easement included: goldenrod (*Solidago* spp.), grape (*Vitis* spp.), blackberry (*Rubus* spp.), Nepal grass (*Microstegium vimineum*), pokeweed (*Phytolacca americana*), sweetgum, sedges (*Carex* spp.), winged sumac (*Rhus copallina*), asters (*Aster* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and trumpet creeper (*Campsis radicans*).

The recently harvested areas and areas adjacent to the recent home construction and I-485 construction had an occasional seed tree (swamp chestnut oak, *Quercus michauxii*) but were dominated primarily by mid-canopy and understory early successional species including: Russian olive (*Elaeagnus umbellate*), winged sumac (*Rhus copallina*), black oak (*Quercus velutina*), mockernut hickory (*Carya tomentosa*), overcup oak (*Quercus lyrata*), tulip poplar (*Liriodendron tulipifera*), box elder (*Acer negundo*), sweetgum (*Liquidambar styraciflua*), ironwood (*Carpinus caroliniana*), southern sugar maple (*Acer barbatum*), red cedar (*Juniperus virginiana*), giant cane (*Arundinaria gigantean*), Virginia creeper (*Parthenocissus quinquefolia*), blackberry (*Rubus* spp.), Nepal grass (*Microstegium vimineum*), poison ivy (*Toxicodendron radicans*), bedstraw (*Galium* spp.), pokeweed (*Phytolacca americana*), asters (*Aster* spp.), goldenrod (*Solidago* spp.), Virginia creeper (*Parthenocissus quinquefolia*), grape (*Vitis* spp.), false nettle (*Boehmeria cylindrical*), and sedges (*Carex* spp.).

3.6 Endangered/Threatened Species

Some populations of plants and animals are declining because of either natural forces or their inability to compete for resources with the encroachment of humans. The North Carolina Natural Heritage Program (NCNHP) and United States Fish and Wildlife Service (USFWS) composed a list of rare and protected animal and plant species that contains five federally listed and thirty-six state listed species known to exist in Mecklenburg County (North Carolina Department of Environment and Natural Resources, 2004).

Legal protection for federally listed species, Threatened (T) or Endangered (E) status, is conferred by the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1534). This act makes illegal the killing, harming, harassing, or removing of any federally listed animal species from the wild; plants are similarly protected but only on federal lands. Section 7 of this act requires federal agencies to ensure that actions they fund or authorize do not jeopardize any federally listed species.

Organisms that are listed as Endangered (E), Threatened (T), or Special Concern (SC) on the NCNHP list of Rare Plant and Animal Species are afforded state protection under the State Endangered Species Act and the North Carolina Plant Protection and Conservation Act of 1979.

Species that the NCNHP lists under federal protection for Mecklenburg County as of September 19, 2005 are listed in Table 3.5. A brief description of the characteristics and habitat requirements of the federally protected species follow in Section 3.6.1, along with a conclusion regarding potential project impacts.

Table 3.5
Species of Federal and State Status in Mecklenburg County

Family	Scientific Name	Common Name	Federal Status	State Status	Habitat Present / Biological Conclusion
Vertebrates					
Accipitridae	*Haliaeetus leucocephalus*	Bald Eagle	T	T	May affect, but not likely to adversely affect
Invertebrates					
Unionidae	*Lasmigona decorata*	Carolina Heelsplitter	E	E	No/No Effect
Vascular Plants					
Asteraceae	*Echinacea laevigata*	Smooth Coneflower	E	E-SC	Marginal /No Effect
Asteraceae	*Helianthus schweinitzii*	Schweinitz's Sunflower	E	E	Marginal/No Effect
Anacardiaceae	*Rhus michauxii*	Michaux's Sumac	E	E-SC	Marginal/No Effect

Notes:	
E	An Endangered species is one whose continued existence as a viable component of the state's flora or fauna is determined to be in jeopardy.
T	Threatened
SC	A Special Concern species is one that requires monitoring but may be taken or collected and sold under regulations adopted under the provisions of Article 25 of Chapter 113 of the General Statutes (animals) and the Plant Protection and Conservation Act (plants).

The North Carolina Wildlife Resources Commission (WRC) has been contacted and they have not expressed concerns regarding protected species on the project site. Beaverdam Creek is not a Designated Public Trout Water, so trout buffer restrictions do not apply to this site. A copy of the WRC letter is included in Appendix A.

USFWS has also been contacted, and they believe that impacts to listed species from the activities proposed are unlikely. Based on their comments, all large trees in the project area will try to be avoided without compromising the integrity of the natural channel design. A copy of the USFWS correspondence is included in Appendix A.

No federally listed threatened, endangered, candidate or species of concern have been recorded within 1.0 mile of the project area based on the NCNHP database checked on September 19, 2005. No federal or state protected species were observed in or adjacent to the project area during the field survey. Critical habitat for the listed species, as defined by the USFWS, is not designated in the proposed project area.

3.6.1 Federally-Protected Species

3.6.1.1 Vertebrates

Haliaeetus leucocephalus **(Bald Eagle)**

Bald eagles are large raptors, 32 to 43 inches long, with a white head, white tail, yellow bill, yellow eyes, and yellow feet. The lower section of the leg has no feathers. Wingspread is about seven feet. The characteristic plumage of adults is dark brown to black with young birds completely dark brown. Juveniles have a dark bill, pale markings on the belly, tail, and under the wings and do not develop the white head and tail until five to six years old. Bald eagles in the southeast frequently build their nests in the transition zone between forest and marsh or open water. Nests are cone-shaped, six to eight feet from top to bottom, and six feet or more in diameter. They are typically constructed of sticks lined with a combination of leaves, grasses, and Spanish moss. Nests are built in dominant live pines or cypress trees that provide a good view and clear flight path, usually less than 0.5 miles from open water. Winter roosts are usually in dominant trees, similar to nesting trees, but may be somewhat farther from water. In North Carolina, nest building takes place in December and January, with egg laying (clutch of one to three eggs) in February and hatching in March. Bald eagles are opportunistic feeders consuming a variety of living prey and carrion. Up to 80 percent of their diet is fish, which is self caught, scavenged, or robbed from osprey. They may also take various small mammals and birds, especially those weakened by injury or disease.

No bald eagle nests or specimens were observed during the pedestrian surveys, but because the proposed restoration project is just over 0.5 miles from open water, the preferred nesting distance of the bald eagle, there may be a marginal chance of the site being used for winter roosting. Therefore, all large trees in the project area will try to be avoided without compromising the integrity of the natural channel design. A determination was made that the proposed work “may affect, but not likely to adversely affect” for this species.

3.6.1.2 Invertebrates

***Lasmigona decorata* (Carolina Heelsplitter)**

The Carolina heelsplitter is a bivalve that may be more than 4.5 inches long as an adult. The shell has an ovate, trapezoid-shaped, unsculptured shell. The shell's outer surface varies from greenish brown to dark brown in color and may be orange on the inner surface. Younger individuals have fine rays (stripes radiating outward from the hinge area) on the outer shell, which are greenish brown or black. The inner shell varies from pearly white to bluish white, becoming orange on the inner surface.

The Carolina heelsplitter is usually found in cool, slow-moving, small to medium-sized streams or rivers along, stable, well shaded streambanks with mud, muddy sand, or muddy gravel substrate. The stability of the stream banks appears to be very important factor in the habitat. Only six populations of the species are presently known to exist. Known populations in North Carolina are located in Goose Creek (Yadkin-Pee Dee River Basin) and Waxhaw Creek (Catawba River Basin) in Union County, according to the NCNHP database.

The study site does not possess favorable habitat for Carolina heelsplitter since the site has been impacted by silt deposition from incised, unstable streambanks. A search of the NCNHP database on September 19, 2005 found no known populations within five miles of the immediate project area. No record has been reported in Mecklenburg County in the past 20 years. Beaverdam Creek does not drain into either Goose Creek or Waxhaw Creek. Therefore, it is anticipated that project construction will have "no effect" on the Carolina heelsplitter.

3.6.1.3 Vascular Plants

***Echinacea laevigata* (Smooth Coneflower)**

Smooth Coneflower grows up to 5 feet tall with smooth stems and few elliptical to lanceolate leaves. Flowers are normally solitary, raylike, and light pink to purplish in color. Smooth coneflower can be distinguished from its popular relative *Echinacea purpurea* (purple coneflower) by leaves, which are never cordate like purple coneflower. Also, the awn of the pale is incurved while the purple coneflower's is straight.

There are 24 known populations of smooth coneflower with 6 known in North Carolina. Historically, the species habitat was prairie-like, often controlled by fire. Now, due to urbanization and fire suppression, known populations are limited to open woods, cedar barrens, utility right-of-ways, and dry limestone bluffs normally with magnesium or calcium rich soils associated with mafic rock.

The study site does have marginal habitat for the smooth coneflower along the utility right-of-ways and open woods of the project corridor. A pedestrian survey during the fruiting period was conducted on September 9, 2005 for potential individuals throughout the project area and none was identified. A September 19, 2005 search of the NCNHP database indicated no known populations within five miles of the study areas. Therefore, a "no effect" determination was made for the Smooth coneflower.

***Helianthus schweinitzii* (Schweinitz's Sunflower)**

Schweinitz's sunflower, usually three to six feet tall, is a perennial herb with one to several fuzzy purple stems growing from a cluster of carrot-like tuberous roots. Leaves are two to seven inches long, 0.4 to 0.8 inch wide, lance shaped, and usually opposite, with upper leaves alternate. Flowers are yellow and generally smaller than other sunflowers in North America. Flowering and fruiting occurs from mid-September to frost. The Schweinitz's sunflower grows in clearings and along edges of upland woods, thickets, and pastures. It is also found along roadsides, power line clearings, and woodland openings. It prefers full sunlight or partial shade and is tolerant of full shade.

According to the NCNHP database, the closest know Schweinitz's sunflower has been identified 2.8 miles to the southwest of the proposed project area. Marginal habitat exists for the Schweinitz's sunflower within the power line easements, the recently logged areas, and maintained roadside right-of-ways for the proposed project. A survey for this plant was conducted on September 9, 2005 for potential individuals throughout the project area and none was identified. Therefore, a "no effect" determination was made for the Schweinitz's sunflower.

***Rhus michauxii* (Michaux's Sumac)**

Michaux's sumac is a densely pubescent rhizomatous shrub that grows 0.7 to 3.3 feet in height. The narrowly winged or rachis supports nine to thirteen sessile, oblong-lanceolate leaflets that are 1.6 to 3.6 inches long, 0.8 to2 inches wide, acute, and acuminate. The bases of the leaves are rounded and their edges are simple or doubly serrate. Plants flower in June, producing a terminal, erect, dense cluster of four to five greenish-yellow to white flowers.

This plant occurs in rocky or sandy open woods and roadsides. It is dependent on disturbance such as mowing, clearing or fire to maintain the openness of its habitat. It grows in open habitat where it can get full sunlight, and it is often found with other members of its genus as well as with poison ivy. Michaux's sumac is endemic to the inner Coastal Plain and Piedmont Physiographic Provincesof North Carolina.

The study site possessed marginal habitat for Michaux's sumac within the power line easement. A survey was conducted on September 9, 2005 for possible existence of individual plants throughout the project area and none was identified. A September 19, 2005 search of the NCNHP database indicated no known populations within five miles of the study area. Therefore, a "no effect" determination was made for Michaux's sumac.

3.7 Cultural Resources

A letter was sent to the North Carolina State Historic Preservation Office (SHPO) on July 25, 2005, requesting a review for the potential existence of cultural resources within the vicinity of the Beaverdam Creek restoration site. A response was received on September 13, 2005, indicating that the SHPO had reviewed the proposed project and was not aware of any historic resources that would be affected by the project. Correspondence with the SHPO can be found in Appendix A.

3.8 Potentially Hazardous Environmental Sites

Buck Engineering obtained from EDR a Transaction Screen Map Report that identifies and maps real or potential hazardous environmental sites within a given distance, as specified by the American Society of Testing and Materials (ASTM) Transaction Screen Process (E 1528). A copy of the report with an overview map is included in Appendix B. The overall environmental risk for this site was determined to be low. Environmental sites including Superfund (National Priorities List [NPL]); hazardous waste treatment, storage, or disposal facilities; the Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS); suspect state hazardous waste, solid waste or landfill facilities; or leaking underground storage tanks were not identified by the report in the proposed project area. During field data collection, there was no evidence of potentially hazardous environmental sites in the proposed project vicinity, and conversations with landowners did not reveal any further knowledge of hazardous environmental sites in the area.

3.9 Potential Constraints

Buck Engineering assessed the Beaverdam Creek project site in regards to potential fatal flaws and site constraints. Following a thorough review of likely potential constraints, we have determined that no major constraints or fatal flaws presently threaten or compromise the restoration potential or level of project success for the proposed work.

3.9.1.1 Property Ownership and Conservation Easement

The State of North Carolina has acquired conservation easements for all project restoration areas. The conservation easement encompasses the entire project with more than a 50-foot buffer along the alignment of the new channels in the majority of locations.

3.9.2 Hydrologic Trespass and Floodplain Characterization.

3.9.2.1 UT1

The restoration activities will impact the regulated Federal Emergency Management Agency (FEMA) floodway. Whenever the floodway is subject to impact within a reach identified by FEMA as a “detailed study area” or within a watershed greater than one square mile in Mecklenburg County, revisions to FEMA flood mapping must be provided through the Conditional Letter of Map Revision (CLOMR) process. The new floodplain mapping for UT1 is currently under revision, later to be reviewed and approved by FEMA.

3.9.2.2 UT2

The topography of the site supports the design without creating the potential for hydrologic trespass. The site does not have a FEMA mapped floodplain.

3.9.3 Site Access

The site can be accessed for construction and post-restoration monitoring from either Dixie River Road or Windy Gap Road.

3.9.4 Utilities

An overhead power line (belonging to Duke Power) crosses through the project site across the mainstem of UT1. The associated easement corridor along the power line right-of-way will not be excluded from the conservation easement or restoration project. However, within this right-of-way, restoration will be limited. In general, while the utility line does not interfere with restoration activities, it does limit vegetation selected for proposed landscaping and the overall potential for benefit.

Throughout UT2, only two interruptions in restoration connectivity occur. The most substantial interruption is a roadway, embankment, and triple culvert proposed by others. During the restoration design process, the elevations of the culvert inverts (proposed by others) were modified to reduce disturbance associated with Priority 2 tie-ins. Additionally, revisions to the proposed culvert inlets allow the stream restoration work to be performed non-contingent and independently from the roadway, embankment, and triple culvert construction activities. The second interruption, a single 24-inch culvert, exists within the sewer line easement at the downstream end of UT2A, Reach 2. However, because of the existing invert of the channel at the easement boundaries, no Priority 2 design is required. No restoration work is proposed anywhere within this utility easement.

An existing sewer line easement lies on the right flood plain of the existing main channel and the conservation easement cannot extend beyond it. Many areas along the existing left flood plain of the mainstem of UT2 are steep. Due to these constraints, the proposed channel alignment approaches within 50 feet of the edge of the conservation easement on the right side of the channel. To compensate for this adjusted alignment, increased buffer widths have been provided throughout.

3.9.5 Threatened and Endangered Species

Rare, threatened and endangered species occurrences were examined as part of the existing conditions survey and discussed earlier in Section 3.6. No federally listed threatened, endangered, candidate or species of concern have been recorded within 1.0 mile of the project area based on the NCNHP database checked on September 19, 2005. No federal or state protected species were observed in or adjacent to the project area during the field survey. Critical habitat for the listed species, as defined by the U.S. Fish and Wildlife Service, is not designated in the proposed project area.

The NC Wildlife Resources Commission (WRC) has been contacted and has no identified concerns regarding protected species. Beaverdam Creek is not a Designated Public Trout Water, so trout buffer restrictions do not apply to this site. A copy of the WRC letter is included in Appendix A.

USFWS has also been contacted, and believes that it is unlikely there would be any effects to listed species from the activities proposed. Based on their comments, all large trees in the project area will try to be avoided without compromising the integrity of the natural channel design. A copy of the USFWS correspondence is included in Appendix A.

3.9.6 Cultural Resources

No known cultural or archaeological sites are recorded within the property boundary. It is anticipated that this project will have no impact on such sites.

3.9.7 Farm Operations

The Beaverdam Creek Site is not actively used for agricultural purposes. The Shaw property has some pasture used for two horses that will be fenced out.

3.9.8 Soils

Site soils have been investigated, and no constraints or fatal flaws have been identified.

4.0 STREAM CORRIDOR ASSESSMENT RESULTS

4.1 Reach Identification

During the analysis and design process, the mainstem of Beaverdam Creek and the two unnamed tributaries (UT1 and UT2) were subdivided into 15 individual reaches based on their hydrologic and geomorphic differences, thereby warranting unique design considerations. The mainstem of Beaverdam Creek consists of only 1 of the 15 design reaches, where only preservation and no restoration activities are proposed. The remaining 14 reaches exist within UT1 (8 reaches) and UT2 (6 reaches). Among these 14 reaches, 13 are scheduled for restoration while the downstream reach of UT2 is only scheduled for conservation. All reach locations are shown in Figure 4.1. Individual reach lengths are itemized in tables 4.1 and 4.3 below.

4.1.1 UT1 Reaches

Proposed treatments along UT1 begin after the stream passes beneath I-485 from the northeast. Individual reach identification begins upstream with UT1 Reach 1 and continues in sequence downstream through UT1 Reach 5, changing designation at tributary confluences or at significant grade breaks. Reach 1 flows southwest to station 15+55, the confluence with UT1B. Reach 2 begins at the terminus of Reach 1 (station 15+55) and continues southwest to the confluence with UT1C, where Reach 3 begins (station 31+27). Reach 3 continues to the confluence with UT1D, at which point Reach 4 begins (station 39+82). Reach 5 begins at station 53+96 and continues through to the end of UT1, where at a triple culvert crosses at Dixie River Road.

There are three tributary design reaches to UT1 identified from upstream to downstream as UT1B, UT1C, and UT1D. Because of the short length and similarity within each tributary, they are not further divided by reach. Tributary design reach UT1B is the northeastern most tributary extending 790 LF at a slope of 0.673 percent and terminates at the confluence with UT1 at station 17+64. Reach UT1C is the lower 628 LF of an unnamed tributary ending at the confluence with UT1 at station 16+27. The existing slope of UT1C is 1.68 percent. The final reach of the UT1 system is UT1D. Reach UT1D is the lower 352 LF of a northwesterly flowing tributary entering UT1. The confluence of UT1D and UT1 marks the end of UT1D (station 13+51). The existing slope of UT1D is 0.725 percent.

4.1.2 UT2 Reaches

The UT2 watershed abuts the UT1 watershed to the south, is bordered by Dixie River Road, and generally slopes west and south. The mainstem of UT2 has been divided into four reaches; two are above the confluence of UT2A (UT2 Reach 1 and 2) and two are below the confluence of UT2A (UT2 Reach 3 and 4). Furthest upstream in the eastern portion of UT2 Reach 1 (STA 10+00 to 16+40) has an existing stream length of 545 LF a channel slope of 2.3 percent. Immediately below Reach 1, Reach 2, from STA 16+40 to 25+06, has an existing reach length of 750 LF, ending at the confluence with UT2A, and has an existing channel slope of 1.2 percent. UT2 Reach 3 (STA 25+06 to 36+70) begins downstream of the confluence of UT2A and has an existing reach length of 1,125 LF. The current channel slope is 1.6 percent. UT2 Reach 4 has an existing reach length of 710 LF and a channel slope of 0.8 percent. It begins below UT2 Reach 3, STA 36+70 and terminates at STA 44+44 where the existing channel is less incised and preservation will begin. The entire length of UT2 is interrupted only once by a proposed roadway and associated right-of-way.

The existing UT2A flows southerly through the central portion of the watershed prior to its confluence with the mainstem of UT2. UT2A Reach 1 consists only of a non-disturbance area (not for credit) within the conservation easement downstream to STA 10+00. UT2A Reach 2 has an existing reach length of 826 LF and a channel slope of 1.4 percent. It begins at a head-cut (STA 10+00) and ends at the confluence of UT2A and the mainstem of UT2, STA 21+51, interrupted once on the downstream end by a sewer line easement.

4.1.3 Preservation Reaches

Preservation is proposed for reaches within the project area that are currently in stable, functioning condition and do not warrant restoration. As mentioned previously, the two reaches proposed for preservation are along the mainstem of Beaverdam and the downstream section of UT2. The reach along the mainstem of Beaverdam Creek proposed for preservation has a reach length of 1641 LF. It begins at the confluence with UT1 and extends downstream to the confluence of UT2. The reach along the mainstem of UT2 proposed for preservation has a reach length of 962 LF. It begins immediately downstream of UT2, reach 4 and ends at its confluence with the mainstem of Beaverdam Creek.

4.2 Site Hydrologic and Hydraulic Characteristics

4.2.1 Surface Water Classification

Under the federal Clean Water Act, NCDWQ designates surface water classifications for water bodies such as streams, rivers, and lakes, which define the best uses to be protected within these waters (e.g., swimming, fishing, and drinking water supply). These classifications are associated with water quality standards that govern those uses. All surface waters in North Carolina must meet the minimum standards for fishable/swimmable waters (Class C). Other classifications provide additional levels of protection for primary water contact recreation (Class B) and drinking water supplies (WS) and are associated with standards beyond those for Class C. Class C waters are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture, and other uses. Classifications and their associated protection standards may also be designated to protect the free-flowing nature of a stream or other special characteristics.

4.2.2 FEMA Designations

The FEMA Flood Insurance Rate Map (FIRM) for Mecklenburg County, NC, (FIRM Number 37119C0203E) indicates that there are regulatory floodplains associated with the UT1 project site, but none associated with UT2. Further, downstream and outside of the project site, the mainstem of Beaverdam Creek and Lake Wylie are both FEMA regulated areas. Figure 4.2 illustrates the FEMA mapping near the site. The flood elevation for UT1 may potentially be impacted because of the proposed restoration. Modeling of the revised 100-year water surface elevation is currently in progress for approval by FEMA.

4.3 Geomorphic Characterization

Buck Engineering performed longitudinal and cross-section surveys of the stream reaches proposed for restoration to assess the current condition and overall stability of the channels. Buck Engineering also performed pebble counts and collected substrate samples to characterize sediments. Figure 4.1 illustrates the locations of cross-section surveys on the project reaches. The following sections of this report summarize the survey results for project areas UT1 and UT2. Surveyed cross-sections, profiles, and sediment data are included in Appendix C. A photo log is included in Appendix G.

4.3.1 Channel Geomorphology

4.3.1.1 UT1 Channel Geomorphology

The channel restoration reaches are depicted in Figure 4.1 and described in Table 4.1. Watershed areas were calculated at the beginning of the project boundary and at the terminus of each reach. Watershed areas indicated are cumulative from Reaches 1 through 5 as they comprise the mainstem of UT1.

Table 4.1
UT1 Reach Descriptions

Reach	Existing Reach Length (LF)	Watershed Size at Downstream End of Reach (mi^2)
UT1 Reach 1	931	0.70
UT1 Reach 2	862	1.10
UT1 Reach 3	849	1.14
UT1 Reach 4	809	1.31
UT1 Reach 5	3824	1.73
UT1B	732	0.34
UT1C	744	0.15
UT1D	313	0.16

Table 4.2 summarizes the geomorphic parameters of the reaches to be restored. Though bedform diversity is fair to poor, there often exist segments of distinct riffles-pool morphology separated by extensive runs and glides. The existing riffles exhibit shallow, uniform depth and generally consist of varying composition of sand, gravel and cobble. In general, poorly formed, shallow pools lack definition.

Currently, Reach 1 and Reach 2 classify as Rosgen G5c-type streams. Typically, G-type streams are characterized by low width/depth ratios, high entrenchment, and moderate sinuosity. The d_{50} of the overall channel bed material classifies as medium to coarse sand. It appears that this reach has evolved from an E-type stream. An increase in slope, due to straightening, has resulted in increased shear stress and the onset of incision to the point where channel-forming discharge remains confined in the channel and through lateral erosion, initiates channel widening, as the slope tends to increase (sinuosity reduced). The reach has changed from an E to a G, typical of stage IV in the Simon Channel Evolution Model. Riffles are dominated by small cobble size particles, while the reach-wide pebble count indicates the d_{50} is in the medium sand range. Much of the channel has been straightened for farming, resulting in reduced sinuosity. Symptomatic of this channel evolution is the severe bank erosion throughout.

Reaches 3 and 4 classify as a G4c streams. Similar to Reach 1 and 2 these reaches have evolved from an E-type stream. However, different from the upstream reaches, the presence of bedrock, large cobble, woody vegetation and shrubs have provided some resistance to the incision-widening process that dictate the upstream morphology. Left unmanaged over a long period, UT1 Reach 1 through 4 may continue widening and evolve toward an F-channel en-route to becoming a somewhat stable C-type stream channel, slowly returning to an E.

Reach UT1B is classifies as Rosgen F4-type stream having high banks, a wide shallow channel, and significant channelization reducing sinuosity. This reach has evolved one stage further than most of the mainstem of UT1, and also is en-route to slowly becoming an E. The current vegetation found on the reach is a mix of early-successional with a significant invasive and nonnative community.

Reach UT1C is also characterized as a Rosgen Gc channel. The reach has been ditched and is therefore deeply incised and with no floodplain access. Similar to the UT1 mainstem, the existing bedform lacks diversity and is without significant pool formation limiting the quality of aquatic habitat. The steep valley slope of this reach resembles that of a typical B-type stream channel with step-pool morphology having deeper pools and well developed steps and riffles.

The existing condition of reach UT1D is characterized as a Rosgen F4 channel. The restoration section downstream of the Duke Power easement is a low gradient reach in a gravel substrate. The channel does not have access to the adjacent floodplain and all flood flows are thusly contained in the channel. The channel slope increases and morphology changes to a Rosgen B4 channel upstream of the restoration reach. The restoration reach shows significant incision similar to that of the mainstem. Incision in the reach decreases as channel substrate changes to larger diameter material upstream of restoration reach.

Table 4.2

Existing Conditions Geomorphic Data for UT1 – Stream Channel Classification Level II

Parameter	Value						Units
	UT1, Reaches 1& 2[1]	UT1, Reaches 3, 4[1]	UT1, Reach 5[1]	UT1, Reach UT1B	UT1 Reach UT1C	UT 1 Reach UT1D	
Bankfull Width (W_{bkf})	10.3	16.5	17.0	6.8	12.7	7.1	Feet
Bankfull Mean Depth (d_{bkf})	0.9	1.7	1.95	1.1	1.5	1.9	Feet
Bankfull Discharge (Q_{bkf})	80	135	155	50	30	40	Cubic feet per second
Cross-Sectional Area (A_{bkf})	9.4	27.5	33.0	7.51	19.4	13.6	Square feet
Width/Depth Ratio (W/D ratio)	12.2	10.5	8.9	6.2	8.3	3.7	
Bankfull Max Depth (d_{mbkf})	1.2	2.4	2.7	1.57	2.1	2.2	Feet
Floodprone Area Width (W_{fpa})	10.3	24.9	>200	9	16.4	13.1	Feet
Entrenchment Ratio (ER)	1.2	1.45	12	1.32	1.3	1.9	
Channel Materials (Particle Size Index – d_{50})	1.0 (Fine Sand)	48.2 (V. Coarse Gravel)	1.3 (Coarse sand)	20 (Course Gravel)	72 (Small Cobble)	35 (V Coarse Gravel)	mm
d_{16}	<0.062	0.13	0.58	4.5	6.5	0.24	mm
d_{35}	0.66	28.48	0.88	14	50	0.77	mm
d_{50}	0.97	48.2	1.28	20	72	35	mm
d_{84}	104.4	80.55	3.31	51	128	110	mm
d_{95}	167.0	118.5	4.66	110	200	175	mm
Water Surface Slope (s)	0.0062	0.0061	0.0012	0.0105	0.0179	.0045	Feet per foot
Channel Sinuosity (K)	1.15	1.08	1.16	1.1	1.0	1.11	
Rosgen Stream Type	G5c	G4c	E5	Fc	Gc	Fc	

Notes:

1. Values presented represent the average of all data collected throughout the study reach.

4.3.1.2 UT2 Channel Geomorphology

Although the drainage area for UT2 and its tributary, UT2A, are relatively small, all of the restoration activities are proposed only on perennial streams, classified as such based on the NCDWQ stream assessment protocol. Variation of hydraulics and geomorphology within UT2 and 2A warrant dividing the two reaches into five sub-reaches. UT2 is consists of four design reaches, UT2 Reach 1 and Reach 3 (upstream of the confluence with UT2A) and UT2 Reach 3 and Reach 4 (downstream of the confluence with 2A). UT2A was originally subdivided into UT2A Reach 1 and Reach 2, but because of modified conditions throughout Reach 1, only restoration activities on Reach 2 are currently proposed. Table 4.3 summarizes the reach lengths and watershed sizes, and Table 4.4 provides a geomorphic summary.

Table 4.3
UT2 Reach Descriptions

Reaches	Existing Reach Lengths (LF)	Watershed Size at Downstream End of Reach (mi^2)
UT2, Reaches 1 and 2	1,280	0.10
UT2, Reaches 3 and 4	1,850	0.30
UT2A, Reach 2	886	0.10

Table 4.4 summarizes the geomorphic parameters of the reaches within the UT2 system to be restored. Similar to the UT1 system, riffles are generally coarse and pools are not deep or well formed. Distinct riffles and pools are present on all five reaches, but are isolated by long runs and glides, and bedform diversity is poor. These reaches appear to have been straightened likely to accommodate past agricultural land use and timber harvesting operations. All of the reaches appear to follow either the C-Gc-F-Bc or Bc-Gc-F-Bc evolution scenarios. In general, all of the reaches in the UT2 system are deeply incised with little access to the floodplain and have riparian vegetation that consists of a mix of young successional and invasive species.

UT2, reaches 1 and 2 classify as an F-type stream characterized by high entrenchment, high width/depth ratios, moderate sinuosity, and channel slopes less that 2 percent. The valley slopes on the upper and lower portions of UT2 Reaches 1 and 2 are approximately 1.2 percent and 2 percent, respectively. It appears that UT2 Reach 1 has evolved from a C-type stream and UT2 Reach 2 has evolved from a B-type stream. In terms of Simon Channel Evolution Model, these reaches appear to be in between Stage IV and Stage V, as they have incised and widened. Although many of the riffles appear to be dominated by small cobble size particles, the d_{50} of the channel bed material classifies as medium sand.

Reaches 3 and 4 of UT2 classify as a Gc-type stream and similar to F-type streams are also characterized by high entrenchment, moderate sinuosity, and channel slopes less than two percent, but have substantially lower width/depth ratios. The d_{50} of the UT2 Reaches 3 and 4 channel bed material classifies as very coarse gravel. It appears that these reaches have evolved from a C-type stream. These reaches appear within range of Stage III to Stage IV evolution, as they have incised but only recently just begun the widening process. A large portion of the left side of UT2, Reaches 3 and 4 does not have access to an active floodplain. This is because these reaches were previously ditched-up along the valley wall, inhibiting natural channel adjustments including widening processes and the tendency to migrate while promoting mass wasting.

UT2A Reach 2 also classifies as a Gc-type stream type in the Rosgen system. The UT2A Reach 2 is very similar to UT2 Reaches 1 and 2 in drainage area, channel dimension, and channel bed material size. Similar to UT2 Reaches 1 and 2, the drainage area is approximately 0.1 square mile, the bankfull cross-sectional area is also approximately 10 square feet, and the d_{50} of the channel bed material also classifies is medium sand. The main difference between UT2A Reach 2 and UT2 Reaches 1 and 2 is primarily a slightly higher width/depth ratio and associated slope. This reach also appears to have evolved from a C stream type, but appears to be not as far along in Stage III to Stage IV evolution.

Table 4.4
Existing Conditions Geomorphic Data for UT2 – Stream Channel Classification Level II

Parameter	Value			Units
	UT2 Reaches 1 and 2	UT2A Reach 2	UT2 Reaches 3 and 4	
Bankfull Width (Wbkf)	12.3	7	10.6	Feet
Bankfull Mean Depth (d bkf)	0.8	1.8	1.9	Feet
Cross-Sectional Area (Abkf)	9.4	12.2	20.2	Square feet
Bankfull Discharge (Q_{bkf})	45	45	150	Cubic feet per second
Width/Depth Ratio (W/D ratio)	16.1	4.0	5.5	
Bankfull Max Depth (d_{mbkf})	1.9	2.5	2.9	Feet
Floodprone Area Width (W_{fpa})	22	11	40	Feet
Entrenchment Ratio (ER)	1.8	1.6	1.7	
Channel Materials (Particle Size Index – d_{50})	0.5 (Med Sand)	0.3 (Med Sand)	34.2 (Course Gravel)	mm
d_{16}	0.2	0.1	6.9	mm
d_{35}	0.4	0.2	21.8	mm
d_{50}	0.5	0.3	34.2	mm
d_{84}	1.9	4.0	102.7	mm
d_{95}	5.3	5.0	>2,048	mm
Water Surface Slope (s)	0.016	0.0140	0.0086	Feet per foot
Channel Sinuosity (K)	1.04	1.03	1.10	
Rosgen Stream Type	F5	G5c	G4c[2]	

Notes:
1. Values presented represent the average of all data collected throughout the study reach.
2. Lower entrenchment ratios more representative of the average conditions were also considered.

Although recent geomorphic data has not been obtained for the preservation locations, the previously submitted Beaverdam Creek Watershed Geomorphic Assessment (2004) identified the preservation reach of UT 2, downstream of the proposed restoration, as ranging between aggradational to vertically stable, having very low erosion potential, and was a B5c stream type at its upper end and a C5 stream type at its lower end. It was determined to be in stage V-VI of evolution.

4.4 Channel Stability Assessment

4.4.1 UT1 Channel Stability

Geomorphic cross-sectional data were collected and compared with records from previous years (Buck Engineering, 2004) indicating slight, but noticeable, changes throughout the sub-watershed over a short period, despite well-vegetated riparian vegetation throughout. As noted in the previous observations UT1 Reach 1, UT1 Reach 1B, and UT1 Reach 2 were vertically stable with continued to widening, consistent with Stage V of the Simon evolution model.

Similarly, UT1 Reach 3, UT1 Reach 1D, UT1 Reach 1C, and UT1 Reach 4 are vertically stable, due to a gravel bed, while further widening of the channel consistent with Stage IV to Stage V evolution. This aggradation process may possibly be catalyzed by the excess of available sediment associated with continued bank erosion.

In contrast to UT1 Reaches 1-4; UT1 Reach 5 is less incised but still has areas of high bank erosion as well as lateral accretion. UT1 Reach 5 is a sand-dominated E stream type utilizing lateral adjustment to move toward quasi-equilibrium (Simon stage IV).

4.4.2 UT2 Channel Stability

Geomorphic cross-sectional data were collected and compared with records from previous years (Buck Engineering, 2004) indicating slight but noticeable changes throughout the sub-watershed over a short period, despite well-vegetated riparian vegetation throughout. As previously speculated, UT2A Reach 2, UT2 Reach 3 and UT2 Reach 4 are continuing to incise and beginning to widen, consistent with Stage III to Stage IV of the Simon evolution model.

Similarly, UT2 Reach 1 and UT2 Reach 2 are further along the widening process and beginning to aggrade consistent with Stage IV to Stage V evolution. This aggradation process may possibly be catalyzed by the excess of available sediment associated with ongoing watershed development. Though vertically stable, bank erosion continues as sinuosity develops. However, the upstream-most sections of UT2 Reach 1 demonstrate a slight tendency toward Stage VI evolution characterized by a state quasi-equilibrium.

Though the UT2 preservation reach downstream from proposed channel restoration exhibits channel bed aggradation and little bank erosion, this reach suffers from instability. The tendency of this channel is to aggrade as excess sediment is deposited throughout. Minimization of sediment contribution from the upstream system will prevent the instable evolution toward a multi-channel D-type stream.

4.4.3 Bank Erosion at UT1 and UT2

Bank erosion rates can be approximated using BEHI procedures developed by Rosgen (2001). The application of the BEHI methodology allows for an estimation of sediment tonnage entering the stream reach due to bank erosion each year.

The information collected by Buck Engineering for the Beaverdam Creek Geomorphic Assessment in 2002 and 2003 represents the expected reach erosion potential for UT1 and UT2. A summary of the results of the study are presented in Table 4.5. The reach lengths listed are based on design lengths and total erosion estimates are extrapolated using direct ratios for those reach lengths. The erosion rates used for this table are average values from the entire study reach. Actual erosion at any specific location within each reach may be deviate from than the average value used.

The Beaverdam Creek Watershed Geomorphic Assessment incorporates data from scour chains, bank pins and pebble counts to estimate a sediment contribution of 246 tons to UT1 from bank erosion each year over approximately 8,520 LF of stream. This rate translates to approximately 29 tons per 1,000 LF of stream per year. The erosion rate for UT2, slightly lower than UT1, produces approximately 19 tons per 1,000 LF of stream per year (97 tons per year over approximately 5,085 linear feet of stream). The significant erosion that is seen in these reaches is a consequence of lateral instability and is an indicator of channel evolution.

While the 2003 data indicate very low erosion rates, recent observations suggest significant aggradation throughout the UT2 preservation reach due to a downstream sewer crossing. We are working with the Charlotte-Mecklenburg Utilities Department (CMUD) to adjust the crossing for better conveyance. Once the constructed channels are stabilized following channel restoration, sediment contributions from bank erosion within UT1 and UT2 will be minimized to approximately less than one percent of that of the disturbed channel. As a result, downstream aggradation will be reduced and natural channel evolution will allow the preserved reaches to increase in stability.

4.5 Bankfull Verification

Field indicators of bankfull stage (including vertical slope breaks, depositional features, and a high scour line) were identified for UT1 and UT2 and validated by existing vegetation trends and surveyed during geomorphic data collections. In general, bankfull indicators appeared at a constant distance above baseflow stage. Dimensional and slope data through this cross-section were considered using multiple techniques for developing estimates for bankfull discharge. Collectively, these techniques produced converging lines of evidence used to identify a design bankfull discharge for each design reach.

One method of estimating bankfull discharge involved the use of one-dimensional Manning's resistance equation (Manning, 1889). A discharge was calculated for each reach at a stable riffle cross-section. Manning's roughness coefficients between 0.033 and 0.040 were selected based on visual reference (channel size, cross-sectional variation, measured bed material, and presence of vegetation) and validated using Strickler's Method.

Additionally, the 2-, 5-, and 10-year recurrence discharge event was computed using previously developed USGS rural and urban regression equations for North Carolina (based on empirical data and largely a function of contributing drainage area and the degree of urbanization). The rural USGS regression equation was used for UT1. The urban regression equation was used for UT2 and a future watershed condition assumed (30 percent impervious surface throughout the watershed equivalent to approximately 70 percent residential development). The recurrence interval for bankfull discharge was approximated at 1.5-years, and the corresponding discharge for individual design reaches was extrapolated from these equations. Using these USGS regression equations, bankfull discharges estimated for UT1 reaches resemble those computed using Manning's equation. However, USGS regression estimates of bankfull discharge for UT2 were substantially higher than those computed using the Manning's equation likely because of the future conditions assumption; the UT2 watershed has yet to become 30 percent impervious.

Next, field identified bankfull hydraulic geometry, as well as the computed and estimated design bankfull discharges for each reach were compared to the North Carolina rural and urban Piedmont regional curves (Doll *et al.*, 2002). The bankfull cross-sectional area and width/depth ratios corresponded consistently with the regional curves. The bankfull discharges of all the UT1 reaches plotted between the rural and urban regional discharge curve, slightly above the rural regional curve data, indicating some level of disturbance but a design discharge within acceptable limits. While design discharges selected for UT1 design reaches plot closer to the rural regional curve, design discharges selected for UT2 reaches plot slightly closer to the urban regional curve (Figure 4.3).

A final technique for estimating bankfull design discharge involved application of NRCS TR55 hydrologic calculations for the individual project reaches. Input parameters included existing land use data for UT1 reaches, and proposed land use data, for UT2 reaches, as well identification of the 24-hr SCS Type II design storm in Mecklenburg County. The existing condition TR55 bankfull discharge results were similar to those of the USGS regression equations, though slightly larger typical of the 24-hr SCS Type II unit hydrograph.

These results indicate that the calculated existing condition bankfull discharges fall in the generally expected recurrence interval for an existing condition bankfull event. The results also indicate that the design discharges for UT2 accommodate for the increased flows generated from increased impervious surface area associated with the future land use.

4.6 Riparian Vegetation

Most of the existing stream buffers are greater than 50 feet (and at times exceed 125 feet) from the top of the existing banks of both unnamed tributaries to Beaverdam Creek. Some isolated areas of disturbance include power-line corridor, recent timber harvest and residential clearing, and I-485 construction.

The dominant species in the overstory of this community included sourwood (*Oxydendrum arboreum*), sweet gum (*Liquidambar styraciflua*), northern red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), southern sugar maple (*Acer floridanum*), red maple (*Acer rubrum*), ironwood (*Carpinus caroliniana*), elm (*Ulmus* spp.), sycamore (*Platanus occidentalis*), green ash (*Fraxinus pennsylvanica*), yellow poplar (*Liriodendron tulipifera*), black gum (*Nyssa sylvatica*) and black walnut (*Juglans nigra*). Mid-canopy species included Chinese privet (*Ligustrum sinense*), black willow (*Salix nigra*), flowering dogwood (*Cornus florida*), alder (*Alnus serrulata*), red mulberry (*Morus rubra*), and Russian olive (*Elaeagnus umbellate*). Herbaceous and vine species consisted of Japanese honeysuckle (*Lonicera japonica*), grape (*Vitis* spp), Christmas fern (*Polystichum acrostichoides*), poison ivy (*Toxicodendron radicans*), Japanese grass (*Microstegium vimineum*), asters (*Aster* spp.), river cane (*Arundinaria gigantea*) and various grasses and sedges. Several of these species, such as Japanese honeysuckle and Russian olive, are non-native, invasive species.

4.7 Wetlands

The proposed project area was reviewed for the presence of wetlands and waters of the United States in accordance with the provisions of Executive Order 11990, the Clean Water Act, and subsequent federal regulations. Wetlands have been defined by the USACE as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (33 CFR 328.3(b) and 40 CFR 230.3 (t)).

Following an in-office review of the National Wetland Inventory (NWI) map, NRCS Soil Survey, and the USGS Quadrangle map, a field survey of the project area was conducted to delineate wetlands and waters of the U.S. The project was examined utilizing the jurisdictional definition detailed in the *Corps of Engineers Wetland Delineation Manual* (USACE, 1987). Supplementary information to further support wetland determinations was found in the *National List of Plant Species that Occur in Wetlands: Southeast* (Region 2) (Reed, 1988).

Comprehensive field surveys throughout the project area were conducted on August 9 and 10, 2005, to assess vegetation, soils and hydrology for determination of the presence of jurisdictional wetlands. There were no areas in the project site that displayed true wetland characteristics. There is one wetland downstream of the project area that will only benefit from proposed preservation activities. This wetland will be preserved in a conservation easement as a part of the project but will not be included in calculations for wetland preservation credit. Therefore, no wetland monitoring is required.

4.8 Precipitation

Mecklenburg County has an average annual rainfall of 43.5 inches (NRCS 2003) and an average growing season that is 257 days long, beginning on March 10 and ending on November 22. Buck Engineering collected rainfall data for the monitoring period from the nearest automated weather station, located in Charlotte, approximately three miles northeast of the project site (Charlotte Douglas International Airport). Monthly precipitation amounts from January through December 2004 are compared with Mecklenburg County WETS table (NRCS 1995) average monthly rainfall, in Table 4.5. These data indicate that over the entire year, total rainfall was slightly below normal.

Table 4.5
Beaverdam Creek Watershed Precipitation Summary

Month-Year	Observed Precipitation (in)	WETS Table Average Monthly Precipitation (in)	Deviation of Observed from Average (in)
January-04	0.86	4.00	-3.13
February-04	3.05	3.55	-0.49
March-04	1.56	4.39	-2.83
April-04	1.23	2.95	-1.72
May-04	2.78	3.66	-0.877
June-04	8.23	3.42	4.81
July-04	3.17	3.79	-0.62
August-04	5.25	3.72	1.53
September-04	6.18	3.83	2.35
October-04	0.75	3.66	-2.91
November-04	2.99	3.36	-0.36
December-04	2.64	3.18	-0.54
Total	**38.73**	**43.52**	**-4.78**

4.9 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate samples were collected at three sites (two within the project area and one reference site near project area) on December 12, 2005 (see Figure 4.4 for sampling locations). Sites 1 and 2 are located in the downstream section of the proposed restoration reaches of unnamed tributaries one and two (UT1 and UT2) to Beaverdam Creek, respectively. Site 3 is located in Beaverdam Creek, upstream of the confluence with UT1, and served as the reference reach. Reference sites upstream of the project area could not be used because of their very small drainage areas. The sampling methodology followed the Qual-4 protocol listed in the North Carolina Department of Environment and Natural Resources', *Standard Operating Procedures for Benthic Macroinvertebrates* (2003). Benthic macroinvertebrate sampling results are summarized in Table 4.6 and provided in greater detail in Appendix E.

The components of the benthic macroinvertebrate community that are commonly used to evaluate water quality are the EPT taxa. The EPT taxa include specimens belonging to the insect orders *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Trichoptera* (caddisflies). These groups are generally the least tolerant to water pollution and therefore are very useful indicators of water quality. Therefore, the presence of substantial numbers of EPT taxa and individuals are considered indicative of relatively undisturbed "higher quality" streams. EPT metrics commonly used to assess water quality include EPT taxa richness, EPT biotic index, and EPT abundance, which are shown in Table 4.6.

All the sites sampled exhibited impaired benthic macroinvertebrate communities. All sites received low total and EPT taxa richness and high biotic index values. However, Site 2 (UT2) received the lowest total and EPT taxa richness and highest total biotic index values. A healthier community is characterized by higher total and EPT taxa richness values and lower biotic indices values. The total and EPT taxa richness values between sites should be emphasized when comparing the sites for this project. Comparing biotic indices (both total and EPT) between sites is not as useful when total and EPT taxa richness are low as those experienced in the Beaverdam Creek watershed.

The benthic communities found at all sites corresponded with their moderately low habitat assessment scores (56 – 60 out of a possible 100). All three sites are experiencing excessive sedimentation. Sites 1 (UT1) and 3 (Beaverdam Creek) primarily consist of shallow runs with very few riffle/pool sequences due to excess sedimentation. Site 2 (UT2) has a better riffle/pool sequence than the other sites but the riffles are heavily embedded with silt; burying potential optimal habitat (interstitial spaces between cobble) for the benthic macroinvertebrate community. The stream banks along Site 2 appear to be more incised and less stable, leaving less desirable habitat for benthos colonization along the banks. The smaller drainage area and slower flow velocity of Site 2 also contributed to its lower benthic macroinvertebrate rating compared to the other sites.

One parameter in analyzing the benthic macroinvertebrate community that relates to riparian habitat is evaluating the shredder community. Shredders are important organisms that break down coarse particulate organic matter (CPOM) such as leaves and woody debris for food and cover. Many of the shredder organisms are stoneflies and caddisflies that are intolerant to pollution. The lack of shredders along with other intolerant organisms throughout the Beaverdam Creek watershed, even when availability of CPOM is high (wide, intact, forested buffer), indicates that the benthic macroinvertebrate community within the watershed is impaired by the ambient water quality and not just by habitat degradation.

The potential recruitment of intolerant organisms into Sites 1 and 2 is very limited as long as the water quality remains impaired within the Beaverdam Creek watershed. Stabilizing stream banks should reduce sedimentation, which then should help increase the abundance of the organisms already established in the benthic macroinvertebrate community. Recruitment for Site 2 will most likely come from Sites 1 and 3. No appreciable recruitment will come from upstream of the restoration areas due to development and small upstream drainage areas.

Table 4.6
Summary of Benthic Macroinvertebrate Sampling Data

Metric	UT1	UT2	Mainstem Beaverdam Creek
Total Taxa Richness	24	12	17
EPT Taxa Richness	5	1	4
Total Biotic Index	5.34	6.12	5.13
EPT Biotic Index	4.02	2.5	3.35
EPT Abundance	23	3	19

5.0 SELECTED DESIGN CRITERIA FOR STREAM RESTORATION

5.1 Potential for Restoration

The unnamed tributaries to Beaverdam Creek are appropriate for restoration because of their ongoing and persistent condition of instability. Left un-maintained, additional erosion would occur before the channels begin evolving toward a stable, quasi-equilibrium state. Ongoing and persistent vertical incision and bank over-widening results in excess sediment mobilization and ultimate deposition within and downstream of the proposed project reaches. Restoration will produce stable channel bed and banks minimizing unnecessary sediment contributions while establishing and promoting development of improved self-maintaining aquatic and riparian habitat

In some isolated instances, reclamation of the abandoned floodplain is not possible. This typically occurs where a proposed channel ties into an existing channel, upstream and downstream. In this situation, a Priority 2 design was applied in transition to a Priority 1 design. Because of increased unnecessary disturbance and costs associated with excess excavation, Priority 2 designs are applied with the objective of minimizing the length or floodplain requiring excavation. In one particular instance, the upstream tie-in of UT1, a Priority 3 restoration concept was applied to prevent hydraulic encroachment onto North Carolina Department of Transportation (NCDOT) right-of-way adjacent to I-485. In this case, stable channel geometry was proposed for a straightened stream that may not have naturally occurred if not for human disturbance. Although a Priority 2 restoration may have achieved similar results, application of the Priority 3 alternative eliminates unnecessary disturbance of a healthy forest while minimizing excavation operations.

5.1.1 UT 1 Channel Restoration Potential

Despite limited development of this watershed, the existing channel shows no sign of short-term recovery. Although vertical erosion may be limited throughout UT1, continued natural channel adjustment in the form of lateral migration and new floodplain development would occur indefinitely, resulting in continuation of sediment pollution to receiving waters.

5.1.2 UT 2 Channel Restoration Potential

As previously discussed, the UT2 system is predominantly incised and actively widening. Unattended, UT2 would likely continue vertical down cutting where bedrock is not present, and definitely continue migrating laterally, resulting in massive bank erosion and excessive sediment pollution of receiving waters, as well as initiating downstream channel instability in the areas proposed for preservation. These processes would be exacerbated by increases in peak discharge associated with scheduled residential and commercial development throughout the watershed.

5.2 Design Criteria Selection

Once the potential for restoration is realized, the restoration approach must be defined before selection of design criteria. As discussed in Section 2.5, the selection of natural channel design criteria is based on multiple considerations including existing conditions assessment, review of reference reach data, regime equations, and evaluation of past projects.

5.2.1 Restoration Approach

Throughout most of UT1, the restoration approach identifies the existing evolutionary process and establishes the naturally successional stable C/E-type stream channel development. Additionally, soil bioengineering, structural reinforcement, and revetment will be applied to promote stability immediately following construction when the stream is most vulnerable. Given the wide floodplain, relatively flat slopes, generally stable nature of the soil, and favorable growing conditions at the site, this restoration approach is an achievable goal. Removal of invasive and planting of native vegetative species throughout the existing riparian buffer will complement the channel restoration and promote climax successional habitat.

Similar to UT1, the restoration approach throughout UT2 entails establishing a successional C/E-type stream channel while maintaining the ability to accommodate subsequent natural channel evolution towards an E-type channel, as warranted by future influences to the discharge and sediment regime. This will also be accomplished through application of a Priority 1 design throughout with short segments of Priority 2 design to tie into existing incised channels.

5.2.2 Reference Reach Survey

After selection of the general restoration approach, specific design criteria were developed based on reference reach data, leading to establishment of cross-section dimensions, followed by horizontal alignment planform layout, and the vertical alignment channel profile as part of developing construction documents. An undisturbed reference reach could not be found within adjacent reaches or the same watershed as the project site, so reference reaches in adjacent watersheds as well as those within a common physiographic province (Figure 4.5) were identified and reconnaissance performed. Among all of the systems considered, only Latta Plantation and McDowell Park were geomorphic surveys performed specifically for use in design of the restored Beaverdam Creek unnamed tributaries. Additionally, NCDOT and Buck Engineering's internal database were reviewed for applicability. A summary of the reference data are provided in Table 5.1a and 5.1b.

Table 5.1a
Geomorphic Characteristics for Reference Reaches

	UT to Cleghorn		**UT to Spencer Ck**		**McClintock Ck (Stockwood)**		**McClintock Ck (McNair)**		**UT to Lake Jeanette**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
1. Stream Type	E5		E5		E5		E5		E5	
2. Drainage Area – square miles	0.200		0.014		0.20		0.30		0.15	
3. Bankfull Width (w_{bkf}) – feet	7.8		7.0		9.1		10.6		12.0	
4. Bankfull Mean Depth (d_{bkf}) – feet	0.8		1.1		1.6		2.0		1.4	
5. Width/Depth Ratio (w/d ratio)	**9.8**		**6.4**		**5.7**		**5.3**		**8.6**	
6. Cross-sectional Area (A_{bkf}) – SF	7.5		7.7		14.2		21.8		18.8	
7. Bankfull Mean Velocity (v_{bkf}) - fps	3.1		3.2		3.2		4.4		2.5	
8. Bankfull Discharge (Q_{bkf}) – cfs	23		25		45		95		47	
9. Bankfull Max Depth (d_{mbkf}) - feet	1.3		2.0		2.2		3.1		2.3	
10. d_{mbkf} / d_{bkf} ratio	**1.6**		**1.8**		**1.3**		**1.6**		**1.6**	
11. Low Bank Height to d_{mbkf} Ratio	1.0		1.0		1.1		1.3		-	
12. Floodprone Area Width (w_{fpa}) – feet	17		81+		-		-		49	
13. Entrenchment Ratio (ER)	1.8		11.6		-		-		4.1	
14. Meander length (L_m) – feet	64		38		47		47		22	
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	**6.1**		**5.4**		**5.2**		**4.4**		**1.8**	
16. Radius of curvature (R_c) – feet	13		5.8	16	18	25	27	30	7.3	17
17. Ratio of radius of curvature to bankfull width (R_c / w_{bkf})	**1.6**		**0.8**	**2.3**	**2.0**	**2.7**	**2.6**	**2.8**	**0.6**	**1.4**
18. Belt width (w_{blt}) – feet	62		11	27	32	45	32	35	45	
19. Meander Width Ratio (w_{blt}/W_{bkf})	**8.0**		**1.6**	**3.8**	**3.5**	**4.9**	**3.0**	**3.3**	**3.3**	**3.8**
20. Sinuosity (K) Stream Length/ Valley Distance	1.87		2.45		1.33		2.38		-	
21. Valley Slope – feet per foot	0.0168		0.0081		0.0080		0.0190		-	
22. Channel Slope ($s_{channel}$) – feet per foot	0.0090		0.0033		0.0060		0.0080		0.0033	
23. Pool Slope (s_{pool}) – feet per foot	0.0000		0.0013		-		-		-	
24. Ratio of Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	**0.00**		**0.39**		**-**		**-**		**-**	
25. Maximum Pool Depth (d_{pool}) – feet	2.2		2.5		2.1	2.8	3.2	3.4	3.1	

Table 5.1a
Geomorphic Characteristics for Reference Reaches

	UT to Cleghorn		UT to Spencer Ck		McClintock Ck (Stockwood)		McClintock Ck (McNair)		UT to Lake Jeanette	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
26. Ratio of Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	**1.9**		**2.3**		**1.3**	**1.8**	**1.6**	**1.7**	**1.8**	**2.2**
27. Pool Width (w_{pool}) – feet	8.1		6.5		13.9	17.1	11.4	12.5	20.8	
28. Ratio of Pool Width to Bankfull Width (w_{pool} / w_{bkf})	**0.9**		**0.9**		**1.5**	**1.9**	**1.1**	**1.2**	**1.7**	**1.5**
29. Pool Area (A_{pool}) – square feet	9.1		8.8		20.6	24.2	24.9	25.2	26.9	
30. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})	**1.0**		**1.1**		**1.5**	**1.7**	**1.1**	**1.2**	**-**	**-**
31. Pool-to-Pool Spacing – feet	23.7		19		-		39		-	
32. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	**3.1**		**2.7**		**-**		**3.7**		**-**	
33. Riffle Slope (4((s_{riffle}) – feet per foot	0.0006		0.0140		0.0100		0.0162		-	
34. Ratio of Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	0.1		4.2		1.7		2.0		-	

Particle Size Distribution of Riffle Material					
Material (d_{50})	Fine gravel	Coarse sand	Fine Sand	Fine Sand	Coarse Sand
d_{16} – mm	N/A	< 0.062	-	-	-
d_{35} – mm	0.35	0.062	0.30	0.19	-
d_{50} – mm	0.92	1.0	0.40	0.28	0.50
d_{84} – mm	30	16	10	2.5	3.5
d_{95} – mm	57	22	36	11	-

- : data not available

Table 5.1 b
Geomorphic Characteristics for Reference Reaches

	UT to Big Lost Cove		Spencer Creek		McDowell Park		Latta Plantation	
	Min	Max	Min	Max	Min	Max	Min	Max
1. Stream Type	E4b		E4/C4		B4/5c		C4/5	
2. Drainage Area – square miles	0.2		1.0		0.6		-	
3. Bankfull Width (w_{bkf}) – feet	7.8		10.7	11.2	11.6		11.2	
4. Bankfull Mean Depth (d_{bkf}) – feet	1.1		1.6	1.8	1.2		1.2	
5. Width/Depth Ratio (w/d ratio)	**7.2**		**5.8**	**7.1**	**9.4**		**9.4**	
6. Cross-sectional Area (A_{bkf}) – SF	8.5		17.8	19.7	14.5		13.22	
7. Bankfull Mean Velocity (v_{bkf}) - fps	4.7		3.0	3.1	5.2		-	
8. Bankfull Discharge (Q_{bkf}) – cfs	40		54		75		-	
9. Bankfull Max Depth (d_{mbkf}) - feet	1.2		2.1		1.7		1.5	
10. d_{mbkf} / d_{bkf} ratio	**1.1**		**2.6**		**1.3**		**1.3**	
11. Low Bank Height to d_{mbkf} Ratio	1.0		1.0		1.0		0.9	
12. Floodprone Area Width (w_{fpa}) – feet	73		59	114	49		58	
13. Entrenchment Ratio (ER)	>2.2		5.5	10.2	4.2		5.2	
14. Meander length (L_m) – feet	95		46		90		100	
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	**12.1**		**4.1**	**4.4**	**7.7**		**9.0**	
16. Radius of curvature (R_c) – feet	16		15		16		110	

Table 5.1 b
Geomorphic Characteristics for Reference Reaches

	UT to Big Lost Cove		Spencer Creek		McDowell Park		Latta Plantation	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
17. Ratio of radius of curvature to bankfull width (R_c / w_{bkf})	**2.1**		**1.3**	**1.4**	**1.4**		**10.0**	
18. Belt width (w_{blt}) – feet	29		39		30		29	
19. Meander Width Ratio (w_{blt}/W_{bkf})	**3.7**		**3.5**	**3.6**	**2.6**		**2.6**	
20. Sinuosity (K) Stream Length/ Valley Distance	1.18		2.31		1.22		1.05	
21. Valley Slope – feet per foot	0.0340		0.0109		0.0151		0.0144	
22. Channel Slope ($s_{channel}$) – feet per foot	0.0290		0.0047		0.0124		0.0137	
23. Pool Slope (s_{pool}) – feet per foot	0.0010		0.0070	0.0090	0.0033		0.0044	
24. Ratio of Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	0.10		-		0.27		0.32	
25. Maximum Pool Depth (d_{pool}) – feet	1.7		-		2.7		2.2	
26. Ratio of Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	**1.5**		**-**		**2.2**		**1.9**	
27. Pool Width (w_{pool}) – feet	8.0		-		11.9		16.9	
28. Ratio of Pool Width to Bankfull Width (w_{pool} / w_{bkf})	**1.0**		**-**		**1.0**		**1.5**	
29. Pool Area (A_{pool}) – square feet	-		-		21.8		19.7	
30. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})	**-**		**-**		**1.5**		**1.5**	
31. Pool-to-Pool Spacing – feet	42.5		-		45.2		32.5	
32. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	**5.4**		**-**		**3.9**		**2.9**	
33. Riffle Slope (4((s_{riffle}) – feet per foot	-		0.130		0.040		0.020	
34. Ratio of Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	-		2.8		3.2		1.5	
Particle Size Distribution of Riffle Material								
Material (d_{50})	-		Fine sand		Fine Sand		Coarse Sand	
d_{16} – mm	-		0.06		N/A		-	
d_{35} – mm	-		3.0		0.30		-	
d_{50} – mm	-		8.6		0.40		-	
d_{84} – mm	-		77		10		-	
d_{95} – mm	-		180		36		-	

- : data not available

5.3 Design Criteria for UT1 and UT2

After examining the existing condition, recognizing the potential for restoration, and reviewing reference reach data, design criteria were developed. Assigning an appropriate stream type for the corresponding valley that will accommodate the existing and future hydrologic and sediment contributions was considered conceptually prior to selecting reference reach streams. Design criteria for the proposed stream concept were selected based on the range of the reference data and the desired performance of the proposed channel. Following initial application of the design criteria, detail refinements were made to accommodate nuances in existing valley morphology, to avoid encroachment of easement boundaries and valley wall, to minimize unnecessary disturbance of the existing riparian forest, and to promote natural channel adjustment following construction. The proposed stream types for the project are summarized in Table 5.2.

Table 5.2 Project Design Stream Types		
Reach	**Proposed Stream Type**	**Rationale**
UT1 Reaches 1-5 UT1B	C4/E4	Priority 1 restoration will increase sinuosity, pool development, and native re-vegetation will improve habitat. Promote development of natural floodplain wetlands through elevated groundwater levels. Priority 2 restoration will facilitate the transition between the constructed and the existing channel. A small segment of the uppermost UT1 will consist of Priority 3 adjustments, where a different stream type was required to make the transition between the constructed and existing channel more efficient.
UT1D	C4/E4	Priority 2 restoration will increase sinuosity, pool development, and native re-vegetation will improve habitat. Excavation of the floodplain will provide energy dissipation and deposition areas.
UT1C	B4	A Priority 1 step-pool channel will be used to stabilize the reach, dissipate excess energy of a steep reach, increase vertical bed diversity and promote natural development of aquatic habitat.
UT2 Reach 1	C4/E4	Priority 1 restoration will increase sinuosity, pool development, and reestablish connection with the floodplain. Native re-vegetation will improve habitat and stabilize the banks. UT2 Reach 1 will tie into a constructed riffle creating an upstream backwater condition.
UT2 Reach 2	B5	A Priority 1 step-pool channel will be constructed since this reach is near 2% slope and is confined in a steep valley.
UT2A Reach 2 UT2 Reach 3-4	C4/E4	Priority 1 restoration will increase sinuosity, pool development, and re-establish connection with the floodplain. Native re-vegetation will improve habitat and stabilize the banks. Priority 2 restoration will transition the connection between the constructed channel of UT2 Reach 4 with the existing channel and UT2A Reach 2 with the upstream existing channel.

6.0 RESTORATION DESIGN

6.1 Restoration Approach

The primary objective of the restoration design is to construct a stream with a stable dimension, pattern, and profile that has access to its floodplain at bankfull flows while enhancing riparian and aquatic habitat. The philosophy applied by Buck Engineering throughout the Beaverdam Creek watershed consisted of creating C-type channels with the potential to naturally adjust where E-type tendencies occur. Areas where the planform was limited (transitional reaches) were designed more to resemble Bc-type stream channels. The proposed design for UT1 and UT2 are detailed in Figures 6.1 and 6.2.

Although UT1 exists in a more rural environment than UT2, the mainstem reaches on UT1 and UT2 have similar geomorphic characteristics. The design rationale and design parameters for all of the design reaches are presented below.

6.1.1 Dimension

Throughout the entire proposed design, the cross-section dimensions were adjusted to reduce velocities and near-bank shear stress. The selected design parameters eliminate incision and restore access to the floodplain. Typically, a C/E-type stream with a width/depth ratio ranging between 10 and 12 and a low bank height ratio (BHR) tending toward 1.0 was produced. Typical cross-sections are shown on the plan sheets.

6.1.2 Pattern

The proposed channel alignment will increase the sinuosity of most reaches to approximately 1.2. The overall length of restored and enhanced streams will increase from 12,598 to 12,871 LF. However, some local stream lengths were reduced because of the need to minimize Priority 2 efforts. Higher meander width ratios on the restored channel were intended to allow for lateral dissipation of energy and provide a floodplain sufficient for future natural channel development. Some isolated lengths of both tributaries were constrained by a narrow valley. In these locations, the proposed belt width reflects that of a Bc-type stream, falling in the lower end of the design range. Plan views of the main channel are shown on the attached plan sheets.

Aside from reaches that are confined by steep valleys, radii of curvature (approximately two to three times the channel's proposed bankfull width) range between that typical of a C/E-type stream throughout to that more typical of a Bc-type stream in transitions. A majority of bends incorporate radius of curvature ratios equal to or greater than 2.5, in an effort to enhance stability immediately following completion of construction and prior to establishment of stabilizing vegetative root mass.

6.1.3 Profile/Bedform

Though moderately functional and somewhat stable, the channel profile of the existing mainstem is lacking sufficient vertical grade control, woody debris, and overall bedform diversity. During the construction of the proposed channel, access to the existing floodplain will first be acquired, followed by facet development (riffle, run, pool, glide, and step-pool) mimicking those characteristic of the reference reaches. Average channel slope for UT1 ranges between 0.23 percent (UT1 Reach 3) to 1.7 percent (UT1C), while average channel slope for UT2 range between 0.75 percent (UT2 Reach 4) to 1.8 percent (UT2 Reach 2). Riffles throughout the design reaches range between 0.38 percent (UT1 Reach 3) and 2.8 percent (UT2 Reach 3), or the equivalent of 1.1 to 2.0 times the average channel slope for UT1 and 1.1 to 3.1 times the average channel slope for UT2. The maximum pool depth is proposed to be constructed from the meander curve apex to a point one-third of the distance along the profile from the apex to the head of the next downstream riffle (Copeland et al., 2001).

6.1.4 Design of UT1 Reaches

A stable cross-section will be achieved by widening the channel and increasing the width/depth ratio. The channel will be designed as a C/E stream type, and the sinuosity will be increased by adding meanders to lengthen the channel. Grade control at the bed will be provided by in-stream structures such as constructed riffles, cross-vanes and step-pool structures. These structures will also help to improve bedform diversity. Bioengineering and in-stream structures will be used at the outside of meander bends (including root wads, brush mattressing, log vanes and cover logs) to promote additional bank stability and improve habitat.

UT1 Reach 1 is the beginning of the UT1 mainstem and starts at the upstream end of the conservation easement. This reach was designed with low slope, minimal meander and floodplain benching in order to tie proposed bankfull elevations into existing ground as quick as possible. A series of cross vanes will serve to prevent future headcut.

UT1 Reach 2 is approximately 1,575 LF and begins at the confluence with UT1B (station 15+52). This point is the beginning of a full priority 1 design. The new channel alignment utilizes the existing wide, flat floodplain on the left overbank.

UT1 Reach 3 lies between the confluences of UT1C (station 31+27) and UT1D (station 39+82). The valley through this section is relatively narrow, and the belt width of the proposed channel reflects this.

The narrow valley continues at the beginning of UT1 Reach 4 (station 39+82) for approximately 800 LF. The Shaw property on the right bank will be fenced with gates for access. The proposed alignment through the Duke Power easement is relatively straight, with a constructed riffle for stream crossing.

UT1 Reach 5 begins at station 53+96 and continues to the end of the project. The floodplain in this reach is wide and flat. Several ephemeral pools will be constructed within this reach and wetlands may develop.

UT1B Reach 1 begins at the upstream conservation easement and connects with UT1. This reach is approximately 764 LF and will cut through an old dam. The valley is pinched and floodplain grading will be utilized to create adequate benching.

UT1C Reach 1 is a B-type channel with a 1.68 percent slope. This will be a step-pool design dominated by log drops. The valley is narrow throughout the reach, so there is minimal proposed meander. The channel is approximately 640 LF and the floodplain will be benched the entire length.

UT1D Reach 1 is approximately 351 LF of proposed C/E-type channel. There is ample floodplain to construct a channel with the appropriate belt width. A series of drop structures at the end of the reach will tie into UT1.

Tables 6.1 & 6.2 presents the proposed stream restoration design criteria applied throughout UT1.

Table 6.1
Design Parameters and Proposed Geomorphic Characteristics – UT1

	UT1 Design Reach 1		UT1 Design Reach 2		UT1 Design Reach 3		UT1 Design Reach 4	
	Min	Max	Min	Max	Min	Max	Min	Max
1. Stream Type	Bc		C/E		C/E		C/E	
2. Drainage Area – square miles	0.70		1.14		1.30		1.48	
3. Bankfull Width (w_{bkf}) – feet	14.6		16.8		19.2		19.6	
4. Bankfull Mean Depth (d_{bkf}) – feet	1.5		1.7		2.0		2.0	
5. Width/Depth Ratio (w/d ratio)	**10**		**10.1**		**9.8**		**9.9**	
6. Cross-sectional Area (A_{bkf}) – SF	21		28		38		39	
7. Bankfull Mean Velocity (v_{bkf}) - fps	3.5		3.8		3.1		3.4	
8. Bankfull Discharge (Q_{bkf}) – cfs	75		105		115		130	

Table 6.1
Design Parameters and Proposed Geomorphic Characteristics – UT1

	UT1 Design Reach 1		UT1 Design Reach 2		UT1 Design Reach 3		UT1 Design Reach 4	
	Min	Max	Min	Max	Min	Max	Min	Max
9. Bankfull Max Depth (d_{mbkf}) - feet	2.1		2.4		2.8		2.8	
10. d_{mbkf} / d_{bkf} ratio	**1.3**		**1.3**		**1.3**		**1.3**	
11. Low Bank Height to d_{mbkf} Ratio	**1.0**		**1.0**		**1.0**		**1.0**	
12. Floodprone Area Width (w_{fpa}) – feet	45		100.0		100.0		100.0	
13. Entrenchment Ratio (ER)	**3.1**		**6.0**		**5.2**		**5.1**	
14. Meander length (L_m) – feet	0	29	134	168	154	192	157	196
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	**0**	**2.0**	**8.0**	**10.0**	**8.0**	**10.0**	**8.0**	**10.0**
16. Radius of curvature (R_c) – feet	0	15	34	50	38	58	39	59
17. Ratio of radius of curvature to bankfull width (R_c / w_{bkf})	**0**	**1.0**	**2.0**	**3.0**	**2.0**	**3.0**	**2.0**	**3.0**
18. Belt width (w_{blt}) – feet	0.0		84		96		98	
19. Meander Width Ratio (w_{blt}/W_{bkf})	**0.0**		**5.0**		**5.0**		**5.0**	
20. Sinuosity (K) Stream Length/ Valley Distance	**1.02**		**1.1**		**1.15**		**1.20**	
21. Valley Slope – feet per foot	0.0080		0.0066		0.0026		0.0034	
22. Channel Slope ($s_{channel}$) – feet per foot	**0.0045**		**0.0060**		**0.0023**		**0.0028**	
23. Pool Slope (s_{pool}) – feet per foot	0		0		0		0	
24. Ratio of Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	0.00		0.00		0.00		0.00	
25. Maximum Pool Depth (d_{pool}) – feet	4.4		5.0		5.9		5.9	
26. Ratio of Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	3.0		3.0		3.0		3.0	
27. Pool Width (w_{pool}) – feet	22.7		25.7		30.8		30.8	
28. Ratio of Pool Width to Bankfull Width (w_{pool} / w_{bkf})	**1.6**		**1.5**		**1.6**		**1.6**	
29. Pool Area (A_{pool}) – square feet								
30. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})								
31. Pool-to-Pool Spacing – feet	43.8		100.8		115.2		117.6	
32. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	**3.0**		**6.0**		**6.0**		**6.0**	
33. Riffle Slope [(4(] (s_{riffle}) – feet per foot	**0.0067**	**0.009**	**0.009**	**0.0120**	**0.0038**	**0.0045**	**0.0048**	**0.0057**
34. Ratio of Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	**1.5**	**2.0**	**1.5**	**2.0**	**1.5**	**2.0**	**1.5**	**2.0**

Table 6.2
Design Parameters and Proposed Geomorphic Characteristics – UT1

	UT1 Design Reach 5		UT1 B Design Reach		UT1 C Design Reach		UT1 D Design Reach	
	Min	Max	Min	Max	Min	Max	Min	Max
1. Stream Type	C/E		C/E		B		C/E	
2. Drainage Area – square miles	1.75		0.34		0.15		0.16	
3. Bankfull Width (w_{bkf}) – feet	20.0		10.4		11.2		10.4	
4. Bankfull Mean Depth (d_{bkf}) – feet	2		1.1		0.8		0.9	
5. Width/Depth Ratio (w/d ratio)	**9.9**		**9.7**		**14.8**		**11.2**	
6. Cross-sectional Area (A_{bkf}) – SF	40		11		8		10	
7. Bankfull Mean Velocity (v_{bkf}) - fps	3.8		4.0		3.2		2.9	
8. Bankfull Discharge (Q_{bkf}) – cfs	155		45		27		28	
9. Bankfull Max Depth (d_{mbkf}) - feet	2.9		1.4		0.9		1.2	
10. d_{mbkf} / d_{bkf} ratio	**1.3**		**1.3**		**1.2**		**1.3**	
11. Low Bank Height to d_{mbkf} Ratio	1.0		1.0		1.0		1.0	

Table 6.2 Design Parameters and Proposed Geomorphic Characteristics – UT1								
	UT1 **Design Reach 5**		**UT1 B** **Design Reach**		**UT1 C** **Design Reach**		**UT1 D** **Design Reach**	
	Min	Max	Min	Max	Min	Max	Min	Max
12. Floodprone Area Width (w_{fpa}) – feet	100.0		100.0		100.0		100.0	
13. Entrenchment Ratio (ER)	**5**		**9.6**		**8.9**		**9.6**	
14. Meander length (L_m) – feet	160	200	83	104	NA		83	104
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	**8.0**	**10.0**	**8.0**	**10.0**	**NA**		**8.0**	**10.0**
16. Radius of curvature (R_c) – feet	40	60	21	31	NA		21	31
17. Ratio of radius of curvature to bankfull width (R_c / w_{bkf})	**2.0**	**3.0**	**2.0**	**3.0**	**NA**		**2.0**	**3.0**
18. Belt width (w_{blt}) – feet	100		52				52	
19. Meander Width Ratio (w_{blt}/W_{bkf})	5.0		5.0				5.0	
20. Sinuosity (K) Stream Length/ Valley Distance	**1.20**		**1.15**		**1.05**		**1.15**	
21. Valley Slope – feet per foot	0.0041		0.0105		0.0171		0.0077	
22. Channel Slope ($s_{channel}$) – feet per foot	**0.0034**		**0.0091**		**0.0169**		**0.0067**	
23. Pool Slope (s_{pool}) – feet per foot	0		0		0		0	
24. Ratio of Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	0.00		0.00		0.00		0.00	
25. Maximum Pool Depth (d_{pool}) – feet	6.1		3.2		1.5		3.2	
26. Ratio of Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	**3.0**		**3.0**		**2.0**		**3.0**	
27. Pool Width (w_{pool}) – feet	31.4		16.7		12.3		15.1	
28. Ratio of Pool Width to Bankfull Width (w_{pool} / w_{bkf})	**1.6**		**1.6**		**1.1**		**1.5**	
29. Pool Area (A_{pool}) – square feet								
30. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})								
31. Pool-to-Pool Spacing – feet	120		52		44.8		52	
32. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	6.0		5.0		4.0		5.0	
33. Riffle Slope (4((s_{riffle}) – feet per foot	**0.0051**	**0.0068**	**0.104**	**0.0138**	**0.186**		**0.0101**	**0.0134**
34. Ratio of Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	**1.5**	**2.0**	**1.5**	**2.0**	**1.1**		**1.5**	**2.0**

6.1.5 Design of UT2 Reaches

Similar to UT1, lateral and vertical stability features contributing to bed diversity will be supplemented with bioengineering habitat improvements. The following section provides a brief narrative description specific to each proposed design reach. All of the reaches except UT2 Reach 2 are designed as C to C/E-type streams. UT2 Reach 2 is designed as a Bc-type stream.

The mainstem of UT2 will begin upstream (UT2 Reach 1) with a constructed riffle, which ties into a culvert/outfall within a future natural park area, proposed by others. This prevents the need for benching and allows Priority 1 restoration throughout the reach. The first 500 LF of the mainstem of UT2 will meander completely outside of the existing channel utilizing the maximum available belt width on the existing left floodplain.

The next 1,000 LF (UT2 Reach 2) consists of the section of Bc-type channel with a width/depth ratio of 12. A road crossing and associated culvert is proposed approximately half way through this reach. The first 500 LF crosses the existing channel and then aligns back within the existing channel prior to proposed upstream culvert location. The remaining section comes out onto the right flood plain and forms a left sweeping curve prior to the confluence with UT2A at the max pool of this arc. Eight drops are proposed in this reach, the last of which is a double drop.

UT2 Reach 3 begins at the proposed confluence of UT2 Reach 2 and UT2A Reach 2 in a pool feature and continues approximately 500 LF within the existing right flood plain prior to crossing the existing channel. In an effort to follow the low point of the valley and to use the available belt width whenever possible, the remaining 700 LF of this reach crosses the existing channel three more times before transitioning into UT2 Reach 4 along right flood plain. Three meander bends within this reach come within approximately 25 feet of the conservation easement. Due to an existing sewer line easement, the conservation easement could not be adjusted. Adjustment of the proposed planform would reduce the belt width ratio below 3.5. Because the proposed channel alignment is located closer than desired to the conservation easement, the conservation easement was widened to approximately 140 feet.

UT2 Reach 4 (700 LF) is proposed along the existing right flood plain, with the exception of two meanders that will briefly enter the existing channel alignment. The proposed UT2 Reach 4 channel dimension will ensure adequate sediment transport through this lower slope section. Following a sequence of step-pool features, downstream UT2 Reach 4 transitions into the existing channel at the beginning of the proposed preservation reach.

UT2A, the tributary to the mainstem of UT2, is approximately 1,150 LF and because of similarity in the watershed properties, has very similar design criteria as UT2 Reach 1. The upper 350 LF has many small drops at the end of riffles due to the steeper nature of this section. This reach begins at an existing headcut and is designed to be constructed within the existing right flood plain, except where seven bends briefly enter the location of the existing channel. In these seven locations, the design specifies that the outer bend match the existing channel bank and that the existing tree at each bend be saved for instant bank stabilization.

Some benching will be required at the lower end of the reach where the channel needs to be dropped back down to existing grade prior to the existing sewer line easement and associated culvert. Beyond the sewer line easement, a step pool sequence is proposed prior to the confluence with the mainstem of UT2. To ensure structural stability at the confluence, the inverts at the upstream confluence drop structures on UT2A Reach 2 and UT2 Reach 2 are identical.

Table 6.3 presents the proposed stream restoration design criteria applied throughout UT2.

Table 6.3
Design Parameters and Proposed Geomorphic Characteristics – UT2

	UT2 Design Reach 1		**UT2 Design Reach 2**		**UT2 Design Reach 3**		**UT2 Design Reach 4**		**UT2A, Design Reach 2**	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1. Stream Type	C/E		B		C/E		C/E		C/E	
2. Drainage Area – square miles	0.08		0.10		0.25		0.30		0.10	
3. Bankfull Width (w_{bkf}) – feet	10.2		10.8		16.0		15.6		10.2	
4. Bankfull Mean Depth (d_{bkf}) – feet	1.0		0.92		1.3		1.5		1.0	
5. Width/Depth Ratio (w/d ratio)	10.2		11.7		12.6		10.2		10.2	
6. Cross-sectional Area (A_{bkf}) – SF	10.2		9.9		20.3		23.9		10.2	
7. Bankfull Mean Velocity (v_{bkf}) - fps	4.7		5.4		5.3		5.0		5.1	
8. Bankfull Discharge (Q_{bkf}) – cfs	48		54		107		120		51	
9. Bankfull Max Depth (d_{mbkf}) - feet	1.4		1.3		1.7		2.3		1.4	
10. d_{mbkf} / d_{bkf} ratio	**1.4**		**1.4**		**1.3**		**1.5**		**1.4**	
11. Low Bank Height to d_{mbkf}	1.0		1.0		1.0		1.0		1.0	

Table 6.3
Design Parameters and Proposed Geomorphic Characteristics – UT2

	UT2 Design Reach 1		**UT2 Design Reach 2**		**UT2 Design Reach 3**		**UT2 Design Reach 4**		**UT2A, Design Reach 2**	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Ratio										
12. Floodprone Area Width (w_{fpa}) – feet	60		30		55		80		60	
13. Entrenchment Ratio (ER)	5.9		2.8		3.4		5.1		5.9	
14. Meander length (L_m) – feet	100	120	250	300	170	200	150	180	100	120
15. Ratio of meander length to bankfull width (L_m/w_{bkf})	**9.8**	**11.8**	**23.1**	**27.8**	**10.6**	**12.5**	**9.6**	**11.5**	**9.8**	**11.8**
16. Radius of curvature (R_c) – feet	23	28	50	100	35	100	30	45	24	30
17. Ratio of radius of curvature to bankfull width (R_c / w_{bkf})	**2.25**	**2.75**	**4.63**	**9.26**	**2.19**	**6.25**	**1.92**	**2.88**	**2.35**	**2.94**
18. Belt width (w_{blt}) – feet	40	55	20	30	35	65	55	75	40	55
19. Meander Width Ratio (w_{blt}/w_{bkf})	**3.9**	**5.4**	**1.9**	**2.8**	**2.2**	**4.1**	**3.5**	**4.8**	**3.9**	**5.4**
20. Sinuosity (K) Stream Length/ Valley Distance	**1.21**		**1.03**		**1.14**		**1.21**		**1.21**	
21. Valley Slope – feet per foot	0.0121		0.0190		0.0125		0.0091		0.0145	
22. Channel Slope ($s_{channel}$) – feet per foot	**0.0100**		**0.0185**		**0.0110**		**0.0075**		**0.0120**	
23. Pool Slope (s_{pool}) – feet per foot	0.0000	0.0025	0.0000	0.0025	0.0000	0.0025	0.0000	0.0025	0.0000	0.0025
24. Ratio of Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	0.0	0.25	0.0	0.14	0.0	0.23	0.0	0.33	0.0	0.21
25. Maximum Pool Depth (d_{pool}) – feet	2.50		2.50		3.25		3.75		2.50	
26. Ratio of Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	**2.50**		**2.72**		**2.57**		**2.45**		**2.50**	
27. Pool Width (w_{pool}) – feet	16.0		13.5		20.4		25.8		16.0	
28. Ratio of Pool Width to Bankfull Width (w_{pool} / w_{bkf})	**1.57**		**1.25**		**1.28**		**1.65**		**1.57**	
29. Pool Area (A_{pool}) – square feet	21		21		35		58		21	
30. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})	**2.08**		**2.11**		**1.75**		**2.43**		**2.08**	
31. Pool-to-Pool Spacing – feet	57		40		105		88		57	
32. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	**5.59**		**3.70**		**6.56**		**5.64**		**5.59**	
33. Riffle Slope (4((s_{riffle}) – feet per foot	**0.0177**	**0.0279**	**0.0209**	**0.0271**	**0.0209**	**0.0278**	**0.0122**	**0.0229**	**0.0200**	**0.0273**
34. Ratio of Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	**1.77**	**2.79**	**1.13**	**1.46**	**1.90**	**2.53**	**1.63**	**3.05**	**1.67**	**2.28**

6.2 Sediment Transport

Original channel dimensions based on hydraulics were checked against their associated sediment transport function. Sediment competency calculations were performed for the existing and proposed channel for each design reach. In order to make a valid comparison between the existing and proposed conditions, the competency calculation must be applicable for both conditions.

In only a few cases (UT1B, UT1C, UT1D, UT2 Reach 3, and UT2 Reach 4) were traditional competency calculations applicable (Andrews, 1983 and Rosgen, 2001a) (Appendix F). For these cases (UT1B, UT1C, UT1D, UT2 Reach 3, and UT2 Reach 4) the boundary shear stress (τ) was reduced, as was the unit stream power (ω). Additionally, the calculated critical depths (D_{crit}) and critical slopes (S_{crit}) increased for these reaches. Collectively, this suggests a reduction in scour and erosion potential, and a potential for deposition. This is desirable, especially during the vulnerable state immediately following construction and prior to establishment of vegetation. Although deposition is often regarded as an indicator of instability, the design of the proposed channels offer the opportunity for the channel to make natural adjustments risking neither excessive aggradation nor channel incision.

Other valid traditional competency calculations include those of the proposed UT1 Reach 1, UT1 Reach 2, UT1 Reach 3, UT1 Reach 4, and UT1 Reach 5. Because the existing conditions calculations are invalid (ratios of $d_{50pavement}/d_{50subpavement}$ and $d_i/d_{50pavement}$ fall out of acceptable range), no comparisons can be made with these proposed sections. However, it may be valuable to note that the unit stream power for these reaches compute within the range of the proposed UT1B, UT1C, and UT1D, between 30 and 50 watts/m^2.

In all cases other than those previously mentioned, the competency calculations are invalid because the ratios of $d_{50pavement}/d_{50subpavement}$ and $d_i/d_{50pavement}$ fell out of acceptable range rendering subsequent critical shear stress calculations and comparisons invalid. This is often the case when dealing with substrate consisting predominantly of coarse sand to fine gravel and finer. For this reason, an alternative calculation required. Yang's method (1973, 1984) for computing critical velocity, and back calculating critical depth was applied. Like the traditional calculation for competency, this selected function is also based on the principle of unit stream power as the dominant factor in total sediment concentration. However, Yang's equation applies to sediment ranging between 0.062 and 7.0 mm. The general transport equations for sand and gravel using the Yang function for a single grain size is represented by the following:

Input Parameters

Temperature, F	T = 55	Average Velocity, ft/s	V
Kinematic viscosity, ft^2/s	$\nu = 0.00001315$	Discharge, ft^3/s	Q
Hydraulic Radius, ft	R =	Unit Weight water, lb/ft^3	γ
Slope,	S =		
Meidan Particle Diamter, ft	d_{si} =		
Specific Gravity of Sediment	s = 2.65		

Constants

Acceleration of gravity, ft/s^2 g = 32.2

Solution

Shear Velocity, ft/s,

$$u_* = \sqrt{g \cdot R \cdot S}$$

Particle Fall Velocity, ft/s,

Use Rubey's equation,

$$F_1 = \sqrt{\frac{2}{3} + \frac{36 \cdot \nu^2}{g \cdot d_{si}^{\ 3} \cdot (s-1)}} - \sqrt{\frac{36 \cdot \nu^2}{g \cdot d_{si}^{\ 3} \cdot (s-1)}}$$

$$\omega = F_1 \cdot \sqrt{(s-1) \cdot g \cdot d_{si}}$$

Shear Reynold's Number,

$$R_s = \frac{u_* \cdot d_{si}}{\nu}$$

Critical Velocity, ft/s,

$$V_{cr} = \begin{cases} \omega \cdot \left(\dfrac{2.5}{\log\left(\dfrac{u_* \cdot d_{si}}{\nu}\right) - 0.06} + 0.66 \right) & \text{if } 0 < R_s < 70 \\ (\omega \cdot 2.05) & \text{if } R_s \geq 70 \end{cases}$$

Computation of unit stream power for the existing and proposed UT1B, UT1C, UT1D, UT2 Reach 3 and UT2 Reach 4 using the Yang method produces results similar to those computed using the traditional competency calculations. Based on this validation, the Yang method was applied to those reaches where previous calculations failed to apply. For the remaining reaches, (UT1 Reach 1, UT1 Reach 2, UT1 Reach 3, UT1 Reach 4, UT1 Reach 5, UT2 Reach 1, UT2 Reach 2, and UT2A Reach 2) calculations using Yang's method produced lower values for proposed channel boundary shear stress and increased critical velocity than for the existing channel. Stated simply, the proposed conditions will result in increased stability for all design reaches.

Table 6.4 Sediment transport calculations summary		
Design Reach	**Transport function(s)**	**Results**
UT1 Reach 1	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT1 Reach 2	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT1 Reach 3	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT1 Reach 4	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT1 Reach 5	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT1B	Andrews (1983), Rosgen (2001a)	Proposed conditions produce: 1) lower boundary shear stress (τ) and unit stream power (ω) and 2) increased critical depths (D_{crit}) and critical slopes (S_{crit}).
UT1C	Andrews (1983), Rosgen (2001a)	Proposed conditions produce: 1) lower boundary shear stress (τ) and unit stream power (ω) and 2) increased critical depths (D_{crit}) and critical slopes (S_{crit}).
UT1 D	Andrews (1983), Rosgen (2001a)	Proposed conditions produce: 1) lower boundary shear stress (τ) and unit stream power (ω) and 2) increased critical depths (D_{crit}) and critical slopes (S_{crit}).
UT2 Reach 1	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT2 Reach 2	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).
UT2 Reach 3	Andrews (1983), Rosgen (2001a)	Proposed conditions produce: 1) lower boundary shear stress (τ) and unit stream power (ω) and 2) increased critical depths (D_{crit}) and critical slopes (S_{crit}).
UT2 Reach 4	Andrews (1983), Rosgen (2001a)	Proposed conditions produce: 1) lower boundary shear stress (τ) and unit stream power (ω) and 2) increased critical depths (D_{crit}) and critical slopes (S_{crit}).
UT2A	Yang (1973, 1984)	Proposed conditions produce: 1) lower boundary shear stress (τ) and 2) increased critical shear velocity (v_{cr}).

6.3 In-Stream Structures

A variety of in-stream structures are proposed for the Beaverdam Creek site. Structures such as root wads, constructed riffles, and log vanes will be used to stabilize the newly-restored stream. Wood structures will primarily be used on this site, because that is the material observed in the existing system and it is often difficult to construct scale-appropriate boulder structures in a stream of this size. Table 6.4 summarizes the use of in-stream structures at the site.

Table 6.4 Proposed In-Stream Structure Types and Locations	
Structure Type	**Location**
Root Wad	UT1 &UT2: Outside bank of smaller radius meander bends.
Brush Mattress	UT1 &UT2: Outside bank of shorter and larger radius meander bends.
Rock Cross Vane	UT1: Reach 5 to align stream velocity vectors with existing culvert. UT1 B: downstream end of riffle to hold grade at confluence with UT1.

	UT2: At the confluence of UT2 Reach 2 and UT2A Reach 2.
Constructed Riffle	UT1&UT2: Through straight, steeper sections to provide grade control.
Rock or Log Vane	UT1 &UT2: In meander bends to turn water.
Cover Log	UT1 &UT2: In pools to provide habitat features.
Boulder or Log Sill	UT1 & UT2: for grade control and pool habitat.
Boulder Cluster	UT1 & UT2: for energy dissipation and habitat in between riffles in straight sections.
Boulder Step Pool	UT2: At the downstream tie in location.
Log Step Pool	UT1 & UT2: place between log or boulder sills to promote lateral and vertical diversity through straight sections.

6.3.1 Root Wad

Root wads are placed at the toe of the stream bank in the outside of meander bends for the creation of habitat and for stream bank protection. Root wads include the root mass or root ball of a tree plus a portion of the trunk. They are used to armor a stream bank by deflecting stream flows away from the bank. In addition to stream bank protection, they provide structural support to the stream bank and habitat for fish and other aquatic animals. They also serve as a food source for aquatic insects. Root wads will be placed throughout the Beaverdam Creek project.

6.3.2 Brush Mattress

Brush mattresses are placed on bank slopes on the outside of meander bends for stream bank protection. Layers of live, woody cuttings are wired together and staked into the bank. Brush mattresses help to establish vegetation on the bank to secure the soil. Once the vegetation is established, the cover also provides habitat for wildlife.

6.3.3 Cross Vanes

Cross vanes are used to provide grade control, keep the thalweg in the center of the channel, and protect the stream bank. A cross vane consists of two rock or log vanes joined by a center structure installed perpendicular to the direction of flow. This center structure sets the invert elevation of the stream bed. Vanes are located just downstream of the point where the stream flow intercepts the bank at acute angles. These structures will be placed in the main channel at both the upstream and downstream project limits.

6.3.4 Constructed Riffle

A constructed riffle consists of the placement of coarse bed material in the stream at specific riffle locations along the profile. A buried log or rock boulders at the upstream and downstream end of riffles may be used to control the slope through the riffle in steeper sections. The purpose of this structure is to provide grade control and establish riffle habitat. Constructed riffles will be placed throughout all reaches. In the higher slope reaches, the constructed riffles and cross vanes will be intermixed to provide diversity of structure and in-stream habitat.

6.3.5 Rock or Log Vane

A rock or log vane is used to protect the stream bank. The length of a single vane structure can span one-half to two-thirds the bankfull channel width. Vanes are located either upstream or downstream along a meander bend and function to initiate or complete the redirecting of flow energies resulting in reduced near bank shear stress and alignment maintenance. In an effort to promote structural diversity, the proposed restoration indicates a mixed use of rock and logs to construct vanes.

6.3.6 Cover Log

A cover log is placed in the outside of a meander bend to provide habitat in the pool area. The log is buried into the outside bank of the meander bend; the opposite end extends through the deepest part of the pool and may be buried in the inside of the meander bend, in the bottom of the point bar. The placement of the cover log near the bottom of the bank slope on the outside of the bend encourages scour in the pool. This increased scour provides a deeper pool for bedform variability. Cover logs will be used on all reaches, but fewer will be placed in the small and steep reaches because the habitat value is not as great.

6.3.7 Boulder or Log Sill

Boulder and log sills consist of either header stones and footer stones or header log and a footer log placed in the bed of the stream channel, perpendicular to stream flow. The rocks or logs extend into the stream banks on both sides of the structure to prevent erosion and bypassing of the structure. The rocks or logs are installed flush with the channel bottom upstream of the rock or log. The footer rock or log is placed to the depth of scour expected, to prevent the structure from being undermined. This weir structure creates the "step" in the step-pool system. Rock and log weirs provide bedform diversity, maintain channel profile, and provide pool and cover habitat.

6.3.8 Boulder Cluster Placement

Boulder cluster placement is proposed in areas between short riffles. While the short riffles act as grade control, the boulder placement produced lateral and vertical flow diversity at low flows. At bankfull flows, the boulders serve as energy dissipation features, adding to the overall bed roughness and provide local downstream eddy microhabitat.

6.3.9 Boulder Step Pool

Currently, only one boulder step pool is proposed throughout the entire project, at the downstream tie in of UT2 with the existing channel. The notched sills of each drop will be constructed with some boulders at lower elevations will function as weirs consolidating of low flows and promoting more passable flow depths. Boulder clusters are placed intermittently throughout the pools to provide increased habitat value and energy dissipation.

6.3.10 Log Step Pool

In straight sections of channel where long riffles are inappropriate, log step pools placed at angles to the stream flow are proposed between short riffles to increase habitat value and energy dissipation. This type of log placement promotes flow diversity an as a result encourages development of aquatic microhabitat. Root wads will be placed within the downstream, acute angles to offset redirected base flows and provide bank stability.

6.4 Vegetation

Native riparian vegetation will be established in the restored stream buffer. Also, areas of invasive vegetation such as Russian olive and rivercane will be managed so as not to threaten the newly-established native plants within the conservation easement.

6.4.1 Stream Buffer Vegetation

Bare-root trees, live stakes, and permanent seeding will be planted within designated areas of the conservation easement. A preferred 50-foot buffer measured from the top of banks (sometimes slightly less and quite often, substantially more) will be established along all restored stream reaches. In many areas, the buffer width will be in excess of 100 feet. In general, bare-root vegetation will be planted at a target density of 680 stems per acre, or an 8-foot by 8-foot grid. Planting of bare-root trees and live stakes will be conducted during the first dormant season following construction. If construction activities are completed in summer/fall of 2006; all vegetation will be installed prior to March 20, 2007.

Species selection for re-vegetation of the site will generally follow those suggested by Schafale and Weakley (1990) and tolerances cited in the USACE Wetland Research Program (WRP) Technical Note VN-RS-4.1 (1997). Selected species for hardwood re-vegetation are presented in Table 6.8 below. Tree species selected for stream restoration areas will be generally weak to tolerant of flooding. Weakly tolerant species are able to survive and grow in areas where the soil is saturated or flooded for relatively short periods of time. Moderately tolerant species are able to survive in soils that are saturated or flooded for several months during the growing season. Flood tolerant species are able to survive on sites in which the soil is saturated or flooded for extended periods during the growing season (WRP, 1997).

Observations will be made during construction of the site regarding the relative wetness of areas to be planted. Planting zones will be determined based on these observations, and planted species will be matched according to their wetness tolerance and the anticipated wetness of the planting area.

Once trees are transported to the site, they will be planted within two days. Soils across the site will be sufficiently disked and loosened prior to planting. Trees will be planted by manual labor using a dibble bar, mattock, planting bar, or other approved method. Planting holes for the trees will be sufficiently deep to allow the roots to spread out and down without "J-rooting." Soil will be loosely compacted around trees once they have been planted to avoid drying out.

Live stakes will be installed randomly two to three feet apart using triangular spacing or at a density of 160 to 360 stakes per 1,000 square feet along the stream banks between the toe of the stream bank and bankfull elevation. Site variations may require slightly different spacing.

Permanent seed mixtures will be applied to all disturbed areas of the project site. Table 6.9 lists the species, mixtures, and application rates that will be used. A mixture is provided for floodplain wetland and floodplain non-wetland areas. Mixtures will also include temporary seeding (rye grain or browntop millet) to allow for application with mechanical broadcast spreaders. The permanent seed mixture specified for floodplain areas will be applied to all disturbed areas outside the banks of the restored stream channel and is intended to provide rapid growth of herbaceous ground cover and biological habitat value. The species provided are deep-rooted and have been shown to proliferate along restored stream channels, providing long-term stability.

Temporary seeding will be applied to all disturbed areas of the site that are susceptible to erosion. These areas include constructed streambanks, access roads, side slopes, and spoil piles. If temporary seeding is applied from November through April, rye grain will be used and applied at a rate of 130 pounds per acre. If applied from May through October, temporary seeding will consist of browntop millet, applied at a rate of 45 pounds per acre.

Bare-root trees and live stake species selected for revegetation of the restoration site are listed in Table 6.8. Table 6.9 summarizes the permanent seed mixtures for the restoration site. Species selection may change due to availability at the time of planting.

Table 6.8
Proposed Bare-Root and Live Stake Species

Common Name	Scientific Name	Percent Planted by Species	Planting Density
Stream Restoration and Enhancement Areas- Zone 1 (>15' from channel)			
Persimmon	*Diospyros virginiana*	10%	68 stems per acre
Tulip Poplar	*Liriodendron tulipifera*	10%	68 stems per acre

Table 6.8 Proposed Bare-Root and Live Stake Species			
Common Name	**Scientific Name**	**Percent Planted by Species**	**Planting Density**
Green ash	*Fraxinus pennsylvanica*	20%	136 stems per acre
Black walnut	*Juglans nigra*	10%	68 stems per acre
Sycamore	*Platanus occidentalis*	20%	136 stems per acre
Willow Oak	*Quercus phellos*	7%	48 stems per acre
Swamp chestnut oak	*Quercus michauxii*	15%	102 stems per acre
Blackgum	*Nyssa salvatica*	8%	54 stems per acre
Alternate Species			
River Birch	*Betula nigra*		
Sugarberry	*Celtis laevigata*		
Redbud	*Cercis canadensis*		
Flowering dogwood	*Cornus florida*		
Southern red oak	*Quercus rubra*		
Stream Restoration Buffer- zone 2 (<15 from channel)			
Redbud	*Cercis canadensis*	5%	34 stems per acre
Silky dogwood	*Cornus amomum*	15%	102 stems per acre
Flowering dogwood	*Cornus florida*	5%	34 stems per acre
Tag alder	*Alnus serrulata*	20%	136 stems per acre
Paw paw	*Asimina triloba*	20%	136 stems per acre
Silky willow	*Salix sericea*	15%	102 stems per acre
Elderberry	*Sambucus canadensis*	10%	68 stems per acre
Arrow-wood viburnum	*Vibernum dentatum*	10%	68 stems per acre
Alternate Species			
Ninebark	*Physocarpus opulifolia*		
Black haw viburnum	*Viburnum prunifolium*		
Streambanks (Live Stakes)			
Silky dogwood	*Cornus amomum*	40%	65 to 100 stems per 1,000 SF
Silky willow	*Salix sericea*	40%	65 to 100 stems per 1,000 SF
Elderberry	*Sambucus canadensis*	20%	33 to 50 stems per 1,000 SF

Table 6.9 Proposed Permanent Seed Mixture				
Common Name	**Scientific Name**	**Percent of Mixture**	**Seeding Density (lbs/acre)**	**Wetness Tolerance**
Zone 1 –Wetland Restoration and Enhancement Areas				
Virginia wildrye	*Elymus virginicus*	25%	2	FAC
Switchgrass	*Panicum virgatum*	25%	3	FAC+
Fox sedge	*Carex vulpinoidea*	25%	3	OBL

Table 6.9
Proposed Permanent Seed Mixture

Common Name	Scientific Name	Percent of Mixture	Seeding Density (lbs/acre)	Wetness Tolerance
Soft rush	*Juncus effusus*	25%	2	FACW+
Zones 2 and 3 – Floodplain and Buffer Areas				
Virginia wildrye	*Elymus virginicus*	30%	12	FAC
River oats	*Chasmanthum latifolium*	20%	8	FAC-
Switchgrass	*Panicum virgatum*	20%	3	FAC+
Soft rush	*Juncus effusus*	10%	2	FACW+
Deertongue	*Dichathelium Clandestinum*	20%	12	FACW

6.4.2 Invasive Species Removal

The site has an extensive infestation of Russian olive (*Elaeagnus umbellata*), Chinese pPrivet (*Ligustrum sinense*), and Japanese honeysuckle (*Lonicera japonica*) in the floodplains of the riverine system. These areas will be treated and monitored so that the invasive species do not threaten the newly-planted riparian vegetation.

7.0 MONITORING AND EVALUATION

Channel stability and vegetation survival will be monitored on the project site. Post-restoration monitoring will be conducted for five years following the completion of construction to document project success.

7.1 Stream Monitoring

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

7.1.1 Bankfull Events

The occurrence of bankfull events within the monitoring period will be documented by the use of a crest gage and photographs. The crest gage will be installed on the floodplain within 10 feet of the restored channel. The crest gage will record the highest watermark between site visits, and the gage will be checked each time there is a site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events in separate years must be documented within the 5-year monitoring period. Otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

7.1.2 Cross-sections

Two permanent cross-sections will be installed per 1,000 linear feet of stream restoration work, with one located at a riffle cross-section and one located at a pool cross-section. Each cross-section will be marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently used to facilitate easy comparison of year-to-year data. The annual cross-section survey will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections will be classified using the Rosgen Stream Classification System, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

7.1.3 Longitudinal Profile

A longitudinal profile will be completed in years one, three, and five of the monitoring period. The profile will be conducted on the total length of all segments measuring less than 3000 LF (UT1B, UT1C, UT1D, and UT2A) and 3000LF of mainstem UT1 and UT2. The preservation reaches found on UT2 and Beaverdam Creek will receive full longitudinal profile measurements to document reach stability. Measurements will include thalweg, water surface, inner berm, bankfull, and top of low bank. Each of these measurements will be taken at the head of each feature (e.g., riffle, pool) and at the maximum pool depth. The survey will be tied to a permanent benchmark.

The longitudinal profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep, with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed for channels of the design stream type.

7.1.4 Bed Material Analyses

Pebble counts will be conducted for the permanent cross-sections (100 counts per cross-section) on the project reaches. Pebble counts will be conducted one year after construction and at two-year intervals thereafter, at the time the longitudinal field surveys are performed. Pebble count data will be plotted on a semi-log graph and compared with data from previous years. Data should indicate a relative coarsening of the riffles (or maintenance of a coarse bed in constructed riffles) and a relative fining in the pools.

7.1.5 Photo Reference Sites

Photographs will be used to visually document restoration success. Reference stations will be photographed before construction and continued annually for at least five years following construction. Photographs will be taken from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) on the site are monitored in each monitoring period.

Lateral reference photos. Reference photo transects will be taken at each permanent cross-section.

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

Structure photos. Photographs will be taken at each grade control structure along the restored stream. Photographers should make every effort to consistently maintain the same area in each photo over time.

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

7.2 Vegetation Monitoring

Successful restoration of the vegetation on a stream and wetland mitigation site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, vegetation-monitoring quadrants will be installed across the restoration site, as directed by EEP monitoring guidance. The number of quadrants required will be based on the species/area curve method, with a minimum of three quadrants. The size of individual quadrants will be 100 square meters for woody tree species, 25 square meters for shrubs, and 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

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

Specific and measurable success criteria for plant density on the project site will be based on the recommendations found in the WRP Technical Note and past project experience.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. While measuring species density is the current accepted methodology for evaluating vegetation success on restoration projects, species density alone may be inadequate for assessing plant community health. For this reason, the vegetation monitoring plan will incorporate the evaluation of additional plant community indices to assess overall vegetative success.

7.3 Reporting Methods

A mitigation plan and as-built report documenting the stream restoration will be developed within 90 days of planting completion on the restored site. The report will include all information required by current NCEEP mitigation plan guidelines, including elevations, photographs, sampling plot locations, a description of initial species composition by community type, and monitoring stations. The report will include a list of the species planted and the associated densities. The monitoring program will be implemented to document system development and progress toward achieving the success criteria referenced in the previous sections. Stream morphology and vegetation will be assessed to determine the success of the mitigation. The monitoring program will be undertaken for five years, or until the final success criteria are achieved, whichever is longer. Monitoring reports will be prepared in the fall of each year of monitoring and submitted to EEP. The monitoring reports will include:

- A detailed narrative summarizing the condition of the restored site and all regular maintenance activities
- As-built topographic maps showing location of vegetation monitoring gages, sampling plots, permanent photo points, and location of transects
- Photographs showing views of the restored site taken from fixed-point stations;
- Hydrologic information
- Vegetative data
- Identification of any invasion by undesirable plant species, including quantification of the extent of invasion of undesirable plants by either stem counts, percent cover, or percent area, whichever is appropriate
- A description of any vandalism or damage done by animals
- Wildlife observation
- Reference stream data.

7.4 Maintenance Issues

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

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

Maintenance issues and recommended remediation measures will be detailed and documented in the as-built and monitoring reports. The conditions listed above and any other factors that may have necessitated maintenance will be discussed.

8.0 REFERENCES

Andrews, E. D. 1983. Entrainment of gravel from naturally sorted river bed material. *Geological Society of America Bulletin* 94: 1225-1231.

Buck Engineering, Beaverdam Creek Watershed Geomorphic Assessment, Year 2. July 2004. 60 pp. + app.

Budd, W.W, P.L. Cohen, P.R. Saunders, and F.R. Steiner. 1987. Stream corridor management in the Pacific Northwest: I. Determination of stream corridor widths. *Environmental Management*.

Bunte, K. and S. Abt. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics, and streambed monitoring. Gen. Tech. Rep. RMRS-GTR-74. Fort Collins, CO: U.S. Department of Agriculture, Forest Service. Rocky Mountain Research Station. 428 pp.

Copeland, R.R, D.N. McComas, C.R. Thorne, P.J. Soar, M.M. Jones, and J.B. Fripp. 2001. United States Army Corps of Engineers (USACE). Hydraulic Design of Stream Restoration Projects. Washington, DC.

Doll, B.A., D.E. Wise-Frederick, C.M. Buckner, S.D. Wilkerson, W.A. Harman, R.E. Smith and J. Spooner. 2002. Hydraulic Geometry Relationships for Urban Streams throughout the Piedmont of North Carolina. Journal of the American water Resource Association. 38(3):641-651.

Dunne, T. and L. B. Leopold. 1978. Water in Environmental Planning. New York: W. H. Freeman and Company.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream corridor restoration: Principles, processes and practices. National Technical Information Service. Springfield, VA.

Goldsmith, R., Milton, D.J., and Horton, J.W. 1985. Geologic Map of the Charlotte 1° x 2° Quadrangle, North Carolina and South Carolina. USGS Map I-1251-E, 3p.

Gomez, B. 1991. Bedload transport. *Earth-Science Reviews* 31: 89-132.

Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith. 1999. Bankfull hydraulic geometry relationships for North Carolina streams. *Wildland Hydrology.* AWRA Symposium Proceedings. D.S. Olsen and J.P. Potyondy, eds. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.

Inglis, C. C., 1947: Meanders and their Bearing on River Training. Proc. Instn. Civ. Engrs., Maritime and Waterways Pap. No.7, January.

Knighton, D. 1998. Fluvial Forms and Processes – A New Perspective. London: Arnold Publishers.

Lane, E. W. 1955. Design of stable channels. Transactions of the American Society of Civil Engineers. Paper No. 2776: 1234-1279.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1992. Fluvial Processes in Geomorphology. New York: Dover Publications, Inc.

Leopold, L.B., 1994. A View of the River. Cambridge: Harvard University Press.

Manning, R., 1889, On the Flow of Water in Open Channels and Pipes, Transactions, Institution of Civil Engineers of Ireland, 20, pp 161-207.

McCandless, T. L. 2003. Maryland stream survey: Bankfull discharge and channel characteristics of streams in the Allegheny Plateau and the valley and ridge hydrologic regions. U.S. Fish and Wildlife Service. Annapolis, MD.

North Carolina Department of Environment and Natural Resources. 2003. Standard operating procedures for benthic macroinvertebrates biological assessment unit. Division of Water Quality, Water Quality Section, Environmental Sciences Branch. July 2003. Raleigh, NC.

North Carolina Department of Environment and Natural Resources, 2004. List of Rare Plant Species of North Carolina. Edited by Franklin and Finnegan. Natural Heritage Program, Office of Conservation and Community Affairs. Raleigh, NC.

Rosgen, D. L. 1994. A classification of natural rivers. *Catena* 22:169-199.

___. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.

___. 1997. A geomorphological approach to restoration of incised rivers. Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. Wang, S.S.Y, E.J. Langendoen, and F.D. Shields, Jr., eds. 12-22.

___. 1998. The reference reach - A blueprint for natural channel design (draft). ASCE Conference on River Restoration. Denver CO. March, 1998. ASCE. Reston, VA.

___. 2001. A stream channel stability assessment methodology. Proceedings of the Federal Interagency Sediment Conference. Reno, NV. March, 2001.

___. 2001b. The cross-vane, w-weir and j-hook vane structures…their description, design and application for stream stabilization and river restoration. ASCE conference. Reno, NV. August, 2001.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. North Carolina Natural Heritage Program. Division of Parks and Recreation, NCDEHNR. Raleigh, NC.

Schumm, S.A. 1960. The shape of alluvial channels in relation to sediment type. US Geological Survey. Professional Paper 352-B. Washigton, DC.

Simon, A. 1989. A model of channel response in disturbed alluvial channels. *Earth Surface Processes and Landforms* 14(1):11-26.

Soar and Thorne. 2001. Channel Restoration Design for Meandering Rivers. US Army Corps of Engineers. Engineering Research and Development Center. Coastal and Hydraulics Laboratory. ERDC\CHL CR-01-1. September, 2001.

US Army Corps of Engineers (USACE). 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. Environmental Laboratory. US Army Engineer Waterways Experiment Station. Vicksburg, MS.

US Department of Agriculture, Natural Resources Conservation Service (NRCS). 1997. Part 650, Chapter 19 of the NRCS Engineering Field Handbook: Hydrology Tools for Wetland Determination.

___. 1996. Field Indicators of Hydric Soils in the United States. G.W. Hurt, Whited, P.M., and Pringle, R.F., eds. Fort Worth, TX.

United States Department of Agriculture, Soil Conservation Service (SCS). 1968. Soil Survey of Mecklenburg County, North Carolina.

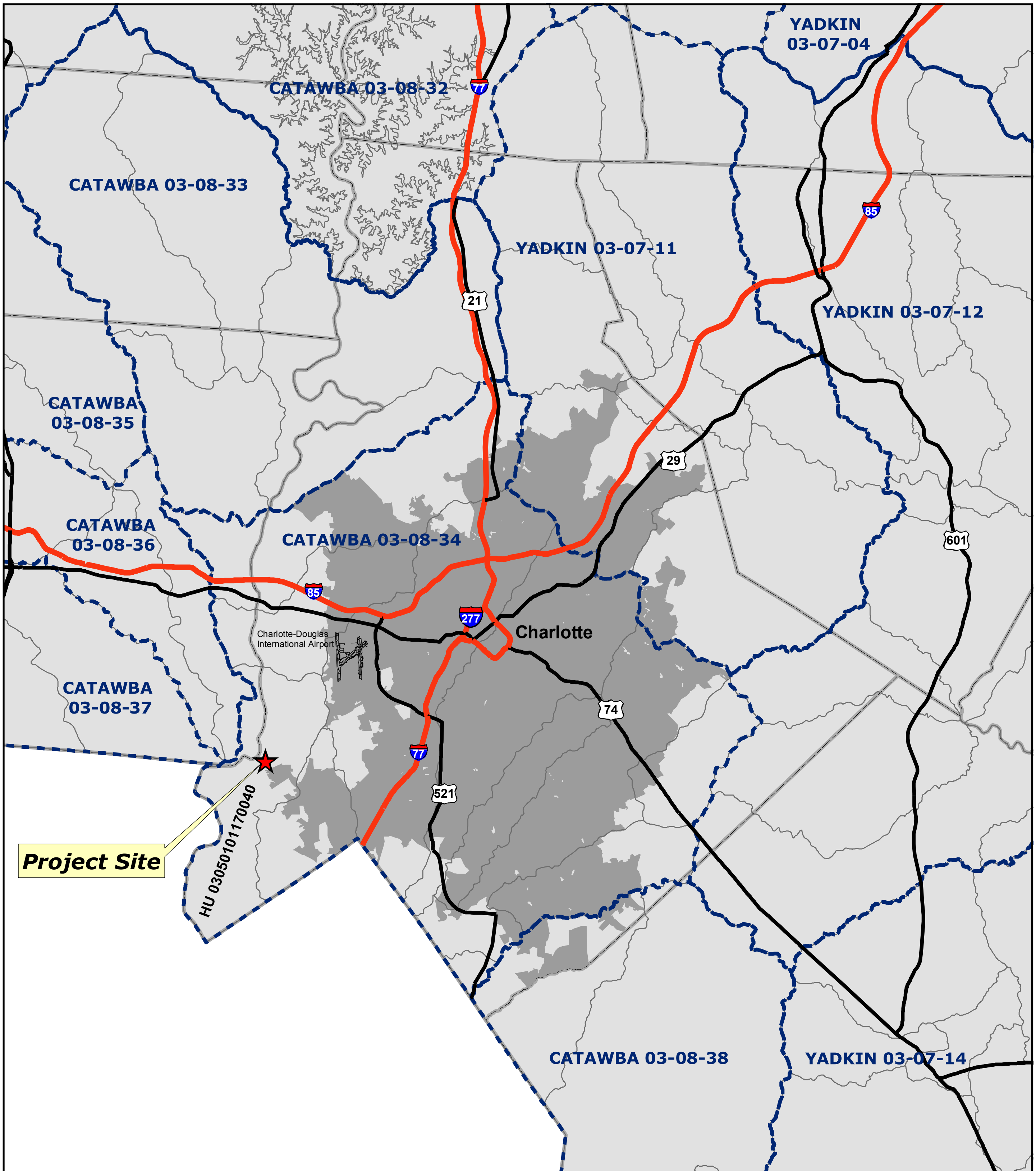
Wohl, E.E. 2000. Mountain Rivers. American Geophysics. Union Press. 320 pp.

Wolman, M.G., 1954. A Method of Sampling Coarse River-Bed Material. Transactions of American Geophysical Union 35:951-956.

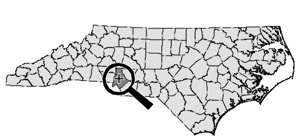
Yang, C.T. 1973. "Incipient Motion and Sediment Transport," Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 99, No HY10, October, 1973, pp 1679-1704.

Yang, C.T. 1984. "Unit Stream Power Equations for Gravel," Journal of the Hydraulics Division, American Society of Civil Engineers, Vol. 110, No. 12, December, 1984, pp 1783-1797.

Figures



Map Inset



Mecklenburg County, NC

LEGEND

HU

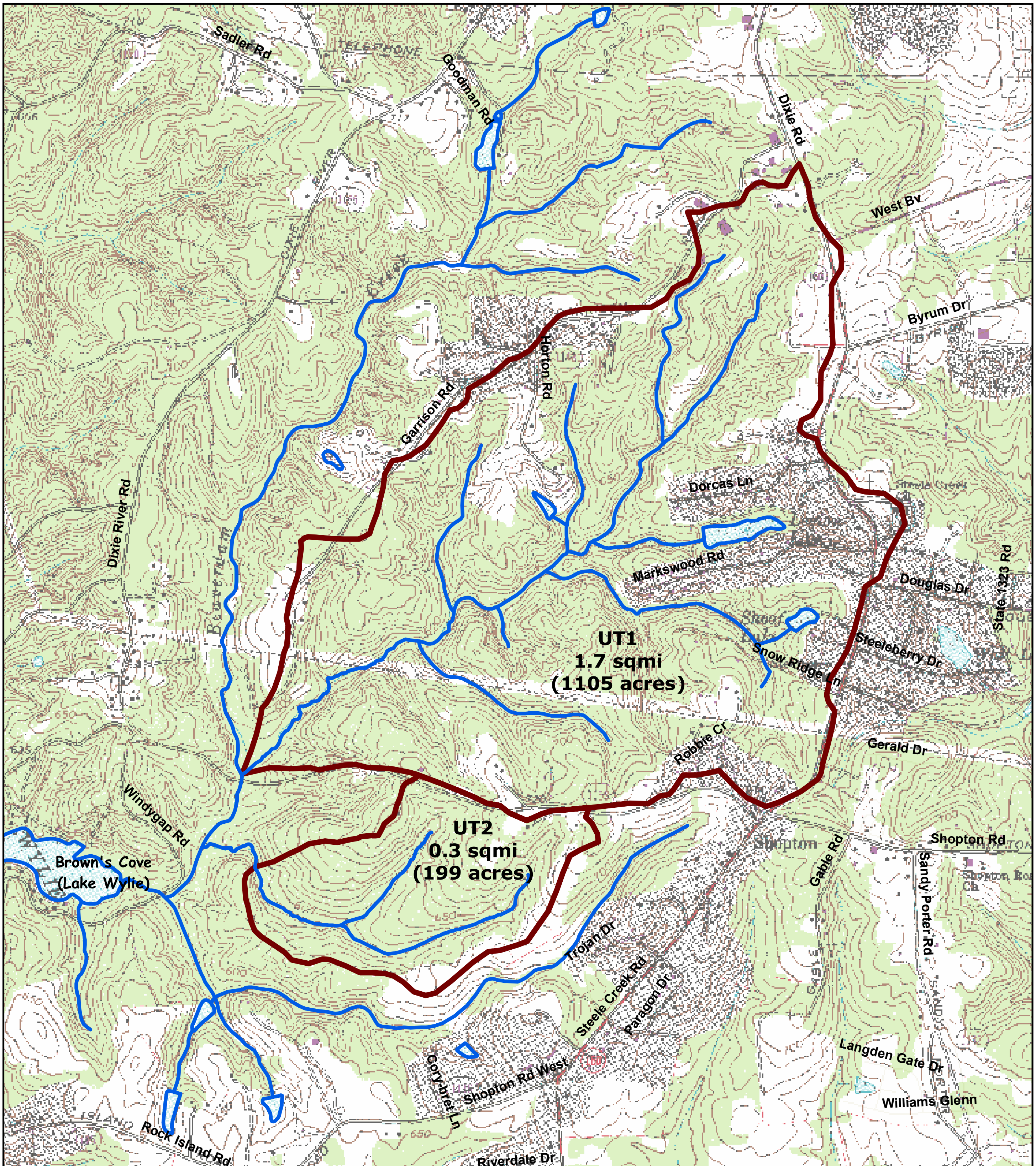
Counties

DWQ Sub-basin

4 2 0 4 Miles

Figure 1.1: Project Vicinity Map

Beaverdam Creek Restoration Plan
Mecklenburg County, NC



LEGEND

Project Watershed Boundary

Creeks

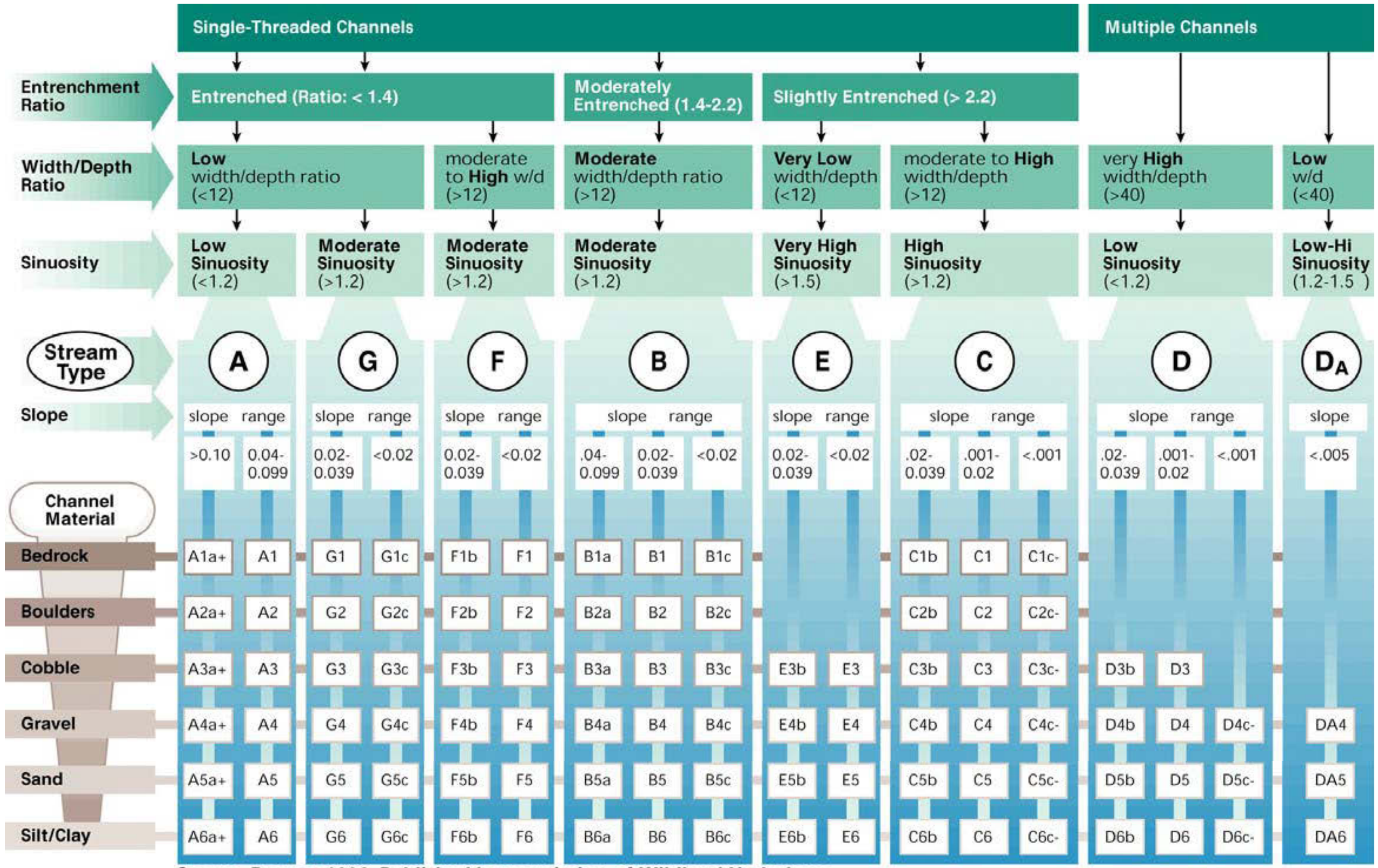
1,000 500 0 1,000 2,000 Feet

Ecosystem Enhancement PROGRAM

Figure 1.2: Site Topographic Map

Beaverdam Creek Restoration Plan Mecklenburg County, NC

BUCK ENGINEERING

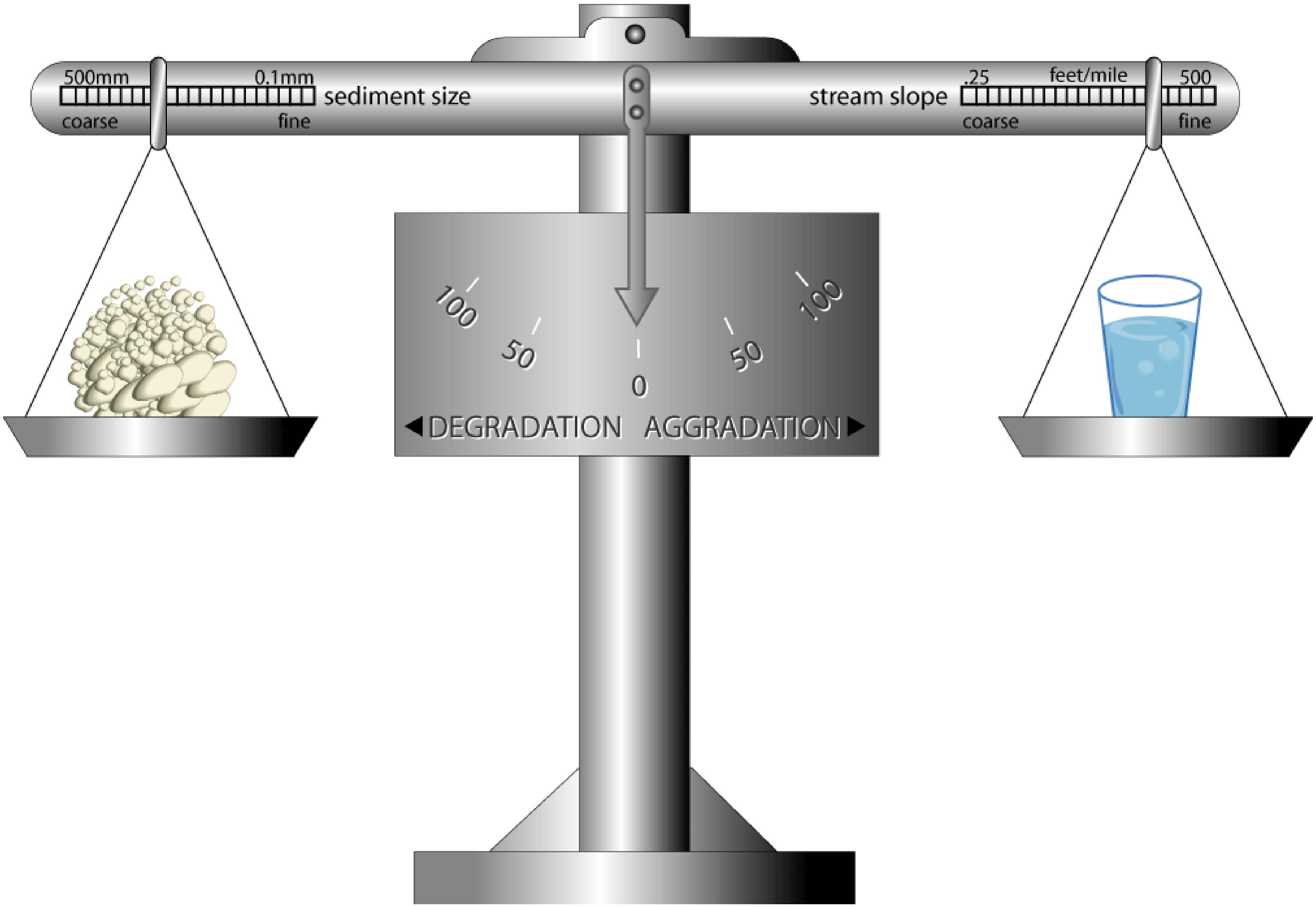


Source: Rosgen 1996. Published by permission of Wildland Hydrology.

Fig. 7.12 -- Rosgen's stream classification system (Level II).
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

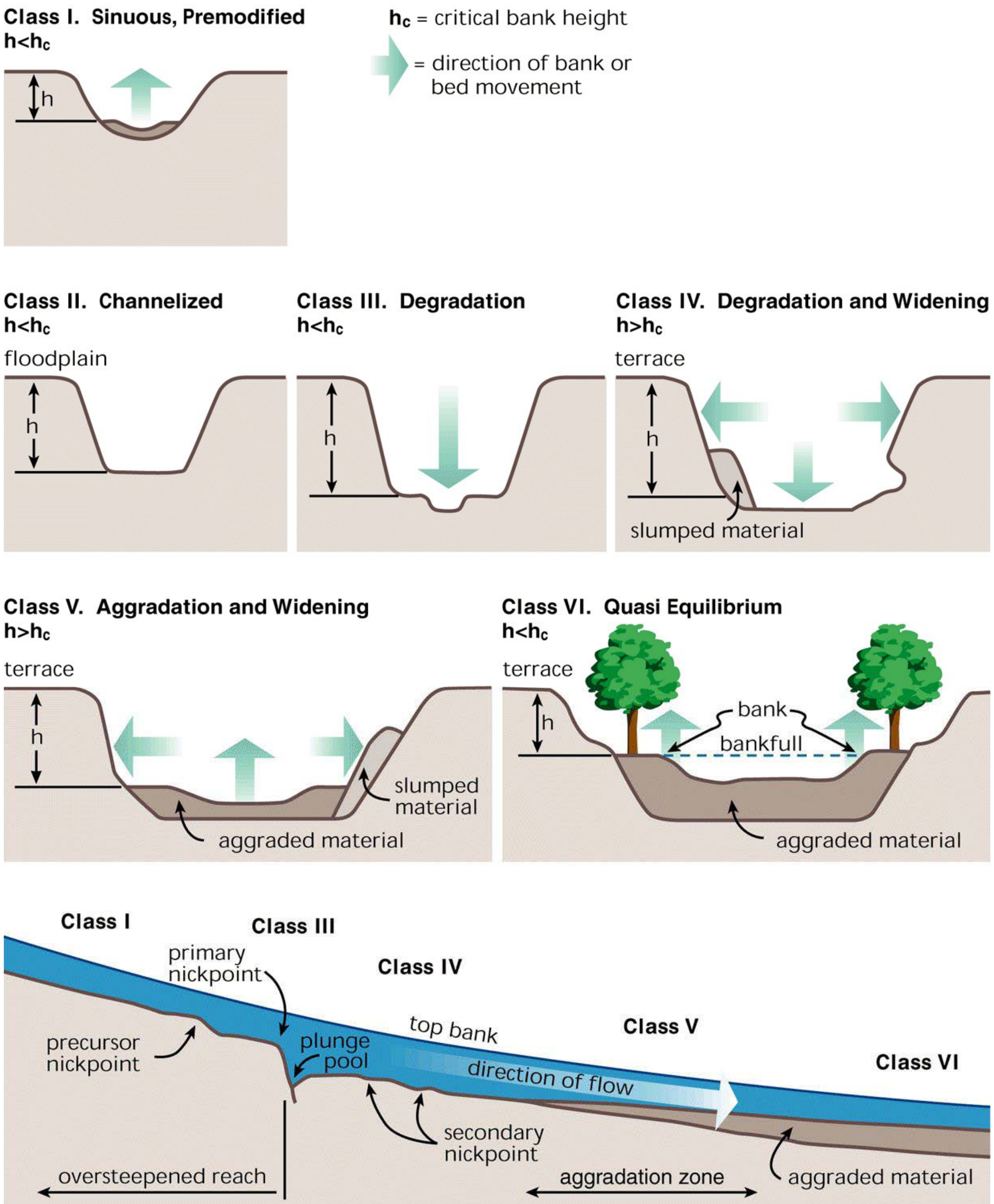
Figure 2.1
Rosgen Stream Classification
Beaverdam Creek Restoration Plan

Source: Rosgen, David L., *Applied River Morphology*, Wildland Hydrology, 1996



After: Lane, 1955

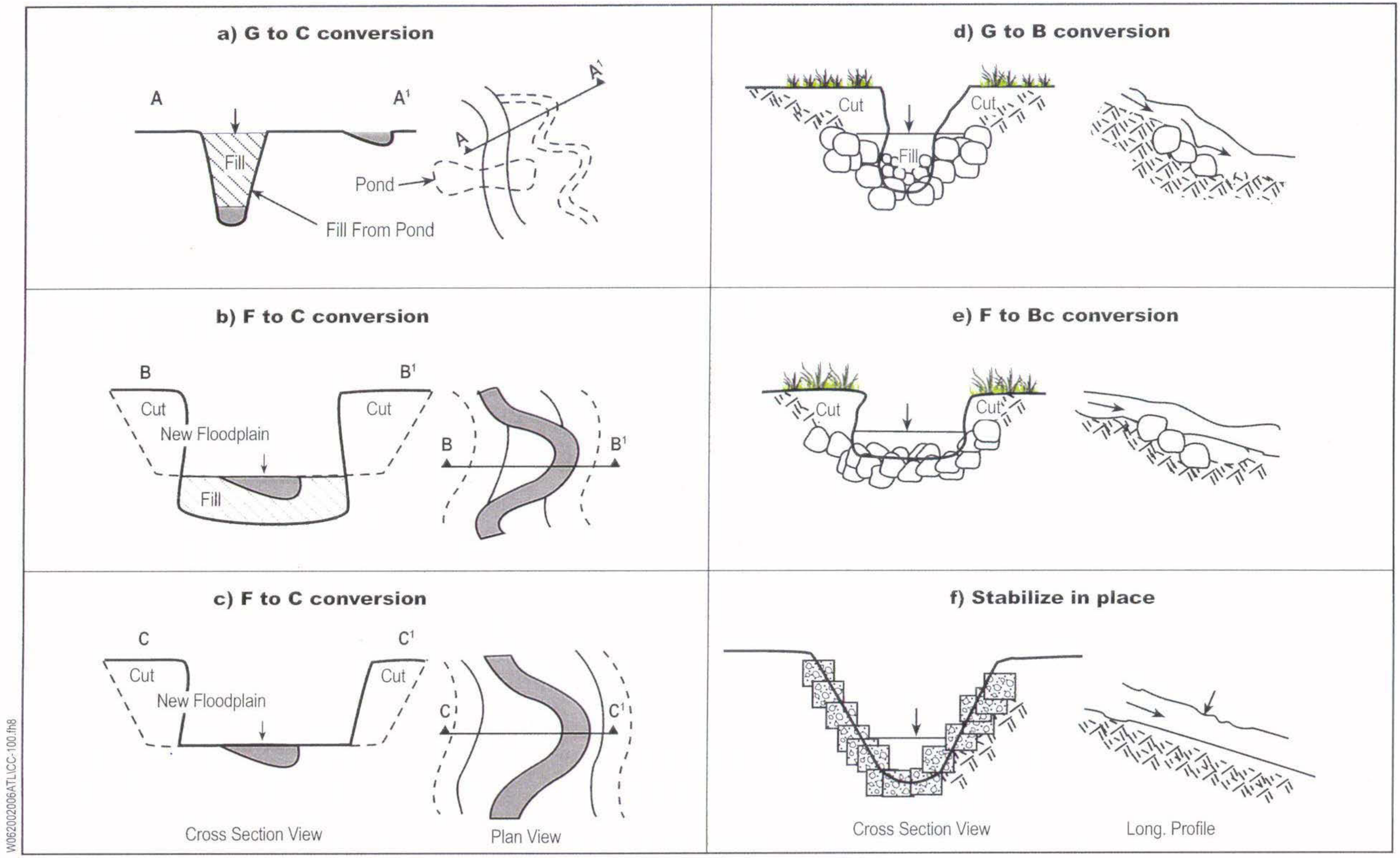
Figure 2.2
Factors Influencing Stream Stability
BeaverdamCreek Restoration Plan



Source: Simon, 1989; US Army Corps of Engineers, 1990.
Fig. 7.14 -- Channel evolution model..
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

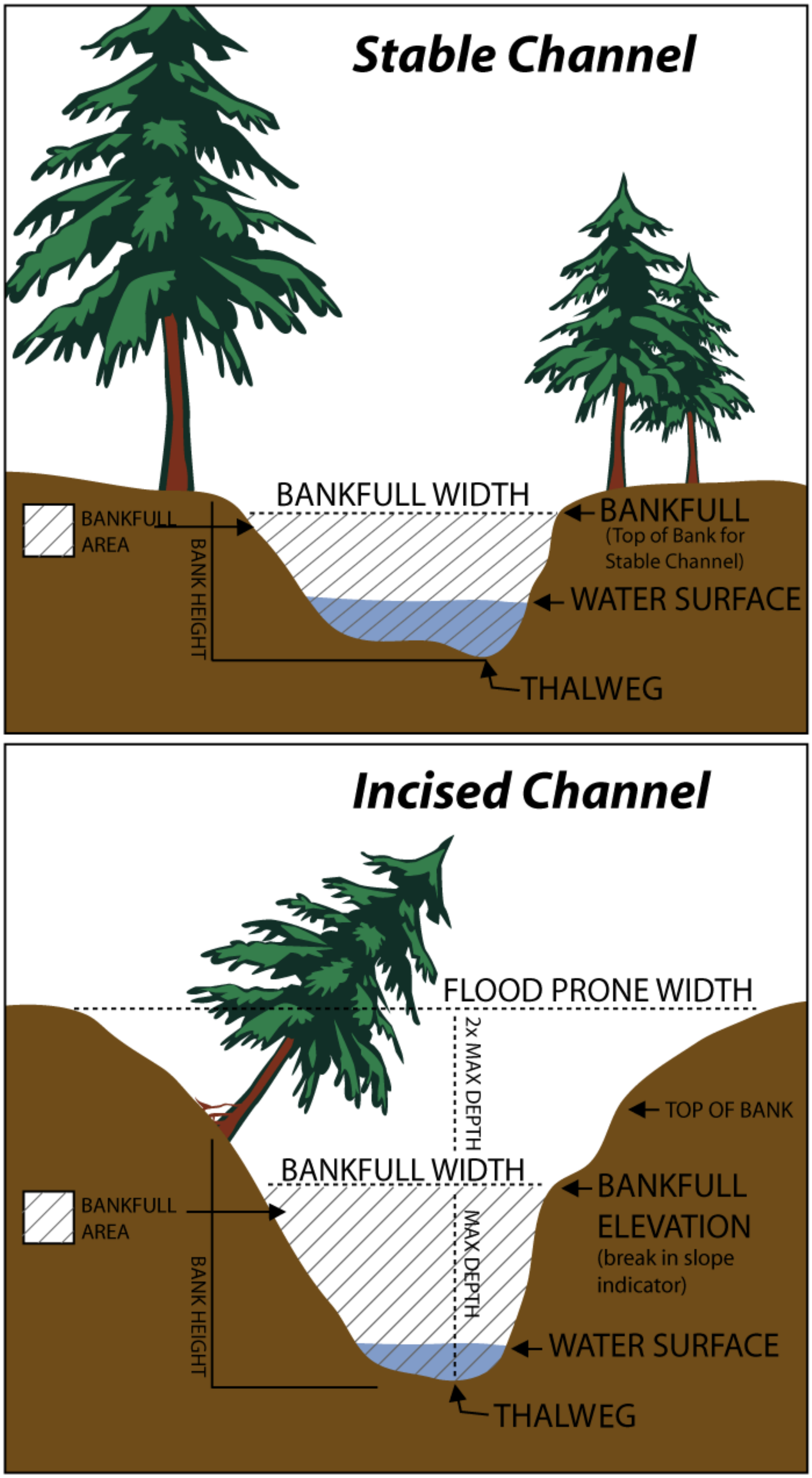
Figure 2.3
Simon Channel Evolution Model
Beaverdam Creek Restoration Plan

Source: Simon, 1989



Source: Rosgen, David L., "A Geomorphological Approach to Restoration of Incised Rivers," *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*, 1997

Figure 2.4
Restoration Priorities for Incised Channels
Beaverdam Creek Restoration Plan



Channel Dimension Measurements

Bankfull Elevation is associated with the channel forming discharge. It is the point where channel processes and flood plain processes begin.

Bankfull width: the distance between the left bank bankfull elevation and the right bank bankfull elevation

Bankfull mean depth: the average depth from bankfull elevation to the bottom of the stream channel

Max depth (dmax): the deepest point within the cross-section measured to the bankfull elevation

Width to Depth Ratio: Bankfull width ÷ Bankfull mean depth

Bank Height Ratio: Bank height (measured from top of bank to the bottom of the stream channel) ÷ the max depth of the bankfull elevation (dmax)

Flood Prone Width: Width measured at the elevation of two times (2x) the maximum depth at bankfull (dmax)

Entrenchment Ratio: Floodprone width ÷ bankfull width

Figure 2.5
Channel Dimension Measurements
Beaverdam Creek Restoration Plan

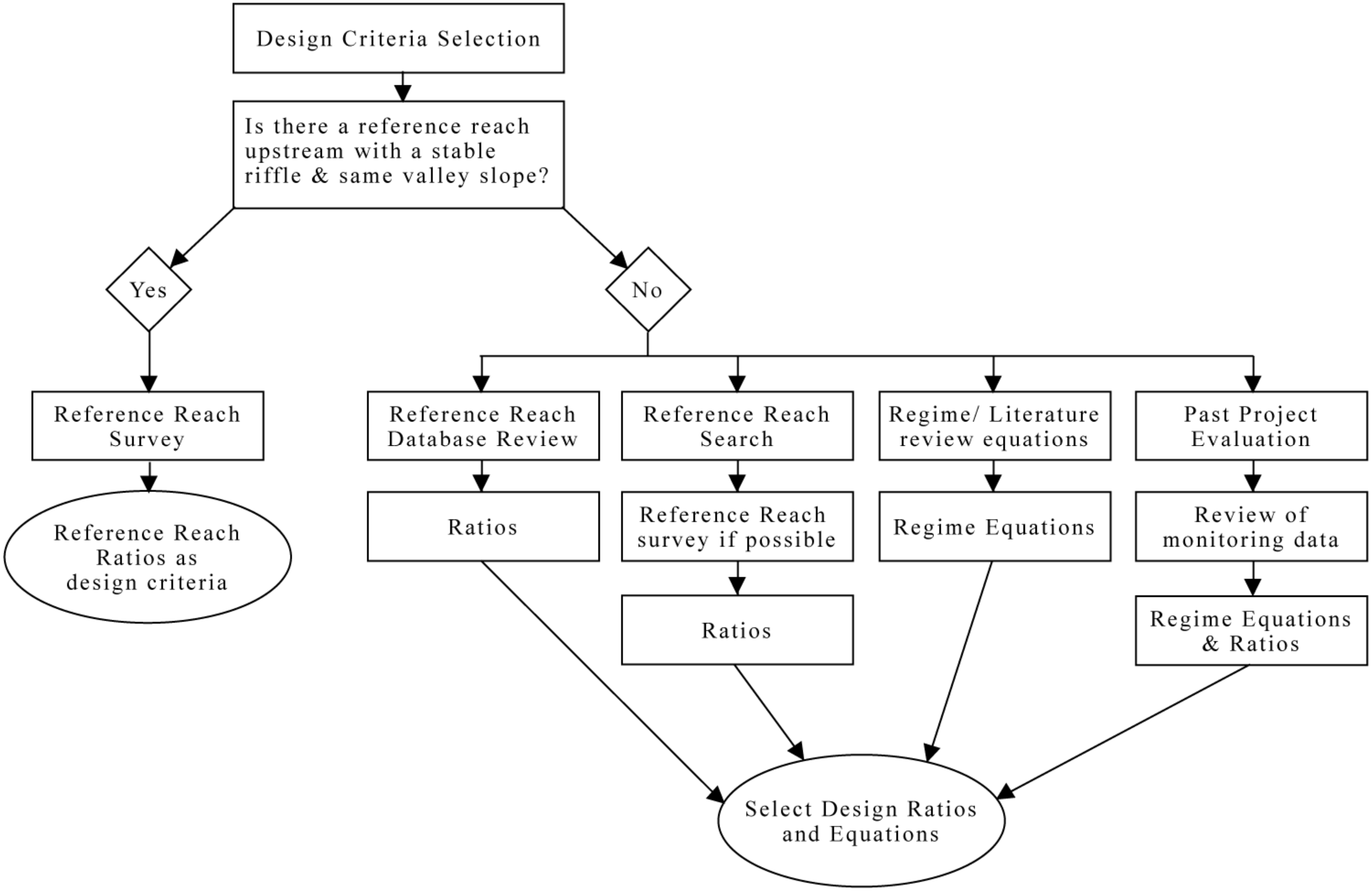
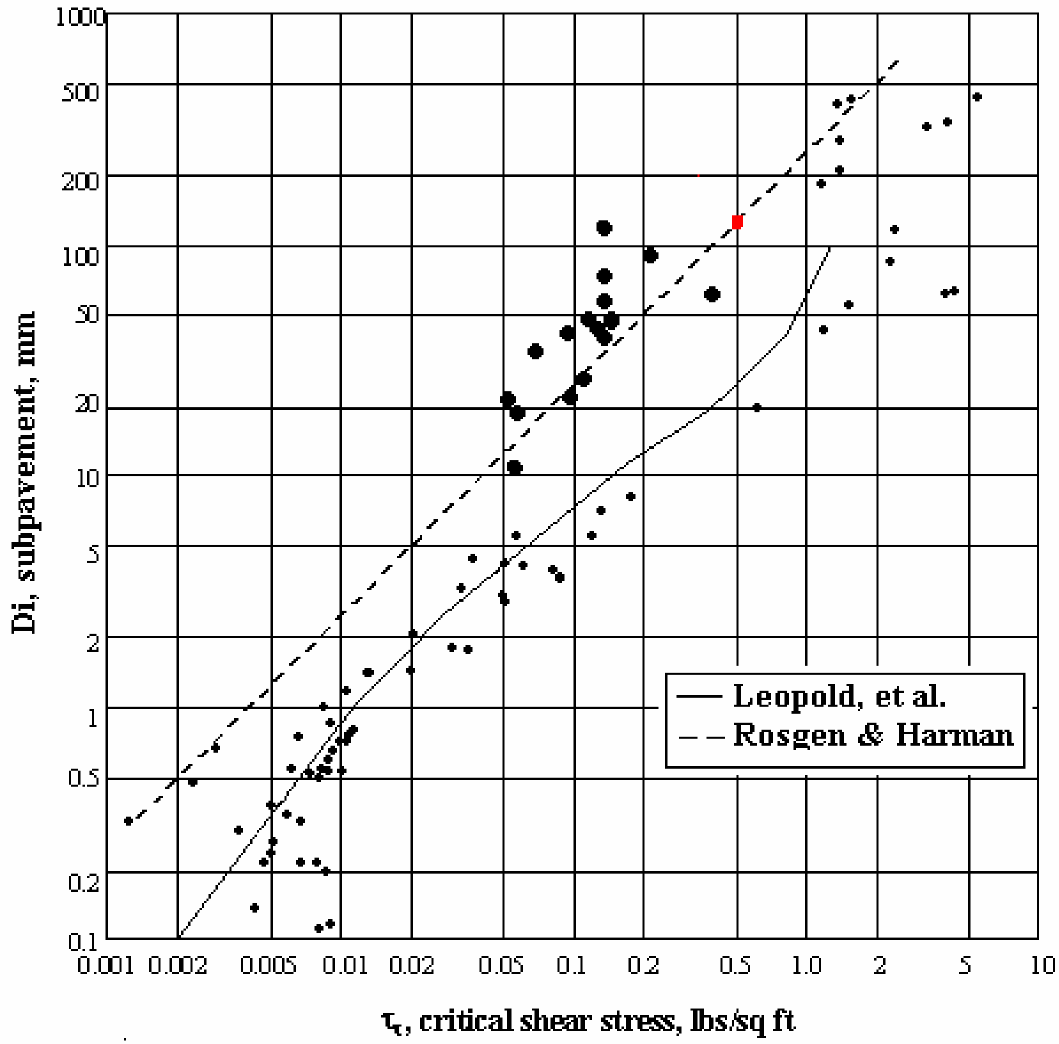
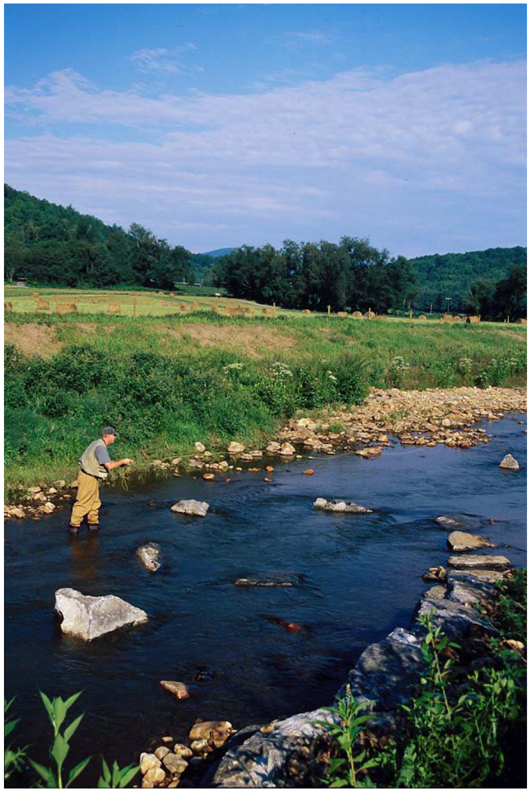


Figure 2.6
Design Criteria Selection
Beaverdam Creek Restoration Plan



(Data from: Leopold, Wolman, and Miller 1964; Rosgen, personal commun.; and Harman, personal commun.)

Figure 2.7
Modified Shields Curve
Beaverdam Creek Restoration Plan



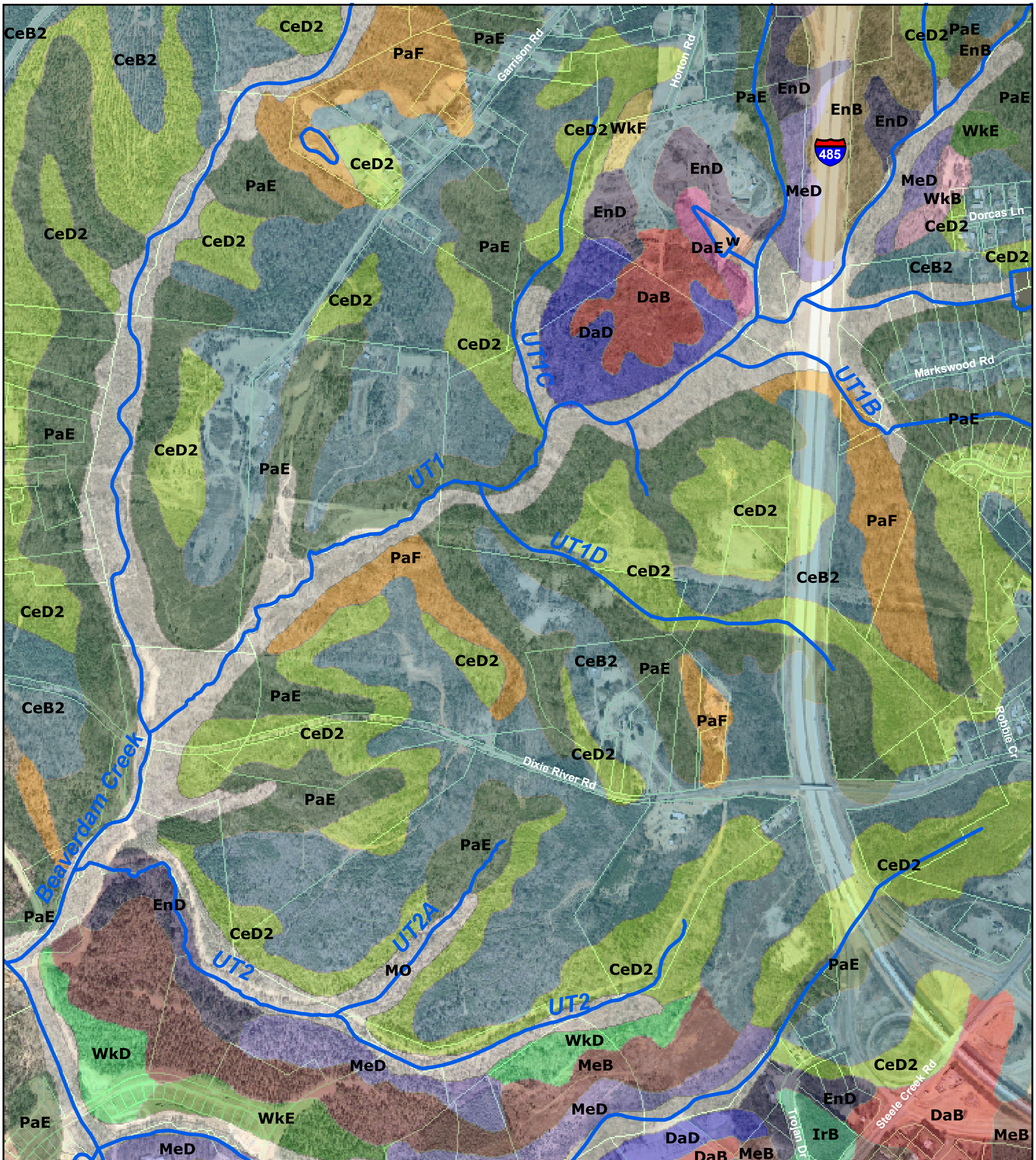
J-Hook

Double Wing Deflector

Rock Vane

Double Drop Rock Cross Vane

Figure 2.8
Examples of In-Stream Structures
Beaverdam Creek Restoration Plan



LEGEND

* Date of aerial photography: March 2004

Soils

- CeB2, Cecil sandy clay loam
- CeD2, Cecil sandy clay loam
- DaB, Davidson sandy clay loam
- DaD, Davidson sandy clay loam
- DaE, Davidson sandy clay loam
- EnB, Enon sandy loam
- EnD, Enon sandy loam
- IrB, Iredell fine sandy loam
- MO, Monacan soils
- MeB, Mecklenburg fine sandy loam
- MeD, Mecklenburg fine sandy loam
- PaE, Pacolet sandy loam
- PaF, Pacolet sandy loam
- WkB, Wilkes loam
- WkD, Wilkes loam
- WkE, Wilkes loam
- WkF, Wilkes loam
- w, Water

400 200 0 400 Feet

Parcels

Creeks

Ecosystem Enhancement PROGRAM

Figure 3.1: Soils Map

Beaverdam Creek Restoration Plan Mecklenburg County, NC

BUCK ENGINEERING

Ecosystem Enhancement PROGRAM

LEGEND

* Date of aerial photography: March 2004

Design Reaches

Preservation Area

Pre-existing Geomorphic Survey Data

Recent Geomorphic Survey Data

Parcels

Creeks

400 200 0 400 800 Feet

Figure 4.1: Project Reaches and Geomorphic Survey Locations

Beaverdam Creek Restoration Plan Mecklenburg County, NC

BUCK ENGINEERING

LEGEND

* Date of aerial photography: March 2004

- Future 100 Year Floodplain
- Existing 100 Year Floodplain
- Floodway (0.1 ft)
- Floodway (0.5 ft)
- Parcels
- Creeks

800 400 0 800 Feet

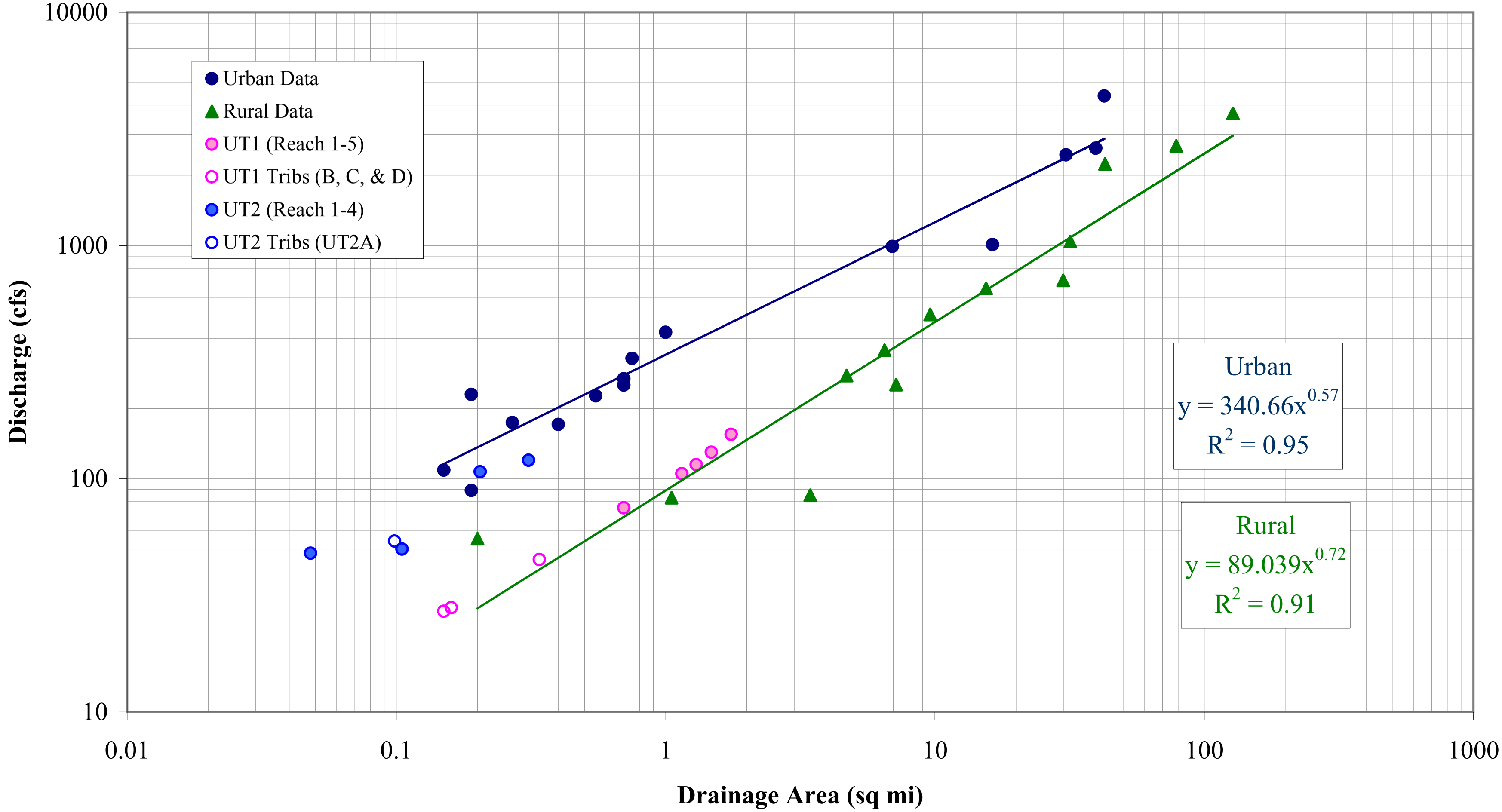
Figure 4.2: FEMA Floodplain Map

Beaverdam Creek Restoration Plan
Mecklenburg County, NC

Ecosystem Enhancement PROGRAM

BUCK ENGINEERING

Figure 4.3 - North Carolina Piedmont Regional Curve



LEGEND

* Date of aerial photography: March 2004

Sampling Sites

Parcels

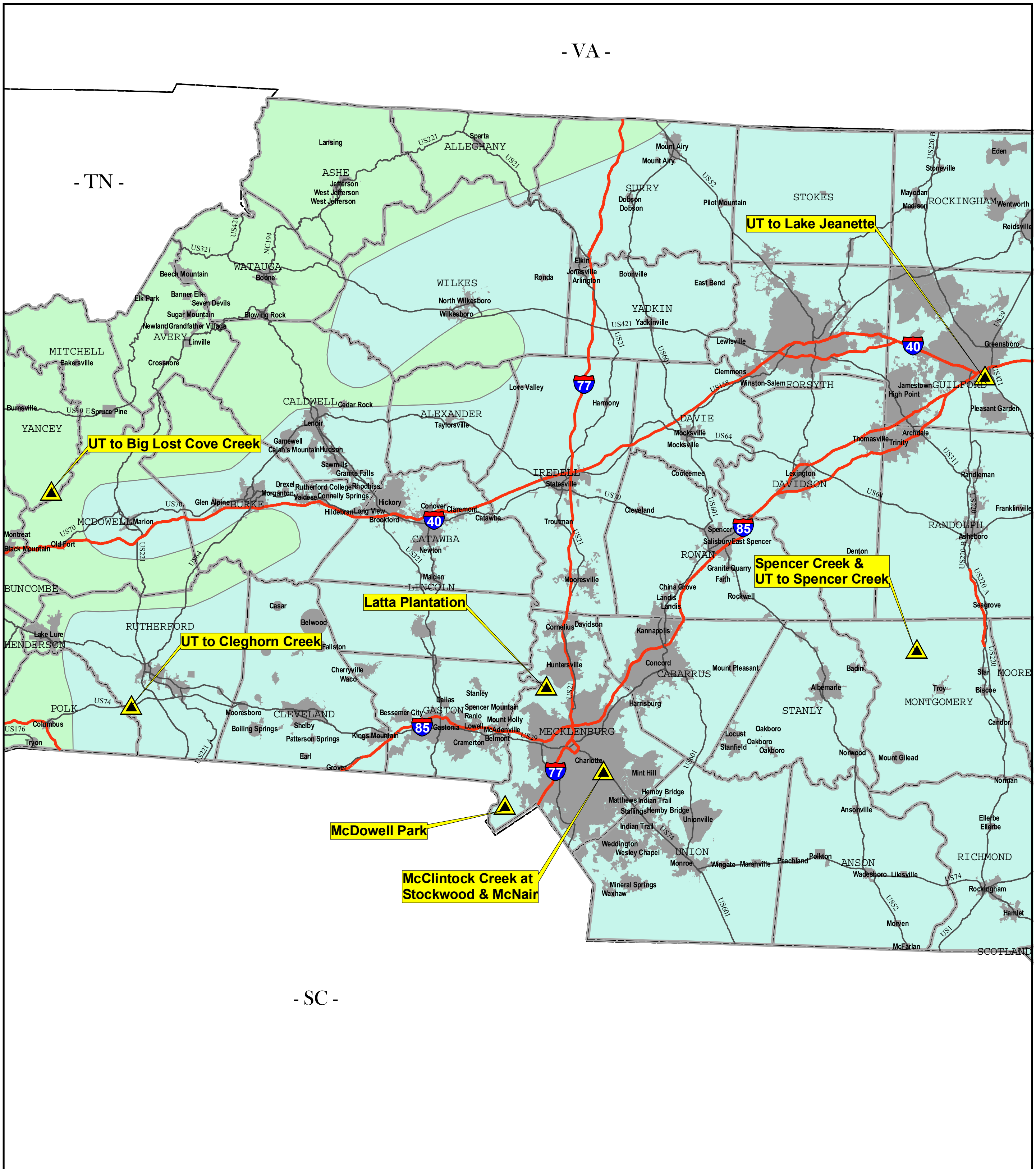
Creeks

1,000 500 0 1,000 Feet

Figure 4.4:
Benthic Macroinvertebrate Sampling Sites
Beaverdam Creek Restoration Plan
Mecklenburg County, NC

Ecosystem Enhancement PROGRAM

BUCK ENGINEERING



Map Inset

LEGEND

Reference Reach Sites

Counties

Physiographic Province

Mountain

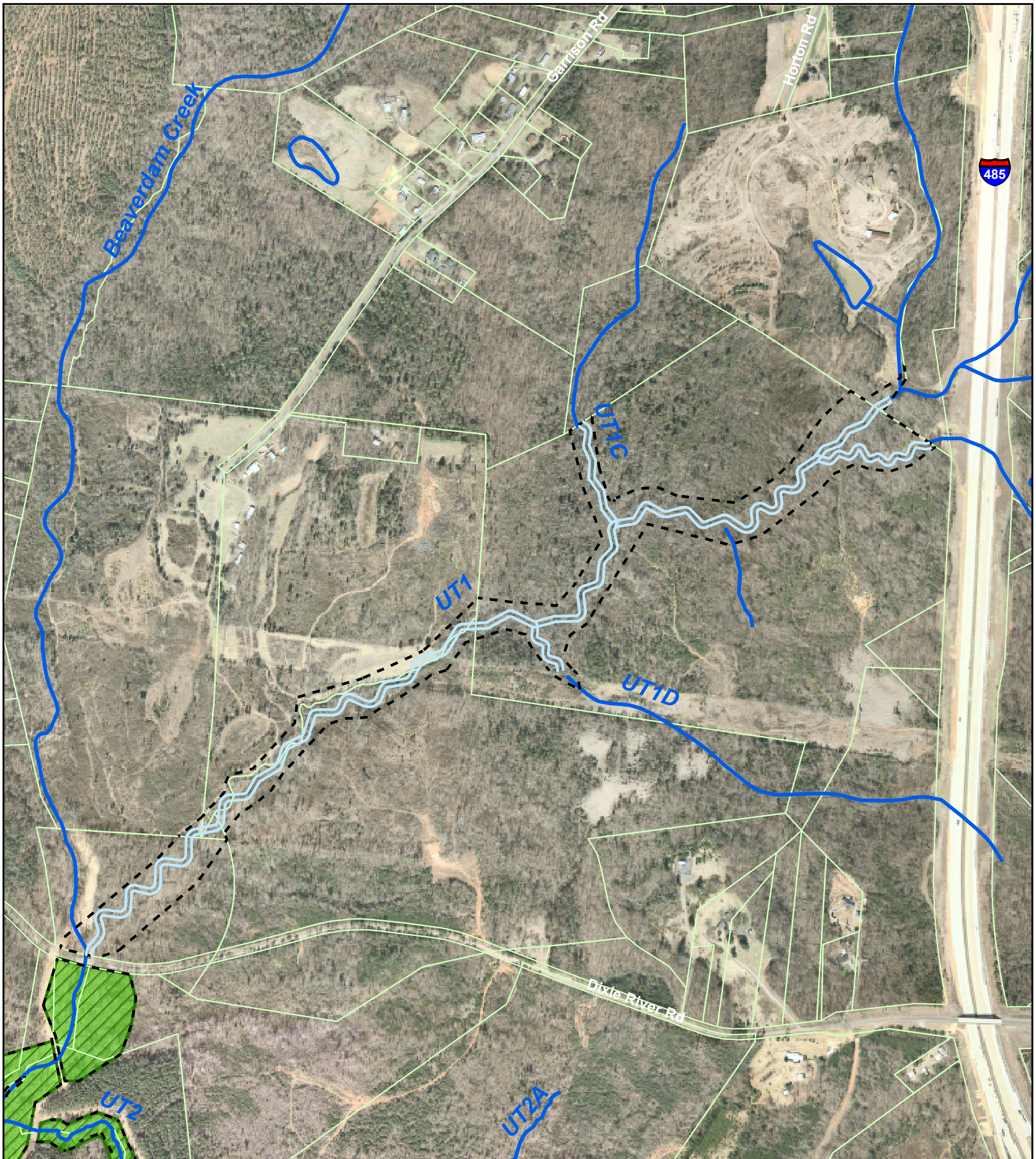
Piedmont

10 5 0 10 Miles

Figure 4.5: Reference Reach Map

Beaverdam Creek Restoration Plan Mecklenburg County, NC

BUCK ENGINEERING



LEGEND

* Date of aerial photography: March 2004

Proposed Channel Alignment

Preservation Area

Easement Boundary

Parcels

Creeks

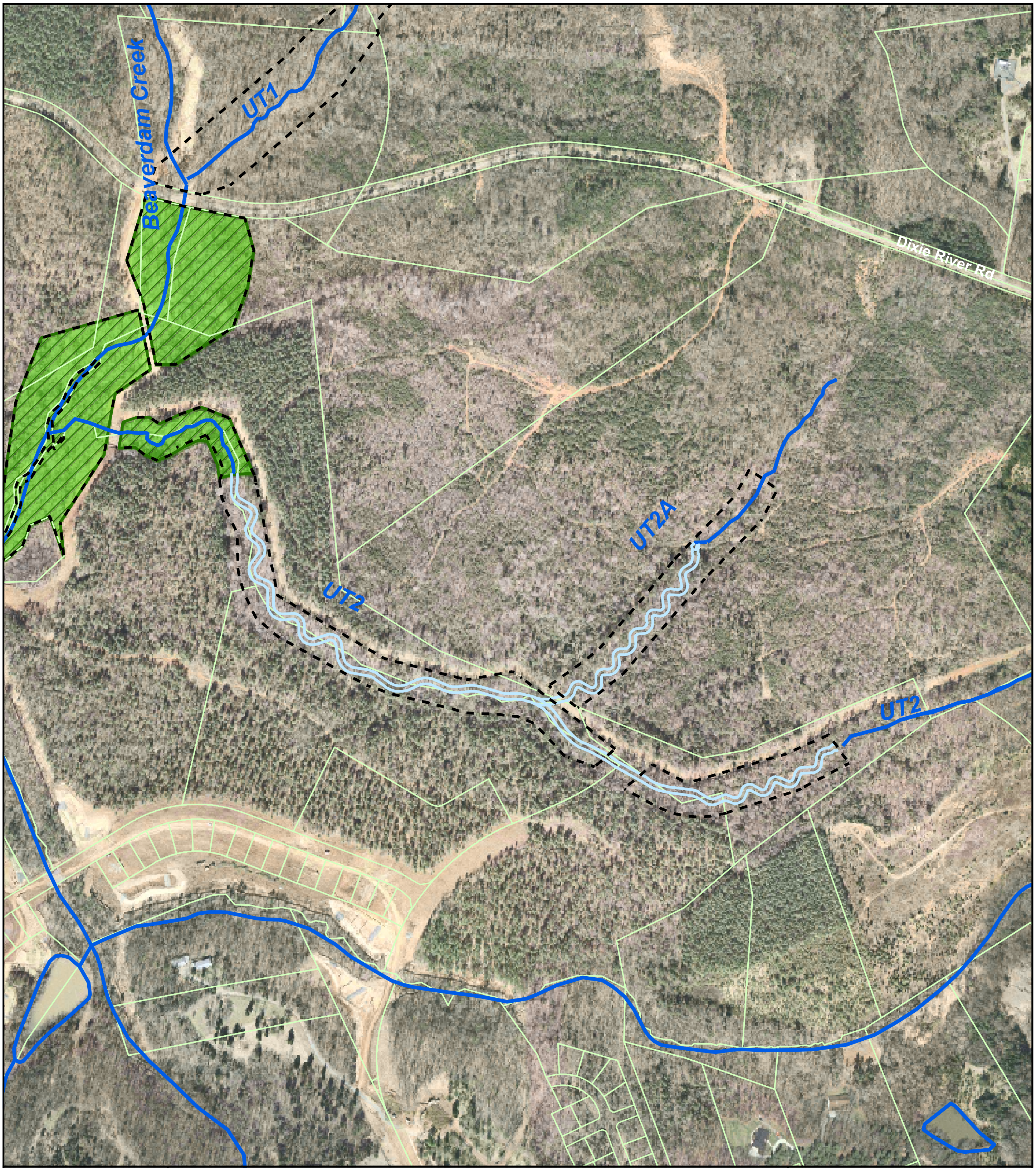
800 400 0 800 Feet

Figure 6.1: UT1 Proposed Restoration Design

Beaverdam Creek Restoration Plan Mecklenburg County, NC

Ecosystem Enhancement PROGRAM

BUCK ENGINEERING



LEGEND

* Date of aerial photography: March 2004

- Proposed Channel Alignment
- Preservation Area
- Easement Boundary
- Parcels
- Creeks

400 200 0 400 Feet

Figure 6.2: UT2 Proposed Restoration Design

Beaverdam Creek Restoration Plan Mecklenburg County, NC

Ecosystem Enhancement PROGRAM

BUCK ENGINEERING

Appendix A

Regulatory Agency Correspondence

Categorical Exclusion Form for Ecosystem Enhancement Program Projects

Part 1: General Project Information	
Project Name:	Beaverdam Creek Stream Restoration Plan
County Name:	Mecklenburg County
EEP Number:	
Project Sponsor:	Riverworks
Project Contact Name:	Will Pedersen
Project Contact Address:	8000 Regency Parkway Suite 200, Cary NC 27511
Project Contact E-mail:	wpedersen@buckengineering.com
EEP Project Manager:	Jeff Jurek

Project Description

The Beaverdam Creek Stream Restoration Site is located in western Mecklenburg County, approximately 3 miles southwest of the Charlotte-Douglas International Airport in the Catawba River Basin (Figure 1). The project site is part of degraded stream system that extends from the newly constructed I-485 corridor to Lake Wylie, and includes the restoration of approximately 12,800 LF of stream for the purpose of obtaining stream mitigation credit for the NC Ecosystem Enhancement Program.

For Official Use Only

Reviewed By:

12-18-05

Date **EEP Project Manager**

Conditional Approved By:

Date **For Division Administrator FHWA**

☐ **Check this box if there are outstanding issues**

Final Approval By:

12-15-05

Date **For Division Administrator FHWA**

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
530 West Innes Street
Salisbury, NC 28144
alan.walters@nc.usda.gov

704-637-2400
704-637-8077 FAX
704-798-8044 CELL
800-677-6913..mailbox 3900

August 30, 2005

Robin Mahoney
Buck Engineering
1447 S. Tryon Street
Suite 200
Charlotte, NC 28203

Dear Mr. Mahoney;

Enclosed is the Farmland Conversion Impact Rating form (AD 1006). I have completed parts II, IV and V. After a decision has been made regarding site selection, please have the appropriate Federal agency complete part VII and send me a copy for the bean counters.

Thanks,

Alan Walters

Alan Walters
Resource Soil Scientist

BUCK

September 12, 2005

Mr. Alan Walters
USDA NRCS
530 West Innes Street
Salisbury, NC 28144

Subject: AD1006 : Beaverdam Creek Stream Restoration Project, Mecklenburg County, NC

Dear Mr. Walters:

Enclosed is the final Farmland Conversion Impact Rating form (AD 1006) for the Beaverdam Creek Stream Restoration Project. Per your request, we have completed sections VI and VII. The total points for this site are 74.

Please let me know if you need any additional information on the project.

Sincerely,

Robin Mahoney, PE
1447 S. Tryon Street, Suite 200
Charlotte, NC 28203
Ph: (704) 334-4454
Fax: (704) 334-4492
Email: rmahoney@buckengineering.com

Enclosures: AD 1006

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request
Name Of Project Beaverdam Creek Stream Restoration Project	Federal Agency Involved FHWA/EEP
Proposed Land Use Stream Restoration and Enhancement	County And State Mecklenburg County, NC
PART II *(To be completed by NRCS)*	Date Request Received By NRCS 8/10/05

Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*	Yes ☒	No ☐	Acres Irrigated 0	Average Farm Size 85
Major Crop(s) CORN	Farmable Land In Govt. Jurisdiction Acres: 248 301 % 73.8		Amount Of Farmland As Defined in FPPA Acres: 230 317 % 68.4	
Name Of Land Evaluation System Used Mecklenburg LESA	Name Of Local Site Assessment System None		Date Land Evaluation Returned By NRCS 8/30/05	

	Maximum Points	Site A	Site B	Site C	Site D
PART III *(To be completed by Federal Agency)*		Alternative Site Rating			
A. Total Acres To Be Converted Directly					
B. Total Acres To Be Converted Indirectly					
C. Total Acres In Site		0.0	0.0	0.0	0.0
PART IV *(To be completed by NRCS)* Land Evaluation Information					
A. Total Acres Prime And Unique Farmland		0			
B. Total Acres Statewide And Local Important Farmland		50.2			
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted		0.0218			
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value		68.4			
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*		0 48	0	0	0
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*	Maximum Points				
1. Area In Nonurban Use	15	7			
2. Perimeter In Nonurban Use	10	4			
3. Percent Of Site Being Farmed	20	0			
4. Protection Provided By State And Local Government	20	0			
5. Distance From Urban Builtup Area	15	NA			
6. Distance To Urban Support Services	15	NA			
7. Size Of Present Farm Unit Compared To Average	10	10			
8. Creation Of Nonfarmable Farmland	25	0			
9. Availability Of Farm Support Services	5	5			
10. On-Farm Investments	20	0			
11. Effects Of Conversion On Farm Support Services	25	0			
12. Compatibility With Existing Agricultural Use	10	0			
TOTAL SITE ASSESSMENT POINTS	160	26	0	0	0
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	0 48	0	0	0
Total Site Assessment *(From Part VI above or a local site assessment)*	160	0 26	0	0	0
TOTAL POINTS *(Total of above 2 lines)*	260	0 74	0	0	0

Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

Reason For Selection:

(See Instructions on reverse side) **Form AD-1006 (10-83)**

This form was electronically produced by National Production Services Staff

North Carolina Department of Cultural Resources
State Historic Preservation Office
Peter B. Sandbeck, Administrator

Michael F. Easley, Governor
Lisbeth C. Evans, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

September 13, 2005

Robin Mahoney
Buck Engineering
1447 South Tryon Street, Suite 200
Charlotte, NC 28203

Re: Beaverdam Creek Stream Restoration Project, Mecklenburg County, ER 05-1745

Dear Ms. Mahoney:

Thank you for your letter of July 25, 2005, concerning the above project. We apologize for the delay in our response.

We have conducted a review of the proposed undertaking and are aware of no historic resources which would be affected by the project. Therefore, we have no comment on the undertaking as proposed.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, contact Renee Gledhill-Earley, environmental review coordinator, at 919/733-4763. In all future communication concerning this project, please cite the above referenced tracking number.

Sincerely,

Renee Gledhill-Earley
for Peter Sandbeck

RECEI

SEP 21 2005

BUCK
ENGINEERING

BUCK

July 25, 2005

Renee Gledhill-Earley
State Historic Preservation Office
Environmental Review Coordinator
Survey & Planning Branch
4617 Mail Service Center
Raleigh, NC 27699-4617

Subject: Beaverdam Creek Stream Restoration Project, Mecklenburg County, NC

Dear Ms. Gledhill-Earley:

The purpose of this letter is to request review and comment on any possible issues that might emerge with respect to architectural or archaeological resources from a stream restoration project conducted on the attached site (Vicinity map and USGS site map with approximate property lines enclosed).

The Beaverdam Creek Stream Restoration Project Site has been identified for the purpose of providing in-kind restoration for unavoidable stream channel impacts. Several sections of channel have been identified as significantly degraded. This stream restoration site was selected based on its probability to restore high quality stream habitat where it has ceased to exist.

No architectural structures or artifacts have been observed or noted during preliminary surveys of the site for restoration purposes. We have enclosed a copy of the USGS topo map that includes the proposed stream restoration project site. We ask that you review this site based on the USGS topo map in your office to determine the presence of any architectural or archaeological resources.

The conceptual restoration plan calls for the restoration of the channels on this site to a stable condition. This process will involve the restoration of natural channel dimension, pattern and profile and the reestablishment of forested riparian buffers within the project area.

The restoration site will be protected through a conservation easement. If there are any conceptual protection mechanisms germane to your expertise that you would like amended to the easement, please forward them when you reply to this request.

We believe that no impacts will occur from restoration efforts, however, no surveys by archaeologists have been conducted, and we wish to obtain your concurrence that no impact assessment or additional studies are needed. Your correspondence will be forwarded to the North Carolina Ecosystem Enhancement Program for consideration.

We thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent or site disturbance associated with this project.

Sincerely,

Robin Mahoney, PE
1447 S. Tryon Street, Suite 200
Charlotte, NC 28203
Ph: (704) 334-4454
Fax: (704) 334-4492
Email: rmahoney@buckengineering.com

Enclosures: Project Vicinity Map
USGS Site Map with Approximate Project Boundary

EDR TOXICHECK® 1.0 Environmental Risk Summary

May 10, 2005

Target Property

PIEDMONT EQUESTRIAN PARK
651 BAXTER RD
CHERRYVILLE, NC 28021

440 Wheelers Farms Road
Milford, CT 06460
Phone:800-352-0050
Fax:800-231-6802
Web:www.edrnet.com

EDR™ Environmental Data Resources Inc

ENVIRONMENTAL RISK LEVEL

To help evaluate environmental risk, the *ToxiCheck 1.0 Environmental Risk Summary* provides an Environmental Risk Level, based on a search of current government records. Refer to the supporting report for additional detail.

☐ **HIGH RISK** Based on the records found in this report, the environmental risk level for this property is High. Please see page 2 for information on the records in this report that contribute to this risk level.

☐ **LOW RISK** Based on the records found in this report, the environmental risk level for this property is minimal.

Current Government Records

Current government regulatory files may identify known or potential sites of environmental concern.

EDR Radius Map Report

(Not Requested for ToxiCheck) Historical Records

The prior use of a property may contribute to environmental contamination. Historical sources such as fire insurance maps, city directories, and other databases may identify sites of potential environmental concern not identified in current government records. The following reports and/or databases were not requested for ToxiCheck by customer:

EDR Fire Insurance Map Abstract
EDR City Directory Abstract
EDR Proprietary Gas Station/Dry Cleaner Database
EDR Proprietary Coal Gas Database

TOXICHECK® 1.0 Environmental Risk Summary

FINDINGS CONTRIBUTING TO THE ENVIROMENTAL RISK LEVEL

The environmental LOW RISK is based upon the findings listed below. Refer to the supporting report(s) for additional detail.

CURRENT GOVERNMENT RECORDS

Target Property

No records identified (if any) were determined to be of high risk.

Surrounding Properties

No records identified (if any) were determined to be of high risk.

HISTORICAL RECORDS (NOT REQUESTED)

Property historical reports and/or data was not requested for ToxiCheck by the customer.

TOXICHECK® 1.0 Environmental Risk Summary

PROPERTY TIMELINE

The property timeline indicates the year of the finding contributing to a LOW RISK environmental risk level.
For details on data points along the timeline, refer to page 2 of the ToxiCheck Environmental Risk Summary.

Target Property Timeline

Historical Not Requested for ToxiCheck													
1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2005

Historical — Current

Surrounding Properties Timeline

Historical Not Requested for ToxiCheck													
1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2005

Historical — Current

○ Timeline ID (refer to page 2)

TERMS AND DEFINITIONS

Data Source
Data Source indicates the government database or historical record contributing to a HIGH Environmental Risk Level. Current government records sources include federal, state and local databases. Detailed information for current government records can be found in the EDR Radius Map Report Government Records Searched section. When requested to be searched by the customer, and where available, historical records sources include the EDR Proprietary Gas Station/Dry Cleaner Database, EDR Proprietary Coal Gas Database, EDR Fire Insurance Abstract and EDR City Directory Abstract. Additional information about the EDR Gas Station/Dry Cleaner Database and EDR Proprietary Coal Gas Database can be found in the EDR Radius Map Report. Additional information about the EDR Fire Insurance Abstract and EDR City Directory Abstract is located in the respective report(s).

Surrounding Properties
Surrounding Properties included in the ToxiCheck Environmental Risk Summary are those sites found in the EDR Radius Map Report and Historical Reports near the target property. Surrounding Properties are also known as adjoining properties. Surrounding Property data which contribute to a HIGH Environmental Risk Level can be found in the Surrounding Properties section of the ToxiCheck Environmental Risk Summary.

Target Property
The Target Property is the location for which this inquiry is conducted. Target Property is also known as the subject site. Target Property data which contribute to a HIGH Environmental Risk Level can be found in the Target Property section of the ToxiCheck Environmental Risk Summary.

Timeline ID
Timeline ID is the identification number assigned to a property and used on the ToxiCheck Property Timeline to show the publication year of the document(s) which identify the property.

EDR Radius Map(tm) Report
The EDR Radius Map Report is a map-based radius search of current government regulatory information that identifies sites of real or potential environmental concern. The report searches federal, state, local, and EDR proprietary databases for the target property and surrounding properties. Government records are regularly updated according to industry standards.

EDR Proprietary Gas Station/Dry Cleaner Database
EDR has searched select national collections of business directories and has collected listings of potential dry cleaner and gas station/filling station/service station sites that were available to EDR researchers. EDR's review

was limited to those categories of sources that might, in EDR's opinion, include dry cleaning and gas station/filling station/service station establishments. The categories reviewed included, but were not limited to: gas, gas station, gasoline station, filling station, auto, automobile repair, auto service station, service station, dry cleaner, cleaners, laundry, laundromat, cleaning/laundry, wash & dry, etc. The information provided in this proprietary database may or may not be complete; i.e., the absence of a dry cleaner or gas station/filling station/service station site does not necessarily mean that such a site did not exist in the area covered by this report.

EDR Fire Insurance Map Abstract
Fire insurance maps were initially produced by private companies for the insurance industry to provide information on the fire risks of buildings and other structures. Sanborn Maps are a valuable historical resource for persons concerned with evaluating the potential for site contamination based on the history of past use. Fire insurance maps are available for approximately 12,000 U.S. cities and towns from the mid-1800s to the present. Map coverage is most comprehensive in urban core areas and in older suburbs; map coverage is limited in suburban areas developed after 1950. When requested by the customer, EDR conducts a keyword search of the EDR Fire Insurance Map Abstract to identify records contributing to the Toxicheck Environmental Risk Level. Keyword searches are limited and should not be considered a substitute for review by an environmental professional. For more information about the keywords used for the ToxiCheck Environmental Risk Level, contact your EDR Account Executive.

EDR City Directory Abstract
City directories have been published for cities and towns across the U.S. since the 1800s. Originally a list of residents, the city directory developed into a sophisticated tool for locating individuals and businesses in a particular urban or suburban area. Twentieth century directories are generally divided into three sections: a business index, a list of resident names and addresses, and a street index. With each address, the directory lists the name of the resident or, if a business is operated from this address, the name and type of business (if unclear from the name). While city directory coverage is comprehensive for major cities, it may be spotty for rural areas and small towns. When requested by the customer, EDR conducts a keyword search of the EDR City Directory Abstract to identify records contributing to the Toxicheck Environmental Risk Level. Keyword searches are limited and should not be considered a substitute for review by an environmental professional. For more information about the keywords used for the ToxiCheck Environmental Risk Level, contact your EDR Account Executive.
The following keywords were used to evaluate the EDR City Directory Abstract: 7-Eleven, AAMCO, AM General, Acura, Amerada Hess Corporation, Amoco, Arco, Aston Martin, Atlantic Richfield Oil Company, Audi, Auto, Autobody, Automobile, Automotive, BMW, BP, Battery, Beacon, Bentley, Body Shop, Body Works, Brake, British Petroleum, Buick, Cadillac, Caltex, Car, Chemical, Chevrolet, Chevron, Chevrontexaco, Chrysler, Circle K, Citgo, Cities Service Company, Cleaner, Cleaning, Clnr, Coastal Petroleum, Collision, Conoco, Conocophillips, Cumberland Farms, Daewoo, Dealer, Diamond Shamrock, Dodge, Dry Cleaner, Dry Cleaning, Drycleaning, Dyer, Dying, Eagle, Engine, Esso, Exxon, Exxonmobil, Ferrari, Ford, Fuel, GMC, Garage, Gas, Goodrich, Gulf Oil, Hanger, Heating, Hess, Honda, Hummer, Hyundai, Imperial Oil, Infiniti, Isuzu, Jaguar, Jeep, Jersey Standard, Jet Oil, Junk Yard, Junkyard, Kia, Kleaner, Laboratory, Lamborghini, Land Rover, Landfill, Launderer, Launderette, Laundries, Laundromat, Laundry, Lexus, Lincoln, Lndry, Lndy, Lotus, Magnolia Petroleum Co, Manufacturing, Marathon, Marathon Ashland Petroleum, Martinizing, Maserati, Mazda, Mechanic, Meineke, Mercedes-Benz, Mercury, Midas, Mirastar, Mitsubishi, Mobil, Motor, Muffler, Nissan, Oil, Oldsmobile, Paint, Panoz, Pep Boys, Petroleum, Phillips 66, Photo, Photography, Pilot, Plymouth, Pontiac, Porsche, Press, Print, Printer, Printing, Prntr, Radiator, Railroad, Railway, Recycling, Repair, Richfield, Rolls-Royce, Royal Dutch/Shell, STA, STN, Saab, Saturn, Shell Oil, Sinclair Oil, Socony, Sohio, Speedway, Standard Oil, Standard Oil of Ohio, Station, Subaru, Sun Oil Company, Sunoco, Suzuki, Tailor, Tesoro, Texaco, Tire, Towing, Toyota, Transmission, Ultramar, Union 76, Union Oil, Vacuum Oil Co, Valero, Valero Energy, Volkswagen, Volvo, Wash, Waste, Wyatt Oil.

EDR Proprietary Coal Gas Database
The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc.
 For a technical description of the types of hazards which may be found at such sites, contact your EDR Account Executive.

Disclaimer Provided by Real Property Scan, Inc.
The information contained in this report has predominantly been obtained from publicly available sources produced by entities other than Real Property Scan. While reasonable steps have been taken to insure the accuracy of this report, Real Property Scan does not guarantee the accuracy of this report. Any liability on the part of Real Property Scan is strictly limited to a refund of the amount paid. No claim is made for the actual existence of toxins at any site.
This report does not constitute a legal opinion.

Andrea Spangler

From: Brew, Donnie [Donnie.Brew@fhwa.dot.gov]
Sent: Wednesday, June 29, 2005 9:19 AM
To: aspangler@buckengineering.com
Cc: Ayers, Rob; mike.mcdonald@ncmail.net; Marc.Recktenwald@ncmail.net; Edward.Hajnos@ncmail.net; Jason.Guidry@ncmail.net
Subject: Uniform Act

Andrea,

I am sending you this e-mail for confirmation of our phone conversation yesterday regarding compliance to the Uniform Act.

The State Property Office (SPO) handles property acquisitions for all of EEP's design-bid-build projects. The SPO handles compliance to the Uniform Act for all of these acquisitions, therefore, no further documentation is required by project managers. I will clarify this in the CE checklist and instructions.

For projects that involve property acquisition not handled by the SPO (i.e. full-delivery projects), then the current procedure in the checklist should be followed.

Thanks,

Donnie

p.s. please be sure to send me a copy of the scoping letter you sent to SHPO and THPO regarding the project you spoke about yesterday as well as their responses to you.

Donnie Brew
Environmental Protection Specialist / EEP Liaison Federal Highway Administration 310 New Bern Avenue, Suite 410 Raleigh, NC 27601
(919) 715-2231
fax: (919) 715-2219

BUCK
ENGINEERING

1447 South Tryon Street, Suite 200
Charlotte, North Carolina 28203
Phone: 704.334.4454
Fax: 704.334.4492
www.buckengineering.com

October 17, 2005

Marella Buncick
US Fish and Wildlife Service
Asheville Field Office
160 Zillicoa Street
Asheville, NC 28801

Subject: Beaverdam Creek Stream Restoration Project, Mecklenburg County, NC

Dear Ms. Buncick:

The purpose of this letter is to provide additional information to your office on the potential effects to threatened and endangered species from the Beaverdam Creek Stream Restoration Project in Mecklenburg County for your review and comment.

Buck Engineering reviewed both the NC Natural Heritage Program (NCNHP) and the US Fish and Wildlife Service (USFWS) lists of rare and protected animal and plant species and found that five federally listed species are known to occur in Mecklenburg County: Smooth coneflower (*Echinacea laevigata*), Schweinitz's sunflower (*Helianthus schweinitzii*), Michaux's sumac (*Rhus michauxii*), bald eagle (*Haliaeetus leucocephalus*), and the Carolina heelsplitter (*Lasmigona decorata*).

Since the project involves primarily degraded streams and wooded areas, federally protected species are not expected to be impacted by the proposed project. Potential habitat, although marginal, does exist for Smooth coneflower, Schweinitz's sunflower, Michaux's sumac and the bald eagle within the proposed project area. Due to the degraded conditions of the stream, suitable habitat does not exist for the Carolina heelsplitter.

A pedestrian survey of the project area was conducted on August 15, 2005 to identify the general habitats existing within and near the area. No federal protected species were observed in or adjacent to the project area during the field survey. As a result, a "no effect" determination was made for the smooth coneflower and Michaux's sumac for this project. Suitable habitat for Schweinitz's sunflower was identified in a small portion of the project site, but a biological conclusion could not be determined at the time. An additional pedestrian survey was performed on September 9, 2005 to search for the sunflower during blooming season. Schweinitz's sunflower was not observed during this visit; therefore it is anticipated that project construction will have "no effect" on the sunflower.

No bald eagle nests or specimens were observed during the pedestrian surveys, but because the proposed restoration project is just over 0.5 miles from open water, the preferred nesting distance of the bald eagle, there may be a marginal chance of the site being used for winter roosting. Therefore, a "may affect, but not likely to adversely affect" determination was made for this species.

The Carolina heelsplitter is usually found in mud, muddy sand, or muddy gravel substrate in cool, slow-moving, small to medium-sized streams or rivers along stable, well-shaded streambanks. The stability of the streambanks appears to be a very important factor in the habitat. Its range has been drastically reduced by impoundments and deterioration of habitat and water quality by siltation and other pollution resulting from stream channelization, dredging, sand mining, sewage effluents, and poorly implemented agricultural, forestry, and development practices. Known populations in North Carolina are located in Goose Creek (Yadkin-Pee Dee River Basin) and Waxhaw Creek (Catawba River Basin) in Union County, according to the NC Natural Heritage Program database.

Based on the heavily degraded conditions of Beaverdam Creek, suitable habitat does not exist for the Carolina heelsplitter. Beaverdam Creek does not drain into either Goose Creek or Waxhaw Creek. No record has been reported in Mecklenburg County in the past 20 years. Therefore, it is anticipated that project construction will have "no effect" on the Carolina heelsplitter.

We wish to obtain your concurrence that no impact assessment or additional studies are needed for this project. Your correspondence will be forwarded to the North Carolina Ecosystem Enhancement Program for consideration. Thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent or site disturbance associated with this project.

Sincerely,

Andrea M. Spangler
1447 S. Tryon Street, Suite 200
Charlotte, NC 28203
Ph: (704) 334-4454
Fax: (704) 334-4492
Email: aspangler@buckengineering.com

Cc: Donnie Brew, FHWA
Jeff Jurek, EEP

Andrea Spangler

From: Marella_Buncick@fws.gov
Sent: Thursday, November 17, 2005 11:57 AM
To: Andrea Spangler
Subject: Re: Beaverdam Stream Restoration Project
Attachments: USFWS - 10-17-05.pdf

Andrea,

I've looked at both Beaverdam and Piedmont Equestrian. I would suggest that if the Beaverdam project either: 1. removes no large trees, particularly conifers or 2. is not within some reasonable distance of an occupied body of water (2 miles) it is unlikely that there would be any effect on bald eagle. I think you have addressed the potential plant impacts adequately.

If you have questions or if FHWA does, please let me know.

marella

marella buncick
USFWS
160 Zillicoa St.
Asheville, NC 28801
828-258-3939 ext 237

"Dogs are our link to paradise. They don't know evil or jealousy or discontent. To sit with a dog on a hillside on a glorious afternoon is to be back in Eden, where doing nothing was not boring---it was peace." Milan Kundera

"Andrea Spangler" <aspangler@buckengineering.com>

10/17/2005 10:40 AM

To <Marella_Buncick@fws.gov>
cc "Brew, Donnie" <Donnie.Brew@fhwa.dot.gov>
Subject Beaverdam Stream Restoration Project

Marella-
Based on comments we received from the NC Ecosystem Enhancement Program, we have clarified the determinations made for possible effects to threatened and endangered species by the Beaverdam Creek Stream Restoration Project. I've attached the information to this email and also sent you a hard copy in the mail. .

Once you've had a chance to review the letter, please let me know if you concur with our conclusions or if you need additional information.

Thank you for your help.

Andrea

Andrea Spangler
Buck Engineering
1447 S. Tryon Street Suite 200
Charlotte, NC 28203
Direct Phone Line : 704-319-7884

BUCK ENGINEERING
1447 South Tryon Street, Suite 200
Charlotte, North Carolina 28203
www.buckengineering.com

July 25, 2005

Ron Lineville
Wildlife Resource Commission
Western Piedmont Region
3855 Idlewild Road
Kernersville, NC 27284-9180

Subject: Beaverdam Creek Stream Restoration Project,
Mecklenburg County, NC

Dear Mr. Linville:

The purpose of this letter is to request review and comment on any possible issues that might emerge with respect to protected species from a stream restoration project conducted on the attached site (Vicinity map and USGS site map with approximate property lines enclosed).

The Beaverdam Creek Stream Restoration Project Site has been identified for the purpose of providing in-kind restoration for unavoidable stream channel impacts. Several sections of channel have been identified as significantly degraded. This stream restoration site was selected based on its probability to restore high quality stream habitat where it has ceased to exist.

We have enclosed a copy of the vicinity map and USGS topo map that includes the proposed stream restoration project site. We ask that you review this site based on the USGS topo map in your office to determine the presence of any constraints concerning trout waters or protected species.

The conceptual restoration plan calls for the restoration of these channels to a stable condition. This process will involve the restoration of natural channel dimension, pattern and profile and the reestablishment of forested riparian buffers within the project area.

The restoration site will be protected through a conservation easement. If there are any conceptual protection mechanisms germane to your expertise that you would like amended to the easement or construction of this project, please forward them when you reply to this request. Your correspondence will be forwarded to the North Carolina Ecosystem Enhancement Program for consideration.

We thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent or site disturbance associated with this project.

Sincerely,

Robin Mahoney, PE
1447 S. Tryon Street, Suite 200
Charlotte, NC 28203
Ph: (704) 334-4454
Fax: (704) 334-4492
Email: rmahoney@buckengineering.com

Enclosures: Project Vicinity Map
USGS Site Map with Approximate Project Boundary

North Carolina Wildlife Resources Commission

Richard B. Hamilton, Executive Director

EIVED

AUG 0 4 2005

August 2, 2005

Mr. Robin Mahoney, PE
BUCK, Engineering
1447 S. Tryon St. Suite 200
Charlotte ,North Carolina 28203

RE: Beaverdam Creek, Potential Mitigation/Restoration Project, Mecklenburg County

Dear Mr. Maloney:

This correspondence is in response to your letter of July 25, 2005 concerning the proposed stream restoration project. Biologists with the North Carolina Wildlife Resources Commission (NCWRC) are familiar with habitat values in the area. The NCWRC is authorized to comment and make recommendations which relate to the impacts of this project on fish and wildlife pursuant to Clean Water Act of 1977, North Carolina Environmental Policy Act, US National Environmental Policy Act, Endangered Species Act (16 U. S. C. 1531-1543; 87 Stat 884), the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667d) and/or Federal License of Water Resource Project Act (Federal Power Act-16 U.S.C. 791a et seq.) as applicable.

The project area has been identified as a possible in-kind restoration site for unavoidable impacts. Restoration is proposed that restores stable channel conditions. We have reviewed the information provided by you. Our review found that the Highfin carpsucker, (*Carpiodes velifer* (NCSR) has been found in the Catawba River basin.

Based on our cursory review, we believe that improvements to the watershed should benefit long-term viability of aquatic life in the area, including the carpsucker. Providing that the restoration is properly permitted and certified by state and federal authorities, we do not anticipate impacts to listed wildlife species. All activities should follow Clean Water Act provisions and any other special conditions specified by the NC Department of Environment and Natural Resources, including applicable sediment and erosion control measures. State-of-the-art bioengineering methodologies should be used for the project.

Thank you for the opportunity to comment during the early planning stages of this project. If you have any questions regarding these comments, please contact me at 336/769-9453.

Sincerely,

Ron Linville
Regional Coordinator
Habitat Conservation Program

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 733-3633 • **Fax:** (919) 715-7643

Appendix B

EDR Transaction Screen Map Report

The EDR Radius Map
with GeoCheck®

Dixie River Rd
Dixie River Rd
Charlotte, NC 28278

Inquiry Number: 01465089.1r

July 13, 2005

EDR™ Environmental Data Resources Inc

The Standard in Environmental Risk Management Information

440 Wheelers Farms Road
Milford, Connecticut 06460

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

TABLE OF CONTENTS

SECTION | **PAGE**

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR). The report meets the government records search requirements of ASTM Standard Practice for Environmental Site Assessments, E 1527-00. Search distances are per ASTM standard or custom distances requested by the user.

TARGET PROPERTY INFORMATION

ADDRESS

DIXIE RIVER RD
CHARLOTTE, NC 28278

COORDINATES

Latitude (North):	35.173500 - 35° 10’ 24.6’’
Longitude (West):	80.979200 - 80° 58’ 45.1’’
Universal Tranverse Mercator:	Zone 17
UTM X (Meters):	501894.1
UTM Y (Meters):	3892086.0
Elevation:	692 ft. above sea level

USGS TOPOGRAPHIC MAP ASSOCIATED WITH TARGET PROPERTY

Target Property:	35080-B8 CHARLOTTE WEST, NC
Source:	USGS 7.5 min quad index

TARGET PROPERTY SEARCH RESULTS

The target property was not listed in any of the databases searched by EDR.

DATABASES WITH NO MAPPED SITES

No mapped sites were found in EDR’s search of available ("reasonably ascertainable ") government records either on the target property or within the ASTM E 1527-00 search radius around the target property for the following databases:

FEDERAL ASTM STANDARD

NPL - National Priority List
Proposed NPL - Proposed National Priority List Sites
CERC-NFRAP - CERCLIS No Further Remedial Action Planned
CORRACTS - Corrective Action Report
RCRA-TSDF - Resource Conservation and Recovery Act Information
RCRA-LQG - Resource Conservation and Recovery Act Information
RCRA-SQG - Resource Conservation and Recovery Act Information
ERNS - Emergency Response Notification System

STATE ASTM STANDARD

SWF/LF - List of Solid Waste Facilities

EXECUTIVE SUMMARY

OLI Old Landfill Inventory
VCP Responsible Party Voluntary Action Sites
INDIAN LUST Leaking Underground Storage Tanks on Indian Land
INDIAN UST Underground Storage Tanks on Indian Land

FEDERAL ASTM SUPPLEMENTAL

CONSENT Superfund (CERCLA) Consent Decrees
ROD Records Of Decision
Delisted NPL National Priority List Deletions
HMIRS Hazardous Materials Information Reporting System
MLTS Material Licensing Tracking System
MINES Mines Master Index File
NPL Liens Federal Superfund Liens
PADS PCB Activity Database System
US ENG CONTROLS Engineering Controls Sites List
ODI Open Dump Inventory
UMTRA Uranium Mill Tailings Sites
FUDS Formerly Used Defense Sites
INDIAN RESERV Indian Reservations
DOD Department of Defense Sites
RAATS RCRA Administrative Action Tracking System
TRIS Toxic Chemical Release Inventory System
TSCA Toxic Substances Control Act
SSTS Section 7 Tracking Systems
FTTS INSP FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)

STATE OR LOCAL ASTM SUPPLEMENTAL

NC HSDS Hazardous Substance Disposal Site
AST AST Database
DRYCLEANERS Drycleaning Sites

EDR PROPRIETARY HISTORICAL DATABASES

Coal Gas Former Manufactured Gas (Coal Gas) Sites

BROWNFIELDS DATABASES

US BROWNFIELDS A Listing of Brownfields Sites
US INST CONTROL Sites with Institutional Controls
Brownfields Brownfields Projects Inventory
INST CONTROL No Further Action Sites With Land Use Restrictions Monitoring
VCP Responsible Party Voluntary Action Sites

SURROUNDING SITES: SEARCH RESULTS

Surrounding sites were identified.

Elevations have been determined from the USGS Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified. Sites with an elevation equal to or higher than the target property have been differentiated below from sites with an elevation lower than the target property.
Page numbers and map identification numbers refer to the EDR Radius Map report where detailed data on individual sites can be reviewed.

Sites listed in ***bold italics*** are in multiple databases.

Unmappable (orphan) sites are not considered in the foregoing analysis.

EXECUTIVE SUMMARY

FEDERAL ASTM STANDARD

CERCLIS: The Comprehensive Environmental Response, Compensation and Liability Information System contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).
CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

A review of the CERCLIS list, as provided by EDR, and dated 02/15/2005 has revealed that there is 1 CERCLIS site within approximately 1.5 miles of the target property.

Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
LAKE WYLIE - BROWNS COVE	*OUTWELL & MALLARANNY RD*	*1 - 2 WSW*	*6*	*14*

STATE ASTM STANDARD

SHWS: The State Hazardous Waste Sites records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. The data come from the Department of Environment & Natural Resources' Inactive Hazardous Sites Program.

A review of the SHWS list, as provided by EDR, has revealed that there is 1 SHWS site within approximately 2 miles of the target property.

Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
LAKE WYLIE - BROWNS COVE	*OUTWELL & MALLARANNY RD*	*1 - 2 WSW*	*6*	*14*

LUST: The Leaking Underground Storage Tank Incidents Management Database contains an inventory of reported leaking underground storage tank incidents. The data come from the Department of Environment, & Natural Resources' Incidents by Address.

A review of the LUST list, as provided by EDR, and dated 06/03/2005 has revealed that there are 3 LUST sites within approximately 1.5 miles of the target property.

Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
LEONARD HORNE JR. PROPERTY	*9100 STEELE CREEK ROAD*	*1/2 - 1 SE*	*2*	*6*
FRANCIS RUPPALT PROPERTY	*9001 STEELE CREEK ROAD*	*1/2 - 1 ESE*	*3*	*8*
BYRUMS GENERAL STORE	*8510 STEELE CREEK ROAD*	*1/2 - 1 ESE*	*4*	*10*

UST: The Underground Storage Tank database contains registered USTs. USTs are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA). The data come from the Department of Environment & Natural Resources' Petroleum Underground Storage Tank Database.

A review of the UST list, as provided by EDR, and dated 04/01/2005 has revealed that there is 1 UST site within approximately 1.25 miles of the target property.

Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
BYRUMS GENERAL STORE	***8510 STEELE CREEK ROAD***	***1/2 - 1 E***	***5***	***11***

FEDERAL ASTM SUPPLEMENTAL

FINDS: The Facility Index System contains both facility information and "pointers" to other sources of information that contain more detail. These include: RCRIS; Permit Compliance System (PCS); Aerometric Information Retrieval System (AIRS); FATES (FIFRA [Federal Insecticide Fungicide Rodenticide Act] and TSCA Enforcement System, FTTS [FIFRA/TSCA Tracking System]; CERCLIS; DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes); Federal Underground Injection Control (FURS); Federal Reporting Data System (FRDS); Surface Impoundments (SIA); TSCA Chemicals in Commerce Information System (CICS); PADS; RCRA-J (medical waste transporters/disposers); TRIS; and TSCA. The source of this database is the U.S. EPA/NTIS.

A review of the FINDS list, as provided by EDR, and dated 04/11/2005 has revealed that there are 2 FINDS sites within approximately 1 mile of the target property.

Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
BYRUMS GENERAL STORE	***8510 STEELE CREEK ROAD***	***1/2 - 1 ESE***	***4***	***10***

Lower Elevation	Address	Dist / Dir	Map ID	Page
RAMOTH AME ZION CHURCH	6800 DIXIE RIVER ROAD	1/2 - 1 W	1	6

STATE OR LOCAL ASTM SUPPLEMENTAL

LUST TRUST: This database contains information about claims against the State Trust Funds for reimbursements for expenses incurred while remediating Leaking USTs.

A review of the LUST TRUST list, as provided by EDR, and dated 05/06/2005 has revealed that there is 1 LUST TRUST site within approximately 1.5 miles of the target property.

Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
BYRUMS GENERAL STORE	***8510 STEELE CREEK ROAD***	***1/2 - 1 E***	***5***	***11***

IMD: Incident Management Database.

A review of the IMD list, as provided by EDR, and dated 06/15/2004 has revealed that there are 3 IMD sites within approximately 1.5 miles of the target property.

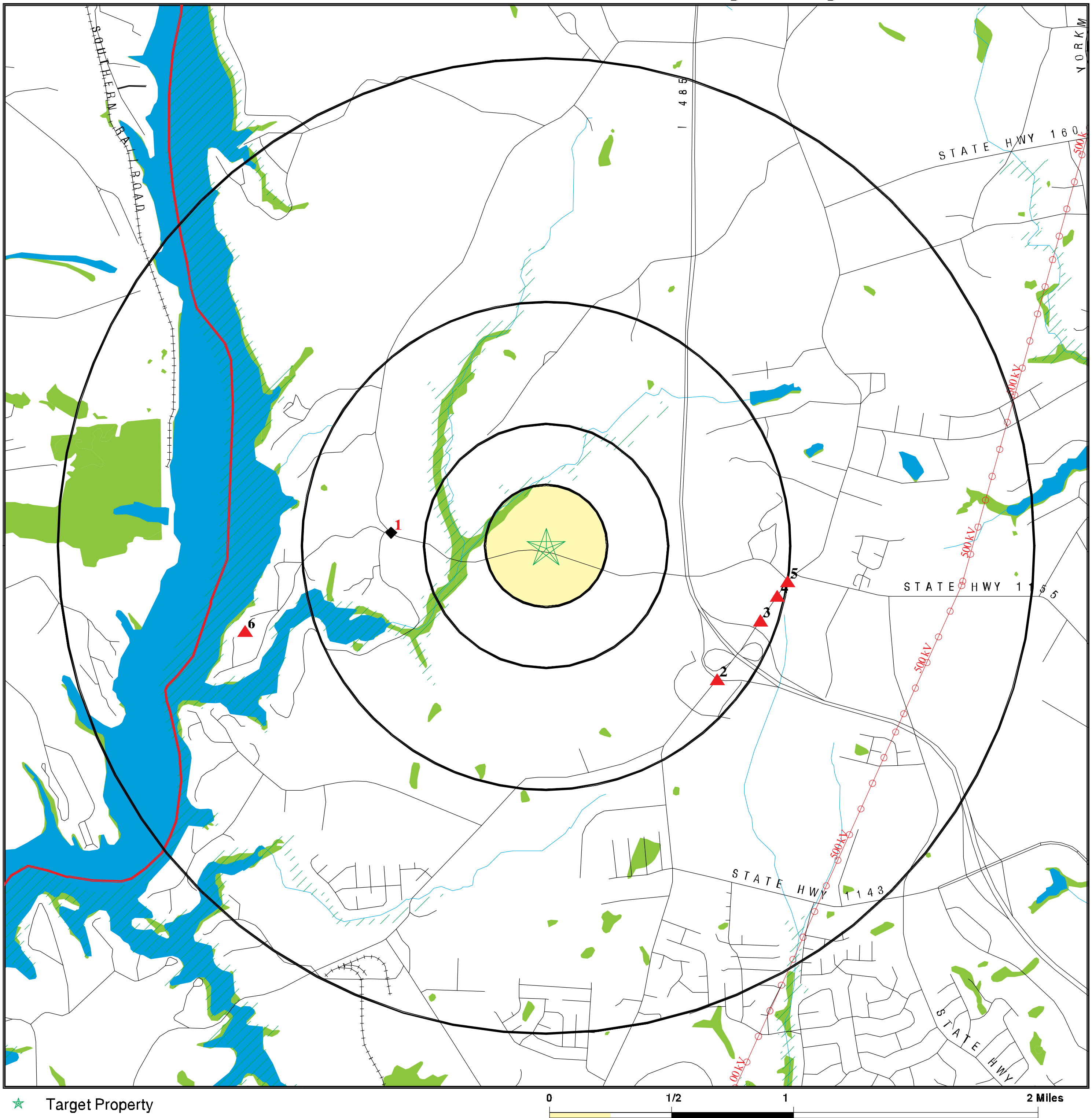
Equal/Higher Elevation	Address	Dist / Dir	Map ID	Page
LEONARD HORNE JR. PROPERTY	***9100 STEELE CREEK ROAD***	***1/2 - 1 SE***	***2***	***6***
FRANCIS RUPPALT PROPERTY	***9001 STEELE CREEK ROAD***	***1/2 - 1 ESE***	***3***	***8***
BYRUMS GENERAL STORE	***8510 STEELE CREEK ROAD***	***1/2 - 1 E***	***5***	***11***

EXECUTIVE SUMMARY

Due to poor or inadequate address information, the following sites were not mapped:

Site Name	Database(s)
INX (FORMER) FACILITY	SHWS
CHARLOTTE CITY DUMP	SHWS, IMD
VAN WATERS & ROGERS	SHWS
POULOS GROUNDWATER CONTAMINATION	SHWS
PRINTING TECHNOLOGY	SHWS
CHARLOTTE COAL GAS PLANT NO. 1	SHWS
H.M. WADE FURNITURE	SHWS, IMD
TEXTILE CHEMICAL FACILITY	SHWS
HWY 49 BATTERY DUMP	SHWS, IMD
OLD MOUNT HOLLY ROAD PCE SITE	SHWS
QUEENS PROPERTY	SHWS
AQUAIR CORPORATION	SHWS, VCP
SCA CHEMICAL SERVICES, INC.	SHWS
DOW CHEMICAL CORP/ALLIED CHEMICAL	SHWS
HARRISBURG ROAD C&D LANDFILL	SWF/LF
HARRISBURG ROAD LANDFILL	SWF/LF
JOHN CROSLAND COMPANY	SWF/LF
HENSON’S, INC. MULCH & MORE	SWF/LF
U-FILLER-UP (BELMONT SUNOCO)	IMD, LUST
MARTIN MARIETTA (FURR PROPERTY	IMD, LUST
AMOCO TERMINAL-SLOP UST	LUST
UNCC	IMD, LUST
LAKE NORMAN QUARRY	IMD, LUST
CRESCENT RESOURCES - DAVIS RD	IMD, LUST
CITY OF CHARLOTTE PROP.-PARCEL	IMD, LUST
HERLOCKER’S PANTRY	IMD, LUST
NCNB - OLD STEELE CREEK RD	IMD, LUST
BELMONT SUNOCO	LUST TRUST
# 2 DAVIS PROPERTY(MARY P. WILLIAM	LUST TRUST
DAVIS PROPERTY(MARY P. WILLIAMS) #	LUST TRUST
PLANTATION PIPELINE - BELMONT	IMD
MALLARD CREEK WWTP	IMD
NCDOT ASPHALT SITE #2 (CROWDER	IMD
STEELE CREEK AND SAM NEELY ROA	IMD
STATESVILLE RD. LF	OLI
CHARLOTTE CITY DUMP/YORK RD LF	OLI

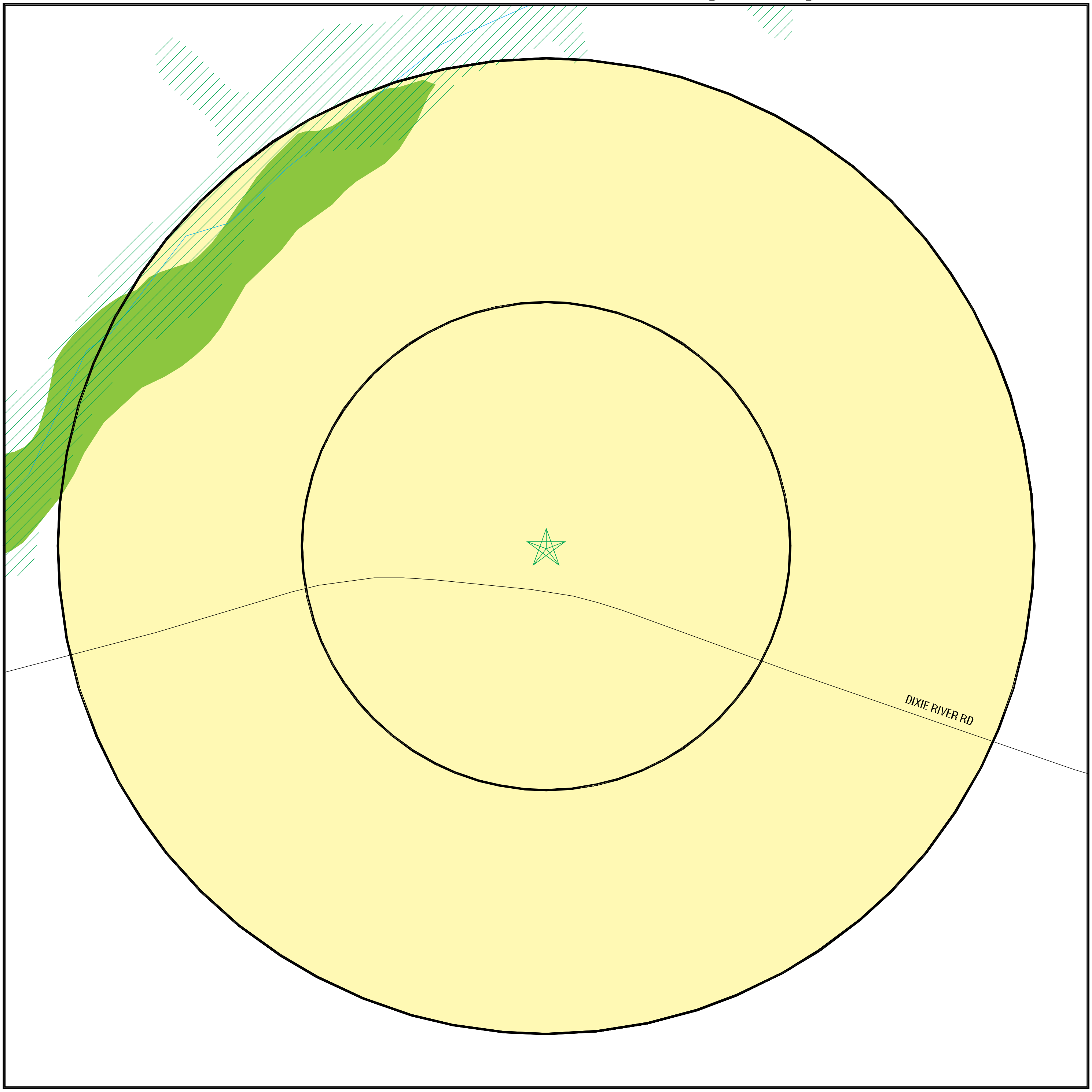
OVERVIEW MAP - 01465089.1r - Buck Engineering



- Target Property
- Sites at elevations higher than or equal to the target property
- Sites at elevations lower than the target property
- Coal Gasification Sites
- National Priority List Sites
- Landfill Sites
- Dept. Defense Sites
- Indian Reservations BIA
- County Boundary
- Power transmission lines
- Oil & Gas pipelines
- 100-year flood zone
- 500-year flood zone
- Federal Wetlands
- Hazardous Substance Disposal Sites

TARGET PROPERTY:	Dixie River Rd	CUSTOMER:	Buck Engineering
ADDRESS:	Dixie River Rd	CONTACT:	Andrea Spangler
CITY/STATE/ZIP:	Charlotte NC 28278	INQUIRY #:	01465089.1r
LAT/LONG:	35.1735 / 80.9792	DATE:	July 13, 2005 7:12 pm

DETAIL MAP - 01465089.1r - Buck Engineering



- Target Property
- Sites at elevations higher than or equal to the target property
- Sites at elevations lower than the target property
- Coal Gasification Sites
- Sensitive Receptors
- National Priority List Sites
- Landfill Sites
- Dept. Defense Sites
- Indian Reservations BIA
- County Boundary
- Oil & Gas pipelines
- 100-year flood zone
- 500-year flood zone
- Federal Wetlands
- Hazardous Substance Disposal Sites

0 1/16 1/8 1/4 Miles

TARGET PROPERTY:	Dixie River Rd	CUSTOMER:	Buck Engineering
ADDRESS:	Dixie River Rd	CONTACT:	Andrea Spangler
CITY/STATE/ZIP:	Charlotte NC 28278	INQUIRY #:	01465089.1r
LAT/LONG:	35.1735 / 80.9792	DATE:	July 13, 2005 7:12 pm

MAP FINDINGS SUMMARY

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
FEDERAL ASTM STANDARD								
NPL		2.000	0	0	0	0	0	0
Proposed NPL		2.000	0	0	0	0	0	0
CERCLIS		1.500	0	0	0	0	1	1
CERC-NFRAP		1.250	0	0	0	0	0	0
CORRACTS		2.000	0	0	0	0	0	0
RCRA TSD		1.500	0	0	0	0	0	0
RCRA Lg. Quan. Gen.		1.250	0	0	0	0	0	0
RCRA Sm. Quan. Gen.		1.250	0	0	0	0	0	0
ERNS		1.000	0	0	0	0	NR	0
STATE ASTM STANDARD								
State Haz. Waste		2.000	0	0	0	0	1	1
State Landfill		1.500	0	0	0	0	0	0
LUST		1.500	0	0	0	3	0	3
UST		1.250	0	0	0	1	0	1
OLI		1.500	0	0	0	0	0	0
VCP		1.500	0	0	0	0	0	0
INDIAN LUST		1.500	0	0	0	0	0	0
INDIAN UST		1.250	0	0	0	0	0	0
FEDERAL ASTM SUPPLEMENTAL								
CONSENT		2.000	0	0	0	0	0	0
ROD		2.000	0	0	0	0	0	0
Delisted NPL		2.000	0	0	0	0	0	0
FINDS		1.000	0	0	0	2	NR	2
HMIRS		1.000	0	0	0	0	NR	0
MLTS		1.000	0	0	0	0	NR	0
MINES		1.250	0	0	0	0	0	0
NPL Liens		1.000	0	0	0	0	NR	0
PADS		1.000	0	0	0	0	NR	0
US ENG CONTROLS		1.500	0	0	0	0	0	0
ODI		1.500	0	0	0	0	0	0
UMTRA		1.500	0	0	0	0	0	0
FUDS		2.000	0	0	0	0	0	0
INDIAN RESERV		2.000	0	0	0	0	0	0
DOD		2.000	0	0	0	0	0	0
RAATS		1.000	0	0	0	0	NR	0
TRIS		1.000	0	0	0	0	NR	0
TSCA		1.000	0	0	0	0	NR	0
SSTS		1.000	0	0	0	0	NR	0
FTTS		1.000	0	0	0	0	NR	0
STATE OR LOCAL ASTM SUPPLEMENTAL								
NC HSDS		2.000	0	0	0	0	0	0

MAP FINDINGS SUMMARY

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
AST		1.000	0	0	0	0	NR	0
LUST TRUST		1.500	0	0	0	1	0	1
DRYCLEANERS		1.250	0	0	0	0	0	0
IMD		1.500	0	0	0	3	0	3
EDR PROPRIETARY HISTORICAL DATABASES								
Coal Gas		2.000	0	0	0	0	0	0
BROWNFIELDS DATABASES								
US BROWNFIELDS		1.500	0	0	0	0	0	0
US INST CONTROL		1.500	0	0	0	0	0	0
Brownfields		1.500	0	0	0	0	0	0
INST CONTROL		1.500	0	0	0	0	0	0
VCP		1.500	0	0	0	0	0	0

NOTES:

AQUIFLOW - see EDR Physical Setting Source Addendum

TP = Target Property

NR = Not Requested at this Search Distance

Sites may be listed in more than one database

Coal Gas Site Search: No site was found in a search of Real Property Scan's ENVIROHAZ database.

1
West
1/2-1
3361 ft.

RAMOTH AME ZION CHURCH
6800 DIXIE RIVER ROAD
CHARLOTTE, NC 28208

FINDS **1007711664**
110018682629

Relative:
Lower

Actual:
661 ft.

FINDS:
Other Pertinent Environmental Activity Identified at Site:
NORTH CAROLINA-FACILITY INFORMATION TRACKING SYSTEM

2
SE
1/2-1
4693 ft.

LEONARD HORNE JR. PROPERTY
9100 STEELE CREEK ROAD
CHARLOTTE, NC

IMD **S105120110**
LUST **N/A**

Relative:
Higher

Actual:
705 ft.

LUST:

Incident Number:	23016	Date Occurred:	11/30/2000
5 Min Quad:	Not reported	Lat/Long:	350955 / 805802
Source Type:	C	Region:	Mooresville
Facility ID:	Not reported	GPS Confirmed:	7
UST Number:	MO-6088	Testlat:	Not reported
Product Type:	Petroleum	Date Reported:	03/08/2001

Responsible Party:

Company:	NCDOT
Contact Person:	GREG SMITH
Address:	PO BOX 25201
City/Stat/Zip:	RALEIGH, NC 27611 - 5201
County:	Not reported
Comm / Non-comm UST Site:	Non commercial
Tank Regulated Status:	Non Regulated
Regional Officer Project Mgr:	AJS
Risk Classification:	H
Risk Classification Based On Review:	L
Corrective Action Plan Type:	Not reported
Level Of Soil Cleanup Achieved:	soil to GW levels
Closure Request Date:	08/31/2001
Close Out:	08/31/2001
Contamination Type:	SL
NORR Issued Date:	04/09/2001

NOV Issued Date:	/ /	Phase Of LSA Req:	1
Site Risk Reason:	Not reported	Land Use:	Residential
MTBE:	0	# Of Supply Wells:	0
Telephone:	Not reported	Flag:	0
Error Flag:	0	LUR Filed:	/ /
Error Code:	Not reported	LUR Filed:	/ /
Valid:	F	Total Tanks:	1
MTBE1:	Unknown	Flag1:	No
Cleanup:	11/30/2000	Current Status:	File Located in Archives
RBCA GW:	Not reported	PETOPT:	4
CD Num:	80	Reel Num:	0
RPOW:	False	RPOP:	False
RPL:	False		
Type:	Not reported		
Ownership:	Private	Location:	Residence
Owner/Operator:	LEONARD HORNE, JR.	Operation Type:	Residential

LEONARD HORNE JR. PROPERTY (Continued) **S105120110**

Site Priority:	Not reported	Priority Update:	03/14/2001
Wells Affected:	No	Wells Affected #:	0
Samples Taken:	Not reported	Samples Include:	Not reported
5minquad:	Not reported	Error Type:	Not reported
Submitted:	03/14/2001		
Description:	SOIL CONTAMINATION DISCOVERED DURING UST REMOVAL		
Last Modified:	09/12/2001		
Incident Phase:	Closed Out		
NOV Issued:	/ /	NORR Issued:	/ /
45 Day Report:	/ /	SOC Sighned:	/ /
Close-out Report:	08/31/2001	RS Designation:	/ /
Public Meeting Held:	/ /		
Corrective Action Planned:	/ /		
Reclassification Report:	/ /		
Closure Request Date:	/ /		
Comments:	Not reported		

IMD:

Incident Number:	23016		
Region:	MOR		
Date Occurred:	11/30/00		
Submit Date:	03/14/01		
GW Contam:	No		
Soil Contam:	Yes		
Operator:	GREG SMITH PO BOX 25201 RALEIGH, NC 27611 - 5201		
Contact Phone:	Not reported		
Priority Code:	H		
Priority Update:	03/14/01		
Site Priority:	H		
Dem Contact:	AJS		
Wells Affected:	No		
Num Affected:	0		
Sampled By:	Samples Include:		
7.5 Min Quad:	Not reported		
5 Min Quad:	Not reported		
Incident Desc:	SOIL CONTAMINATION DISCOVERED DURING UST REMOVAL		
Ownership:	Private		
Operation:	Residential		
Material:	Not reported		
Qty Lost:	Not reported		
Qty Recovered:	Not reported		
Source:	Leak-underground		
Type:	Gasoline/diesel		
Location:	Residence		
Setting:	Residential		
Wells Contam:	Not reported		
Sampled By:	Not reported		
Samples Include:	Not reported		
Owner Company:	NCDOT		
Lat/Long:	350955 / 805802		
Risk Site	H		
Lat/Long Decimal:	35.16528 / 80.96722		
Lat/Long Number :	350955 / 805802		
GPS:	EST	Agency :	DWM
Incident Phase:	Closed Out	Last Modified	09/12/01
NOV Issued:	/ /		

LEONARD HORNE JR. PROPERTY (Continued) **S105120110**

45 Day Report: / /
SOC Sighned: / /
Public Meeting Held: / /
Corrective Action Planned: / /
Reclassification Report: / /
Close-out Report: 08/31/01
RS Designation: / /
Closure Request Date: / /

3
ESE
1/2-1
4911 ft.

FRANCIS RUPPALT PROPERTY
9001 STEELE CREEK ROAD
CHARLOTTE, NC

IMD **S105120118**
LUST **N/A**

Relative:
Higher

Actual:
731 ft.

LUST:
Incident Number: 23028
Date Occurred: 11/30/2000
5 Min Quad: Not reported
Lat/Long: 355759 / 800956
Source Type: C
Region: Mooresville
Facility ID: Not reported
GPS Confirmed: 7
UST Number: MO-6091
Testlat: Not reported
Product Type: Petroleum
Date Reported: 03/20/2001
Responsible Party:
Company: FRANCIS RUPPALT & NCDOT
Contact Person: NCDOT-CYRUS PARKER
Address: Not reported
City/Stat/Zip: NC
County: Not reported
Comm / Non-comm UST Site: Non commercial
Tank Regulated Status: Non Regulated
Regional Officer Project Mgr: AJS
Risk Classification: H
Risk Classification Based On Review: L
Corrective Action Plan Type: Not reported
Level Of Soil Cleanup Achieved: soil to GW levels
Closure Request Date: 08/31/2001
Close Out: 08/31/2001
Contamination Type: SL
NORR Issued Date: 03/14/2001
NOV Issued Date: / /
Phase Of LSA Req: 1
Site Risk Reason: Not reported
Land Use: Residential
MTBE: 0
\# Of Supply Wells: 0
Telephone: Not reported
Flag: 0
Error Flag: 0
LUR Filed: / /
Error Code: Not reported
LUR Filed: / /
Valid: F
Total Tanks: 1
MTBE1: Unknown
Flag1: No
Cleanup: 11/30/2000
Current Status: File Located in Archives
RBCA GW: Not reported
PETOPT: 4
CD Num: 80
Reel Num: 0
RPOW: False
RPOP: False
RPL: False
Type: Not reported
Ownership: Private
Location: Residence
Owner/Operator: Not reported
Operation Type: Residential
Site Priority: Not reported
Priority Update: 03/21/2001
Wells Affected: No
Wells Affected #: 0
Samples Taken: Not reported
Samples Include: Not reported
5minquad: Not reported
Error Type: Not reported
Submitted: 03/20/2001
Description: SOIL CONTAMINATION DISCOVERED DURING UST REMOVAL
Last Modified: 09/12/2001

FRANCIS RUPPALT PROPERTY (Continued) **S105120118**

Incident Phase: Closed Out
NOV Issued: / / NORR Issued: / /
45 Day Report: / / SOC Sighned: / /
Close-out Report: 08/31/2001 RS Designation: / /
Public Meeting Held: / /
Corrective Action Planned: / /
Reclassification Report: / /
Closure Request Date: / /
Comments: Not reported

IMD:
Incident Number: 23028
Region: MOR
Date Occurred: 11/30/00
Submit Date: 03/20/01
GW Contam: No
Soil Contam: Yes
Operator: NCDOT-CYRUS PARKER
Not reported
NC
Contact Phone: Not reported
Priority Code: H
Priority Update: 03/21/01
Site Priority: H
Dem Contact: AJS
Wells Affected: No
Num Affected: 0
Sampled By: Samples Include:
7.5 Min Quad: Not reported
5 Min Quad: Not reported
Incident Desc: SOIL CONTAMINATION DISCOVERED DURING UST REMOVAL
Ownership: Private
Operation: Residential
Material: Not reported
Qty Lost: Not reported
Qty Recovered: Not reported
Source: Leak-underground
Type: Gasoline/diesel
Location: Residence
Setting: Residential
Wells Contam: Not reported
Sampled By: Not reported
Samples Include: Not reported
Owner Company: FRANCIS RUPPALT & NCDOT
Lat/Long: 355759 / 800956
Risk Site H
Lat/Long Decimal: 35.96639 / 80.16556
Lat/Long Number : 355759 / 800956
GPS: EST Agency : DWM
Incident Phase: Closed Out Last Modified 09/12/01
NOV Issued: / /
45 Day Report: / / SOC Sighned: / /
Public Meeting Held: / /
Corrective Action Planned: / /
Reclassification Report: / /
Close-out Report: 08/31/01 RS Designation: / /
Closure Request Date: / /

4 **BYRUMS GENERAL STORE** **FINDS** **1007698931**
ESE **8510 STEELE CREEK ROAD** **LUST** **110018555197**
1/2-1 **CHARLOTTE, NC 28217**
5120 ft.

Relative:
Higher

Actual:
729 ft.

FINDS:
Other Pertinent Environmental Activity Identified at Site:
NORTH CAROLINA-FACILITY INFORMATION TRACKING SYSTEM

LUST:

Incident Number:	16774	Date Occurred:	01/27/1997
5 Min Quad:	W67R	Lat/Long:	351015 / 805746
Source Type:	Not reported	Region:	Mooresville
Facility ID:	0-026128	GPS Confirmed:	7
UST Number:	MO-4917	Testlat:	Not reported
Product Type:	Petroleum	Date Reported:	01/28/1997

Responsible Party:
Company: Not reported
Contact Person: MR. ROBBY BYRUM
Address: 8510 STEELE CREEK ROAD
City/Stat/Zip: CHARLOTTE, NC 28273
County: MECKLENBURG

Comm / Non-comm UST Site:	Commercial
Tank Regulated Status:	Regulated
Regional Officer Project Mgr:	AJS
Risk Classification:	H
Risk Classification Based On Review:	L
Corrective Action Plan Type:	Not reported
Level Of Soil Cleanup Achieved:	Not reported
Closure Request Date:	10/09/1999
Close Out:	/ /
Contamination Type:	GW
NORR Issued Date:	01/31/1997

NOV Issued Date:	08/15/1997	Phase Of LSA Req:	Not reported
Site Risk Reason:	Not reported	Land Use:	Not reported
MTBE:	0	# Of Supply Wells:	0
Telephone:	(704)588-0434	Flag:	0
Error Flag:	0	LUR Filed:	/ /
Error Code:	Not reported	LUR Filed:	/ /
Valid:	F	Total Tanks:	1
MTBE1:	Unknown	Flag1:	No
Cleanup:	01/27/1997	Current Status:	File Located in House
RBCA GW:	Not reported	PETOPT:	3
CD Num:	0	Reel Num:	0
RPOW:	False	RPOP:	False
RPL:	False		
Type:	Pirf		
Ownership:	Private	Location:	Facility
Owner/Operator:	MR. ROBBY BYRUM	Operation Type:	Commercial
Site Priority:	060E	Priority Update:	05/15/1998
Wells Affected:	No	Wells Affected #:	0
Samples Taken:	3	Samples Include:	2
5minquad:	Not reported	Error Type:	Not reported
Submitted:	01/31/1997		

Description: UPON REMOVAL OF TWO USTS; TPH AS HIGH AS 16,000 PPM WAS FOUND.

Last Modified:	08/04/1998		
Incident Phase:	Follow Up		
NOV Issued:	08/15/1997	NORR Issued:	06/11/1998
45 Day Report:	/ /	SOC Sighned:	/ /
Close-out Report:	/ /	RS Designation:	/ /

BYRUMS GENERAL STORE (Continued) **1007698931**

Public Meeting Held: / /
Corrective Action Planned: / /
Reclassification Report: / /
Closure Request Date: / /
Comments: ALL WSW'S ABANDONED AND HOOKED TO CITY WATER

5	**BYRUMS GENERAL STORE**	**IMD**	**U001202794**
East	**8510 STEELE CREEK ROAD**	**UST**	**N/A**
1/2-1	**CHARLOTTE, NC 28217**	**LUST TRUST**	
5279 ft.			

Relative:
Higher

Actual:
729 ft.

LUST TRUST:
Facility ID : 0-026128
Site ID : 16774
Site Note: Not reported
Site Eligible?: True
Commercial Find : 100% Commercial
Priority Rank: High
3rd Party Deductable Amount: 100000
Sum of 3rd Party Amounts Applied: 0
Deductable Amount: 75000

Click this hyperlink while viewing on your computer to access additional NC LUST TRUST detail in the EDR Site Report.

IMD:
Incident Number: 16774
Region: MOR
Date Occurred: 01/27/97
Submit Date: 01/31/97
GW Contam: Yes
Soil Contam: No
Operator: MR. ROBBY BYRUM
8510 STEELE CREEK ROAD
CHARLOTTE, NC 28273
MECKL County
Contact Phone: (704)588-0434
Priority Code: H
Priority Update: 05/15/98
Site Priority: 060B
Dem Contact: AJS
Wells Affected: No
Num Affected: 0
Sampled By: Samples Include:
7.5 Min Quad: Not reported
5 Min Quad: W67R
Incident Desc: UPON REMOVAL OF TWO USTS; TPH AS HIGH AS 16,000 PPM WAS FOUND.
Ownership: Private
Operation: Commercial
Material: GASOLINE
Qty Lost: Not reported
Qty Recovered: Not reported
Source: Leak-underground
Type: Gasoline/diesel
Location: Facility
Setting: Residential
Wells Contam: Not reported
Sampled By: Responsible Parties
Samples Include: Soil Samples

BYRUMS GENERAL STORE (Continued) **U001202794**

Owner Company: Not reported
Lat/Long: 351015 / 805746
Risk Site H
Lat/Long Decimal: 35.17083 / 80.96278
Lat/Long Number : 351015 / 805746
GPS: EST | Agency : DWM
Incident Phase: Follow Up | Last Modified 08/04/98
NOV Issued: 08/15/97
45 Day Report: / / | SOC Sighned: / /
Public Meeting Held: / /
Corrective Action Planned: / /
Reclassification Report: / /
Close-out Report: / / | RS Designation: / /
Closure Request Date: / /

UST:
Facility ID: 0-026128
Telephone: (704) 588-0434
Owner name : BYRUMS GENERAL STORE
Owner Address: 8510 STEELECREEK ROAD

CHARLOTTE, NC 28217
Owner Phone : (704) 588-0434
Tank capacity : 1000
Comment : Not reported
Tank product : Gasoline, Gasoline Mixture
Tank material : Steel
Interior Protection: None
Exterior Protection: Paint
Piping material : Steel
Certify Type : Not reported
Leak Detection Type : Not reported
Leak Detection Type 2: Not reported
Leak Detection Piping 1: Not reported
Corrosn Protec Tank: Not reported
Corrosn Protec Pipe: Not reported
Spill and Overfill : Not reported
Financial Responsiblity : Not reported
Region: 03
Tank ID: 1
Date installed: 09/23/1980
Date removed: 12/31/1996
Status: Permanent Closed
Compartment Tank : No
Main Tank : No
Product Type: NON
Piping System Type Code: Not reported
Piping System Type Description: Not reported
Corrosion Protection Tank1: Not reported
Corrosion Protection Tank Date: / /
Corrosion Piping: Not reported
Corrosion Protection Piping Date: / /
Overfill: Not reported
Spill Overfill Date: / /
Financial Responsibility Code: Not reported
Financial Responsibility Description: Not reported
Surface Water: Not reported
Water Supply Well: Not reported

BYRUMS GENERAL STORE (Continued) **U001202794**

Tank Last Used Date:	/ /
Tank Certified Number:	199601160O
Date Last Certified:	12/03/1996
Begin Certified Number:	01/07/1996
End Certified Number:	/ /
Lat/Long :	0 / 0
Lat/Long 1 :	Not reported
GPS String Confirmed:	No
Initials of Individual Confirming GPS:	Not reported
Tank ID Number:	Not reported
Last Update:	01/06/1997

Facility ID:	0-026128
Telephone:	(704) 588-0434
Owner name :	BYRUMS GENERAL STORE
Owner Address:	8510 STEELECREEK ROAD
	CHARLOTTE, NC 28217
Owner Phone :	(704) 588-0434
Tank capacity :	1000
Comment :	Not reported
Tank product :	Gasoline, Gasoline Mixture
Tank material :	Steel
Interior Protection:	None
Exterior Protection:	Paint
Piping material :	Steel
Certify Type :	Not reported
Leak Detection Type :	Not reported
Leak Detection Type 2:	Not reported
Leak Detection Piping 1:	Not reported
Corrosn Protec Tank:	Not reported
Corrosn Protec Pipe:	Not reported
Spill and Overfill :	Not reported
Financial Responsiblity :	Not reported
Region:	03
Tank ID:	2
Date installed:	09/23/1980
Date removed:	12/31/1996
Status:	Permanent Closed
Compartment Tank :	No
Main Tank :	No
Product Type:	NON
Piping System Type Code:	Not reported
Piping System Type Description:	Not reported
Corrosion Protection Tank1:	Not reported
Corrosion Protection Tank Date:	/ /
Corrosion Piping:	Not reported
Corrosion Protection Piping Date:	/ /
Overfill:	Not reported
Spill Overfill Date:	/ /
Financial Responsibility Code:	Not reported
Financial Responsibility Description:	Not reported
Surface Water:	Not reported
Water Supply Well:	Not reported
Tank Last Used Date:	/ /
Tank Certified Number:	199601160O
Date Last Certified:	12/03/1996

BYRUMS GENERAL STORE (Continued) **U001202794**

Begin Certified Number:	01/07/1996
End Certified Number:	/ /
Lat/Long :	0 / 0
Lat/Long 1 :	Not reported
GPS String Confirmed:	No
Initials of Individual Confirming GPS:	Not reported
Tank ID Number:	Not reported
Last Update:	01/06/1997

6
WSW
> 1
6767 ft.

LAKE WYLIE - BROWNS COVE
OUTWELL & MALLARANNY RD
CHARLOTTE, NC 28208

CERCLIS **1001114865**
SHWS **NC0001329507**
FINDS

Relative:
Equal

Actual:
692 ft.

CERCLIS Classification Data:

Site incident category:	Not reported	Federal Facility:	Not a Federal Facility
Non NPL Status:	NFRAP		
Ownership Status:	Not reported	NPL Status:	Not on the NPL
Contact:	GIEZELLE BENNETT	Contact Tel:	(404) 562-8824
Contact Title:	Not reported		
Contact:	JON BORNHOLM	Contact Tel:	(404) 562-8820
Contact Title:	Not reported		
Contact:	Beth Brown	Contact Tel:	(404) 562-8814
Contact Title:	Not reported		
Contact:	RANDALL CHAFFINS	Contact Tel:	(404) 562-8929
Contact Title:	Not reported		
Contact:	BARBARA DICK	Contact Tel:	(404) 562-8923
Contact Title:	Not reported		
Contact:	Ralph Howard	Contact Tel:	(404) 562-8829
Contact Title:	Not reported		
Contact:	BEVERLY HUDSON	Contact Tel:	(404) 562-8816
Contact Title:	Not reported		
Contact:	William Joyner	Contact Tel:	(404) 562-8795
Contact Title:	Not reported		
Contact:	KEN LUCAS	Contact Tel:	(404) 562-8953
Contact Title:	Not reported		
Contact:	KEN MALLARY	Contact Tel:	(404) 562-8802
Contact Title:	Not reported		
Contact:	Mike Norman	Contact Tel:	(404) 562-8792
Contact Title:	Not reported		
Contact:	STEVE SPURLIN	Contact Tel:	(731) 394-8996
Contact Title:	Not reported		
Contact:	MICHAEL TOWNSEND	Contact Tel:	(404) 562-8813
Contact Title:	Not reported		
Contact:	SAMANTHA URQUHART F	Contact Tel:	(404) 562-8760
Contact Title:	Not reported		
Site Description:	SITE REFERRED TO ERRB FROM STATE. SITE INVESTIGATION INDICATES HIGH LEAD CONC. ON GRAVEL ROADWAY.		

CERCLIS Assessment History:

Assessment:	DISCOVERY	Completed:	01/24/1996
Assessment:	ADMIN ORDER ON CONSENT	Completed:	09/10/1996
Assessment:	PRP REMOVAL	Completed:	12/23/1996
Assessment:	ADMINISTRATIVE RECORDS	Completed:	04/25/1997
Assessment:	INT. RMVL ASSESS AND COMBINED PA/SI	Completed:	09/30/1998

CERCLIS Site Status:
NFRAP (No Futher Remedial Action Planned

LAKE WYLIE - BROWNS COVE (Continued) **1001114865**

FINDS:
Other Pertinent Environmental Activity Identified at Site:
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND INFORMATION SYSTEM
INTEGRATED COMPLIANCE INFORMATION SYSTEM

SHWS:
Facility ID: NC0001329507

City	EDR ID	Site Name	Site Address	Zip	Database(s)
BELMONT	1004376390	BELMONT SUNOCO	I-85 / ROUTE 273	28012	LUST TRUST
BELMONT	S105201494	PLANTATION PIPELINE - BELMONT	HIGHWAY 273	28012	IMD
BELMONT	S105764624	U-FILLER-UP (BELMONT SUNOCO)	HWY 273 / CALDWELL DRIVE	28012	IMD, LUST
CHARLOTTE	S105219555	# 2 DAVIS PROPERTY(MARY P. WILLIAM	4701 SR 1142		LUST TRUST
CHARLOTTE	S105219556	DAVIS PROPERTY(MARY P. WILLIAMS) #	4515 SR 1142		LUST TRUST
CHARLOTTE	S106521456	STATESVILLE RD. LF	HWY 21 OR SR 2691? (STATESVILL		OLI
CHARLOTTE	S105764416	MARTIN MARIETTA (FURR PROPERTY	HWY 27 AT LONG CREEK		IMD, LUST
CHARLOTTE	S106520612	AMOCO TERMINAL-SLOP UST	HIGHWAY 27-PAW CREEK		LUST
CHARLOTTE	S105163848	HARRISBURG ROAD C&D LANDFILL	S.R. 2805		SWF/LF
CHARLOTTE	S105163849	HARRISBURG ROAD LANDFILL	SR 2805		SWF/LF
CHARLOTTE	S105425775	MALLARD CREEK WWTP	12400 HIGHWAY 29 NORTH		IMD
CHARLOTTE	S106846713	INX (FORMER) FACILITY	3200 / 3210 CULLMAN AVE		SHWS
CHARLOTTE	S106521455	CHARLOTTE CITY DUMP/YORK RD LF	NC 49 S/5600 YORK RD, EXPANDED		OLI
CHARLOTTE	S105029487	CHARLOTTE CITY DUMP	HWY 49 - YORK ROAD		SHWS, IMD
CHARLOTTE	S105764583	UNCC	HWY 49 UNC-C STATION		IMD, LUST
CHARLOTTE	S103717750	LAKE NORMAN QUARRY	HWY 73 / KNOX ROAD		IMD, LUST
CHARLOTTE	S103229559	VAN WATERS & ROGERS	ATANDO INDUSTRIAL PARK		SHWS
CHARLOTTE	S103554735	POULOS GROUNDWATER CONTAMINATION	SOUTH BOULEVARD		SHWS
CHARLOTTE	S104919074	PRINTING TECHNOLOGY	1009 CARPET STREET		SHWS
CHARLOTTE	S104918959	CHARLOTTE COAL GAS PLANT NO. 1	S. COLLEGE STREET		SHWS
CHARLOTTE	S105912077	NCDOT ASPHALT SITE #2 (CROWDER	CROWDER CONST, HWY 16		IMD
CHARLOTTE	S104410902	H.M. WADE FURNITURE	SOUTH GRAHAM STREET		SHWS, IMD
CHARLOTTE	S103554595	TEXTILE CHEMICAL FACILITY	GRAHAM STREET		SHWS
CHARLOTTE	S103229259	HWY 49 BATTERY DUMP	NC HIGHWAY 49		SHWS, IMD
CHARLOTTE	S105764740	CRESCENT RESOURCES - DAVIS RD	JOHN B DAVIS ROAD		IMD, LUST
CHARLOTTE	S103240231	JOHN CROSLAND COMPANY	NEWLAND ROAD		SWF/LF
CHARLOTTE	S103554495	OLD MOUNT HOLLY ROAD PCE SITE	OLD MT HOLLY RD / FREEDOM DR		SHWS
CHARLOTTE	S105040811	HENSON'S, INC. MULCH & MORE	OLD LANDCASTER HWY		SWF/LF
CHARLOTTE	S105764597	CITY OF CHARLOTTE PROP.-PARCEL	PARCEL 4, HWY 51 DISTRICT		IMD, LUST
CHARLOTTE	1000707747	QUEENS PROPERTY	RESEARCH DRIVE		SHWS
CHARLOTTE	S105764762	HERLOCKER'S PANTRY	U S HWY 29		IMD, LUST
CHARLOTTE	S103229044	AQUAIR CORPORATION	133000 SAM NEELY RD		SHWS, VCP
CHARLOTTE	S105764572	NCNB - OLD STEELE CREEK RD	2300 STEELE CREEK RD		IMD, LUST
CHARLOTTE	S105911904	STEELE CREEK AND SAM NEELY ROA	STEELE CREEK / SAM NEELY ROA		IMD
CHARLOTTE	S104919092	SCA CHEMICAL SERVICES, INC.	WAS NEVER BUILT		SHWS
CHARLOTTE	1000106575	DOW CHEMICAL CORP/ALLIED CHEMICAL	2 WOODLAWN GREEN RD		SHWS

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Elapsed ASTM days: Provides confirmation that this EDR report meets or exceeds the 90-day updating requirement of the ASTM standard.

FEDERAL ASTM STANDARD RECORDS

NPL: National Priority List
Source: EPA
Telephone: N/A
National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC) and regional EPA offices.

Date of Government Version: 04/28/05
Date Made Active at EDR: 05/16/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 05/04/05
Elapsed ASTM days: 12
Date of Last EDR Contact: 05/04/05

NPL Site Boundaries

Sources:

EPA's Environmental Photographic Interpretation Center (EPIC)
Telephone: 202-564-7333

EPA Region 1
Telephone 617-918-1143

EPA Region 3
Telephone 215-814-5418

EPA Region 4
Telephone 404-562-8033

EPA Region 6
Telephone: 214-655-6659

EPA Region 8
Telephone: 303-312-6774

Proposed NPL: Proposed National Priority List Sites
Source: EPA
Telephone: N/A

Date of Government Version: 04/27/05
Date Made Active at EDR: 05/16/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 05/04/05
Elapsed ASTM days: 12
Date of Last EDR Contact: 05/04/05

CERCLIS: Comprehensive Environmental Response, Compensation, and Liability Information System
Source: EPA
Telephone: 703-413-0223
CERCLIS contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLIS contains sites which are either proposed to or on the National Priorities List (NPL) and sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 02/15/05
Date Made Active at EDR: 04/06/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 03/22/05
Elapsed ASTM days: 15
Date of Last EDR Contact: 03/22/05

CERCLIS-NFRAP: CERCLIS No Further Remedial Action Planned
Source: EPA
Telephone: 703-413-0223
As of February 1995, CERCLIS sites designated "No Further Remedial Action Planned" (NFRAP) have been removed from CERCLIS. NFRAP sites may be sites where, following an initial investigation, no contamination was found, contamination was removed quickly without the need for the site to be placed on the NPL, or the contamination was not serious enough to require Federal Superfund action or NPL consideration. EPA has removed approximately 25,000 NFRAP sites to lift the unintended barriers to the redevelopment of these properties and has archived them as historical records so EPA does not needlessly repeat the investigations in the future. This policy change is part of the EPA's Brownfields Redevelopment Program to help cities, states, private investors and affected citizens to promote economic redevelopment of unproductive urban sites.

Date of Government Version: 03/22/05
Date Made Active at EDR: 04/06/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 04/01/05
Elapsed ASTM days: 5
Date of Last EDR Contact: 04/01/05

CORRACTS: Corrective Action Report
Source: EPA
Telephone: 800-424-9346
CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 03/29/05
Date Made Active at EDR: 05/16/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 04/11/05
Elapsed ASTM days: 35
Date of Last EDR Contact: 03/07/05

RCRA: Resource Conservation and Recovery Act Information
Source: EPA
Telephone: 800-424-9346
RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. RCRAInfo replaces the data recording and reporting abilities of the Resource Conservation and Recovery Information System (RCRIS). The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Conditionally exempt small quantity generators (CESQGs) generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month. Small quantity generators (SQGs) generate between 100 kg and 1,000 kg of hazardous waste per month. Large quantity generators (LQGs) generate over 1,000 kilograms (kg) of hazardous waste, or over 1 kg of acutely hazardous waste per month. Transporters are individuals or entities that move hazardous waste from the generator off-site to a facility that can recycle, treat, store, or dispose of the waste. TSDFs treat, store, or dispose of the waste.

Date of Government Version: 05/20/05
Date Made Active at EDR: 06/09/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 05/24/05
Elapsed ASTM days: 16
Date of Last EDR Contact: 05/24/05

ERNS: Emergency Response Notification System
Source: National Response Center, United States Coast Guard
Telephone: 202-260-2342
Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 12/31/04
Date Made Active at EDR: 03/24/05
Database Release Frequency: Annually
Date of Data Arrival at EDR: 01/27/05
Elapsed ASTM days: 56
Date of Last EDR Contact: 04/25/05

FEDERAL ASTM SUPPLEMENTAL RECORDS

BRS: Biennial Reporting System
Source: EPA/NTIS
Telephone: 800-424-9346
The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/01/01
Database Release Frequency: Biennially
Date of Last EDR Contact: 04/15/05
Date of Next Scheduled EDR Contact: 06/13/05

CONSENT: Superfund (CERCLA) Consent Decrees
Source: Department of Justice, Consent Decree Library
Telephone: Varies
Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: 12/14/04
Database Release Frequency: Varies
Date of Last EDR Contact: 04/26/05
Date of Next Scheduled EDR Contact: 07/25/05

ROD: Records Of Decision
Source: EPA
Telephone: 703-416-0223
Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 03/07/05
Database Release Frequency: Annually
Date of Last EDR Contact: 04/04/05
Date of Next Scheduled EDR Contact: 07/04/05

DELISTED NPL: National Priority List Deletions
Source: EPA
Telephone: N/A
The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 04/28/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 05/04/05
Date of Next Scheduled EDR Contact: 08/01/05

FINDS: Facility Index System/Facility Identification Initiative Program Summary Report
Source: EPA
Telephone: N/A
Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 04/11/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 04/04/05
Date of Next Scheduled EDR Contact: 07/04/05

HMIRS: Hazardous Materials Information Reporting System
Source: U.S. Department of Transportation
Telephone: 202-366-4555
Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 12/31/04
Database Release Frequency: Annually
Date of Last EDR Contact: 04/19/05
Date of Next Scheduled EDR Contact: 07/18/05

MLTS: Material Licensing Tracking System
Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/14/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 04/04/05
Date of Next Scheduled EDR Contact: 07/04/05

MINES: Mines Master Index File
Source: Department of Labor, Mine Safety and Health Administration
Telephone: 303-231-5959
Contains all mine identification numbers issued for mines active or opened since 1971. The data also includes violation information.

Date of Government Version: 02/11/05
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 03/30/05
Date of Next Scheduled EDR Contact: 06/27/05

NPL LIENS: Federal Superfund Liens
Source: EPA
Telephone: 202-564-4267
Federal Superfund Liens. Under the authority granted the USEPA by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner receives notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/91
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 02/22/05
Date of Next Scheduled EDR Contact: 05/23/05

PADS: PCB Activity Database System
Source: EPA
Telephone: 202-564-3887
PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 03/30/05
Database Release Frequency: Annually
Date of Last EDR Contact: 05/10/05
Date of Next Scheduled EDR Contact: 08/08/05

DOD: Department of Defense Sites
Source: USGS
Telephone: 703-692-8801
This data set consists of federally owned or administered lands, administered by the Department of Defense, that have any area equal to or greater than 640 acres of the United States, Puerto Rico, and the U.S. Virgin Islands.

Date of Government Version: 10/01/03
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 02/08/05
Date of Next Scheduled EDR Contact: 05/09/05

UMTRA: Uranium Mill Tailings Sites
Source: Department of Energy
Telephone: 505-845-0011
Uranium ore was mined by private companies for federal government use in national defense programs. When the mills shut down, large piles of the sand-like material (mill tailings) remain after uranium has been extracted from the ore. Levels of human exposure to radioactive materials from the piles are low; however, in some cases tailings were used as construction materials before the potential health hazards of the tailings were recognized. In 1978, 24 inactive uranium mill tailings sites in Oregon, Idaho, Wyoming, Utah, Colorado, New Mexico, Texas, North Dakota, South Dakota, Pennsylvania, and on Navajo and Hopi tribal lands, were targeted for cleanup by the Department of Energy.

Date of Government Version: 12/29/04
Database Release Frequency: Varies
Date of Last EDR Contact: 03/22/05
Date of Next Scheduled EDR Contact: 06/20/05

ODI: Open Dump Inventory
Source: Environmental Protection Agency
Telephone: 800-424-9346
An open dump is defined as a disposal facility that does not comply with one or more of the Part 257 or Part 258 Subtitle D Criteria.

Date of Government Version: 06/30/85
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 05/23/95
Date of Next Scheduled EDR Contact: N/A

FUDS: Formerly Used Defense Sites
Source: U.S. Army Corps of Engineers
Telephone: 202-528-4285
The listing includes locations of Formerly Used Defense Sites properties where the US Army Corps of Engineers is actively working or will take necessary cleanup actions.

Date of Government Version: 12/31/03
Database Release Frequency: Varies

Date of Last EDR Contact: 04/04/05
Date of Next Scheduled EDR Contact: 07/04/05

INDIAN RESERV: Indian Reservations
Source: USGS
Telephone: 202-208-3710
This map layer portrays Indian administered lands of the United States that have any area equal to or greater than 640 acres.

Date of Government Version: 10/01/03
Database Release Frequency: Semi-Annually

Date of Last EDR Contact: 02/08/05
Date of Next Scheduled EDR Contact: 05/09/05

US ENG CONTROLS: Engineering Controls Sites List
Source: Environmental Protection Agency
Telephone: 703-603-8867
A listing of sites with engineering controls in place. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health.

Date of Government Version: 01/10/05
Database Release Frequency: Varies

Date of Last EDR Contact: 04/04/05
Date of Next Scheduled EDR Contact: 07/04/05

RAATS: RCRA Administrative Action Tracking System
Source: EPA
Telephone: 202-564-4104
RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/95
Database Release Frequency: No Update Planned

Date of Last EDR Contact: 03/07/05
Date of Next Scheduled EDR Contact: 06/06/05

TRIS: Toxic Chemical Release Inventory System
Source: EPA
Telephone: 202-566-0250
Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/02
Database Release Frequency: Annually

Date of Last EDR Contact: 03/22/05
Date of Next Scheduled EDR Contact: 06/20/05

TSCA: Toxic Substances Control Act
Source: EPA
Telephone: 202-260-5521
Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/02
Database Release Frequency: Every 4 Years

Date of Last EDR Contact: 04/05/05
Date of Next Scheduled EDR Contact: 06/06/05

FTTS INSP: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
Source: EPA
Telephone: 202-566-1667

Date of Government Version: 04/13/05
Database Release Frequency: Quarterly

Date of Last EDR Contact: 03/21/05
Date of Next Scheduled EDR Contact: 06/20/05

SSTS: Section 7 Tracking Systems
Source: EPA
Telephone: 202-564-4203
Section 7 of the Federal Insecticide, Fungicide and Rodenticide Act, as amended (92 Stat. 829) requires all registered pesticide-producing establishments to submit a report to the Environmental Protection Agency by March 1st each year. Each establishment must report the types and amounts of pesticides, active ingredients and devices being produced, and those having been produced and sold or distributed in the past year.

Date of Government Version: 12/31/03
Database Release Frequency: Annually
Date of Last EDR Contact: 04/19/05
Date of Next Scheduled EDR Contact: 07/18/05

FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
Source: EPA/Office of Prevention, Pesticides and Toxic Substances
Telephone: 202-566-1667
FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act). To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/13/05
Database Release Frequency: Quarterly
Date of Last EDR Contact: 03/21/05
Date of Next Scheduled EDR Contact: 06/20/05

STATE OF NORTH CAROLINA ASTM STANDARD RECORDS

SHWS: Inactive Hazardous Sites Inventory
Source: Department of Environment, Health and Natural Resources
Telephone: 919-733-2801
State Hazardous Waste Sites. State hazardous waste site records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. Available information varies by state.

Date of Government Version: 04/12/05
Date Made Active at EDR: 04/25/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 04/12/05
Elapsed ASTM days: 13
Date of Last EDR Contact: 04/11/05

SWF/LF: List of Solid Waste Facilities
Source: Department of Environment and Natural Resources
Telephone: 919-733-0692
Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 06/09/05
Date Made Active at EDR: 06/29/05
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 06/09/05
Elapsed ASTM days: 20
Date of Last EDR Contact: 04/25/05

LUST: Regional UST Database
Source: Department of Environment and Natural Resources
Telephone: 919-733-1308
This database contains information obtained from the Regional Offices. It provides a more detailed explanation of current and historic activity for individual sites, as well as what was previously found in the Incident Management Database. Sites in this database with Incident Numbers are considered LUSTs.

Date of Government Version: 06/03/05
Date Made Active at EDR: 06/29/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 06/08/05
Elapsed ASTM days: 21
Date of Last EDR Contact: 06/08/05

UST: Petroleum Underground Storage Tank Database
Source: Department of Environment and Natural Resources
Telephone: 919-733-1308
Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 04/01/05
Date Made Active at EDR: 07/01/05
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 06/08/05
Elapsed ASTM days: 23
Date of Last EDR Contact: 06/08/05

OLI: Old Landfill Inventory
Source: Department of Environment & Natural Resources
Telephone: 919-733-4996
Old landfill inventory location information. (Does not include no further action sites and other agency lead sites).

Date of Government Version: 04/06/05
Date Made Active at EDR: 05/26/05
Database Release Frequency: Varies
Date of Data Arrival at EDR: 04/28/05
Elapsed ASTM days: 28
Date of Last EDR Contact: 04/28/05

VCP: Responsible Party Voluntary Action Sites
Source: Department of Environment and Natural Resources
Telephone: 919-733-4996

Date of Government Version: 04/12/05
Date Made Active at EDR: 04/25/05
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 04/12/05
Elapsed ASTM days: 13
Date of Last EDR Contact: 04/11/05

INDIAN UST: Underground Storage Tanks on Indian Land
Source: EPA Region 4
Telephone: 404-562-9424

Date of Government Version: 03/03/05
Date Made Active at EDR: 04/19/05
Database Release Frequency: Varies
Date of Data Arrival at EDR: 03/18/05
Elapsed ASTM days: 32
Date of Last EDR Contact: 02/15/05

INDIAN LUST: Leaking Underground Storage Tanks on Indian Land
Source: EPA Region 4
Telephone: 404-562-8677
LUSTs on Indian land in Florida, Minnesota, Mississippi and North Carolina.

Date of Government Version: 03/01/05
Date Made Active at EDR: 04/19/05
Database Release Frequency: Varies
Date of Data Arrival at EDR: 03/18/05
Elapsed ASTM days: 32
Date of Last EDR Contact: 02/15/05

STATE OF NORTH CAROLINA ASTM SUPPLEMENTAL RECORDS

HSDS: Hazardous Substance Disposal Site
Source: North Carolina Center for Geographic Information and Analysis
Telephone: 919-733-2090
Locations of uncontrolled and unregulated hazardous waste sites. The file includes sites on the National Priority List as well as those on the state priority list.

Date of Government Version: 06/21/95
Database Release Frequency: Biennially
Date of Last EDR Contact: 02/28/05
Date of Next Scheduled EDR Contact: 05/30/05

AST: AST Database
Source: Department of Environment and Natural Resources
Telephone: 919-715-6183
Facilities with aboveground storage tanks that have a capacity greater than 21,000 gallons.

Date of Government Version: 01/14/05
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 04/18/05
Date of Next Scheduled EDR Contact: 07/18/05

LUST TRUST: State Trust Fund Database
Source: Department of Environment and Natural Resources
Telephone: 919-733-1315
This database contains information about claims against the State Trust Funds for reimbursements for expenses incurred while remediating Leaking USTs.

Date of Government Version: 05/06/05
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 05/09/05
Date of Next Scheduled EDR Contact: 08/08/05

DRYCLEANERS: Drycleaning Sites
Source: Department of Environment & Natural Resources
Telephone: 919-508-8400
Potential and known drycleaning sites, active and abandoned, that the Drycleaning Solvent Cleanup Program has knowledge of and entered into this database.

Date of Government Version: 11/12/04
Database Release Frequency: Varies
Date of Last EDR Contact: 04/18/05
Date of Next Scheduled EDR Contact: 07/18/05

IMD: Incident Management Database
Source: Department of Environment and Natural Resources
Telephone: 919-733-3221
Groundwater and/or soil contamination incidents

Date of Government Version: 06/15/04
Database Release Frequency: Quarterly
Date of Last EDR Contact: 04/27/05
Date of Next Scheduled EDR Contact: 07/25/05

EDR PROPRIETARY HISTORICAL DATABASES

Former Manufactured Gas (Coal Gas) Sites: The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc. ©Copyright 1993 Real Property Scan, Inc. For a technical description of the types of hazards which may be found at such sites, contact your EDR customer service representative.

Disclaimer Provided by Real Property Scan, Inc.

The information contained in this report has predominantly been obtained from publicly available sources produced by entities other than Real Property Scan. While reasonable steps have been taken to insure the accuracy of this report, Real Property Scan does not guarantee the accuracy of this report. Any liability on the part of Real Property Scan is strictly limited to a refund of the amount paid. No claim is made for the actual existence of toxins at any site. This report does not constitute a legal opinion.

BROWNFIELDS DATABASES

Brownfields: Brownfields Projects Inventory
Source: Department of Environment and Natural Resources
Telephone: 919-733-4996
A brownfield site is an abandoned, idled, or underused property where the threat of environmental contamination has hindered its redevelopment. All of the sites in the inventory are working toward a brownfield agreement for cleanup and liabitliy control.

Date of Government Version: 09/30/04
Database Release Frequency: Varies
Date of Last EDR Contact: 02/04/05
Date of Next Scheduled EDR Contact: 05/02/05

VCP: Responsible Party Voluntary Action Sites
Source: Department of Environment and Natural Resources
Telephone: 919-733-4996

Date of Government Version: 04/12/05 | Date of Last EDR Contact: 04/11/05
Database Release Frequency: Semi-Annually | Date of Next Scheduled EDR Contact: 07/11/05

INST CONTROL: No Further Action Sites With Land Use Restrictions Monitoring
Source: Department of Environment, Health and Natural Resources
Telephone: 919-733-2801

Date of Government Version: 04/12/05 | Date of Last EDR Contact: 04/11/05
Database Release Frequency: Quarterly | Date of Next Scheduled EDR Contact: 07/11/05

US BROWNFIELDS: A Listing of Brownfields Sites
Source: Environmental Protection Agency
Telephone: 202-566-2777
Included in the listing are brownfields properties addresses by Cooperative Agreement Recipients and brownfields properties addressed by Targeted Brownfields Assessments. Targeted Brownfields Assessments-EPA's Targeted Brownfields Assessments (TBA) program is designed to help states, tribes, and municipalities--especially those without EPA Brownfields Assessment Demonstration Pilots--minimize the uncertainties of contamination often associated with brownfields. Under the TBA program, EPA provides funding and/or technical assistance for environmental assessments at brownfields sites throughout the country. Targeted Brownfields Assessments supplement and work with other efforts under EPA's Brownfields Initiative to promote cleanup and redevelopment of brownfields. Cooperative Agreement Recipients-States, political subdivisions, territories, and Indian tribes become Brownfields Cleanup Revolving Loan Fund (BCRLF) cooperative agreement recipients when they enter into BCRLF cooperative agreements with the U.S. EPA. EPA selects BCRLF cooperative agreement recipients based on a proposal and application process. BCRLF cooperative agreement recipients must use EPA funds provided through BCRLF cooperative agreement for specified brownfields-related cleanup activities.

Date of Government Version: 01/10/05 | Date of Last EDR Contact: 03/14/05
Database Release Frequency: Semi-Annually | Date of Next Scheduled EDR Contact: 06/13/05

US INST CONTROL: Sites with Institutional Controls
Source: Environmental Protection Agency
Telephone: 703-603-8867
A listing of sites with institutional controls in place. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

Date of Government Version: 01/10/05 | Date of Last EDR Contact: 04/04/05
Database Release Frequency: Varies | Date of Next Scheduled EDR Contact: 07/04/05

OTHER DATABASE(S)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

Oil/Gas Pipelines: This data was obtained by EDR from the USGS in 1994. It is referred to by USGS as GeoData Digital Line Graphs from 1:100,000-Scale Maps. It was extracted from the transportation category including some oil, but primarily gas pipelines.

Electric Power Transmission Line Data
Source: PennWell Corporation
Telephone: (800) 823-6277
This map includes information copyrighted by PennWell Corporation. This information is provided on a best effort basis and PennWell Corporation does not guarantee its accuracy nor warrant its fitness for any particular purpose. Such information has been reprinted with the permission of PennWell.

Sensitive Receptors: There are individuals deemed sensitive receptors due to their fragile immune systems and special sensitivity to environmental discharges. These sensitive receptors typically include the elderly, the sick, and children. While the location of all sensitive receptors cannot be determined, EDR indicates those buildings and facilities - schools, daycares, hospitals, medical centers, and nursing homes - where individuals who are sensitive receptors are likely to be located.

AHA Hospitals:
Source: American Hospital Association, Inc.
Telephone: 312-280-5991
The database includes a listing of hospitals based on the American Hospital Association's annual survey of hospitals.

Medical Centers: Provider of Services Listing
Source: Centers for Medicare & Medicaid Services
Telephone: 410-786-3000
A listing of hospitals with Medicare provider number, produced by Centers of Medicare & Medicaid Services, a federal agency within the U.S. Department of Health and Human Services.

Nursing Homes
Source: National Institutes of Health
Telephone: 301-594-6248
Information on Medicare and Medicaid certified nursing homes in the United States.

Public Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on elementary and secondary public education in the United States. It is a comprehensive, annual, national statistical database of all public elementary and secondary schools and school districts, which contains data that are comparable across all states.

Private Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on private school locations in the United States.

Daycare Centers: Child Care Facility List
Source: Department of Health & Human Services
Telephone: 919-662-4499

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 1999 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002 from the U.S. Fish and Wildlife Service.

STREET AND ADDRESS INFORMATION

GEOCHECK ®- PHYSICAL SETTING SOURCE ADDENDUM

TARGET PROPERTY ADDRESS

DIXIE RIVER RD
DIXIE RIVER RD
CHARLOTTE, NC 28278

TARGET PROPERTY COORDINATES

Latitude (North):	35.173500 - 35° 10’ 24.6’’
Longitude (West):	80.979202 - 80° 58’ 45.1’’
Universal Tranverse Mercator:	Zone 17
UTM X (Meters):	501894.1
UTM Y (Meters):	3892086.0
Elevation:	692 ft. above sea level

EDR’s GeoCheck Physical Setting Source Addendum has been developed to assist the environmental professional with the collection of physical setting source information in accordance with ASTM 1527-00, Section 7.2.3. Section 7.2.3 requires that a current USGS 7.5 Minute Topographic Map (or equivalent, such as the USGS Digital Elevation Model) be reviewed. It also requires that one or more additional physical setting sources be sought when (1) conditions have been identified in which hazardous substances or petroleum products are likely to migrate to or from the property, and (2) more information than is provided in the current USGS 7.5 Minute Topographic Map (or equivalent) is generally obtained, pursuant to local good commercial or customary practice, to assess the impact of migration of recognized environmental conditions in connection with the property. Such additional physical setting sources generally include information about the topographic, hydrologic, hydrogeologic, and geologic characteristics of a site, and wells in the area.

Assessment of the impact of contaminant migration generally has two principle investigative components:

1. Groundwater flow direction, and
2. Groundwater flow velocity.

Groundwater flow direction may be impacted by surface topography, hydrology, hydrogeology, characteristics of the soil, and nearby wells. Groundwater flow velocity is generally impacted by the nature of the geologic strata. EDR’s GeoCheck Physical Setting Source Addendum is provided to assist the environmental professional in forming an opinion about the impact of potential contaminant migration.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW DIRECTION INFORMATION

Groundwater flow direction for a particular site is best determined by a qualified environmental professional using site-specific well data. If such data is not reasonably ascertainable, it may be necessary to rely on other sources of information, such as surface topographic information, hydrologic information, hydrogeologic data collected on nearby properties, and regional groundwater flow information (from deep aquifers).

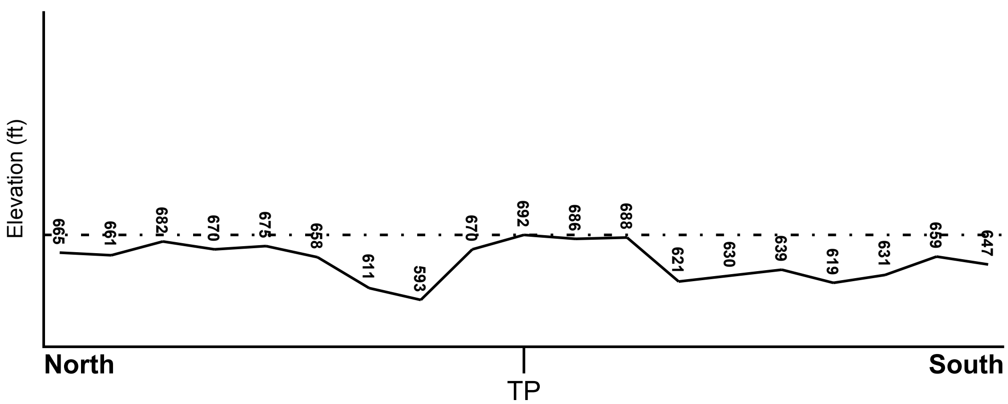
TOPOGRAPHIC INFORMATION

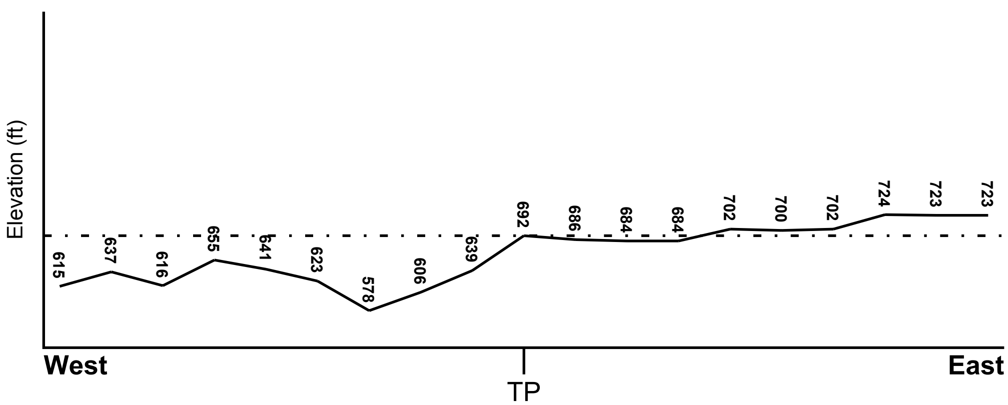
Surface topography may be indicative of the direction of surficial groundwater flow. This information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

TARGET PROPERTY TOPOGRAPHY

USGS Topographic Map:	35080-B8 CHARLOTTE WEST, NC
General Topographic Gradient:	General NW
Source:	USGS 7.5 min quad index

SURROUNDING TOPOGRAPHY: ELEVATION PROFILES





Target Property Elevation: 692 ft.

Source: Topography has been determined from the USGS 7.5' Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

HYDROLOGIC INFORMATION

Surface water can act as a hydrologic barrier to groundwater flow. Such hydrologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

Refer to the Physical Setting Source Map following this summary for hydrologic information (major waterways and bodies of water).

FEMA FLOOD ZONE

Target Property County	FEMA Flood Electronic Data
MECKLENBURG, NC	YES - refer to the Overview Map and Detail Map

Flood Plain Panel at Target Property: 3701580140C

Additional Panels in search area: 3701580100B

NATIONAL WETLAND INVENTORY

NWI Quad at Target Property	NWI Electronic Data Coverage
CHARLOTTE WEST	YES - refer to the Overview Map and Detail Map

HYDROGEOLOGIC INFORMATION

Hydrogeologic information obtained by installation of wells on a specific site can often be an indicator of groundwater flow direction in the immediate area. Such hydrogeologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

AQUIFLOW®

Search Radius: 1.000 Mile.

EDR has developed the AQUIFLOW Information System to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted by environmental professionals to regulatory authorities at select sites and has extracted the date of the report, groundwater flow direction as determined hydrogeologically, and the depth to water table.

MAP ID	LOCATION FROM TP	GENERAL DIRECTION GROUNDWATER FLOW
4	1/2 - 1 Mile ESE	Not Reported

For additional site information, refer to Physical Setting Source Map Findings.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW VELOCITY INFORMATION

Groundwater flow velocity information for a particular site is best determined by a qualified environmental professional using site specific geologic and soil strata data. If such data are not reasonably ascertainable, it may be necessary to rely on other sources of information, including geologic age identification, rock stratigraphic unit and soil characteristics data collected on nearby properties and regional soil information. In general, contaminant plumes move more quickly through sandy-gravelly types of soils than silty-clayey types of soils.

GEOLOGIC INFORMATION IN GENERAL AREA OF TARGET PROPERTY

Geologic information can be used by the environmental professional in forming an opinion about the relative speed at which contaminant migration may be occurring.

ROCK STRATIGRAPHIC UNIT

Era:	Paleozoic
System:	Mississippian
Series:	Paleozoic mafic intrusives
Code:	Pzmi *(decoded above as Era, System & Series)*

GEOLOGIC AGE IDENTIFICATION

Category: Plutonic and Intrusive Rocks

Geologic Age and Rock Stratigraphic Unit Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - a digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

DOMINANT SOIL COMPOSITION IN GENERAL AREA OF TARGET PROPERTY

The U.S. Department of Agriculture's (USDA) Soil Conservation Service (SCS) leads the National Cooperative Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps. The following information is based on Soil Conservation Service STATSGO data.

Soil Component Name:	CECIL
Soil Surface Texture:	sandy clay loam
Hydrologic Group:	Class B - Moderate infiltration rates. Deep and moderately deep, moderately well and well drained soils with moderately coarse textures.
Soil Drainage Class:	Well drained. Soils have intermediate water holding capacity. Depth to water table is more than 6 feet.

Hydric Status: Soil does not meet the requirements for a hydric soil.

Corrosion Potential - Uncoated Steel:	HIGH
Depth to Bedrock Min:	> 60 inches
Depth to Bedrock Max:	> 60 inches

Soil Layer Information							
	Boundary			**Classification**			
Layer	**Upper**	**Lower**	**Soil Texture Class**	**AASHTO Group**	**Unified Soil**	**Permeability Rate (in/hr)**	**Soil Reaction (pH)**
1	0 inches	7 inches	sandy clay loam	Silt-Clay Materials (more than 35 pct. passing No. 200), Silty Soils.	COARSE-GRAINED SOILS, Sands, Sands with fines, Silty Sand.	Max: 2.00 Min: 0.60	Max: 6.50 Min: 4.50
2	7 inches	11 inches	sandy clay loam	Silt-Clay Materials (more than 35 pct. passing No. 200), Silty Soils.	COARSE-GRAINED SOILS, Sands, Sands with fines, Silty Sand.	Max: 2.00 Min: 0.60	Max: 5.50 Min: 4.50
3	11 inches	50 inches	clay	Silt-Clay Materials (more than 35 pct. passing No. 200), Clayey Soils.	FINE-GRAINED SOILS, Silts and Clays (liquid limit 50% or more), Elastic silt.	Max: 2.00 Min: 0.60	Max: 5.50 Min: 4.50
4	50 inches	75 inches	variable	Not reported	Not reported	Max: 0.00 Min: 0.00	Max: 0.00 Min: 0.00

OTHER SOIL TYPES IN AREA

Based on Soil Conservation Service STATSGO data, the following additional subordinant soil types may appear within the general area of target property.

Soil Surface Textures:	sandy loam loam clay loam silt loam very channery - silt loam gravelly - sandy loam
Surficial Soil Types:	sandy loam loam clay loam silt loam very channery - silt loam gravelly - sandy loam
Shallow Soil Types:	silt loam sandy clay clay silty clay loam very channery - silt loam loam
Deeper Soil Types:	weathered bedrock fine sandy loam silty clay loam unweathered bedrock sandy clay loam

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

ADDITIONAL ENVIRONMENTAL RECORD SOURCES

According to ASTM E 1527-00, Section 7.2.2, "one or more additional state or local sources of environmental records may be checked, in the discretion of the environmental professional, to enhance and supplement federal and state sources... Factors to consider in determining which local or additional state records, if any, should be checked include (1) whether they are reasonably ascertainable, (2) whether they are sufficiently useful, accurate, and complete in light of the objective of the records review (see 7.1.1), and (3) whether they are obtained, pursuant to local, good commercial or customary practice." One of the record sources listed in Section 7.2.2 is water well information. Water well information can be used to assist the environmental professional in assessing sources that may impact groundwater flow direction, and in forming an opinion about the impact of contaminant migration on nearby drinking water wells.

WELL SEARCH DISTANCE INFORMATION

DATABASE	SEARCH DISTANCE (miles)
Federal USGS	1.000
Federal FRDS PWS	Nearest PWS within 1 mile
State Database	1.000

FEDERAL USGS WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
No Wells Found		

FEDERAL FRDS PUBLIC WATER SUPPLY SYSTEM INFORMATION

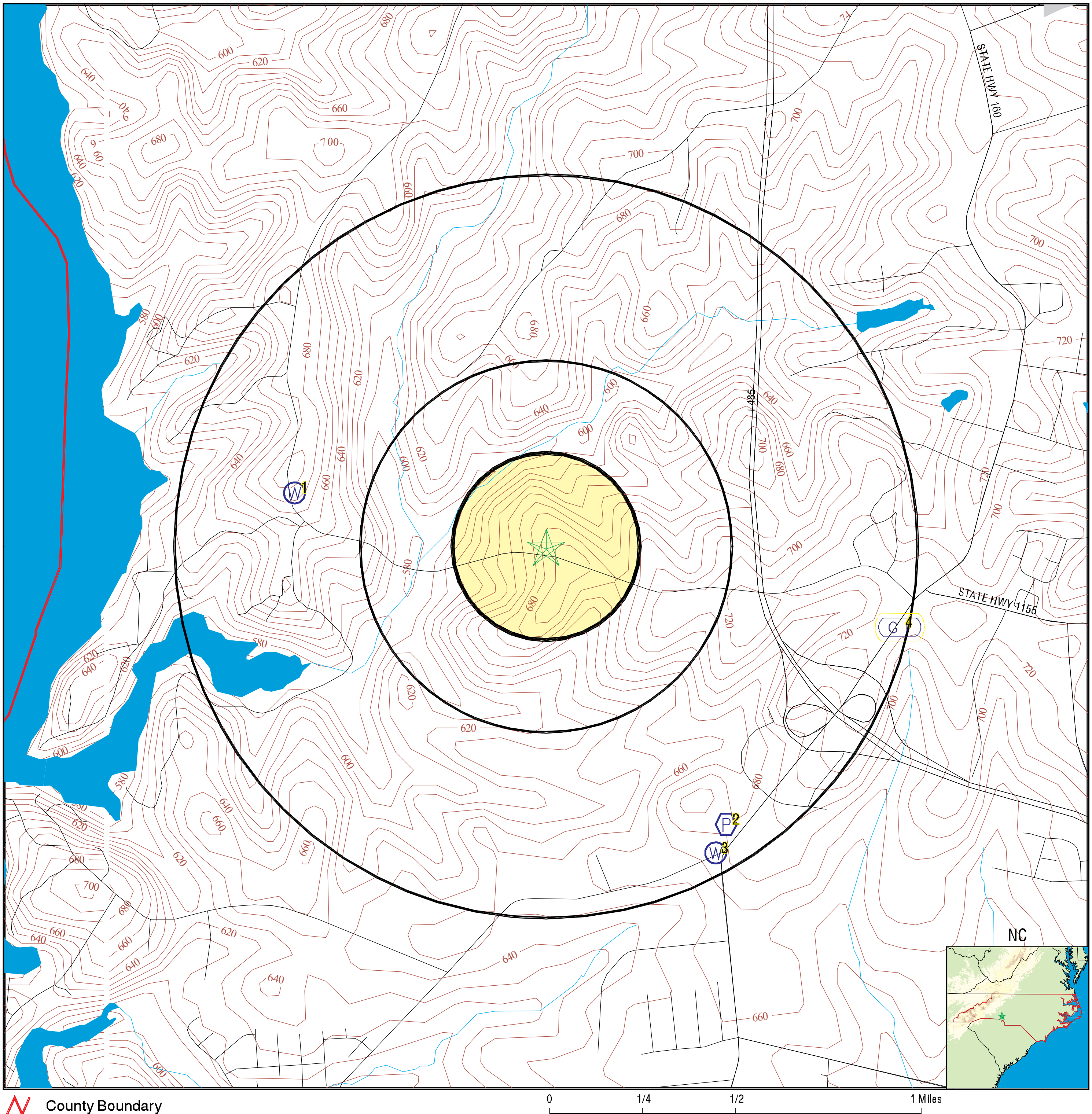
MAP ID	WELL ID	LOCATION FROM TP
2	NC0160693	1/2 - 1 Mile SSE

Note: PWS System location is not always the same as well location.

STATE DATABASE WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
1	NCWS002865	1/2 - 1 Mile WNW
3	NCWS002822	1/2 - 1 Mile SSE

PHYSICAL SETTING SOURCE MAP - 01465089.1r



County Boundary
Major Roads
Contour Lines
Airports
Earthquake epicenter, Richter 5 or greater
Water Wells
Public Water Supply Wells
Cluster of Multiple Icons

Groundwater Flow Direction
Indeterminate Groundwater Flow at Location
Groundwater Flow Varies at Location

Wildlife Areas
Natural Areas
Rare & Endangered Species

TARGET PROPERTY:	Dixie River Rd	CUSTOMER:	Buck Engineering
ADDRESS:	Dixie River Rd	CONTACT:	Andrea Spangler
CITY/STATE/ZIP:	Charlotte NC 28278	INQUIRY #:	01465089.1r
LAT/LONG:	35.1735 / 80.9792	DATE:	July 13, 2005 7:12 pm

Map ID Direction Distance Elevation		Database	EDR ID Number
1 **WNW** **1/2 - 1 Mile** **Lower**		**NC WELLS**	**NCWS002865**

Site Name:	WELL #1		
PWS ID:	0160898	Source code:	S01
City:	CHARLOTTE		
County:	Mecklenburg		
Latitude:	351032.116	Longitude:	805928.164
Availability:	Permanent		
Type:	Ground	Depth:	0
Owner:	RAMOTH AME ZION CHURCH		

---

2 **SSE** **1/2 - 1 Mile** **Lower**		**FRDS PWS**	**NC0160693**

PWS ID:	NC0160693	PWS Status:	Active
Date Initiated:	7706	Date Deactivated:	Not Reported
PWS Name:	STEELE CREEK BAPTIST CHURCH CHARLOTTE, NC 28210		

Addressee / Facility: System Owner/Responsible Party
STEELECREEK BAPT
RT 3 BOX 203
CHARLOTTE, NC 28210

Addressee / Facility: System Owner/Responsible Party
STEELECREEK BAPT
RT 3 BOX 203
CHARLOTTE, NC 28210

Facility Latitude:	35 13 36	Facility Longitude	080 50 35
Facility Latitude:	35 09 45	Facility Longitude	080 58 15
City Served:	CHARLOTTE		
Treatment Class:	Untreated	Population:	00000070

PWS currently has or had major violation(s) or enforcement: Yes

Violations information not reported.

ENFORCEMENT INFORMATION:

System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2000-01-01 - 2000-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0110710
Enforcement Date:	2001-03-16	Enf. Action:	State Formal NOV Issued

System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2002-01-01 - 2002-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0316322
Enforcement Date:	2003-02-18	Enf. Action:	State Formal NOV Issued

ENFORCEMENT INFORMATION:

System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2000-01-01 - 2000-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0110709
Enforcement Date:	2001-03-16	Enf. Action:	State Public Notif Requested
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2002-01-01 - 2002-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0316321
Enforcement Date:	2003-02-18	Enf. Action:	State Public Notif Requested
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2002-01-01 - 2002-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0316323
Enforcement Date:	2003-03-05	Enf. Action:	State Public Notif Received
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2000-01-01 - 2000-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0403488
Enforcement Date:	2004-01-05	Enf. Action:	State Compliance Achieved
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Regular		
Contaminant:	NITRATE		
Compliance Period:	2002-01-01 - 2002-12-31	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0403488
Enforcement Date:	2004-01-05	Enf. Action:	State Compliance Achieved
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2000-01-01 - 2000-03-31	Analytical Value:	0
Violation ID:	0005192	Enforcement ID:	0010950
Enforcement Date:	2000-05-03	Enf. Action:	State Formal NOV Issued
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2001-04-01 - 2001-06-30	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0115630
Enforcement Date:	2001-08-08	Enf. Action:	State Formal NOV Issued
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2000-01-01 - 2000-03-31	Analytical Value:	0
Violation ID:	0104127	Enforcement ID:	0010949
Enforcement Date:	2000-05-03	Enf. Action:	State Public Notif Requested
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2001-04-01 - 2001-06-30	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0115629
Enforcement Date:	2001-08-08	Enf. Action:	State Public Notif Requested

ENFORCEMENT INFORMATION:

System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2001-04-01 - 2001-06-30	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0201773
Enforcement Date:	2001-09-13	Enf. Action:	State Public Notif Received
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2000-01-01 - 2000-03-31	Analytical Value:	0
Violation ID:	0106496	Enforcement ID:	0200032
Enforcement Date:	2002-01-31	Enf. Action:	State Compliance Achieved
System Name:	STEELE CREEK BAPTIST CHURCH		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	2001-04-01 - 2001-06-30	Analytical Value:	0
Violation ID:	0318150	Enforcement ID:	0200032
Enforcement Date:	2002-01-31	Enf. Action:	State Compliance Achieved
System Name:	STEELE CREEK BAPTIST CHURC		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	1999-07-01 - 1999-09-30	Analytical Value:	0000000.000000000
Violation ID:	0000534	Enforcement ID:	Not Reported
Enforcement Date:	Not Reported	Enf. Action:	Not Reported
System Name:	STEELE CREEK BAPTIST CHURC		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	1999-12-01 - 1999-12-31	Analytical Value:	0000000.000000000
Violation ID:	0000534	Enforcement ID:	0006597
Enforcement Date:	2000-02-04	Enf. Action:	State Formal NOV Issued
System Name:	STEELE CREEK BAPTIST CHURC		
Violation Type:	Monitoring, Routine Major (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	1999-12-01 - 1999-12-31	Analytical Value:	0000000.000000000
Violation ID:	0003600	Enforcement ID:	0006598
Enforcement Date:	2000-02-04	Enf. Action:	State Public Notif Requested

---

3
SSE
1/2 - 1 Mile
Lower

NC WELLS **NCWS002822**

Site Name:	WELL #1		
PWS ID:	0160693	Source code:	S01
City:	CHARLOTTE		
County:	Mecklenburg		
Latitude:	350941.52	Longitude:	805816.054
Availability:	Permanent		
Type:	Ground	Depth:	0
Owner:	STEELECREEK BAPT		

Map ID Direction Distance Elevation			Database	EDR ID Number
4 **ESE** **1/2 - 1 Mile** **Higher**	Site ID: Groundwater Flow: Shallowest Water Table Depth: Deepest Water Table Depth: Average Water Table Depth: Depth to rock - shallowest: Depth to rock - deepest: Depth to rock - average: Date:	16774 Not Reported 21.77 26.15 Not Reported Not Reported Not Reported Not Reported 04/30/1998	**AQUIFLOW**	**40579**

AREA RADON INFORMATION

State Database: NC Radon

Radon Test Results

County	Result Type	Total Sites	Avg pCi/L	Range pCi/L
MECKLENBURG	Statistical	55	0.70	-0.30-3.60
MECKLENBURG	Non-Statistical	275	1.06	0.00-8.30

Federal EPA Radon Zone for MECKLENBURG County: 3

Note: Zone 1 indoor average level > 4 pCi/L.
: Zone 2 indoor average level >= 2 pCi/L and <= 4 pCi/L.
: Zone 3 indoor average level < 2 pCi/L.

Federal Area Radon Information for MECKLENBURG COUNTY, NC

Number of sites tested: 46

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor	0.569 pCi/L	100%	0%	0%
Living Area - 2nd Floor	0.900 pCi/L	100%	0%	0%
Basement	1.278 pCi/L	100%	0%	0%

PHYSICAL SETTING SOURCE RECORDS SEARCHED

TOPOGRAPHIC INFORMATION

USGS 7.5' Digital Elevation Model (DEM)
Source: United States Geologic Survey
EDR acquired the USGS 7.5' Digital Elevation Model in 2002. 7.5-Minute DEMs correspond to the USGS 1:24,000- and 1:25,000-scale topographic quadrangle maps.

HYDROLOGIC INFORMATION

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 1999 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002 from the U.S. Fish and Wildlife Service.

HYDROGEOLOGIC INFORMATION

AQUIFLOW[R] **Information System**
Source: EDR proprietary database of groundwater flow information
EDR has developed the AQUIFLOW Information System (AIS) to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted to regulatory authorities at select sites and has extracted the date of the report, hydrogeologically determined groundwater flow direction and depth to water table information.

GEOLOGIC INFORMATION

Geologic Age and Rock Stratigraphic Unit
Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - A digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

STATSGO: State Soil Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Services
The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) leads the national Conservation Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps.

ADDITIONAL ENVIRONMENTAL RECORD SOURCES

FEDERAL WATER WELLS

PWS: Public Water Systems
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: USGS National Water Inventory System (NWIS)
This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on wells, springs, and other sources of groundwater.

PHYSICAL SETTING SOURCE RECORDS SEARCHED

STATE RECORDS

NC Natural Areas: Significant Natural Heritage Areas
Source: Center for Geographic Information and Analysis
Telephone: 919-733-2090
A polygon converage identifying sites (terrestrial or aquatic that have particular biodiversity significance. A site's significance may be due to the presenceof rare species, rare or hight quality natural communities, or other important ecological features.

NC Game Lands: Wildlife Resources Commission Game Lands
Source: Center for Geographic Information and Analysis
Telephone: 919-733-2090
All publicly owned game lands managed by the North Carolina Wildlife Resources Commission and as listed in Hunting and Fishing Maps.

NC Natural Heritage Sites: Natural Heritage Element Occurrence Sites
Source: Center for Geographic Information and Analysis
Telephone: 919-733-2090
A point coverage identifying locations of rare and endangered species, occurrences of exemplary or unique natural ecosystems (terrestrial or aquatic), and special animal habitats (e.g., colonial waterbird nesting sites).

North Carolina Public Water Supply Wells
Source: Department of Environmental Health
Telephone: 919-715-3243

RADON

State Database: NC Radon
Source: Department of Environment & Natural Resources
Telephone: 919-733-4984
Radon Statistical and Non Statiscal Data

Area Radon Information
Source: USGS
Telephone: 703-356-4020
The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 - 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

EPA Radon Zones
Source: EPA
Telephone: 703-356-4020
Sections 307 & 309 of IRAA directed EPA to list and identify areas of U.S. with the potential for elevated indoor radon levels.

OTHER

Airport Landing Facilities: Private and public use landing facilities
Source: Federal Aviation Administration, 800-457-6656

Epicenters: World earthquake epicenters, Richter 5 or greater
Source: Department of Commerce, National Oceanic and Atmospheric Administration

EDR TOXICHECK® 1.0 Environmental Risk Summary

May 10, 2005

Target Property

PIEDMONT EQUESTRIAN PARK
651 BAXTER RD
CHERRYVILLE, NC 28021

440 Wheelers Farms Road
Milford, CT 06460
Phone:800-352-0050
Fax:800-231-6802
Web:www.edrnet.com

EDR™ Environmental Data Resources Inc

ENVIRONMENTAL RISK LEVEL

To help evaluate environmental risk, the *ToxiCheck 1.0 Environmental Risk Summary* provides an Environmental Risk Level, based on a search of current government records. Refer to the supporting report for additional detail.

☐	**HIGH RISK**	Based on the records found in this report, the environmental risk level for this property is High. Please see page 2 for information on the records in this report that contribute to this risk level.
4	**LOW RISK**	Based on the records found in this report, the environmental risk level for this property is minimal.

Current Government Records

Current government regulatory files may identify known or potential sites of environmental concern.

- EDR Radius Map Report

(Not Requested for ToxiCheck) Historical Records

The prior use of a property may contribute to environmental contamination. Historical sources such as fire insurance maps, city directories, and other databases may identify sites of potential environmental concern not identified in current government records. The following reports and/or databases were not requested for ToxiCheck by customer:

- EDR Fire Insurance Map Abstract
- EDR City Directory Abstract
- EDR Proprietary Gas Station/Dry Cleaner Database
- EDR Proprietary Coal Gas Database

TOXICHECK® 1.0 Environmental Risk Summary

FINDINGS CONTRIBUTING TO THE ENVIROMENTAL RISK LEVEL

The environmental LOW RISK is based upon the findings listed below. Refer to the supporting report(s) for additional detail.

CURRENT GOVERNMENT RECORDS

Target Property

No records identified (if any) were determined to be of high risk.

Surrounding Properties

No records identified (if any) were determined to be of high risk.

HISTORICAL RECORDS (NOT REQUESTED)

Property historical reports and/or data was not requested for ToxiCheck by the customer.

TOXICHECK® 1.0 Environmental Risk Summary

PROPERTY TIMELINE

The property timeline indicates the year of the finding contributing to a LOW RISK environmental risk level.
For details on data points along the timeline, refer to page 2 of the ToxiCheck Environmental Risk Summary.

Target Property Timeline

Historical Not Requested for ToxiCheck													
1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2005

Historical — Current

Surrounding Properties Timeline

Historical Not Requested for ToxiCheck													
1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2005

Historical — Current

Timeline ID (refer to page 2)

TERMS AND DEFINITIONS

Data Source
Data Source indicates the government database or historical record contributing to a HIGH Environmental Risk Level. Current government records sources include federal, state and local databases. Detailed information for current government records can be found in the EDR Radius Map Report Government Records Searched section. When requested to be searched by the customer, and where available, historical records sources include the EDR Proprietary Gas Station/Dry Cleaner Database, EDR Proprietary Coal Gas Database, EDR Fire Insurance Abstract and EDR City Directory Abstract. Additional information about the EDR Gas Station/Dry Cleaner Database and EDR Proprietary Coal Gas Database can be found in the EDR Radius Map Report. Additional information about the EDR Fire Insurance Abstract and EDR City Directory Abstract is located in the respective report(s).

Surrounding Properties
Surrounding Properties included in the ToxiCheck Environmental Risk Summary are those sites found in the EDR Radius Map Report and Historical Reports near the target property. Surrounding Properties are also known as adjoining properties. Surrounding Property data which contribute to a HIGH Environmental Risk Level can be found in the Surrounding Properties section of the ToxiCheck Environmental Risk Summary.

Target Property
The Target Property is the location for which this inquiry is conducted. Target Property is also known as the subject site. Target Property data which contribute to a HIGH Environmental Risk Level can be found in the Target Property section of the ToxiCheck Environmental Risk Summary.

Timeline ID
Timeline ID is the identification number assigned to a property and used on the ToxiCheck Property Timeline to show the publication year of the document(s) which identify the property.

EDR Radius Map(tm) Report
The EDR Radius Map Report is a map-based radius search of current government regulatory information that identifies sites of real or potential environmental concern. The report searches federal, state, local, and EDR proprietary databases for the target property and surrounding properties. Government records are regularly updated according to industry standards.

EDR Proprietary Gas Station/Dry Cleaner Database
EDR has searched select national collections of business directories and has collected listings of potential dry cleaner and gas station/filling station/service station sites that were available to EDR researchers. EDR's review

was limited to those categories of sources that might, in EDR's opinion, include dry cleaning and gas station/filling station/service station establishments. The categories reviewed included, but were not limited to: gas, gas station, gasoline station, filling station, auto, automobile repair, auto service station, service station, dry cleaner, cleaners, laundry, laundromat, cleaning/laundry, wash & dry, etc. The information provided in this proprietary database may or may not be complete; i.e., the absence of a dry cleaner or gas station/filling station/service station site does not necessarily mean that such a site did not exist in the area covered by this report.

EDR Fire Insurance Map Abstract
Fire insurance maps were initially produced by private companies for the insurance industry to provide information on the fire risks of buildings and other structures. Sanborn Maps are a valuable historical resource for persons concerned with evaluating the potential for site contamination based on the history of past use. Fire insurance maps are available for approximately 12,000 U.S. cities and towns from the mid-1800s to the present. Map coverage is most comprehensive in urban core areas and in older suburbs; map coverage is limited in suburban areas developed after 1950. When requested by the customer, EDR conducts a keyword search of the EDR Fire Insurance Map Abstract to identify records contributing to the Toxicheck Environmental Risk Level. Keyword searches are limited and should not be considered a substitute for review by an environmental professional. For more information about the keywords used for the ToxiCheck Environmental Risk Level, contact your EDR Account Executive.

EDR City Directory Abstract
City directories have been published for cities and towns across the U.S. since the 1800s. Originally a list of residents, the city directory developed into a sophisticated tool for locating individuals and businesses in a particular urban or suburban area. Twentieth century directories are generally divided into three sections: a business index, a list of resident names and addresses, and a street index. With each address, the directory lists the name of the resident or, if a business is operated from this address, the name and type of business (if unclear from the name). While city directory coverage is comprehensive for major cities, it may be spotty for rural areas and small towns. When requested by the customer, EDR conducts a keyword search of the EDR City Directory Abstract to identify records contributing to the Toxicheck Environmental Risk Level. Keyword searches are limited and should not be considered a substitute for review by an environmental professional. For more information about the keywords used for the ToxiCheck Environmental Risk Level, contact your EDR Account Executive.
The following keywords were used to evaluate the EDR City Directory Abstract: 7-Eleven, AAMCO, AM General, Acura, Amerada Hess Corporation, Amoco, Arco, Aston Martin, Atlantic Richfield Oil Company, Audi, Auto, Autobody, Automobile, Automotive, BMW, BP, Battery, Beacon, Bentley, Body Shop, Body Works, Brake, British Petroleum, Buick, Cadillac, Caltex, Car, Chemical, Chevrolet, Chevron, Chevrontexaco, Chrysler, Circle K, Citgo, Cities Service Company, Cleaner, Cleaning, Clnr, Coastal Petroleum, Collision, Conoco, Conocophillips, Cumberland Farms, Daewoo, Dealer, Diamond Shamrock, Dodge, Dry Cleaner, Dry Cleaning, Drycleaning, Dyer, Dying, Eagle, Engine, Esso, Exxon, Exxonmobil, Ferrari, Ford, Fuel, GMC, Garage, Gas, Goodrich, Gulf Oil, Hanger, Heating, Hess, Honda, Hummer, Hyundai, Imperial Oil, Infiniti, Isuzu, Jaguar, Jeep, Jersey Standard, Jet Oil, Junk Yard, Junkyard, Kia, Kleaner, Laboratory, Lamborghini, Land Rover, Landfill, Launderer, Launderette, Laundries, Laundromat, Laundry, Lexus, Lincoln, Lndry, Lndy, Lotus, Magnolia Petroleum Co, Manufacturing, Marathon, Marathon Ashland Petroleum, Martinizing, Maserati, Mazda, Mechanic, Meineke, Mercedes-Benz, Mercury, Midas, Mirastar, Mitsubishi, Mobil, Motor, Muffler, Nissan, Oil, Oldsmobile, Paint, Panoz, Pep Boys, Petroleum, Phillips 66, Photo, Photography, Pilot, Plymouth, Pontiac, Porsche, Press, Print, Printer, Printing, Prntr, Radiator, Railroad, Railway, Recycling, Repair, Richfield, Rolls-Royce, Royal Dutch/Shell, STA, STN, Saab, Saturn, Shell Oil, Sinclair Oil, Socony, Sohio, Speedway, Standard Oil, Standard Oil of Ohio, Station, Subaru, Sun Oil Company, Sunoco, Suzuki, Tailor, Tesoro, Texaco, Tire, Towing, Toyota, Transmission, Ultramar, Union 76, Union Oil, Vacuum Oil Co, Valero, Valero Energy, Volkswagen, Volvo, Wash, Waste, Wyatt Oil.

EDR Proprietary Coal Gas Database
The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc.
 For a technical description of the types of hazards which may be found at such sites, contact your EDR Account Executive.

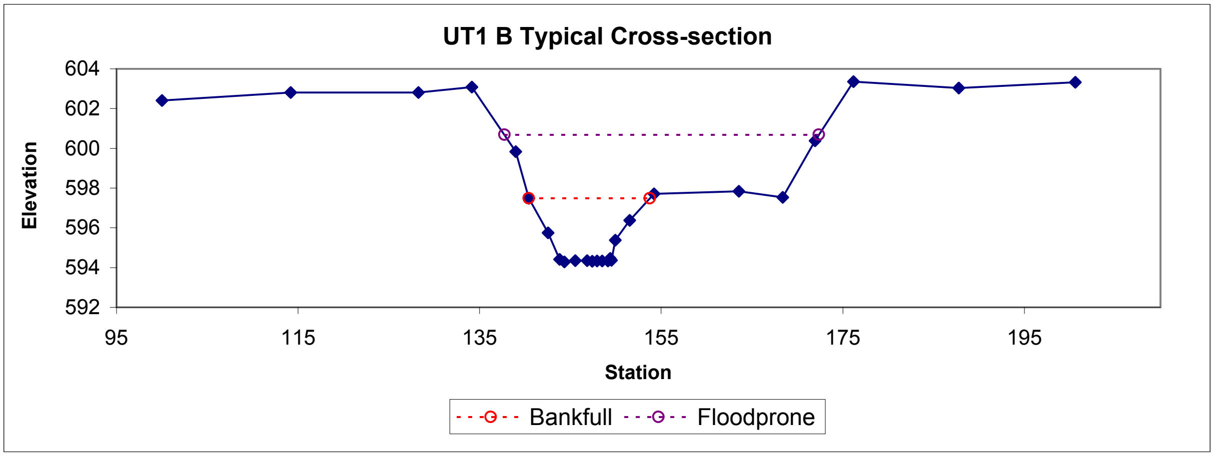
Disclaimer Provided by Real Property Scan, Inc.
The information contained in this report has predominantly been obtained from publicly available sources produced by entities other than Real Property Scan. While reasonable steps have been taken to insure the accuracy of this report, Real Property Scan does not guarantee the accuracy of this report. Any liability on the part of Real Property Scan is strictly limited to a refund of the amount paid. No claim is made for the actual existence of toxins at any site.
This report does not constitute a legal opinion.

Appendix C

Existing Conditions Data

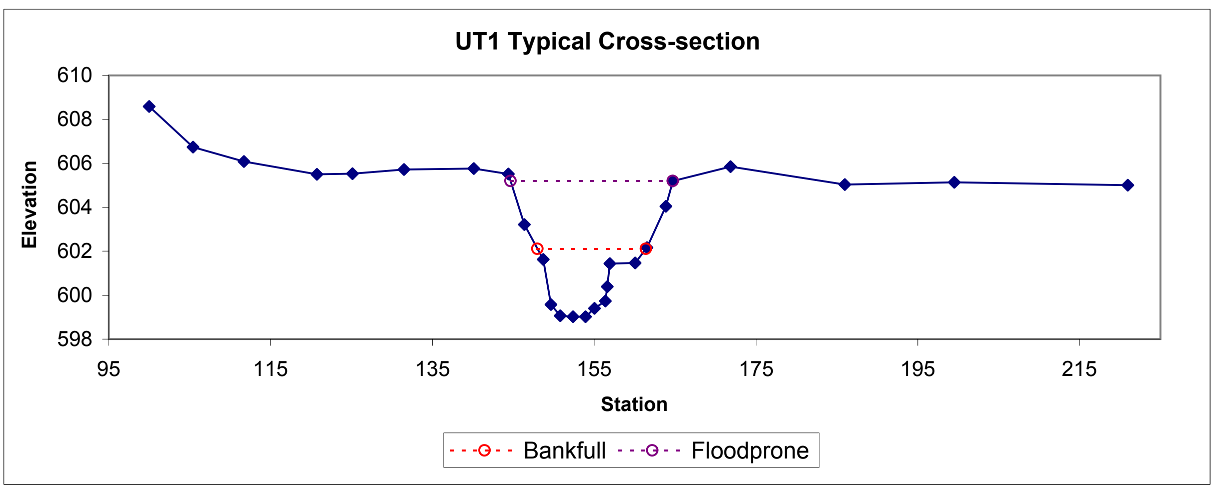
XS #11

Feature	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	27.7	13.32	2.08	3.2	6.41	2.8	2.6	597.48	603.09



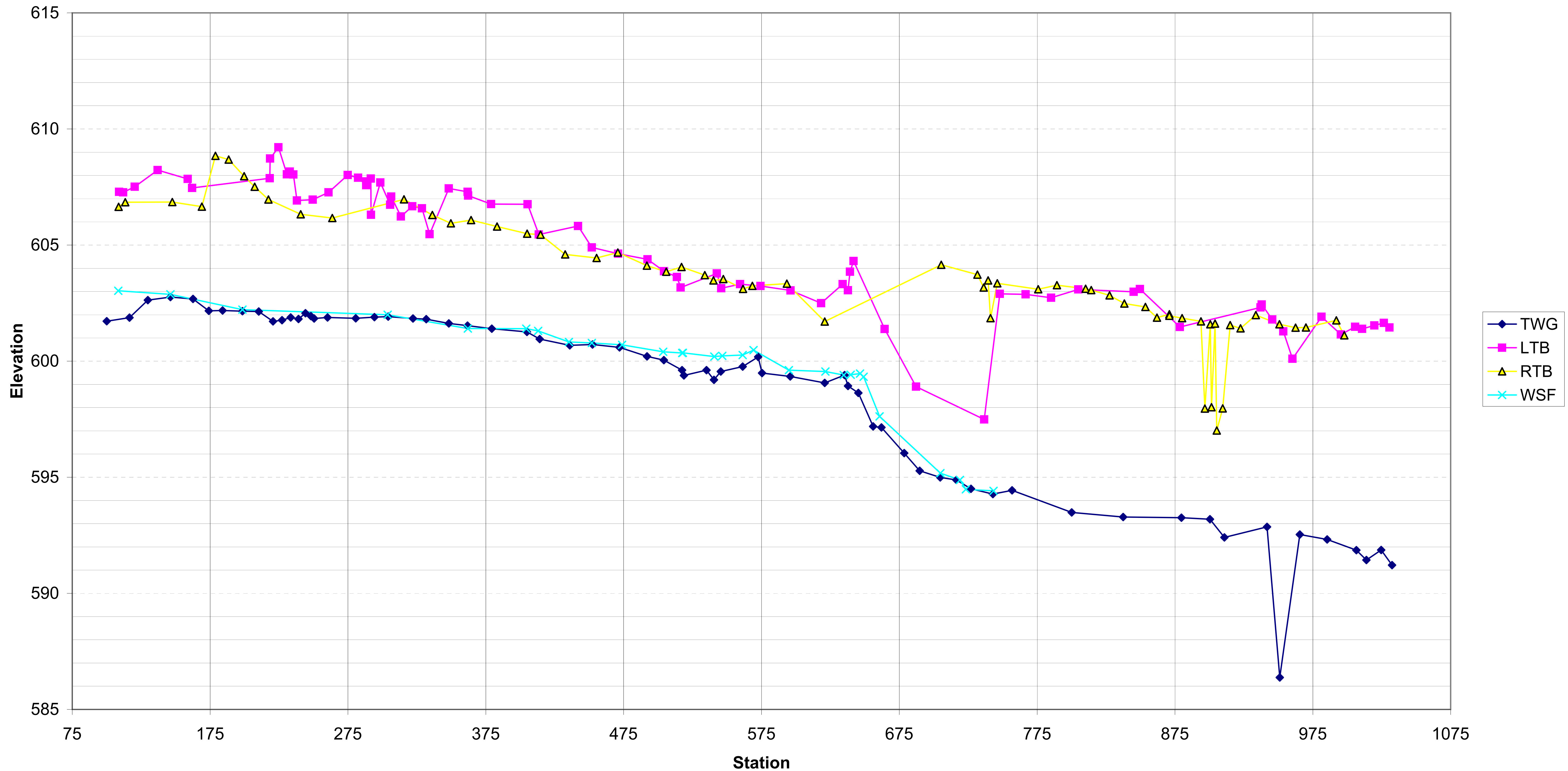
XS #12

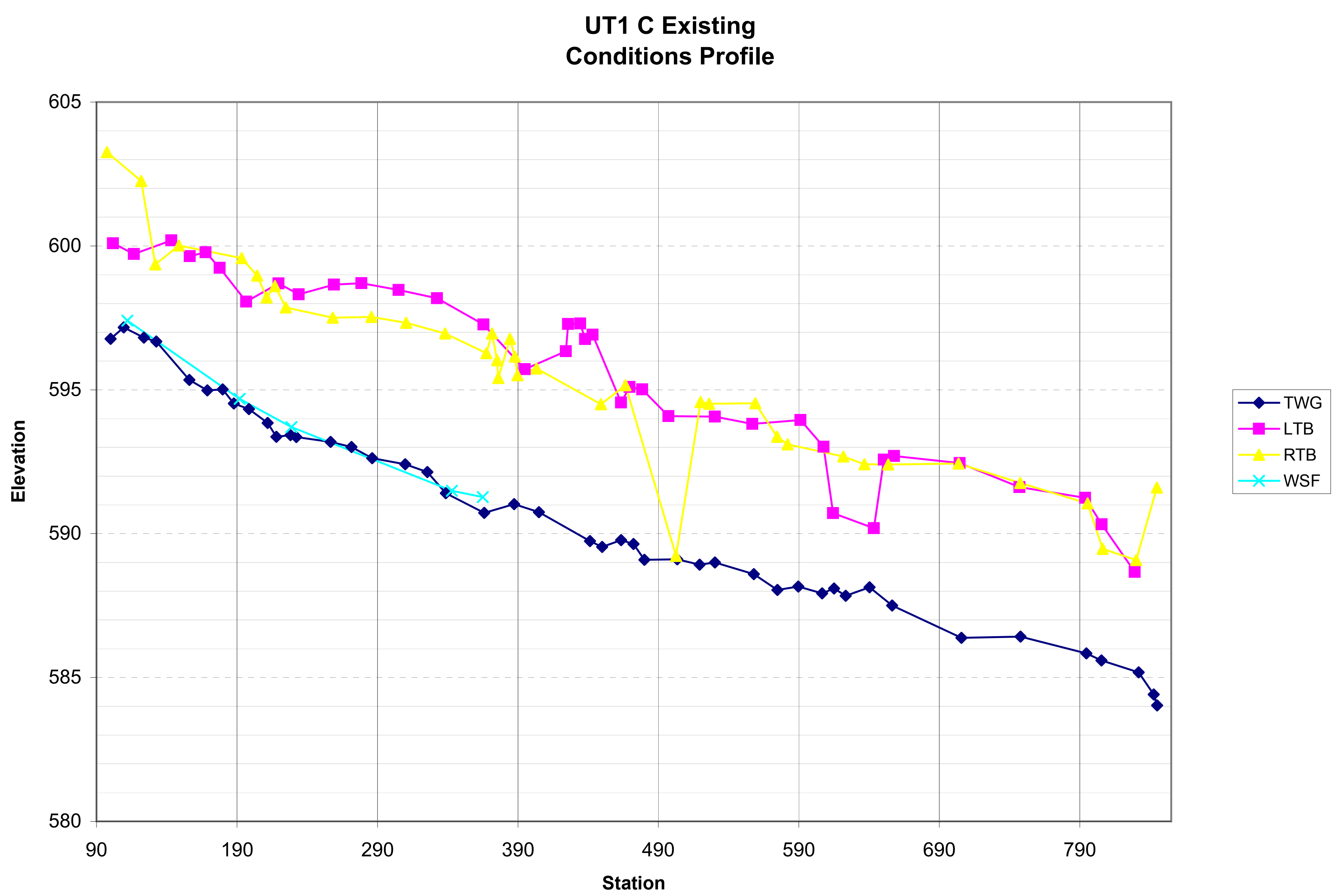
BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
24.4	13.44	1.82	3.09	7.39	2	1.5	602.1	605.19

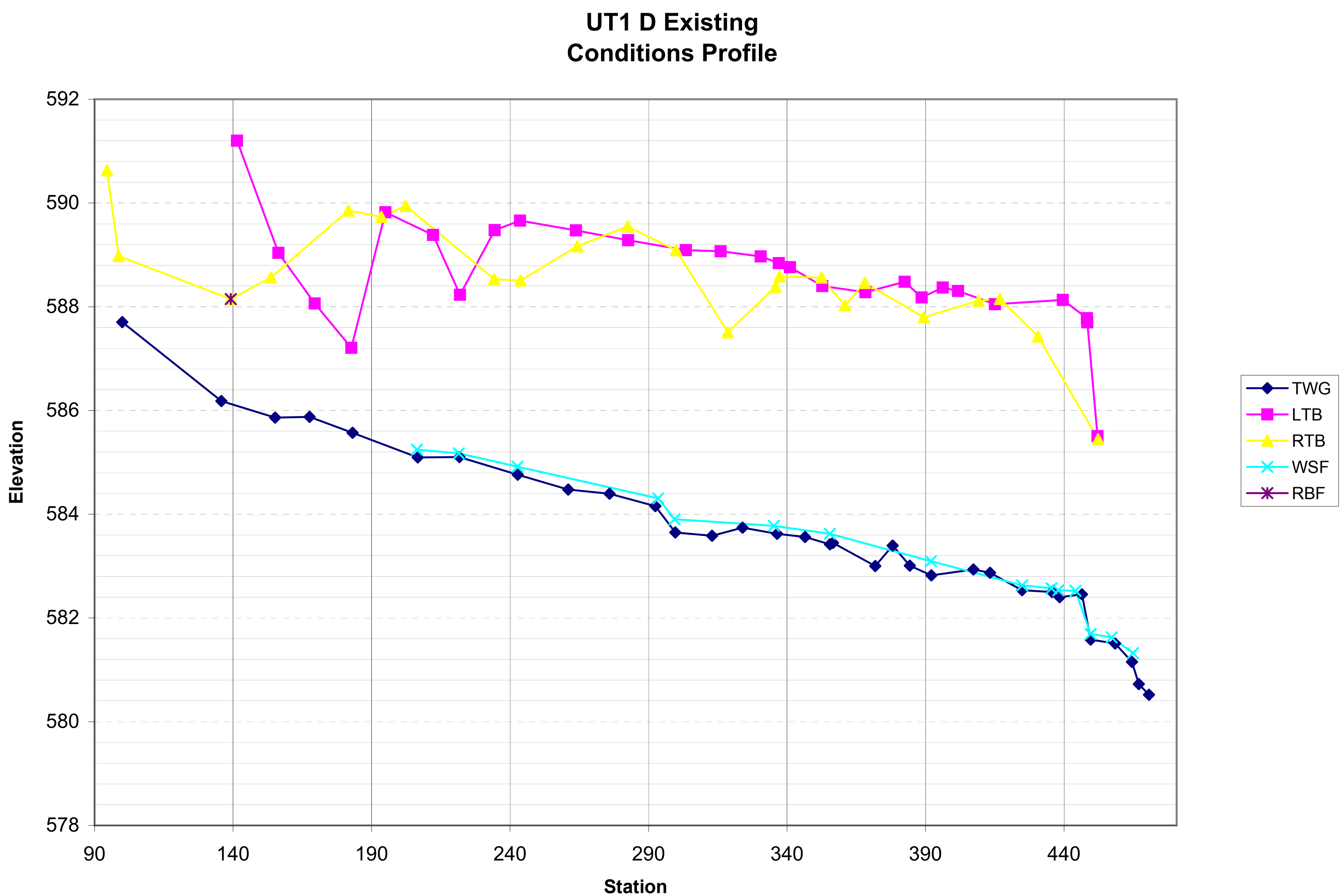


note: Cross Section locations shown on **Figure 4.1**

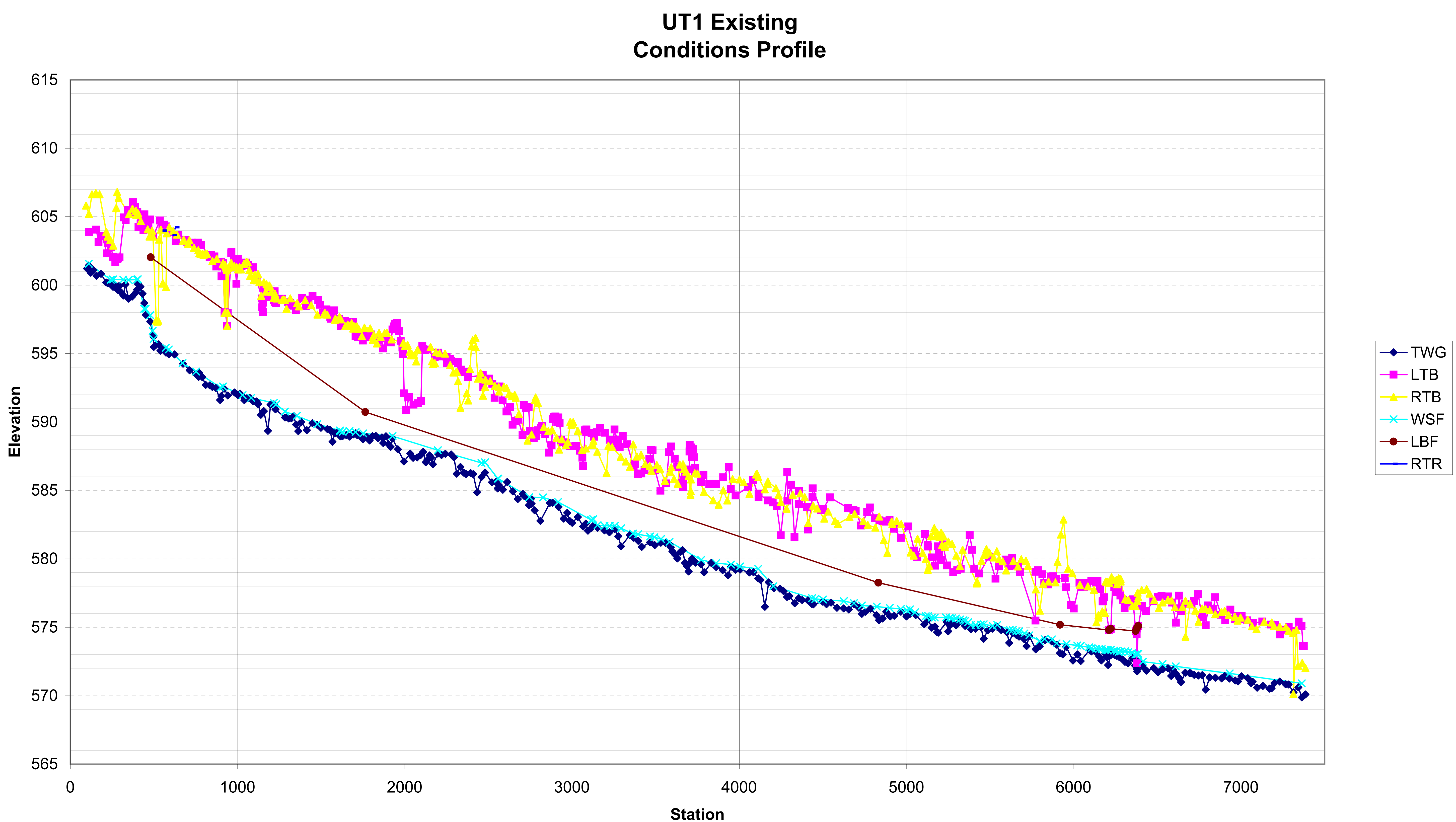
UT 1B Existing Conditions Profile

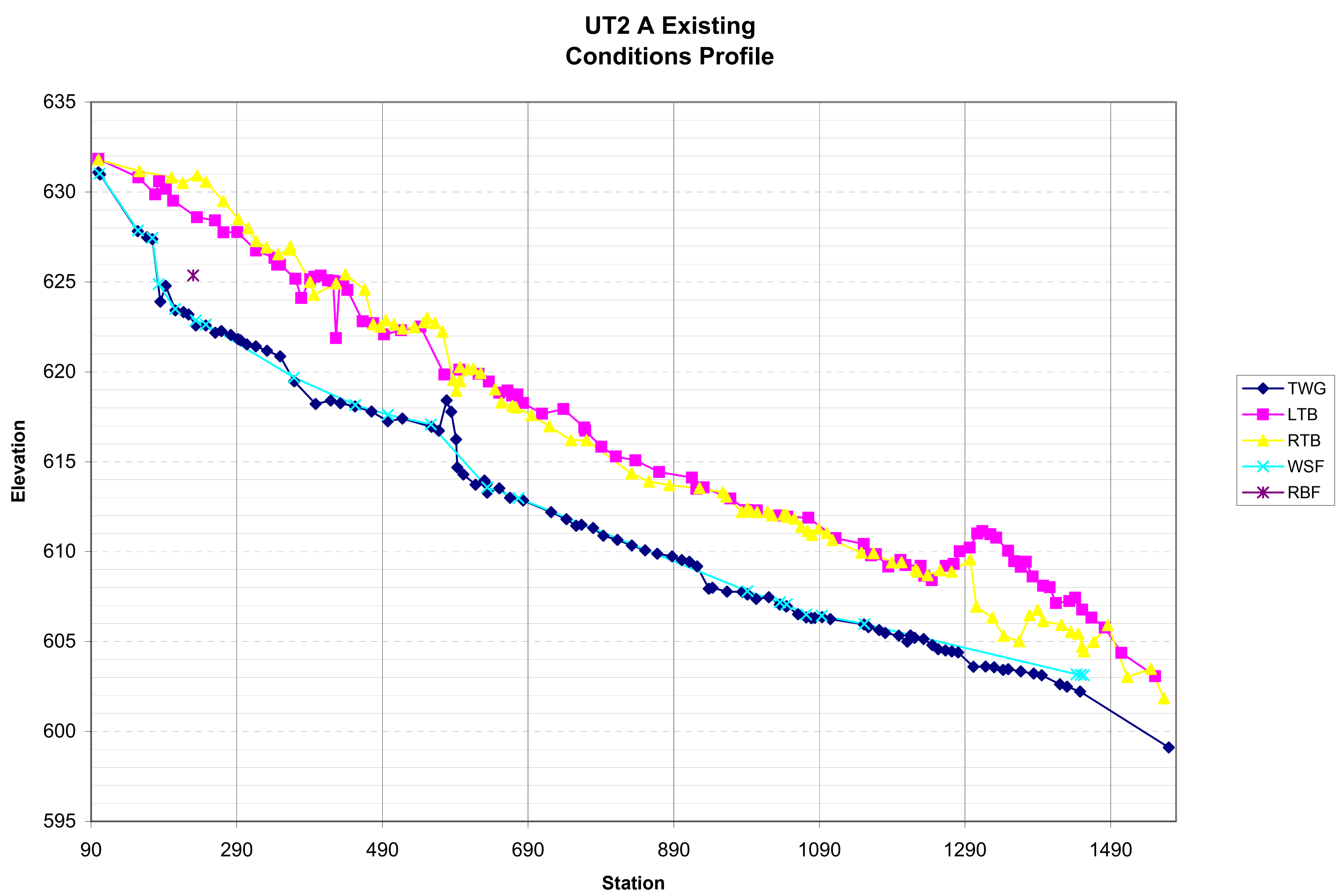



UT1 C Existing
Conditions Profile
Elevation
Station
605
600
595
590
585
580
90
190
290
390
490
590
690
790
TWG
LTB
RTB
WSF

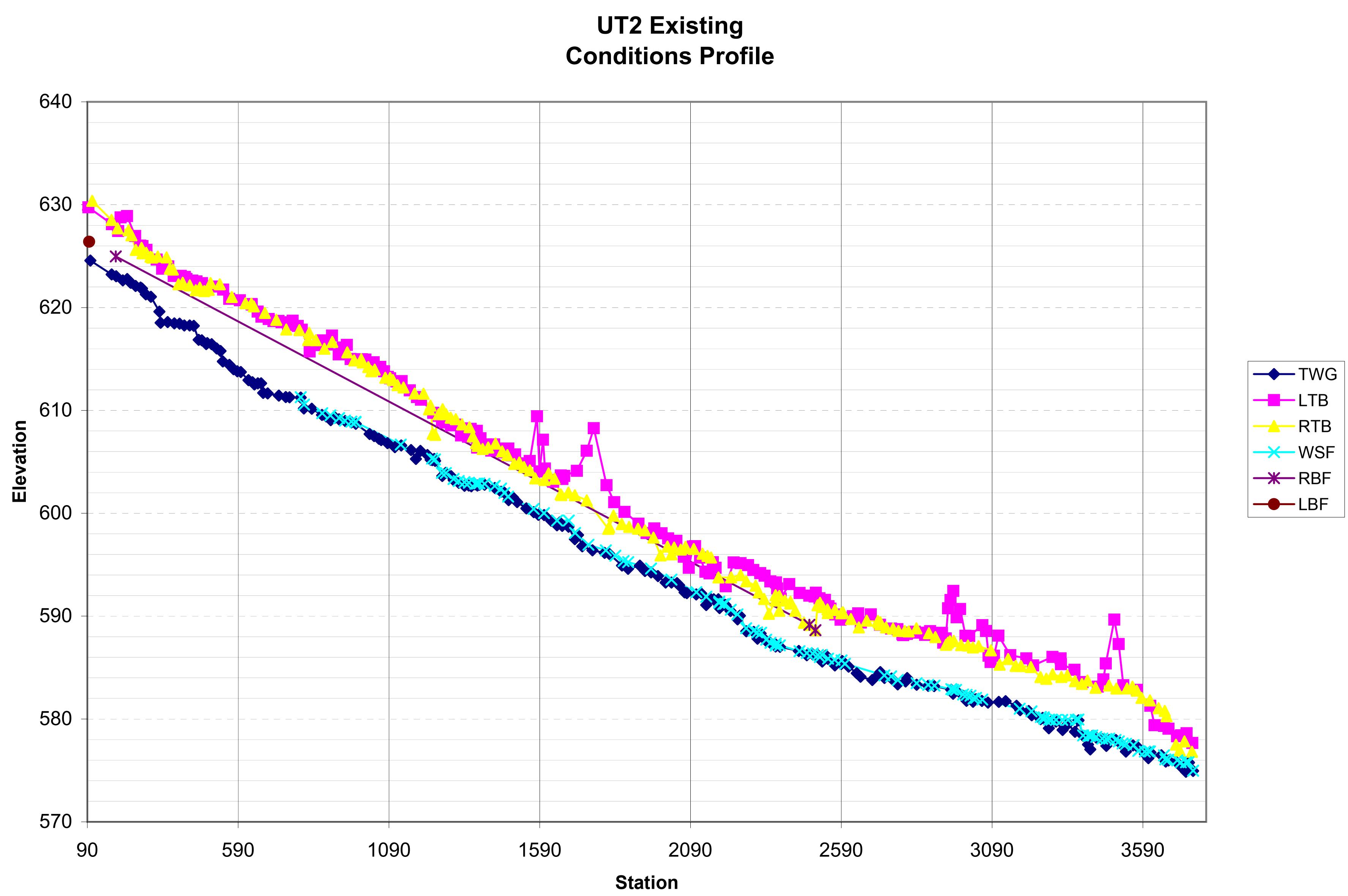


UT1 D Existing
Conditions Profile
Elevation
Station
592
590
588
586
584
582
580
578
90
140
190
240
290
340
390
440
TWG
LTB
RTB
WSF
RBF


UT1 Existing
Conditions Profile
Elevation
Station
615
610
605
600
595
590
585
580
575
570
565
0
1000
2000
3000
4000
5000
6000
7000
TWG
LTB
RTB
WSF
LBF
RTR



UT2 A Existing
Conditions Profile
Elevation
Station
635
630
625
620
615
610
605
600
595
90
290
490
690
890
1090
1290
1490
TWG
LTB
RTB
WSF
RBF



UT2 Existing
Conditions Profile
640
630
620
610
600
590
580
570
Elevation
90
590
1090
1590
2090
2590
3090
3590
Station
TWG
LTB
RTB
WSF
RBF
LBF

Appendix D

Conservation Agreements of Sale

The State of North Carolina has acquired conservation easements for all project restoration areas. The conservation easement encompasses the entire project with more than a 50-foot buffer along the alignment of the new channels in the majority of locations.

Appendix E

Benthic Macroinvertebrate Monitoring Data

Benthos Data for Beaverdam Creek Project Collected on December 12, 2005

SPECIES	Tolerance Values[1]	Feeding Group[2]	Site 1 UT1	Site 2 UT2	Site 3 Beaverdam Creek
ANNELIDA					
Oligochaeta					
Lumbricidae (Megadrile)	**9.0**	**CG**	R		C
Lumbriculidae	**7.0**	**CG**			C
Naididae					
Stylaria lacustris	**9.4**	**CG**	R	R	
MOLLUSKA					
Bivalva					
Cyrenidae					
Corbicula fluminea	**6.1**	**FC**			C
Gastropoda					
Physidae					
Physella sp.	**8.8**	**SC**	R		R
ARTHROPODA					
Crustacea					
Decapoda					
Cambaridae		**OM**	C		C
Amphipoda					
Talitridae					
Hyalella azteca	**7.8**	**CG**		R	
Insecta					
Ephemeroptera					
Baetidae			R		
Ephemerellidae					
Ephemerella sp.	**2.0**	**CG**			C
Heptageniidae					
Stenonema modestum	**5.5**	**SC**	A		C
Plecoptera					
Capniidae					
Allocapnia sp.	**2.5**	**SH**	A	C	A
Perlidae					
Eccoptura xanthenes	**3.7**	**PR**	R		
Perlodidae					
Clioperla clio	**4.7**	**PR**	R		C
Odonata					
Aeshnidae					
Boyeria vinosa	**5.9**	**PR**	R		R
Calopterygidae					
Calopteryx sp.	**7.8**	**PR**	C		R
Cordulegastridae					

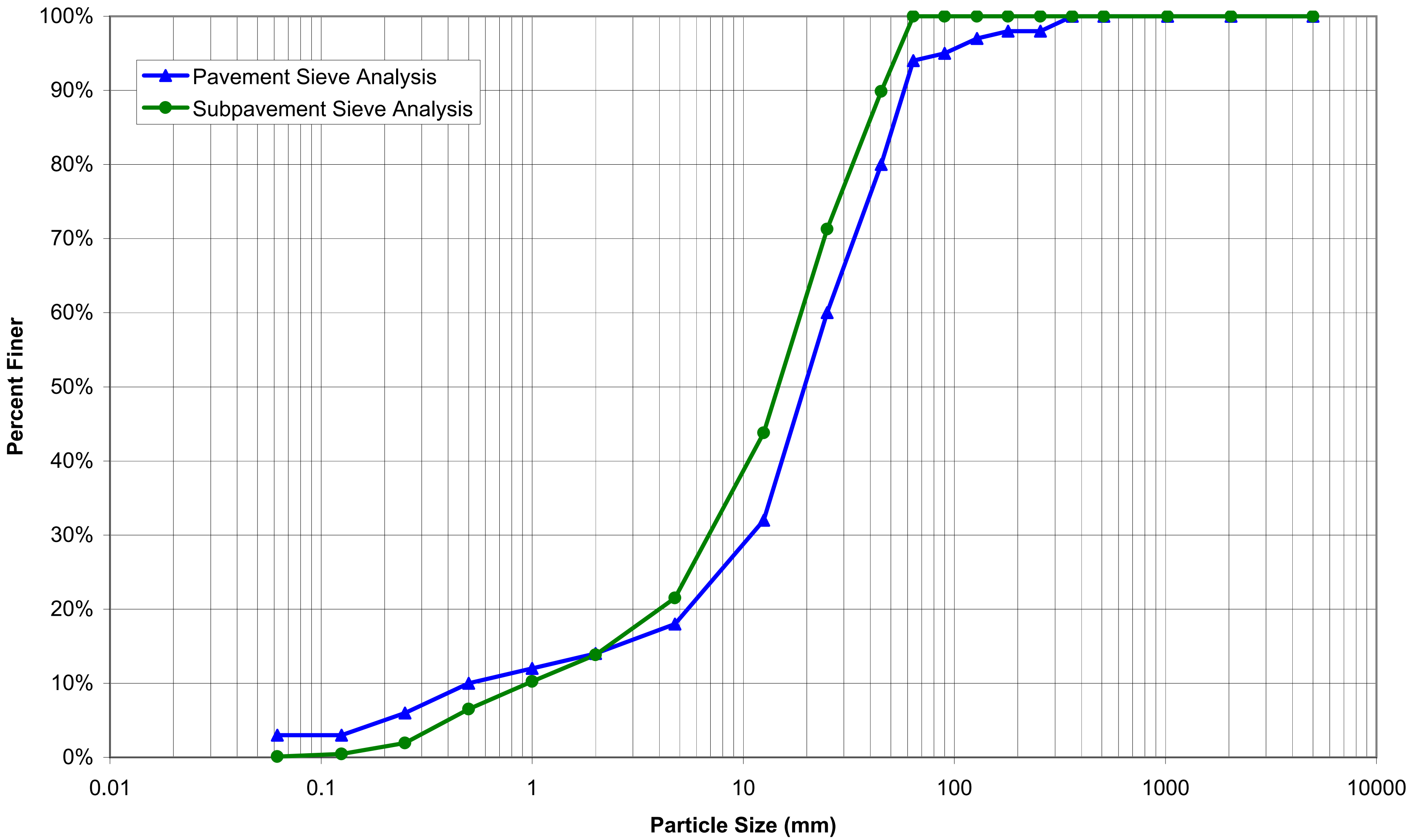
SPECIES	Tolerance Values[1]	Feeding Group[2]	Site 1 UT1	Site 2 UT2	Site 3 Beaverdam Creek
Cordulegaster sp.	**5.7**	**PR**	C		C
Gomphidae					
Ophiogompus sp.	**5.5**	**PR**	R		R
Progomphus obscurus	**8.2**	**PR**	R		
Coleoptera					
Dryopidae					
Helichus sp.	**4.6**	**SH**	C		
Dytiscidae					
Neoporus sp.	**8.6**	**PR**	R	R	R
Elmidae					
Stenelmis sp.	**5.1**	**OM**		R	
Ptilodactylidae					
Anchytarsus bicolor	**3.6**	**SH**			R
Hemiptera					
Corixidae					
Sigara sp.	**9.1**	**PR**		R	
Lepidoptera					
Pyralidae	**2.0**	**SH**	R		
Diptera					
Chironomidae					
Conchapelopia grp.	**8.4**	**PR**	R		
Diplocladius cultriger	**7.4**	**CG**	R	R	
Microtendipes sp.	**5.5**	**FC**		R	R
Parametriocnemus lundbecki	**3.7**	**CG**	R	R	
Tribelos sp.	**6.3**	**CG**		R	
Zavrelimyia sp.	**9.1**	**PR**		R	
Tabanidae					
Chrysops sp.	**6.7**	**CG**	C		
Tipulidae					
Dicranota sp.	**0.0**	**PR**	R		
Limnophila sp.		**PR**	R	C	
Tipula sp.	**7.3**	**SH**	C		R
Total Taxa Richness			**24**	**12**	**17**
EPT Taxa Richness			**5**	**1**	**4**
Biotic Index			**5.34**	**6.12**	**5.13**
EPT Biotic Index			**4.02**	**2.5**	**3.35**
EPT Abundance			**23**	**3**	**19**
NCDWQ Habitat Assessment Score (Max = 100)			**55**	**60**	**56**

Notes: [1] Tolerance Values ranges from 0 (least tolerant to organic pollution) to 10 (most tolerant to organic pollution).
[2] Functional Feeding Group: CG = Collector-Gatherer, DE = Detritovore FC = Filterer-Collector, HE = Herbivore, OM = Omnivore, PR = Predator, SC = Scraper, SH = Shredder;

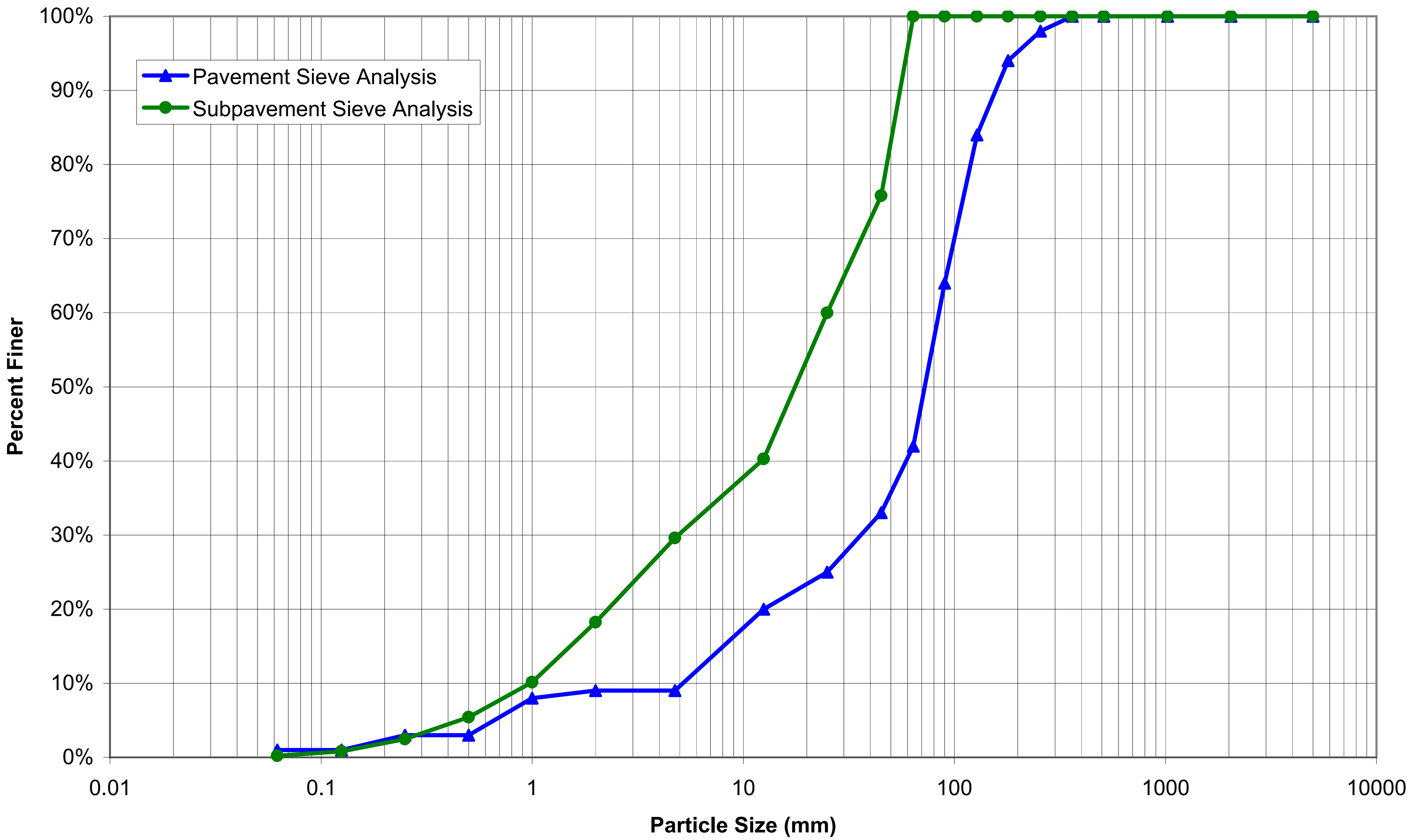
Appendix F

Sediment Transport Analysis

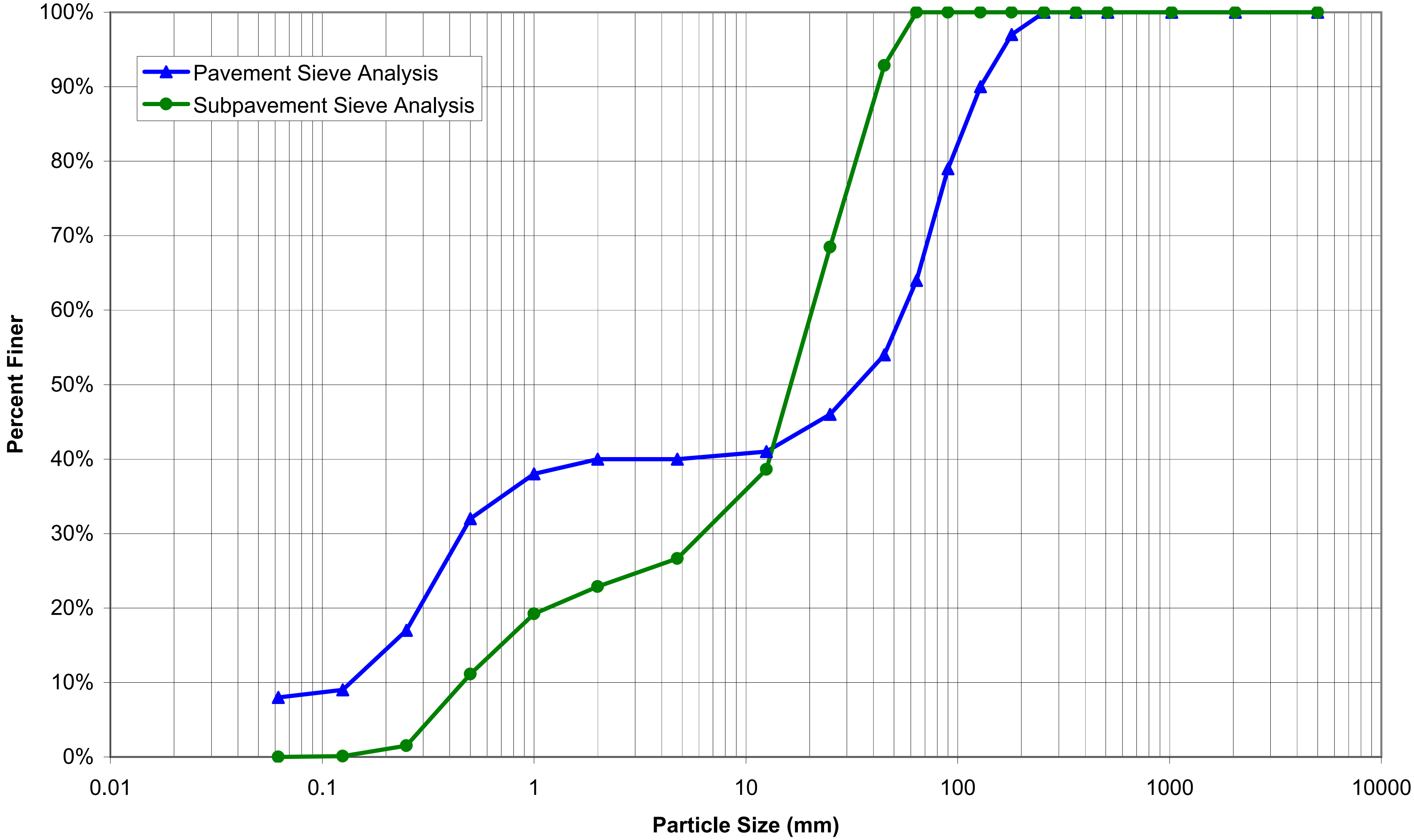
Stream Beaverdam Creek
Reach UT1B
Pavement and Subpavement Particle Size Distributions

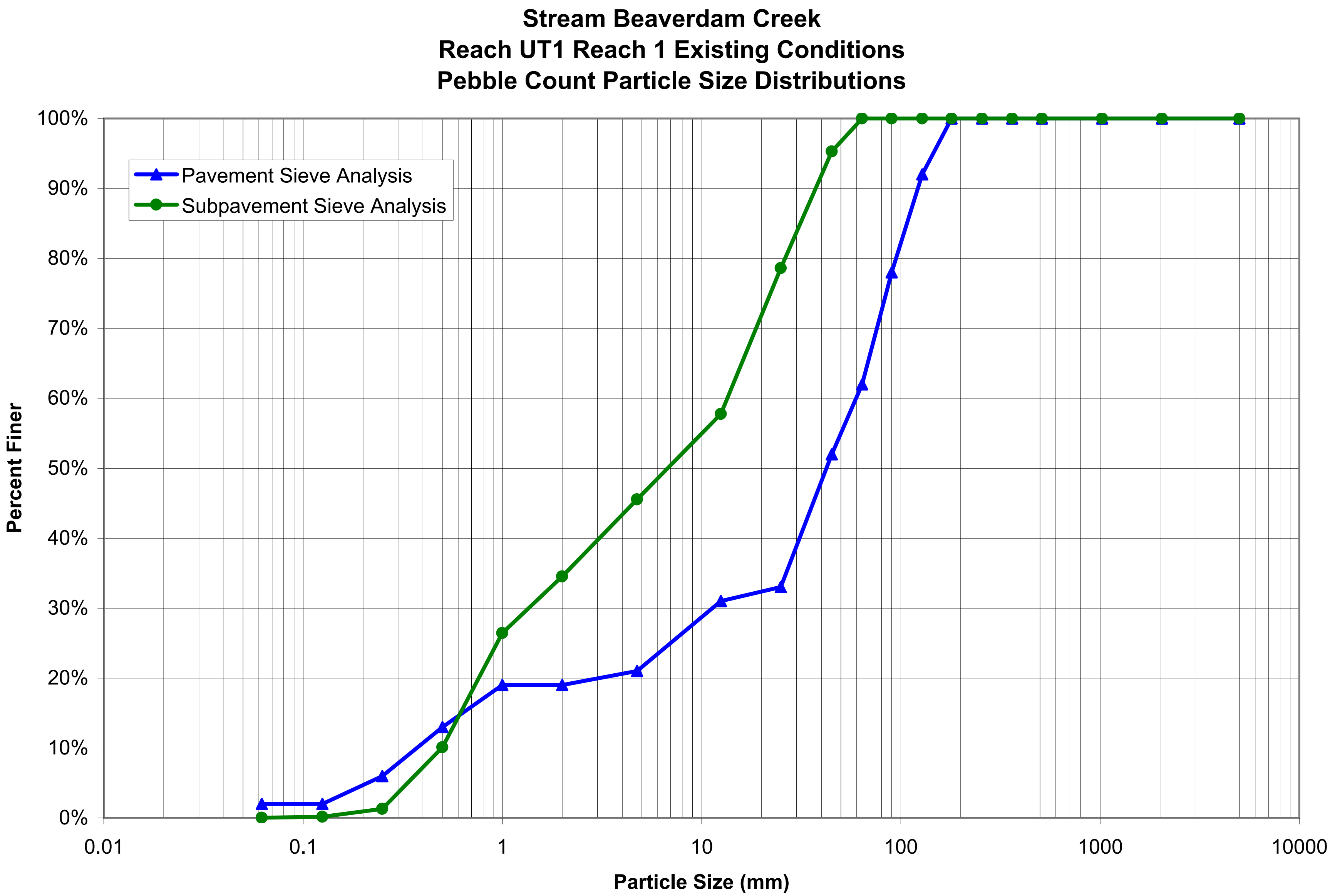


Stream Beaverdam Creek
Reach UT1C
Pavement and Subpavement Particle Size Distributions



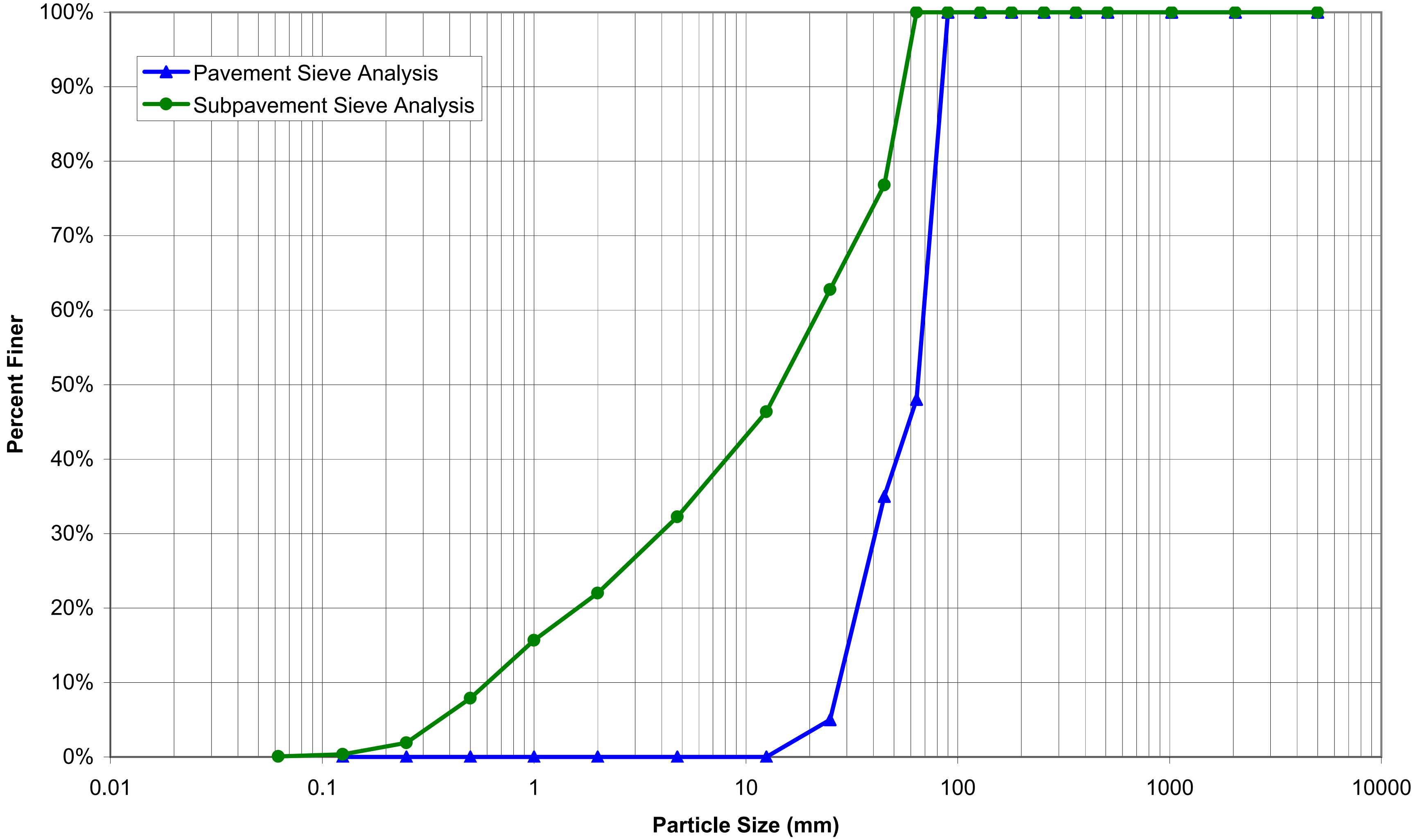
Stream Beaverdam Creek
Reach UT1D
Pavement and Subpavement Particle Size Distributions



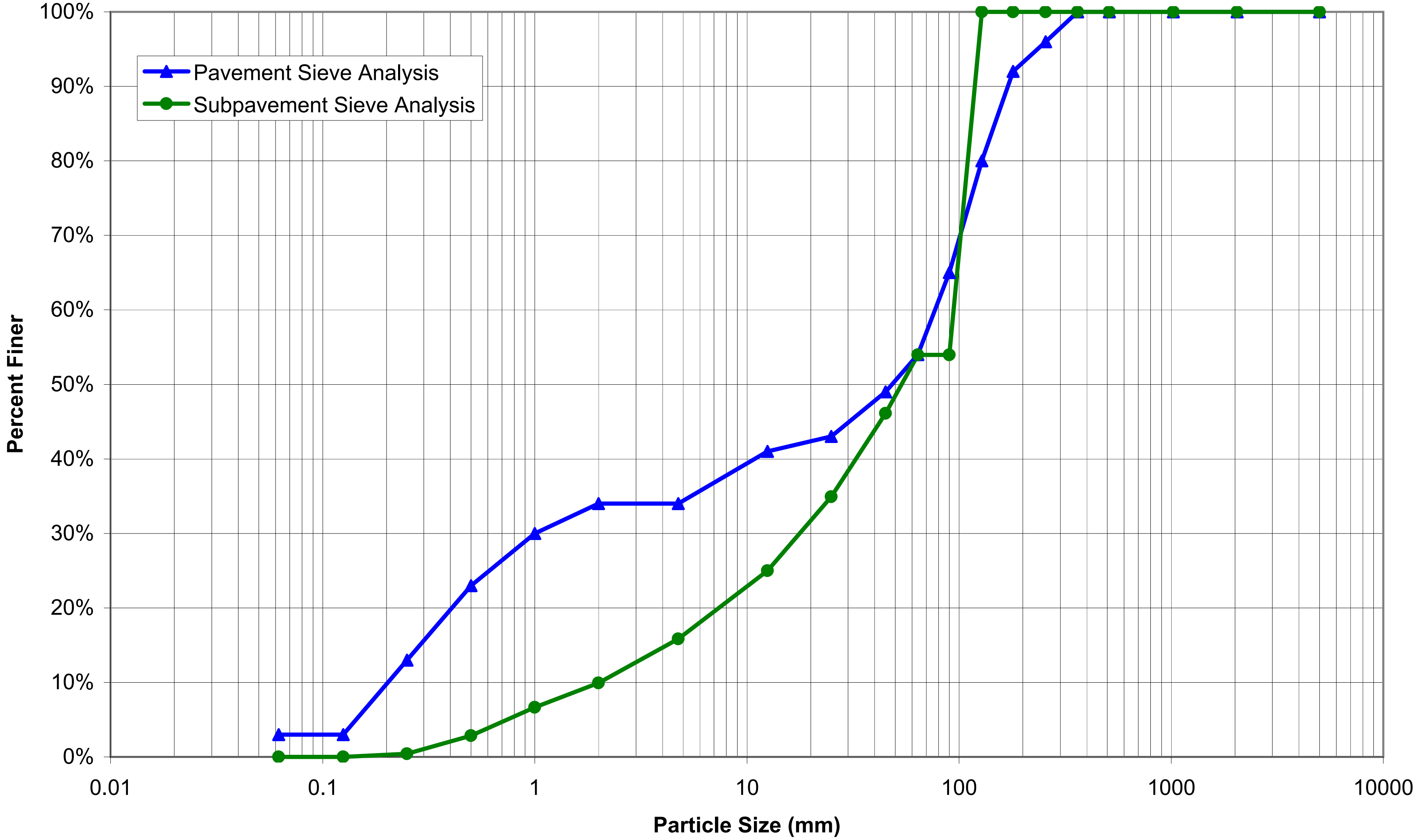


L:\Projects\0269C\Assessment\Exist_Cond\Sediment\UT1\12-7-05\UT1_UP_ PVMT SUBPVMT, Distribution Graph 2/15/2006 @ 3:58 PM

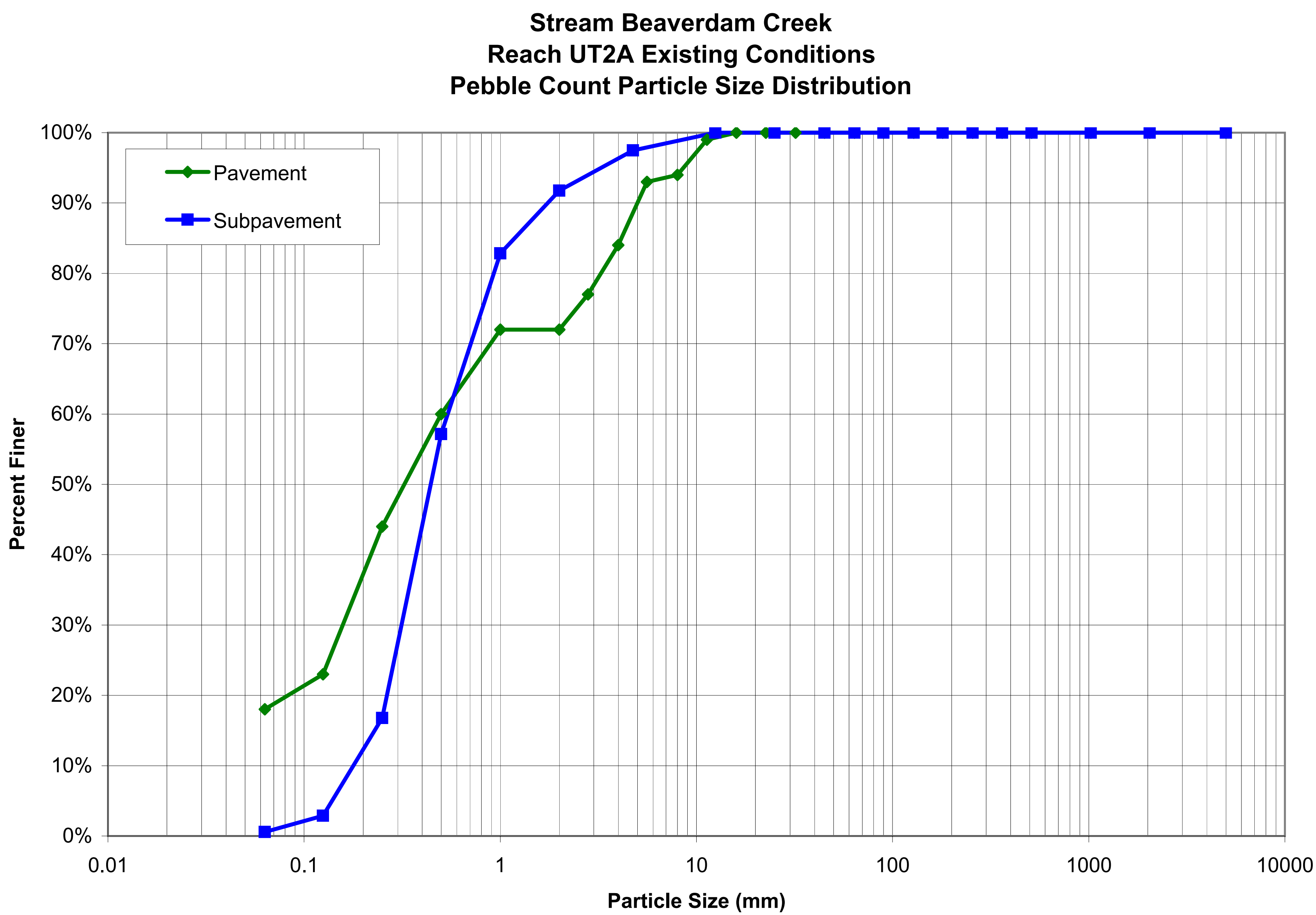
Stream Beaverdam Creek
Reach UT1 Reach 2 and 3 Existing Conditions
Pebble Count Particle Size Distributions

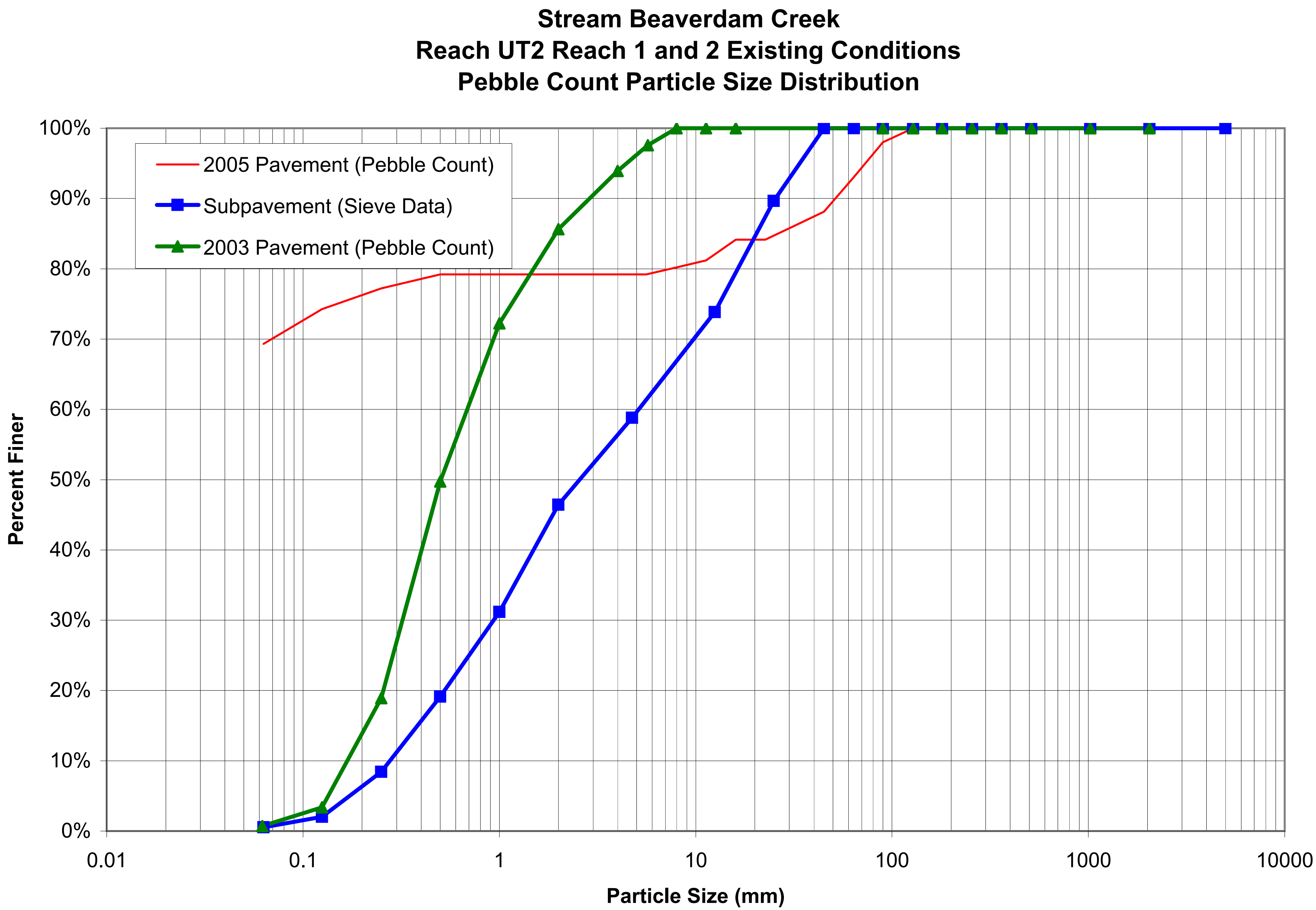


Stream Beaverdam Creek
Reach UT1 Reach 4 and 5 Existing Conditions
Pebble Count Particle Size Distributions



L:\Projects\0269C\Assessment\Exist_Cond\Sediment\UT1\12-7-05\UT1_PL_ PVMT SUBPVMT, Distribution Graph 2/15/2006 @ 4:10 PM

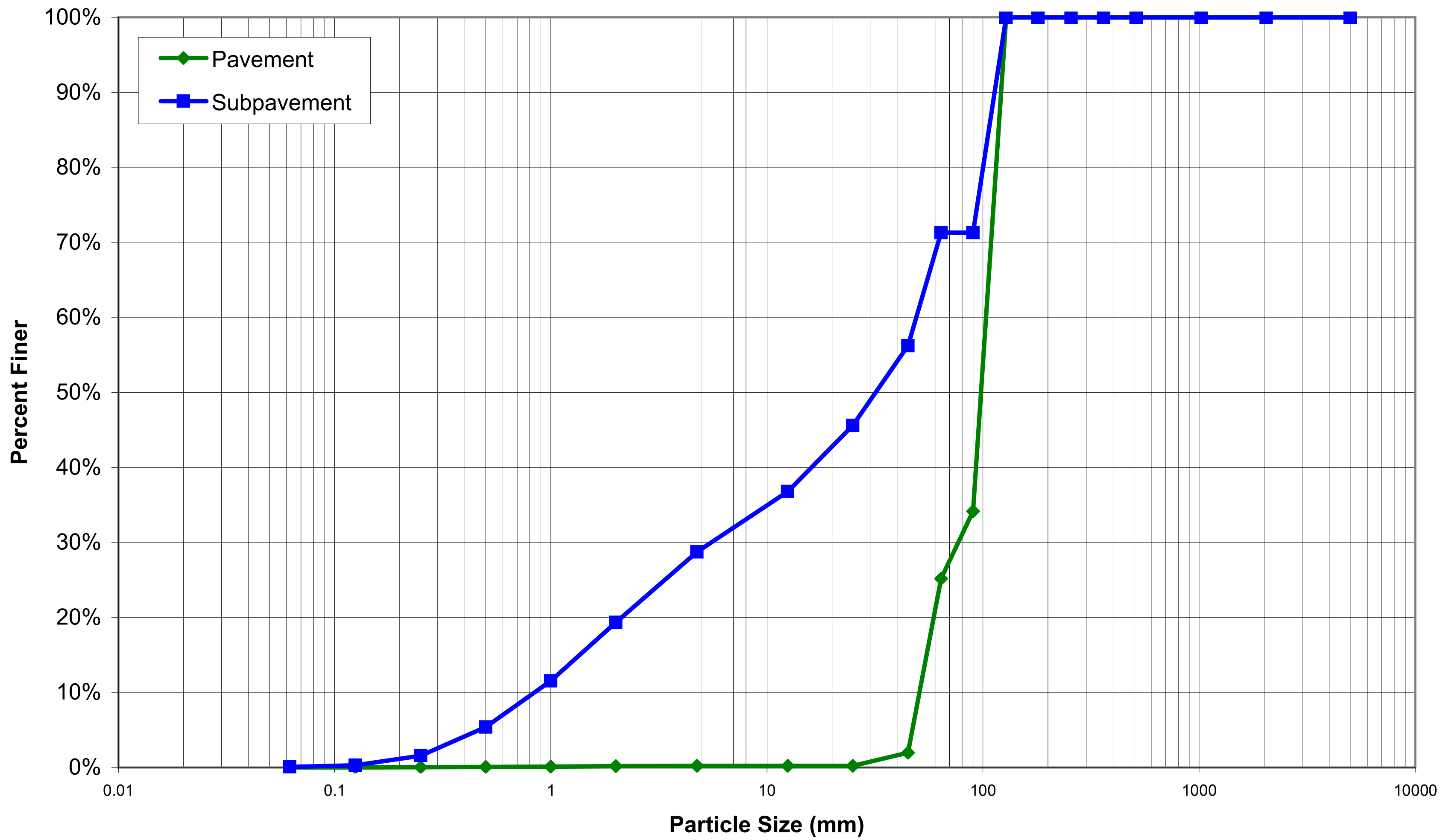

Stream Beaverdam Creek
Reach UT2A Existing Conditions
Pebble Count Particle Size Distribution
Pavement
Subpavement
Percent Finer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)



L:\Projects\0269C\Design\Sed Trans\UT2compileddata\UT2aboveconfl2A.xls, Riffle Dist

2/15/2006

Stream Beaverdam Creek
Reach UT2 Reach 3 and 4
Pavement/Subpavement Particle Size Distribution



Competancy and Capacity Analysis (Shear Stress and Stream Power)

Project: Beaverdam Creek - Existing Sections

Creek Name	UT1 Beaverdam Creek				
Shear Stress Analysis	**UT1 Rch 4**	**UT1 Rch 2**	**UT1B**	**UT1C**	**UT1D**
Bankfull Xsec Area, A_{bkf} (sq ft)	32.2	21.5	27.7	19.4	13.6
Bankfull Width, W_{bkf} (ft)	14.9	12.7	13.3	12.7	7.1
Bankfull Mean Depth, D_{bkf} (ft)	2.2	1.7	2.1	1.5	1.9
Wetted Perimeter, $P_w \sim W+2D$ (ft)	19.3	16.1	17.5	15.7	10.9
Hydraulic Radius, R (ft)	1.67	1.3	1.6	1.2	1.2
S_{chan} (ft/ft)	0.0026	0.018	0.012	0.024	0.015
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.27	1.50	1.19	1.87	1.18
$d_{50\ /\ pavement}$ (mm) - pebble count	0.80	1.80	20.00	72.00	53.00
$d_{50\ /\ subpavement}$ (mm) - bar sample	0.98	1.06	15.30	18.70	17.30
d_i (mm) - subpavement d_{100}	13	25	48	54	50
ratio - $d_{50\ /\ pvmt}$ / $d_{50subpvmt}$ (between 3 - 7, eqn 1)	0.8	1.7	1.3	3.9	3.1
ratio - d_i / d_{50} pavement (between 1.3 - 3.0, eqn 2)	15.6	13.9	2.4	0.8	0.9
τ_{ci} -equation 1	0.0995	0.0526	0.0660	**0.0257**	**0.0314**
τ_{ci} - equation 2	0.0034	0.0037	**0.0177**	0.0496	0.0404
d bar large (ft)	0.04	0.08	0.16	0.18	0.16
D_{crit} (ft) (equation 1)	2.59	0.40	1.43	**0.31**	**0.56**
D_{crit} (ft) (equation 2)	0.09	0.03	**0.38**	0.60	0.72
S_{crit} (equation 1)	0.00306	0.00418	0.00817	**0.00502**	**0.00448**
S_{crit} (equation 2)	0.00010	0.00030	**0.00219**	0.00966	0.00576
Largest moveable particle (shields/CO curves)	75	400	350	480	350
Unit Stream Power (lbs/ft-sec)	1.5	8.3	6.5	10.3	6.5
Unit Stream Power (watts/m^2)	21.8	120.6	95.3	150.0	95.1

Yang's Critical Velocity - Existing Channel

	UT1 DR 1	UT1 DR 2	UT1 DR 3	UT1 DR 4	UT1 DR 5	UT1B	UT1C	UT1D
Bankfull Xsec Area, A_{bkf} (sq ft)	21.5	21.5	27.3	32.2	30.6	27.7	19.4	13.6
Bankfull Width, Wbkf (ft)	12.7	12.7	16.1	14.9	16.9	13.3	12.7	7.1
Bankfull Mean Depth, D_{bkf} (ft)	1.69	1.69	1.70	2.17	1.80	2.08	1.53	1.92
Wetted Perimeter, $P_w \sim W+2D$ (ft)	24.9	24.9	30.7	36.6	34.2	31.8	22.4	17.5
Hydraulic Radius, R (ft)	0.86	0.86	0.89	0.88	0.89	0.87	0.86	0.78
S_{chan} (ft/ft)	0.0046	0.0046	0.0062	0.0050	0.0012	0.0105	0.0179	0.0045
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.25	0.25	0.34	0.27	0.07	0.57	0.96	0.22
$d_{50\ /\ pavement}$ (mm) - pebble count	43.00	65.00	65.00	48.00	48	20	72	36
$d_{50\ /\ pavement}$ (ft)	1.41E-01	2.13E-01	2.13E-01	1.57E-01	1.57E-01	6.56E-02	2.36E-01	1.18E-01
u_* =	0.358	0.358	0.421	0.377	0.186	0.542	0.706	0.336
F_1 =	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816
ω =	2.235	2.748	2.748	2.361	2.361	1.523	2.892	2.045
R_s =	3838.33	5802.13	6832.95	4511.00	2226.73	2705.26	12673.50	3019.93
v_{cr} (for 0 < Rs < 70) in ft/sec =	3.034	3.639	3.605	3.174	3.322	2.115	3.671	2.818
v_{cr} (for Rs > 70) in ft/sec =	**4.581**	**5.634**	**5.634**	**4.841**	**3.842**	**3.842**	**3.842**	**3.842**

Competancy and Capacity Analysis (Shear Stress and Stream Power)
Project: Beaverdam Creek - Proposed Sections

Creek Name	UT 1 Beaverdam Creek								
Shear Stress Analysis	**UT1 Rch 1a**	**UT1 Rch 1b**	**UT1 Rch 2**	**UT1 Rch 3**	**UT1 Rch 4**	**UT1 Rch 5**	**UT1B**	**UT1C**	**UT1D**
Bankfull Xsec Area, A_{bkf} (sq ft)	21.2	27.8	27.8	37.6	38.6	40.3	11.1	8.5	23.0
Bankfull Width, W_{bkf} (ft)	14.6	16.8	16.8	19.2	19.6	20.0	10.4	11.2	16.4
Bankfull Mean Depth, D_{bkf} (ft)	1.5	1.7	1.7	2.0	2.0	2.0	1.1	0.8	1.4
Wetted Perimeter, $P_w \sim W+2D$ (ft)	17.5	20.1	20.1	23.1	23.5	24.0	12.5	12.7	19.2
Hydraulic Radius, R (ft)	1.21	1.4	1.4	1.6	1.6	1.7	0.9	0.7	1.2
S_{chan} (ft/ft)	0.0045	0.005	0.006	0.002	0.003	0.003	0.007	0.015	0.007
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.34	0.39	0.52	0.23	0.29	0.36	0.38	0.61	0.50
$d_{50\ /\ pavement}$ (mm) - pebble count	43	65	65	65	48	48	20.00	90.00	53.00
$d_{50\ /\ subpavement}$ (mm) - bar sample	7	15	15	15	53	53	15.30	18.70	17.30
d_i (mm) - subpavement d_{100}	50	54	54	54	104	104	48	54	50
ratio - $d_{50\ /\ pvmt}$ / $d_{50subpvmt}$ (between 3 - 7, eqn 1)	6.1	4.3	4.3	4.3	0.9	0.9	1.3	4.8	3.1
ratio - d_i / d_{50} pavement (between 1.3 - 3.0, eqn 2)	1.2	0.8	0.8	0.8	2.2	2.2	2.4	0.6	0.9
τ_{ci} -equation 1	0.0171	0.0232	0.0232	0.0232	**0.0909**	**0.0909**	0.0660	**0.0212**	**0.0314**
τ_{ci} - equation 2	**0.0336**	**0.0453**	**0.0453**	**0.0453**	0.0193	0.0193	**0.0177**	0.0604	0.0404
d bar large (ft)	0.16	0.18	0.18	0.18	0.34	0.34	0.16	0.18	0.16
D_{crit} (ft) (equation 1)	1.03	1.51	1.13	2.95	**18.28**	**15.06**	2.49	**0.42**	**1.27**
D_{crit} (ft) (equation 2)	**2.02**	**2.94**	**2.21**	**5.75**	3.89	3.20	**0.67**	1.20	1.63
S_{crit} (equation 1)	0.00319	0.00410	0.00410	0.00347	**0.02597**	**0.02538**	0.01605	**0.00818**	**0.00605**
S_{crit} (equation 2)	**0.00626**	**0.00798**	**0.00798**	**0.00676**	0.00552	0.00540	**0.00429**	0.02332	0.00779
Largest moveable particle (shields/CO curves)	60	70	65	70	70	70	350	480	350
Unit Stream Power (lbs/ft-sec)	1.9	2.1	2.9	1.3	1.6	2.0	2.1	3.4	2.8
Unit Stream Power (watts/m^2)	27.4	31.2	41.6	18.7	23.0	28.6	30.7	49.2	40.3

Yang's Critical Velocity - Proposed Channel

	UT1 DR 1	UT1 DR 2	UT1 DR 3	UT1 DR 4	UT1 DR 5	UT1B	UT1C	UT1D
Bankfull Xsec Area, A_{bkf} (sq ft)	21.2	27.8	37.6	38.6	40.3	11.1	8.5	9.6
Bankfull Width, Wbkf (ft)	14.6	16.8	19.2	19.6	20.0	10.4	11.2	10.4
Bankfull Mean Depth, D_{bkf} (ft)	1.45	1.66	1.96	1.97	2.02	1.07	0.76	0.93
Wetted Perimeter, P_w ~ W+2D (ft)	24.1	31.2	41.5	42.6	44.4	13.3	10.0	11.5
Hydraulic Radius, R (ft)	0.88	0.89	0.91	0.91	0.91	0.84	0.85	0.84
S_{chan} (ft/ft)	0.0045	0.0045	0.0023	0.0028	0.0034	0.0069	0.0147	0.0067
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.25	0.25	0.13	0.16	0.19	0.36	0.78	0.35
$d_{50\ /\ pavement}$ (mm) - pebble count	43.00	65.00	65.00	48.00	48	20	90	34
$d_{50\ /\ pavement}$ (ft)	1.41E-01	2.13E-01	2.13E-01	1.57E-01	1.57E-01	6.56E-02	2.95E-01	1.12E-01
u_* =	0.357	0.360	0.259	0.286	0.315	0.432	0.634	0.425
F_1 =	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816
ω =	2.235	2.748	2.748	2.361	2.361	1.523	3.234	1.987
R_s =	3829.87	5835.56	4199.98	3425.38	3778.08	2154.01	14230.18	3608.36
v_{cr} (for 0 < Rs < 70) in ft/sec =	3.034	3.638	3.710	3.229	3.209	2.148	4.081	2.708
v_{cr} (for Rs > 70) in ft/sec =	**4.581**	**5.634**	**5.634**	**4.841**	**4.841**	**3.123**	**6.629**	**4.073**

Competancy and Capacity Analysis (Shear Stress and Stream Power)

Project: Beaverdam Creek - Existing Sections (UT2/UT2A)

Creek Name	UT 2/2a Beaverdam Creek		
Shear Stress Analysis	**UT2 dgn rch 1 & 2 (above confl.)**	**UT2 dgn rch 3 & 4 (below confl.)**	**UT 2A dgn rch 1 & 2**
Bankfull Xsec Area, A_{bkf} (sq ft)	9	20	12
Bankfull Width, W_{bkf} (ft)	12.3	10.3	7.0
Bankfull Mean Depth, D_{bkf} (ft)	0.8	2.0	1.8
Wetted Perimeter, $P_w \sim W+2D$ (ft)	13.8	14.3	10.5
Hydraulic Radius, R (ft)	0.68	1.4	1.2
S_{chan} (ft/ft)	0.0160	0.009	0.021
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.68	0.77	1.50
$d_{50\ /\ pavement}$ (mm) - pebble count	0.50	100	0.31
$d_{50\ /\ subpavement}$ (mm) - bar sample	2.3	31	0.4
d_i (mm) - subpavement d_{100}	37	115	5
ratio - $d_{50\ /\ pvmt}$ / $d_{50subpvmt}$ (between 3 - 7, eqn 1)	0.22	3.23	0.72
ratio - d_i / d_{50} pavement (between 1.3 - 3.0, eqn 2)	74	1.15	16.1
τ_{ci} -equation 1	0.3156	**0.0300**	0.1109
τ_{ci} - equation 2	0.0008	0.0339	0.0033
d bar large (ft)	0.12	0.38	0.02
D_{crit} (ft) (equation 1)	3.95	**2.18**	0.15
D_{crit} (ft) (equation 2)	0.01	2.47	0.00
S_{crit} (equation 1)	0.08262	**0.00944**	0.00172
S_{crit} (equation 2)	0.00022	0.01067	0.00005
Largest moveable particle (shields/CO curves)			

Unit Stream Power (lbs/ft-sec)	3.7	5.0	9.7
Unit Stream Power (watts/m^2)	54.5	72.6	141.9

Yang's Critical Velocity - Existing Channel

	UT2 dgn rch 1 & 2 (above confl.)	UT2 dgn rch 3 & 4 (below confl.)	UT 2A dgn rch 1 & 2
Bankfull Xsec Area, A_{bkf} (sq ft)	9.4	20.5	12.2
Bankfull Width, Wbkf (ft)	12.3	10.3	7.0
Bankfull Mean Depth, D_{bkf} (ft)	0.77	1.98	1.75
Wetted Perimeter, $P_w \sim W+2D$ (ft)	10.9	24.4	15.7
Hydraulic Radius, R (ft)	0.86	0.84	0.78
S_{chan} (ft/ft)	0.0160	0.0086	0.0206
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.86	0.45	1.00
$d_{50\ /\ pavement}$ (mm) - pebble count	0.50	100.00	0.31
$d_{50\ /\ pavement}$ (ft)	1.64E-03	3.28E-01	1.02E-03
u_* =	0.666	0.481	0.718
F_1 =	0.670	0.816	0.548
ω =	0.198	3.409	0.127
R_s =	83.0	11994.3	55.5
v_{cr} (for 0 < Rs < 70) in ft/sec =	**0.388**	**4.339**	**0.267**
v_{cr} (for Rs > 70) in ft/sec =	0.405	6.988	0.261

Competancy and Capacity Analysis (Shear Stress and Stream Power)
Project: Beaverdam Creek - Proposed Sections (UT2/UT2A)

Creek Name	UT 2/2a Beaverdam Creek				
Shear Stress Analysis	**UT2 dgn rch 1 C/E-channel (above confl.)**	**UT2 dgn rch 2 B-channel (above confl.)**	**UT2 dgn rch 3 C/E-channel (below confl.)**	**UT2 dgn rch 4 C/E-channel (below confl.)**	**UT2A dgn rch 2 B-channel (above confl.)**
Bankfull Xsec Area, A_{bkf} (sq ft)	10.2	10.0	20.0	20.8	10.2
Bankfull Width, W_{bkf} (ft)	10.2	11.0	15.6	14.4	10.2
Bankfull Mean Depth, D_{bkf} (ft)	1.00	0.91	1.28	1.44	1.00
Wetted Perimeter, $P_w \sim W+2D$ (ft)	12.2	12.8	18.2	17.3	12.2
Hydraulic Radius, R (ft)	0.84	0.78	1.10	1.20	0.8
S_{chan} (ft/ft)	0.0125	0.019	0.0125	0.008	0.008
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.65	0.90	0.86	0.60	0.42
$d_{50\,/\,pavement}$ (mm) - pebble count	0.50	0.50	100	100	0.31
$d_{50\,/\,subpavement}$ (mm) - bar sample	2.3	2.3	31	31	0.42
d_i (mm) - subpavement d_{100}	37	37	115	115	5
ratio - $d_{50\,/\,pvmt}$ / $d_{50subpvmt}$ (between 3 - 7, eqn 1)	0.2	0.2	**3.2**	**3.2**	0.7
ratio - d_i / d_{50} pavement (between 1.3 - 3.0, eqn 2)	74.0	74.0	1.2	1.2	16.1
τ_{ci} -equation 1	0.3156	0.3156	**0.0300**	**0.0300**	0.1087
τ_{ci} - equation 2	0.0008	0.0008	0.0339	0.0339	0.0033
d bar large (ft)	0.12	0.12	0.38	0.38	0.02
D_{crit} (ft) (equation 1)	5.06	3.42	**1.50**	**2.34**	0.37
D_{crit} (ft) (equation 2)	0.00	0.00	0.00	0.00	0.00
Actual Design Depth (ft)	**1.00**	**0.91**	**1.28**	**1.44**	**1.00**
S_{crit} (equation 1)	**0.06317**	**0.06928**	**0.01458**	**0.01295**	**0.00294**
S_{crit} (equation 2)	0.00017	0.00019	0.01646	0.01463	0.00009
Actual Design Slope	**0.0100**	**0.0185**	**0.0110**	**0.0075**	**0.0120**
Largest moveable particle (shields/CO curves)					
Unit Stream Power (lbs/ft-sec)	3.6	5.9	5.6	3.9	2.7
Unit Stream Power ($watts/m^2$)	52.4	85.5	81.3	56.8	39.5

Yang's Critical Velocity - Proposed Channel

	UT2 dgn rch 1 C/E-channel (above confl.)	UT2 dgn rch 2 B-channel (above confl.)	UT2 dgn rch 3 C/E-channel (below confl.)	UT2 dgn rch 4 C/E-channel (below confl.)	UT2A dgn rch 2 B-channel (above confl.)
Bankfull Xsec Area, A_{bkf} (sq ft)	10.2	10.0	20.0	20.8	10.2
Bankfull Width, Wbkf (ft)	10.2	11.0	15.6	14.4	10.2
Bankfull Mean Depth, D_{bkf} (ft)	1.00	0.91	1.28	1.44	1.00
Wetted Perimeter, $P_w \sim W+2D$ (ft)	12.2	11.9	22.6	23.7	12.2
Hydraulic Radius, R (ft)	0.84	0.85	0.89	0.88	0.84
S_{chan} (ft/ft)	0.0100	0.0185	0.0165	0.0146	0.0120
τ (lb/ft^2) - Boundary/Bankfull Shear Stress,	0.52	0.98	0.91	0.80	0.63
$d_{50\,/\,pavement}$ (mm) - pebble count	0.50	0.50	100.00	100.00	0.31
$d_{50\,/\,pavement}$ (ft)	1.64E-03	1.64E-03	3.28E-01	3.28E-01	1.02E-03
$u_* =$	0.519	0.710	0.685	0.643	0.568
$F_1 =$	0.670	0.670	0.816	0.816	0.548
$\omega =$	0.198	0.198	3.409	3.409	0.127
$R_s =$	64.73	88.57	17102.57	16043.49	43.96
v_{cr} (for 0 < Rs < 70) in ft/sec =	**0.403**	0.384	4.263	4.276	**0.278**
v_{cr} (for Rs > 70) in ft/sec =	0.405	**0.405**	**6.988**	**6.988**	0.261

Appendix G

Photograph Log

Photo 1 UT1 Bank Erosion at Riffle

Photo 2 UT1 Channel Widening

Photo 3 UT1 Headcut

Photo 4 Incision along UT1

Photo 5 UT1 Bank Erosion

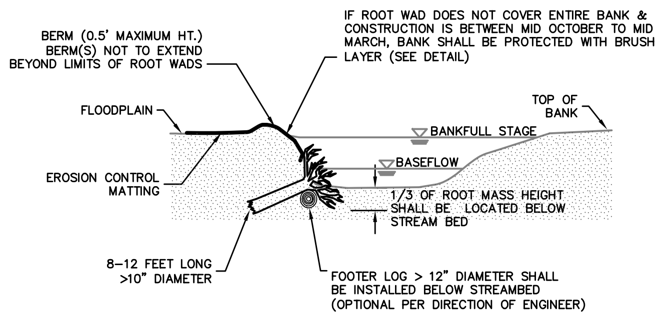
Photo 6 UT1 Mid-Channel Bar


Photo 7 UT2 Debris Jam

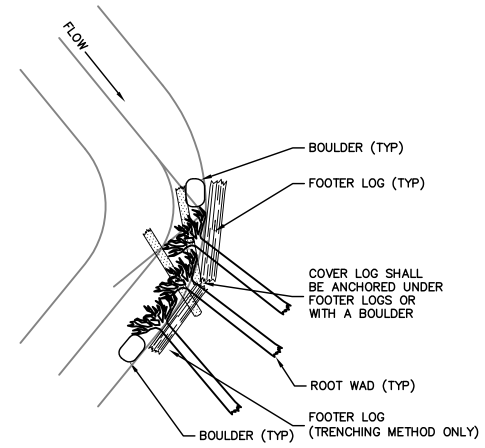

Photo 8 UT2 Bank Erosion


Photo 9 UT2 Headcut

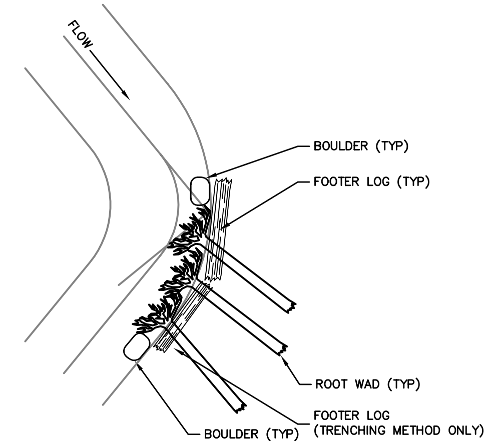
1 / D1 ROOT WAD
NTS



CROSS-SECTION VIEW



PLAN VIEW W/ COVERLOGS



PLAN VIEW W/OUT COVERLOGS

NOTE #1

TRENCHING METHOD:
IF THE ROOT WAD CANNOT BE DRIVEN INTO THE BANK OR THE BANK REQUIRES RECONSTRUCTION, THE TRENCHING METHOD SHALL BE USED. THIS METHOD REQUIRES THAT A TRENCH BE EXCAVATED FOR THE LOG PORTION OF THE ROOT WAD. IN THIS CASE, A FOOTER LOG SHALL BE INSTALLED UNDERNEATH THE ROOT WAD IN A TRENCH EXCAVATED PARALLEL TO THE BANK AND WELL BELOW THE STREAMBED. ONE-THIRD OF THE ROOT WAD SHALL REMAIN BELOW NORMAL BASE FLOW CONDITIONS.

NOTE #2

DRIVE POINT METHOD:
THE TRUNK END OF THE LOG SHALL BE SHARPENED WITH A CHAINSAW BEFORE "DRIVING" IT INTO THE BANK. ROOT WADS SHALL BE ORIENTED UPSTREAM SO THAT THE STREAM FLOW MEETS THE ROOT WAD AT A 90-DEGREE ANGLE, DEFLECTING THE WATER AWAY FROM THE BANK. A TRANSPLANT OR BOULDER SHALL BE PLACED ON THE DOWNSTREAM SIDE OF THE ROOT WAD IF A BACK EDDY IS FORMED BY THE ROOT WAD. THE BOULDER SHALL BE APPROXIMATELY 4' X 3' X 2'.

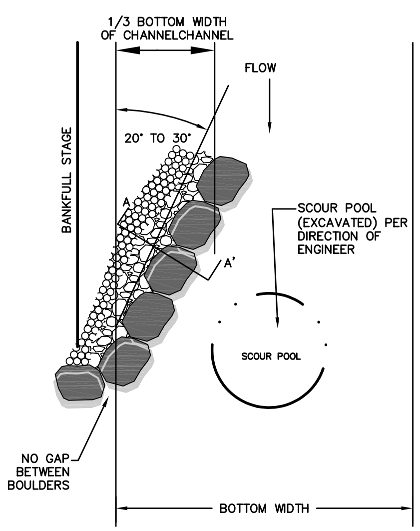
PROJECT REFERENCE NO.	SHEET NO.
0269C	D1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

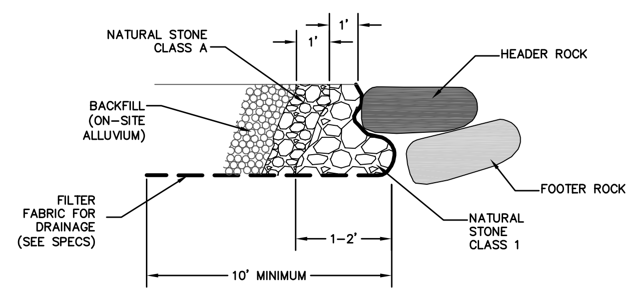
PROJECT ENGINEER: JBG
APPROVED BY
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

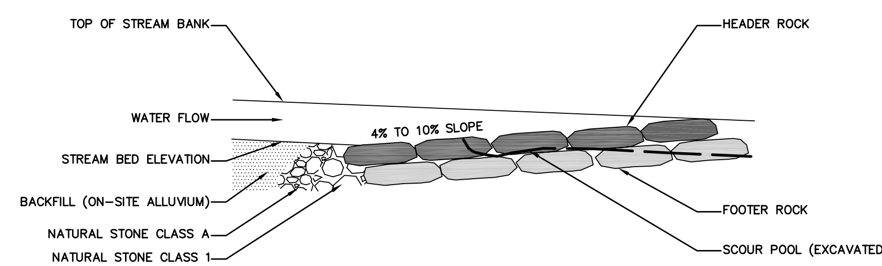
2 / D1 ROCK VANE
NTS



PLAN VIEW



SECTION A-A'

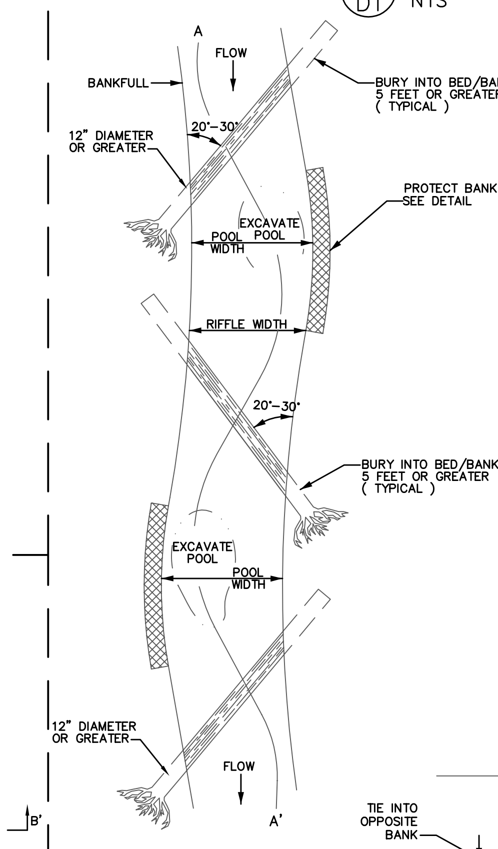


PROFILE VIEW

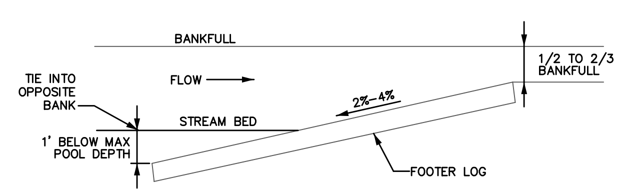
NOTES FOR ALL VANE STRUCTURES:

1. BOULDERS MUST BE AT LEAST 4' X 3' X 2'.
2. INSTALL FILTER FABRIC FOR DRAINAGE BEGINNING AT THE MIDDLE OF THE HEADER ROCKS AND EXTEND DOWNWARD TO THE DEPTH OF THE BOTTOM FOOTER ROCK, AND THEN UPSTREAM TO A MINIMUM OF TEN FEET.
3. DIG A TRENCH BELOW THE BED FOR FOOTER ROCKS AND PLACE FILL ON UPSTREAM SIDE OF VANE ARM, BETWEEN THE ARM AND STREAM BANK.
4. START AT BANK AND PLACE FOOTER ROCKS FIRST AND THEN HEADER (TOP) ROCK.
5. CONTINUE WITH STRUCTURE, FOLLOWING ANGLE AND SLOPE SPECIFICATIONS.
6. AN EXTRA BOULDER CAN BE PLACED IN SCOUR POOL FOR HABITAT IMPROVEMENT.
7. USE NATURAL STONE CLASS 1 TO FILL GAPS ON UPSTREAM SIDE OF BOULDERS, AND NATURAL STONE CLASS A TO FILL GAPS ON UPSTREAM SIDE OF NATURAL STONE CLASS 1.
8. AFTER ALL STONE HAS BEEN PLACED, FILL IN THE UPSTREAM SIDE OF THE STRUCTURE WITH ON-SITE ALLUVIUM TO THE ELEVATION OF THE TOP OF THE HEADER ROCK.
9. START SLOPE AT 1/2 TO 2/3 BANKFULL STAGE.

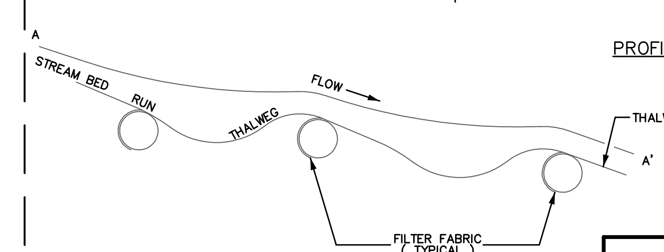
5 / D1 LOG STEP POOL
NTS



PLAN VIEW



PROFILE VIEW

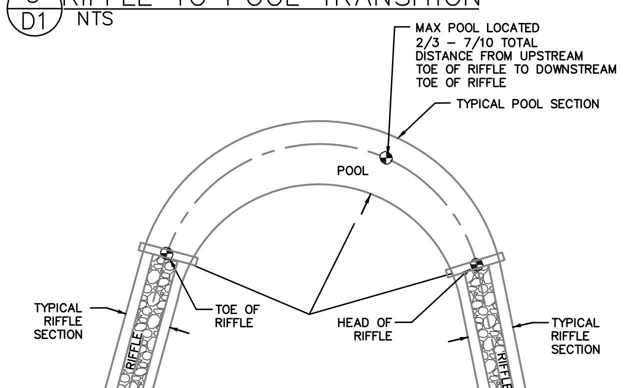


SECTION A - A'

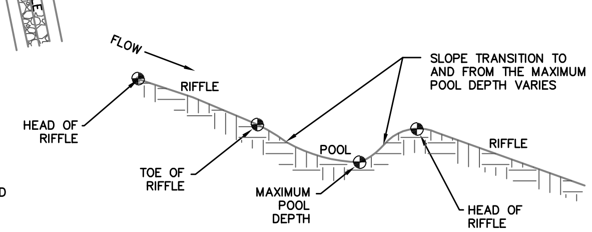
NOTES:

1. LOGS WITHOUT ROOT MASS MAY BE USED IF APPROVED BY PROJECT ENGINEER.

3 / D1 RIFFLE TO POOL TRANSITION
NTS



PLAN VIEW

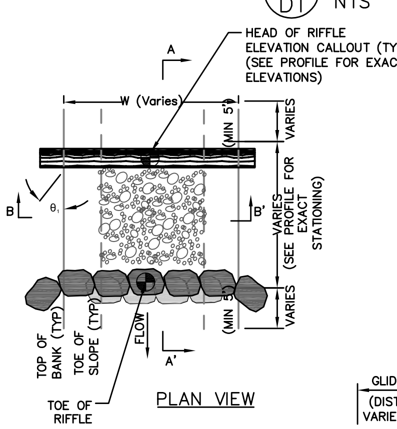


PROFILE VIEW

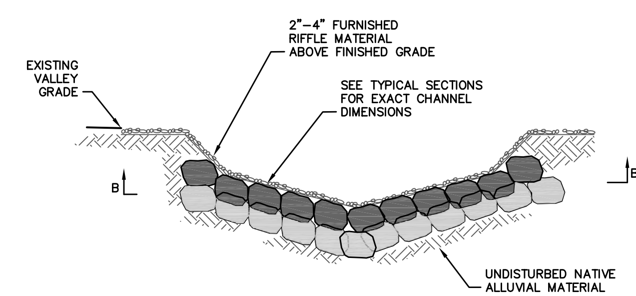
NOTES

1. THE POINTS SHOWN, E.G. HEAD OF RIFFLE, TOE OF RIFFLE AND MAXIMUM DEPTH OF POOL, ARE THE CONTROL POINTS USED TO ESTABLISH THE PROFILE. HOWEVER, THE CONTRACTOR SHALL CREATE SMOOTH TRANSITIONS BETWEEN CONTROL POINTS AS SHOWN ABOVE.
2. THE DOWNSTREAM HEAD OF RIFFLE ELEVATION SHALL NOT EXCEED THE UPSTREAM TOE OF RIFFLE ELEVATION.
3. STREAM CROSS-SECTION SHALL TRANSITION DIMENSION FROM THE TYPICAL POOL SECTION AT THE MAXIMUM POOL DEPTH LOCATION TO THE TYPICAL RIFFLE SECTION

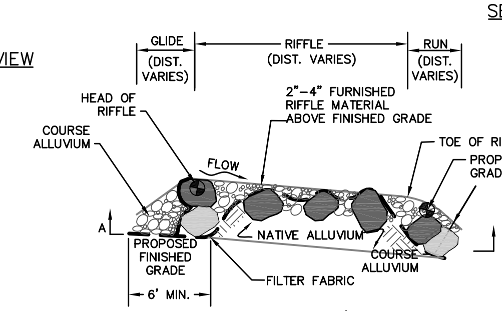
4 / D1 CONSTRUCTED RIFFLE
NTS



PLAN VIEW



SECTION B-B'



PROFILE A-A'

BEAVERDAM

DETAILS

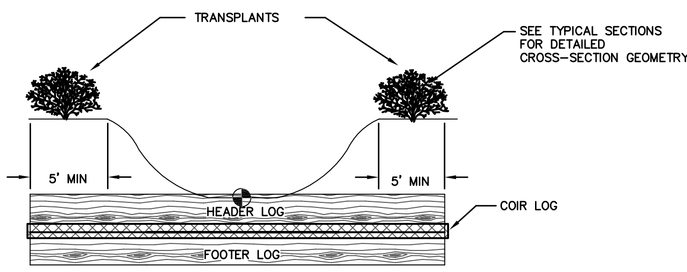
L:\Projects\0269C\Design\Plans\DETAILS.dwg, Feb. 21, 2006

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

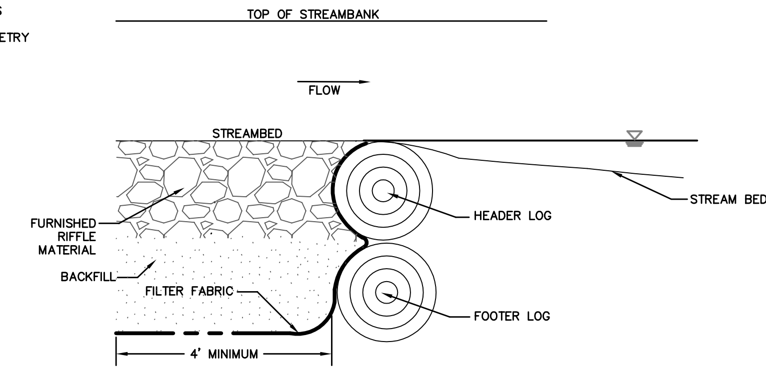
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

1/D2 LOG SILL
NTS



CROSS SECTION VIEW

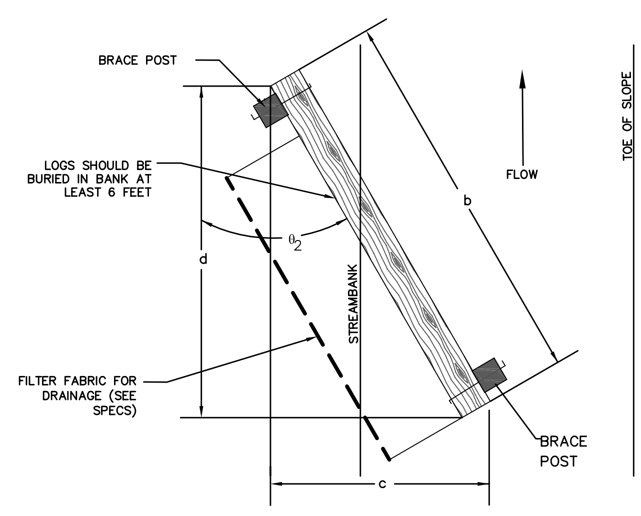


SECTION A–A'

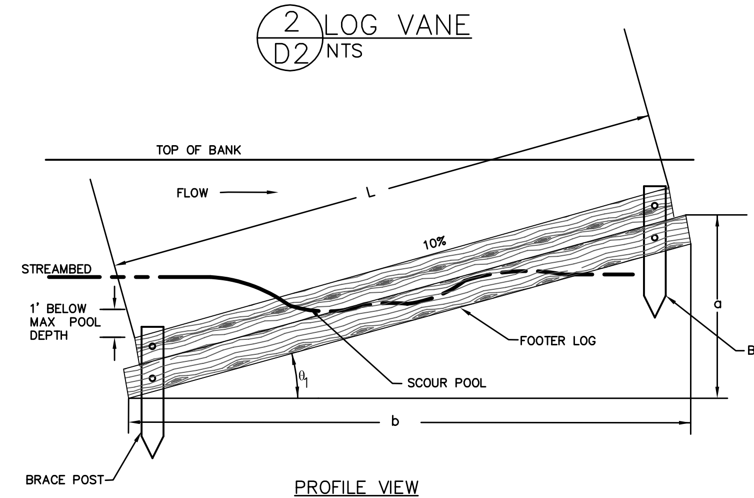
NOTES:

1. LOGS SHOULD BE AT LEAST 10 INCHES IN DIAMETER, RELATIVELY STRAIGHT, HARDWOOD, AND RECENTLY HARVESTED.
2. TOP OF HEADER LOG SHOULD BE SET AT SAME ELEVATION AS THE STREAMBED.
3. DIAMETER OF COIR LOG SHOULD BE APPROXIMATELY 1/2 DIAMETER OF LOGS.
4. USE FILTER FABRIC WITH COIR LOGS TO SEAL GAPS BETWEEN LOGS.
5. NAIL FILTER FABRIC USING 3" 10D GALVANIZED COMMON NAIL EVERY 2' ALONG THE LOG.

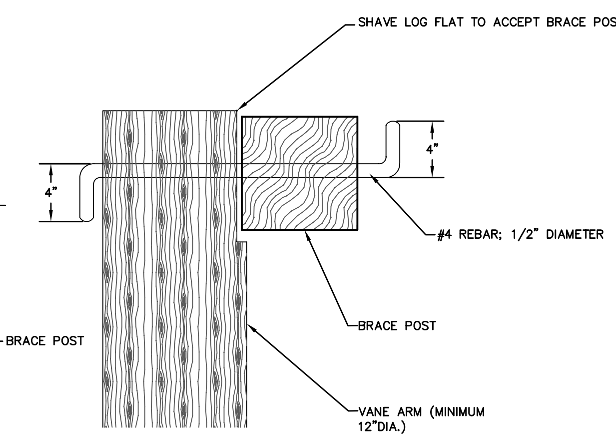
2/D2 LOG VANE
NTS



PLAN VIEW



PROFILE VIEW



CLOSE–UP OF BRACE POST

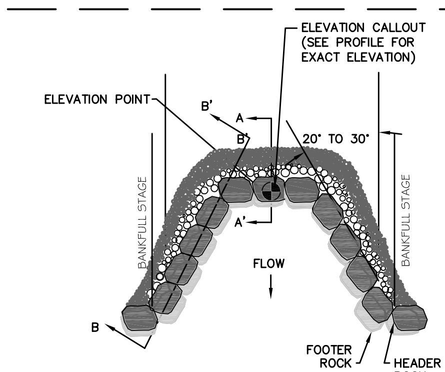
NOTES FOR ALL LOG VANE STRUCTURES:

1. LOGS SHOULD BE AT LEAST 12 INCHES IN DIAMETER, RELATIVELY STRAIGHT, AND HARDWOOD.
2. CROSS LOGS SHOULD BE BURIED AT A MINIMUM OF 5 FEET INTO BANK.
3. VANE LOG ARMS SHOULD BE BURIED INTO THE BANK A MINIMUM OF 6 FEET.
4. SET ELEVATION OF TOP OF LOG CROSS PIECES TO DESIRED ELEVATION OF STREAMBED.
5. DEPTH OF FOOTER LOG SHOULD EQUAL 1.5 x MAX SCOUR DEPTH.
6. DIAMETER OF COIR LOGS SHOULD EQUAL 1/2 DIAMETER OF LOGS.
7. USE FILTER FABRIC FOR DRAINAGE AND COIR LOG TO SEAL GAPS BETWEEN LOGS.
8. NAIL FILTER FABRIC FOR DRAINAGE TO TOP OF COIR LOGS USING 3" 10d GALVANIZED COMMON NAILS WITHIN A 2' SPACING ALONG LOG.
9. NAIL COIR LOG TO VANE LOG AS SHOWN USING 8" GALVANIZED SMOOTHSPIKES ON 3' SPACING.
10. NOTCH IS FORMED BY MAKING CUTS WITH A CHAINSAW 1–2" APART AND THEN KNOCKING OUT SECTIONS WITH A CHISEL AND HAMMER.
11. ANGLE OF NOTCH SHOULD MATCH ANGLE BETWEEN LOG ARMS OF CROSS VANE AND THE STREAMBANK.

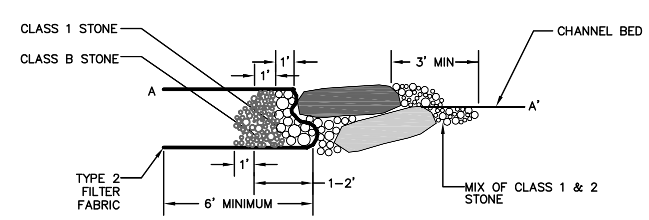
NOTES:

1. PRE–DRILL HOLES FOR REBAR WITH 5/8" DRILL BIT.
2. AFTER PLACING POSTS DRIVE REBAR THROUGH POST AND LOG AND BEND ENDS AS SHOWN.
3. REBAR MAY BE REPLACED BY LAG BOLT OR LAG SCREW WITH APPROVAL OF THE ENGINEER.

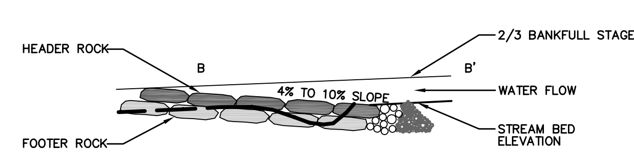
3/D2 CROSS VANE
NTS



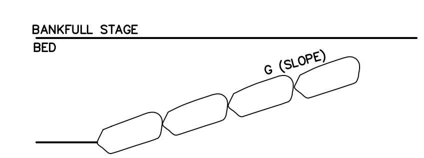
PLAN VIEW



SECTION A – A'



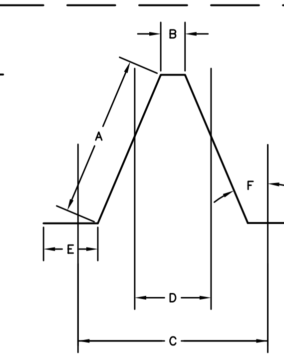
PROFILE VIEW B–B'



PROFILE VIEW

		BEAVERDAM CREAK CROSSVANE GEOMETRY	
		REACH NAME	REACH NAME
A	(ft)		
B	(ft)		
C	(ft)		
D	(ft)		
E	(ft)		
F	(deg)		
G	%		

NOTE: CROSS VANE GEOMETRY TABLE TO BE COMPLETED WITH 90% DESIGN DOCUMENTS



PLAN VIEW

BEAVERDAM

DETAILS

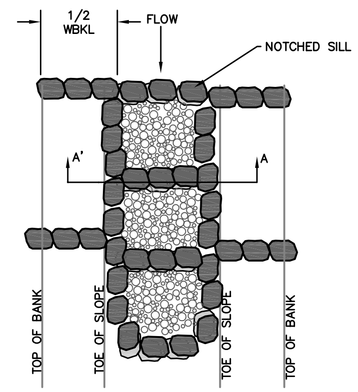
PROJECT REFERENCE NO.	SHEET NO.
0269C	D3

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

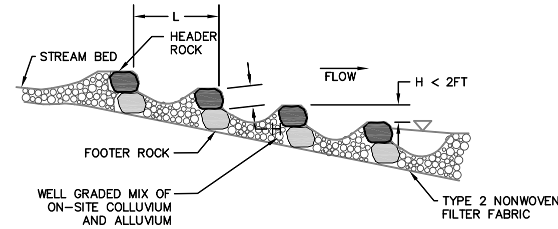
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

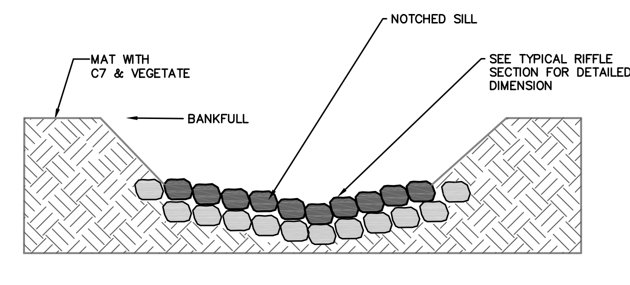
1 D3 STEP POOL
NTS



PLAN VIEW (NTS)



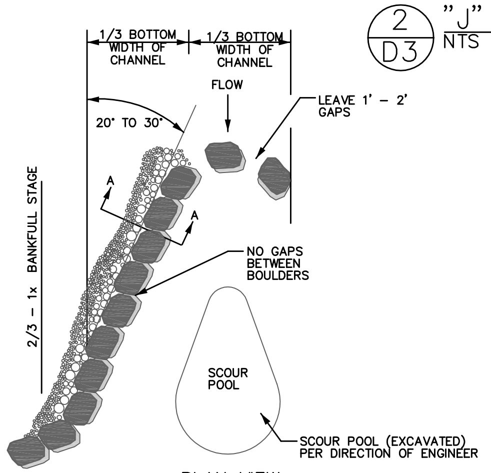
PROFILE VIEW (NTS)



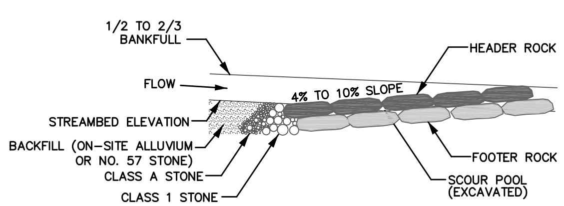
CROSS SECTION A–A' (NTS)

NOTE:
MINIMUM BOULDER SIZE 4' X 3' X 2'

2 D3 "J" HOOK VANE
NTS



PLAN VIEW



PROFILE VIEW

NOTE: HEADER AND FOOTER ROCKS MAY BE REPLACED WITH LOGS AS IN LOG VANE DETAIL 3/6C

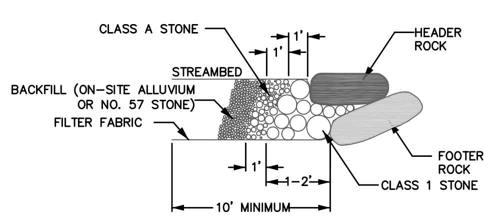
UT1, UT1B, UT1C, UT1D

REACH	VANE LENGTH	VERTICAL ANGLE (%)	HORIZONTAL ANGLE (DEGREES)	TIE IN HEIGHT/BANKFULL HEIGHT	TIE IN HEIGHT @ APEX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX
XXX	XXX	XXX	XXX	XXX	XXX

UT2 & UT2A

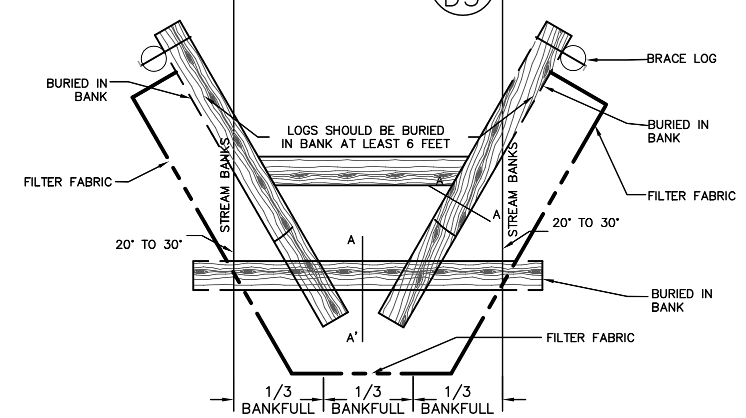
REACH	VANE LENGTH	VERTICAL ANGLE (%)	HORIZONTAL ANGLE (DEGREES)	TIE IN HEIGHT/BANKFULL HEIGHT	TIE IN HEIGHT @ APEX
UT2A, R2	XXX	XXX	XXX	XXX	XXX
UT2, R1	XXX	XXX	XXX	XXX	XXX
UT2, R2	XXX	XXX	XXX	XXX	XXX
UT2, R3	XXX	XXX	XXX	XXX	XXX
UT2, R4	XXX	XXX	XXX	XXX	XXX

NOTES FOR ALL VANE STRUCTURES:
1. BOULDERS MUST BE AT LEAST 4' x 3' x 2'.
2. INSTALL FILTER FABRIC FOR DRAINAGE BEGINNING AT THE MIDDLE OF THE HEADER ROCKS AND EXTEND DOWNWARD TO THE DEPTH OF THE BOTTOM FOOTER ROCK, AND THEN UPSTREAM TO A MINIMUM OF TEN FEET.
3. DIG A TRENCH BELOW THE BED FOR FOOTER ROCKS AND PLACE FILL ON UPSTREAM SIDE OF VANE ARM, BETWEEN THE ARM AND STREAMBANK.
4. START AT BANK AND PLACE FOOTER ROCKS FIRST AND THEN HEADER (TOP) ROCK.
5. CONTINUE WITH STRUCTURE, FOLLOWING ANGLE AND SLOPE SPECIFICATIONS.
6. AN EXTRA BOULDER CAN BE PLACED IN SCOUR POOL FOR HABITAT IMPROVEMENT.
7. USE CLASS 1 STONE TO FILL GAPS ON UPSTREAM SIDE OF BOULDERS, AND CLASS A STONE TO FILL GAPS ON UPSTREAM SIDE OF CLASS 1 STONE.
8. AFTER ALL STONE HAS BEEN PLACED, FILL IN THE UPSTREAM SIDE OF THE STRUCTUREWITH ON-SITE ALLUVIUM TO THE ELEVATION OF THE TOP OF THE HEADER ROCK.



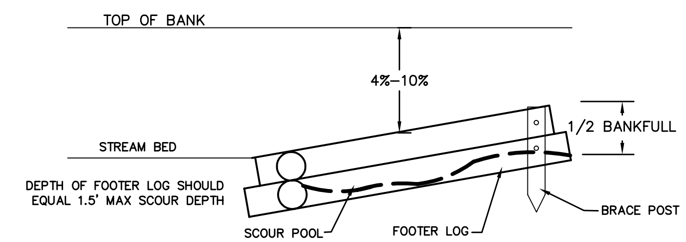
SECTION A – A

3 D3 LOG DOUBLE DROP
NTS



NOTES:
1. LOGS SHOULD BE AT LEAST 12 INCHES IN DIAMETER, RELATIVELY STRAIGHT, AND HARDWOOD.
2. CROSS LOGS SHOUDL BE BURIED INTO BANK A MINIMUM OF 5 FEET.
3. VANE ARM LOGS SHOULD BE BURIED INTO THE BANK A MINIMUM OF 8 FEET.

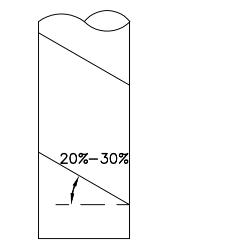
PLAN VIEW



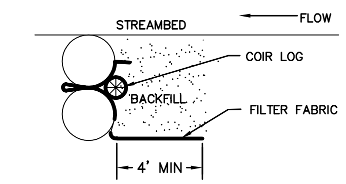
NOTE:
SET ELEVATION OF TOP OF LOGS CROSS PIECE TO DESIRED ELEVATION OF STREAMBED

ELEVATION VIEW

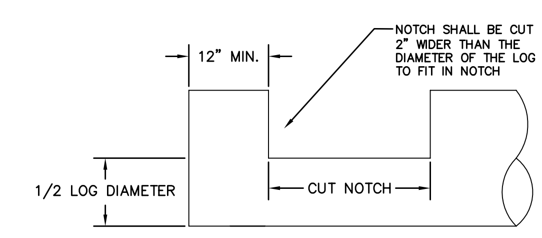
NOTES:
1. DIAMETER OF COIR LOG SHOULD EQUAL 1/2 DIAMETER OF LOGS.
2. USE FILTER FABRIC AND COIR LOG TO SEAL GAPS BETWEEN LOGS.
3. NAIL FILTER FABRIC TO TOP OF FOOTER LOG USING 3" 10d GALVANIZED COMMON NAIL ON 2' SPACING ALONG LOG.
4. NAIL COIR LOG TO VANE LOG AS SHOWN USING 8" GALVANIZED SMOOTHSPIKE ON 3' SPACING.



PLAN VIEW OF NOTCH



SECTION A–A' THROUGH LOG VANE



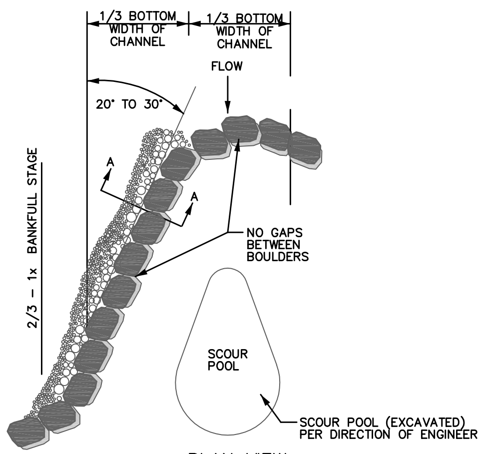
SIDE VIEW OF NOTCH

NOTES:
1. NOTCH IS FORMED BY MAKING CUTS WITH A CHAINSAW 1–2" APART AND THEN KNOCKING OUT SECTIONS WITH A CHISEL AND HAMMER.
2. ANGLE OF NOTCH SHOULD MATCH ANGLE BETWEEN LOG ARMS OF CROSSVANE AND STREAMBANK.

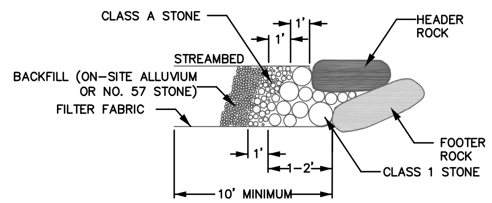
BEAVERDAM

DETAILS

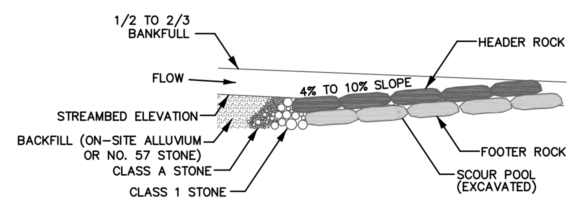
(1/D4) GRADE CONTROL "J" HOOK VANE
NTS



PLAN VIEW



SECTION A - A



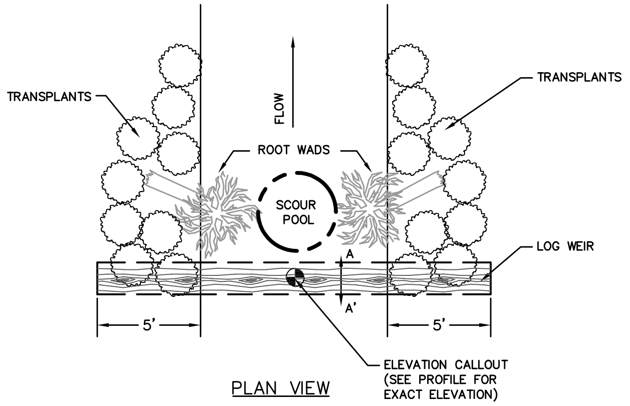
PROFILE VIEW

NOTE: HEADER AND FOOTER ROCKS MAY BE REPLACED WITH LOGS AS IN LOG VANE DETAIL (3/6C)

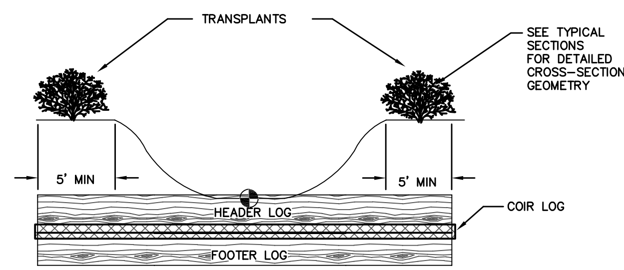
NOTES FOR ALL VANE STRUCTURES:

1. BOULDERS MUST BE AT LEAST 4' x 3' x 2'.
2. INSTALL FILTER FABRIC FOR DRAINAGE BEGINNING AT THE MIDDLE OF THE HEADER ROCKS AND EXTEND DOWNWARD TO THE DEPTH OF THE BOTTOM FOOTER ROCK, AND THEN UPSTREAM TO A MINIMUM OF TEN FEET.
3. DIG A TRENCH BELOW THE BED FOR FOOTER ROCKS AND PLACE FILL ON UPSTREAM SIDE OF VANE ARM, BETWEEN THE ARM AND STREAMBANK.
4. START AT BANK AND PLACE FOOTER ROCKS FIRST AND THEN HEADER (TOP) ROCK.
5. CONTINUE WITH STRUCTURE, FOLLOWING ANGLE AND SLOPE SPECIFICATIONS.
6. AN EXTRA BOULDER CAN BE PLACED IN SCOUR POOL FOR HABITAT IMPROVEMENT.
7. USE CLASS 1 STONE TO FILL GAPS ON UPSTREAM SIDE OF BOULDERS, AND CLASS A STONE TO FILL GAPS ON UPSTREAM SIDE OF CLASS 1 STONE.
8. AFTER ALL STONE HAS BEEN PLACED, FILL IN THE UPSTREAM SIDE OF THE STRUCTUREWITH ON-SITE ALLUVIUM TO THE ELEVATION OF THE TOP OF THE HEADER ROCK.

(2/D4) LOG DROP
NTS



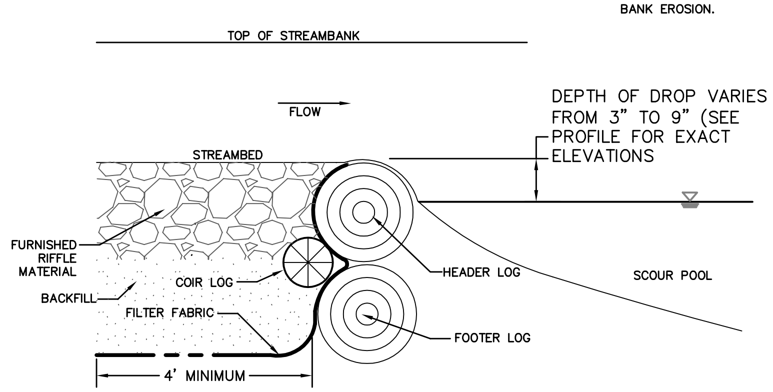
PLAN VIEW



CROSS SECTION VIEW

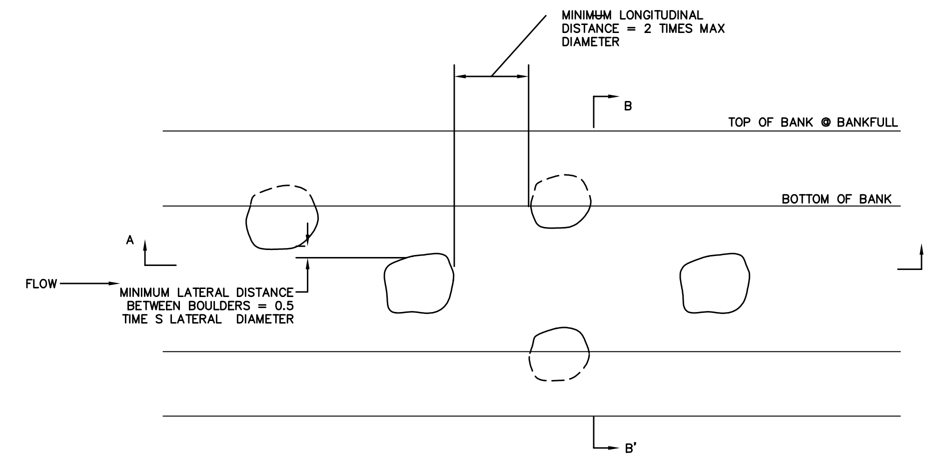
NOTES:

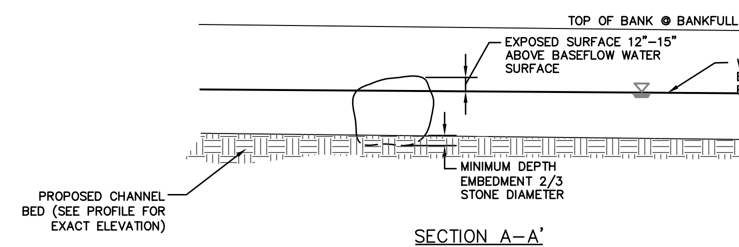
1. LOGS SHOULD BE AT LEAST 10 INCHES IN DIAMETER, RELATIVELY STRAIGHT, HARDWOOD, AND RECENTLY HARVESTED.
2. TOP OF HEADER LOG SHOULD BE SET AT SAME ELEVATION AS THE STREAMBED.
3. DIAMETER OF COIR LOG SHOULD BE APPROXIMATELY 1/2 DIAMETER OF LOGS.
4. USE FILTER FABRIC WITH COIR LOGS TO SEAL GAPS BETWEEN LOGS.
5. NAIL FILTER FABRIC USING 3" 10D GALVANIZED COMMON NAIL EVERY 2' ALONG THE LOG.
6. NAIL COIR LOG TO HEADER AND FOOTER LOGS USING 8" GALVANIZED SMOOTH SPIKE ON 3' SPACING.
7. PLACE ROOT WADS AS CLOSE AS POSSIBLE TO LOG WEIRS TO PROTECT AGAINST BANK EROSION.



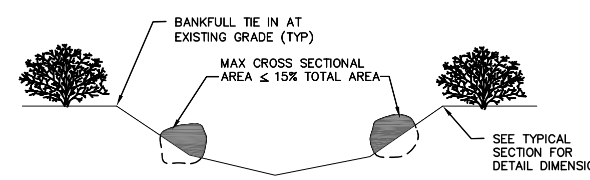
SECTION A-A'

(3/D4) BOULDER CLUSTER
NTS





SECTION A-A'



CROSS SECTION VIEW

PROJECT REFERENCE NO.	SHEET NO.
0269C	D4

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG
APPROVED BY
DATE: 02/17/06

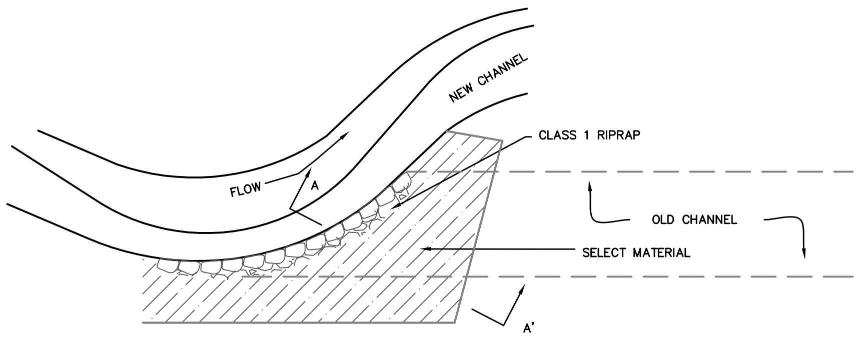
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM

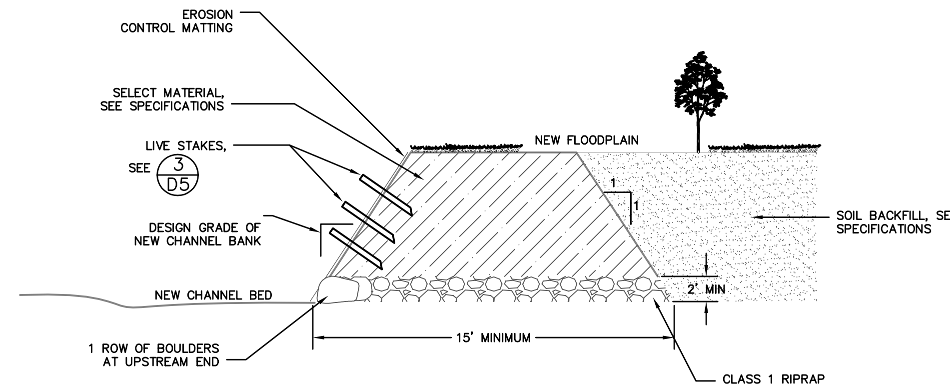
DETAILS

L:\Projects\0269C\Design\Plans\DETAILS.dwg Feb 21, 2006

1/D5 CHANNEL PLUG
NTS

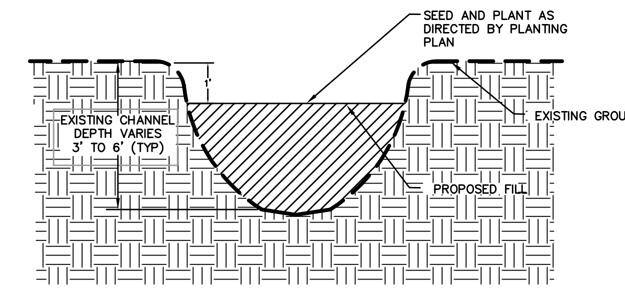


PLAN VIEW



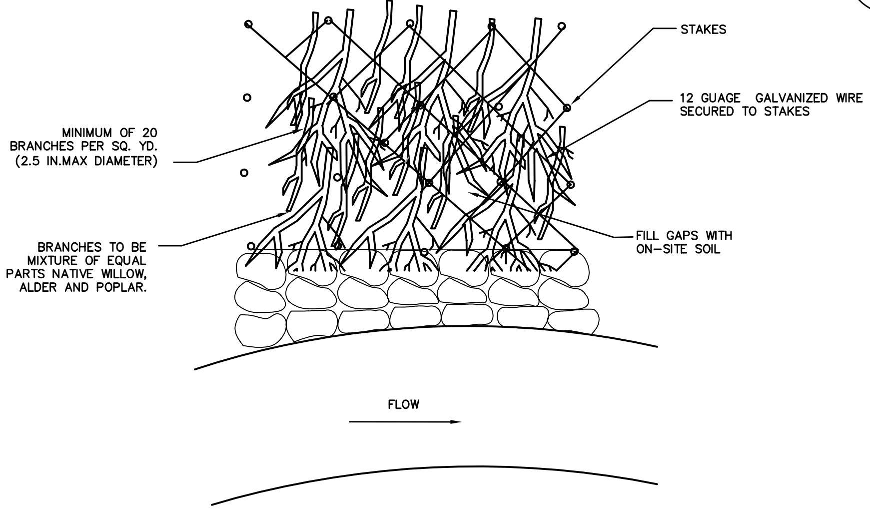
SECTION A–A'

2/D5 EPHEMERAL POOL
NTS

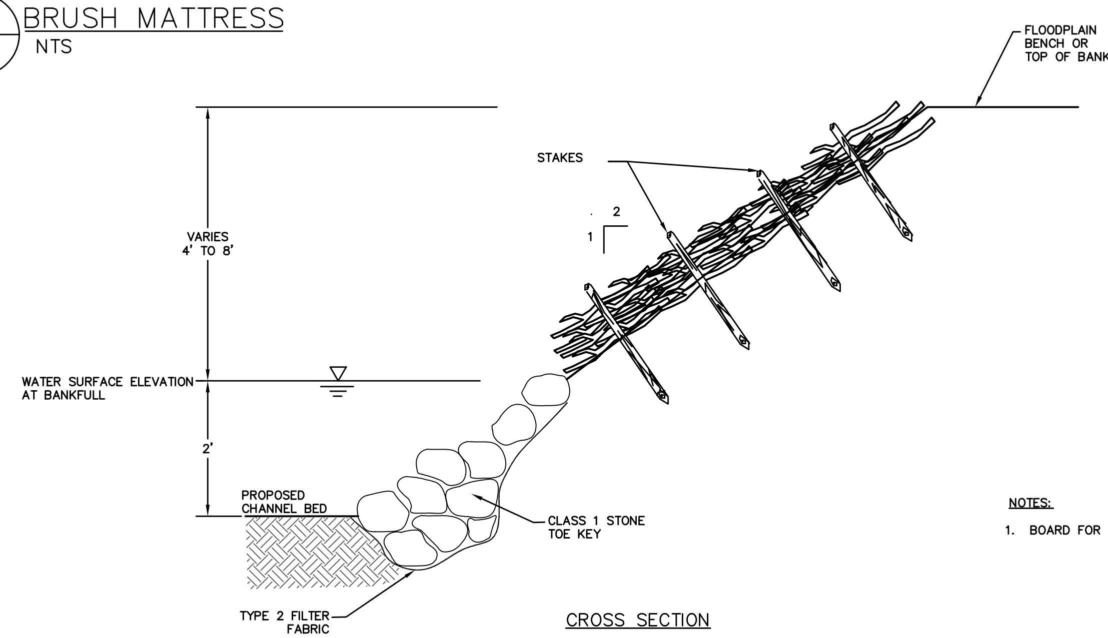


CROSS SECTION A–A'

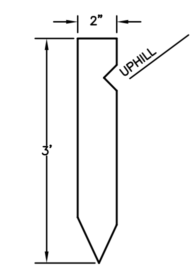
2/D5 BRUSH MATTRESS
NTS



PLAN VIEW



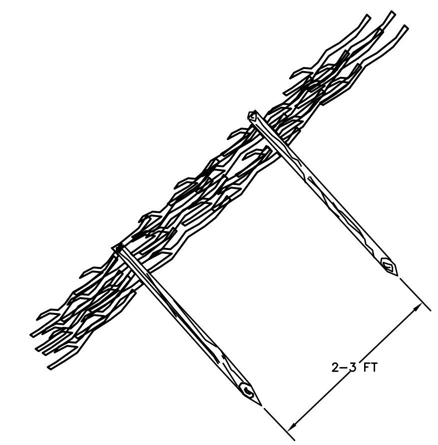
CROSS SECTION



TYPICAL STAKE

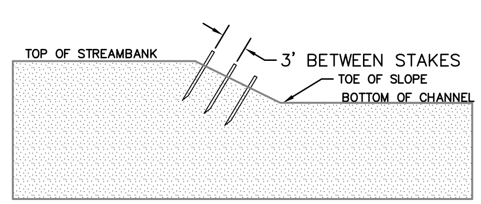
NOTES:

1. BOARD FOR STAKE SHALL BE 2" X 4" X 3'

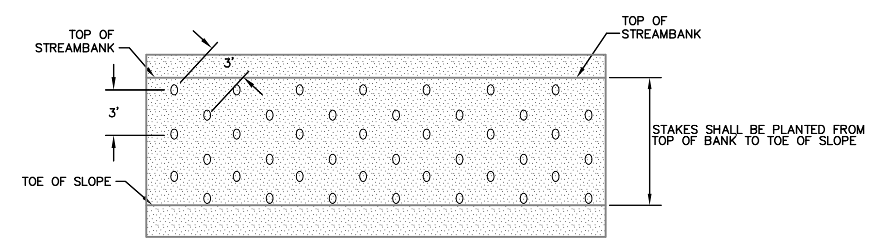


DETAIL

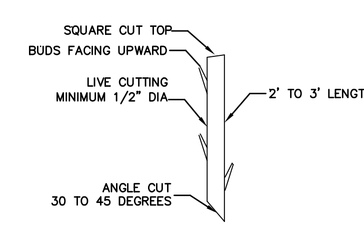
3/D5 LIVE STAKING
NTS



CROSS–SECTION VIEW



PLAN VIEW



LIVE STAKE DETAIL

NOTES
1. STAKES SHALL BE CUT AND INSTALLED ON THE SAME DAY.
2. STAKES THAT HAVE BEEN SPLIT SHALL BE REJECTED AND NOT USED FOR CONSTRUCTION.
3. STAKES SHALL BE INSTALLED WITH BUDS POINTING UPWARD.
4. STAKES SHALL BE INSTALLED PERPENDICULAR TO BANK.
5. STAKES SHALL BE 1/2 TO 2 INCHES IN DIAMETER AND 2 TO 3 FT LONG.
6. STAKES SHALL BE INSTALLED WITH 1/5 OF STAKE REMAINING ABOVE GROUND.
7. 80% OF STAKE SHALL BE BELOW GROUND.

PROJECT REFERENCE NO.	SHEET NO.
0269C	D5

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG

APPROVED BY:

DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM

DETAILS

L:\Projects\0269C\Design\Plans\DETAILS.dwg Feb 21, 2006

LIVE STAKES, see detail for app. rate

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE
Cornus amomun	Silky Dogwood	35%
Salix sericea	Silky willow	35%
Sambucus canadensis	Elderberry	20%
Salix nigra	Black willow	10%

BRUSH MATTRESS, see detail for app. rate

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE
Cornus amomun	Silky Dogwood	40 %
Salix sericea	Silky willow	40 %
Sambucus canadensis	Elderberry	20 %

FLOODPLAIN BUFFER PLANTING SPECIES, app. rate 650 stems/acre

Undisturbed / Area? / 650 stems/acre

Disturbed / Area?

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE	WETLAND CODE	SIZE
Primary Species				
Diospyros virginiana	Persimmon	5%	FAC	Bare Root
Liriodendron tulipifera	Tulip Poplar	10%	FAC	Bare Root
Fraxinus pennsylvanica	Green Ash	20%	FACW	Bare Root
Juglans nigra	Black Walnut	10%	FACU	Bare Root
Platanus occidentalis	Sycamore	15%	FACW-	Bare Root
Quercus phellos	Willow Oak	7%	FACW-	Bare Root
Quercus michauxii	Swamp Chestnut Oak	15%	FACW-	Bare Root
Asimina triloba	Paw Paw	10%	FAC	Bare Root
Nyssa sylvatica	Blackgum	8%	FAC	Bare Root
Alternate Species				
Betula nigra	River Birch		FACW	Bare Root
Celtis laevigata	Sugarberry		FACW	Bare Root

UPLAND BUFFER PLANTING SPECIES, app. rate 680 stems/acre

Undisturbed / Area? / 680 stems/acre

Disturbed / Area?

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE	WETLAND CODE	SIZE
Primary Species				
Diospyros virginiana	Persimmon	5%	FAC	Bare Root
Liriodendron tulipifera	Tulip Poplar	15%	FAC	Bare Root
Fraxinus pennsylvanica	Green Ash	20%	FACW	Bare Root
Juglans nigra	Black Walnut	5%	FACU	Bare Root
Celtis laevigata	Sugarberry	15%	FAC	Bare Root
Quercus phellos	Willow Oak	10%	FACW-	Bare Root
Nyssa sylvatica	Blackgum	15%	FAC	Bare Root
Quercus rubra	Northern Red Oak	10%	FACU	Bare Root
Cornus florida	Flowering Dogwood	5%	FACU	Bare Root
Alternate Species				
Platanus occidentalis	Sycamore		FACW-	Bare Root
Cercis canadensis	Redbud		FACU	Bare Root
Viburnum prunifolium	Black Haw Viburnum		FACU	Bare Root

RIPARIAN PERMANENT SEEDING MIX, application rate 15 lb/acre

SCIENTIFIC NAME	COMMON NAME	MIX PERCENT	WETLAND CODE
Elymus virginicus	Virginia Wild Rye	20%	FAC
Panicum virgatum	Switchgrass	10%	FAC+
Chasmanthium latifolium	River Oats	5%	FAC-
Juncus effusus	Soft Rush	15%	FACW+
Carex vulpinoidea	Fox Sedge	10%	OBL
Dichathelium clandestinum	Deer Tongue	15%	FACW
Persicaria pennsylvanica	Common Smartweed	10%	FACW
Bidens frondosum	Beggar's ticks	15%	FACW

TEMPORARY SEEDING MIX, application rate 15 lb/acre

Summer Seeding (May 1- August 15)	Seed Rate with Permanent Seed	Seed Rate Without Permanent Seed
Browntop Millet	13 lb/ acre	44 lb/acre
Winter Seeding (August 15- May 1)		
Rye Grain	44 lb/ acre	130 lb/ acre

EPHEMERAL POOL PLANTING SPECIES, app. rate 15 lb/acre

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE	WETLAND CODE
Elymus virginicus	Virginia Wild Rye	20%	FAC
Panicum virgatum	Switchgrass	10%	FAC+
Chasmanthium latifolium	River Oats	5%	FAC-
Juncus effusus	Soft Rush	15%	FACW+
Carex vulpinoidea	Fox Sedge	10%	OBL
Dichathelium clandestinum	Deer Tongue	15%	FACW
Persicaria pennsylvanica	Common Smartweed	10%	FACW
Bidens frondosum	Beggar's ticks	15%	FACW

RIGHT-OF-WAY SEEDING MIX, app. rate 15 lb/acre

SCIENTIFIC NAME	COMMON NAME	PERCENTAGE
Elymus virginicus	Virginia Wild Rye	20%
Panicum virgatum	Switchgrass	10%
Chasmanthium latifolium	River Oats	5%
Juncus effusus	Soft Rush	15%
Carex vulpinoidea	Fox Sedge	10%
Dichathelium clandestinum	Deer Tongue	15%
Persicaria pennsylvanica	Common Smartweed	10%
Bidens frondosum	Beggar's ticks	15%

PROJECT REFERENCE NO.	SHEET NO.
0269C	L1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

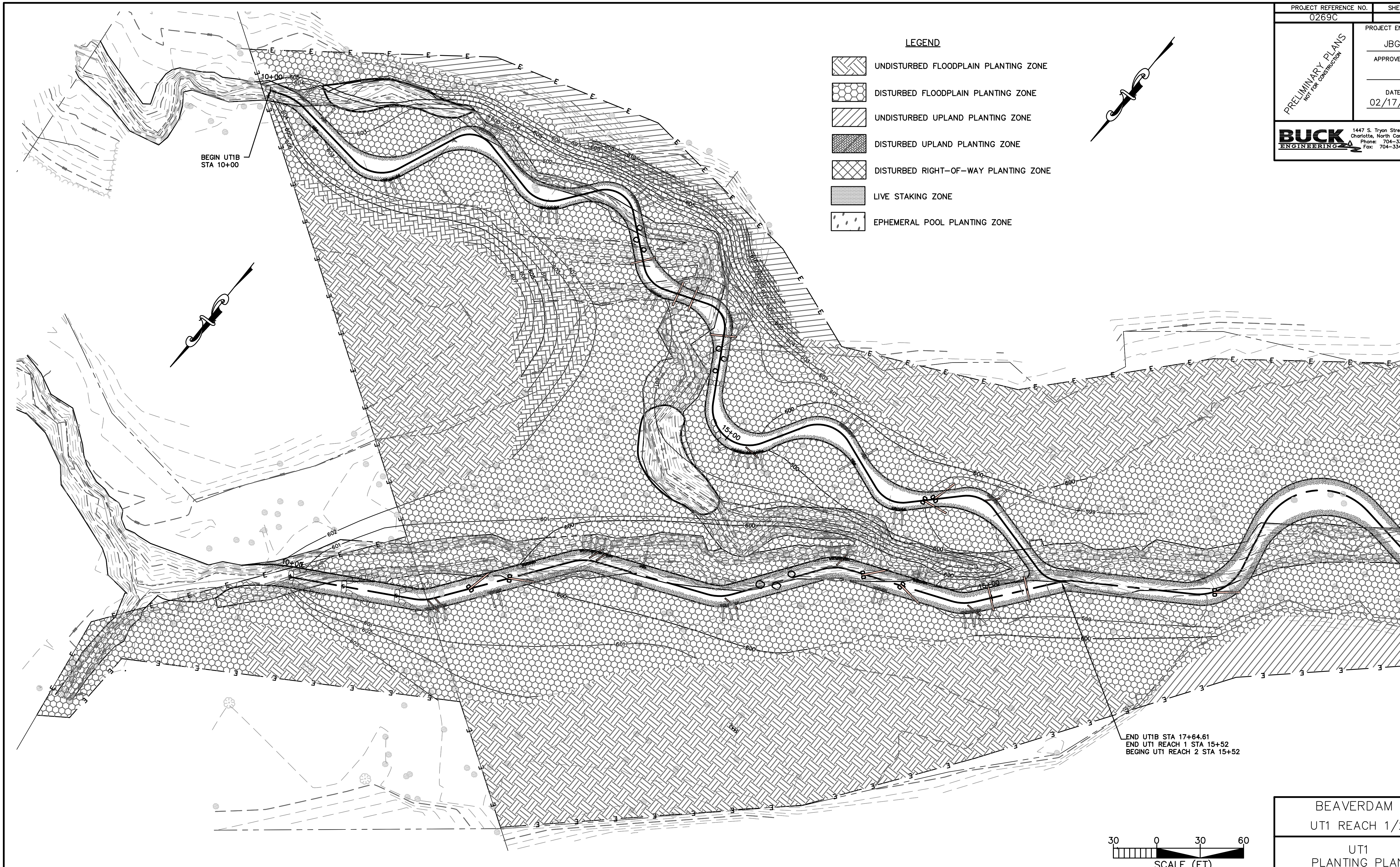
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM

PLANTING SCHEDULE

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	L2

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 1/2

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006

LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

PROJECT REFERENCE NO.	SHEET NO.
0269C	L3

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

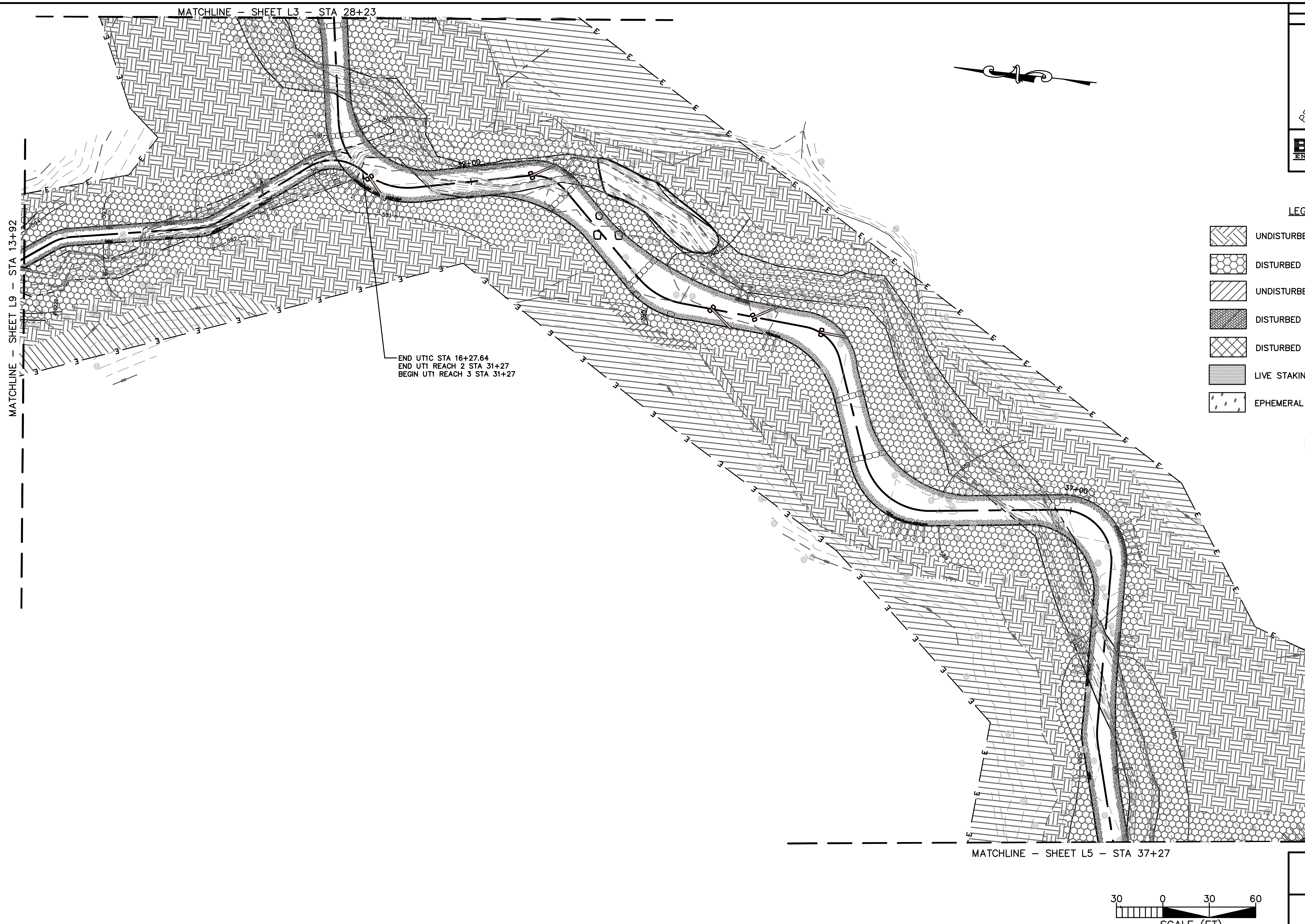
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 2

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	L4

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

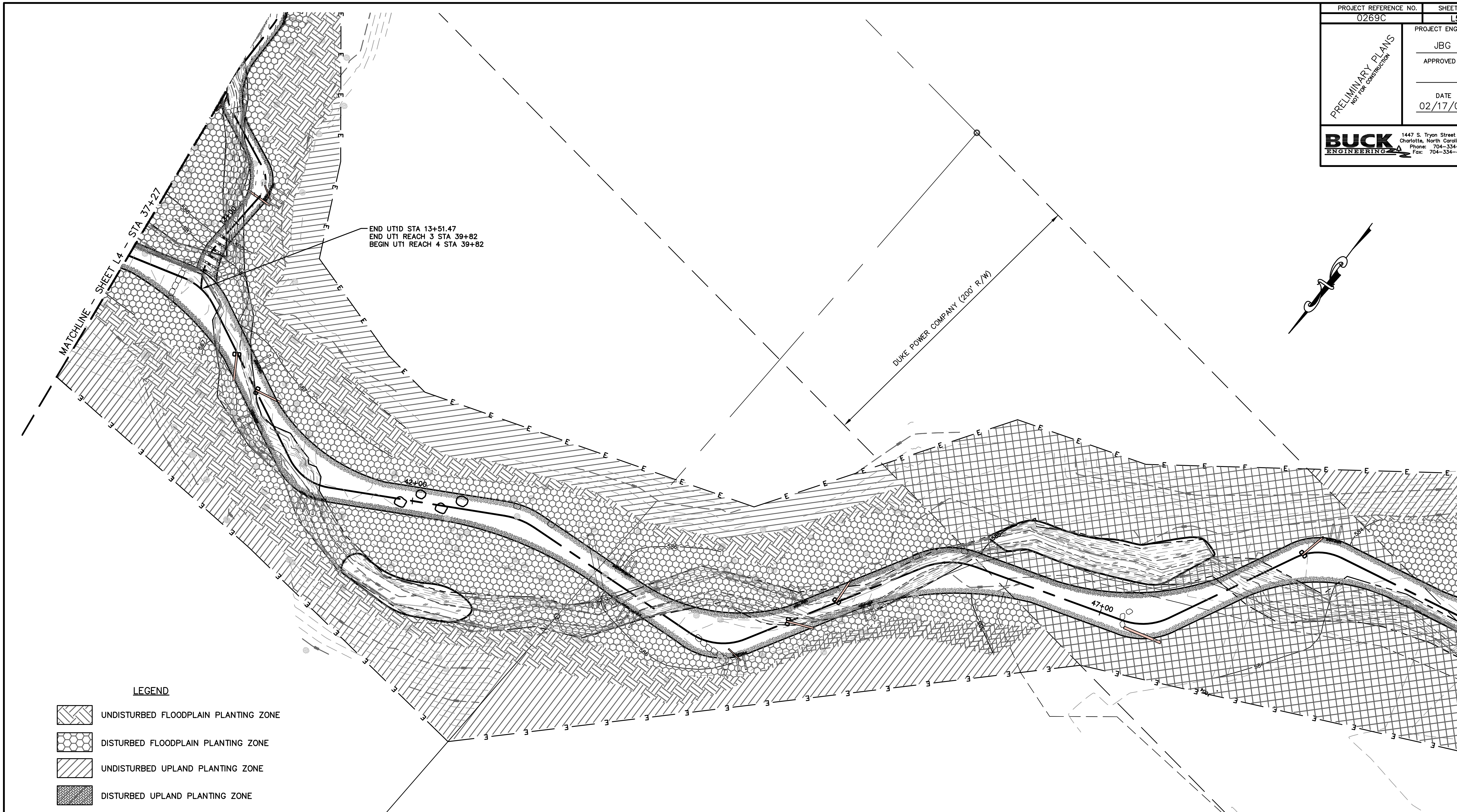
LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

BEAVERDAM
UT1 REACH 2/3
UT1C

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

PROJECT REFERENCE NO.	SHEET NO.
0269C	L5

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

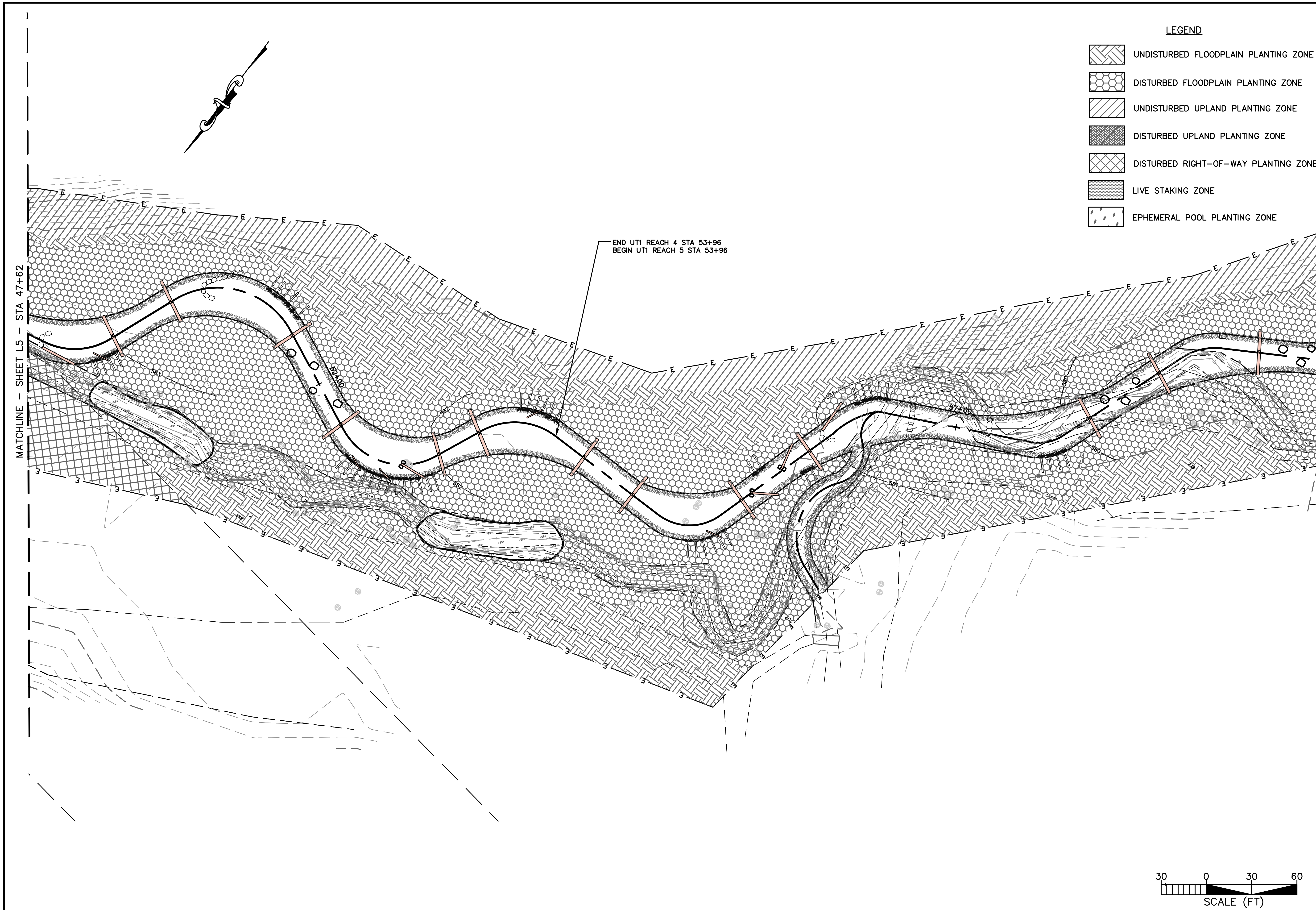
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 3/4
UT1D

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

PROJECT REFERENCE NO.	SHEET NO.
0269C	L6

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

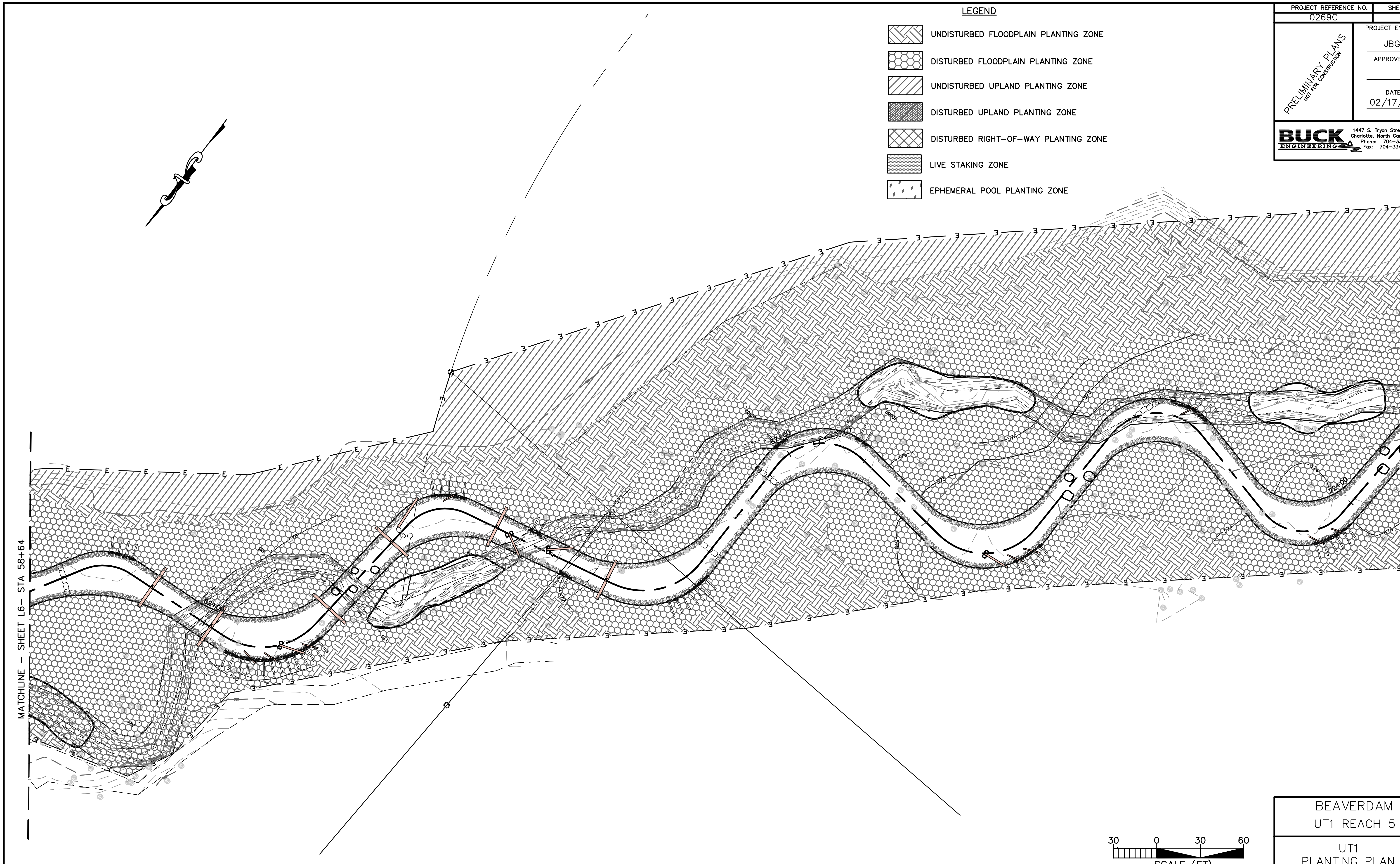
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 4/5

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	L7

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

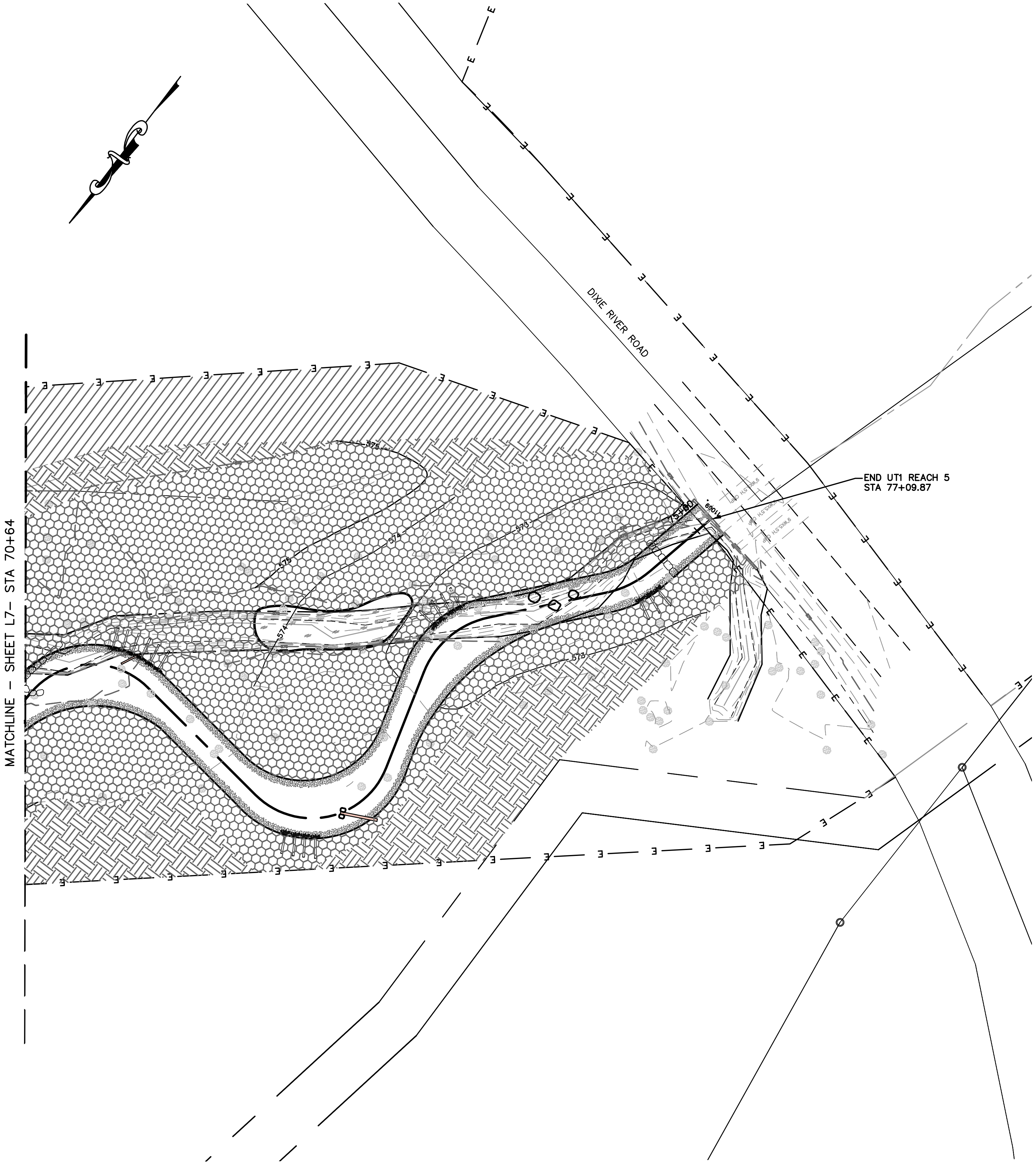
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 5

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

30 0 30 60
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	L8

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

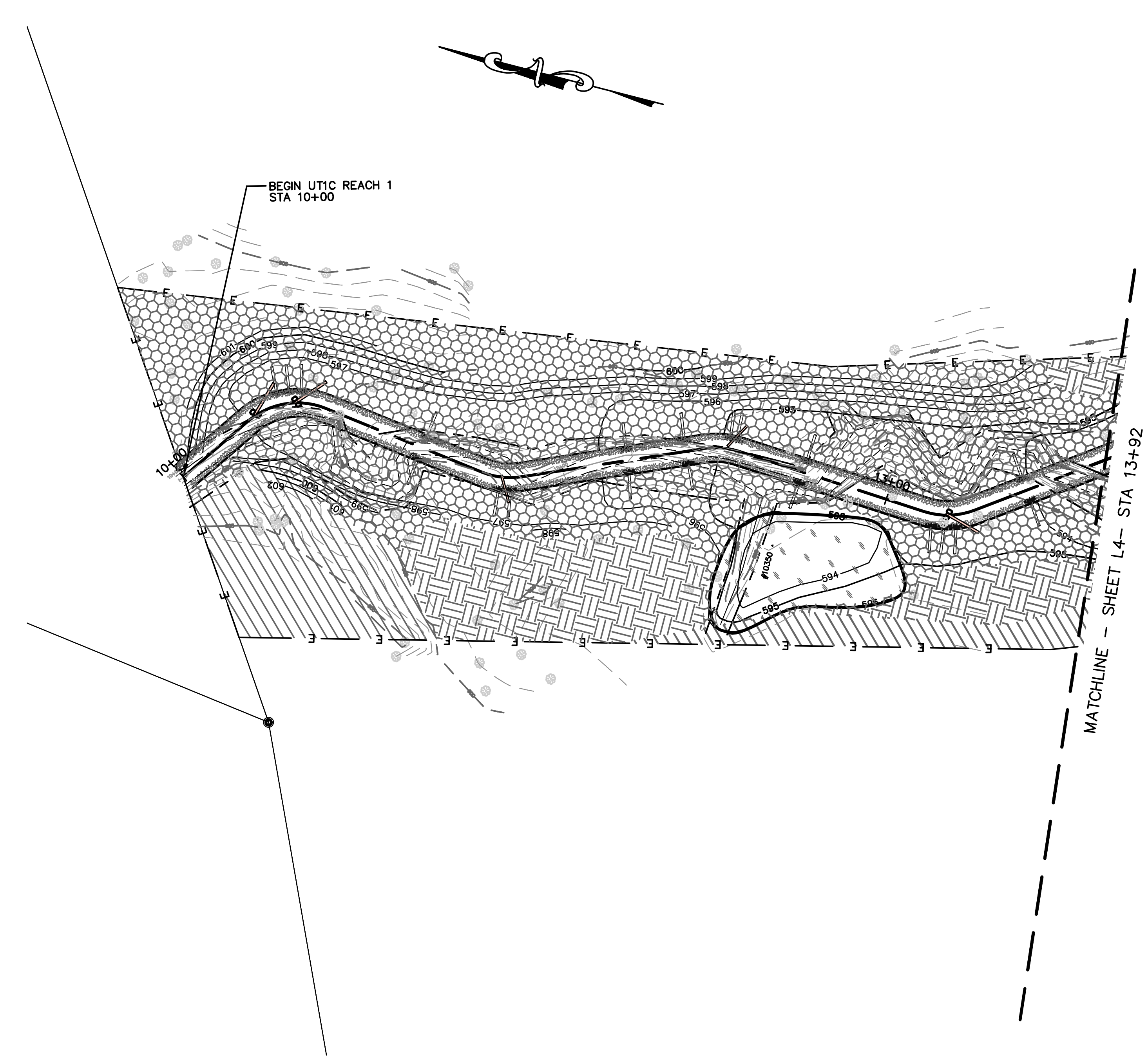
DATE
02/17/06

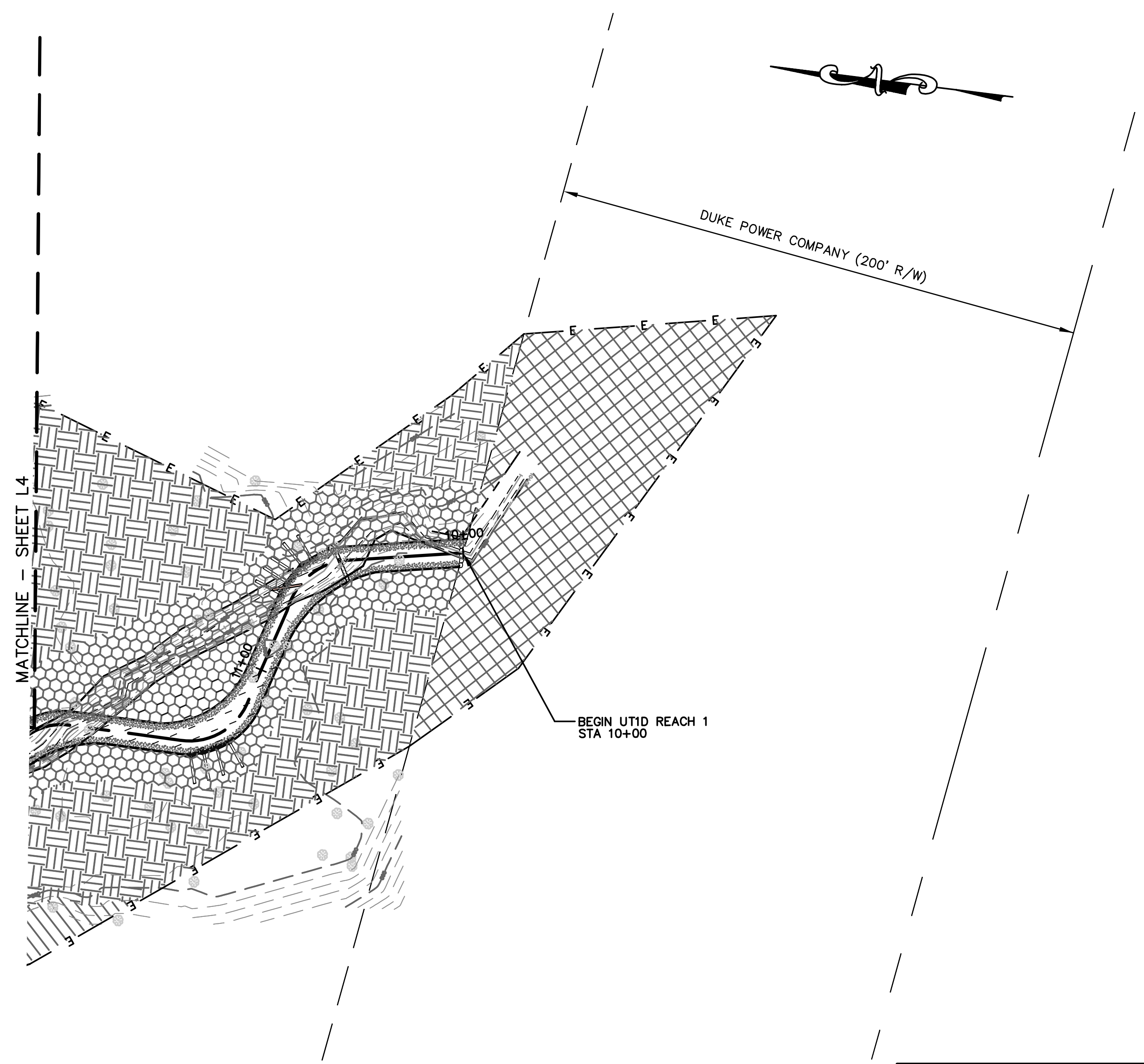
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 5

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006





LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

30 0 30 60
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	L9

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1C / UT1D

UT1
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	L10

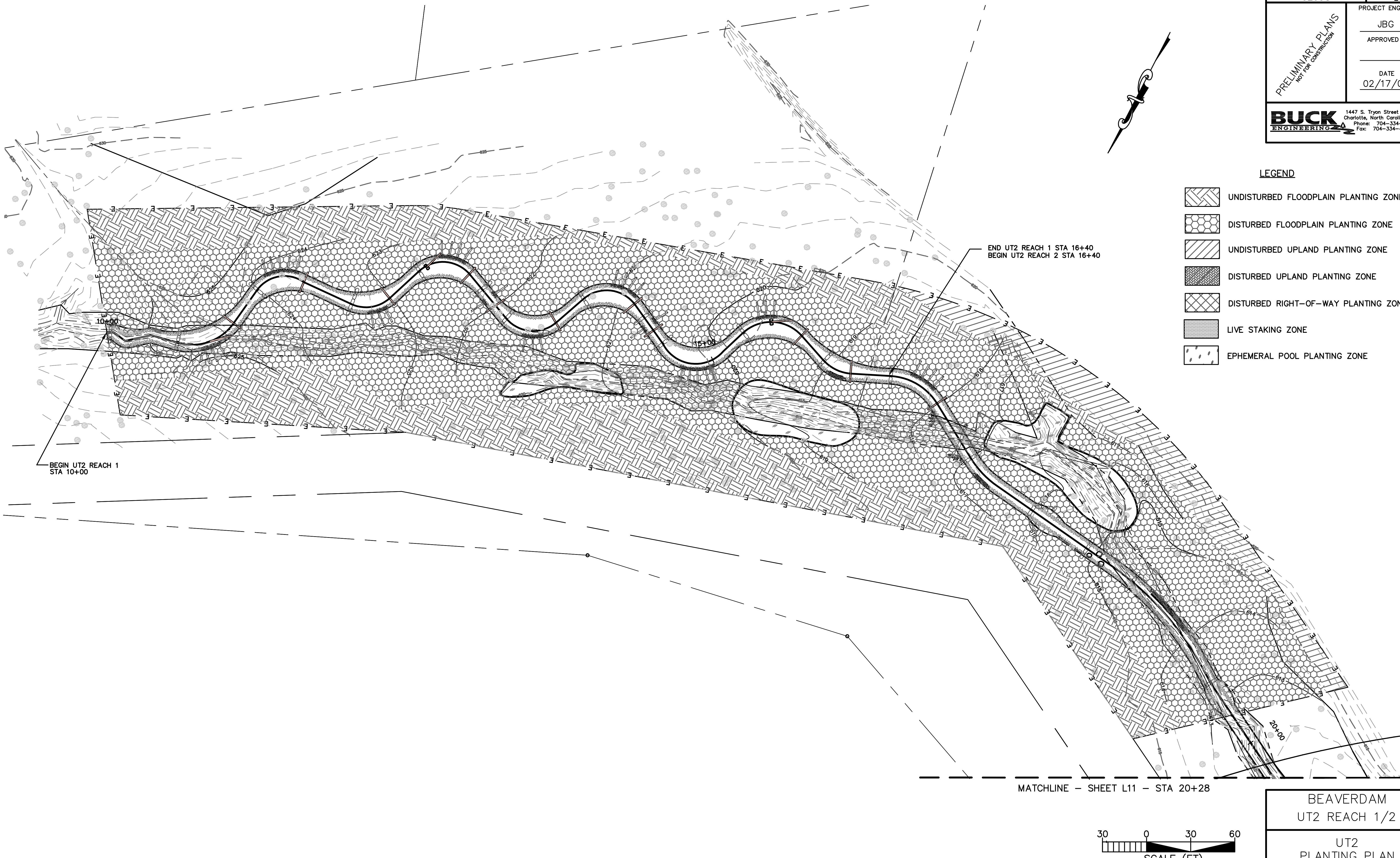
PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG

APPROVED BY:

DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



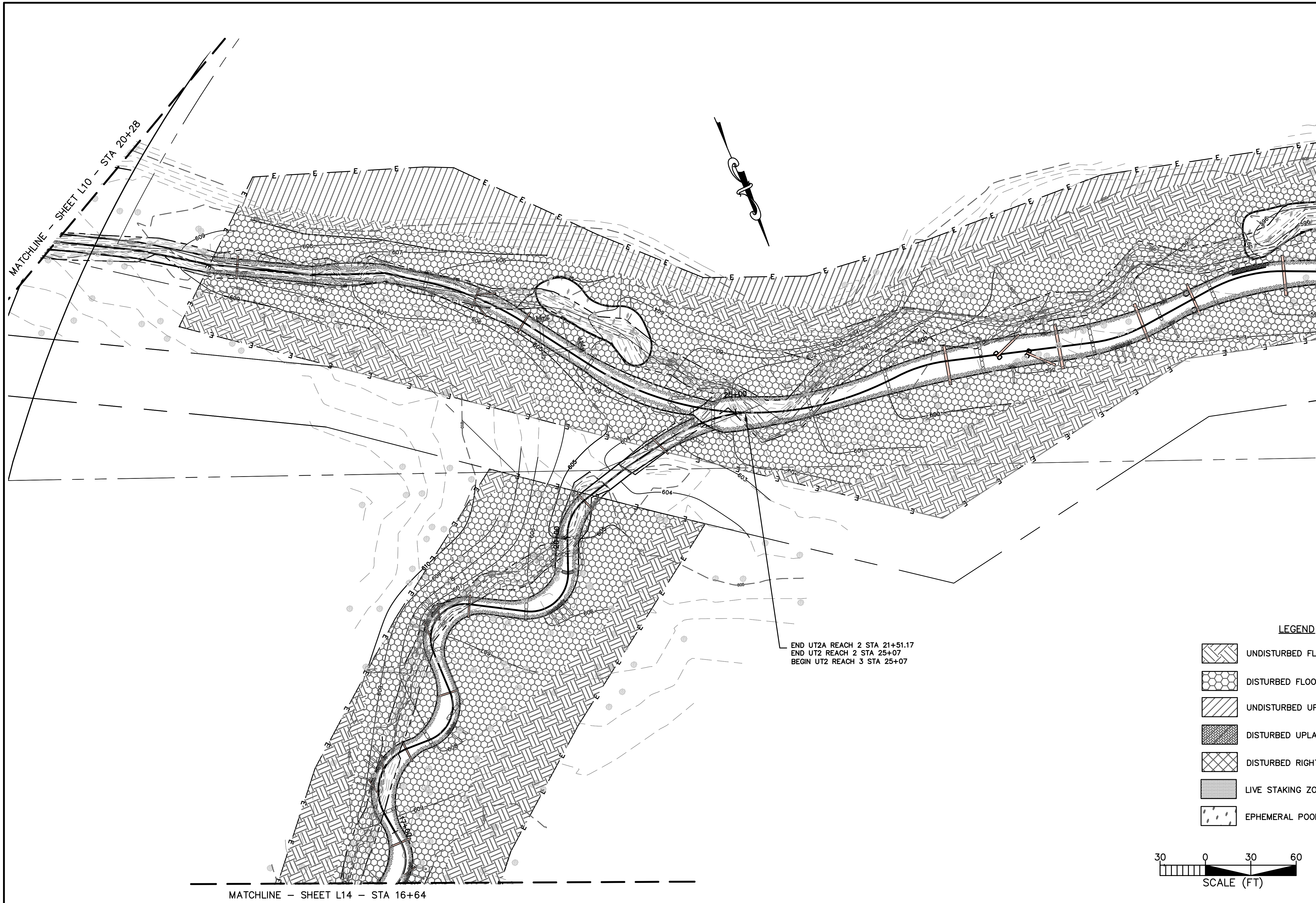
LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

BEAVERDAM
UT2 REACH 1/2

UT2
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

30 0 30 60
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	L11

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 2/3
UT2A REACH 2

UT2
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006

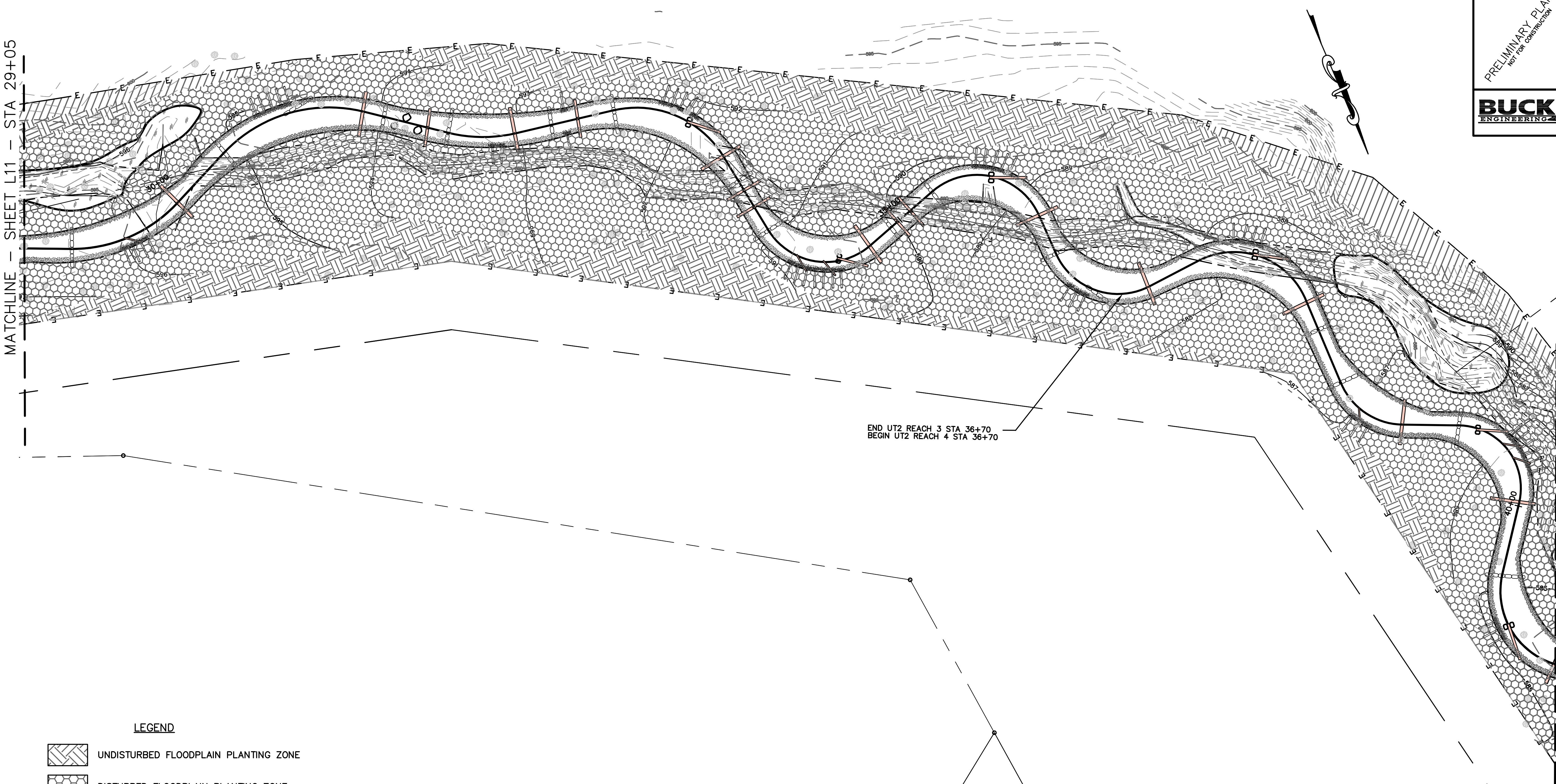
PROJECT REFERENCE NO.	SHEET NO.
0269C	L12

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



LEGEND

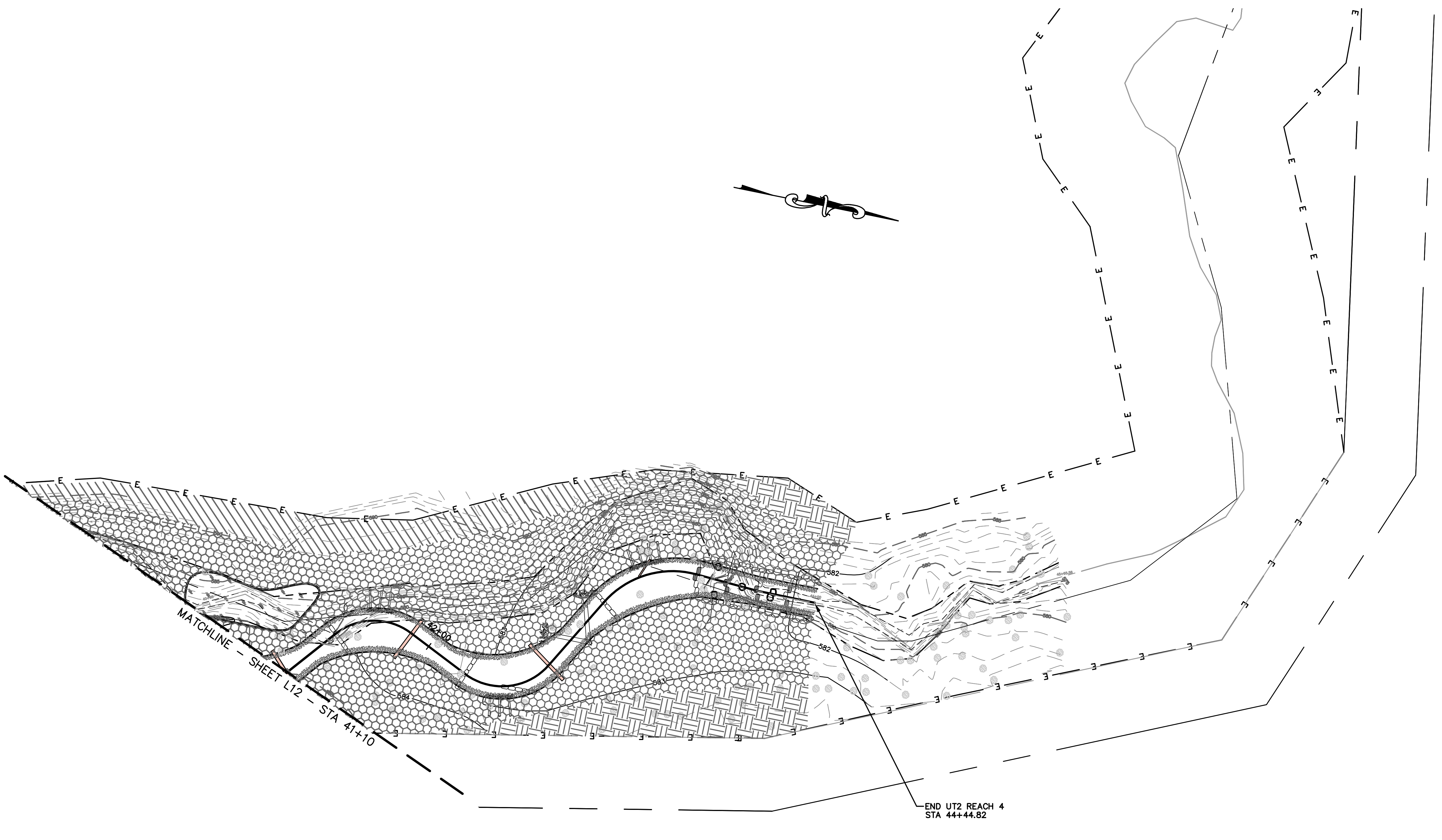
- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

30 0 30 60
SCALE (FT)

BEAVERDAM
UT2 REACH 3/4

UT2
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	L13

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG

APPROVED BY:

DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE

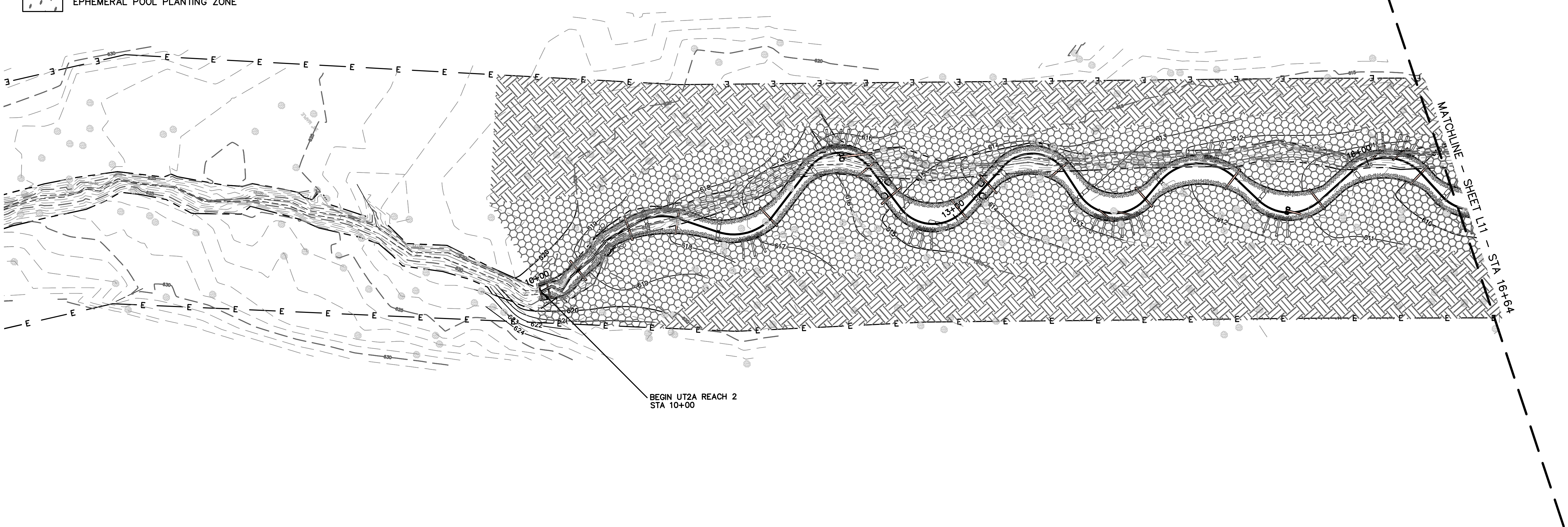
BEAVERDAM
UT2 REACH 4

UT2
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006

LEGEND

- UNDISTURBED FLOODPLAIN PLANTING ZONE
- DISTURBED FLOODPLAIN PLANTING ZONE
- UNDISTURBED UPLAND PLANTING ZONE
- DISTURBED UPLAND PLANTING ZONE
- DISTURBED RIGHT-OF-WAY PLANTING ZONE
- LIVE STAKING ZONE
- EPHEMERAL POOL PLANTING ZONE



30 0 30 60
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	L14

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

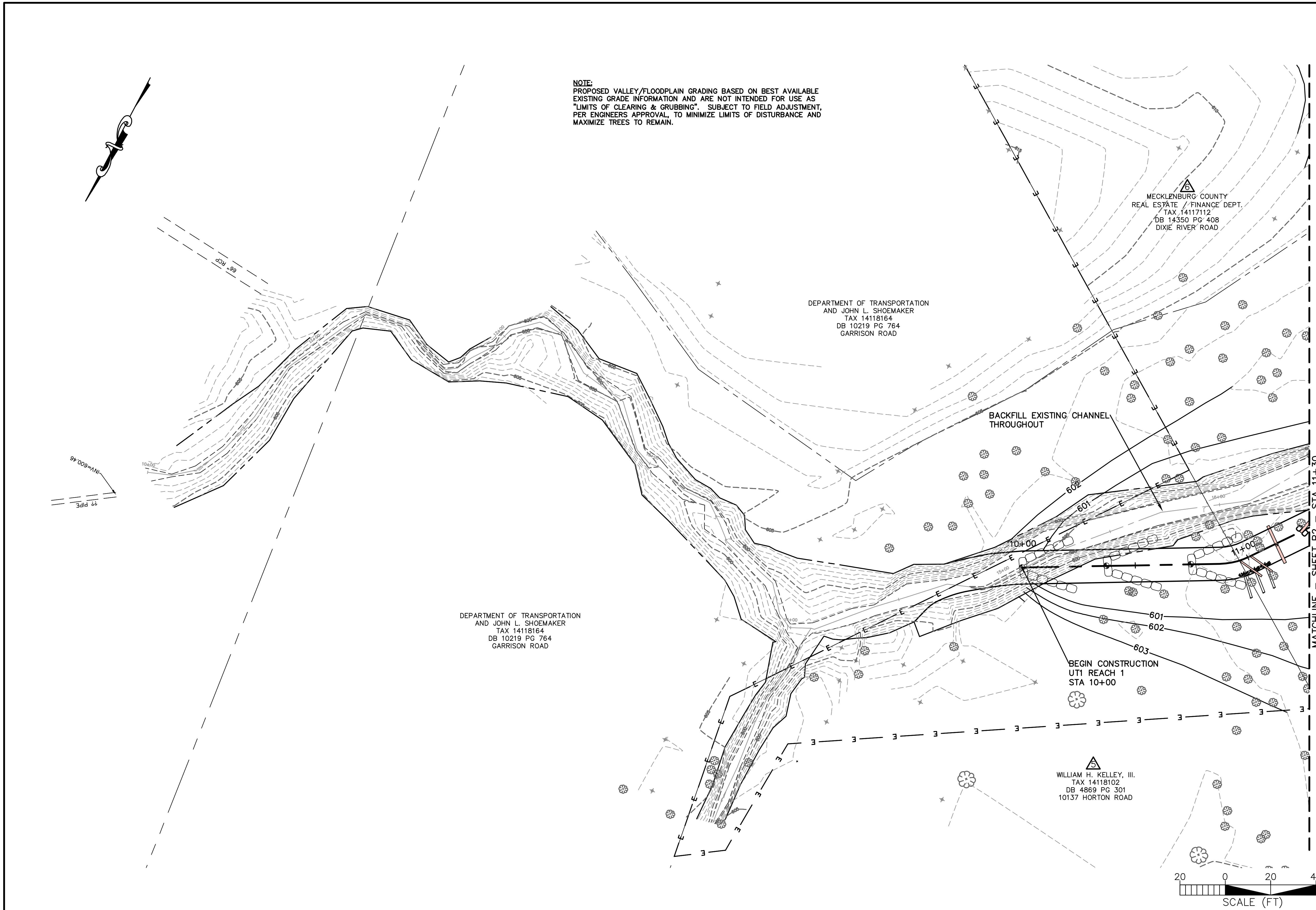
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2A REACH 2

UT2
PLANTING PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANTSHEETS.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	P1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

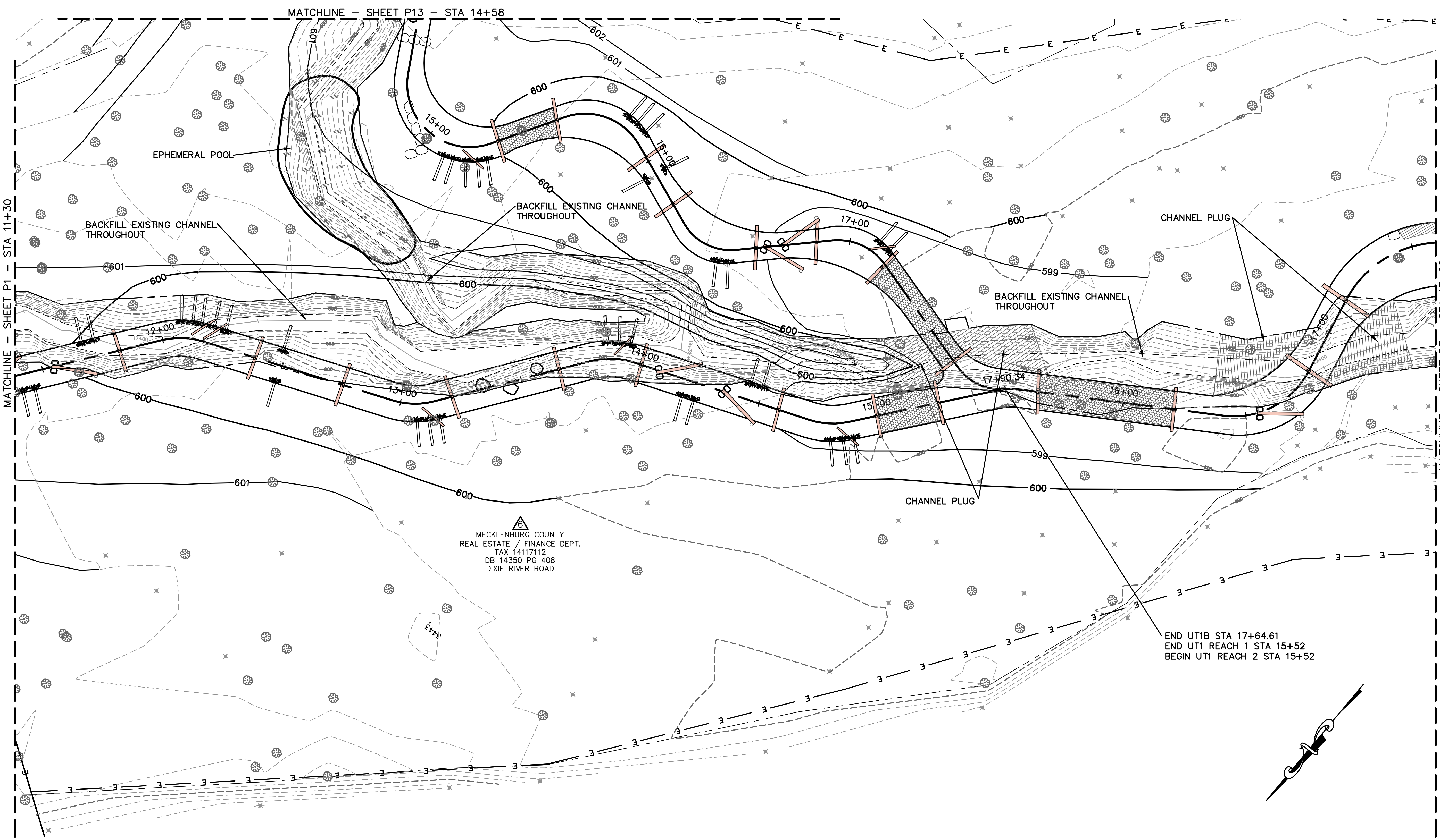
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 1

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P2

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

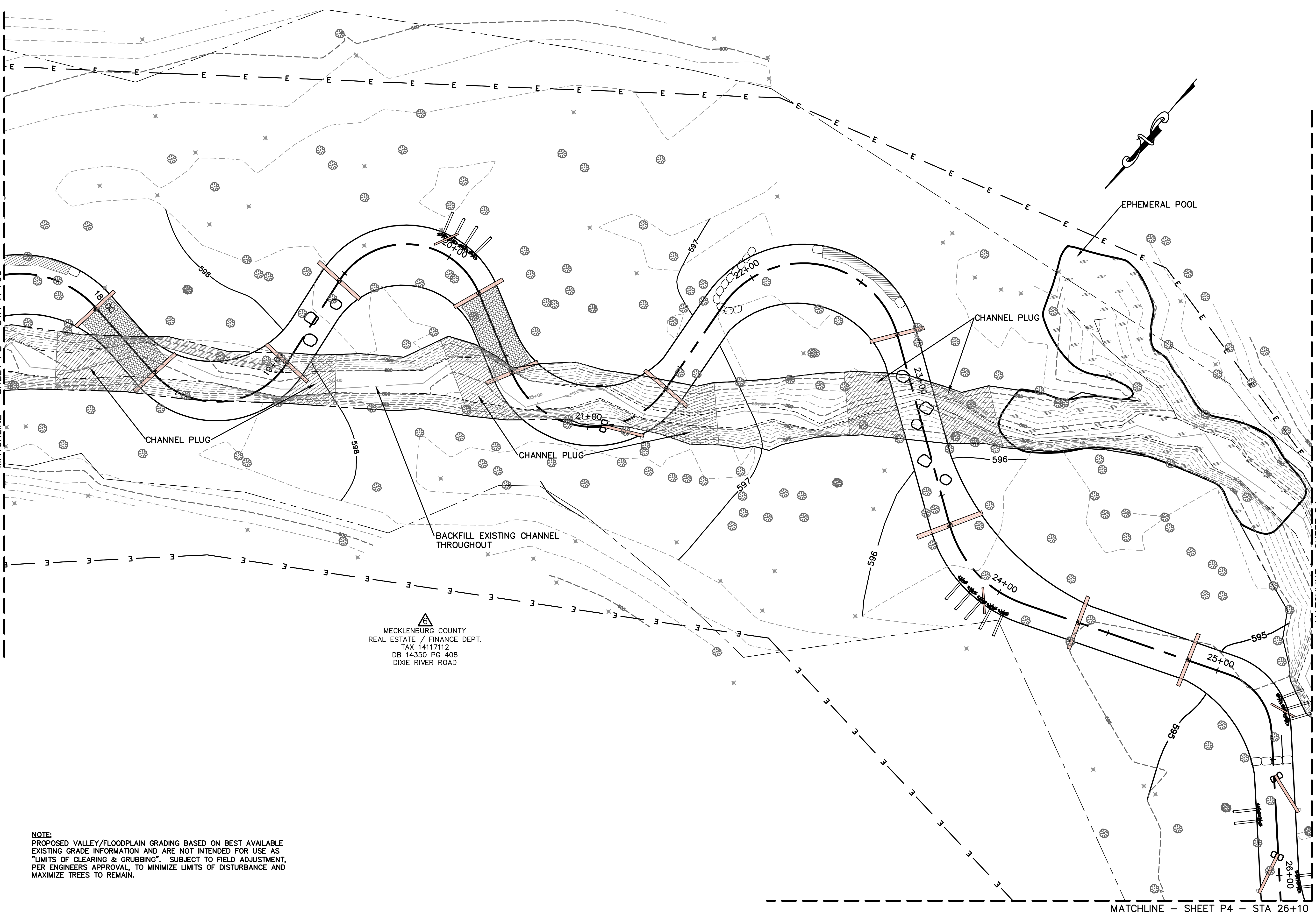
PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 1/2
UT1B

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P3

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

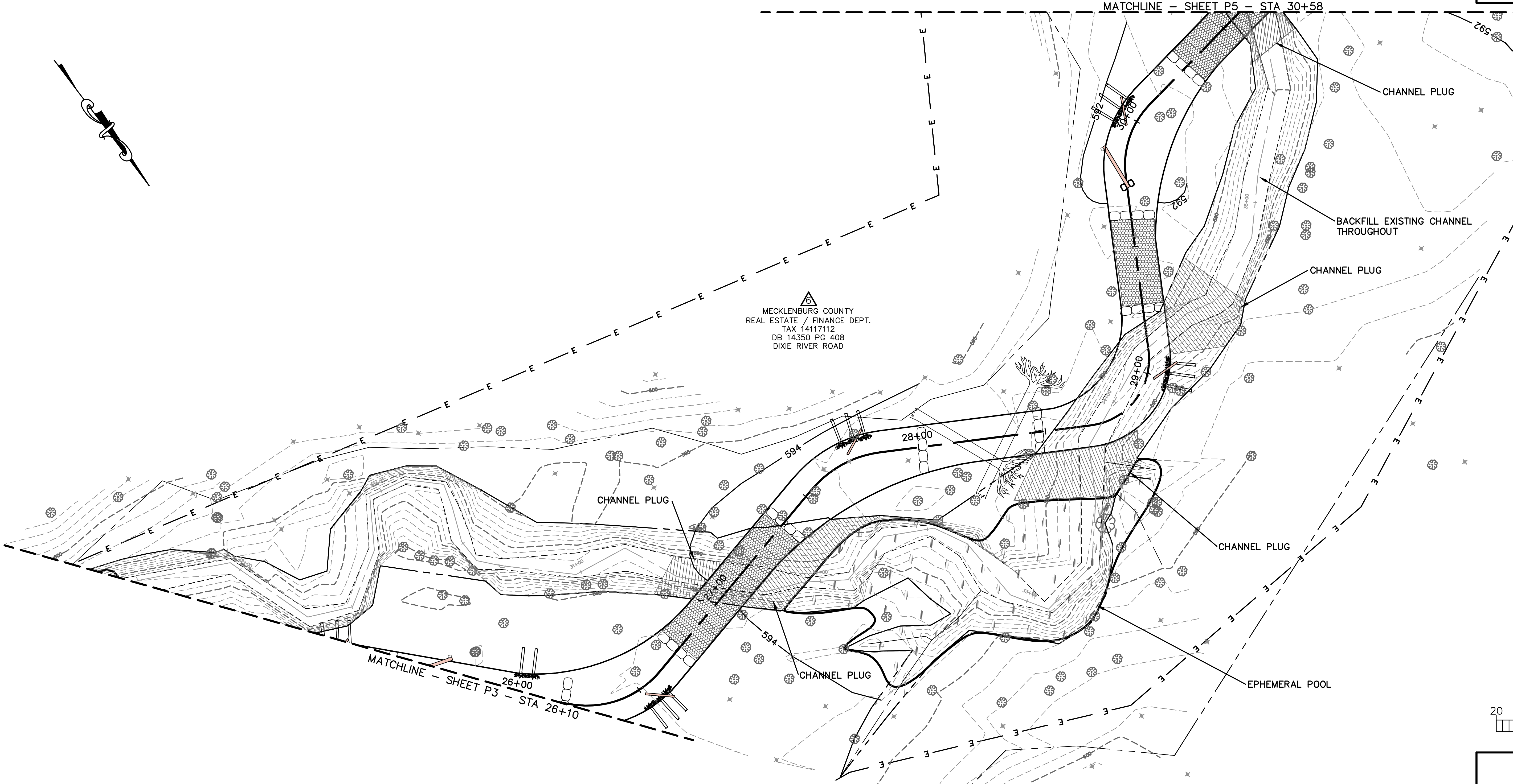
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 2

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



SCALE (FT) 20 0 20 40

PROJECT REFERENCE NO.	SHEET NO.
0269C	P4

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

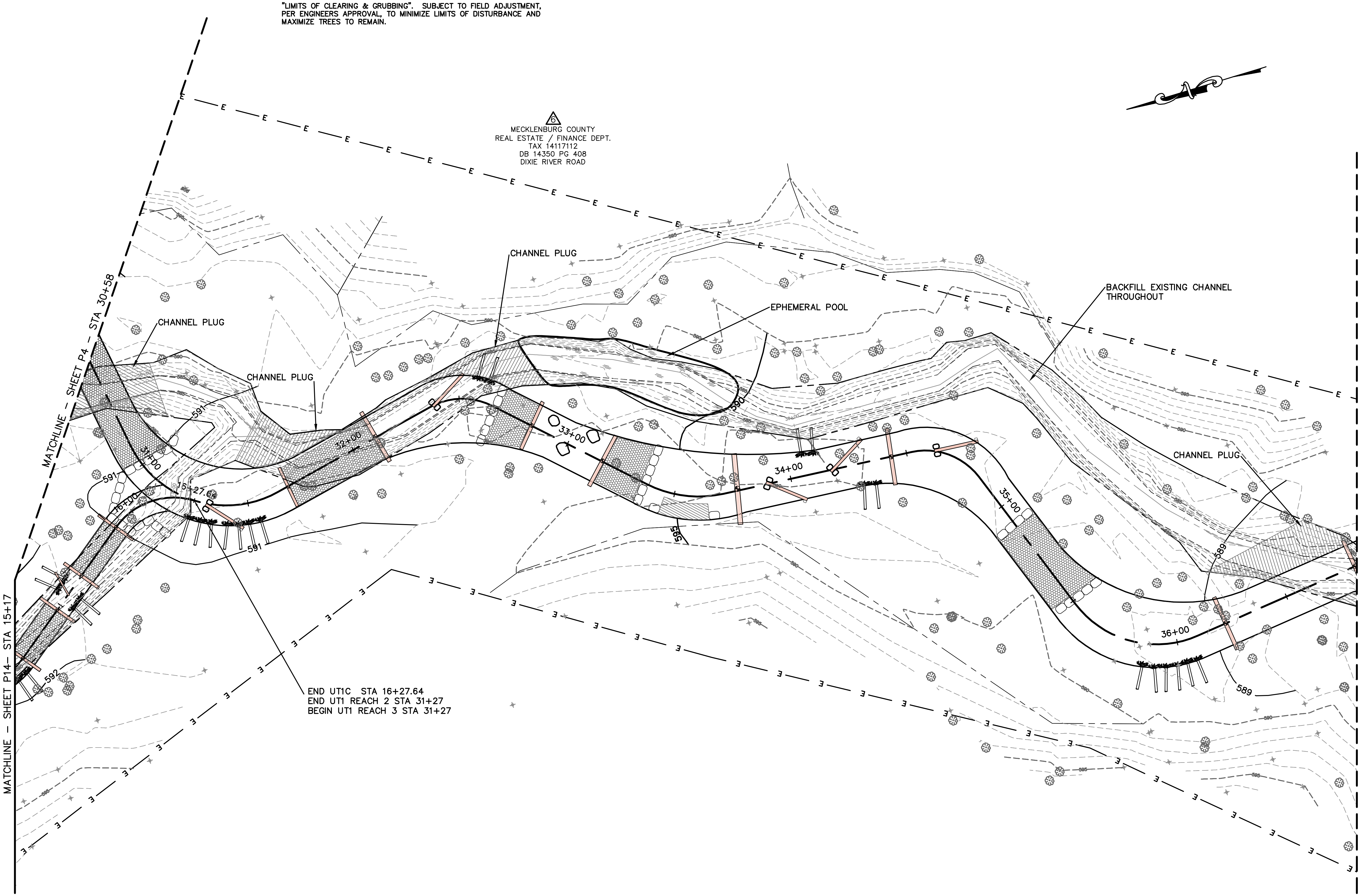
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 2

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P5

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

20 0 20 40
SCALE (FT)

BEAVERDAM
UT1 REACH 2/3
UT1C

SITE PLAN

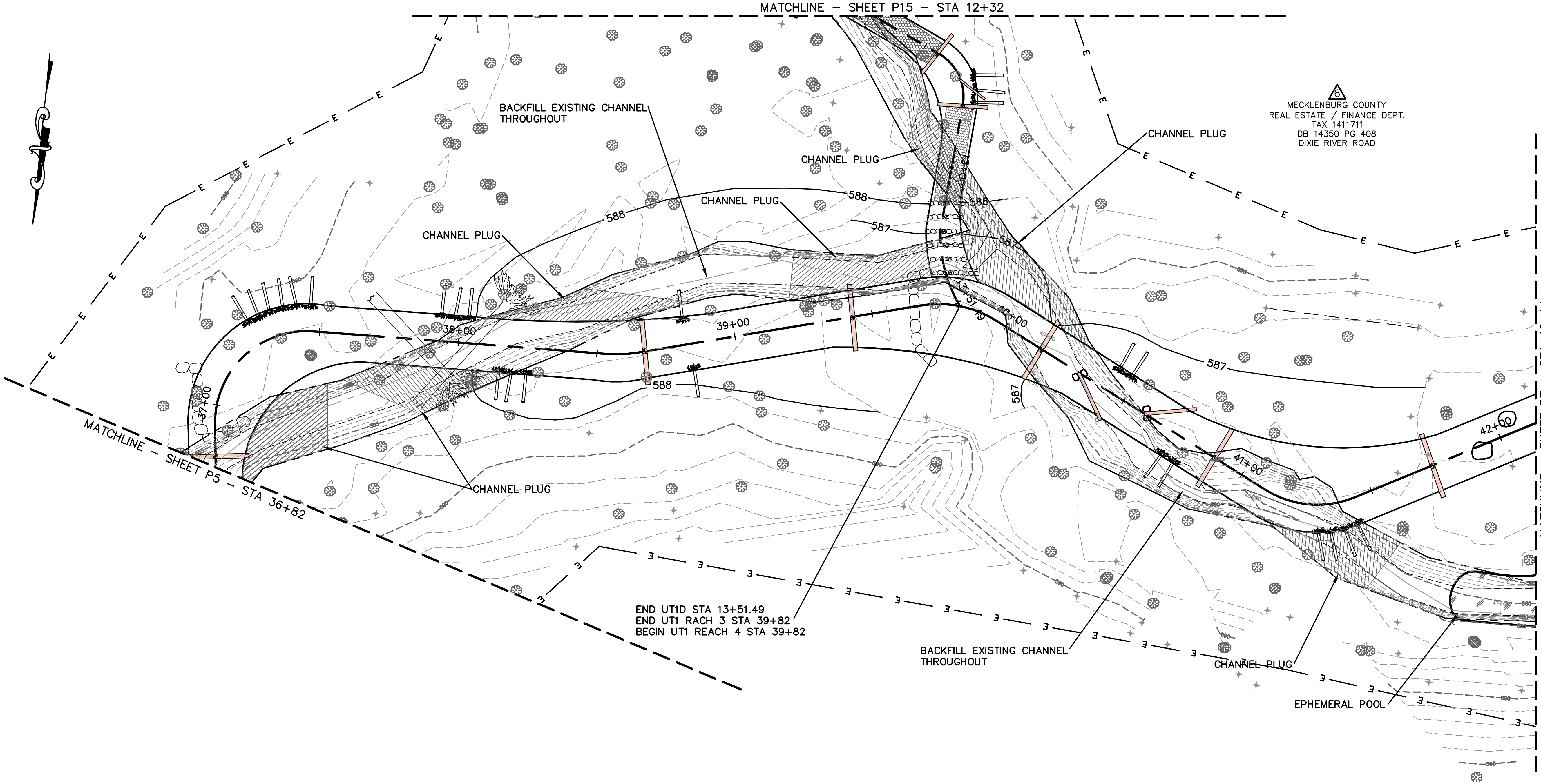
L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	P6

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



20 0 20 40
SCALE (FT)

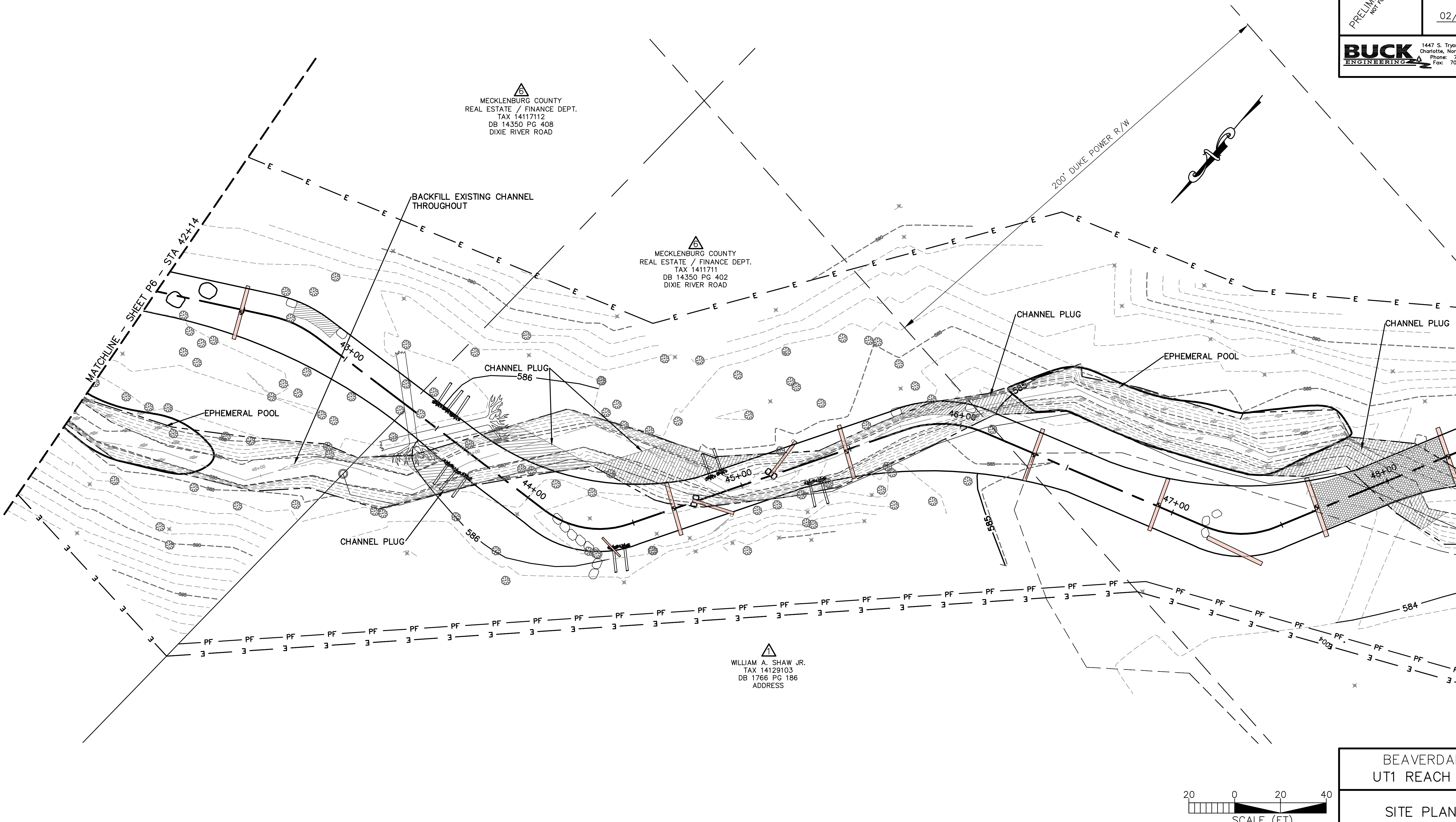
BEAVERDAM
UT1 REACH 3/4

SITE PLAN

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P7

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

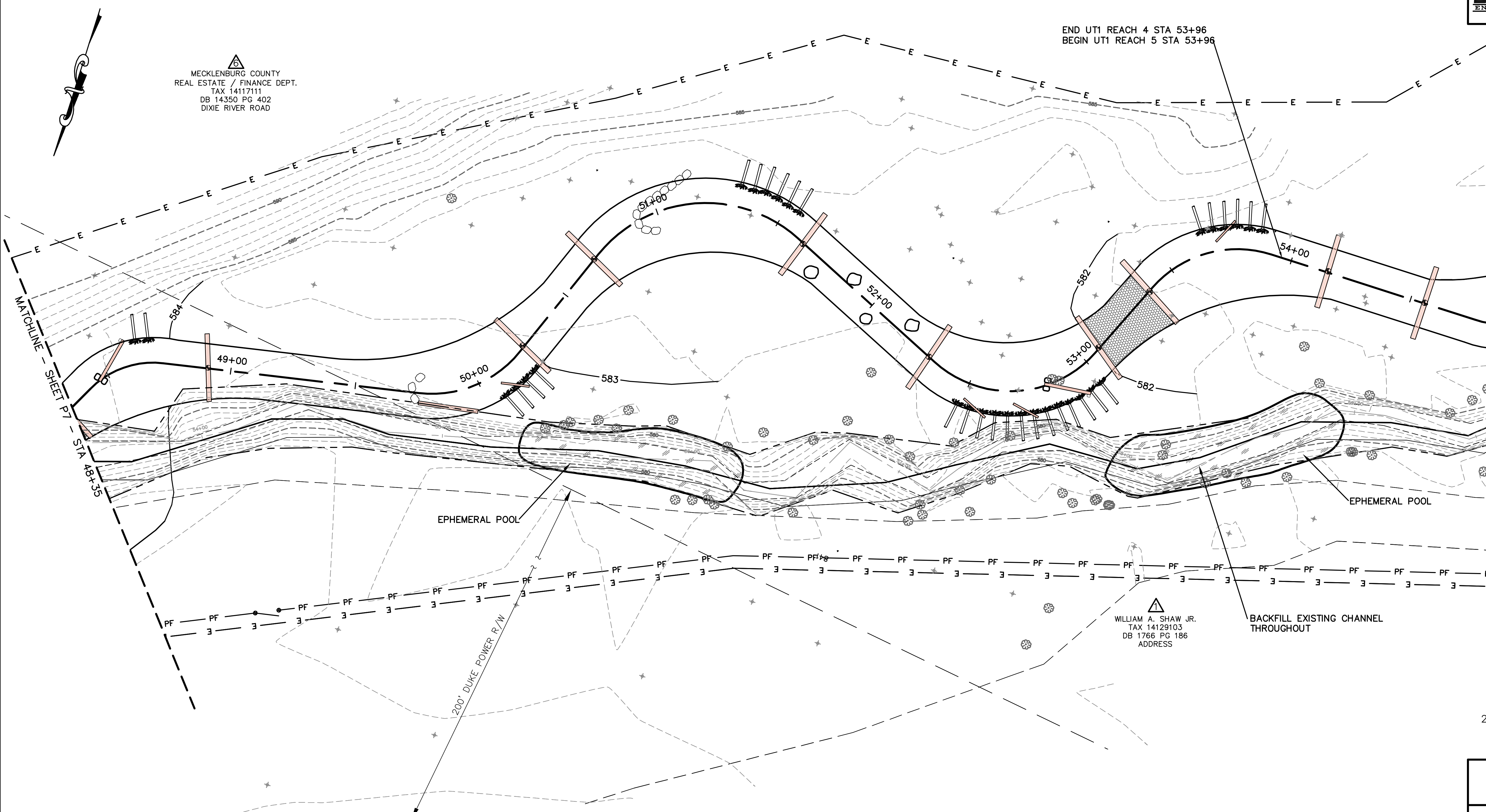
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 4

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P8

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

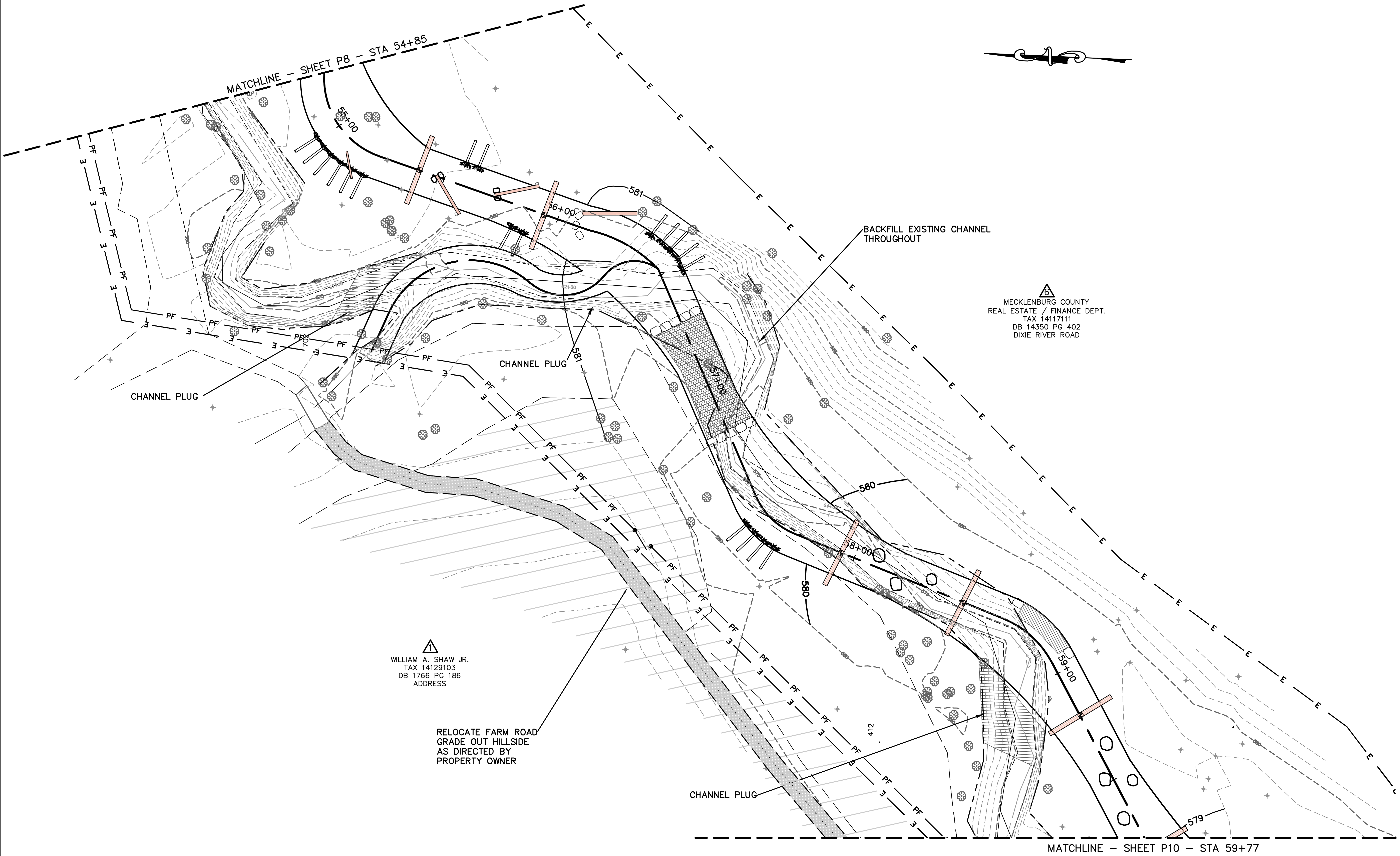
PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 4/5

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	P9

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 5

SITE PLAN

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

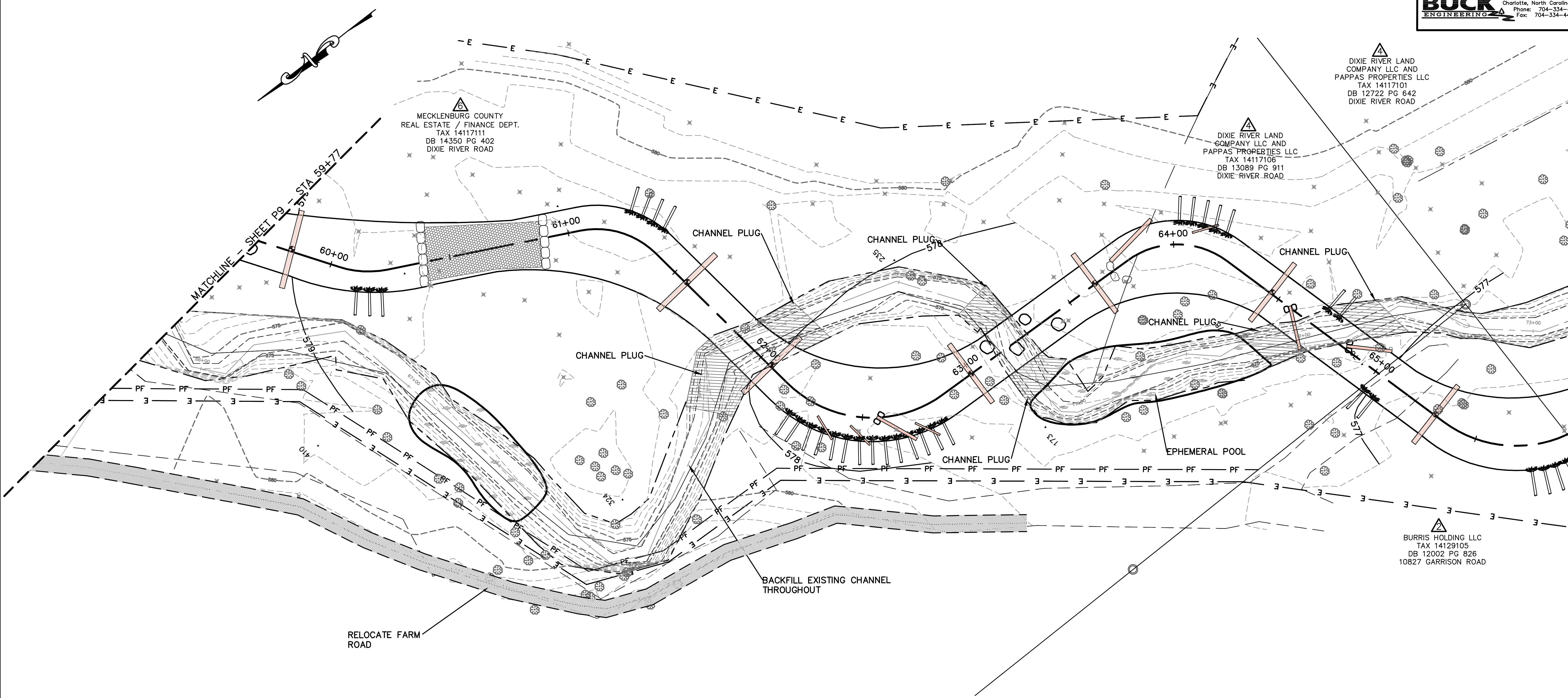
NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P10

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

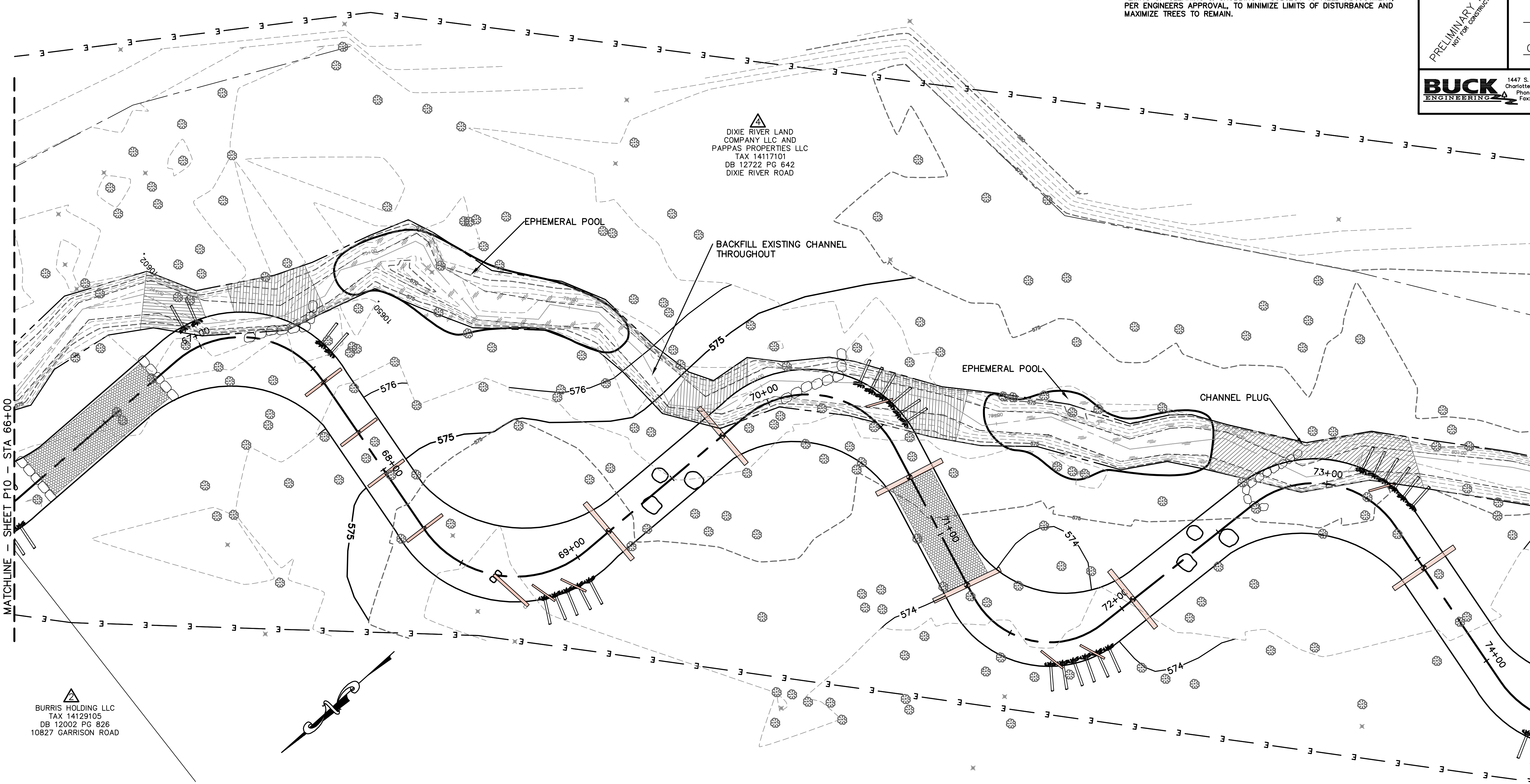
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



BEAVERDAM
UT1 REACH 5

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P11

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

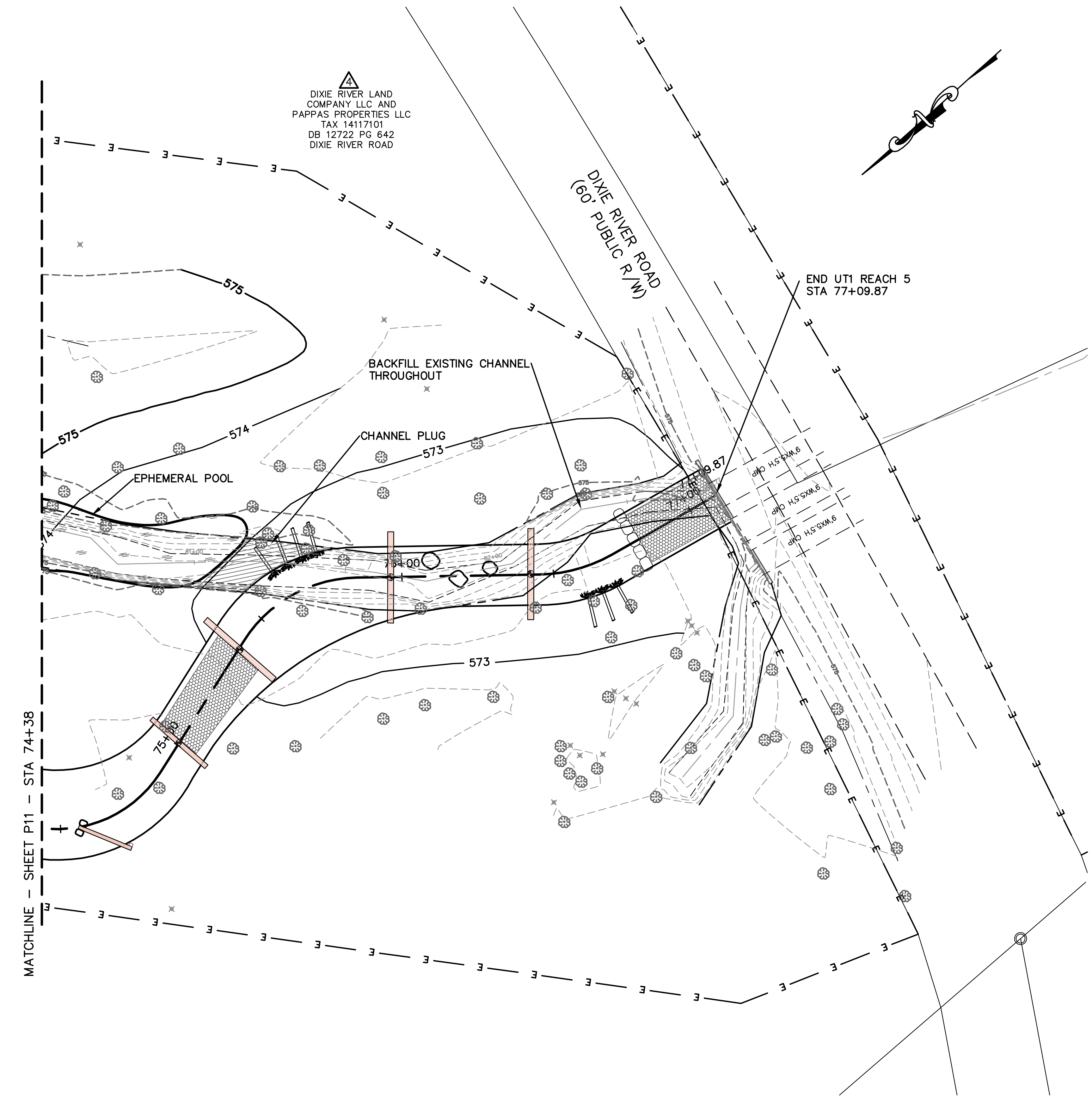
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 5

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P12

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

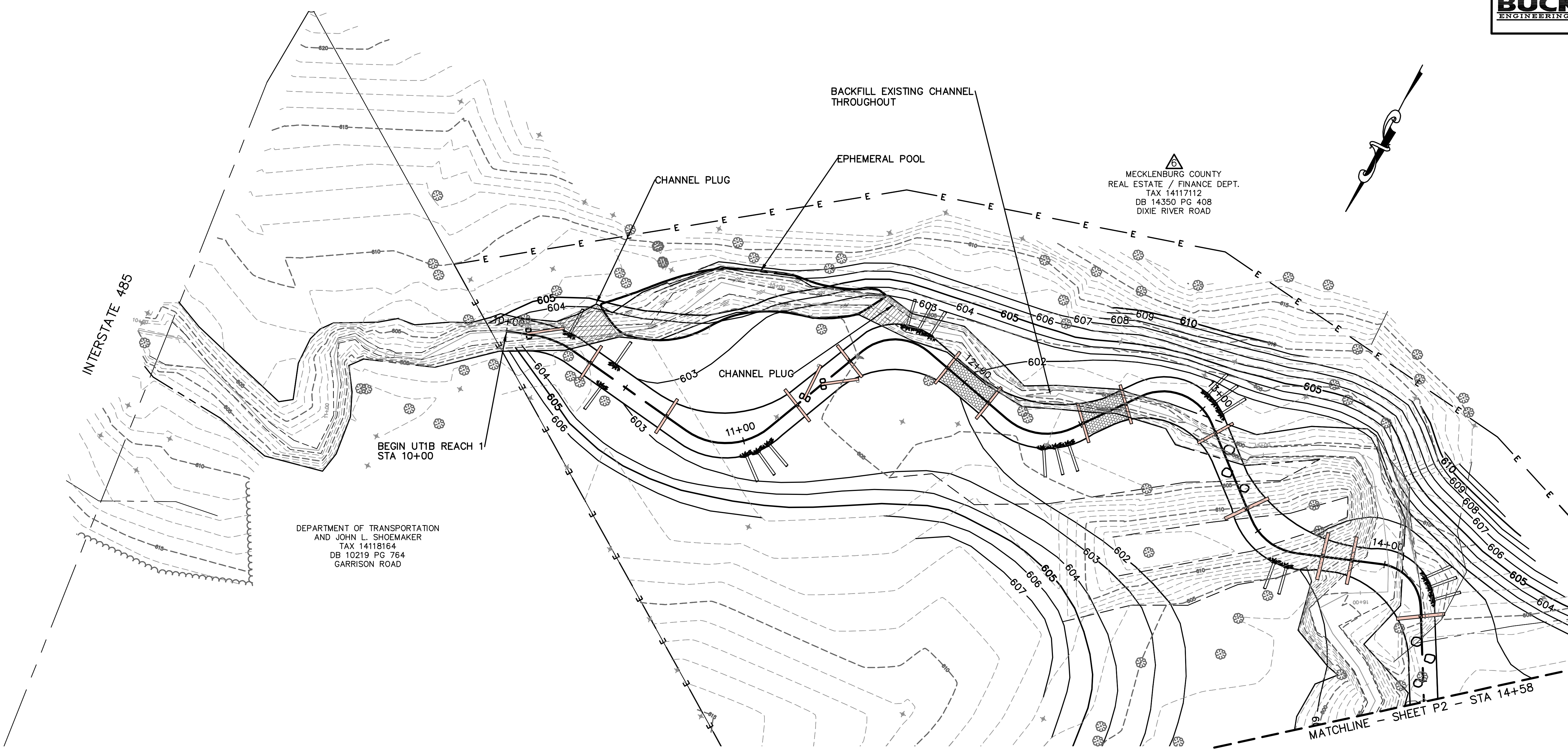
20 0 20 40
SCALE (FT)

BEAVERDAM
UT1 REACH 5

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P13

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

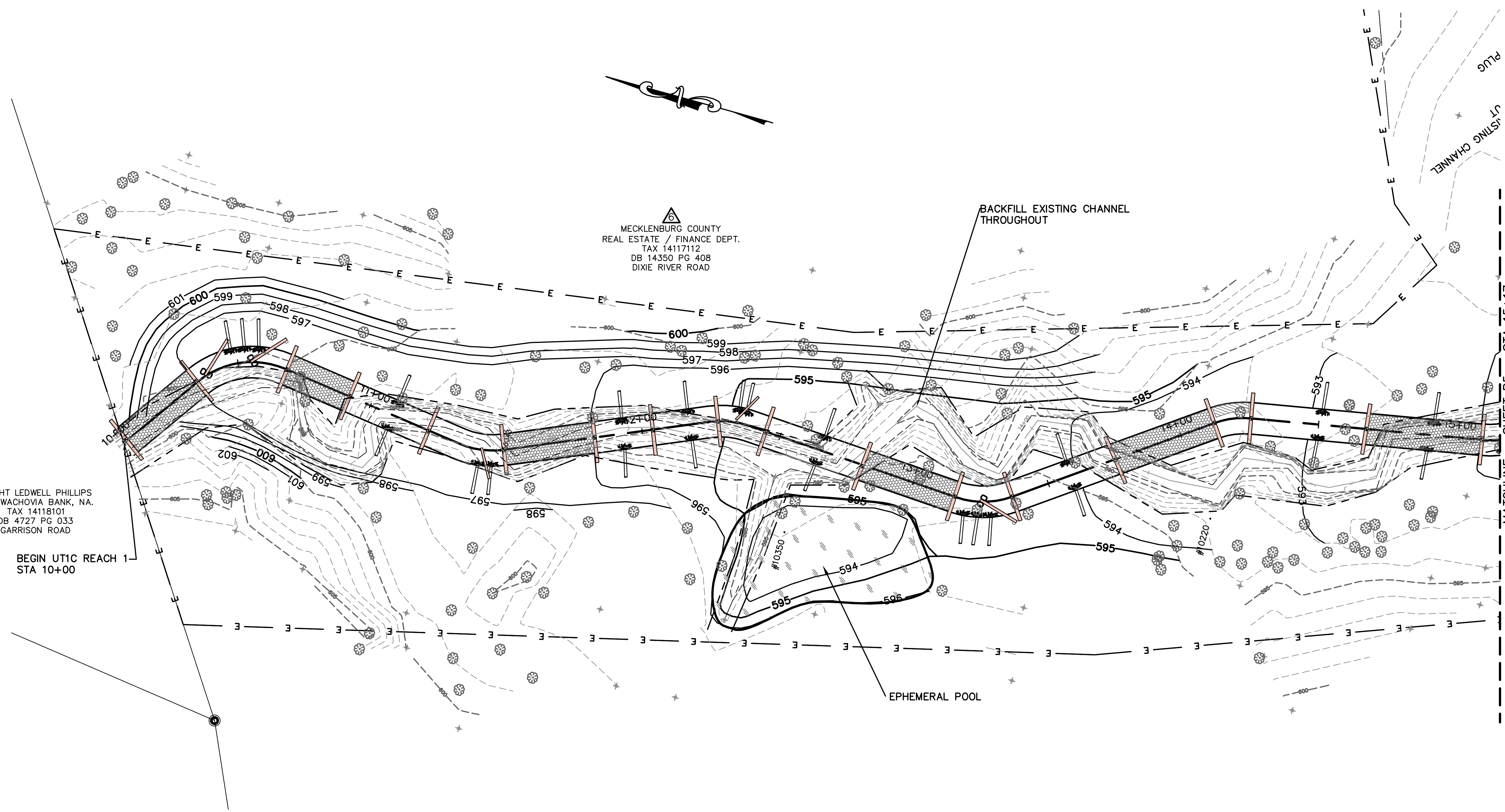
20 0 20 40
SCALE (FT)

BEAVERDAM
UT1B

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P14

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

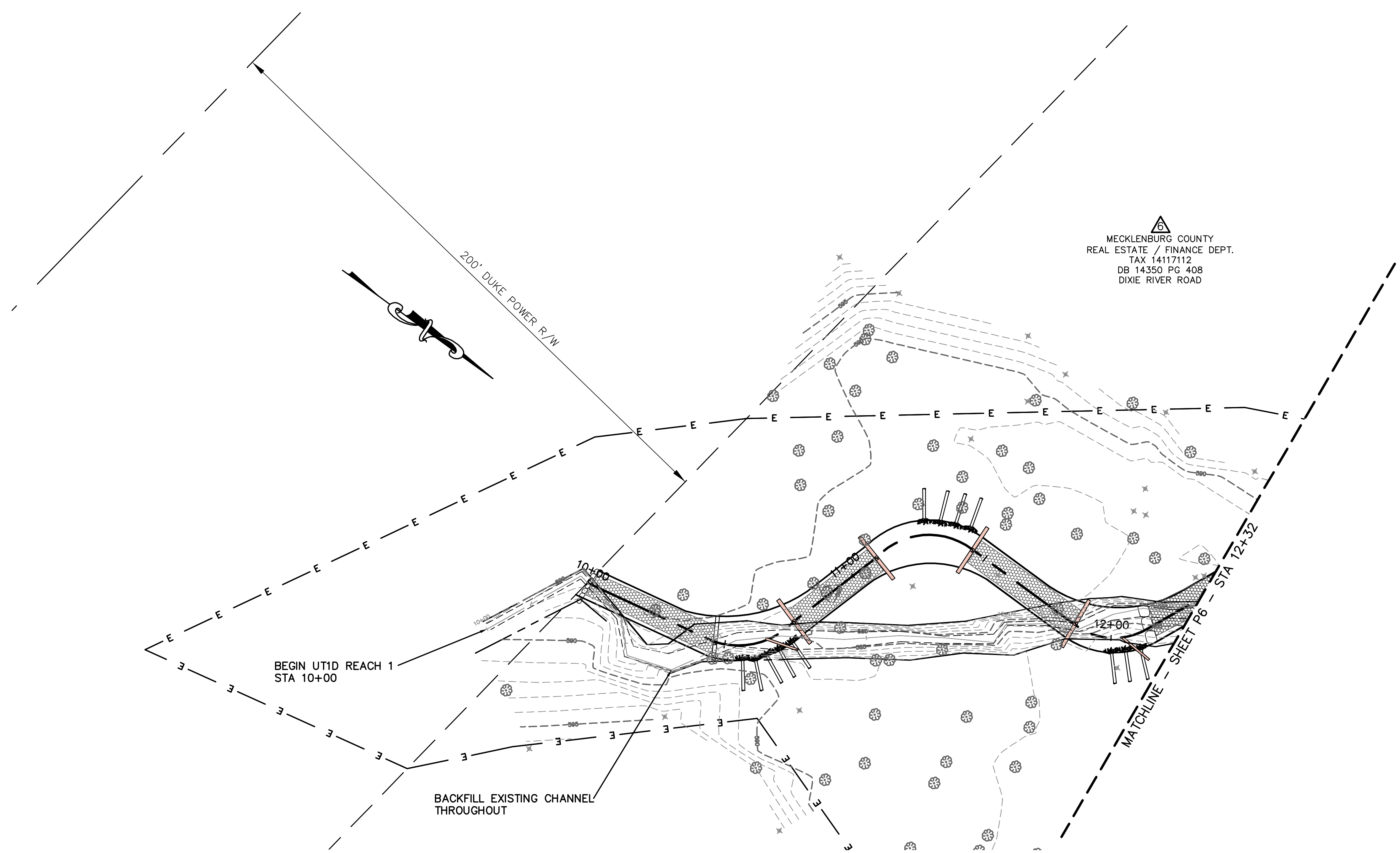
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

SCALE (FT) 20 0 20 40

BEAVERDAM
UT1C

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P15

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

20 0 20 40
SCALE (FT)

BEAVERDAM
UT1D

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT1.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	P16

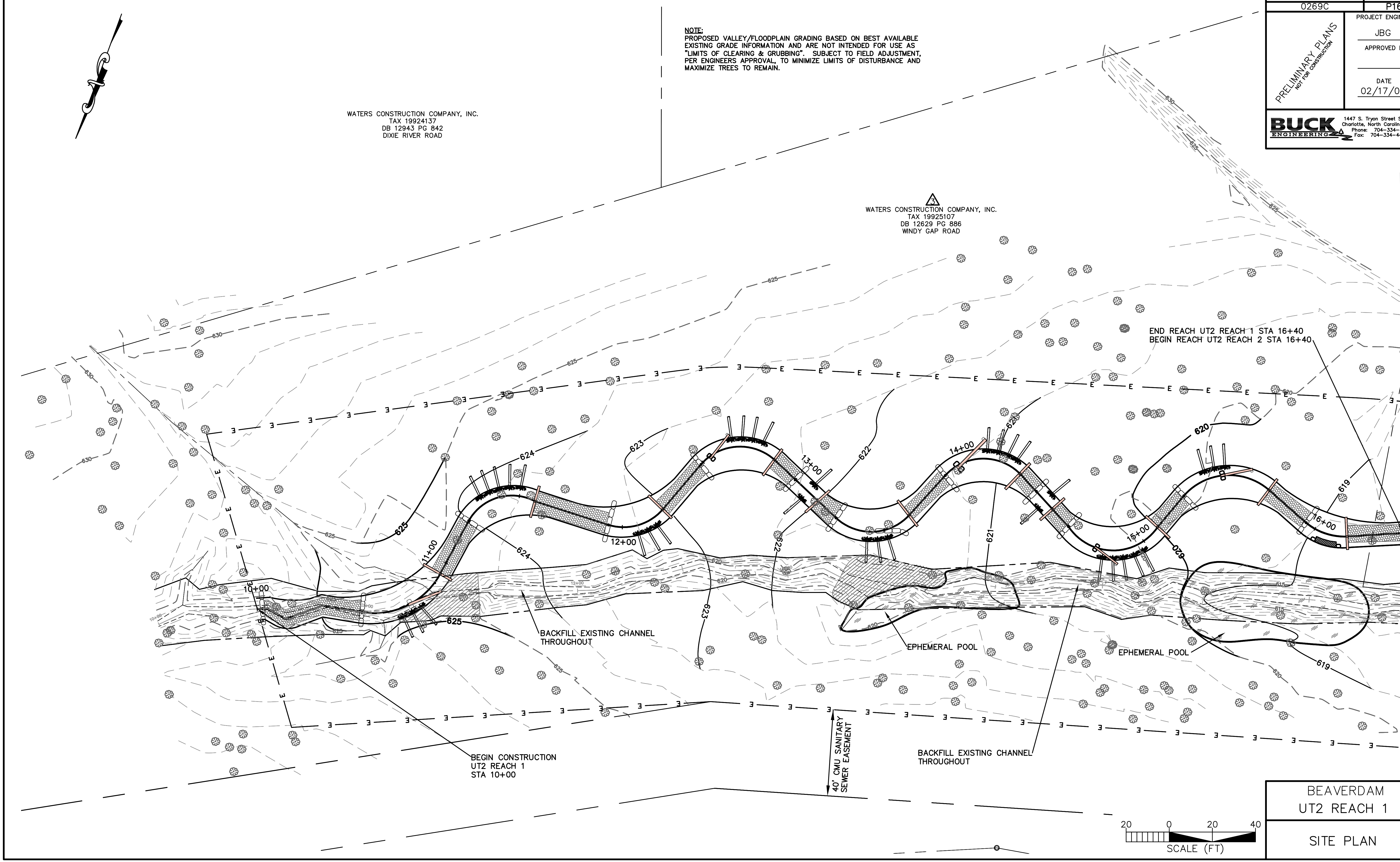
PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



BEAVERDAM
UT2 REACH 1

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

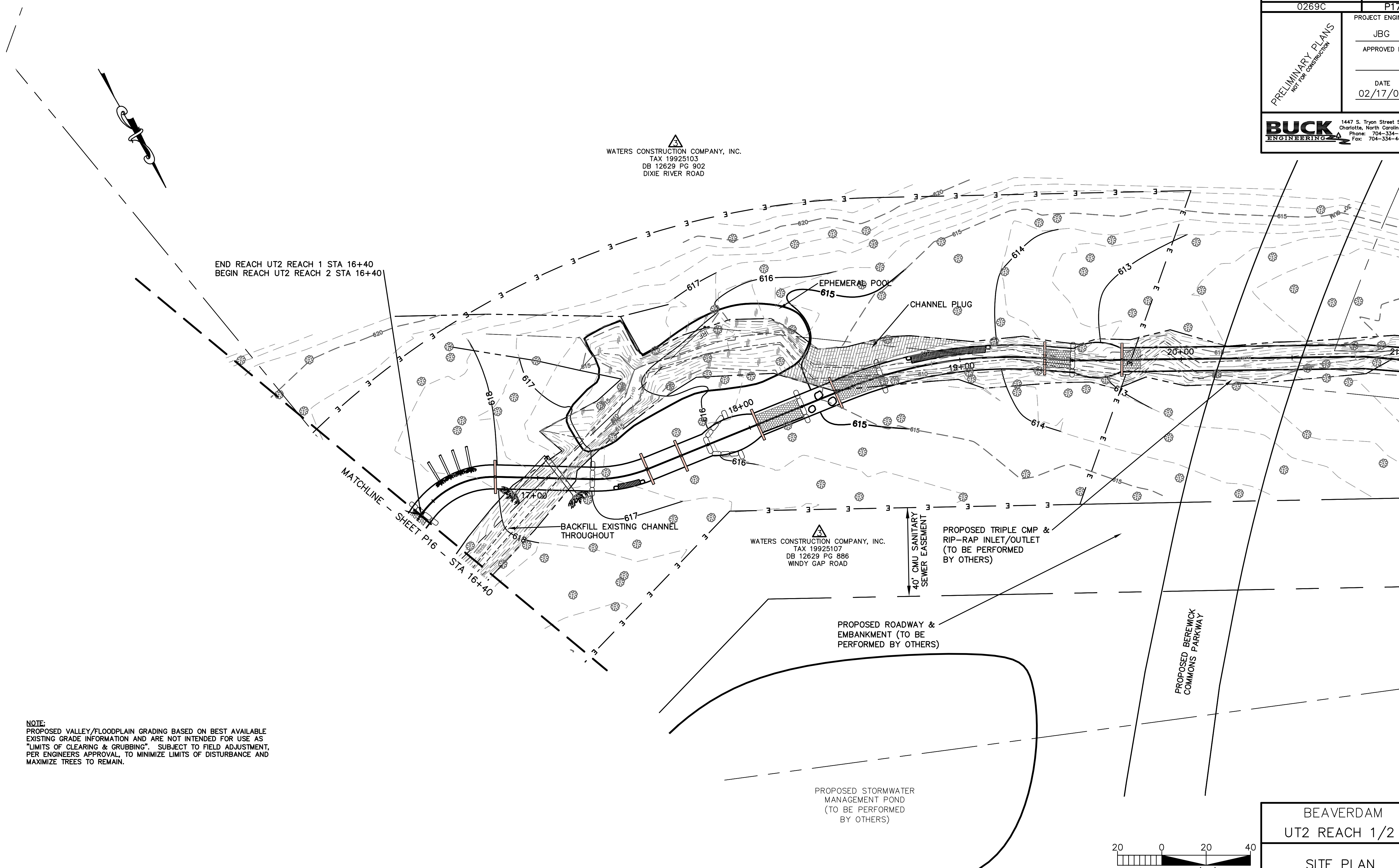
PROJECT REFERENCE NO.	SHEET NO.
0269C	P17

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

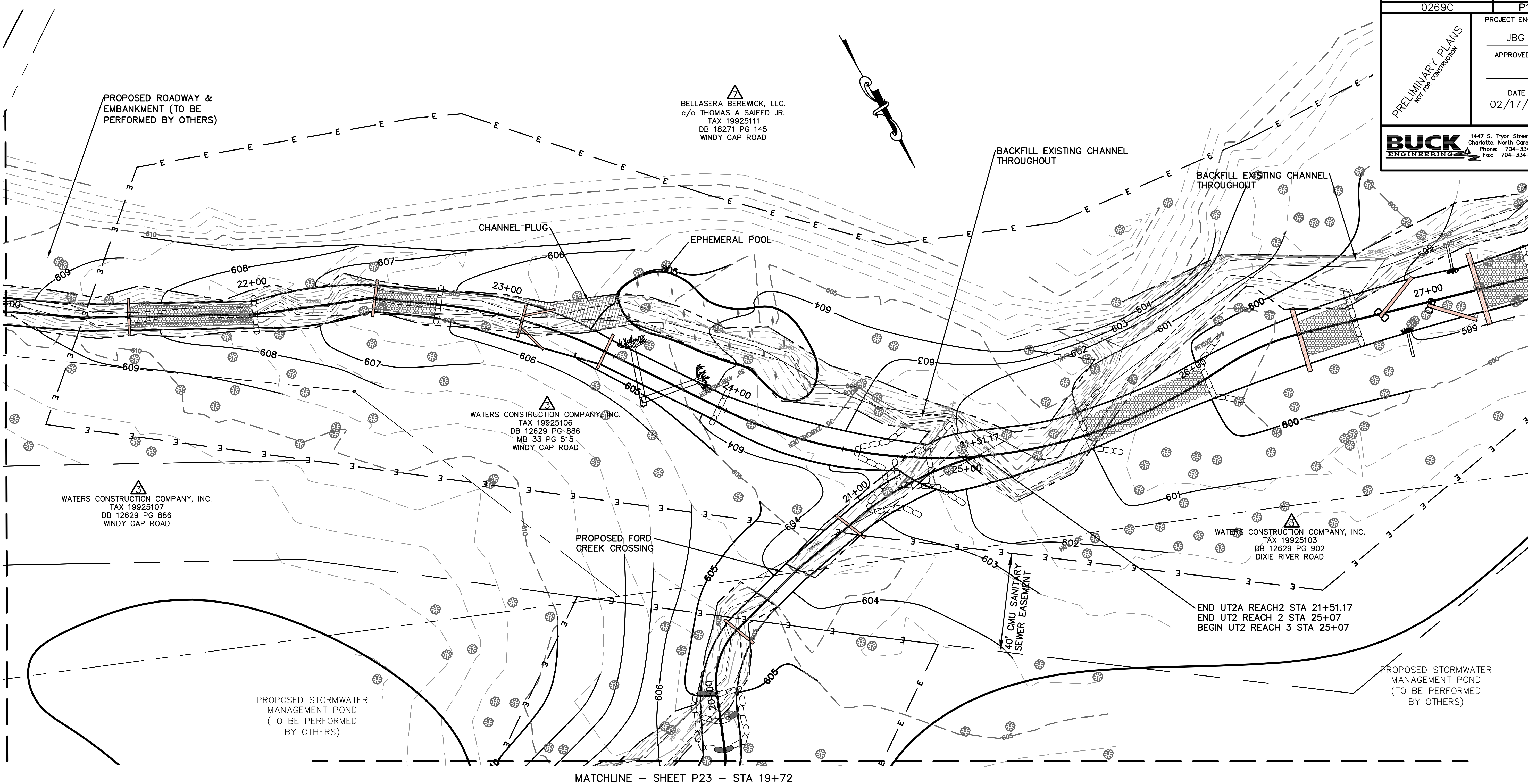


NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

BEAVERDAM
UT2 REACH 1/2

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	P18

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

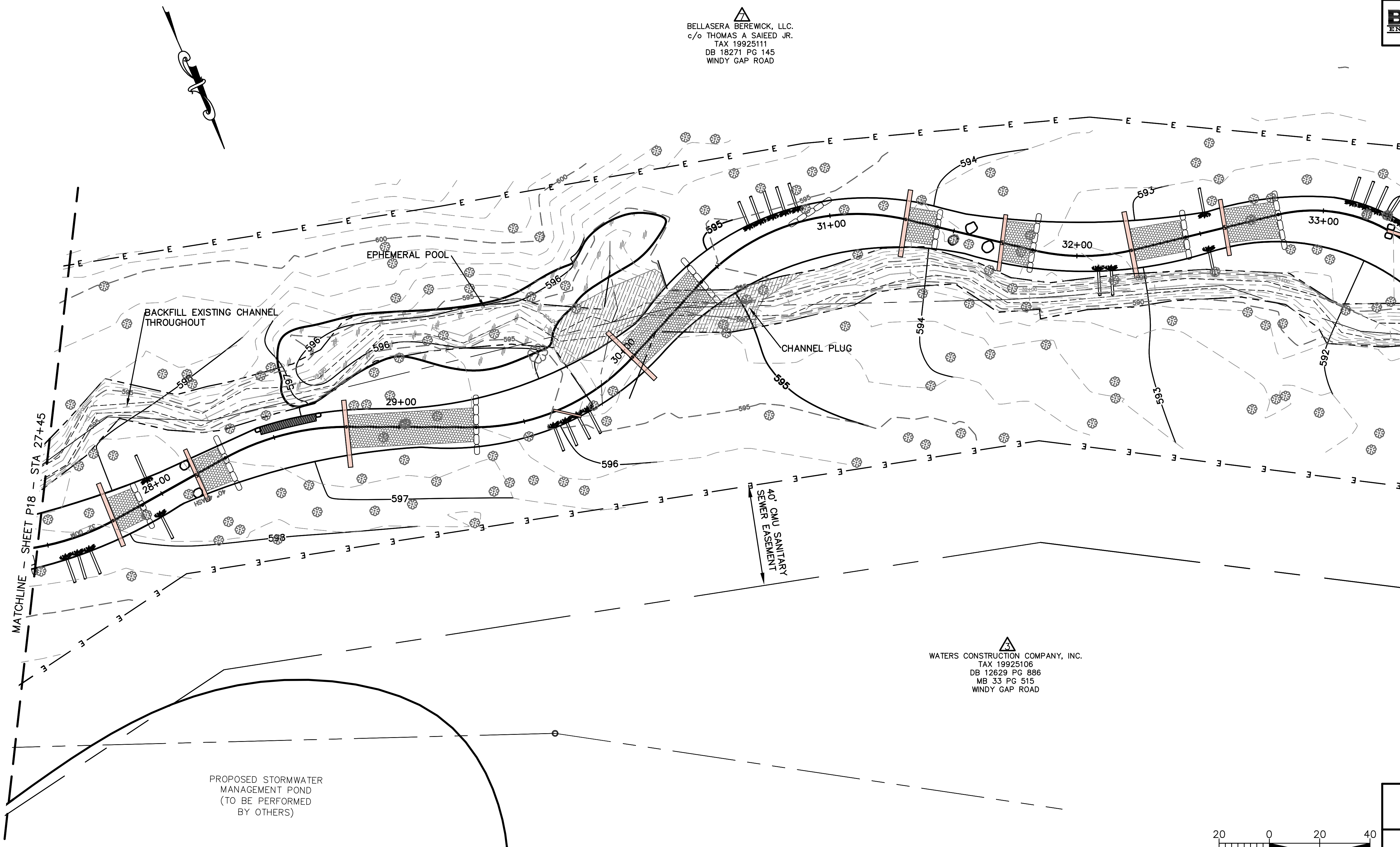
NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

20 0 20 40
SCALE (FT)

BEAVERDAM
UT2 REACH 2/3
SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.



PROJECT REFERENCE NO.	SHEET NO.
0269C	P19

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 3
SITE PLAN

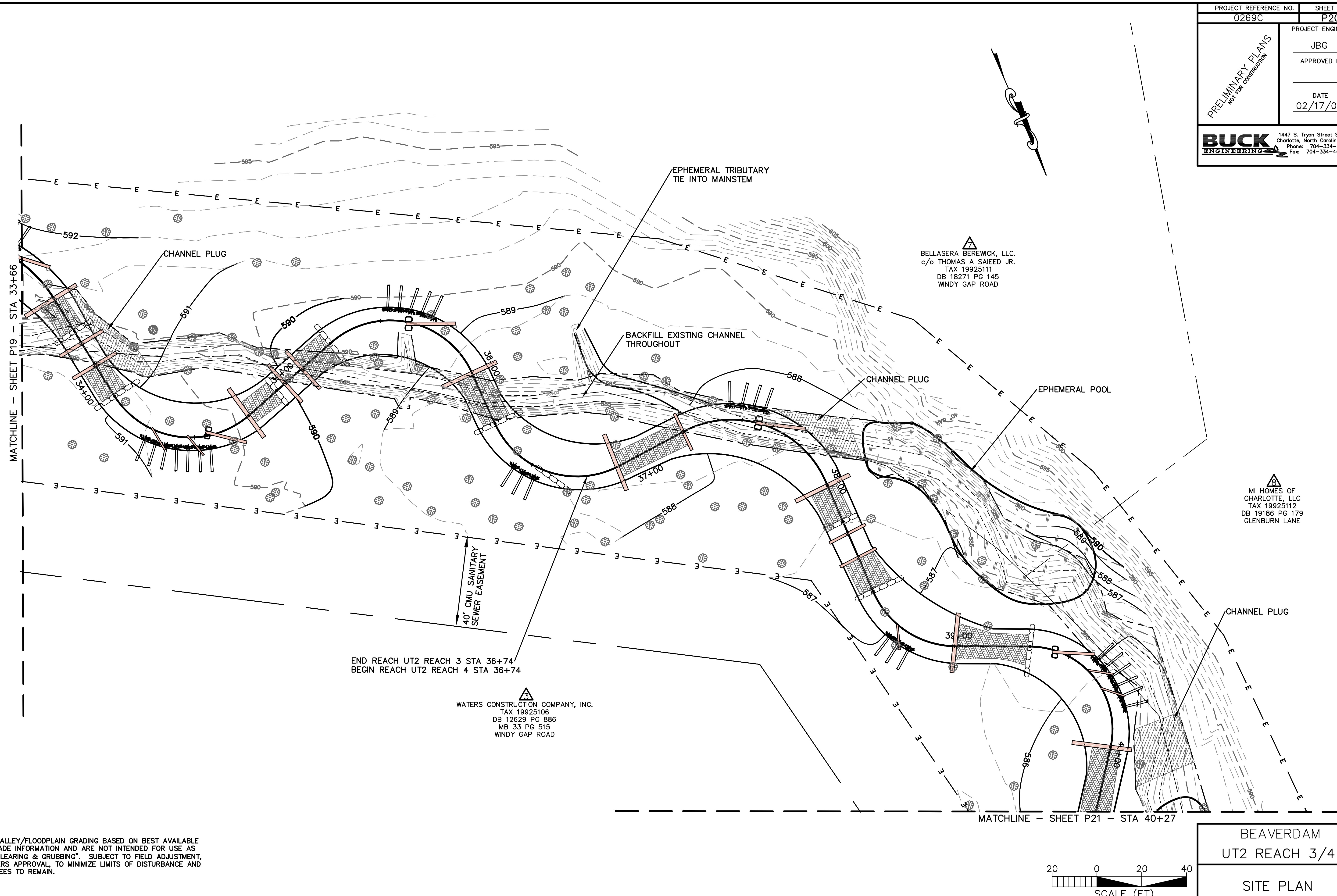
L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	P20

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

BEAVERDAM
UT2 REACH 3/4
SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

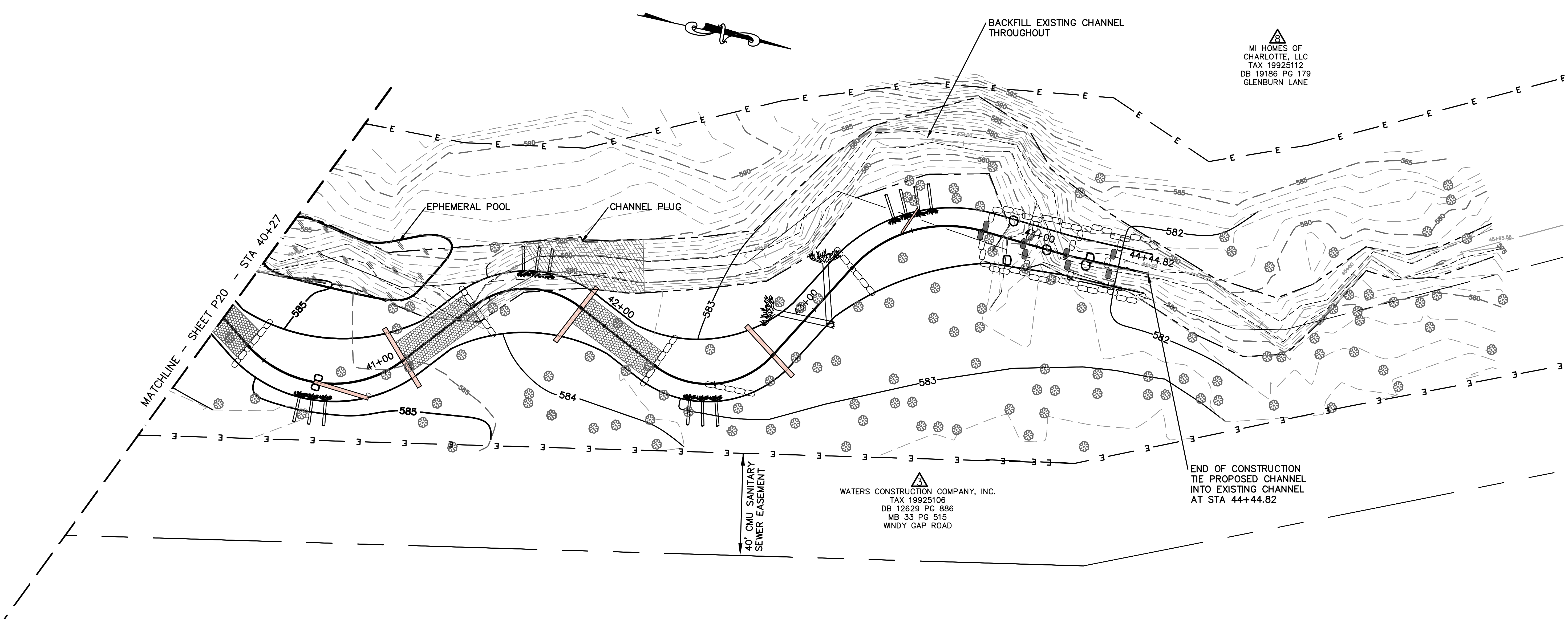
PROJECT REFERENCE NO.	SHEET NO.
0269C	P21

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

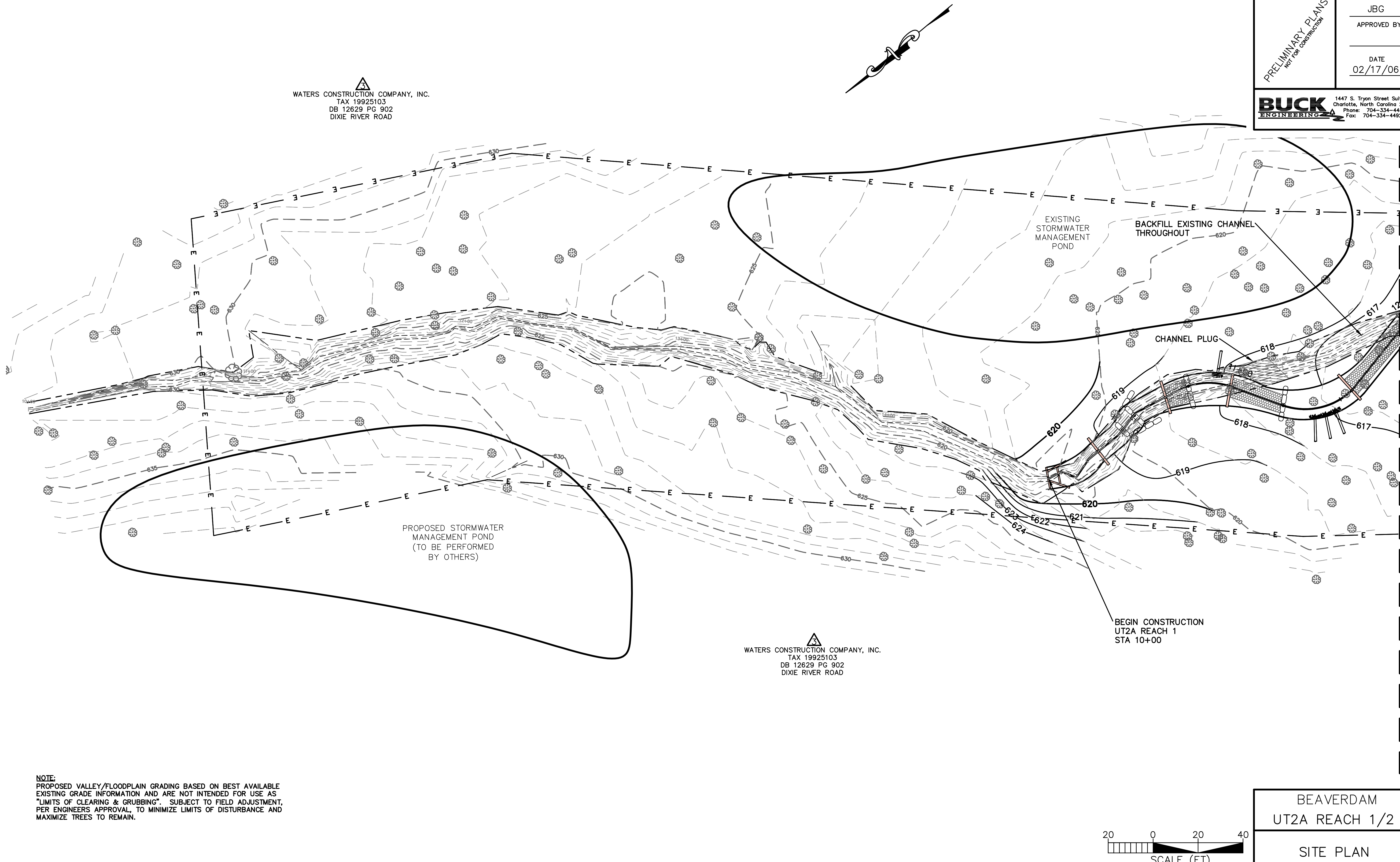


NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

BEAVERDAM
UT2 REACH 4

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P22

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

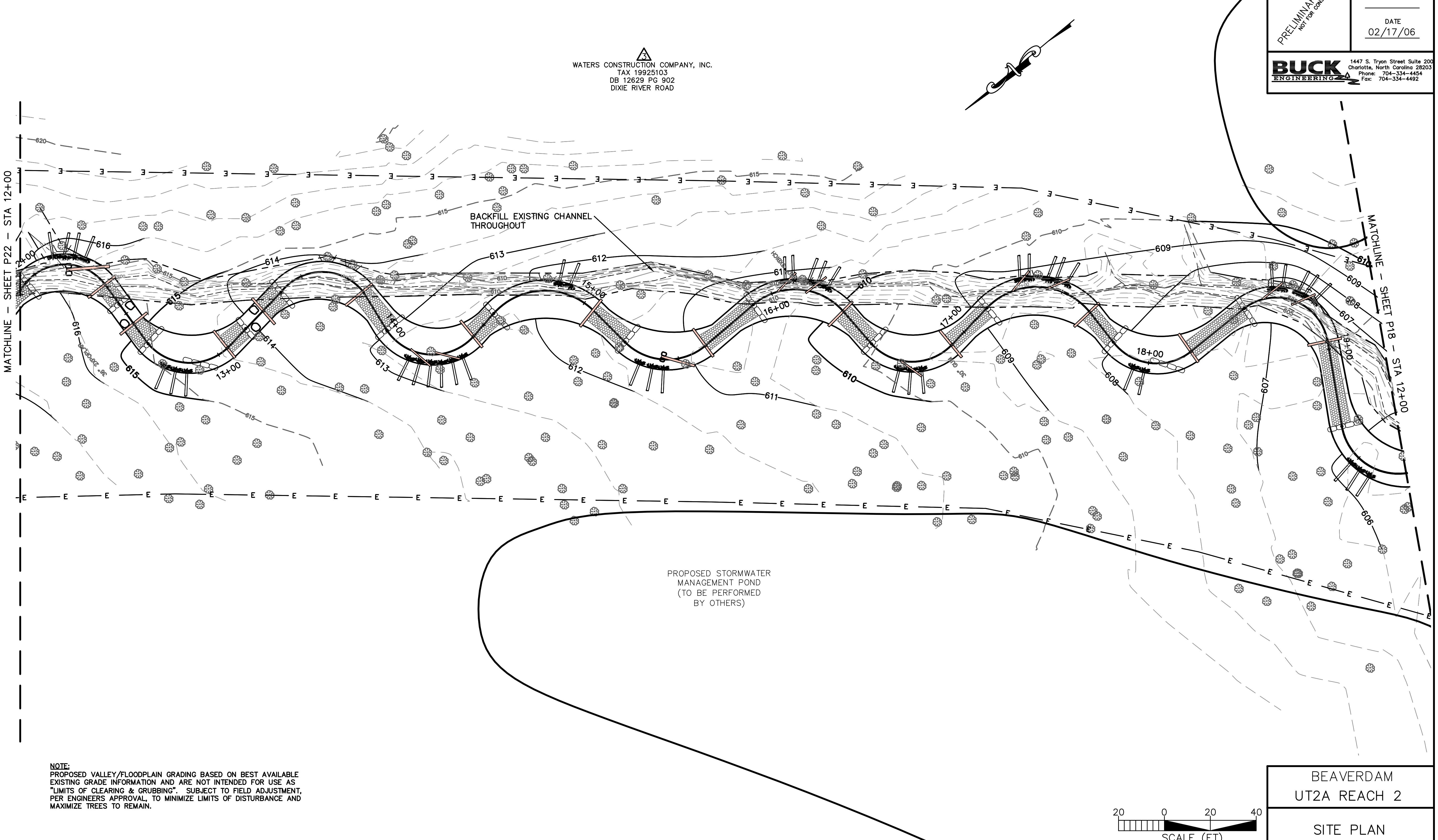
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2A REACH 1/2

SITE PLAN

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006



NOTE:
PROPOSED VALLEY/FLOODPLAIN GRADING BASED ON BEST AVAILABLE EXISTING GRADE INFORMATION AND ARE NOT INTENDED FOR USE AS "LIMITS OF CLEARING & GRUBBING". SUBJECT TO FIELD ADJUSTMENT, PER ENGINEERS APPROVAL, TO MINIMIZE LIMITS OF DISTURBANCE AND MAXIMIZE TREES TO REMAIN.

PROJECT REFERENCE NO.	SHEET NO.
0269C	P23

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2A REACH 2
SITE PLAN

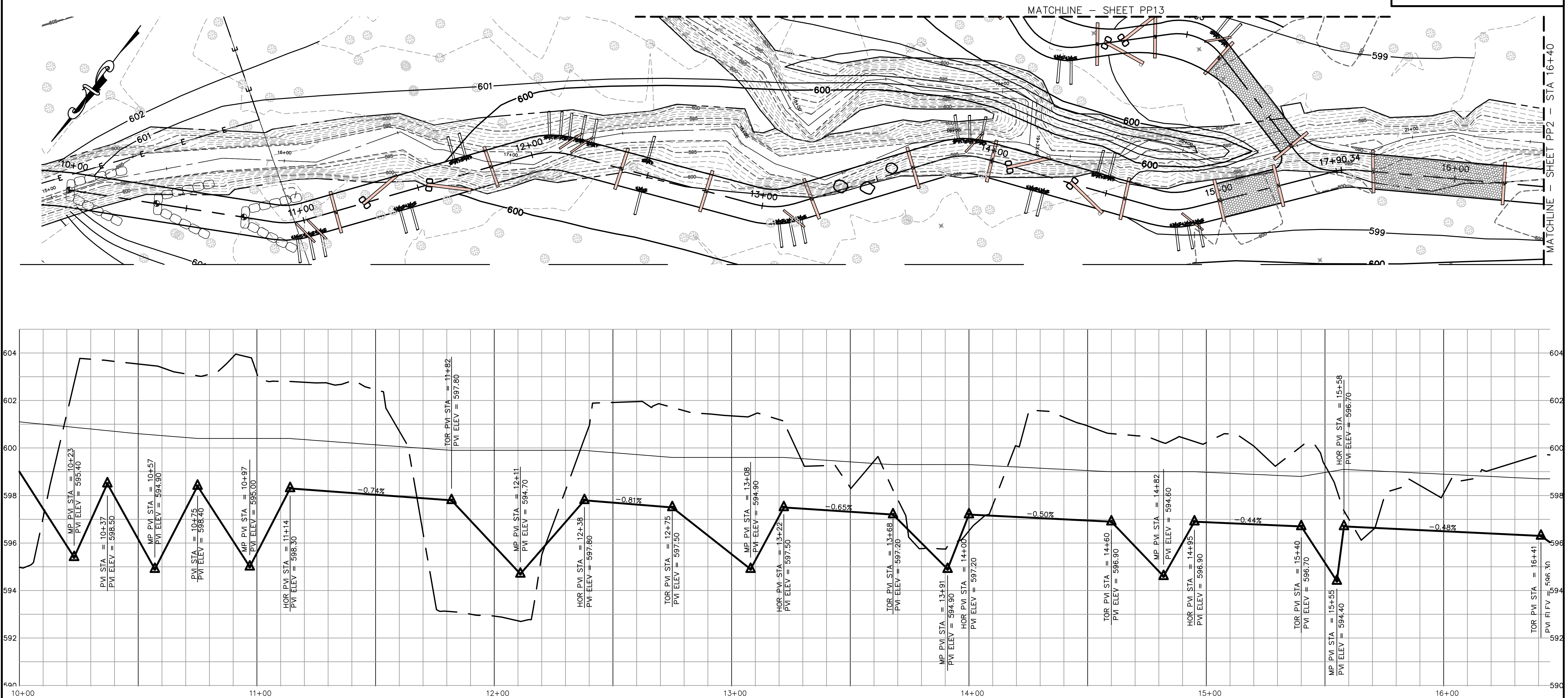
L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



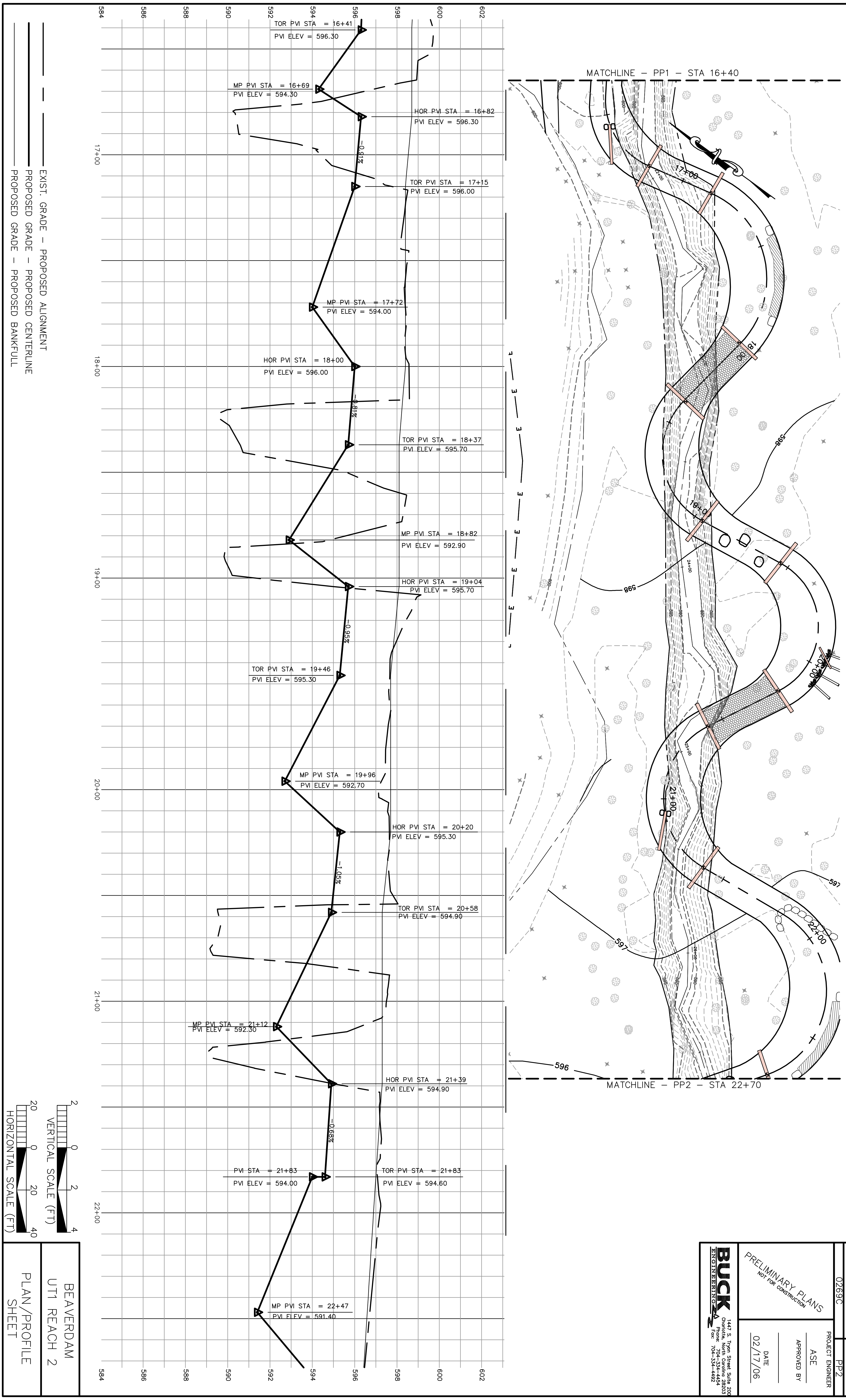
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

VERTICAL SCALE (FT): 2 0 2 4
HORIZONTAL SCALE (FT): 20 0 20 40

BEAVERDAM
UT1 REACH 1/2

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



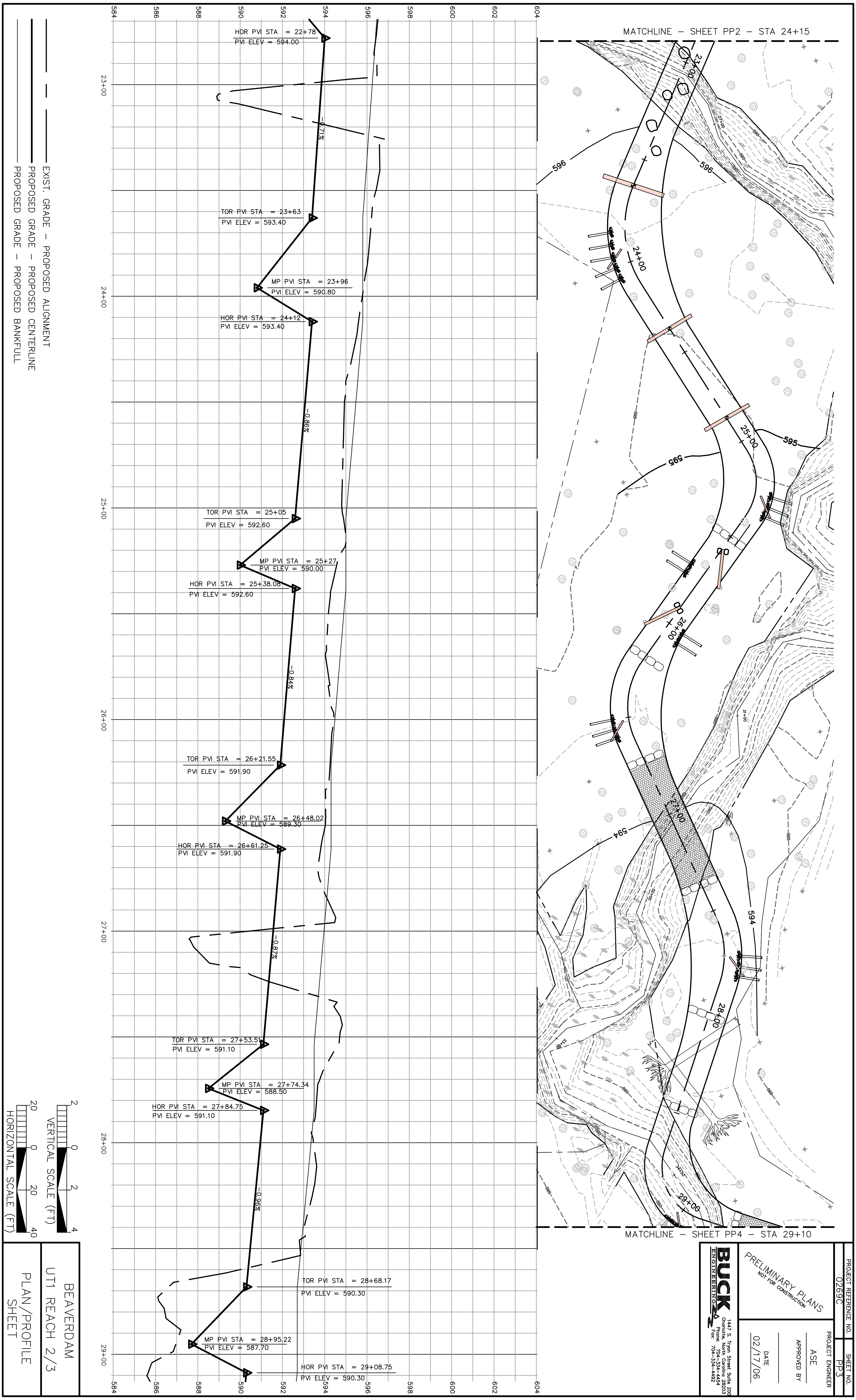
BEAVERDAM
UT1 REACH 2
PLAN/PROFILE
SHEET

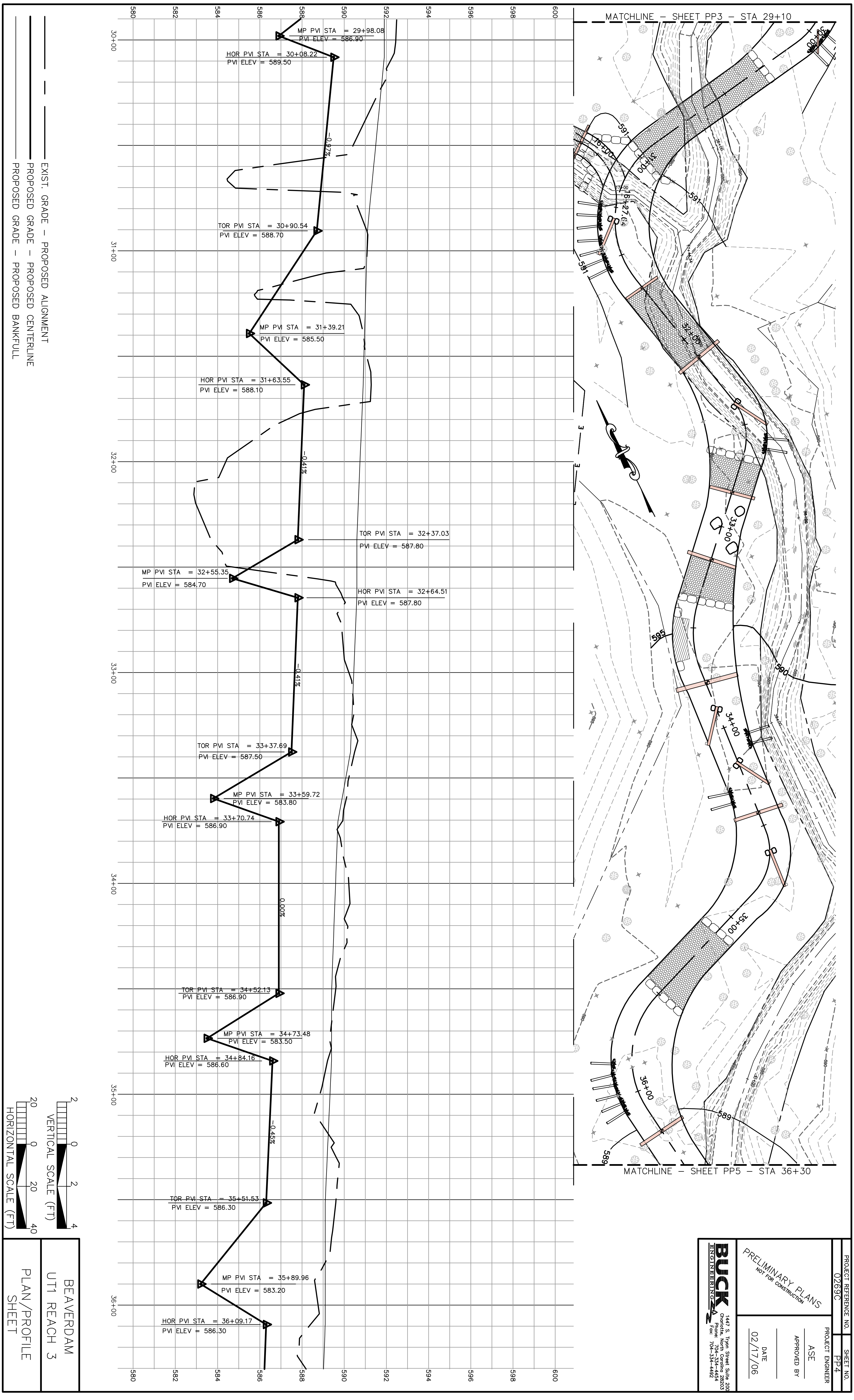
PRELIMINARY PLANS
NOT FOR CONSTRUCTION

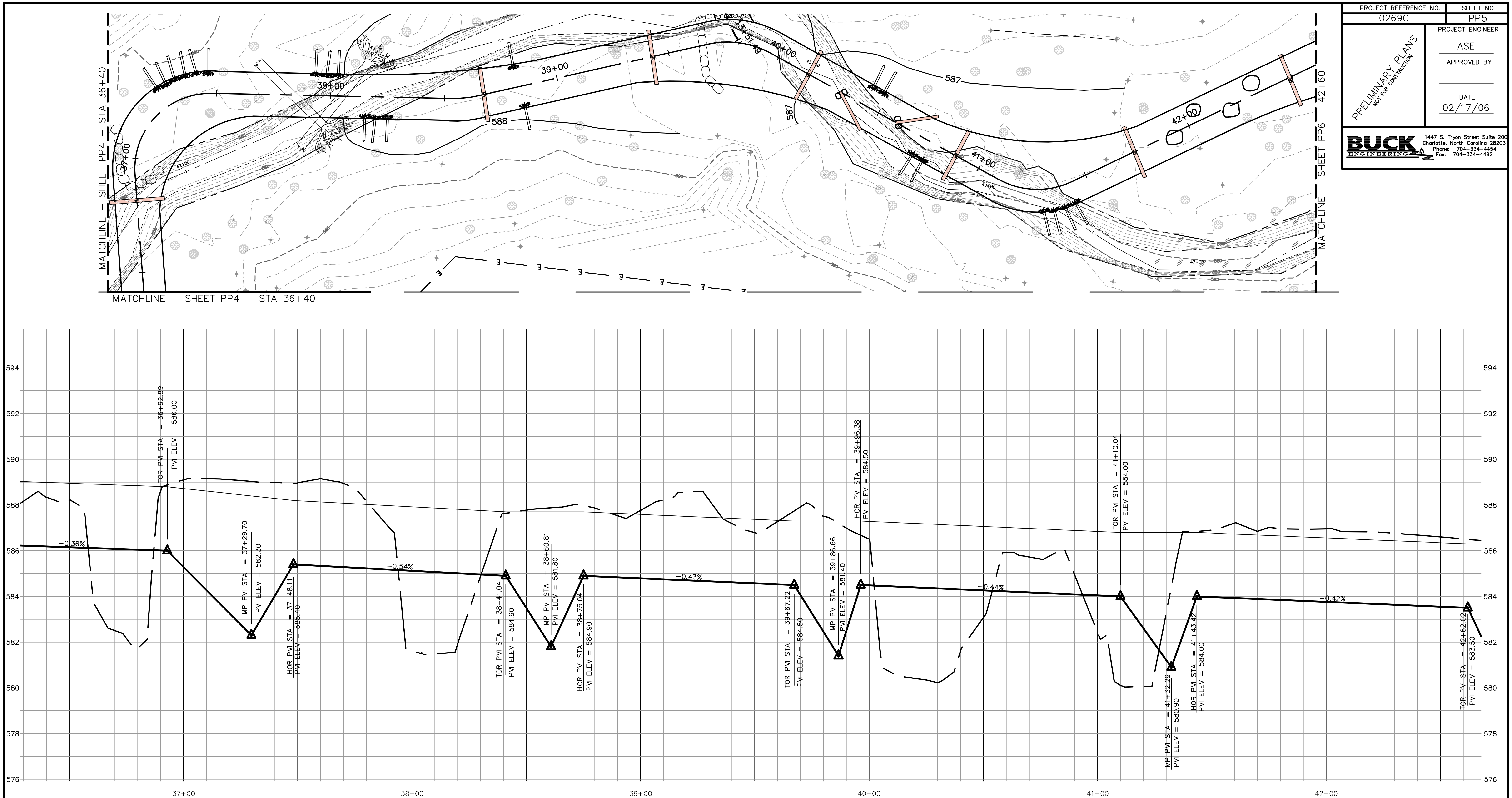
BUCK
ENGINEERING

1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP2
PROJECT ENGINEER	
ASE	
APPROVED BY	
DATE	
02/17/06	


MATCHLINE - SHEET PP2 - STA 24+15
MATCHLINE - SHEET PP4 - STA 29+10
HOR PVI STA = 22+78
PVI ELEV = 594.00
-0.71%
TOR PVI STA = 23+63
PVI ELEV = 593.40
MP PVI STA = 23+96
PVI ELEV = 590.80
HOR PVI STA = 24+12
PVI ELEV = 593.40
-0.86%
TOR PVI STA = 25+05
PVI ELEV = 592.60
MP PVI STA = 25+27
PVI ELEV = 590.00
HOR PVI STA = 25+38.08
PVI ELEV = 592.60
-0.84%
TOR PVI STA = 26+21.55
PVI ELEV = 591.90
MP PVI STA = 26+48.02
PVI ELEV = 589.30
HOR PVI STA = 26+61.25
PVI ELEV = 591.90
-0.87%
TOR PVI STA = 27+53.51
PVI ELEV = 591.10
MP PVI STA = 27+74.34
PVI ELEV = 588.50
HOR PVI STA = 27+84.75
PVI ELEV = 591.10
-0.96%
TOR PVI STA = 28+68.17
PVI ELEV = 590.30
MP PVI STA = 28+95.22
PVI ELEV = 587.70
HOR PVI STA = 29+08.75
PVI ELEV = 590.30
584 586 588 590 592 594 596 598 600 602 604
23+00 24+00 25+00 26+00 27+00 28+00 29+00
596
595
594
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL
VERTICAL SCALE (FT)
2 0 2 4
HORIZONTAL SCALE (FT)
20 0 20 40
BEAVERDAM
UT1 REACH 2/3
PLAN/PROFILE
SHEET
PROJECT REFERENCE NO.
0269C
SHEET NO.
PP3
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
PROJECT ENGINEER
ASE
APPROVED BY
DATE
02/17/06
BUCK
ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492
L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006


MATCHLINE - SHEET PP3 - STA 29+10
MATCHLINE - SHEET PP5 - STA 36+30
MP PVI STA = 29+98.08
PVI ELEV = 586.90
HOR PVI STA = 30+08.22
PVI ELEV = 589.50
-0.97%
TOR PVI STA = 30+90.54
PVI ELEV = 588.70
MP PVI STA = 31+39.21
PVI ELEV = 585.50
HOR PVI STA = 31+63.55
PVI ELEV = 588.10
-0.41%
TOR PVI STA = 32+37.03
PVI ELEV = 587.80
MP PVI STA = 32+55.35
PVI ELEV = 584.70
HOR PVI STA = 32+64.51
PVI ELEV = 587.80
-0.41%
TOR PVI STA = 33+37.69
PVI ELEV = 587.50
MP PVI STA = 33+59.72
PVI ELEV = 583.80
HOR PVI STA = 33+70.74
PVI ELEV = 586.90
0.00%
TOR PVI STA = 34+52.13
PVI ELEV = 586.90
MP PVI STA = 34+73.48
PVI ELEV = 583.50
HOR PVI STA = 34+84.16
PVI ELEV = 586.60
-0.45%
TOR PVI STA = 35+51.53
PVI ELEV = 586.30
MP PVI STA = 35+89.96
PVI ELEV = 583.20
HOR PVI STA = 36+09.17
PVI ELEV = 586.30
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL
VERTICAL SCALE (FT)
HORIZONTAL SCALE (FT)
BEAVERDAM
UT1 REACH 3
PLAN/PROFILE
SHEET
PROJECT REFERENCE NO.
0269C
SHEET NO.
PP4
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
PROJECT ENGINEER
ASE
APPROVED BY
DATE
02/17/06
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492
L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP5

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

EXIST. GRADE – PROPOSED ALIGNMENT
PROPOSED GRADE – PROPOSED CENTERLINE
PROPOSED GRADE – PROPOSED BANKFULL

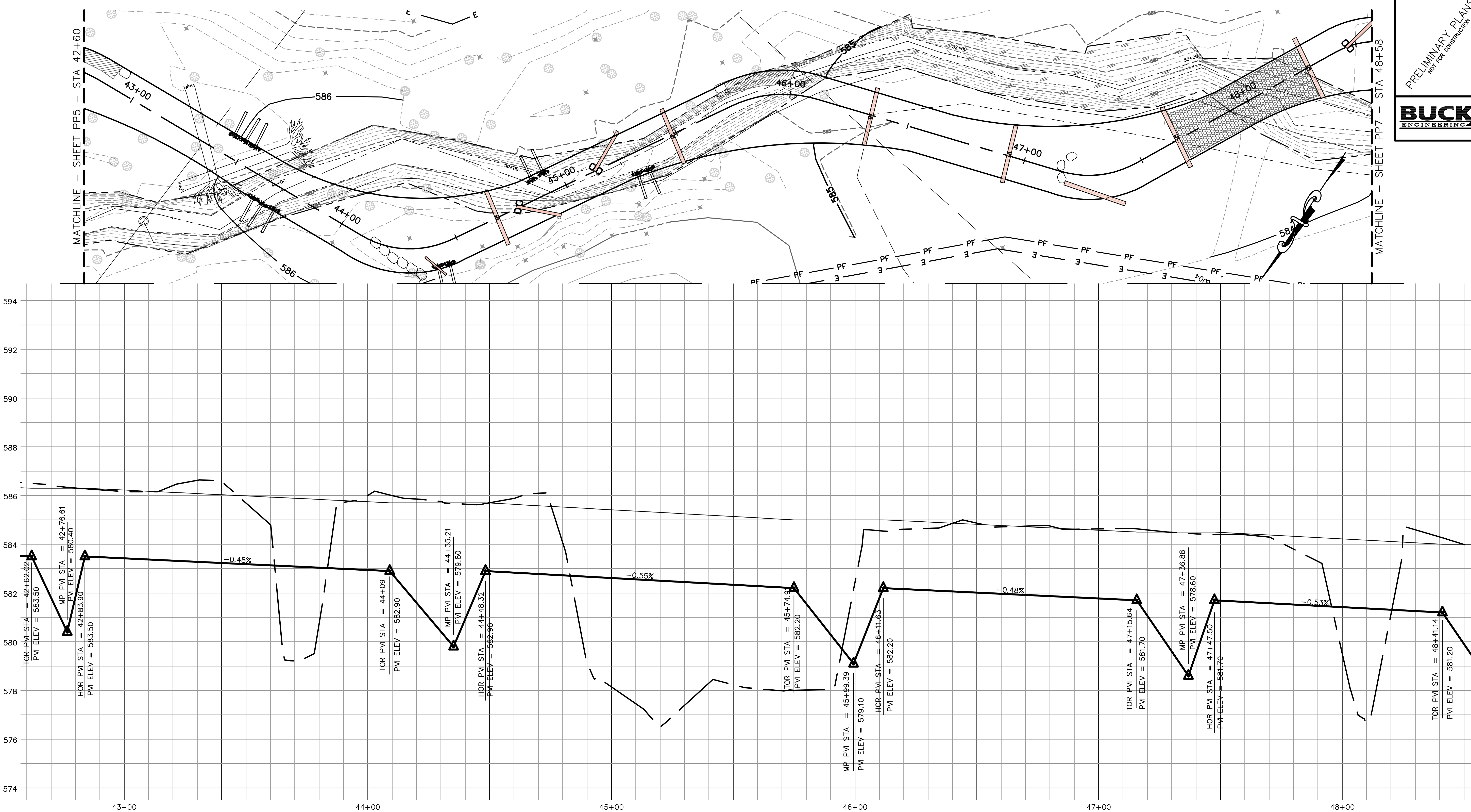
2 0 2 4
VERTICAL SCALE (FT)

20 0 20 40
HORIZONTAL SCALE (FT)

BEAVERDAM
UT1 REACH 3/4

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP6

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

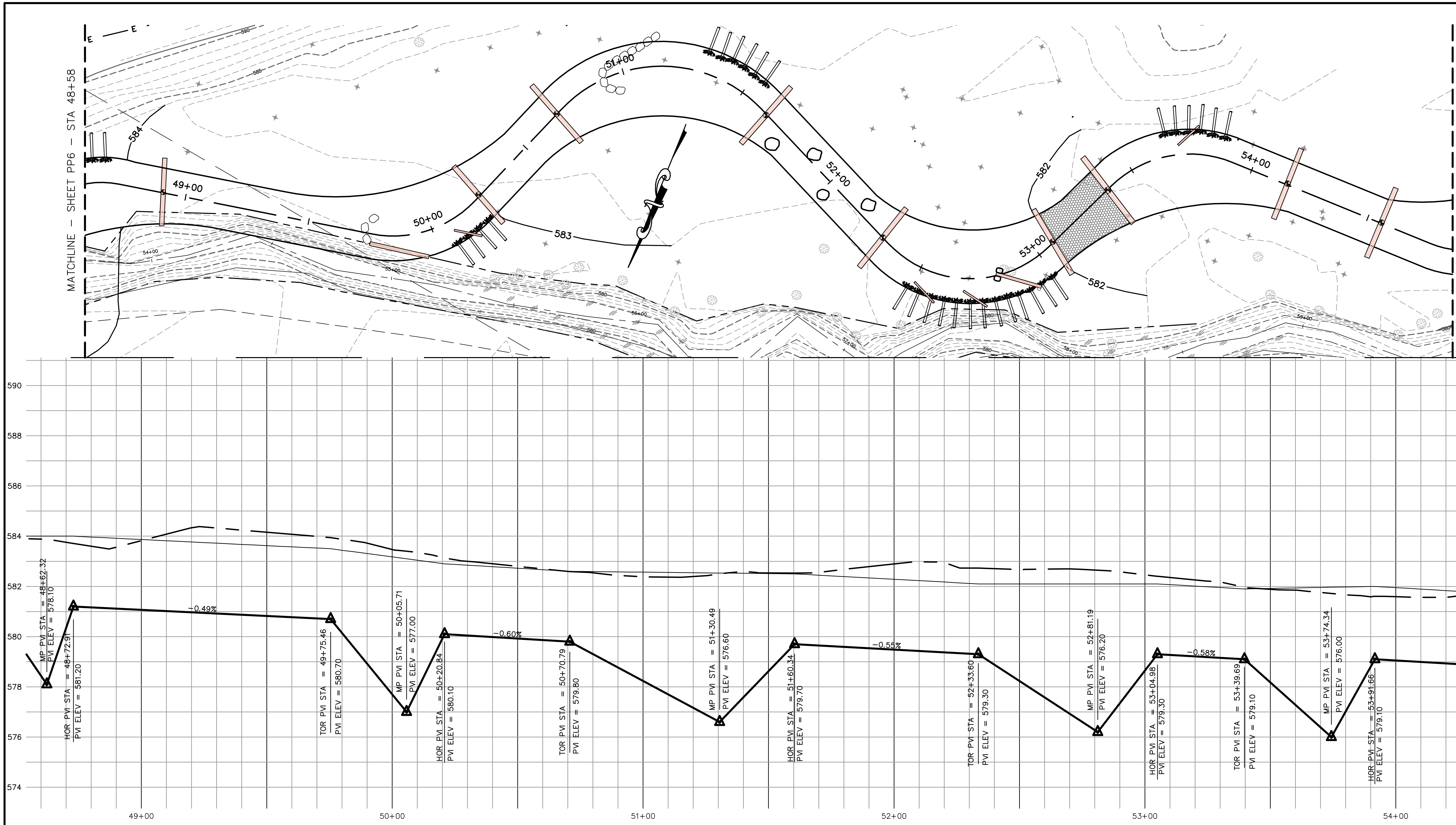
EXIST. GRADE – PROPOSED ALIGNMENT
PROPOSED GRADE – PROPOSED CENTERLINE
PROPOSED GRADE – PROPOSED BANKFULL

VERTICAL SCALE (FT): 2 0 2 4
HORIZONTAL SCALE (FT): 20 0 20 40

BEAVERDAM
UT1 REACH 4

PLAN/PROFILE SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP7

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

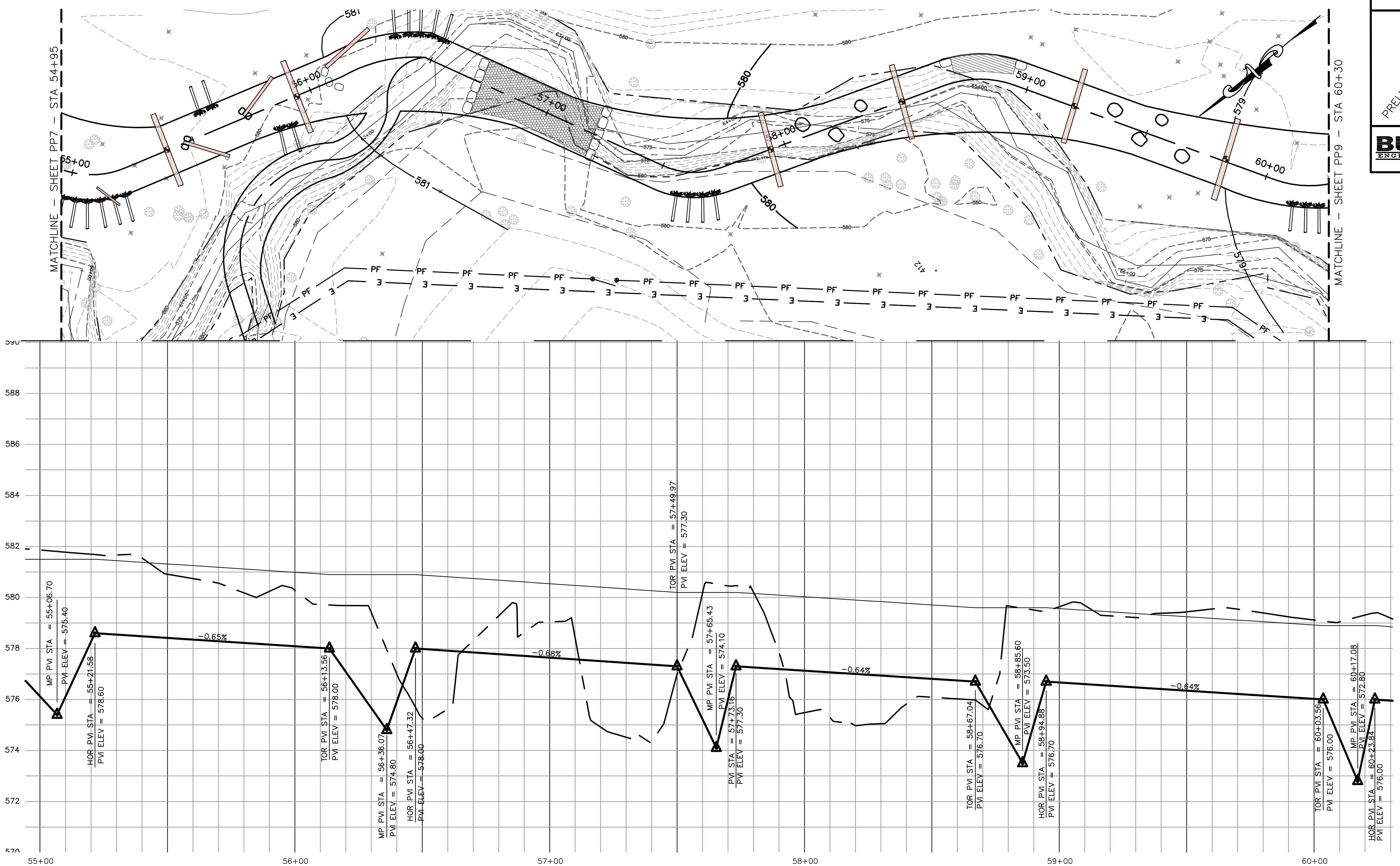
EXIST. GRADE – PROPOSED ALIGNMENT
PROPOSED GRADE – PROPOSED CENTERLINE
PROPOSED GRADE – PROPOSED BANKFULL

2 0 2 4
VERTICAL SCALE (FT)
20 0 20 40
HORIZONTAL SCALE (FT)

BEAVERDAM
UT1 REACH 4/5

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



EXIST. GRADE – PROPOSED ALIGNMENT
PROPOSED GRADE – PROPOSED CENTERLINE
PROPOSED GRADE – PROPOSED BANKFULL

VERTICAL SCALE (FT) 2 0 2 4

HORIZONTAL SCALE (FT) 20 0 20 40

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP8

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 5

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006

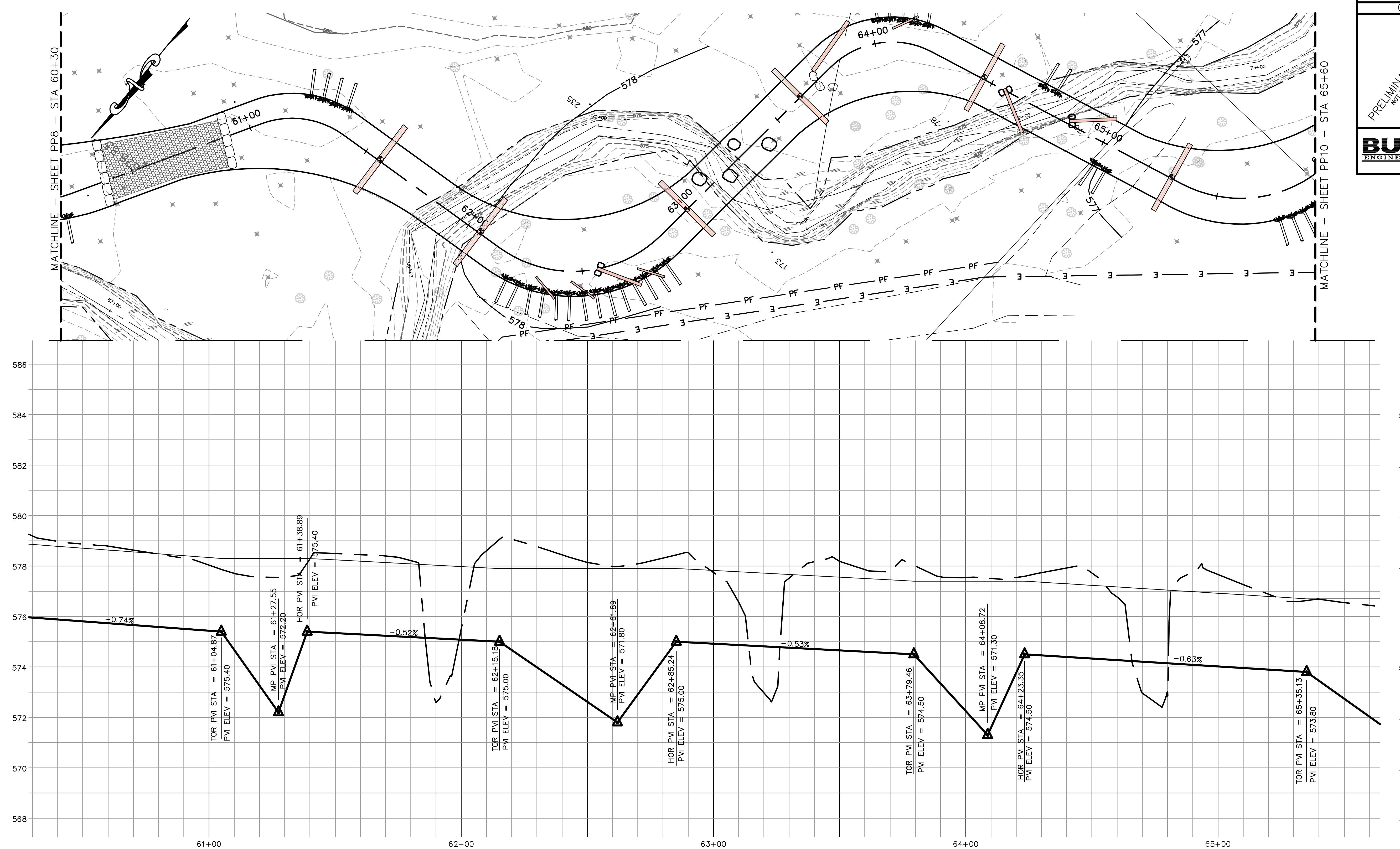
PROJECT REFERENCE NO.	SHEET NO.
0269C	PP9

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

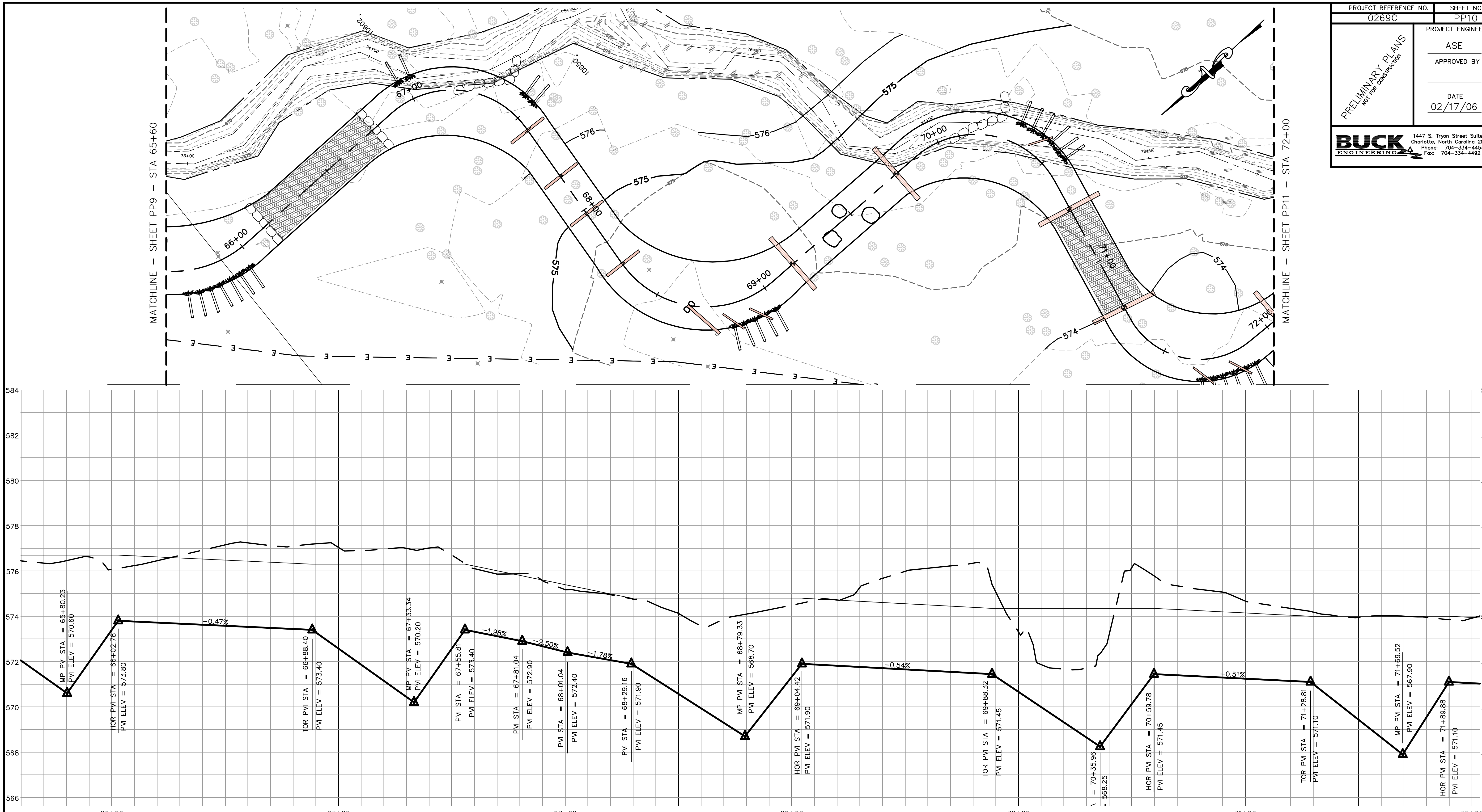
2 0 2 4
VERTICAL SCALE (FT)

20 0 20 40
HORIZONTAL SCALE (FT)

BEAVERDAM
UT1 REACH 5

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP10

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

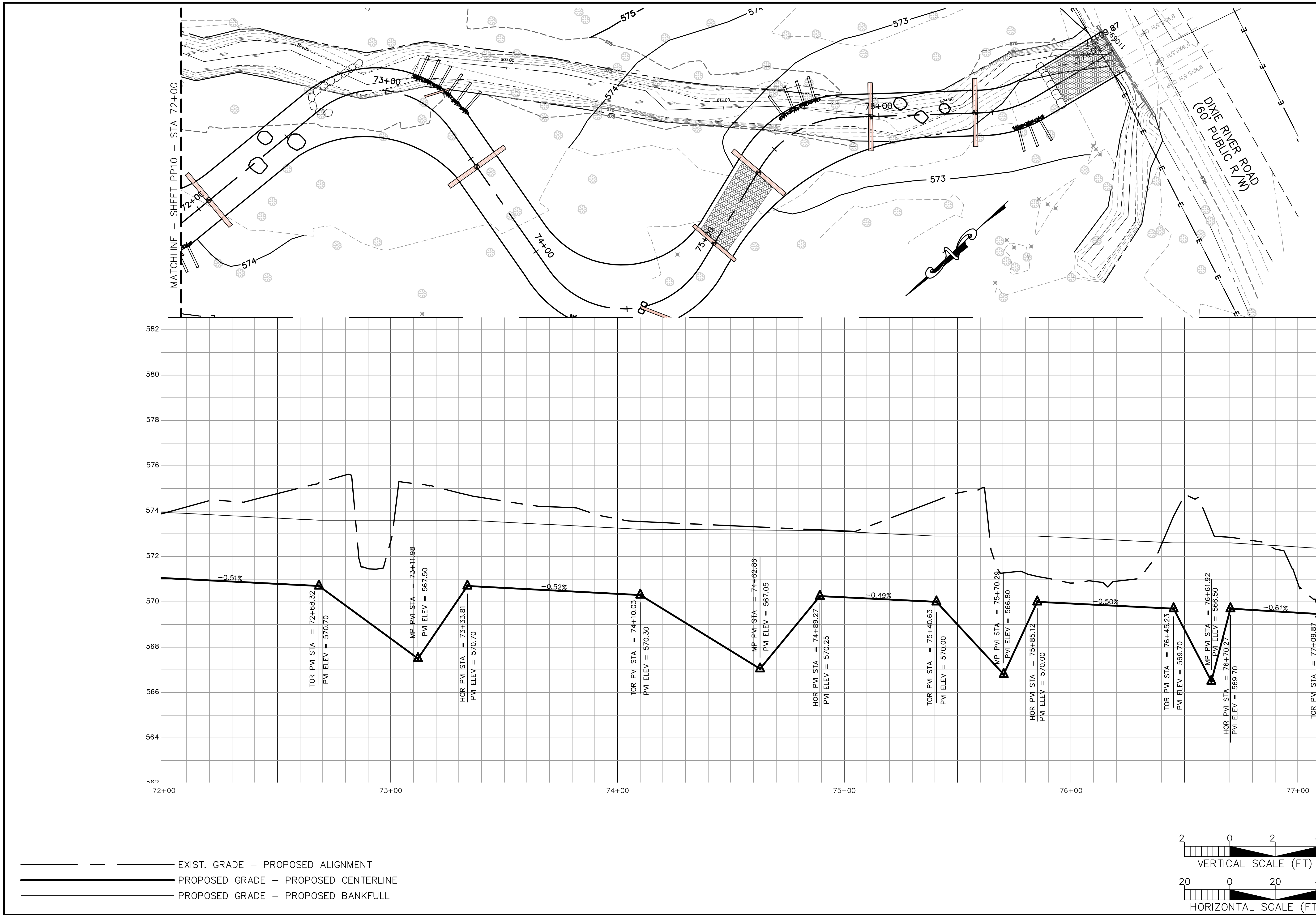
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

VERTICAL SCALE (FT) 2 0 2 4
HORIZONTAL SCALE (FT) 20 0 20 40

BEAVERDAM
UT1 REACH 5

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP11

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

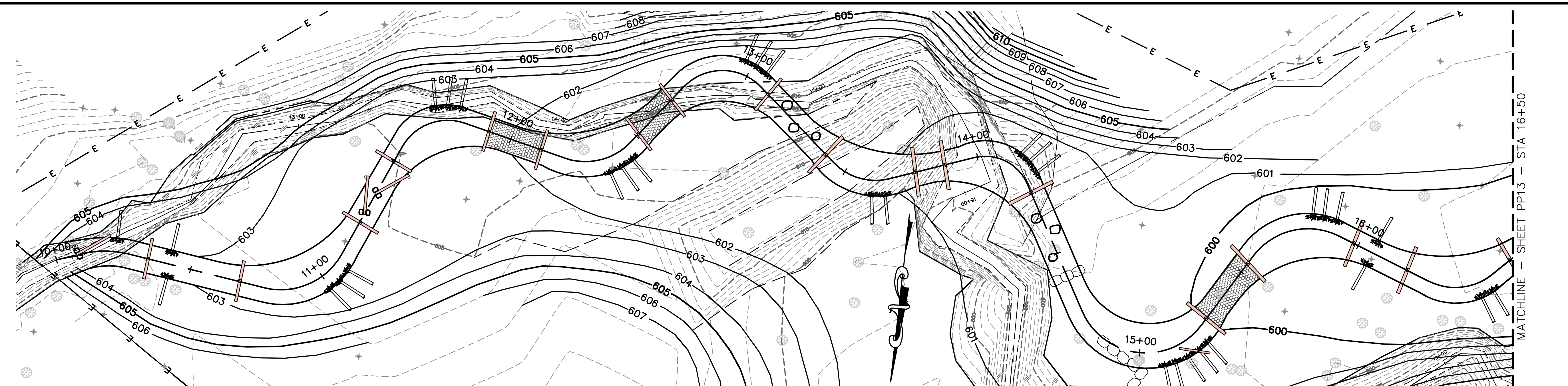
DATE
02/17/06

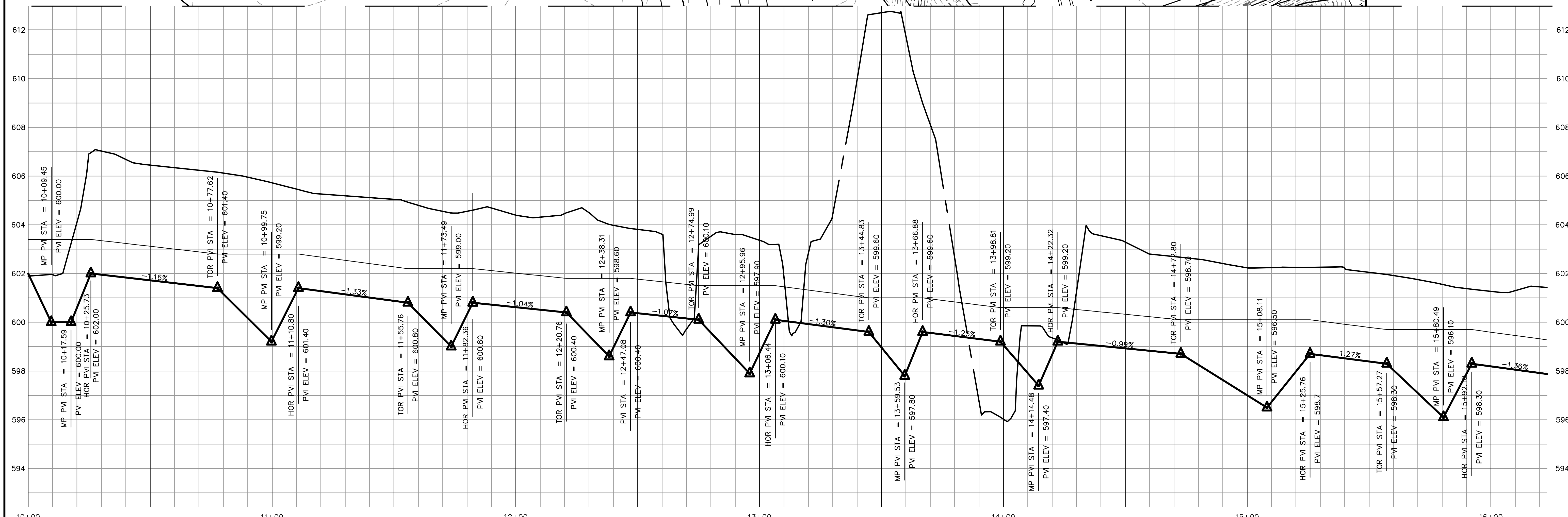
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1 REACH 5

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006





EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

VERTICAL SCALE (FT) 2 0 2 4
HORIZONTAL SCALE (FT) 20 0 20 40

BEAVERDAM
UT1B

PLAN/PROFILE
SHEET

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP12

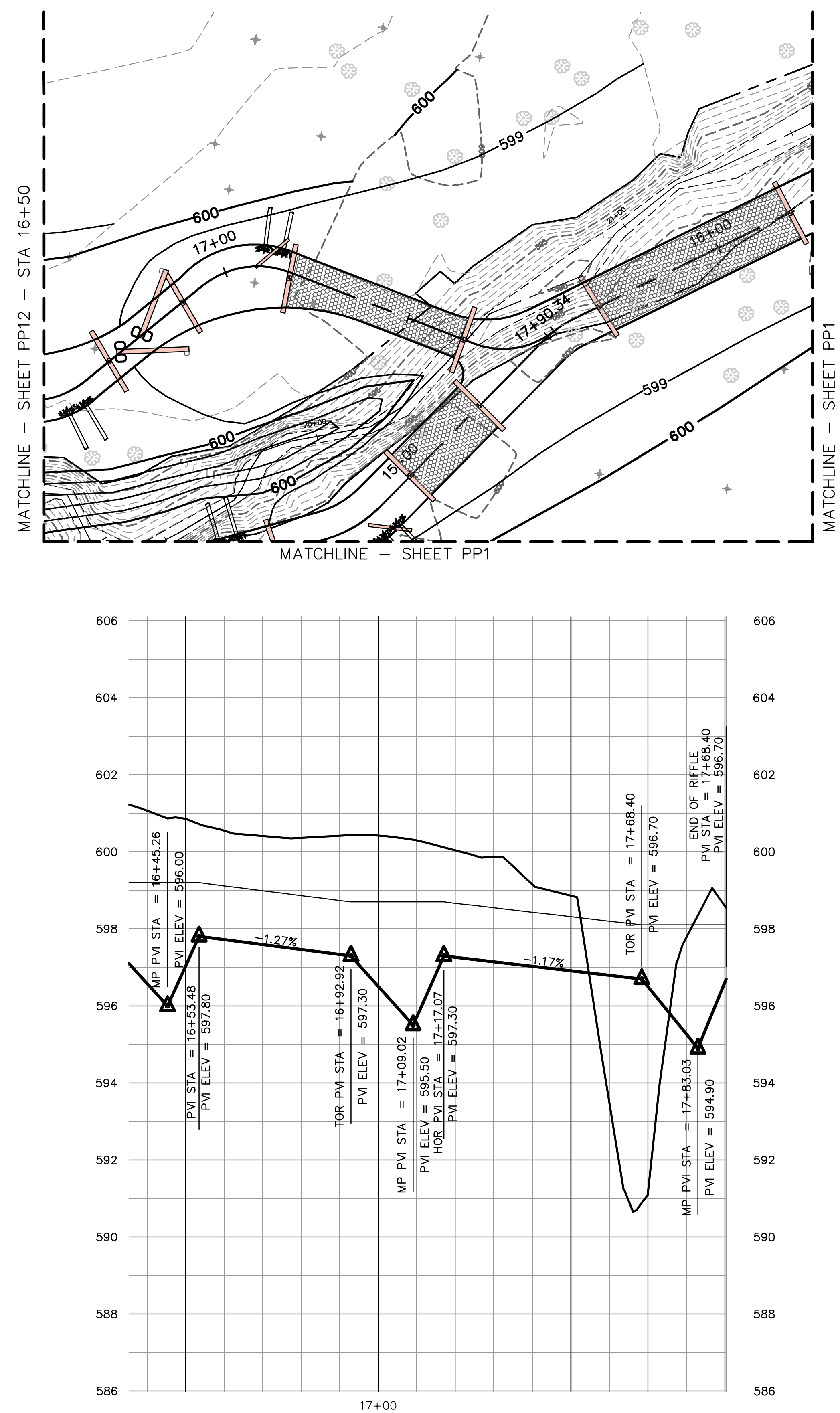
PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP13

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING

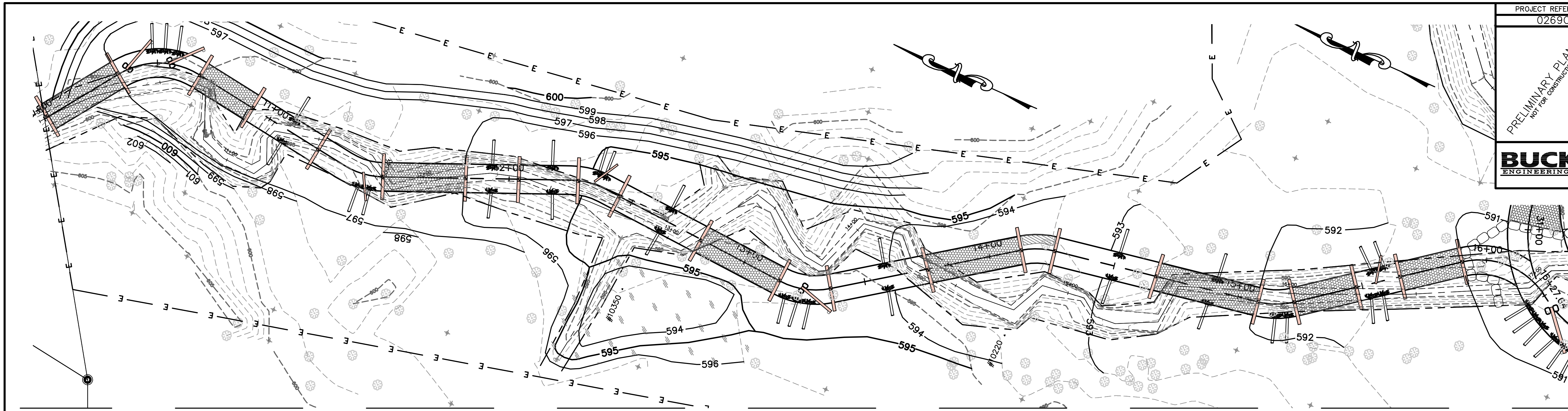
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

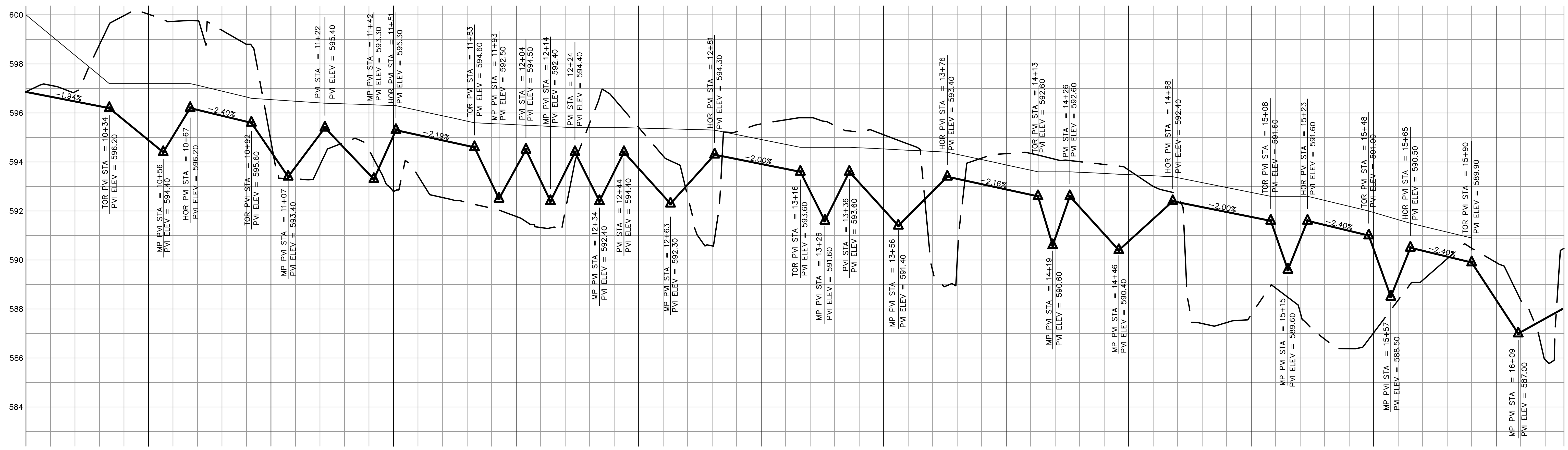
VERTICAL SCALE (FT): 2 0 2 4
HORIZONTAL SCALE (FT): 20 0 20 40

BEAVERDAM
UT1B

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006





EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

VERTICAL SCALE (FT): 2 0 2 4
HORIZONTAL SCALE (FT): 20 0 20 40

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP14

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

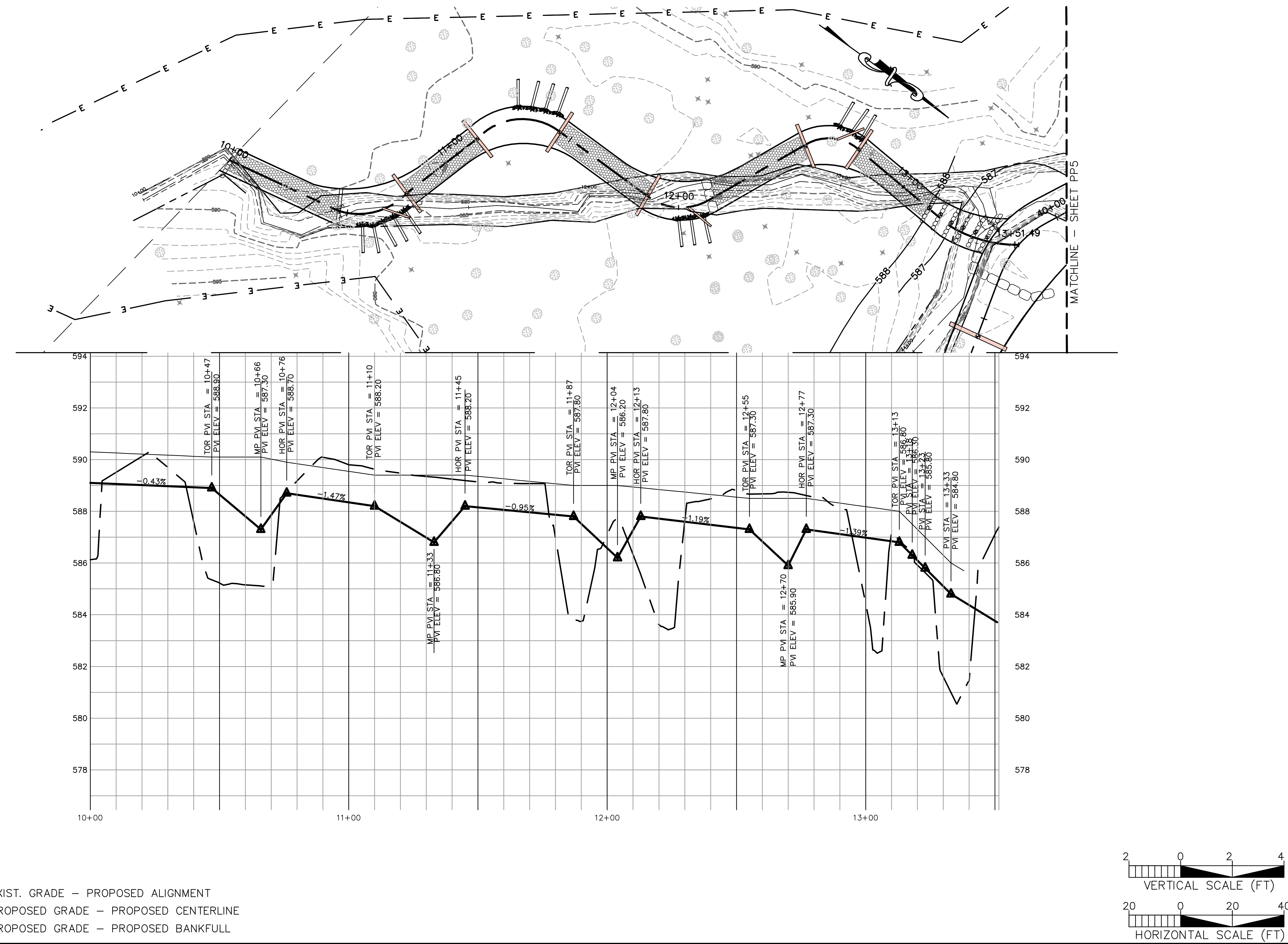
PROJECT ENGINEER: ASE
APPROVED BY
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1C

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP15

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT1D

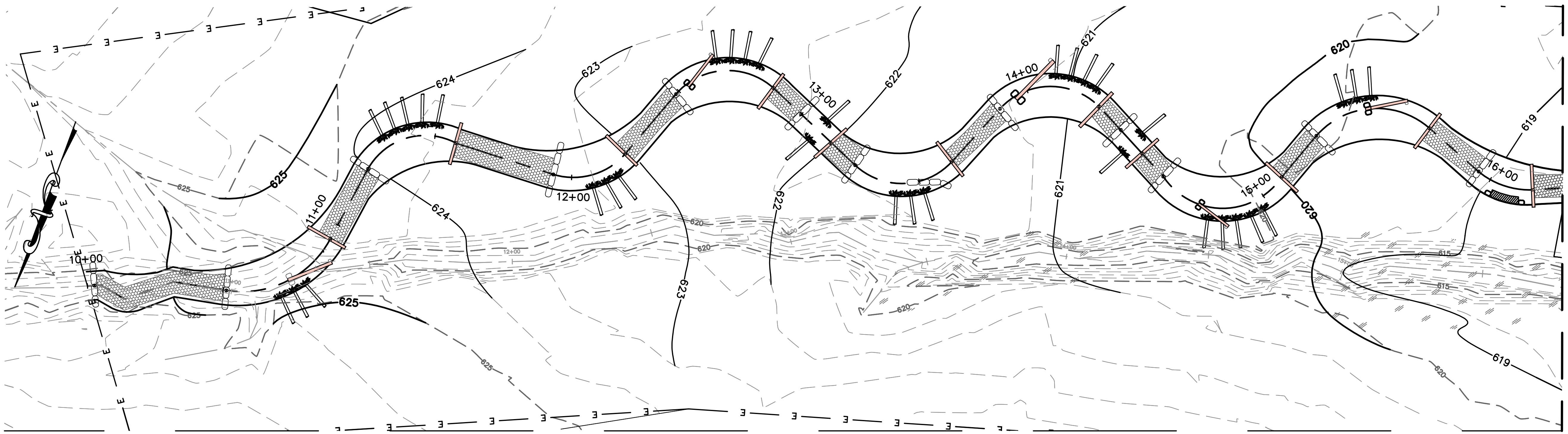
PLAN/PROFILE
SHEET

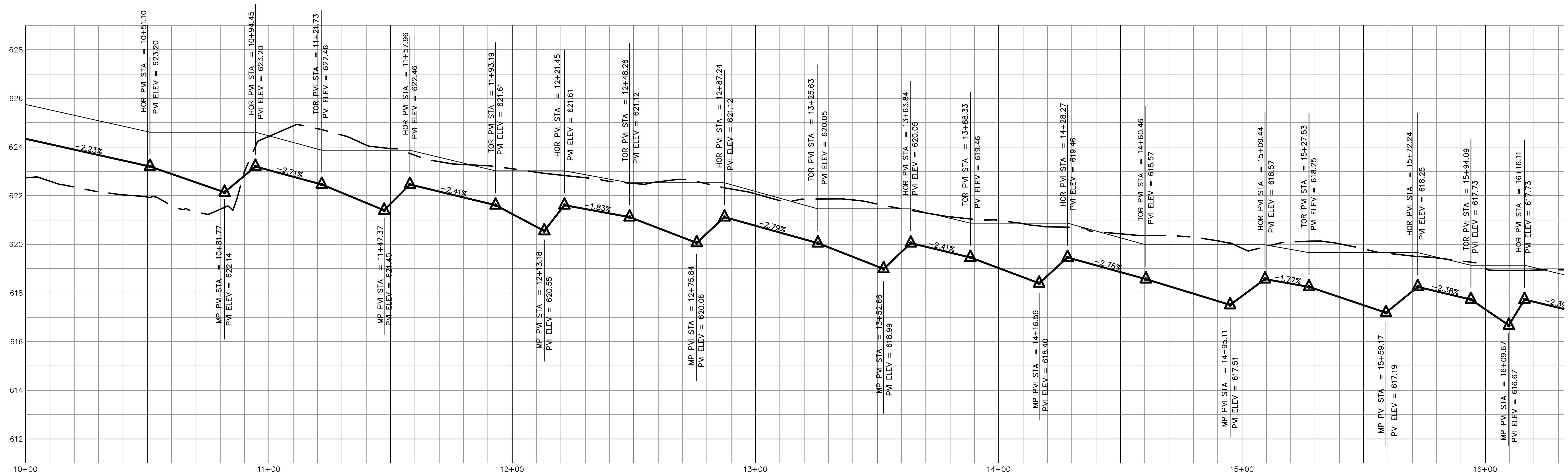
L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT1.dwg Feb 21, 2006

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492





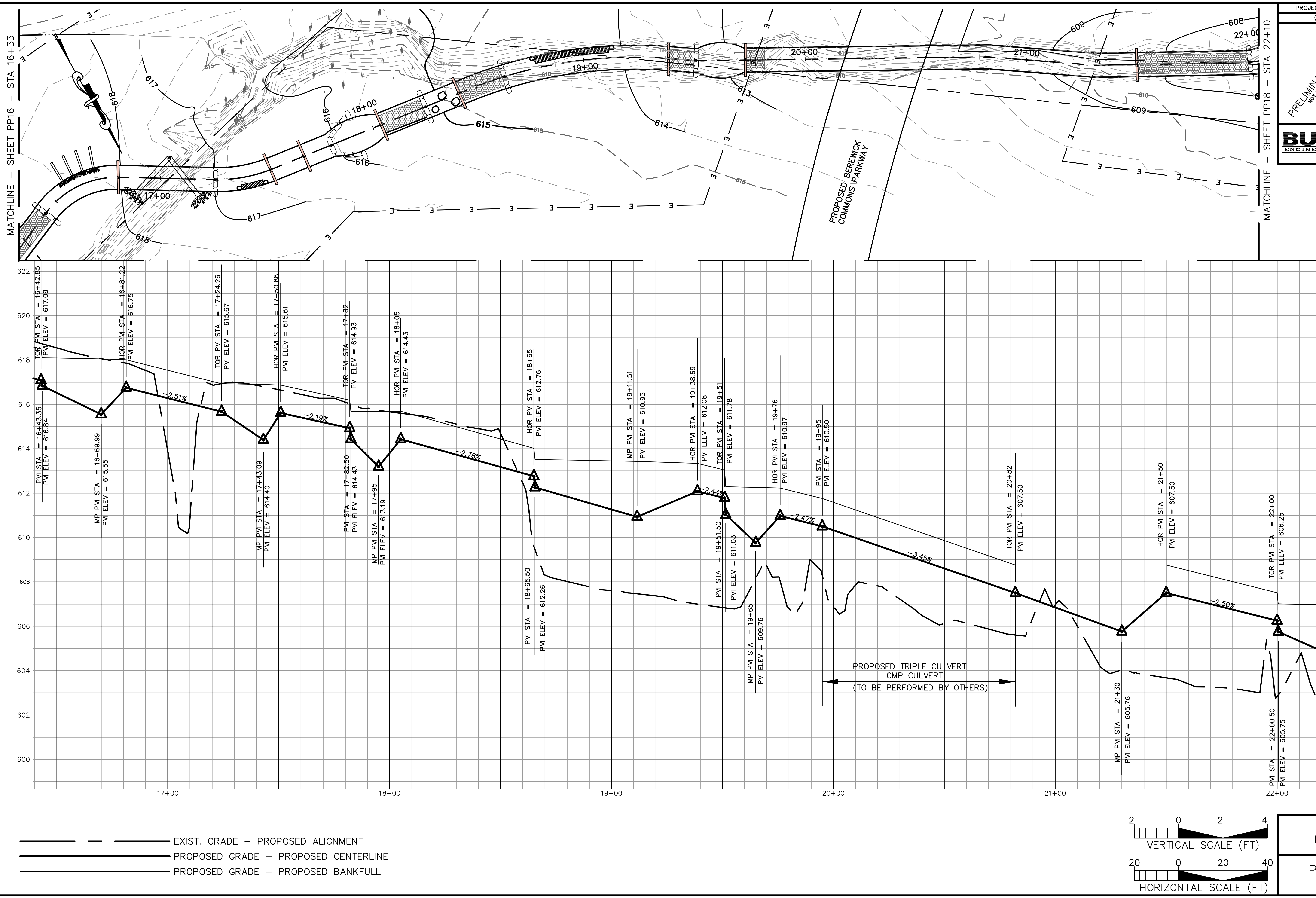
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

VERTICAL SCALE (FT): 2 0 2 4
HORIZONTAL SCALE (FT): 20 0 20 40

BEAVERDAM
UT2 REACH 1

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP17

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

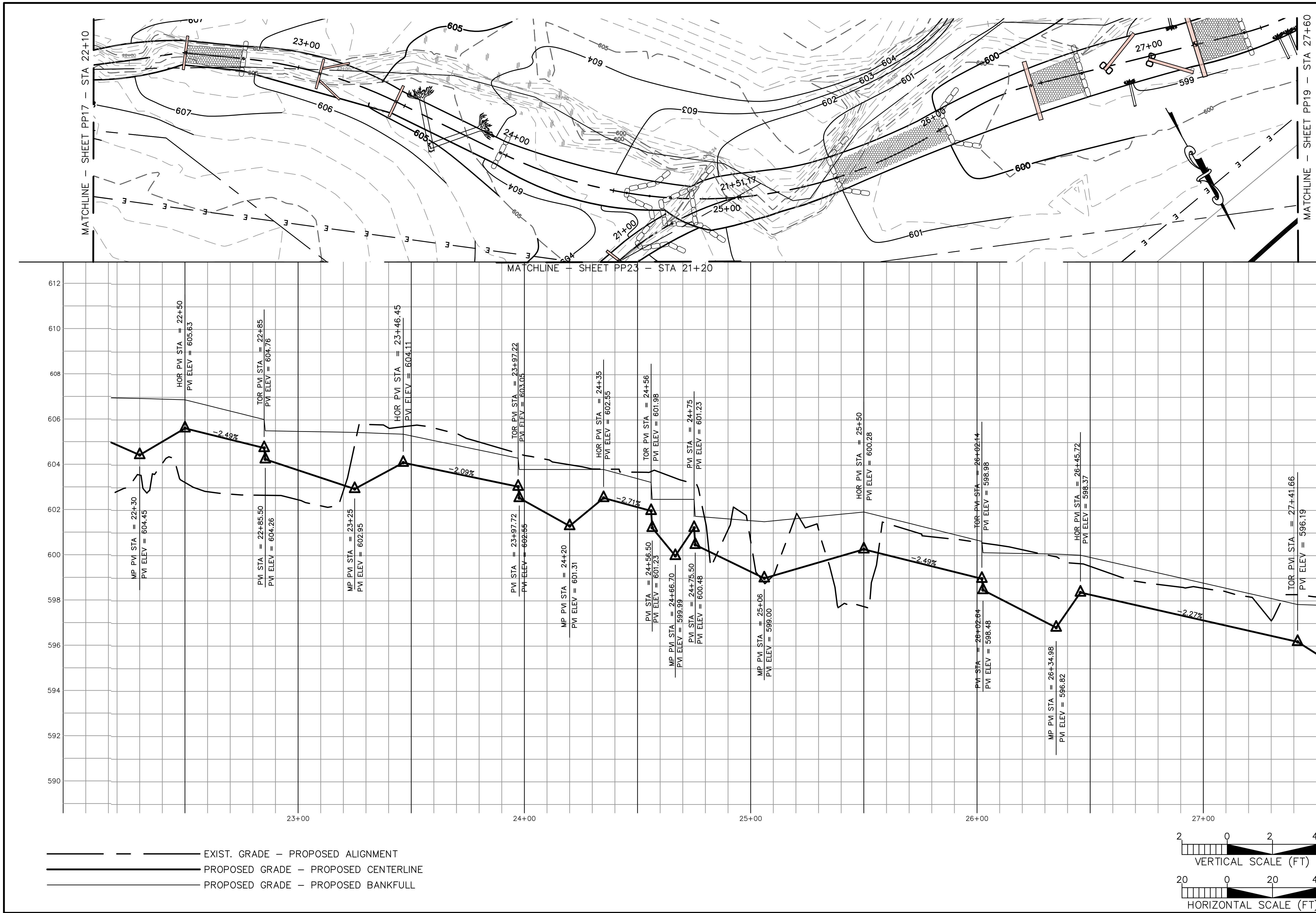
PROJECT ENGINEER
JBG
APPROVED BY
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 2

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006



PROJECT REFERENCE NO.	SHEET NO.
0269C	PP18

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

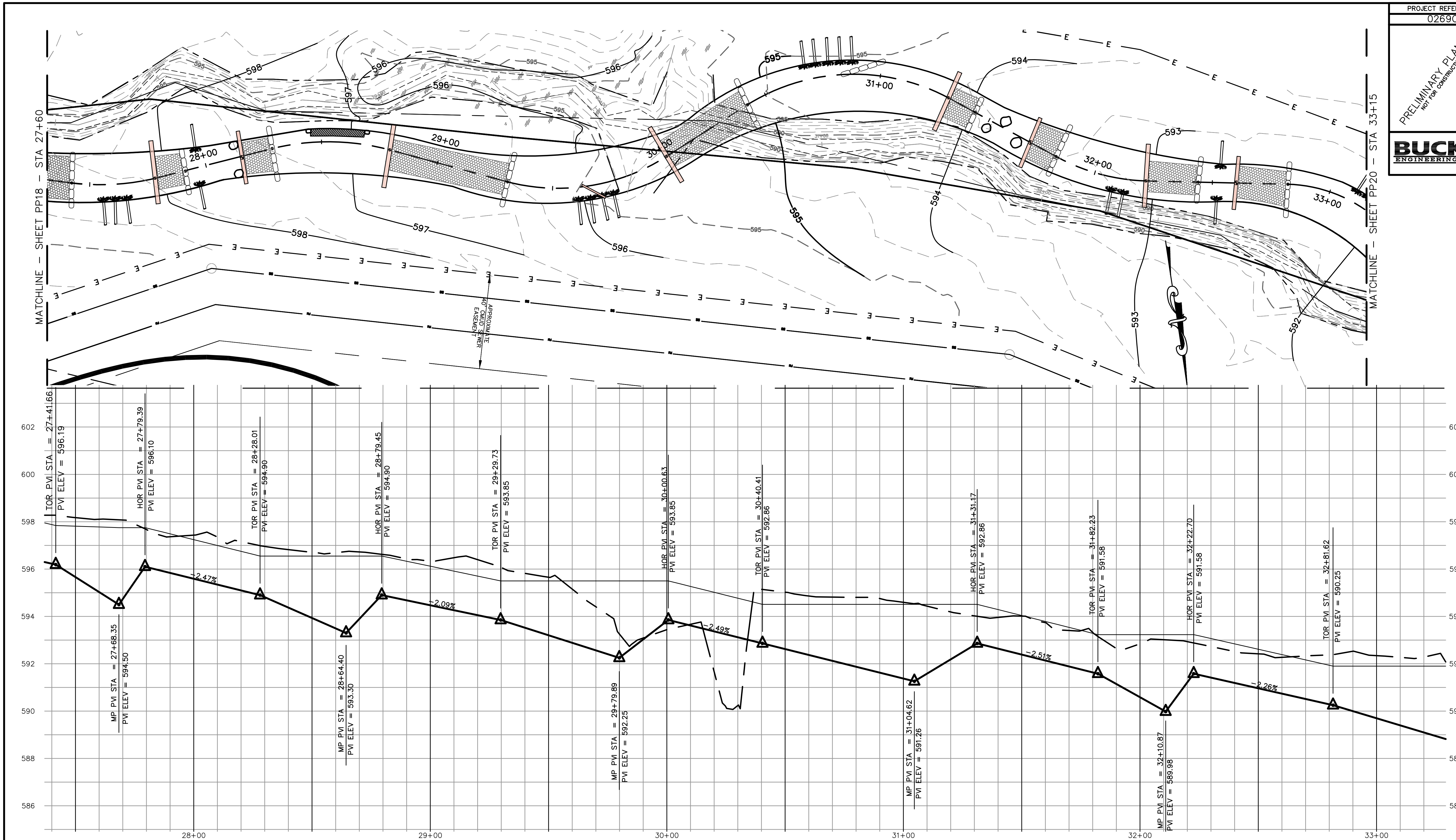
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 2/3

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006



EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL

VERTICAL SCALE (FT) 2 0 2 4

HORIZONTAL SCALE (FT) 20 0 20 40

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP19

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

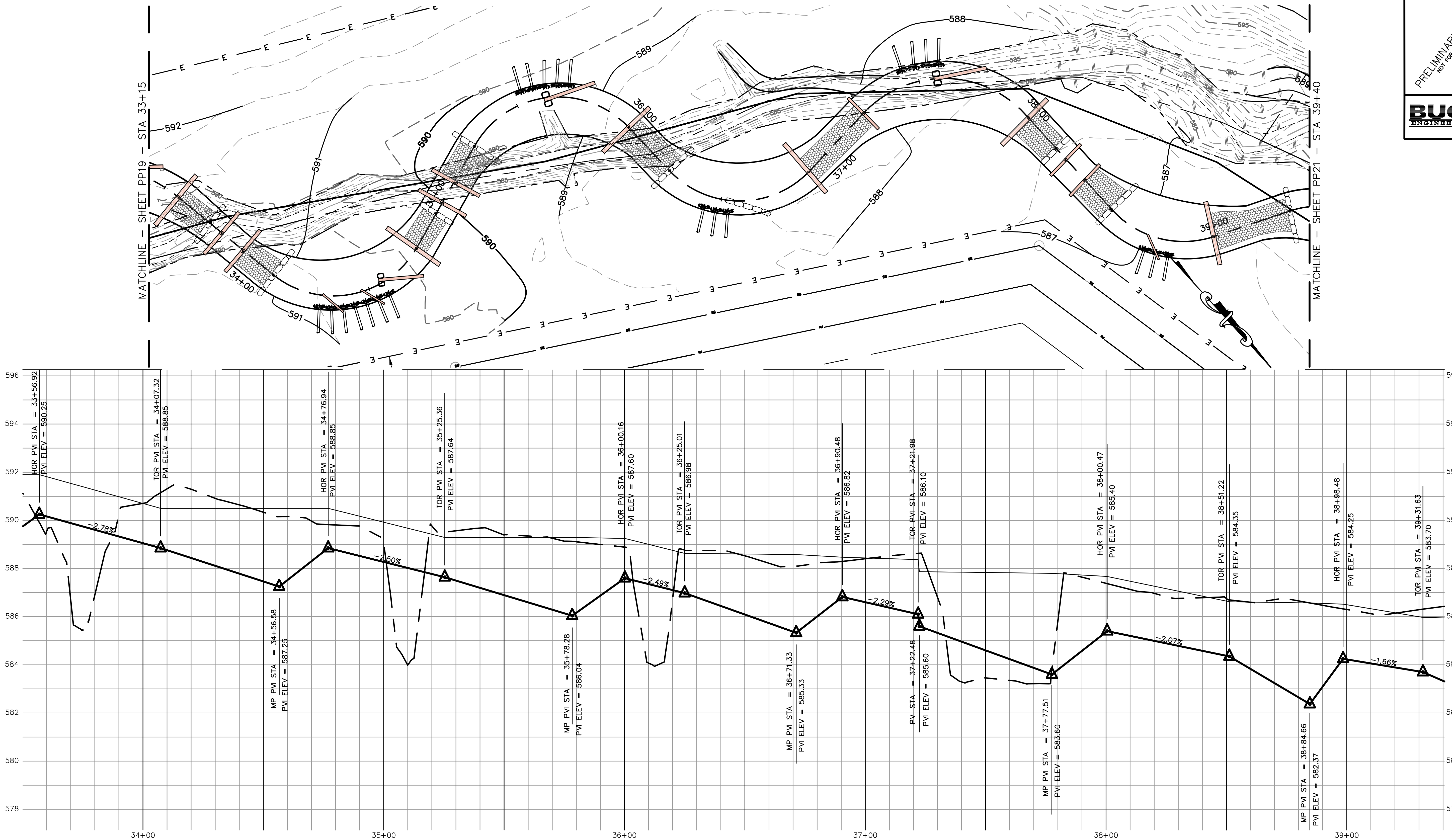
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 3

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006



EXIST. GRADE – PROPOSED ALIGNMENT
PROPOSED GRADE – PROPOSED CENTERLINE
PROPOSED GRADE – PROPOSED BANKFULL

2 0 2 4
VERTICAL SCALE (FT)

20 0 20 40
HORIZONTAL SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP20

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

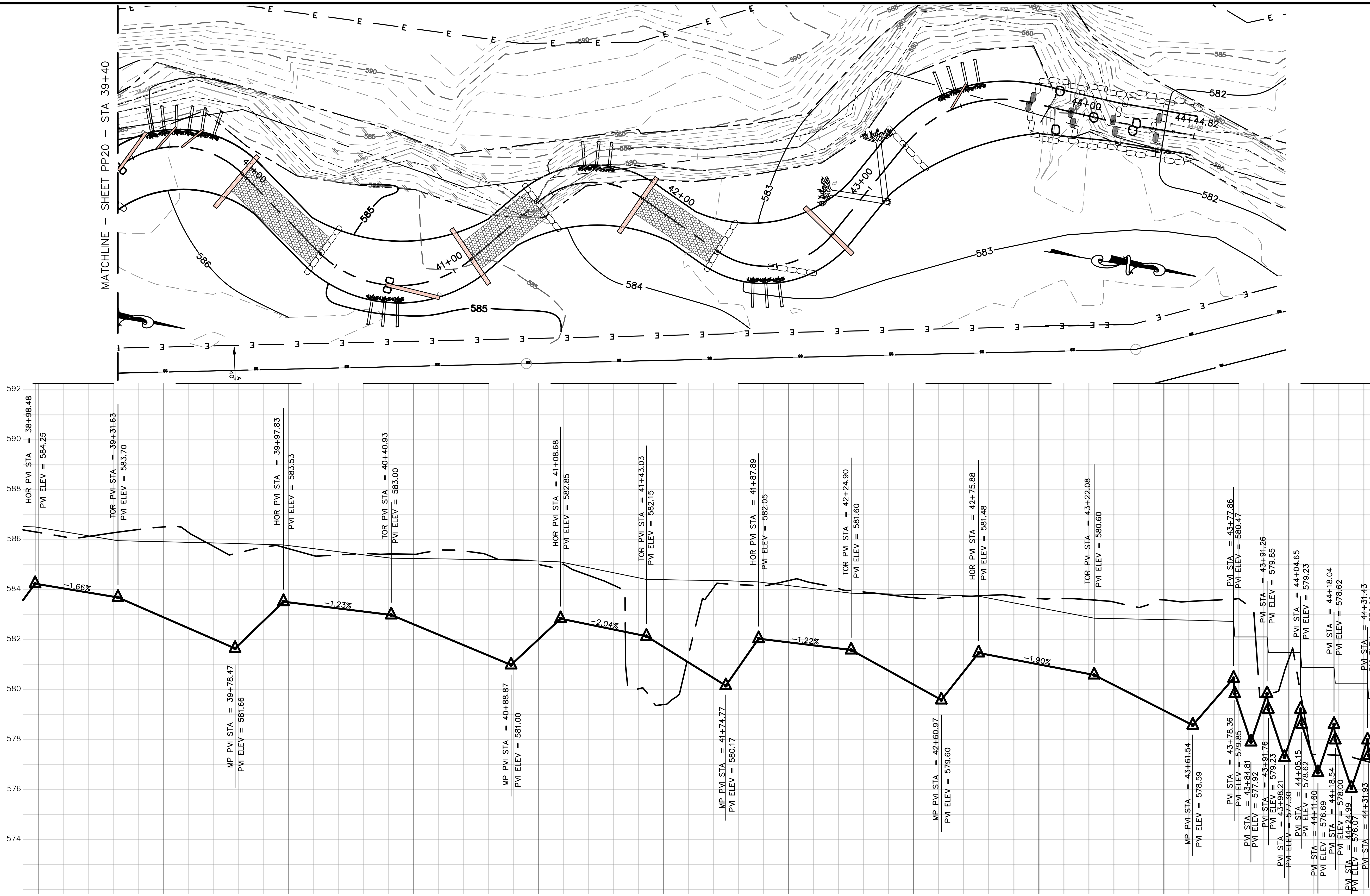
DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 3/4

PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006



EXIST. GRADE – PROPOSED ALIGNMENT

PROPOSED GRADE – PROPOSED CENTERLINE

PROPOSED GRADE – PROPOSED BANKFULL

2 0 2 4
VERTICAL SCALE (FT)

20 0 20 40
HORIZONTAL SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	PP21

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG

APPROVED BY

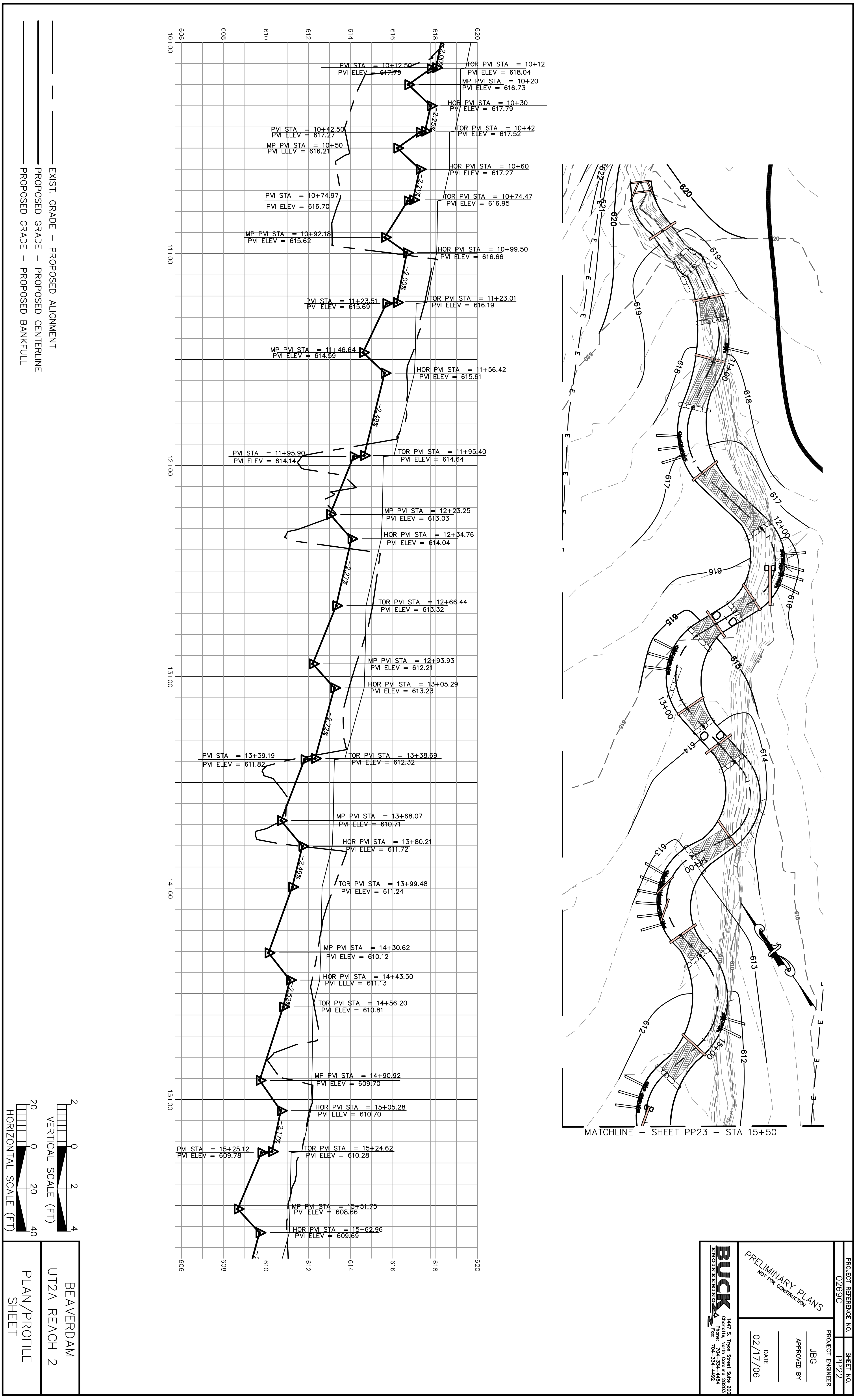
DATE
02/17/06

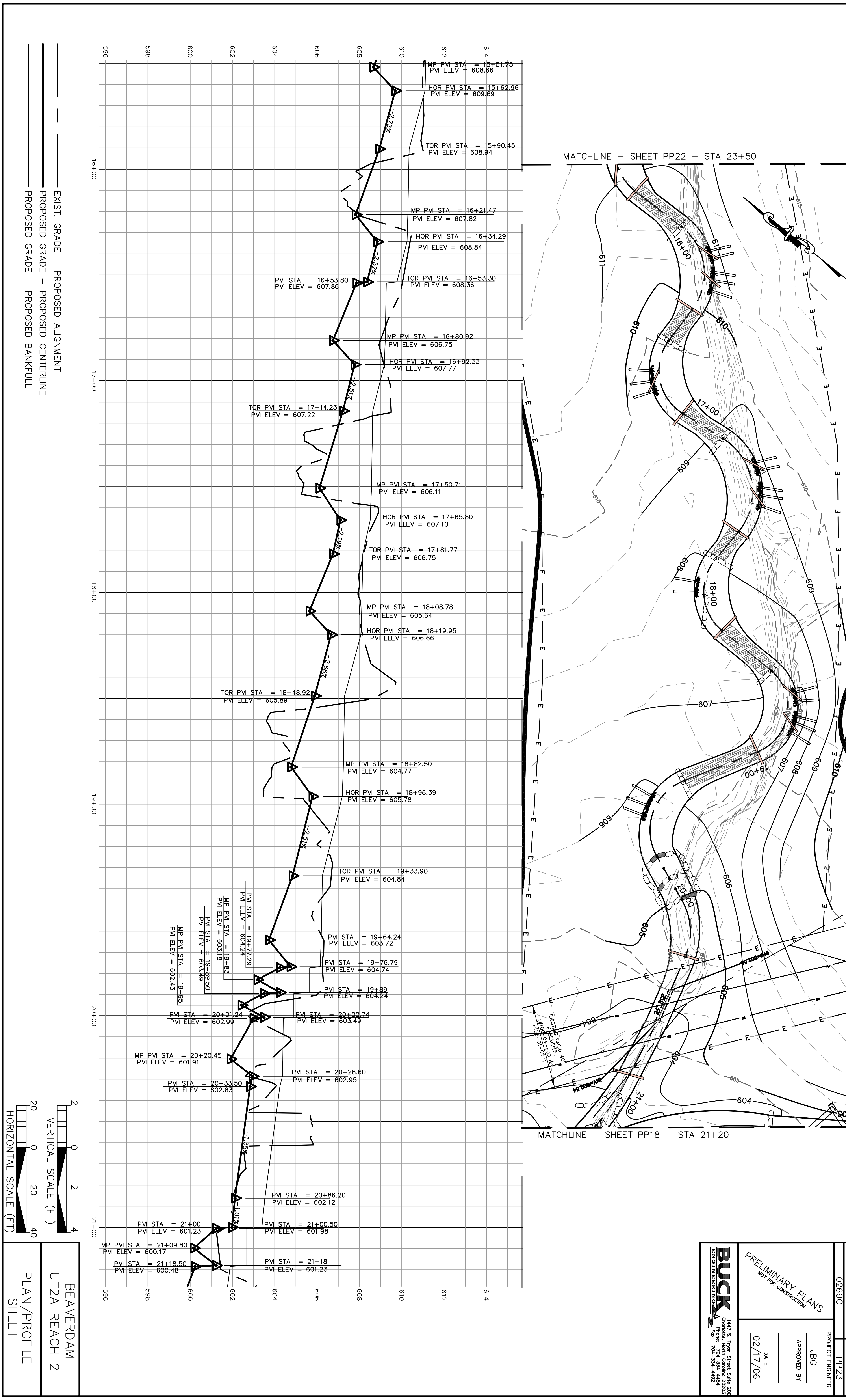
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 REACH 4

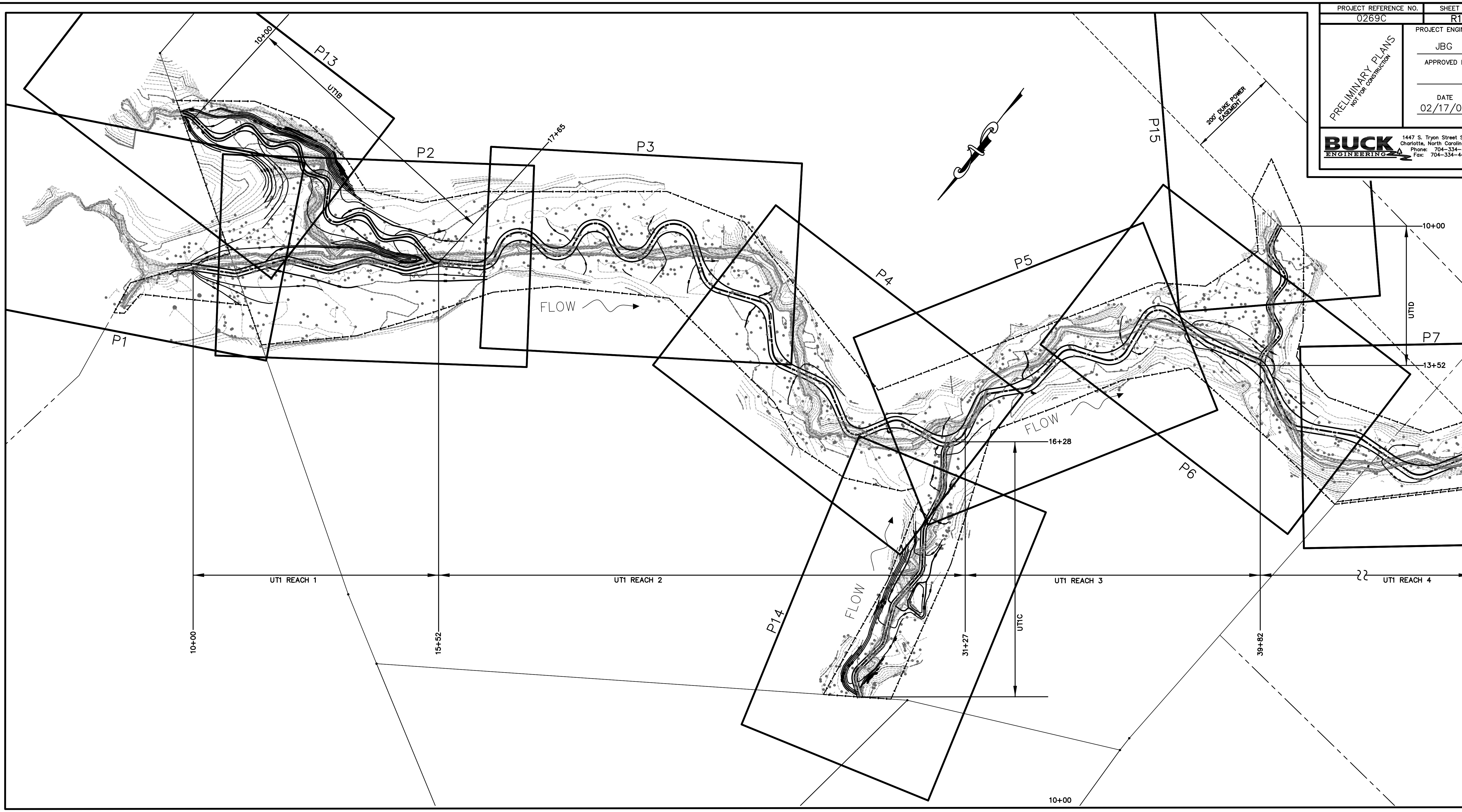
PLAN/PROFILE
SHEET

L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006


L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb 21, 2006
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL
PVI STA = 10+12.50
PVI ELEV = 617.79
TOR PVI STA = 10+12
PVI ELEV = 618.04
MP PVI STA = 10+20
PVI ELEV = 616.73
HOR PVI STA = 10+30
PVI ELEV = 617.79
PVI STA = 10+42.50
PVI ELEV = 617.27
TOR PVI STA = 10+42
PVI ELEV = 617.52
MP PVI STA = 10+50
PVI ELEV = 616.21
HOR PVI STA = 10+60
PVI ELEV = 617.27
PVI STA = 10+74.97
PVI ELEV = 616.70
TOR PVI STA = 10+74.47
PVI ELEV = 616.95
MP PVI STA = 10+92.18
PVI ELEV = 615.62
HOR PVI STA = 10+99.50
PVI ELEV = 616.66
PVI STA = 11+23.51
PVI ELEV = 615.69
TOR PVI STA = 11+23.01
PVI ELEV = 616.19
MP PVI STA = 11+46.64
PVI ELEV = 614.59
HOR PVI STA = 11+56.42
PVI ELEV = 615.61
PVI STA = 11+95.90
PVI ELEV = 614.14
TOR PVI STA = 11+95.40
PVI ELEV = 614.64
MP PVI STA = 12+23.25
PVI ELEV = 613.03
HOR PVI STA = 12+34.76
PVI ELEV = 614.04
TOR PVI STA = 12+66.44
PVI ELEV = 613.32
MP PVI STA = 12+93.93
PVI ELEV = 612.21
HOR PVI STA = 13+05.29
PVI ELEV = 613.23
PVI STA = 13+39.19
PVI ELEV = 611.82
TOR PVI STA = 13+38.69
PVI ELEV = 612.32
MP PVI STA = 13+68.07
PVI ELEV = 610.71
HOR PVI STA = 13+80.21
PVI ELEV = 611.72
TOR PVI STA = 13+99.48
PVI ELEV = 611.24
MP PVI STA = 14+30.62
PVI ELEV = 610.12
HOR PVI STA = 14+43.50
PVI ELEV = 611.13
TOR PVI STA = 14+56.20
PVI ELEV = 610.81
MP PVI STA = 14+90.92
PVI ELEV = 609.70
HOR PVI STA = 15+05.28
PVI ELEV = 610.70
PVI STA = 15+25.12
PVI ELEV = 609.78
TOR PVI STA = 15+24.62
PVI ELEV = 610.28
MP PVI STA = 15+51.75
PVI ELEV = 608.66
HOR PVI STA = 15+62.96
PVI ELEV = 609.69
-2.00%
-2.25%
-2.21%
-2.00%
-2.49%
-2.27%
-2.27%
-2.49%
-2.52%
-2.17%
10+00
11+00
12+00
13+00
14+00
15+00
606
608
610
612
614
616
618
620
MATCHLINE - SHEET PP23 - STA 15+50
VERTICAL SCALE (FT)
HORIZONTAL SCALE (FT)
BEAVERDAM
UT2A REACH 2
PLAN/PROFILE SHEET
PROJECT REFERENCE NO. 0269C
SHEET NO. PP22
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
PROJECT ENGINEER
JBG
APPROVED BY
DATE
02/17/06
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



L:\Projects\0269C\Design\Plans\0269C-PP-SHEETS-UT2.dwg Feb. 21, 2006
EXIST. GRADE - PROPOSED ALIGNMENT
PROPOSED GRADE - PROPOSED CENTERLINE
PROPOSED GRADE - PROPOSED BANKFULL
MATCHLINE - SHEET PP22 - STA 23+50
MATCHLINE - SHEET PP18 - STA 21+20
MP PVI STA = 15+51.75
PVI ELEV = 608.66
HOR PVI STA = 15+62.96
PVI ELEV = 609.69
TOR PVI STA = 15+90.45
PVI ELEV = 608.94
MP PVI STA = 16+21.47
PVI ELEV = 607.82
HOR PVI STA = 16+34.29
PVI ELEV = 608.84
PVI STA = 16+53.80
PVI ELEV = 607.86
TOR PVI STA = 16+53.30
PVI ELEV = 608.36
MP PVI STA = 16+80.92
PVI ELEV = 606.75
HOR PVI STA = 16+92.33
PVI ELEV = 607.77
TOR PVI STA = 17+14.23
PVI ELEV = 607.22
MP PVI STA = 17+50.71
PVI ELEV = 606.11
HOR PVI STA = 17+65.80
PVI ELEV = 607.10
TOR PVI STA = 17+81.77
PVI ELEV = 606.75
MP PVI STA = 18+08.78
PVI ELEV = 605.64
HOR PVI STA = 18+19.95
PVI ELEV = 606.66
TOR PVI STA = 18+48.92
PVI ELEV = 605.89
MP PVI STA = 18+82.50
PVI ELEV = 604.77
HOR PVI STA = 18+96.39
PVI ELEV = 605.78
TOR PVI STA = 19+33.90
PVI ELEV = 604.84
PVI STA = 19+64.24
PVI ELEV = 603.72
PVI STA = 19+77.29
PVI ELEV = 604.24
MP PVI STA = 19+83
PVI ELEV = 603.18
PVI STA = 19+76.79
PVI ELEV = 604.74
PVI STA = 19+89.50
PVI ELEV = 603.49
PVI STA = 19+89
PVI ELEV = 604.24
MP PVI STA = 19+95
PVI ELEV = 602.43
PVI STA = 20+01.24
PVI ELEV = 602.99
PVI STA = 20+00.74
PVI ELEV = 603.49
MP PVI STA = 20+20.45
PVI ELEV = 601.91
PVI STA = 20+28.60
PVI ELEV = 602.95
PVI STA = 20+33.50
PVI ELEV = 602.83
PVI STA = 20+86.20
PVI ELEV = 602.12
PVI STA = 21+00
PVI ELEV = 601.23
PVI STA = 21+00.50
PVI ELEV = 601.98
MP PVI STA = 21+09.80
PVI ELEV = 600.17
PVI STA = 21+18.50
PVI ELEV = 600.48
PVI STA = 21+18
PVI ELEV = 601.23
-2.73%
-2.52%
-2.51%
-2.19%
-2.66%
-2.51%
-1.35%
-1.01%
16+00
17+00
18+00
19+00
20+00
21+00
596
598
600
602
604
606
608
610
612
614
VERTICAL SCALE (FT)
2 0 2 4
HORIZONTAL SCALE (FT)
20 0 20 40
EXISTING CMUD EASEMENT (#1004-609 & #1501-650)
BEAVERDAM
UT2A REACH 2
PLAN/PROFILE SHEET
PROJECT REFERENCE NO.
0269C
SHEET NO.
PP23
PRELIMINARY PLANS
NOT FOR CONSTRUCTION
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492
PROJECT ENGINEER
JBG
APPROVED BY
DATE
02/17/06



PROJECT REFERENCE NO.	SHEET NO.
0269C	R1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM CREEK – UT1

100 0 100 200
SCALE (FT)

BEAVERDAM

REFERENCE SHEET

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

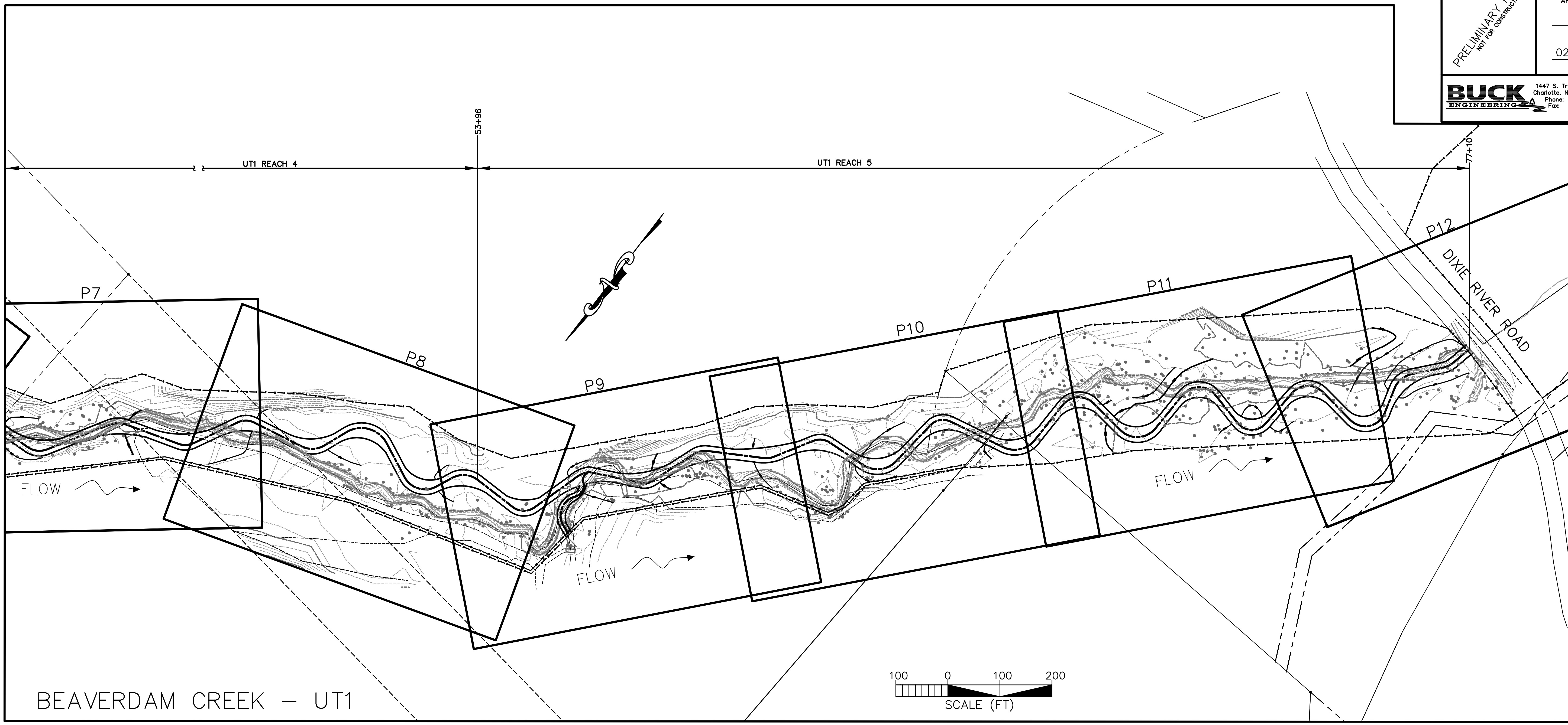
PROJECT REFERENCE NO.	SHEET NO.
0269C	R2

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



BEAVERDAM

REFERENCE SHEET

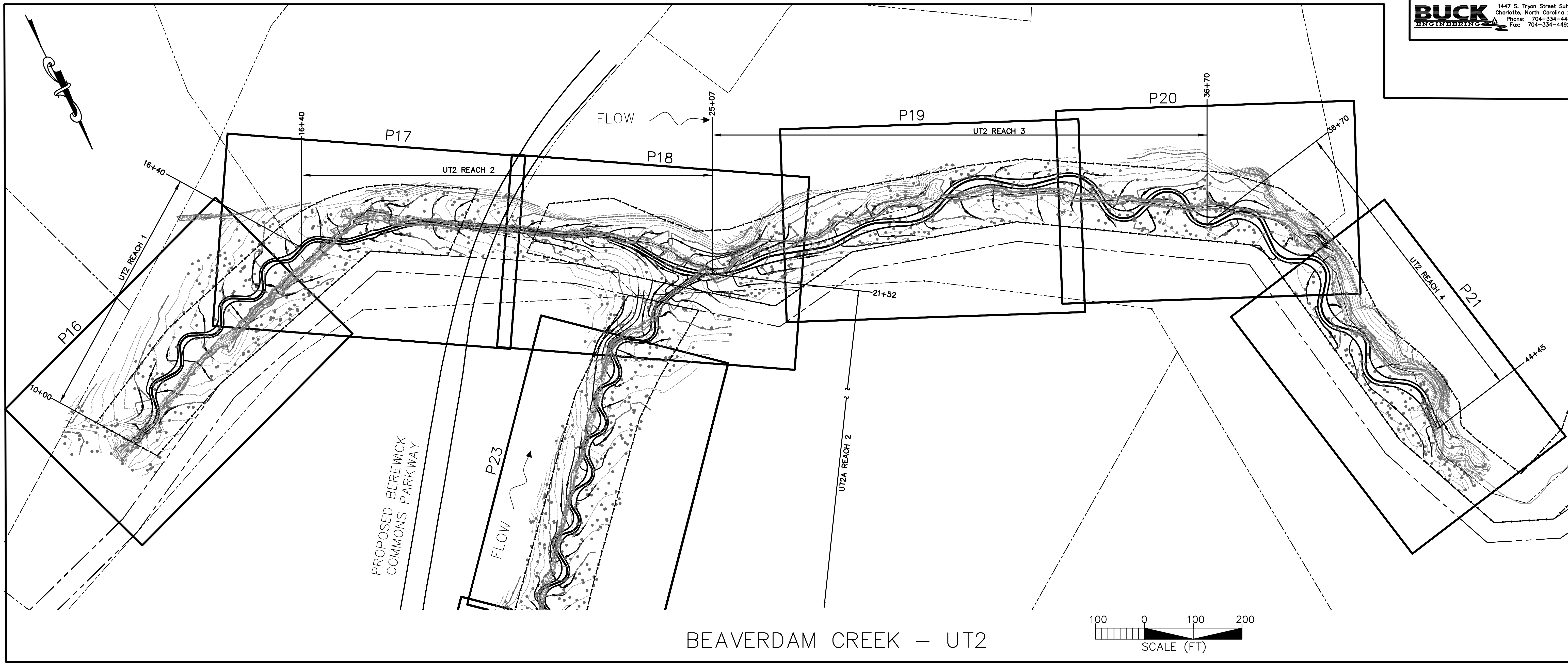
L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	R3

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



BEAVERDAM CREEK – UT2

BEAVERDAM

REFERENCE SHEET

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

PROJECT REFERENCE NO.	SHEET NO.
0269C	R4

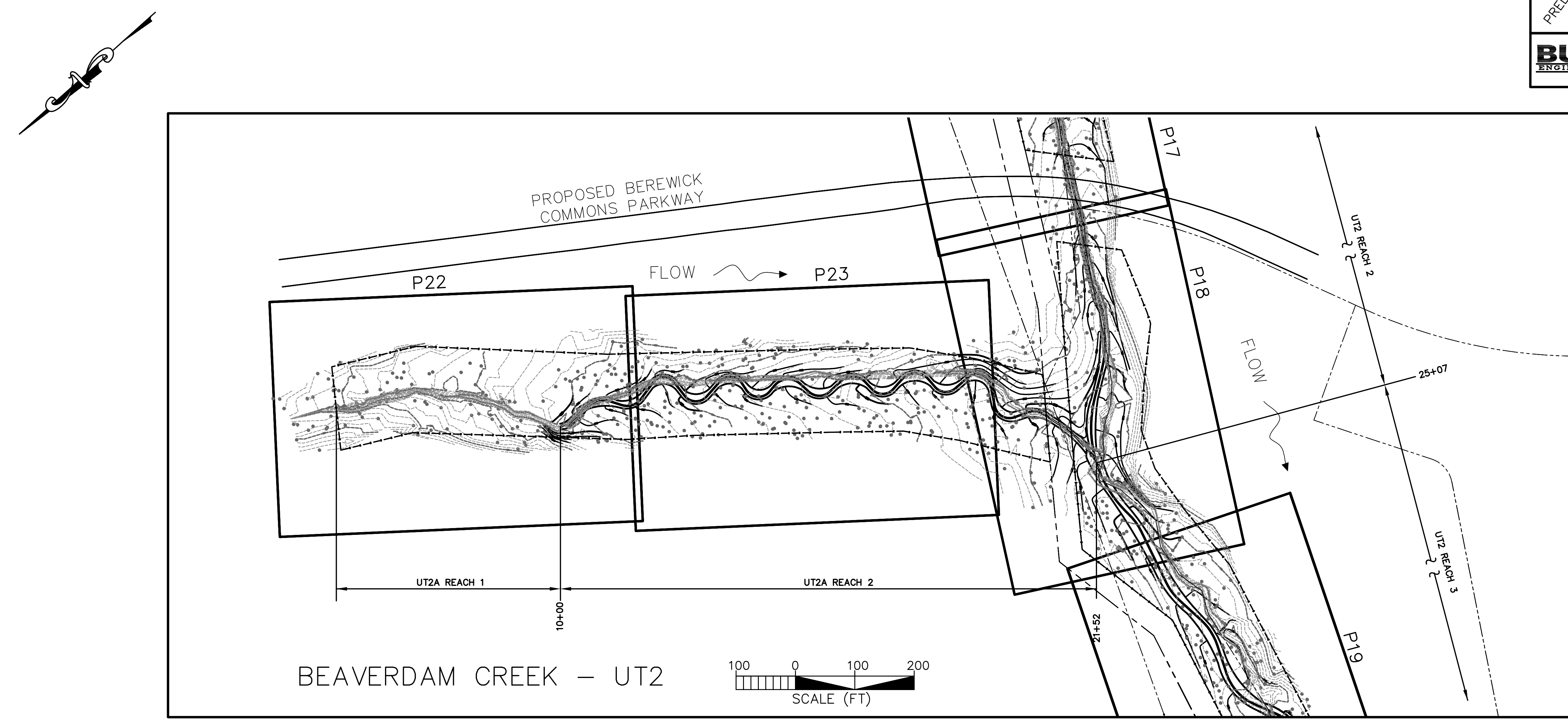
PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: JBG

APPROVED BY:

DATE: 02/17/06

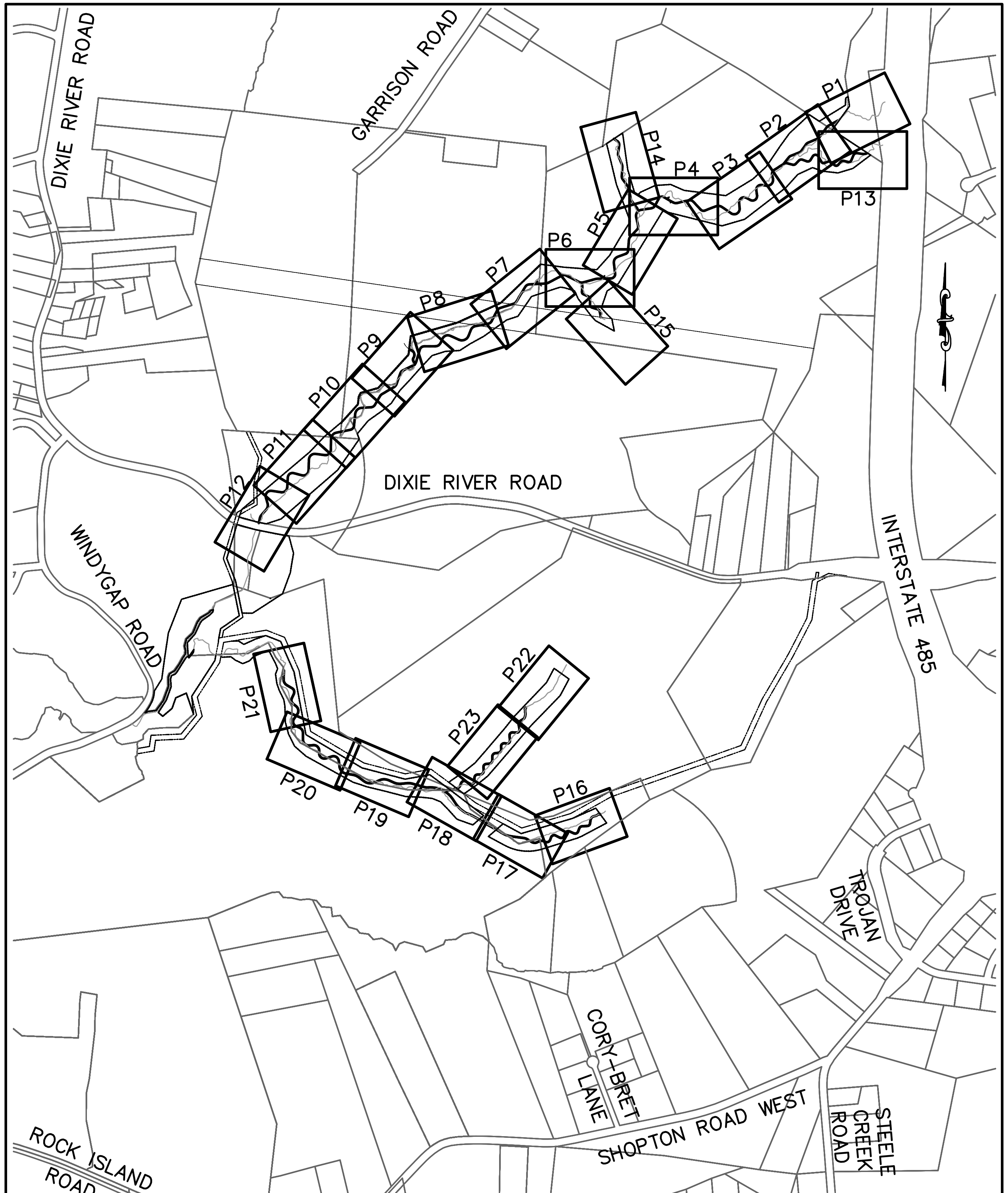
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492



BEAVERDAM

REFERENCE SHEET

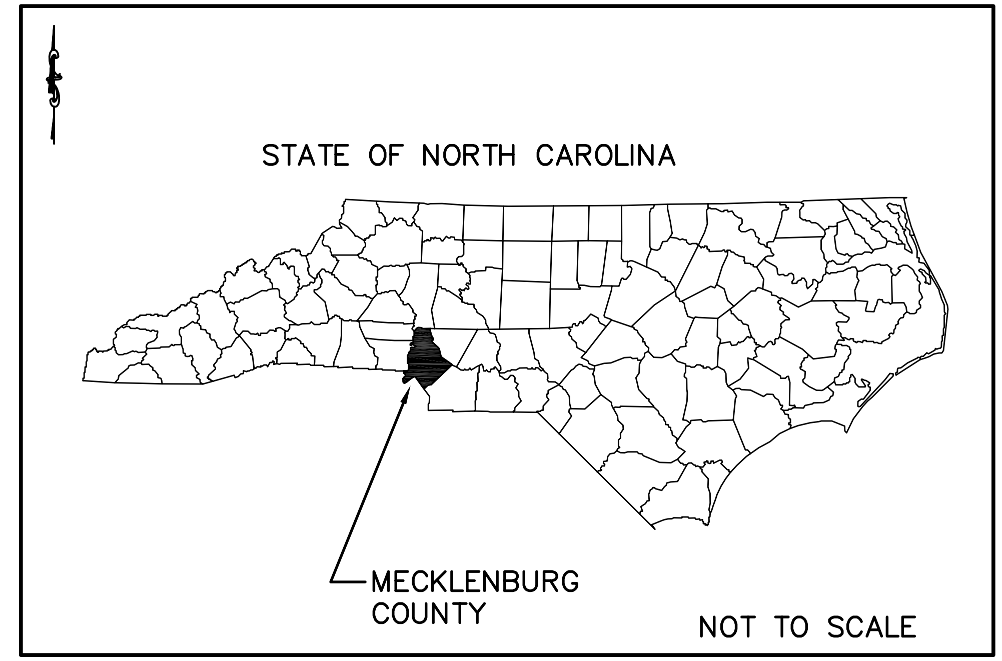
L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006



VICINITY MAP

500 0 500 1000
SCALE (FT)

BEAVERDAM CREEK
STREAM RESTORATION
60% DESIGN PLANS



INDEX OF SHEETS

TITLE SHEET	T1
CONVENTIONAL SYMBOLS/NOTES	T2
REFERENCE SHEET	R1–R4
SITE PLAN	P1–P23
PLAN/PROFILE	PP1–PP23
PLANTING PLAN	L1–L14
TYPICAL SECTIONS	X1–X9
DETAILS	D1–D5

PROJECT REFERENCE NO.	SHEET NO.
0269C	T1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
JBG
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM

TITLE SHEET

L:\Projects\0269C\Design\Plans\0269C-PLANSHEET-UT2.dwg Feb 21, 2006

CONVENTIONAL SYMBOLS

ORIGINAL BASELINE OF CONSTRUCTION (PER SURVEY DATED SEPTEMBER 2005)	
EXISTING TOP OF BANKFULL (FLOODPLAIN)	
CONSERVATION EASEMENT	
EXISTING MAJOR CONTOUR	
EXISTING MINOR CONTOUR	
EDGE OF ASPHALT	
PF — PROPOSED FENDE	
X — EXISTING FENCE	
EXISTING WETLAND	
ROW	
PARCEL BOUNDARY	
EXISTING ROAD/PAVEMENT	
EXISTING TRIBUTARY	
PROPOSED BASELINE OF CONSTRUCTION	
EXISTING EDGE OF WOODS	
PROPOSED TOP OF BANK	
BOTTOM OF BANK	
EXISTING TREE	
EXISTING OVERHEAD UTILTY POLE	
EXISTING GUY WIRE	
EXISTING STRUCTURE / BUILDING	
FLOW	
TREE BARRICADE	

PROPOSED ROCK CROSS VANE	3/D2
PROPOSED DOUBLE DROP CROSS VANE	3/D3
PROPOSED ROCK VANE	2/D1
PROPOSED ROCK J-HOOK VANE	2/D3
PROPOSED LOG J-HOOK VANE	D2/D3
PROPOSED CONSTRUCTED RIFFLE	4/D1
PROPOSED DOUBLE DROP LOG VANE	3/D3
PROPOSED SINGLE LOG CROSS VANE	3/D2
PROPOSED BOULDER SILL	1/D2
PROPOSED LOG SILL	1/D2
ROOT WAD	1/D1
BRUSH MATTRESS	2/D5
LOG VANE	2/D2
COVER LOG	1/D1
LOG STEP POOL	5/D1
PROPOSED GRADE CONTROL J-HOOK	1/D4
BOULDER CLUSTER	3/D4
LOG STEP POOL	1/D3
BOULDER STEP POOL	1/D3

NOTES

1. THE CONTRACTOR IS REQUIRED TO INSTALL INSTREAM STRUCTURES USING EQUIPMENT OF SUFFICIENT SIZE TO MOVE BOULDERS 4FT X 3FT X 2FT (APPROXIMATELY 2 TONS).
2. THE CONTRACTOR WILL BE REQUIRED TO PROVIDE, AT A MINIMUM, TWO OPERATORS AT ALL TIMES DURING CONSTRUCTION OF THE NEW STREAM CHANNEL. IN GENERAL, ONE OPERATOR WILL CUT THE NEW CHANNEL WITH A TRACK HOE, WHILE THE OTHER OPERATOR FOLLOWS AND INSTALLS INSTREAM STRUCTURES, BANK STABILIZATION PRACTICES, AND TRANSPLANTS.
3. A VEGETATIVE COVER SHALL BE ESTABLISHED ON DISTURBED AREAS WITHIN 15 WORKING DAYS OR 90 CALENDER DAYS AFTER ANY PHASE OF GRADING IS COMPLETED. EXPOSED SLOPES DISTURBED SHALL HAVE BEGETAION ESTABLISHED WITHIN 15 WORKING DAYS OR 30 CALENDER DAYS AFTER ANY PHASE OF GRADING IS COMPLETED.
4. CONTRACTOR IS RESPONSIBLE FOR LOCATING AND PROTECTING EXISTING UTILITIES ON SITE.

PROJECT REFERENCE NO.	SHEET NO.
0269C	T2

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

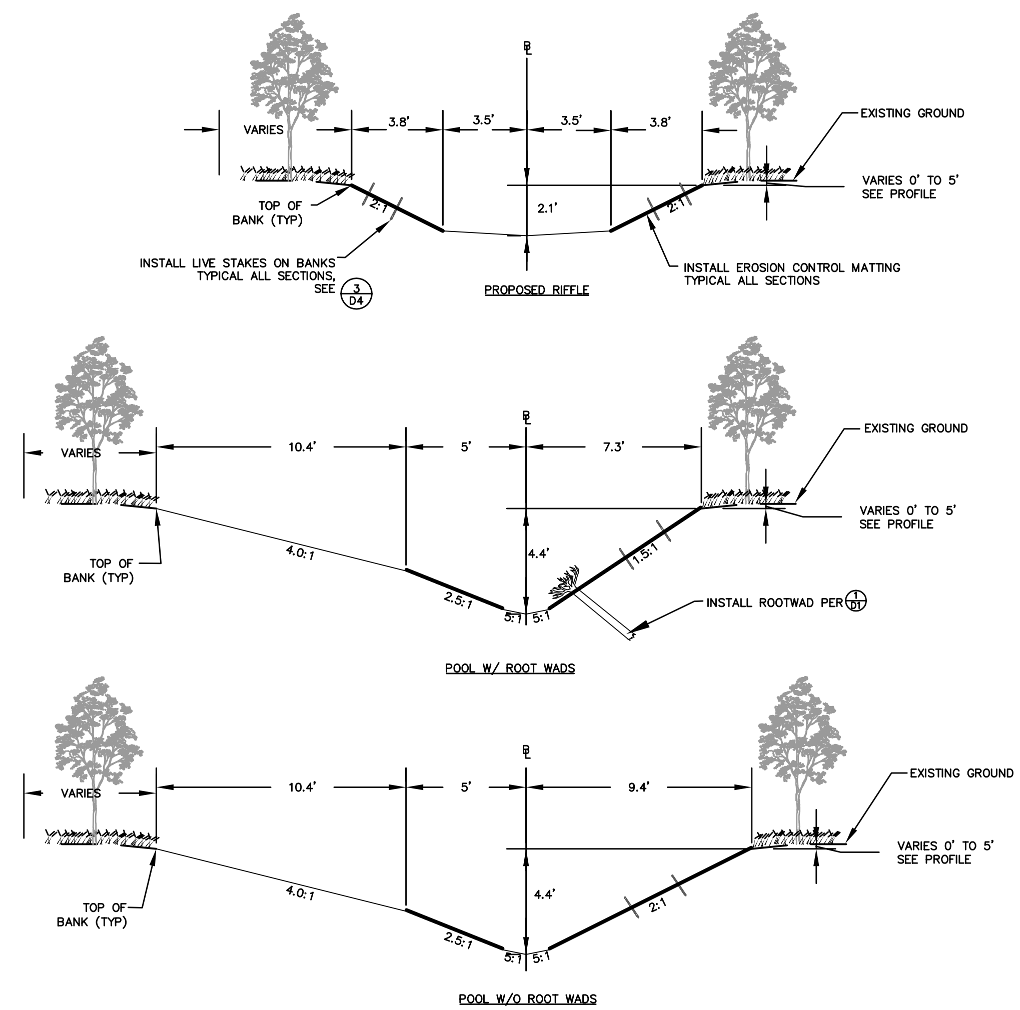
PROJECT ENGINEER: JBG
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM

CONVENTIONAL SYMBOLS / NOTES

UT1 REACH 1
STA 10+00 TO STA 15+52



PROJECT REFERENCE NO.	SHEET NO.
0269C	X1

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

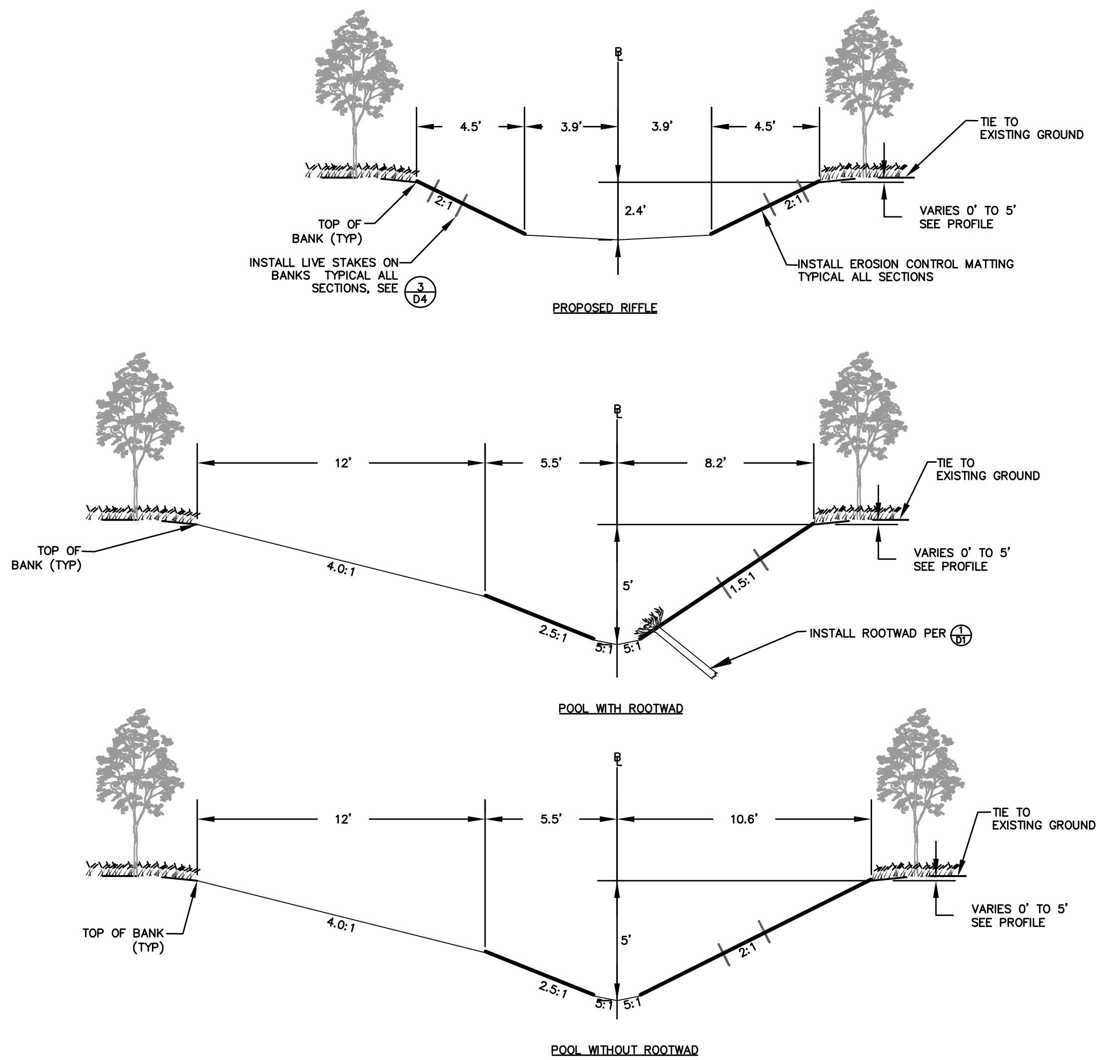
2 0 2 4
SCALE (FT)

BEAVERDAM
UT1

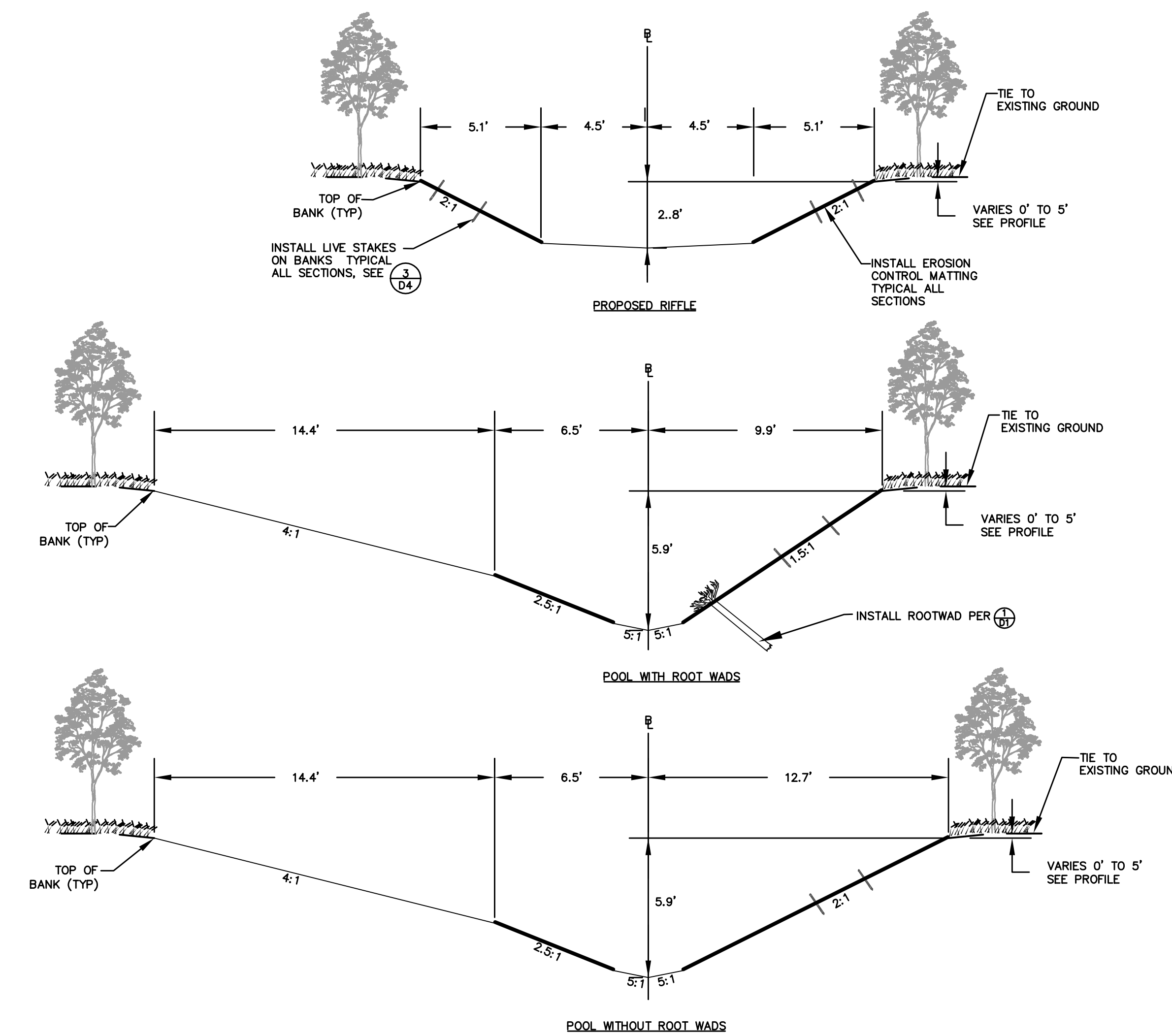
TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006

UT1 REACH 2
STA 15+52 TO STA 31+27



UT1 REACH 3
STA 31+27 TO STA 39+82



PROJECT REFERENCE NO.	SHEET NO.
0269C	X2

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

2 0 2 4
SCALE (FT)

BEAVERDAM
UT1

TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006

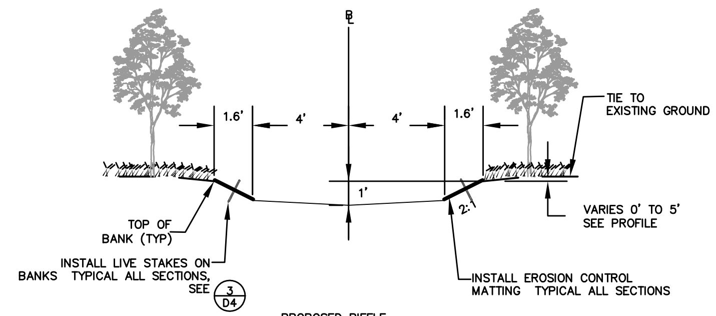
PROJECT REFERENCE NO.	SHEET NO.
0269C	X3

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

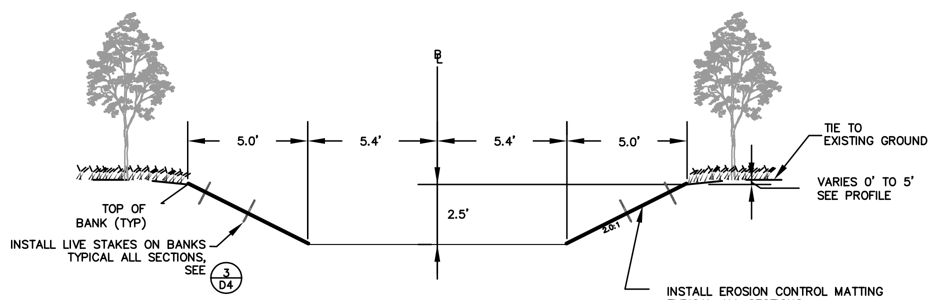
PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

UT1C
STA 10+00 TO STA 16+28

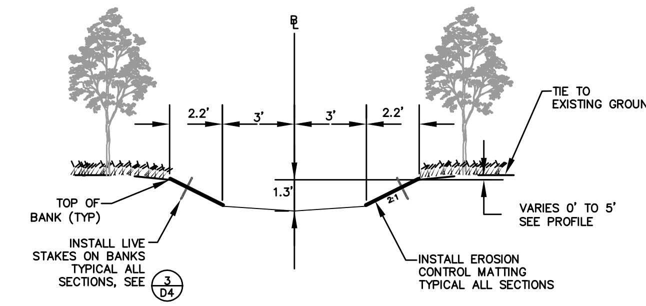


PROPOSED RIFFLE

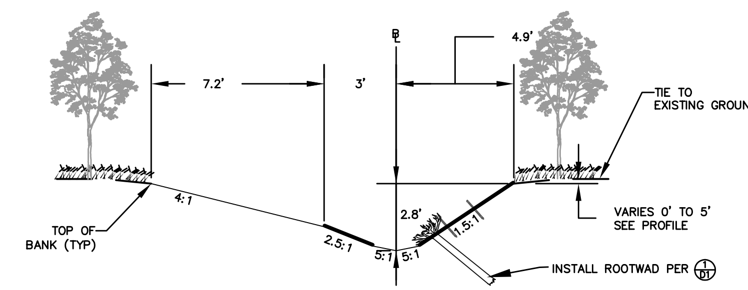


PROPOSED POOL

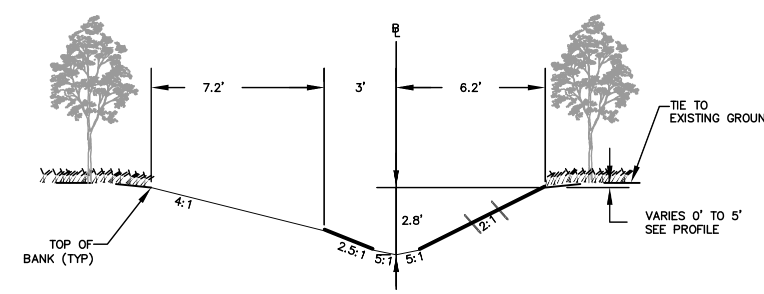
UT1D
STA 10+00 TO STA 13+52



PROPOSED RIFFLE



POOL WITH ROOT WADS



POOL WITHOUT ROOT WADS

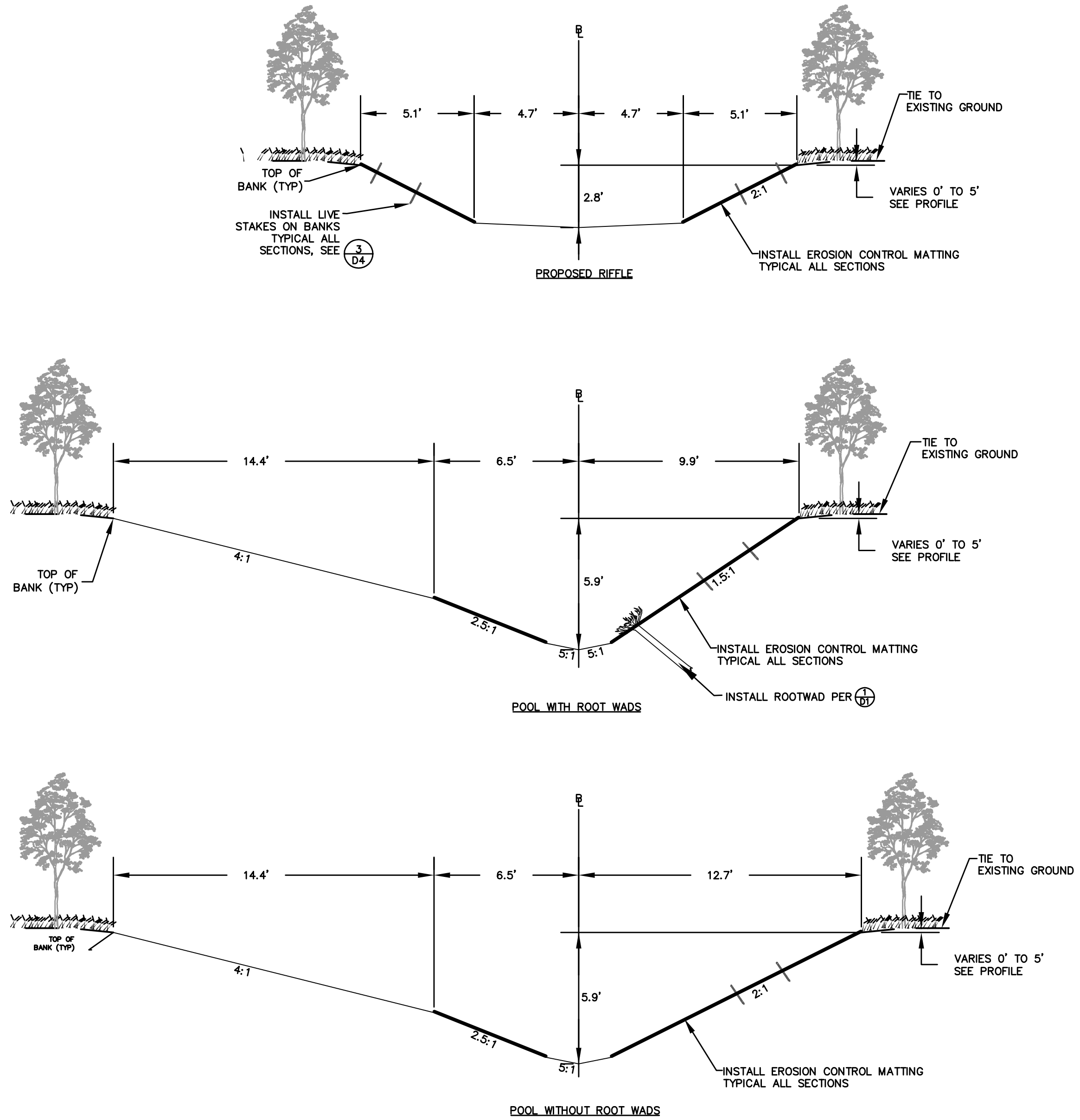
2 0 2 4
SCALE (FT)

BEAVERDAM
UT1

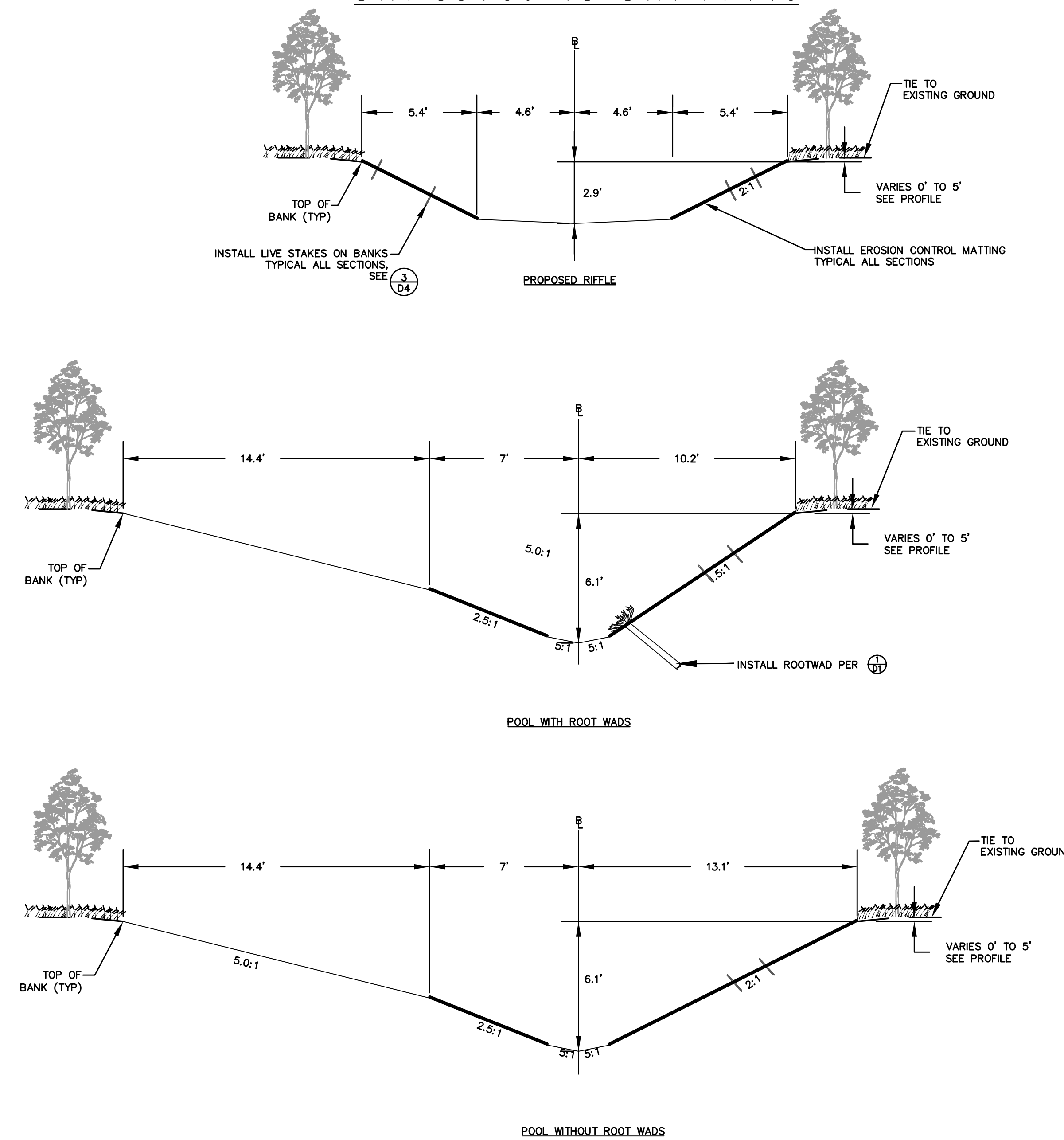
TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006

UT1 REACH 4
STA 39+82 TO STA 53+96



UT1 REACH 5
STA 53+96 TO STA 77+10



PROJECT REFERENCE NO.	SHEET NO.
0269C	X4

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER: ASE
APPROVED BY:
DATE: 02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

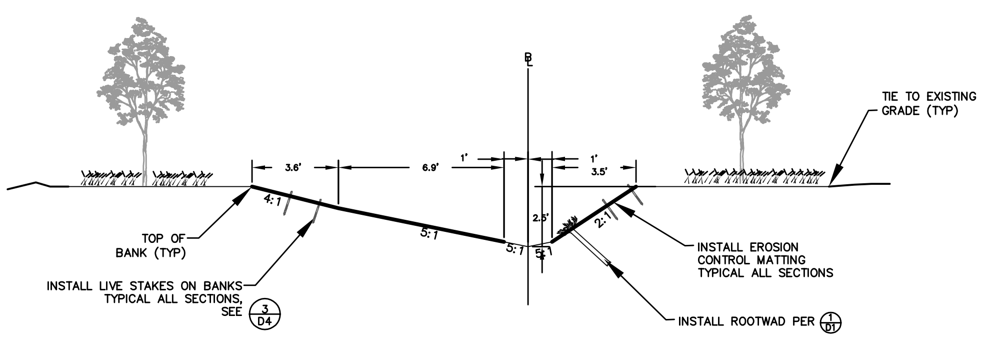
SCALE (FT) 2 0 2 4

BEAVERDAM
UT1

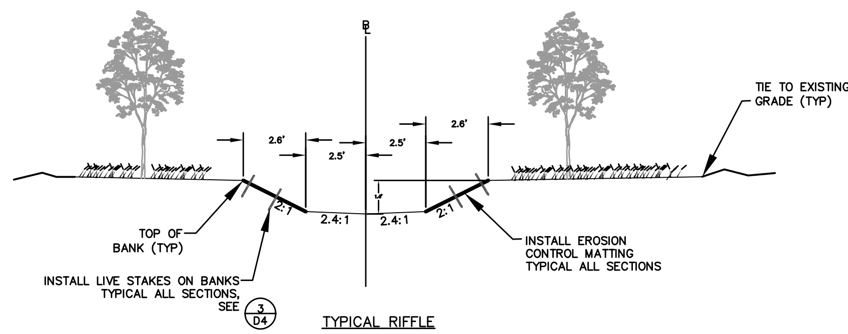
TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006

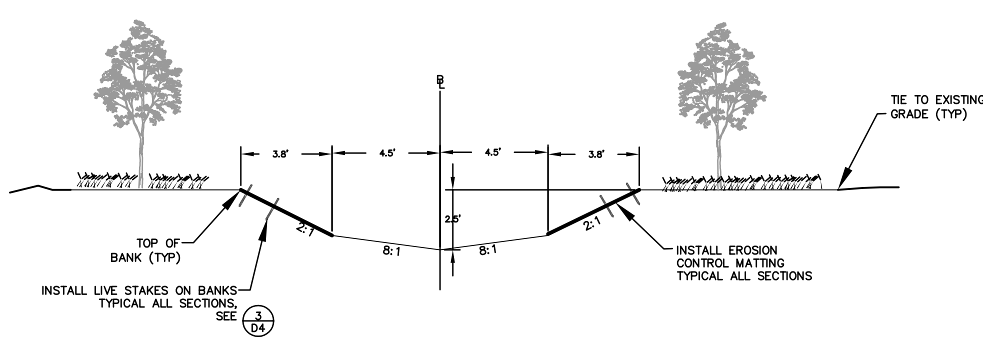
UT2A REACH 2
STA 16+40 TO STA 25+10



TYPICAL POOL WITH ROOTWADS

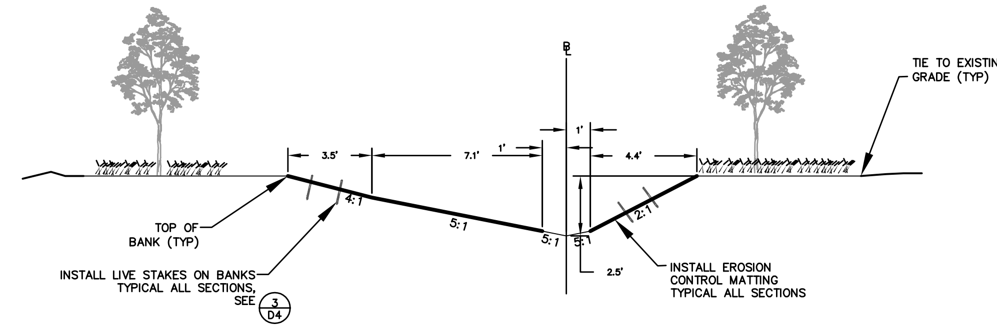


TYPICAL RIFFLE

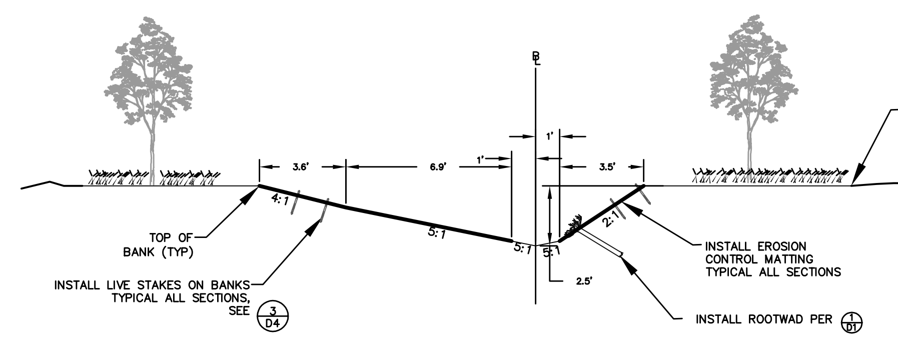


INLINE POOL

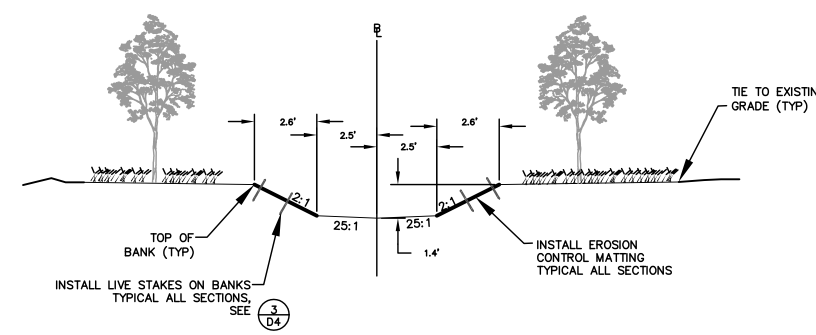
UT2 REACH 1
STA 10+00 TO STA 16+40



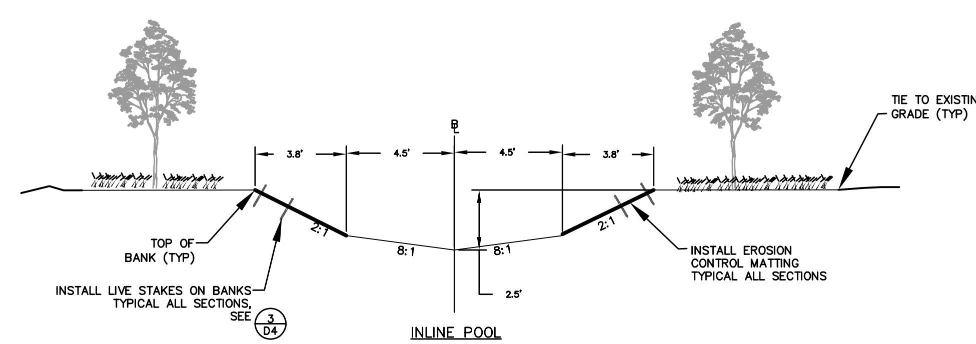
TYPICAL POOL WITHOUT ROOTWADS



TYPICAL POOL WITH ROOTWADS



TYPICAL RIFFLE



INLINE POOL

2 0 2 4
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	X5

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

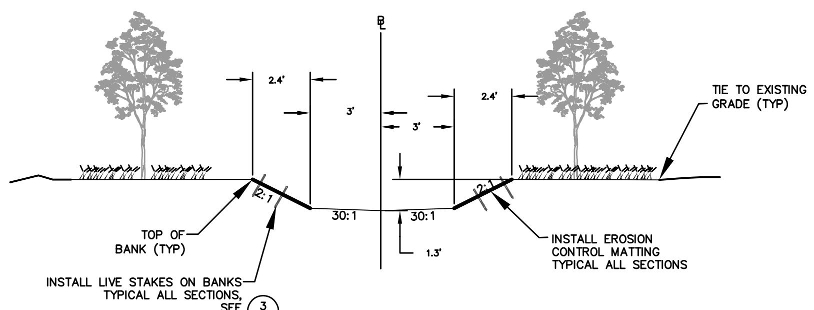
BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2 / UT2A

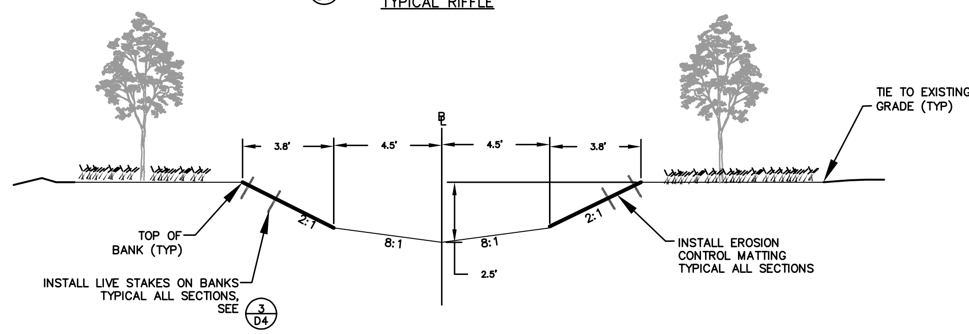
TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006

UT2 REACH 2
STA 16+40 TO STA 25+00

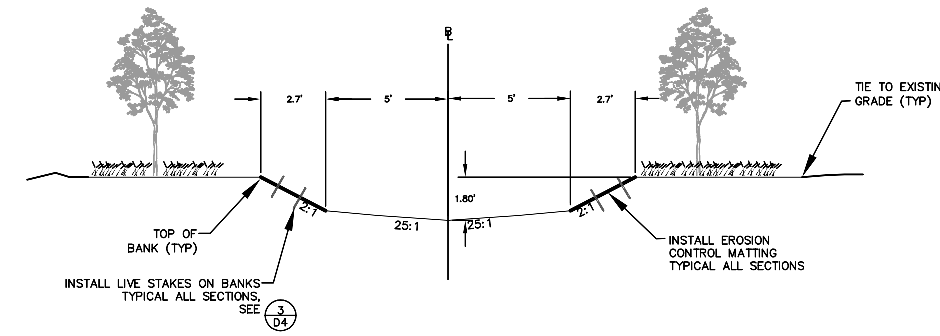


TYPICAL RIFFLE

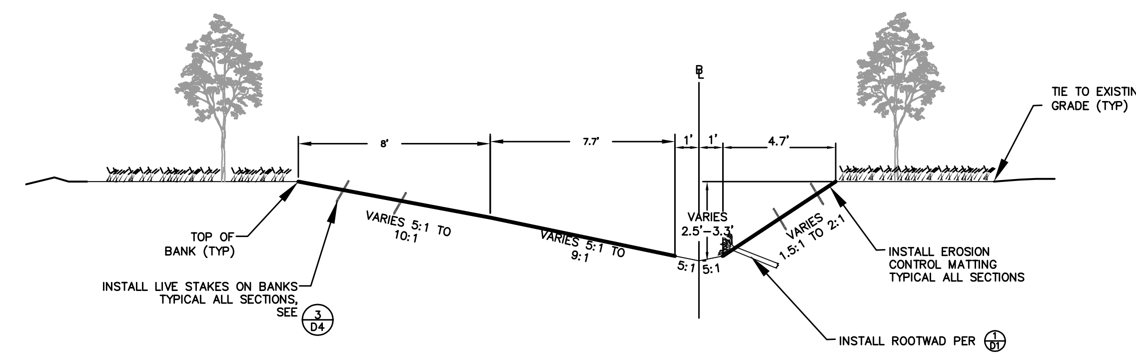


INLINE POOL

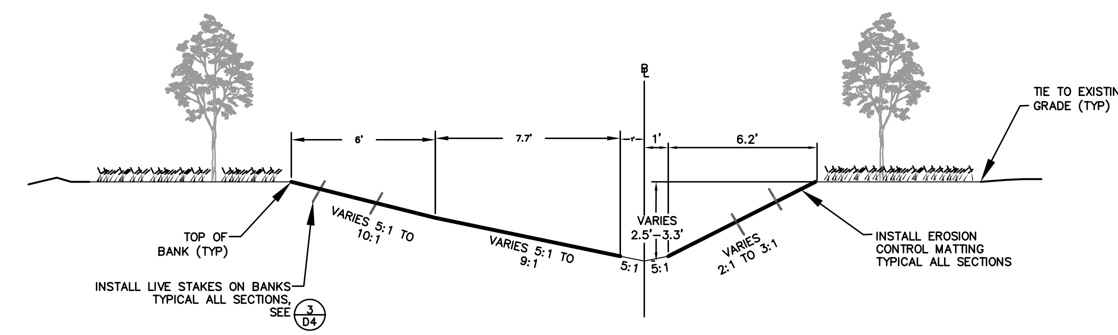
UT2 REACH 3
STA 25+00 TO STA 16+70



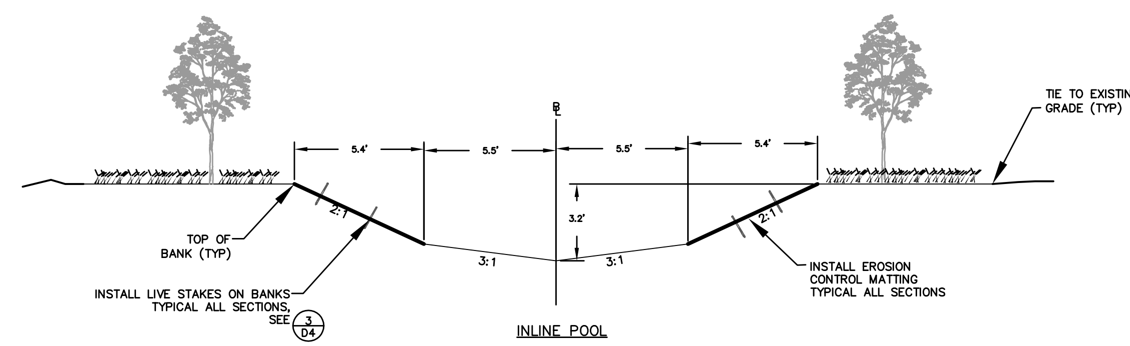
TYPICAL RIFFLE



TYPICAL POOL WITH ROOTWADS



TYPICAL POOL WITHOUT ROOTWADS



INLINE POOL

2 0 2 4
SCALE (FT)

PROJECT REFERENCE NO.	SHEET NO.
0269C	X6

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING

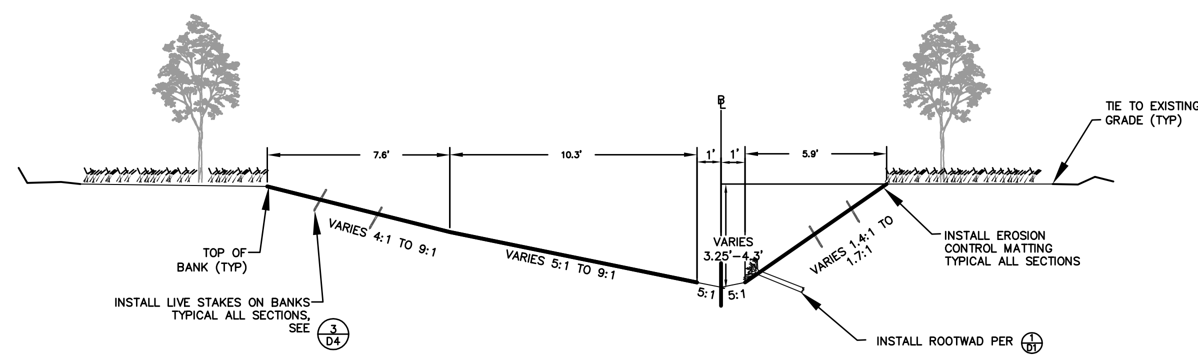
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

BEAVERDAM
UT2

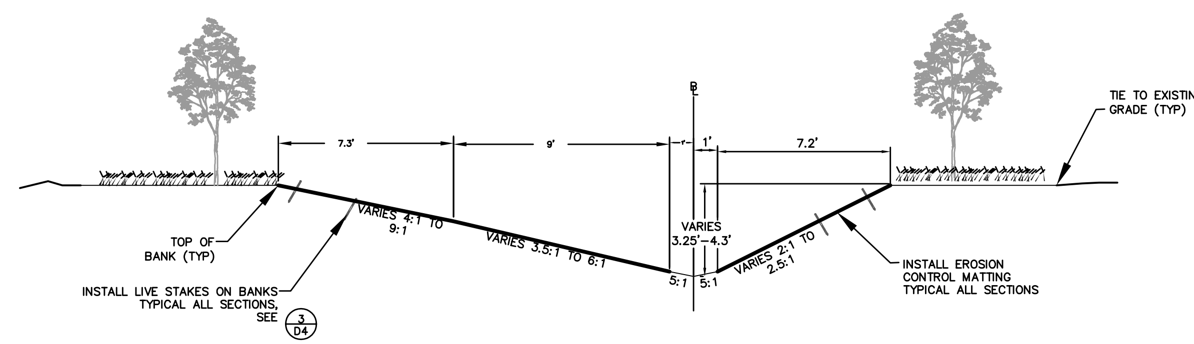
TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006

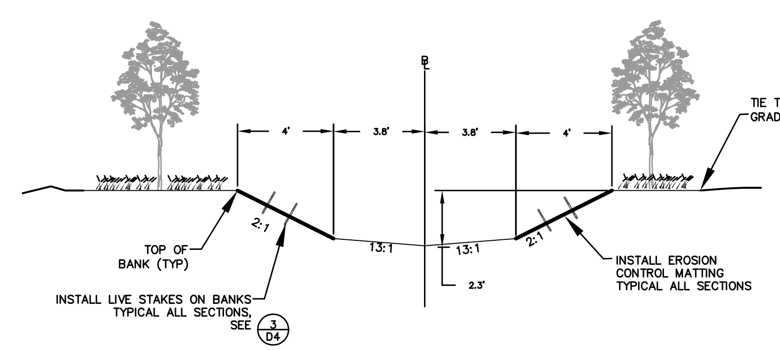
UT2 REACH 4
STA 36+70 TO STA 44+45



TYPICAL POOL WITH ROOTWADS



TYPICAL POOL WITHOUT ROOTWADS



TYPICAL RIFFLE

PROJECT REFERENCE NO.	SHEET NO.
0269C	X7

PRELIMINARY PLANS
NOT FOR CONSTRUCTION

PROJECT ENGINEER
ASE
APPROVED BY

DATE
02/17/06

BUCK ENGINEERING
1447 S. Tryon Street Suite 200
Charlotte, North Carolina 28203
Phone: 704-334-4454
Fax: 704-334-4492

2 0 2 4
SCALE (FT)

BEAVERDAM
UT2

TYPICAL SECTIONS

L:\Projects\0269C\Design\Plans\TYPICAL Sections.dwg Feb 21, 2006