# Little White Oak Stream Restoration Site

# Polk County, North Carolina

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Prepared For:

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# RESTORATION PLAN

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**Executive Summary**

As part of the Ecosystem Enhancement Program's (EEP) Request for Proposal (RFP) issued October 26, 2005, Mulkey,Inc. (Mulkey) submitted the Little White Oak Creek Site (LWO, Site) for consideration.

The Little White Oak Creek Site is a large, stream restoration and conservation easement acquisition project to create a contiguous, high quality ecosystem restoration project. The project is located in Polk County, North Carolina. The LWO Site is situated southeast of the Town of Mills Springs and northeast of the intersection of NC Highway 9 and US 74 (Exit 167). The Site is within the USGS 14 Digit HUC 03050105030010, the USGS 14 Digit HUC 03050105, and NC Division of Water Quality (DWQ) subbasin 03-08-02.

The LWO Site lies within two parcels that have historically been used for pasture and forest land. Cattle and other land uses have resulted in substantial degradation to the stream throughout the Site for the past 50 years. There are approximately 200 grazing cattle and horses currently utilizing the pastures. The livestock have not been fenced from the streams at any location within the Site. This continual livestock access to the streams has resulted in substantial erosion along the stream banks, incision of the channels, channel widening in some areas, and poor bed form diversity throughout the Site, as well as degraded water quality due to the introduction of fecal matter into the stream system. The property owner explained that many of the streams at the Site, particularly the smaller tributaries, were historically maintained through channelization, dredging, and clearing of the riparian buffer. Fecal and nutrient contamination to streams within the Site is currently a concern.

*Project goals and objectives*

The goal of the Little White Oak Creek Stream Restoration Site are as follows:

- To improve water quality for the project stream reaches, as well as downstream reaches
- To reduce the rate of bank erosion along the project stream reaches
- To better attenuate flood flows
- To enhance wildlife habitat at the project site

Theses goal will be met through the following objectives:

- By using natural channel design to restore stable pattern, dimension, and profile for the project stream reaches
- By reestablishing a flood plain or connecting the stream back to its historic floodplain, or a combination of both, for each project stream reach
- By creating or restoring floodplain features such as vernal pools, off channel ponds, or riparian wetlands
- By increasing the amount of instream habitation through the addition of rock and wood structures, the
- By re-establishing a more natural riparian buffer, thereby reintroducing shading, cover areas, and travel corridors.

How these goals will be met through the described objectives are discussed in more detail in the following paragraphs.

The goal of improving water quality will be accomplished by meeting two objectives: first, by reducing sedimentation, and second by restoring riparian buffers. Restoring stable stream pattern, dimension, and profile will reduce sedimentation to the stream by preventing the mass wasting of stream banks currently prevalent at the Site. All of the stream restoration design and construction will follow methodologies consistent with natural channel design. Our proposed restoration plan includes re-establishing a floodplain and forested riparian buffer which will both provide an area of filtration for surface and ground water from the adjacent, heavily grazed pastures. The floodplain will be re-established by raising the existing streambed elevation in order to reconnect the streams to their historic floodplains, or in the cases where this is not feasible due to site constraints, through the construction of bankfull benches. By reconnecting the streams to their original floodplains or by creating improved floodplains through bankfull bench construction, the streams are provided a much larger area to attenuate flood flows. The sections of abandoned channel that will be left open and modified to create vernal pools, off channel ponds, or riparian wetlands will also provide additional flood storage.

The second goal will be to enhance instream and terrestrial wildlife habitat and will be achieved by increasing the amount and quality of habitat within the stream and within the riparian buffer. The existing condition of the streams and riparian buffers at the site provide limited available habitat for aquatic and terrestrial species in and around the stream. The objective is to utilize the proposed restoration site to enhance habitat within the stream by restoring natural channel stability and through the introduction of in-stream boulder and wood structures. The restoration of a forested riparian buffer will also provide stream shading, as well as cover areas and travel corridors that are vital for traveling, foraging, loafing and nesting for many wildlife species. The Site provides an excellent opportunity to restore and preserve a substantial riparian zone on lands that are currently being used for pasture. The riparian buffers, at least 50 feet in width, will be established along both sides of all of the streams at the Site. These buffers will be fenced to prevent future cattle intrusion.

*Amount of existing and designed stream*

Mulkey has acquired 55.3 acres of conservation easement for the State of North Carolina to provide buffer for the stream site. The existing stream footage within the Site totaled 16,278 linear feet. A design has been completed using parameters from reference reach data which anticipated 18,200 linear feet of potential restoration. Mulkey anticipates that this project will generate a minimum of 18,200 Stream Mitigation Units (SMUs). The SMUs are determined by using the formula [SMU = (Restoration/1.0) + (Enhancement Level I/1.5) + (Enhancement Level II/2.5) + (Preservation/5.0)] as noted in the EEP RFP.

## 1.0 Project Site Identification and Location

The Little White Oak Creek Stream Restoration Site is located in Polk County approximately 2.5 miles east/southeast from the Community of Mill Springs along NC Highway 9 South, and approximately 0.5 mile northwest from the intersection of NC Highway 9 South and US Highway 74. The Site is situated in the Broad River Basin 8-digit cataloging unit of 03050105 and the 14-digit cataloging unit 03050105030010. Mulkey has purchased an easement covering 55.3 acres, which will encompass the streams and associated buffers at the Site. (Figure 1)

## 1.1 Directions to Project Site

The Little White Oak Site is located 0.6 mile north of Exit 167 at the intersection of NC Highway 9 and US 74. The Site is approximately 78 miles from Charlotte and approximately 47 miles from Asheville.

## 1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

The Little White Oak Creek Stream Restoration Site is located within the Broad River Basin, 8-digit cataloging unit of 03050105 and the 14-digit cataloging unit 03050105030010. The Site is also within the

NC Division of Water Quality Subbasin 03-08-02. The Little White Oak Creek Stream Restoration Site consists of first, second, third, and fourth order streams which generally flow eastward across the Site and exit the Site as the main channel of Little White Oak Creek. This Site is not located in a water supply watershed. (Figure 2)

## 2.0 Watershed Characterization

It is estimated that 78% of the land cover within the watershed is forest or wetland. Although urbanization is dramatically increasing in the area, it is estimated there is **currently 2% of urbanized (impervious) area** in the watershed. The remaining land cover is pasture and cultivated cropland.

Topography at the Site consists of gently sloping hills and valleys along with broad, flat floodplain areas adjacent to the South Fork Little White Oak Creek and Little White Oak Creek. The elevations of the Site range 885 feet above mean sea level to approximately 875 feet above mean sea level on the Little White Oak Creek and South Branch Little White Oak Creek and the tributaries range from 905 feet above mean sea level and 875 feet above mean sea level.
The Site is located within the Southern Inner Piedmont Ecoregion. This ecoregion is denoted as dissected irregular plains, some low to high hills, ridges, and isolated monadnocks; low to moderate gradient streams with mostly cobble, gravel, and sandy substrates.

### 2.1 Drainage Area

The two main streams at the Site are third order streams, Little White Oak Creek at the north end of the Site and South Branch Little White Oak Creek at the south end of the Site. These two streams converge at the center of the Site as Little White Oak Creek to form a fourth order stream. The Site also includes one second order unnamed tributary and five first order unnamed tributaries. The headwaters of the Little White Oak Creek are located southeast of Lake Adger and north and east of Little White Oak Mountain then flow in an easterly direction through the project site. The drainage area of Little White Oak Creek as it enters the project area is approximately 3,400 acres (5.3 square miles). The headwaters of the South Branch Little White Oak Creek are located north and east of Fox Mountain and flow east to its confluence with Little White Oak Creek. The drainage area of the South Branch of the Little White Oak Creek as it enters the project area is approximately 2,560 acres (4.0 square miles). The overall drainage area of the project is 7,124 acres (11.1 square miles). (Figure 2)

### 2.2 Surface Water Classification / Water Quality

Little White Oak Creek has been identified by the Division of Water Quality as use classification C which denotes uses for fresh water aquatic life, secondary recreation. Little White Oak Creek flows into White Oak Creek approximately four miles downstream of the Site which is also classified as class C waters. The 2003 Broad River Basin Water Quality Plan (Basinwide Plan) identifies water quality parameters for White Oak Creek as supporting its designates uses from its source to its confluence with the Green River. The Basinwide Plan noted habitat degradation as problem parameters and identified agricultural and urban runoff and storm sewers as potential impairment sources. A Benthic Monitoring Station (Station B-8) is located near the confluence of the Green River and White Oak Creek. The Basinwide Plan notes a bioclassification of Good-Fair at this station in 2000. The Little White Oak Creek Stream Restoration Site is not a 303 (d) listed waterbody (NCDWQ, 2004b).

## 2.3 Physiography, Geology and Soils

The Site is located within the Outer Piedmont Belt portion of the Piedmont physiographic region of North Carolina. The geologic composition of the project site is magmatitic granitic gneiss which consists of foliated to massive, granitic to quartz dioritic, biotite gneiss, and amphibolite common. (NCDLR, 1985)

According to the Soil Survey of Polk County, soils within the project area are nearly level or gently sloping soils on floodplains and stream terraces. Most of these areas are found within the western Piedmont region of the county adjacent to major rivers and creeks (Figure 3).

Riverview loam, 0 to 2 percent, (RvA) underlies the majority of the stream channels and floodplain within the Site. Chewacla loam, 0 to 2 percent (ChA), Skyuka clay loam, 2 to 8% eroded (SkB2), and Dogue-Roanoke Complex, 0 to 6%, occurs along several of the floodplain areas and stream terraces. Grover Loam, 25 to 45% slopes is mapped along some of the hillslope areas within the project boundary. Riverview loam is identified as a hydric soil according to the North Carolina Hydric Soils List, August, 2005.

Riverview loam soil series is classified as fine-loamy, mixed, thermic Fluventic Dystrochrepts. These are nearly level, very deep, well drained soils with moderate permeability. Riverview loam soils experience occasional flooding for brief periods.
Chewacla loam soils series is classified as fine-loamy, mixed, thermic Fluaquentic Dystrocrepts. These are nearly level, very deep, somewhat poorly drained soils with moderate permeability. Chewacla loam soils experience occasional flooding for brief periods. Chewacla loam soils are identified as class B hydric soils.

Skyuka clay loam soil series is classified as fine, mixed, thermic Ultic Hapludalfs. These are gently sloping, very deep, well drained soils with moderate permeability. Skyuka clay loam have generally have no flooding potential.

Within the Dogue-Roanoke Complex, the Douge soil series is classified as clayey, mixed, thermic Auqic Hapludults. The Roanoke soil series is classified as clayey, mixed, thermic Typic Endoaquults. Theses soils are nearly level to sloping, very deep, moderately well drained to poorly drained soils with moderately slow to slow permeability. Soils within this complex rarely experience flooding. The Dogue-Roanoke Complex is listed as a hydric soil according to the North Carolina Hydric Soils List, August, 2005.

The Grover Loam soil series is classified as a fine-loamy, micaceous, thermic Typic Hapludult. These soils are steep, very deep, well drained soils with moderate permeability. Due to the steepness of these soils, there is no potential of flooding (Keenan, et al, 1998).

## 2.4 Historical Land Use and Development Trends

The Site has been used as a pasture for cattle for the past 50 years. There are approximately 200 grazing cattle and horses currently utilizing the pastures. The livestock have not been fenced from the streams at any location within the Site. This continual livestock access to the streams has resulted in substantial erosion along the stream banks, incision of the channels, channel widening in some areas, and poor bed form diversity throughout the Site, as well as reduced water quality due to the introduction of fecal matter into the stream system. The property owner explained that many of the streams at the Site, particularly the smaller tributaries, were historically maintained through channelization, dredging, and clearing of the riparian buffer. Fecal and nutrient contamination to streams within the Site is currently a concern.

Polk County is located in the mountain foothills known as the "Thermal Belt", where warm air settles and moderates the temperature. The county's location in relation to the mountains also is a large attraction for newcomers and tourist. Development within the county has increased steadily in the last 5 to 10 years. There are multiple equestrian estates, vacation homes, new homes for retirees, subdivisions, and golf courses being built in the vicinity of the LWO Site.

## 2.5 Endangered / Threatened Species

According to the US Fish and Wildlife Service (USFWS), there are three federally protected species, dwarf flowered heartleaf (*Hexastylis naniflora*), small-whorled pagonia (*Isotria medeoloides*), and white irisette (*Sisyrinchium dichotomum*), along with eleven federal species of concern potentially occurring in Polk County (USFWS, 2003). Mulkey performed a review of mapping for compliance with ESA as well as an in-field survey for the listed species.

### 2.5.1 Federally Protected Species

As of the March 8, 2006 list, the USFWS identified two Threatened (T) species and one Endangered (E) species as occurring in Polk County. North Carolina National Heritage Program maps (updated July, 2006) were reviewed to determine if any protected species have been identified near the project area. This map review confirmed that no federally protected species and no designated critical habitat areas are known to occur within an one-mile radius of the study area. A description of habitat requirements and a biological conclusion is provided for these species in the following sections.

<u>2.5.1.1 Dwarf-flowered heartleaf (*Hexastylis naniflora*)</u>
Federal Status: Threatened
State Status: Threatened

The dwarf-flowered heartleaf has the smallest flower of any North American Hexastylis. Most flowers are less that 0.4 inch long, with narrow sepal tubes (never more than 0.28 inch wide). The jug-shaped flowers range from beige to dark brown, sometimes greenish or purplish. Leathery evergreen leaves are dark green and heart-shaped. Dwarf-flowered heartleaf commonly occurs in areas of acidic sandy loam soils found along bluffs and nearby slopes, hillsides and ravines, and in boggy areas adjacent to creekheads and streams. Soil type is the most important habitat requirement (Pacolet, Madison, or Musella types). Abundant sunlight in early spring is necessary for maximum flowering and seed production. Flowering generally occurs between mid-March and early June.

Biological Conclusion: *No Effect*

Appropriate habitat for dwarf-flowered heartleaf consisting of acidic sandy loam soils (specifically Madison and Pacolet types) is not present within the study site but is present within the property encompassing the study site. A review of NCNHP records showed no occurrence of dwarf-flowered heartleaf within a one-mile radius of the project site. In addition, a pedestrian survey was conducted by qualified biologists from Mulkey on July 17, 2006. No occurrence of dwarf-flowered heartleaf was found on-site during the plant-by-plant survey. Therefore, project construction will have No Effect on this species.

<u>2.5.1.2 Small-whorled pogonia (*Isotria medeoloides*)</u>
Federal Status: Threatened
State Status: Endangered

Small-whorled pogonia is a small perennial member of the Orchidaceae with long, pubescent roots and a smooth, hollow stem 3.8 to 10 inches (9.5 to 25 centimeters) tall terminating in a whorl of 5 or 6 light green, elliptical leaves that are somewhat pointed and measure up to 1.6 to 3.2 inches (8 by 4 centimeters). It is distinguishable from similar species such as purple fiveleaf orchid (*I. verticillata*) and Indian cucumber-root (*Medeola virginiana*) by its hollow stem. These plants arise from long slender roots with hollow stems terminating in a whorl of five or six light green leaves. The single flower is approximately 1 inch (2.5 centimeters) long, with yellowish-green to white petals and three longer green sepals. This orchid blooms in late spring from mid-May to mid-June. This plant is believed to be self-pollinating by mechanical processes. Populations of this plant are reported to have extended periods of dormancy and to bloom sporadically. This small spring ephemeral orchid is not observable outside of the spring growing season.

The small-whorled pogonia grows in young as well as maturing (second- or third-growth) forests, but typically grows in open, dry deciduous woods and areas along stream with acidic soils. It also grows in rich, mesic woods in association with white pine and rhododendron. Habitat is characterized by sparse to moderate ground cover, open understory canopy, and proximity to clearings such as roads, streams or canopy gaps. When it occurs in habitat where there is relatively high shrub coverage or high sapling density, flowering appears to be inhibited. Decaying organic matter such as wood litter from fallen limbs and trees, leaves, bark or stumps may be important for plant growth as various types of decaying vegetation are found in habitat of extant populations (von Oettingen, 1992).

Biological Conclusion: *No Effect*

Suitable habitat for the small-whorled pogonia is not present in the project study area. For this reason, no survey for this species was conducted. NCNHP does not list any occurrences of the small-whorled pogonia within a 1-mile radius of the project site. Therefore, project construction will have No Effect on this species.

2.5.1.3 White irisette (*Sisyrinchium dichotomum*)
Federal Status: Endangered
State Status: Endangered

The white irisette is a small perennial herb that grows in a dichotomously-branching pattern, reaching heights of approximately 4.3 to 7.9 inches (11 to 20 centimeters). The basal leaves, usually pale to bluish green, are from one-third to one-half the height of the plant. They are long-attenuate, with an acuminate apex. The tiny white flowers are 0.3 inches (0.75 centimeters) long and appear from late May through July in clusters of four to six at the ends of winged stems. The stems have from three to five nodes, each with one to three winged peduncles 1.6 to 2.8 inches (4 to 7 centimeters) long and 0.02 to 0.04 inches (0.06 to 0.09 centimeters) wide. There are successively shorter internodes between the dichotomous branches. Individual plants may have 10 or more stems arising from the fibrous roots. The fruit is a round, pale to medium brown capsule containing three to six round or elliptical black seeds. The dichotomous branching pattern and white flowers combine to distinguish this herb from other species within the genus (Feil, 1995).

White irisette closely resembles narrow-leaved blue-eyed grass (*Sisyrinchium angustifolium*). It is distinguished by the branching from the first node, with plant parts becoming noticeably smaller above. Blue-eyed grass usually has one node, with no noticeable reduction in the top of the plant. This species occurs on rich, basic soils probably weathered from amphibolite. It grows in clearings and the edges of upland woods where the canopy is thin and often where down-slope runoff has removed much of the deep litter layer ordinarily present on these sites. It is found on mid-elevation mountain slopes with a southeast to southwest aspect and shallow soils due to rockiness or steep terrain. The irisette is dependent on some form of disturbance to maintain the open quality of its habitat. It is also grows in open disturbed sites such as woodland edges, power line easements, and roadsides (Feil, 1995).

Biological Conclusion: *No Effect*

Suitable habitat for the white irisette consisting of clearings and the edges of upland woods where the canopy is thin is present in the project study area. A pedestrian was conducted by qualified biologists from Mulkey on July 17, 2006. No occurrence of white irisette was found on-site during the plant-by-plant survey. In addition, NCNHP does not list any occurrences of white irisette within a 1-mile radius of the project site. Therefore, project construction will have No Effect on this species.

### 2.5.2 Federal Designated Critical Habitat

In addition to species listed as endangered or threatened, areas designated as Critical Habitat are also recorded under Section 4 of the ESA. As defined by USFWS, critical habitat is "specific geographic areas, whether occupied by a listed species or not, that are essential for their conservation and that have been formally designated by rule published in the Federal Register" (USFWS, 2005). As of the March 8, 2006 list, no critical habitat areas are listed by USFWS as occurring in Polk County.

### 2.5.3 Federal Species of Concern and State Listed Species

Federal Species of Concern (FSC) are not legally protected under the Endangered Species Act and are not subject to any of its provisions, including Section 7. Species designated as FSC are defined as taxa which may or may not be listed in the future. These species were formerly Candidate 2 (C2) species or species under consideration for listing for which there is insufficient information to support listing.

In addition to the federally listed species referred to above, the USFWS lists 11 FSC as occurring in Polk County as of the January 29, 2007 protected species list. In addition, the NCNHP list (dated July 2006) included 18 species as receiving protection under state laws. Natural Heritage Program maps were reviewed to determine if any FSC or state protected species have been identified near the project area. This map review confirmed that no FSC or state species are known to occur within an one-mile radius of the study area.

| Common Name | Scientific name | Federal Status | Record Status |
|---|---|---|---|
| **Vertebrate:** | | | |
| Cerulean warbler | *Dendroica cerulea* | FSC | Current |
| Green salamander | *Aneides aeneus* | FSC | Current |
| Southern Appalachian eastern woodrat | *Neotoma floridana haematoreia* | FSC | Current |
| **Invertebrate:** | | | |
| Diana fritillary (butterfly) | *Speyeria diana* | FSC | Current |
| Grizzled skipper | *Pyrgus wyandot* | FSC | Historic |
| **Vascular Plant:** | | | |
| Big-leaf scurfpea | *Orbexilum macrophyllum* | FSC | Historic |
| Blue Ridge Ragwort | *Packera millefolium* | FSC | Current |
| Butternut | *Juglans cinerea* | FSC | Current |
| Dwarf-flowered heartleaf | *Hexastylis naniflora* | T | Current |
| French Broad heartleaf | *Hexastylis rhombiformis* | FSC | Current |
| Large-flowered barbara's-buttons | *Marshallia grandiflora* | FSC | Historic |
| Small whorled pogonia | *Isotria medeoloides* | T | Probable/potential |
| Sweet pinesap | *Monotropsis odorata* | FSC | Historic |
| White irisette | *Sisyrinchium dichotomum* | E | Current |
| **Nonvascular plant:** | | | |
| **Lichen:** | | | |
| a lichen | *Canoparmelia amabilis* | FSC | Historic |

**Definitions of Federal Status Codes:**

E = endangered. A taxon "in danger of extinction throughout all or a significant portion of its range."
T = threatened. A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."
P = proposed. A taxon proposed for official listing as endangered or threatened.
C = candidate. A taxon under consideration for official listing for which there is sufficient information to support listing. (Formerly "C1" candidate species.)
FSC = federal species of concern.
T(S/A) = threatened due to similarity of appearance.
EXP = experimental population.

**Definitions of "Record Status" qualifiers:**

Current - the species has been observed in the county within the last 50 years.
Historic - the species was last observed in the county more than 50 years ago.
Obscure - the date and/or location of observation is uncertain.
Incidental/migrant - the species was observed outside of its normal range or habitat.
Probable/potential - the species is considered likely to occur in this county based on the proximity of known records (in adjacent counties), the presence of potentially suitable habitat, or both.

## 2.6 Cultural Resources

The LWO project is located in a county listed as territory of the Eastern Band of Cherokee Indians (EBCI). Concurrence letters were sent to the State Historic Preservation Office (SHPO) on July 7, 2006, and to the EBCI on August 2, 2006. Mulkey received a letter of response dated August 3, 2006, from the SHPO office which recommended a comprehensive survey of the project area. Mulkey also received a letter of response from the EBCI dated August 29, 2006, that recommended a Phase I Archaeological Survey. On September 5, 2006, Mulkey subcontracted with Edwards-Pitman Environmental, Inc. (Edwards-Pitman) to complete an archaeological Phase I in a manner that would proceed to Phase II in order to determine eligibility if necessary. The field assessment of the Phase I archaeological survey was completed on September 15, 2006. There were no eligible sites identified within the Area of Potential Effects (APE). Edwards-Pitman completed a report detailing the process of the assessment and stated that there were no eligible sites identified within the APE.

## 2.7 Potential Constraints

Polk Central Elementary School had, in past years, a permitted discharge to Reach R1A of the South Branch of Little White Oak Creek. The Polk Board of Education owned an easement on this portion of the project to ensure it could continue this discharge. The school system was required by the DWQ to abandon their discharge into the Reach R1A in the mid 1990's and discharge directly into the South Branch of Little White Oak Creek. A 3" PVC pipe was installed from the school sand filtration system through the Walker Property and discharged into the South Branch of Little White Oak Creek. The school system never negotiated a new easement for the new discharge, nor was the old discharge easement extinguished. Mulkey worked with the Polk Board of Education to extinguish the easement on Reach 1A and establish and easement along the existing discharge pipe. The conservation easement abuts, but does not enter into the sewer easement. Construction egress and ingress will have to consider the piping as the Site is constructed.

There are multiple utilities that have been considered throughout the design of the LWO Site. The location of these utilities was considered in the design and will not adversely impact the restored stream.

### 2.7.1 Property Ownership and Boundary

The project area for the Little White Oak Creek Stream Restoration is currently owned by the Walker Family Trust, 2255 Smith Waldrop Road, Mill Springs, North Carolina 27856. The Site is located on two parcels owned by the family: the first covering a 312 acre parcel (PIN No. P83-4) and the second covering a 62.9 acre parcel (PIN No. P94-1). The Walker Family has sold a conservation easement for 55.3 acres of land in order to restore the streams within the farm and protect the riparian areas in perpetuity. Acquisition of easement occurred on December 12, 2006.

### 2.7.2 Site Access

The Site is accessible from state maintained roadways along NC Highway 9 and Thompson Road State Road (SR) 1324. Entry to the conservation easement areas is located along state maintained roads. Pedestrian easements were acquired through each of the crossings to ensure access for inspection of the easement from the corridor for perpetuity.

2.7.3 Utilities

A point source discharge which is piped from the sewer system of Polk Central Elementary School and drains to Little White Oak Creek lies near to Reach 1A. The conservation easement abuts, but does not enter into the sewer easement.

The PSNC Energy (PSNC) owns a 50 foot right of way which crosses Reaches R2B and R2C. The conservation easement for the LWO Site abuts, but does not enter into the right of way. Stream construction will be limited within this PSNC right of way area.

The Rutherford Electric Membership Corporation also has a right of way located adjacent to SR1334 and also crosses the upper area of Reach R2C at the PSNC Right of Way. The conservation easement for the LWO Site abuts, but does not enter into the right of way. Stream construction will be limited within this right of way area.

The North Carolina Department of Transportation (NCDOT) owns right of ways which cross the Little White Oak Creek and the South Branch of the Little White Oak Creek. NC Highway 9 and SR 1334 are bridged as they cross the project site.

Utilities located throughout the Site were not considered in stream footage calculated for the proposed SMUs nor were the utility right of ways included in any of the conservation easements.

2.7.4 FEMA / Hydrologic Trespass

The reaches of South Branch Little White Oak Creek and Little White Oak Creek at the Little White Oak Creek Stream Restoration Site are located in Zone A as shown on Flood Insurance Rate Map (FIRM) for Polk County, North Carolina (Unincorporated Areas), Page 4 of 5, Community Panel Number 370194 0004 A, Map Revised: May 19, 1978, Converted by Letter Effective 01/01/87 (Figure 4). Zone A is defined as a Special Flood Hazard Area. Zone A is the flood insurance rate zone that corresponds to 1-percent annual chance floodplains that are determined in the Flood Insurance Study by approximate methods of analysis. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone. Mandatory flood insurance purchase requirements apply. The areas that the other unnamed tributaries at the Site are located in are not defined on the said mapping.

A HEC/RAS analysis was completed and it was determined that the proposed restoration will result in a "no-rise" of the streams within the project area. Mulkey does not anticipate any hydrologic trespass issues during or after restoration of the Site.

## 3.0 <u>Project Site Streams (Existing Conditions)</u>

Reach R1 is the South Branch Little White Oak Creek at the Site. This reach flows eastward from the southwestern end of the Site, under NC Highway 9, to its confluence with Little White Oak Creek at the center of the Site. Reach R1 was divided into two sub-reaches for the existing conditions survey and study: the reach upstream of NC Highway 9 (R1 upstream) and the reach downstream of NC Highway 9 (R1 downstream). Both appeared to be of the same stream type and condition, but were divided into sub-reaches for ease of study due to the difference in drainage area between the two.

Two unnamed tributaries drain to the sub-reach of Reach R1 upstream of NC Highway 9. The first is Reach R1A which is the unnamed tributary that enters the Site from a culvert under NC Highway 9 at the Polk Central School. This stream flows southeastward from the culvert to its confluence with the upstream sub-reach of Reach R1 at the western end of the Site. The second unnamed tributary, Reach

R1B, flows to the upstream sub-reach of Reach R1 just south of the NC Highway 9 Bridge. This stream begins at the toe of the slope at the southern edge of the Site and flows northeastward to its confluence with the upstream sub-reach of Reach R1 just south of the NC Highway 9 Bridge. Restoration work or further study along Reach R1B is not being considered as originally proposed because the other project stream reaches provide the total amount of SMU's proposed by Mulkey for this project.

Reach R2 is the reach of Little White Oak Creek at the Site. This reach flows eastward from the northwest end of the Site to its confluence with Reach R1 at the center of the Site. After this confluence, Reach R2 continues to flow eastward, under SR 1324, to the eastern end of the Site, where Little White Oak Creek leaves the Site. Reach R2 was divided into three sub-reaches for the existing conditions survey and study: The reach upstream of the confluence with Reach R1, the reach between the confluence with Reach R1 and the SR 1324 bridge, and the reach from the SR 1324 bridge and the eastern end of the Site at the property line.

Four unnamed tributaries drain to Reach R2 at the Site. Three of the unnamed tributaries flow into the sub-reaches of Reach R2 upstream of the confluence with Reach R1. The fourth unnamed tributary drains into the sub-reach of Reach R2 downstream of the SR 1324 bridge. The three unnamed tributaries that flow into the sub-reach of Reach R2 is reach R2A, R2B, and reach R2C. Reach R2A which enters from off-site at the northwest end of the Site and flows southward to its confluence with Reach R2. Reach R2B emanates north of the Site and flows south until it reaches the confluence with R2 at the middle of the property. The headwaters of Reach R2C originate on the north end of the Site and the stream flows southward across the Site to its confluence with R2 at the middle of the property. Restoration work or further study along Reach R2C is not being considered as originally proposed because the other project stream reaches provide the total amount of SMU's proposed by Mulkey for this project. The unnamed tributary that flows into the sub-reach of Reach R2 downstream of the SR 1324 bridge is Reach R2D. This stream flows from a culvert under SR 1330 northeastward to its confluence with Reach R2 at the eastern end of the Site. (Figure 4)

### 3.1 Channel Classification

The Reach R1 classifies as a degraded E5 stream type according to Rosgen Classification Methodologies. The existing riparian buffers for Reach R1 range from almost non-existent to a very narrow buffer of scattered trees. Cattle have direct access to the stream and buffer in these areas. Cattle intrusion and the lack of adequate riparian buffer to provide sufficient bank stability have resulted in severe bank erosion, heavy sedimentation, and loss of riparian vegetation along both sub-reaches. Heavy sedimentation is also contributing to the lack of the natural bedform diversity that is expected in stable stream types.

Reach R1A classifies as degraded B6c stream types. Levees or spoil piles were observed along both banks of stream which provides an indication that the streams have been channelized and straightened in the past. This evidence was confirmed by the property owner as he explained that many of the streams at the Site, particularly the smaller tributaries, were historically maintained through channelization, dredging, and clearing of the riparian buffer. Reach R1A is nearly entrenched along much of its length as a result of the historic maintenance practices employed along these streams. The existing riparian buffers for Reach R1A are narrow and consist mainly of shrubs and herbaceous vegetation. Cattle have direct access to the stream and buffer along the entire length of the reach. Bank erosion was not observed to be as severe along some sections of these reaches, likely due to the root mass associated with the thick stand of briars and shrubs adjacent to the streams. A distinct lack of natural dimension, pattern, and profile was observed along the entire length of Reach R1A.

Both sub-reaches of R2 (R2 Upper and R2 Lower) appeared to be of the same stream type and condition, but were divided into sub-reaches for ease of study due to the difference in drainage area between the three. Both of these sub-reach R2 classified as Rosgen degraded E5 stream types. These sub-reaches are incised with a mean low bank height ratios in excess of 1.75.

Reach R2B classifies as Rosgen G5c stream type. Reach R2A is classified as a degraded E4 and Reach R2D also classified as degraded E4. Levees or spoil piles were observed along both banks of these sub-reaches, indicating that these streams have been channelized and likely straightened in the past. This evidence was confirmed by the property owner as he explained that many of the streams at the Site, particularly the smaller tributaries, were historically maintained through channelization, dredging, and clearing of the riparian buffer. The upstream reach of sub-reach R2B is entrenched along much of their length as a result of the historic maintenance practices employed along these streams. R2A and R2D are close to becoming entrenched along their reaches.

### 3.2 Discharge

Mulkey surveyed representative stream cross sections and calculated drainage areas for each for the project stream reaches. This data was used to determine various bankfull parameters, including cross sectional area, width, mean depth and discharge. These parameters for the project stream reaches were compared to the North Carolina Regional Curves for the Piedmont and Mountain Physiographic Regions compiled by SRI. In each case, the data fell within the 95% confidence intervals for the Piedmont and Mountain Curves.

Although 78% of the project watershed is forested, development within the watershed is increasing. As development continues to escalate, impervious and storm water discharges will inevitably increase. This trend would suggest a change in bankfull over time.

### 3.3 Channel Morphology (Pattern, Dimension, and Profile)

The LWO Site lies within two parcels that have historically been used for pasture and forest land. Cattle intrusion and other land uses have resulted in substantial degradation to the stream throughout the Site for the past 50 years. This continual livestock access to the streams has resulted in substantial erosion along the stream banks, incision of the channels, channel widening in some areas, and poor bed form diversity throughout the Site. The property owner explained that many of the streams at the Site, particularly the smaller tributaries, were historically maintained through channelization, dredging, and clearing of the riparian buffer. These landuse practices have significantly impacted the channel morphology of much of the stream reaches at the Site. In conjunction with the conversation with the land owner about the land use practices employed at the site, a research of historical photography seems to indicate the site was timbered prior to 1939, and may have been channelized and dredged periodically since it was initially dredged. Substantial variance from natural channel morphology is evident in the comparison of the existing conditions morphological data from the project stream reaches versus that from the reference reach.

### 3.4 Channel Stability Assessment

Stream stability assessment methodology included the use of Pfankuch, Bank Height Erosion Index (BEHI), and Near Bank Stress (NBS) evaluation processes. Assessments were completed at locations within the reaches representative of the majority of the stream footage within the specific reach.

Mulkey completed the Pfankuch assessment for each reach of the LWO Site. The sediment supply category is designed to assess the availability of sediment based on the observed deposition, transport, and storage within a stream reach. The sediment supply for all reaches was high, with the exception of R2A which was moderate and R2B which was rated as very high. Stream bed stability category documents locations of aggradation and degradation within the stream reach. The stream bed stability was identified as degrading. The width to depth ratio indicates normal or abnormal channel width conditions. Width-to-depth condition was rated as high, with the exception of R2A which rated as normal. Using the system outlined by Rosgen (1996), the stream conditions were determined to be poor for all reaches.

The BEHI assessment methodology was utilized to develop streambank erodibility ratings. This assessment evaluates the bank/bankfull height ratio, rooting depth, root density, bank angle, and the percent of the bank protected by vegetation. The BEHI ratings for the LWO reaches were rated as extreme, with the exception of R1 being rated as very high and R2B rated as high. The combined total estimated sediment loss for the LWO Site is at 2,209 tons/year.

The NBS methodology is used to develop a quantitative prediction of stream bank erosion rates and their relative contribution to the total bedload transported by a stream. The NBS adjective rating was determined using NBS Method No. 5 for each reach. The NBS adjective ratings were identified as low for most of the reaches. The exceptions were R1A and R2D which were rated as high and R1B rated as moderate.

### 3.5 Bankfull Verification

Prior to surveying the existing channel, Mulkey used the North Carolina Regional Curves developed by the Stream Restoration Institute (SRI) to predict the approximate stream dimensions for each reach. Because the Site is located in the mountains physiographic province, but very near the border between the Mountains and Piedmont physiographic province, the regional curves for both were used for bankfull verification. During the establishment of cross section locations, Mulkey utilized stream dimensions and field observations to verify bankfull parameters for each reach. Following field surveys of the existing channel, data for each cross section was computed and plotted against the North Carolina Regional Curves for the Piedmont and Mountain Physiographic Regions. In each case, the data fell within the 95% confidence interval for the Piedmont and Mountain curves.

### 3.6 Vegetation

The existing riparian buffers for the LWO Site range from almost non-existent to a very narrow buffer of scattered trees. There are isolated locations along this reach where the riparian buffer is somewhat wider, but direct access for cattle remains available throughout most of the entire reach of this stream. Cattle intrusion and the lack of adequate riparian buffer to provide sufficient bank stability have resulted in severe bank erosion and associated sedimentation and loss of riparian vegetation along each of the sub-reaches.

The vegetation within the proposed conservation easement areas at the Site is separated into two major groupings. These groupings are based primarily on topographical position and current land use. The first grouping covers the sparsely distributed riparian vegetation found adjacent to the existing streams at the Site.

The dominant species in these areas includes tulip poplar (*Liriodendron tulipifera*), American sycamore (*Platanus occidentalis*), river birch (*Betula nigra*), red maple (*Acer rubrum*), tag alder (*Alnus serrulata*), silky dogwood (*Cornus amomum*), hackberry (*Celtis laevigata*), eastern red cedar (*Juniperus virginiana*), black walnut (*Juglans nigra*), honey locust (*Gleditsia triacanthos*), green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), blackberry (*Rubus* spp.), giant cane (*Arundinaria gigantea*), black willow (*Salix nigra*), elderberry (*Sambucus canadensis*), greenbrier (*Smilax* spp.), honeysuckle (*Lonicera japonica*), and multiflora rose (*Rosa multiflora*).

The second grouping includes areas within the open pastures at the Site. The dominant species in these areas includes fescue (*Festuca* spp.), broomsedge (*Andropogon virginicus*), multiflora rose (*Rosa multiflora*), greenbrier (*Smilax* spp.), blackberry (*Rubus* spp.), and various other grasses and forbs. Wetter areas in the existing pastures were dominated by various rushes (*Juncus* spp.) and sedges (*Carex* spp.)

## 4.0 Reference Stream

Using topographic software, Mulkey staff identified multiple streams within a 7 to 12 mile radius from the Site. Onsite visits were made to approximately 50 stream reaches. Of the 50 reaches examined, Mulkey identified one stream approximately 5 miles northwest of the Site suitable to be used as a reference reach for the LWO Site. The Unnamed Tributary to Ostin Creek (UT to Ostin Creek) is located north of White Oak Mountain and obtains its watershed from Piney Mountain. (Figure 5)

### 4.1 Watershed Characterization

The watershed for the UT to Ostin Creek appears to be more than 90% forested with the remaining 20% in open land. It appears that the open land may be a result of a recent timber harvest within the watershed. While the majority of the watershed appears to be mature stands of timber, there are some indications in the stream condition itself that may indicate timbering within the watershed could have occurred in the past. For instance, while the stream data collected does indicate stream stability, remnant bank features indicate the potential for stream transition in the past. The measured drainage area for the reference reach section evaluated is 554.88 acres (0.87 square miles). (Figure 6)

### 4.2 Channel Classification

Ostin Creek is classified as a C 4/1 according to Rosgen classification of natural rivers (Rosgen, 1994, 1996). The bankfull width was calculated at 20.6 feet with a mean depth of 1.62 feet. The width-to-depth ratio was calculated to be 12.72 and the entrenchment ratio was determined to be 3.53. The UT to Ostin Creek reach was determined to have a moderate to high sinuosity which was calculated to be 1.46.

### 4.3 Discharge (Bankfull, Trends)

Mulkey surveyed representative stream cross sections and calculated drainage areas for each for the reference reach stream. This data was used to determine various bankfull parameters, including cross sectional area, width, mean depth and discharge. These parameters for the reference reach were compared to the North Carolina Regional Curves for the Piedmont and Mountain Physiographic Regions compiled by SRI. In each case, the data fell within the 95% confidence intervals for the Piedmont and Mountain Curves.

### 4.4 Channel Morphology (Pattern, Dimension, and Profile)

Reference reach quality streams are very limited in this area. Development, timber management, and agricultural practices have impacted many of the once stable stream systems. Many of the streams evaluated exhibited characteristics of aggradation, lack of channel bed diversity, and bank instability. The UT to Ostin Creek stream channel exhibited expected natural bed features, including deep pools in bends and wide shallow riffles within straightway areas. The reference reach was surrounded by a mature hardwood buffer and exhibited a wide range of horizontal geometric features, including radii of curvature, belt width, and meander wavelength.

## 4.5 Channel Stability Assessment

Stream stability assessment methodology included the use of Pfankuch, BEHI, and NBS evaluation processes. Assessments were completed at a location within the reach, which most represented the majority of the stream footage within the reach.

Mulkey completed the Pfankuch assessment for the UT to Ostin Creek site. The sediment supply assessment was rated as low. The stream bed stability was identified as stable. Width to depth condition was rated as normal. Using the guidelines provided, the overall stream condition was noted as good for the evaluated reach.

The BEHI assessment methodology was utilized to develop streambank erodibility ratings. This assessment evaluates the bank/bankfull height ratio, rooting depth, root density, bank angle, and the percent of the bank protected by vegetation. The BEHI ratings for the UT to Ostin Creek were moderate. The combined total sediment loss for the reference reach site is estimated at 41.3 tons/year.

The NBS methodology is used to develop a quantitative prediction of stream bank erosion rates and their relative contribution to the total bedload transported by a stream. The NBS adjective rating was determined as high for the reference stream using NBS Method No. 5.

## 4.6 Bankfull Verification

During field investigations, Mulkey compared the surveyed bankfull parameters with the North Carolina Regional Curves for the Piedmont and Mountain Physiographic Regions for verification of correct bankfull identification. Following field investigations, Mulkey rechecked the collected data against the North Carolina Regional Curves for the Piedmont and Mountain Physiographic Regions and found each surveyed bankfull cross sectional area fell within the 95% confidence interval for the Piedmont and Mountain Regional Curve.

## 4.7 Vegetation

During the reference reach survey, vegetative species within the riparian area were noted. The buffer consisted of Eastern white pine (*Pinus strobus*), red maple (*Acer rubrum*), American beech (*Fagus grandifolia*), white oak (*Quercus alba*), tulip tree (*Liriodendron tulipifera*), yellowroot (*Xanthorhizza simplicissima*), sourwood (*Oxydendrum arboretum*), hazel nut (*Corylus americana*), Virginia pine (*Pinus virginiana*), green ash (*Fraxinus pennsylvanica*), hickory (*Carya sp.)*, bigleaf snowbell (*Styrax grandifolius*), Eastern red cedar (*Juniperus virginiana*), American hornbeam (*Carpinus caroliniana*), American sycamore (*Platanus occidentalis*), small carpgrass (*Arthraxon hispidus*), river birch (*Betula nigra*), common persimmon (*Diospyros virginiana*), and eastern hemlock (*Tsuga canadensis*). The understory consisted primarily of giant cane (*Arundinaria gigantea*), highland doghobble (*Leucothoe fontanesiana*), and greenbrier (*Smilax spp*). (Figure 8)

# 5.0 <u>Project Site Restoration Plan</u>

## 5.1 Restoration Project Goals and Objectives

The goal of the Little White Oak Creek Stream Restoration Site are as follows:

- To improve water quality for the project stream reaches, as well as downstream reaches
- To reduce the rate of bank erosion along the project stream reaches
- To better attenuate flood flows

- To enhance wildlife habitat at the project site

Theses goal will be met through the following objectives:

- By using natural channel design to restore stable pattern, dimension, and profile for the project stream reaches
- By reestablishing a flood plain or connecting the stream back to its historic floodplain, or a combination of both, for each project stream reach
- By creating or restoring floodplain features such as vernal pools, off channel ponds, or riparian wetlands
- By increasing the amount of instream habitation through the addition of rock and wood structures, the
- By re-establishing a more natural riparian buffer, thereby reintroducing shading, cover areas, and travel corridors.

How these goals will be met through the described objectives are discussed in more detail in the following paragraphs.

The goal of improving water quality will be accomplished by meeting two objectives: first, by reducing sedimentation, and second by restoring riparian buffers. Restoring stable stream pattern, dimension, and profile will reduce sedimentation to the stream by preventing the mass wasting of stream banks currently prevalent at the Site. All of the stream restoration design and construction will follow methodologies consistent with natural channel design. Our proposed restoration plan includes re-establishing a floodplain and forested riparian buffer which will both provide an area of filtration for surface and ground water from the adjacent, heavily grazed pastures. The floodplain will be re-established by raising the existing streambed elevation in order to reconnect the streams to their historic floodplains, or in the cases where this is not feasible due to site constraints, through the construction of bankfull benches. By reconnecting the streams to their original floodplains or by creating improved floodplains through bankfull bench construction, the streams are provided a much larger area to attenuate flood flows. The sections of abandoned channel that will be left open and modified to create vernal pools, off channel ponds, or riparian wetlands will also provide additional flood storage.

The second goal will be to enhance instream and terrestrial wildlife habitat and will be achieved by increasing the amount and quality of habitat within the stream and within the riparian buffer. The existing condition of the streams and riparian buffers at the site provide limited available habitat for aquatic and terrestrial species in and around the stream. The objective is to utilize the proposed restoration site to enhance habitat within the stream by restoring natural channel stability and through the introduction of in-stream boulder and wood structures. The restoration of a forested riparian buffer will also provide stream shading, as well as cover areas and travel corridors that are vital for traveling, foraging, loafing and nesting for many wildlife species. The Site provides an excellent opportunity to restore and preserve a substantial riparian zone on lands that are currently being used for pasture. The riparian buffers, at least 50 feet in width, will be established along both sides of all of the streams at the Site. These buffers will be fenced to prevent future cattle intrusion.

#### 5.1.1 Designed Channel Classification

The Ostin Creek reference reach was used to design each of the project stream reaches. This reference reach classifies as a C 4/1 stream type according to Rosgen classification of natural rivers (Rosgen, 1994, 1996). The design of each project stream reach was based on the dimensionless ratios developed from the morphological data collected for the reference reach. This resulted in each project stream reach being designed as a C stream type. Entrenchment ratios proposed for each project stream reach exceed 2.2 in all instances. An average width to depth ratio of 12.7 was used for each reach. The design for each stream reach was developed with a target sinuosity of 1.3, lower than the reference reach sinuosity of 1.46. The proposed slope for each project stream reach varied from reach to reach, dependant upon various valley and site constraints, ranging from 0.149 percent to 1.14 percent. The ends of the unnamed tributaries have transition slopes of nearly 2 percent where they tie back into the main channels at their downstream ends. All of the above parameters are typical of those associated with C stream types.

All of this data is summarized for each project stream reach in the included morphological tables. The bankfull width was calculated at 20.6 feet with a mean depth of 1.62 feet. The width-to-depth ratio was calculated to be 12.72 and the entrenchment ratio was determined to be 3.53. The UT to Ostin Creek reach was determined to have a moderate to high sinuosity which was calculated to be 1.46.

5.1.2 Target Buffer Communities

The target buffer communities will be comprised of plants that naturally occur in this physiographic province and within a specific hydrologic setting. The target community will be indicative of the Piedmont/Low Mountain Alluvial Forest described by Shafale and Weakley (1990). The Little White Oak Stream Restoration Planting Plan will include the following:

**Zone 1**
**Stream Banks (6)**
Silky dogwood (*Cornus amomum*)
Silky willow (*Salix sericea*)
Black willow (*Salix nigra*)
Buttonbush (*Cephalanthus occidentalis* )
Tag alder (*Alnus serrulata*)
Cottonwood (*Populus deltoides*)

**Zone 2**
**Riparian Species (13)**
American elm (*Ulmus americana*)
White ash (*Fraxinus americana*)
Silky dogwood (*Cornus amomum*)
Ironwood (*Carpinus caroliniana*)
Buttonbush (*Cephalanthus occidentalis* )
Spicebush (*Lindera benzoin*)
Tag alder (*Alnus serrulata*)
Sycamore (*Plantanus occidentalis*)
River birch (*Betula nigra*)
Cottonwood (*Populus deltoides*)
American hazelnut (*Corylus americana)*
Swamp chestnut oak (*Quercus michauxii*)
Elderberry (*Sambucus canadensis*)

**Zone 3**
**Wetland Species (6)**
Silky dogwood (*Cornus amomum*)
Silky willow (*Salix sericea*)
Black willow (*Salix nigra*)
Buttonbush (*Cephalanthus occidentalis* )
Tag alder (*Alnus serrulata*)
Elderberry (*Sambucus canadensis*)

**Zone 4**
**Upland species (15)**
Eastern white pine (*Pinus strobus*)
Shortleaf pine (*Pinus echinata*),
Virginia Pine (*Pinus virginiana*)
White oak (*Quercus alba*)
Southern red oak (*Quercus falcata*)
Post oak (*Quercus stellata*)
Eastern red cedar (*Juniperus virginiana*),
Common persimmon (*Diospyros virginiana*),
Black walnut (*Juglans nigra*)
Mockernut hickory (*Carya tomentosa*)
Pignut hickory (*Carya glabra*)
American holly (*Ilex opaca*)
Flowering dogwood (*Cornus florida*)
Black walnut (*Juglans nigra*)
American beech (*Fagus grandifolia*)

## 5.2 Sediment Transport Analyses

Sediment plays a major role in the influence of channel stability and morphology (Rosgen, 1996). A stable stream has the capacity to move its sediment load without aggrading or degrading. Sediment analyses are generally divided into measurements of bedload and suspended sediment (washload), changes in sediment storage, size distributions and source areas. Washload is normally composed of fine sands, silts and clay transported in suspension at a rate that is determined by availability and not hydraulically controlled. Bedload is transported by rolling, sliding, or hopping (saltating) along the bed. At higher discharges, some portion of the bedload can be suspended, especially if there is a sand component in the bedload. Bed material transport rates are essentially controlled by the size and nature of the bed material and hydraulic conditions (Hey and Rosgen, 1997).

Two measures are used to calculate sediment loads for natural channel design projects: (1) sediment transport competency and (2) sediment transport capacity. Competency is a stream's ability to move particles of a given size. It is expressed as a measure of force ($lbs/ft^2$). Capacity is a stream's ability to move a quantity of sediment and is a measurement of stream power, expressed in units of lbs/ft•sec. A competence analysis was conducted for the project stream reaches, where reliable measurements and sampling could be conducted, to ensure that the designed stream beds do not aggrade or degrade during bankfull conditions. Brief description of the analyses conducted for the project is presented in the following sub-section.

### 5.2.1 Methodology

The critical dimensionless shear stress ($\tau^*_{ci}$) is the measure of force required to initiate general movement of particles in a bed of a given composition. This calculation is part of several calculations used to determine aggradation/degradation along the stream channel. For shear stresses exceeding this critical value, essentially all grain sizes are transported at rates in proportion to their presence in the bed (Wohl, 2000). For gravel-bed streams, the critical dimensionless shear stress is generally calculated using surface and subsurface particle samples from representative riffle sections. The critical dimensionless shear stress calculation is presented below.

$$\tau^*_{ci} = 0.0834\,(d_i/d_{50})^{-0.872}$$

where,

$\tau^*_{ci}$ = critical dimensionless shear stress ($lbs/ft^2$)

$d_i$ = median particle size of riffle bed surface (mm)

$d_{50}$ = median particle size of subsurface sample (mm)

Note that $d_i$ and $d_{50}$ values were empirically determined by *in situ* measurements.

Based on the reach classification pebble counts, each of the project stream reaches classified as sand bed streams (d50 of the stream bed material between 0,062 mm and 2.0 mm), except for reach R2A, which classified as a gravel bed stream (d50 of the bed material between 2.0 mm and 64 mm). We expect that the bed materials for each of the streams will coarsen as a result of the reduction of fine sediment as the rate of bank erosion is significantly reduced by the restoration project. Although the above-described project stream reaches classified as sand bed streams, each of the reaches had representative riffles with gravel material where pavement and subpavement samples could be taken. Each of these riffles had medium to large gravel particles on the surface. These gravel particles are presumably moved during bankfull events, meaning that using the results of a pavement and subpavment sample from these riffles to conduct an entrainment analyses is a legitamate analyses of sediment competency.

The shear stress placed on the sediment particles is the force that entrains and moves the particles. The critical shear for the proposed channel has to be sufficient to move the $D_{84}$ of the bed material. The critical shear stress was calculated and plotted on the Modified Shield's curve to determine the approximate size of particles that will be moved (Rosgen, 2001).

5.2.2 Calculations and Discussion

Existing and proposed entrainment calculations for each reach are included in Appendix 5. Calculations of critical depth and slope are required and are included in these calculations. Each of the existing project stream reaches exhibited excessive shear, and thus are considered degrading systems. The proposed designs for each reach were developed with the goal of reducing shear stress within the parameters of the reference reach data and the site constraints. Driven by this goal, the slope of each reach was flattened by increasing the sinuosity, and thus the length. In conjunction with changing the slope of each reach, the dimension was also corrected, within the limits dictated by the proposed width to depth ratio, for each to better match that expected for a stable stream. Although it was not possible to completely reduce the shear stresses to the desired value for each reach, significant reduction of the existing shear stress was made in each case. The design channel is predicted to remain stable over time based on the establishment of proper dimension, pattern and profile and an active floodplain. The establishment of riparian vegetation will further enhance the long term stability of the entire system.

**5.3 HEC-RAS Analysis**

5.3.1 No-rise, LOMR, CLOMR

Polk County is one of the areas within the State of North Carolina undergoing the remapping process by the North Carolina Floodplain Mapping Program. Therefore, the current effective map for The Little White Oak Creek Site is the Flood Hazard Boundary Map, Community-Panel Number 370194 0004 A dated May 19, 1978 (see appendix). As depicted by this map, the Little White Oak Creek Site falls within a FEMA Zone A designation meaning the area is subject to the 100-year flood but no Base Flood Elevations (BFEs) or floodways have been determined. Given this Zone A designation, a No-Rise Certification is sufficient in providing evidence for a no rise event of the 100-year storm event associated with the restoration of Little White Oak Creek and it's tributaries.

The approximate limits of flooding for the existing and proposed channels were determined using the Hydrologic Engineering Center's River Analysis System (HEC-RAS) software, version 3.1.3, provided by the US Army Corps of Engineers. Water surface profiles for existing and proposed conditions during the 10-year, 50-year, 100-year, and 500-year storm events were computed and compared as shown in Appendix 5. The tables are arranged to show the discharge (Q) and the comparison of existing and proposed water surface elevations at each cross section with a positive difference indicating a water surface drop from existing to proposed conditions. The 100-year event demonstrates an average drop of 1.26ft, ranging from 0.00ft to 3.41ft. These values for the 100-year event are within the acceptable limits of the No Rise Certification given the Zone A designation.

5.3.2 Hydrologic Trespass

HEC/RAS analysis was completed and it was determined that the proposed restoration will result in a "no-rise" of the streams within the project area. Based upon the modeling that Mulkey has reviewed, it is not anticipate any hydrologic trespass issues during or after restoration of the Site.

## 5.4 Stormwater Best Management Practices

### 5.4.1 Narrative of Site-Specific Stormwater Concerns

Adjacent land uses to the conservation easement at the LWO Site include pasture, forest land, and NC DOT Right of Ways. Mulkey will identify areas of potential concentrated flow from areas of the adjacent to the easement that enter the project area. These areas will be addressed through multiple measures depending on the Site specific conditions.

### 5.4.2 Device Description and Application

Vernal pools and/or oxbow ponds will be used to capture concentrated overland flow and provide energy dissipation and treatment of stormwater prior to entering the stream. These pools will serve as small wetland pockets which will also provide additional habitat for amphibians.

When feasible and agreeable with the landowner, Mulkey will eliminate concentrated flow areas by filling and regarding to provide sheet flow into the riparian buffer. Soil excavated from the restoration channel will be used in these areas and stabilized. These efforts will also provide some valley restoration for the streams being restored. There are currently areas in which hydrology has been removed from historic berming of the channel and rutting within the pasture areas.

## 5.5 Soil Restoration

The majority of the stream restoration activities to be completed within the Little White Oak project will be accomplished by utilizing Priority 2 stream methodologies. This methodology creates a floodplain at the bankfull elevation which is below existing grade. Once the floodplain bench is graded, the remaining subsoil will require amendments and cultural practices to encourage plant growth. To enhance the soil medium to be planted, topsoil previously removed from the construction area will be spread throughout the floodplain. Through ripping or disking topsoil will be incorporated along with soil amendments to prepare the planting medium.

### 5.5.1 Soil Preparation and Amendment

Prior to excavation of the channel and floodplain areas, topsoil will be stripped to the depths that are encountered to prevent intermingling with underlying subsoil or other waste materials. Prior to stripping the topsoil, sod and grass will be removed. Topsoil will be stockpiled away from the edge of excavations. Measures will be taken to control potential erosion from stockpile areas. Once final grading has been completed, excavated areas will be scarified to a depth of at least 6” to loosen the soil. Salvaged topsoil will be placed and spread evenly to a depth of at least 3”of topsoil materials. Prior to completing final grade, lime and fertilizer will be added to the soil as an amendment to enhance the soil medium to a level suitable for plant growth and development.

## 5.6 Natural Plant Community Restoration

Within the LWO Site, much of the riparian zone has been denuded by livestock, dredging, and bank erosion. Restoration of the natural plant community will be four fold: 1) implementing a stream design while remaining cognizant of existing trees and retaining existing trees when possible; 2) establishing woody vegetation within the riparian corridor to restore the buffer; 3) eliminating invasive species; and 4) fencing livestock from all restored areas to eliminate their impact within the riparian zone.

5.6.1 Plant Community Restoration

Mulkey has evaluated multiple plant communities within stream corridors near the Site, including the plant community within the buffer of the Ostin Creek reference reach and has used these evaluations in the development of the planting plan for the Site. The planting plan for the riparian and upland buffers of the LWO Site will provide post-construction erosion control and riparian habitat enhancement. The planting plan will also attempt to blend existing vegetative communities into recently restored areas. Plantings in the buffer areas will include native species appropriate for the Piedmont/Mountain physiographic province and the LWO Site. Native species plants will be used exclusively for all Site plantings. Plants within the floodplain will be flood tolerant species to accommodate periodic flooding events throughout the year. A variety of trees and shrubs will be planted to provide cover and habitat for wildlife as well as soil stabilization.

Shrubs and trees with extensive, deep rooting systems will assist in stabilizing the banks in the long term. Native grasses, transplants, and live stakes will be utilized at the Site for immediate stabilization in conjunction with the erosion control matting along the newly created stream banks. Vegetation will be planted in a random fashion in an effort to mimic natural plant communities. Colonization of local herbaceous vegetation will inevitably occur, which will provide additional stream stability.

Shrubs will be planted in staggered rows on the upslope of random eight-foot centers. Trees will be planted as bare root stock on random eight-foot centers at a frequency of 680 stems per acre. Planting of species will utilize dormant plant stock and will be performed to the extent practicable between December 1 and March 15.

Tree and shrub species will be planted in specific planting zones. These planting zones will accommodate plant species which have specific requirements for growth. Hydrology and topography are the main factors that dictate a plant's ability to survive and to thrive following planting. These planting zones will be created around these requirements and will include the following zones: Zone 1 (Stream Banks), Zone 2 (Riparian Buffer), Zone 3 (Wetlands), and Zone 4 (Upland Buffers). A list of species in each Zone can be found in Table 7.

5.6.2 On-site Invasive Species Management

Invasive and exotic species will be identified and removed during clearing and grubbing of the Site. These species will be destroyed in a manner which will not allow propagation from the parent plant. Further control of the invasive and exotic species will be done on an as-needed basis following construction with either herbicide application and/or through mechanical removal.

## 6.0 Performance Criteria

### 6.1 Streams

Success criteria for stream mitigation sites are based on guidelines established by the USACE, US Environmental Protection Agency (USEPA), NC Wildlife Resources Commission (NCWRC) and the NCDWQ (USACE *et. al,* 2003). These guidelines establish criteria for both hydrologic conditions and vegetation survival.

Stream channel monitoring will determine the degree of success a mitigation project has achieved in meeting the objectives of providing proper channel function and increased habitat quality. Monitoring will be performed each year for the 5-year monitoring period and no less than two bankfull flow events must be documented within the monitoring period, with each of the bankfull events occurring during separate monitoring years. In the event that the required bankfull events do not occur during the 5-year period, consultation with EEP and other resource agencies will be conducted. The monitoring will include reference photos and channel stability analyses, as specified in the Ecosystem Enhancement Program "Content, Format and Data Requirements for EEP Monitoring Reports, Version 1.1, and dated 09/15/05.

The Mulkey Team will evaluate the restored sections of the Site in regard to overall channel stability. Since streams are considered as "active" or "dynamic" systems, restoration is achieved by allowing the channel to develop a stable dimension, pattern, and profile such that, over time, the stream features (riffle, run, pool, glide) are maintained and the channel does not aggrade or degrade. Minor morphologic adjustments from the design stream are anticipated based on the correlation of reference reach data, excessive sediment deposition from upstream sources, and on-going changes in land use within the watershed.

Monitoring of the Little White Oak Creek Stream Restoration Site will be performed until success criteria are met up to a period of five years. Monitoring is proposed for hydrology stream stability and vegetation. The monitoring plan will be designed in accordance with Stream Mitigation Guidelines (USACE *et. al,* 2003) and in coordination with EEP. Results will be documented on an annual basis, with the associated reports submitted to EEP as evidence that goals are being achieved.

**6.2 Vegetation**

Vegetation success at the mitigation site will be measured for survivability over a five year monitoring period. Survivability will be based on achieving at least 320 stems per acre after three years and 260 stems per acre after five years. A survey of vegetation during the growing season (mid-March to early November) will be conducted annually over the five year monitoring period in order to verify survivability of the installed plantings. This survey will track the total mortality on an annual basis and be used to calculate survivability at the end of three and five years. Survivability of less than 320 stems/acre at the end of three years and less than 260 stems/acre at the end of five years may require the installation of additional plantings as replacement for the mortality. Vegetation monitoring protocols will be included in the restoration plans and will be developed through on-going coordination with EEP.

**6.3 Schedule / Reporting**

Mulkey will initiate requests for permits from the USACE, DWQ, and Land Quality Section to begin construction of the Site once this restoration plan is approved by NCEEP. As soon as permits are issued, Mulkey will begin construction of the proposed stream.

It is anticipated that it will take approximately 1 year to complete the stream restoration activities and planting. Mulkey anticipates completion by June 2008.

## 7.0 References


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| Table 1. Project Restoration Structure and Objectives<br>Project Number D06027-B (Little White Oak Creek Stream Restoration) | | | | | | |
|---|---|---|---|---|---|---|
| **Restoration Segment/ Reach ID** | **Station Range** | **Restoration Type** | **Priority Approach** | **Existing Linear Footage** | **Designed Linear Footage*** | **Comment** |
| R1 | 0+00-76+43 | Restoration | P2 | 6530 | 7643 | Restore pattern, dimension, and profile through the reach. |
| R1A | 0+00-12+25 | Restoration | P1/P2 | 906 | 1225 | Restore pattern, dimension, and profile through the reach. |
| R2 Upper | 0+00-51+46 | Restoration | P2 | 3982 | 5146 | Restore pattern, dimension, and profile through the reach. |
| R2 Lower | 51+46-73+37 | Restoration | P2 | 1996 | 2191 | Restore pattern, dimension, and profile through the reach. |
| R2A | 0+00-3+79 | Restoration | P2 | 287 | 379 | Restore pattern, dimension, and profile through the reach. |
| R2B | 0+00-16+54 | Restoration | P1/P2 | 1237 | 1654 | Restore pattern, dimension, and profile through the reach. |
| R2D | 0+00-8+60 | Restoration | P1/P2 | 549 | 860 | Restore pattern, dimension, and profile through the reach. |

*This measurement includes permanent stream crossings not counted in the total footage for mitigation.

| Table II. Drainage Areas<br>Project Number D06027-B (Little White Oak Creek Stream Restoration) | |
|---|---|
| | |
| **Reach** | **Drainage Area (Acres)** |
| R1 Upper | 2785.00 |
| R1 Lower | 2852.68 |
| R1A | 67.39 |
| R1B | 32.80 |
| R2 Upper | 3966.91 |
| R2 Lower | 6944.59 |
| R2A | 345.04 |
| R2B | 74.05 |
| R2C | 63.83 |
| R2D | 31.65 |
| **Total** | **6944.59** |

| Table III. Land Use of Watershed | | |
|---|---|---|
| **Project Number D06027-B (Little White Oak Stream Restoration)** | | |
| **Land Use** | **Acreage** | **Percentage** |
| Transitional | 8 | 1.3% |
| Deciduous Forest | 3 | 0.4% |
| Evergreen Forest | 99 | 15.3% |
| Mixed Forest | 298 | 46.1% |
| Pasture/Hay | 238 | 36.7% |
| Row Crops | 2 | 0.2% |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| | | Existing Channel | | Proposed Reach | | Reference Reach |
| Variables | NAME | R1 | | R1 | | UT to Ostin Creek |
| 1. Stream Type | | Degraded E5 | | C5 | | C4/1 |
| 2. Drainage Area, sq. mi (acres) | | 4.46(2854.4) | | 4.46(2854.4) | | 0.867(554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 18.43 | | | Mean: | 18.52 |
| | Minimum: | 16.55 | Mean: | 25.70 | Minimum: | 15.97 |
| | Maximum: | 20.31 | | | Maximum: | 20.60 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 3.32 | | | Mean: | 1.64 |
| | Minimum: | 3.20 | Mean: | 2.02 | Minimum: | 1.58 |
| | Maximum: | 3.43 | | | Maximum: | 1.72 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 5.55 | | | Mean: | 11.34 |
| | Minimum: | 5.17 | Mean: | 12.70 | Minimum: | 9.28 |
| | Maximum: | 5.92 | | | Maximum: | 12.72 |
| 6. Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 61.33 | | | Mean: | 30.25 |
| | Minimum: | 52.94 | Mean: | 52.00 | Minimum: | 27.41 |
| | Maximum: | 69.72 | | | Maximum: | 33.37 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 4.4 | Mean: | 5.2 | Mean: | 4.2 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 271 | Mean: | 271 | Mean: | 128 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 3.69 | Mean: | 2.34 | Mean: | 1.90 |
| | Minimum: | 2.37 | Minimum: | 1.90 | Minimum: | 1.54 |
| | Maximum: | 5.00 | Maximum: | 2.91 | Maximum: | 2.36 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.11 | Mean: | 1.16 | Mean: | 1.16 |
| | Minimum: | 0.71 | Minimum: | 0.94 | Minimum: | 0.94 |
| | Maximum: | 1.51 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 2.20 | Mean: | 1.00 | Mean: | 1.23 |
| | Minimum: | 1.52 | Minimum: | 1.00 | Minimum: | 1.01 |
| | Maximum: | 2.95 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 94.09 | Mean: | 98.41 | Mean: | 70.18 |
| | Minimum: | 69.59 | Minimum: | 90.79 | Minimum: | 67.15 |
| | Maximum: | 118.58 | Maximum: | 113.62 | Maximum: | 72.78 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 5.02 | Mean: | 3.83 | Mean: | 3.83 |
| | Minimum: | 4.20 | Minimum: | 3.53 | Minimum: | 3.53 |
| | Maximum: | 5.84 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. Meander Length, ft (Lm) | Mean: | 135.70 | Mean: | 130.41 | Mean: | 94.00 |
| | Minimum: | 107.00 | Minimum: | 45.78 | Minimum: | 33.00 |
| | Maximum: | 189.30 | Maximum: | 215.04 | Maximum: | 155.00 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 7.36 | Mean: | 5.07 | Mean: | 5.07 |
| | Minimum: | 5.81 | Minimum: | 1.78 | Minimum: | 1.78 |
| | Maximum: | 10.27 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 37.70 | Mean: | 67.98 | Mean: | 49.00 |
| | Minimum: | 23.40 | Minimum: | 26.36 | Minimum: | 19.00 |
| | Maximum: | 63.80 | Maximum: | 159.54 | Maximum: | 115.00 |
| 17. Ratio of Radius of Curvature to Bankfull Width (Rc/Wbkf) | Mean: | 2.05 | Mean: | 2.65 | Mean: | 2.65 |
| | Minimum: | 1.27 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 3.46 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. Belt Width, ft (Wblt) | Mean: | 39.80 | Mean: | 92.95 | Mean: | 67.00 |
| | Minimum: | 22.00 | Minimum: | 49.94 | Minimum: | 36.00 |
| | Maximum: | 61.60 | Maximum: | 208.10 | Maximum: | 150.00 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 2.16 | Mean: | 3.62 | Mean: | 3.62 |
| | Minimum: | 1.19 | Minimum: | 1.94 | Minimum: | 1.94 |
| | Maximum: | 3.34 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. Low Bank Height, ft (LBH) | Mean: | 7.68 | Mean: | 2.34 | Mean: | 2.30 |
| | Minimum: | 6.32 | Minimum: | 1.90 | Minimum: | 2.09 |
| | Maximum: | 8.90 | Maximum: | 2.91 | Maximum: | 2.67 |
| 21. Sinuosity (K) | Mean: | 1.16 | Mean: | 1.17 | Mean: | 1.46 |
| 22 Valley Slope (VS) | Mean: | 0.00330 | Mean: | 0.00330 | Mean: | 0.01310 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.00284 | Mean: | 0.00282 | Mean: | 0.00897 |
| 24. Pool Slope (Sp) | Mean: | 0.00168 | Mean: | 0.00038 | Mean: | 0.00120 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00548 | Maximum: | 0.00136 | Maximum: | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.59 | Mean: | 0.13 | Mean: | 0.13 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 1.93 | Maximum: | 0.48 | Maximum: | 0.48 |

**Table IV. Morphological Table**
**Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)**

| Variables | | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|
| | NAME | R1 | | R1 | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.01046 | Mean: | 0.00892 | Mean: | 0.02837 |
| | Minimum: | 0.00123 | Minimum: | 0.00199 | Minimum: | 0.00632 |
| | Maximum: | 0.11709 | Maximum: | 0.02059 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 3.68 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.43 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 41.16 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00433 | Mean: | 0.00762 | Mean: | 0.02423 |
| | Minimum: | 0.00051 | Minimum: | 0.00284 | Minimum: | 0.00903 |
| | Maximum: | 0.01120 | Maximum: | 0.02484 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 1.52 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.18 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 3.94 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00371 | Mean: | 0.00102 | Mean: | 0.00325 |
| | Minimum: | 0.00179 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00585 | Maximum: | 0.00410 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 1.30 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.63 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 2.06 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 4.70 | Mean: | 3.55 | Mean: | 2.88 |
| | Minimum: | 3.50 | Minimum: | 2.68 | Minimum: | 2.17 |
| | Maximum: | 6.60 | Maximum: | 4.10 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 1.42 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 1.06 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 1.99 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 4.13 | Mean: | 2.89 | Mean: | 2.34 |
| | Minimum: | 2.69 | Minimum: | 2.73 | Minimum: | 2.21 |
| | Maximum: | 5.79 | Maximum: | 3.36 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 1.25 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 0.81 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 1.75 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 4.20 | Mean: | 2.59 | Mean: | 2.10 |
| | Minimum: | 2.72 | Minimum: | 2.09 | Minimum: | 1.69 |
| | Maximum: | 5.48 | Maximum: | 3.13 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 1.27 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 0.82 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 1.65 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 25.56 | Mean: | 21.26 | Mean: | 15.33 |
| | Minimum: | 25.37 | Minimum: | 16.80 | Minimum: | 12.11 |
| | Maximum: | 25.74 | Maximum: | 26.22 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | 1.39 | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 1.38 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 1.40 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 86.54 | Mean: | 49.16 | Mean: | 28.59 |
| | Minimum: | 70.48 | Minimum: | 36.58 | Minimum: | 21.28 |
| | Maximum: | 102.59 | Maximum: | 66.74 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | 1.41 | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 1.15 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 1.67 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 140.94 | Mean: | 109.41 | Mean: | 78.86 |
| | Minimum: | 50.62 | Minimum: | 69.78 | Minimum: | 50.30 |
| | Maximum: | 402.57 | Maximum: | 146.84 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 7.65 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 2.75 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 21.84 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 39.34 | Mean: | 48.71 | Mean: | 35.11 |
| | Minimum: | 11.35 | Minimum: | 25.44 | Minimum: | 18.34 |
| | Maximum: | 87.94 | Maximum: | 87.22 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull Width (Lp/Wbkf) | Mean: | 2.13 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 0.62 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 4.77 | Maximum: | 3.39 | Maximum: | 3.39 |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| | | **Existing Channel** | | **Proposed Reach** | | **Reference Reach** |
| **Variables** | **NAME** | R1A | | R1A | | UT to Ostin Creek |
| 1. Stream Type | | Degraded B6c | | C5 | | C4/1 |
| 2. Drainage Area, sq. mi (acres) | | 0.11(70.4) | | 0.11(70.4) | | 0.867(554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 7.72 | | | Mean: | 18.52 |
| | Minimum: | 4.51 | Mean: | 7.97 | Minimum: | 15.97 |
| | Maximum: | 10.93 | | | Maximum: | 20.60 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 0.45 | | | Mean: | 1.64 |
| | Minimum: | 0.36 | Mean: | 0.63 | Minimum: | 1.58 |
| | Maximum: | 0.54 | | | Maximum: | 1.72 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 16.38 | | | Mean: | 11.34 |
| | Minimum: | 12.53 | Mean: | 12.70 | Minimum: | 9.28 |
| | Maximum: | 20.24 | | | Maximum: | 12.72 |
| 6. Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 3.74 | | | Mean: | 30.25 |
| | Minimum: | 1.62 | Mean: | 5.00 | Minimum: | 27.41 |
| | Maximum: | 5.85 | | | Maximum: | 33.37 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 5.3 | Mean: | 3.9 | Mean: | 4.2 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 20 | Mean: | 20 | Mean: | 128 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 0.86 | Mean: | 0.73 | Mean: | 1.90 |
| | Minimum: | 0.54 | Minimum: | 0.59 | Minimum: | 1.54 |
| | Maximum: | 1.18 | Maximum: | 0.90 | Maximum: | 2.36 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.91 | Mean: | 1.16 | Mean: | 1.16 |
| | Minimum: | 1.20 | Minimum: | 0.94 | Minimum: | 0.94 |
| | Maximum: | 2.62 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 3.70 | Mean: | 1.00 | Mean: | 1.23 |
| | Minimum: | 3.11 | Minimum: | 1.00 | Minimum: | 1.01 |
| | Maximum: | 4.30 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 13.83 | Mean: | 30.52 | Mean: | 70.18 |
| | Minimum: | 8.58 | Minimum: | 28.15 | Minimum: | 67.15 |
| | Maximum: | 19.07 | Maximum: | 35.23 | Maximum: | 72.78 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 1.82 | Mean: | 3.83 | Mean: | 3.83 |
| | Minimum: | 1.74 | Minimum: | 3.53 | Minimum: | 3.53 |
| | Maximum: | 1.90 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. Meander Length, ft (Lm) | Mean: | 0.00 | Mean: | 40.44 | Mean: | 94.00 |
| | Minimum: | 0.00 | Minimum: | 14.20 | Minimum: | 33.00 |
| | Maximum: | 0.00 | Maximum: | 66.68 | Maximum: | 155.00 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 0.00 | Mean: | 5.07 | Mean: | 5.07 |
| | Minimum: | 0.00 | Minimum: | 1.78 | Minimum: | 1.78 |
| | Maximum: | 0.00 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 0.00 | Mean: | 21.08 | Mean: | 49.00 |
| | Minimum: | 0.00 | Minimum: | 8.17 | Minimum: | 19.00 |
| | Maximum: | 0.00 | Maximum: | 49.47 | Maximum: | 115.00 |
| 17. Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 0.00 | Mean: | 2.65 | Mean: | 2.65 |
| | Minimum: | 0.00 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 0.00 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. Belt Width, ft (Wblt) | Mean: | 0.00 | Mean: | 28.82 | Mean: | 67.00 |
| | Minimum: | 0.00 | Minimum: | 15.49 | Minimum: | 36.00 |
| | Maximum: | 0.00 | Maximum: | 64.53 | Maximum: | 150.00 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 0.00 | Mean: | 3.62 | Mean: | 3.62 |
| | Minimum: | 0.00 | Minimum: | 1.94 | Minimum: | 1.94 |
| | Maximum: | 0.00 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. Low Bank Height, ft (LBH) | Mean: | 3.00 | Mean: | 0.73 | Mean: | 2.30 |
| | Minimum: | 2.32 | Minimum: | 0.59 | Minimum: | 2.09 |
| | Maximum: | 3.67 | Maximum: | 0.90 | Maximum: | 2.67 |
| 21. Sinuosity (K) | Mean: | 1.06 | Mean: | 1.35 | Mean: | 1.46 |
| 22 Valley Slope (VS) | Mean: | 0.01290 | Mean: | 0.01290 | Mean: | 0.01310 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.01217 | Mean: | 0.00956 | Mean: | 0.00897 |
| 24. Pool Slope (Sp) | Mean: | 0.00000 | Mean: | 0.00128 | Mean: | 0.00120 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00000 | Maximum: | 0.00461 | Maximum: | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.00 | Mean: | 0.13 | Mean: | 0.13 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.00 | Maximum: | 0.48 | Maximum: | 0.48 |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| Variables | | Existing Channel | | Proposed Reach | | Reference Reach |
| | NAME | R1A | | R1A | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.00000 | Mean: | 0.03021 | Mean: | 0.02837 |
| | Minimum: | 0.00000 | Minimum: | 0.00673 | Minimum: | 0.00632 |
| | Maximum: | 0.00000 | Maximum: | 0.06977 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 0.00 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.00 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 0.00 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00000 | Mean: | 0.02580 | Mean: | 0.02423 |
| | Minimum: | 0.00000 | Minimum: | 0.00962 | Minimum: | 0.00903 |
| | Maximum: | 0.00000 | Maximum: | 0.08415 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 0.00 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.00 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 0.00 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00000 | Mean: | 0.00346 | Mean: | 0.00325 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00000 | Maximum: | 0.01389 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 0.00 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.00 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 1.38 | Mean: | 1.10 | Mean: | 2.88 |
| | Minimum: | 1.11 | Minimum: | 0.83 | Minimum: | 2.17 |
| | Maximum: | 1.64 | Maximum: | 1.27 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 3.07 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 2.47 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 3.64 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 0.00 | Mean: | 0.90 | Mean: | 2.34 |
| | Minimum: | 0.00 | Minimum: | 0.85 | Minimum: | 2.21 |
| | Maximum: | 0.00 | Maximum: | 1.04 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 0.00 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 0.00 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 0.00 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 0.00 | Mean: | 0.80 | Mean: | 2.10 |
| | Minimum: | 0.00 | Minimum: | 0.65 | Minimum: | 1.69 |
| | Maximum: | 0.00 | Maximum: | 0.97 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 0.00 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 0.00 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 0.00 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 5.22 | Mean: | 6.59 | Mean: | 15.33 |
| | Minimum: | 3.64 | Minimum: | 5.21 | Minimum: | 12.11 |
| | Maximum: | 6.79 | Maximum: | 8.13 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | 0.68 | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 0.47 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 0.88 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 4.66 | Mean: | 4.73 | Mean: | 28.59 |
| | Minimum: | 4.62 | Minimum: | 3.52 | Minimum: | 21.28 |
| | Maximum: | 4.70 | Maximum: | 6.42 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | 1.25 | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 1.24 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 1.26 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 0.00 | Mean: | 33.93 | Mean: | 78.86 |
| | Minimum: | 0.00 | Minimum: | 21.64 | Minimum: | 50.30 |
| | Maximum: | 0.00 | Maximum: | 45.53 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 0.00 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 0.00 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 0.00 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 0.00 | Mean: | 15.10 | Mean: | 35.11 |
| | Minimum: | 0.00 | Minimum: | 7.89 | Minimum: | 18.34 |
| | Maximum: | 0.00 | Maximum: | 27.05 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 0.00 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 0.00 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 0.00 | Maximum: | 3.39 | Maximum: | 3.39 |

## Table IV. Morphological Table

### Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)

| Variables | NAME | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|
| | | R2 Upper | | R2 Upper | | UT to Ostin Creek |
| 1. Stream Type | | Degraded E5 | | C5 | | C4/1 |
| 2. Drainage Area, sq. mi (acres) | | 6.20(3966.91) | | 6.20(3966.91) | | 0.867(554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 24.39 | | | Mean: | 18.52 |
| | Minimum: | 24.27 | Mean: | 31.07 | Minimum: | 15.97 |
| | Maximum: | 24.50 | | | Maximum: | 20.60 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 3.14 | | | Mean: | 1.64 |
| | Minimum: | 3.13 | Mean: | 2.45 | Minimum: | 1.58 |
| | Maximum: | 3.14 | | | Maximum: | 1.72 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 7.78 | | | Mean: | 11.34 |
| | Minimum: | 7.73 | Mean: | 12.70 | Minimum: | 9.28 |
| | Maximum: | 7.83 | | | Maximum: | 12.72 |
| 6. Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 76.43 | | | Mean: | 30.25 |
| | Minimum: | 76.12 | Mean: | 76.00 | Minimum: | 27.41 |
| | Maximum: | 76.73 | | | Maximum: | 33.37 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 4.4 | Mean: | 4.5 | Mean: | 4.2 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 340 | Mean: | 340 | Mean: | 128 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 4.10 | Mean: | 2.83 | Mean: | 1.90 |
| | Minimum: | 3.61 | Minimum: | 2.30 | Minimum: | 1.54 |
| | Maximum: | 4.94 | Maximum: | 3.52 | Maximum: | 2.36 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.31 | Mean: | 1.16 | Mean: | 1.16 |
| | Minimum: | 1.15 | Minimum: | 0.94 | Minimum: | 0.94 |
| | Maximum: | 1.58 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 1.84 | Mean: | 1.00 | Mean: | 1.23 |
| | Minimum: | 1.47 | Minimum: | 1.00 | Minimum: | 1.01 |
| | Maximum: | 2.14 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 164.03 | Mean: | 118.98 | Mean: | 70.18 |
| | Minimum: | 77.05 | Minimum: | 109.76 | Minimum: | 67.15 |
| | Maximum: | 251.00 | Maximum: | 137.36 | Maximum: | 72.78 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 6.74 | Mean: | 3.83 | Mean: | 3.83 |
| | Minimum: | 3.14 | Minimum: | 3.53 | Minimum: | 3.53 |
| | Maximum: | 10.34 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. Meander Length, ft (Lm) | Mean: | 118.20 | Mean: | 157.66 | Mean: | 94.00 |
| | Minimum: | 85.80 | Minimum: | 55.35 | Minimum: | 33.00 |
| | Maximum: | 165.10 | Maximum: | 259.97 | Maximum: | 155.00 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 4.85 | Mean: | 5.07 | Mean: | 5.07 |
| | Minimum: | 3.52 | Minimum: | 1.78 | Minimum: | 1.78 |
| | Maximum: | 6.77 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 45.80 | Mean: | 82.18 | Mean: | 49.00 |
| | Minimum: | 19.70 | Minimum: | 31.87 | Minimum: | 19.00 |
| | Maximum: | 124.40 | Maximum: | 192.88 | Maximum: | 115.00 |
| 17. Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 1.88 | Mean: | 2.65 | Mean: | 2.65 |
| | Minimum: | 0.81 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 5.10 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. Belt Width, ft (Wblt) | Mean: | 32.80 | Mean: | 112.37 | Mean: | 67.00 |
| | Minimum: | 15.20 | Minimum: | 60.38 | Minimum: | 36.00 |
| | Maximum: | 48.70 | Maximum: | 251.58 | Maximum: | 150.00 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 1.35 | Mean: | 3.62 | Mean: | 3.62 |
| | Minimum: | 0.62 | Minimum: | 1.94 | Minimum: | 1.94 |
| | Maximum: | 2.00 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. Low Bank Height, ft (LBH) | Mean: | 7.53 | Mean: | 2.83 | Mean: | 2.30 |
| | Minimum: | 5.94 | Minimum: | 2.30 | Minimum: | 2.09 |
| | Maximum: | 8.93 | Maximum: | 3.52 | Maximum: | 2.67 |
| 21. Sinuosity (K) | Mean: | 1.14 | Mean: | 1.29 | Mean: | 1.46 |
| 22 Valley Slope (VS) | Mean: | 0.00240 | Mean: | 0.00240 | Mean: | 0.01310 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.00211 | Mean: | 0.00186 | Mean: | 0.00897 |
| 24. Pool Slope (Sp) | Mean: | 0.00067 | Mean: | 0.00025 | Mean: | 0.00120 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00178 | Maximum: | 0.00090 | Maximum: | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.32 | Mean: | 0.13 | Mean: | 0.13 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.85 | Maximum: | 0.48 | Maximum: | 0.48 |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| Variables | | Existing Channel | | Proposed Reach | | Reference Reach |
| | NAME | R2 Upper | | R2 Upper | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.00349 | Mean: | 0.00588 | Mean: | 0.02837 |
| | Minimum: | 0.00093 | Minimum: | 0.00131 | Minimum: | 0.00632 |
| | Maximum: | 0.00821 | Maximum: | 0.01358 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 1.66 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.44 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 3.90 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00279 | Mean: | 0.00502 | Mean: | 0.02423 |
| | Minimum: | 0.00089 | Minimum: | 0.00187 | Minimum: | 0.00903 |
| | Maximum: | 0.00486 | Maximum: | 0.01638 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 1.33 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.42 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 2.31 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00351 | Mean: | 0.00067 | Mean: | 0.00325 |
| | Minimum: | 0.00118 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00674 | Maximum: | 0.00270 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 1.67 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.56 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 3.20 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 5.28 | Mean: | 4.30 | Mean: | 2.88 |
| | Minimum: | 4.61 | Minimum: | 3.24 | Minimum: | 2.17 |
| | Maximum: | 6.29 | Maximum: | 4.95 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 1.68 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 1.47 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 2.01 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 4.44 | Mean: | 3.49 | Mean: | 2.34 |
| | Minimum: | 3.91 | Minimum: | 3.30 | Minimum: | 2.21 |
| | Maximum: | 5.53 | Maximum: | 4.06 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 1.42 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 1.25 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 1.76 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 4.44 | Mean: | 3.13 | Mean: | 2.10 |
| | Minimum: | 3.91 | Minimum: | 2.52 | Minimum: | 1.69 |
| | Maximum: | 5.53 | Maximum: | 3.79 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 1.42 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 1.25 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 1.76 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 31.13 | Mean: | 25.71 | Mean: | 15.33 |
| | Minimum: | 30.96 | Minimum: | 20.31 | Minimum: | 12.11 |
| | Maximum: | 31.30 | Maximum: | 31.70 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | 1.28 | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 1.27 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 1.28 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 85.30 | Mean: | 71.85 | Mean: | 28.59 |
| | Minimum: | 76.25 | Minimum: | 53.47 | Minimum: | 21.28 |
| | Maximum: | 94.35 | Maximum: | 97.54 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | 1.12 | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 1.00 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 1.23 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 205.68 | Mean: | 132.27 | Mean: | 78.86 |
| | Minimum: | 38.69 | Minimum: | 84.36 | Minimum: | 50.30 |
| | Maximum: | 442.44 | Maximum: | 177.52 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 8.43 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 1.59 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 18.14 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 42.00 | Mean: | 58.89 | Mean: | 35.11 |
| | Minimum: | 8.52 | Minimum: | 30.76 | Minimum: | 18.34 |
| | Maximum: | 137.06 | Maximum: | 105.45 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 1.72 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 0.35 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 5.62 | Maximum: | 3.39 | Maximum: | 3.39 |

**Table IV. Morphological Table**

**Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)**

| Variables | NAME | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|
| | | R2 Lower | | R2 Lower | | UT to Ostin Creek |
| 1. Stream Type | | Degraded E5 | | C5 | | C4/1 |
| 2. Drainage Area, sq. mi (acres) | | 10.85(6943.97) | | 10.85(6943.97) | | 0.867(554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 30.36 | Mean: | 35.64 | Mean: | 18.52 |
| | Minimum: | 28.53 | | | Minimum: | 15.97 |
| | Maximum: | 32.18 | | | Maximum: | 20.60 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 3.40 | Mean: | 2.81 | Mean: | 1.64 |
| | Minimum: | 3.31 | | | Minimum: | 1.58 |
| | Maximum: | 3.49 | | | Maximum: | 1.72 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 8.95 | Mean: | 12.70 | Mean: | 11.34 |
| | Minimum: | 8.17 | | | Minimum: | 9.28 |
| | Maximum: | 9.72 | | | Maximum: | 12.72 |
| 6. Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 103.14 | Mean: | 100.00 | Mean: | 30.25 |
| | Minimum: | 99.68 | | | Minimum: | 27.41 |
| | Maximum: | 106.59 | | | Maximum: | 33.37 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 4.7 | Mean: | 4.9 | Mean: | 4.2 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 489 | Mean: | 489 | Mean: | 128 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 3.95 | Mean: | 3.25 | Mean: | 1.90 |
| | Minimum: | 3.69 | Minimum: | 2.63 | Minimum: | 1.54 |
| | Maximum: | 4.20 | Maximum: | 4.04 | Maximum: | 2.36 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.16 | Mean: | 1.16 | Mean: | 1.16 |
| | Minimum: | 1.09 | Minimum: | 0.94 | Minimum: | 0.94 |
| | Maximum: | 1.24 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 1.75 | Mean: | 1.00 | Mean: | 1.23 |
| | Minimum: | 1.48 | Minimum: | 1.00 | Minimum: | 1.01 |
| | Maximum: | 1.95 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 124.56 | Mean: | 136.47 | Mean: | 70.18 |
| | Minimum: | 89.48 | Minimum: | 125.91 | Minimum: | 67.15 |
| | Maximum: | 159.64 | Maximum: | 157.57 | Maximum: | 72.78 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 4.05 | Mean: | 3.83 | Mean: | 3.83 |
| | Minimum: | 3.14 | Minimum: | 3.53 | Minimum: | 3.53 |
| | Maximum: | 4.96 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. Meander Length, ft (Lm) | Mean: | 216.40 | Mean: | 180.85 | Mean: | 94.00 |
| | Minimum: | 196.40 | Minimum: | 63.49 | Minimum: | 33.00 |
| | Maximum: | 236.30 | Maximum: | 298.20 | Maximum: | 155.00 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 7.13 | Mean: | 5.07 | Mean: | 5.07 |
| | Minimum: | 6.47 | Minimum: | 1.78 | Minimum: | 1.78 |
| | Maximum: | 7.78 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 57.00 | Mean: | 94.27 | Mean: | 49.00 |
| | Minimum: | 30.00 | Minimum: | 36.55 | Minimum: | 19.00 |
| | Maximum: | 79.50 | Maximum: | 221.25 | Maximum: | 115.00 |
| 17. Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 1.88 | Mean: | 2.65 | Mean: | 2.65 |
| | Minimum: | 0.99 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 2.62 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. Belt Width, ft (Wblt) | Mean: | 42.30 | Mean: | 128.90 | Mean: | 67.00 |
| | Minimum: | 16.20 | Minimum: | 69.26 | Minimum: | 36.00 |
| | Maximum: | 69.50 | Maximum: | 288.59 | Maximum: | 150.00 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 1.39 | Mean: | 3.62 | Mean: | 3.62 |
| | Minimum: | 0.53 | Minimum: | 1.94 | Minimum: | 1.94 |
| | Maximum: | 2.29 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. Low Bank Height, ft (LBH) | Mean: | 6.91 | Mean: | 3.25 | Mean: | 2.30 |
| | Minimum: | 6.04 | Minimum: | 2.63 | Minimum: | 2.09 |
| | Maximum: | 8.17 | Maximum: | 4.04 | Maximum: | 2.67 |
| 21. Sinuosity (K) | Mean: | 1.11 | Mean: | 1.10 | Mean: | 1.46 |
| 22 Valley Slope (VS) | Mean: | 0.00210 | Mean: | 0.00210 | Mean: | 0.01310 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.00189 | Mean: | 0.00191 | Mean: | 0.00897 |
| 24. Pool Slope (Sp) | Mean: | 0.00203 | Mean: | 0.00026 | Mean: | 0.00120 |
| | Minimum: | 0.00016 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00491 | Maximum: | 0.00092 | Maximum: | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 1.07 | Mean: | 0.13 | Mean: | 0.13 |
| | Minimum: | 0.08 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 2.60 | Maximum: | 0.48 | Maximum: | 0.48 |

**Table IV. Morphological Table**
**Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)**

| Variables | | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|
| | NAME | R2 Lower | | R2 Lower | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.00663 | Mean: | 0.00604 | Mean: | 0.02837 |
| | Minimum: | 0.00080 | Minimum: | 0.00134 | Minimum: | 0.00632 |
| | Maximum: | 0.02367 | Maximum: | 0.01394 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 3.50 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.42 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 12.51 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00755 | Mean: | 0.00516 | Mean: | 0.02423 |
| | Minimum: | 0.00074 | Minimum: | 0.00192 | Minimum: | 0.00903 |
| | Maximum: | 0.01919 | Maximum: | 0.01681 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 3.99 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.39 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 10.14 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00344 | Mean: | 0.00069 | Mean: | 0.00325 |
| | Minimum: | 0.00120 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.01026 | Maximum: | 0.00277 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 1.82 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.63 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 5.42 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 4.97 | Mean: | 4.93 | Mean: | 2.88 |
| | Minimum: | 3.72 | Minimum: | 3.71 | Minimum: | 2.17 |
| | Maximum: | 5.96 | Maximum: | 5.68 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 1.46 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 1.09 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 1.75 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 4.14 | Mean: | 4.00 | Mean: | 2.34 |
| | Minimum: | 3.36 | Minimum: | 3.78 | Minimum: | 2.21 |
| | Maximum: | 4.62 | Maximum: | 4.65 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 1.22 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 0.99 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 1.36 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 4.35 | Mean: | 3.59 | Mean: | 2.10 |
| | Minimum: | 3.81 | Minimum: | 2.89 | Minimum: | 1.69 |
| | Maximum: | 4.93 | Maximum: | 4.35 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 1.28 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 1.12 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 1.45 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 44.20 | Mean: | 29.49 | Mean: | 15.33 |
| | Minimum: | 34.70 | Minimum: | 23.30 | Minimum: | 12.11 |
| | Maximum: | 53.70 | Maximum: | 36.36 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | 1.46 | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 1.14 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 1.77 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 152.20 | Mean: | 94.53 | Mean: | 28.59 |
| | Minimum: | 127.99 | Minimum: | 70.35 | Minimum: | 21.28 |
| | Maximum: | 176.40 | Maximum: | 128.34 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | 1.48 | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 1.24 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 1.71 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 149.76 | Mean: | 151.72 | Mean: | 78.86 |
| | Minimum: | 64.67 | Minimum: | 96.77 | Minimum: | 50.30 |
| | Maximum: | 292.54 | Maximum: | 203.63 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 4.93 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 2.13 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 9.64 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 48.59 | Mean: | 67.55 | Mean: | 35.11 |
| | Minimum: | 20.53 | Minimum: | 35.28 | Minimum: | 18.34 |
| | Maximum: | 84.01 | Maximum: | 120.96 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 1.60 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 0.68 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 2.77 | Maximum: | 3.39 | Maximum: | 3.39 |

**Table IV. Morphological Table**
**Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)**

| | Variables | NAME | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|---|
| | | | R2A | | R2A | | UT to Ostin Creek |
| 1. | Stream Type | | Degraded E4 | | C4 | | C4/1 |
| 2. | Drainage Area, sq. mi (acres) | | 0.54(354.6) | | 0.54(354.6) | | 0.867(554.9) |
| 3. | Bankfull Width, ft (Wbkf) | Mean: | 11.19 | | | Mean: | 18.52 |
| | | Minimum: | 11.18 | Mean: | 11.73 | Minimum: | 15.97 |
| | | Maximum: | 11.20 | | | Maximum: | 20.60 |
| 4. | Bankfull Mean Depth, ft (dbkf) | Mean: | 1.24 | | | Mean: | 1.64 |
| | | Minimum: | 0.97 | Mean: | 0.94 | Minimum: | 1.58 |
| | | Maximum: | 1.50 | | | Maximum: | 1.72 |
| 5. | Width/Depth Ratio (Wbkf/dbkf) | Mean: | 9.50 | | | Mean: | 11.34 |
| | | Minimum: | 7.47 | Mean: | 12.50 | Minimum: | 9.28 |
| | | Maximum: | 11.53 | | | Maximum: | 12.72 |
| 6. | Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 13.80 | | | Mean: | 30.25 |
| | | Minimum: | 10.82 | Mean: | 11.00 | Minimum: | 27.41 |
| | | Maximum: | 16.78 | | | Maximum: | 33.37 |
| 7. | Bankfull Mean Velocity, fps (Vbkf) | Mean: | 3.2 | Mean: | 4.0 | Mean: | 4.2 |
| 8. | Bankfull Discharge, cfs (Qbkf) | Mean: | 44 | Mean: | 44 | Mean: | 128 |
| 9. | Maximum Bankfull Depth, ft (dmbkf) | Mean: | 1.48 | Mean: | 1.09 | Mean: | 1.90 |
| | | Minimum: | 0.95 | Minimum: | 0.88 | Minimum: | 1.54 |
| | | Maximum: | 2.23 | Maximum: | 1.35 | Maximum: | 2.36 |
| 10. | Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.20 | Mean: | 1.16 | Mean: | 1.16 |
| | | Minimum: | 0.77 | Minimum: | 0.94 | Minimum: | 0.94 |
| | | Maximum: | 1.81 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. | Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 4.27 | Mean: | 1.00 | Mean: | 1.23 |
| | | Minimum: | 2.28 | Minimum: | 1.00 | Minimum: | 1.01 |
| | | Maximum: | 6.82 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. | Width of Flood Prone Area, ft (Wfpa) | Mean: | 17.52 | Mean: | 44.91 | Mean: | 70.18 |
| | | Minimum: | 15.99 | Minimum: | 41.43 | Minimum: | 67.15 |
| | | Maximum: | 19.05 | Maximum: | 51.85 | Maximum: | 72.78 |
| 13. | Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 1.57 | Mean: | 3.83 | Mean: | 3.83 |
| | | Minimum: | 1.43 | Minimum: | 3.53 | Minimum: | 3.53 |
| | | Maximum: | 1.70 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. | Meander Length, ft (Lm) | Mean: | 76.70 | Mean: | 59.51 | Mean: | 94.00 |
| | | Minimum: | 76.70 | Minimum: | 20.89 | Minimum: | 33.00 |
| | | Maximum: | 76.70 | Maximum: | 98.12 | Maximum: | 155.00 |
| 15. | Meander Length Ratio (Lm/Wbkf) | Mean: | 6.85 | Mean: | 5.07 | Mean: | 5.07 |
| | | Minimum: | 6.85 | Minimum: | 1.78 | Minimum: | 1.78 |
| | | Maximum: | 6.85 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. | Radius of Curvature, ft (Rc) | Mean: | 21.10 | Mean: | 31.02 | Mean: | 49.00 |
| | | Minimum: | 8.80 | Minimum: | 12.03 | Minimum: | 19.00 |
| | | Maximum: | 31.40 | Maximum: | 72.80 | Maximum: | 115.00 |
| 17. | Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 1.89 | Mean: | 2.65 | Mean: | 2.65 |
| | | Minimum: | 0.79 | Minimum: | 1.03 | Minimum: | 1.03 |
| | | Maximum: | 2.81 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. | Belt Width, ft (Wblt) | Mean: | 20.20 | Mean: | 42.41 | Mean: | 67.00 |
| | | Minimum: | 20.20 | Minimum: | 22.79 | Minimum: | 36.00 |
| | | Maximum: | 20.20 | Maximum: | 94.96 | Maximum: | 150.00 |
| 19. | Meander Width Ratio (Wblt/Wbkf) | Mean: | 1.81 | Mean: | 3.62 | Mean: | 3.62 |
| | | Minimum: | 1.81 | Minimum: | 1.94 | Minimum: | 1.94 |
| | | Maximum: | 1.81 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. | Low Bank Height, ft (LBH) | Mean: | 5.64 | Mean: | 1.09 | Mean: | 2.30 |
| | | Minimum: | 4.21 | Minimum: | 0.88 | Minimum: | 2.09 |
| | | Maximum: | 6.68 | Maximum: | 1.35 | Maximum: | 2.67 |
| 21. | Sinuosity (K) | Mean: | 1.12 | Mean: | 1.32 | Mean: | 1.46 |
| 22 | Valley Slope (VS) | Mean: | 0.01200 | Mean: | 0.01200 | Mean: | 0.01310 |
| 23. | Average Water Surface Slope (S) = (VS/K) | Mean: | 0.01071 | Mean: | 0.00909 | Mean: | 0.00897 |
| 24. | Pool Slope (Sp) | Mean: | 0.00260 | Mean: | 0.00122 | Mean: | 0.00120 |
| | | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | | Maximum: | 0.00891 | Maximum: | 0.00439 | Maximum: | 0.00433 |
| 25. | Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.24 | Mean: | 0.13 | Mean: | 0.13 |
| | | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | | Maximum: | 0.83 | Maximum: | 0.48 | Maximum: | 0.48 |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | | **Existing Channel** | | **Proposed Reach** | | **Reference Reach** |
| | NAME | R2A | | R2A | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.01067 | Mean: | 0.02874 | Mean: | 0.02837 |
| | Minimum: | 0.00423 | Minimum: | 0.00640 | Minimum: | 0.00632 |
| | Maximum: | 0.02424 | Maximum: | 0.06637 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 1.00 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.39 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 2.26 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00812 | Mean: | 0.02455 | Mean: | 0.02423 |
| | Minimum: | 0.00315 | Minimum: | 0.00915 | Minimum: | 0.00903 |
| | Maximum: | 0.01367 | Maximum: | 0.08006 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 0.76 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.29 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 1.28 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00817 | Mean: | 0.00329 | Mean: | 0.00325 |
| | Minimum: | 0.00433 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.01018 | Maximum: | 0.01321 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 0.76 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.40 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.95 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 2.21 | Mean: | 1.65 | Mean: | 2.88 |
| | Minimum: | 1.20 | Minimum: | 1.24 | Minimum: | 2.17 |
| | Maximum: | 3.64 | Maximum: | 1.90 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 1.79 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 0.97 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 2.95 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 1.78 | Mean: | 1.34 | Mean: | 2.34 |
| | Minimum: | 1.04 | Minimum: | 1.26 | Minimum: | 2.21 |
| | Maximum: | 2.65 | Maximum: | 1.56 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 1.44 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 0.84 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 2.15 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 1.78 | Mean: | 1.20 | Mean: | 2.10 |
| | Minimum: | 0.64 | Minimum: | 0.97 | Minimum: | 1.69 |
| | Maximum: | 2.43 | Maximum: | 1.45 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 1.44 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 0.52 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 1.97 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 11.15 | Mean: | 9.70 | Mean: | 15.33 |
| | Minimum: | 7.68 | Minimum: | 7.67 | Minimum: | 12.11 |
| | Maximum: | 14.61 | Maximum: | 11.96 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | 1.00 | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 0.69 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 1.31 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 16.99 | Mean: | 10.40 | Mean: | 28.59 |
| | Minimum: | 10.43 | Minimum: | 7.74 | Minimum: | 21.28 |
| | Maximum: | 23.55 | Maximum: | 14.12 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | 1.23 | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 0.76 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 1.71 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 113.24 | Mean: | 49.92 | Mean: | 78.86 |
| | Minimum: | 83.13 | Minimum: | 31.84 | Minimum: | 50.30 |
| | Maximum: | 165.66 | Maximum: | 67.00 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 10.12 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 7.43 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 14.80 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 31.82 | Mean: | 22.23 | Mean: | 35.11 |
| | Minimum: | 17.15 | Minimum: | 11.61 | Minimum: | 18.34 |
| | Maximum: | 65.41 | Maximum: | 39.80 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 2.84 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 1.53 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 5.85 | Maximum: | 3.39 | Maximum: | 3.39 |

**Table IV. Morphological Table**
**Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)**

| | | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|
| **Variables** | **NAME** | R2B | | R2B | | UT to Ostin Creek |
| 1. Stream Type | | G5c | | C4 | | C4/1 |
| 2. Drainage Area, sq. mi (acres) | | 0.12(76.80) | | 0.12(76.80) | | 0.867(554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 5.48 | | | Mean: | 18.52 |
| | Minimum: | 4.51 | Mean: | 7.97 | Minimum: | 15.97 |
| | Maximum: | 6.44 | | | Maximum: | 20.60 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 1.33 | | | Mean: | 1.64 |
| | Minimum: | 1.31 | Mean: | 0.63 | Minimum: | 1.58 |
| | Maximum: | 1.35 | | | Maximum: | 1.72 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 4.11 | | | Mean: | 11.34 |
| | Minimum: | 3.44 | Mean: | 12.70 | Minimum: | 9.28 |
| | Maximum: | 4.77 | | | Maximum: | 12.72 |
| 6. Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 7.33 | | | Mean: | 30.25 |
| | Minimum: | 5.92 | Mean: | 5.00 | Minimum: | 27.41 |
| | Maximum: | 8.73 | | | Maximum: | 33.37 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 4.6 | Mean: | 6.8 | Mean: | 4.2 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 34 | Mean: | 34 | Mean: | 128 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 1.75 | Mean: | 0.73 | Mean: | 1.90 |
| | Minimum: | 1.70 | Minimum: | 0.59 | Minimum: | 1.54 |
| | Maximum: | 1.80 | Maximum: | 0.90 | Maximum: | 2.36 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.32 | Mean: | 1.16 | Mean: | 1.16 |
| | Minimum: | 1.28 | Minimum: | 0.94 | Minimum: | 0.94 |
| | Maximum: | 1.35 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 2.63 | Mean: | 1.00 | Mean: | 1.23 |
| | Minimum: | 1.44 | Minimum: | 1.00 | Minimum: | 1.01 |
| | Maximum: | 3.81 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 100.35 | Mean: | 30.52 | Mean: | 70.18 |
| | Minimum: | 5.42 | Minimum: | 28.15 | Minimum: | 67.15 |
| | Maximum: | 195.28 | Maximum: | 35.23 | Maximum: | 72.78 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 15.76 | Mean: | 3.83 | Mean: | 3.83 |
| | Minimum: | 1.20 | Minimum: | 3.53 | Minimum: | 3.53 |
| | Maximum: | 30.32 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. Meander Length, ft (Lm) | Mean: | 0.00 | Mean: | 40.44 | Mean: | 94.00 |
| | Minimum: | 0.00 | Minimum: | 14.20 | Minimum: | 33.00 |
| | Maximum: | 0.00 | Maximum: | 66.68 | Maximum: | 155.00 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 0.00 | Mean: | 5.07 | Mean: | 5.07 |
| | Minimum: | 0.00 | Minimum: | 1.78 | Minimum: | 1.78 |
| | Maximum: | 0.00 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 0.00 | Mean: | 21.08 | Mean: | 49.00 |
| | Minimum: | 0.00 | Minimum: | 8.17 | Minimum: | 19.00 |
| | Maximum: | 0.00 | Maximum: | 49.47 | Maximum: | 115.00 |
| 17. Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 0.00 | Mean: | 2.65 | Mean: | 2.65 |
| | Minimum: | 0.00 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 0.00 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. Belt Width, ft (Wblt) | Mean: | 0.00 | Mean: | 28.82 | Mean: | 67.00 |
| | Minimum: | 0.00 | Minimum: | 15.49 | Minimum: | 36.00 |
| | Maximum: | 0.00 | Maximum: | 64.53 | Maximum: | 150.00 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 0.00 | Mean: | 3.62 | Mean: | 3.62 |
| | Minimum: | 0.00 | Minimum: | 1.94 | Minimum: | 1.94 |
| | Maximum: | 0.00 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. Low Bank Height, ft (LBH) | Mean: | 4.54 | Mean: | 0.73 | Mean: | 2.30 |
| | Minimum: | 2.60 | Minimum: | 0.59 | Minimum: | 2.09 |
| | Maximum: | 6.47 | Maximum: | 0.90 | Maximum: | 2.67 |
| 21. Sinuosity (K) | Mean: | 1.05 | Mean: | 1.34 | Mean: | 1.46 |
| 22 Valley Slope (VS) | Mean: | 0.01520 | Mean: | 0.01520 | Mean: | 0.01310 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.01448 | Mean: | 0.01134 | Mean: | 0.00897 |
| 24. Pool Slope (Sp) | Mean: | 0.00000 | Mean: | 0.00152 | Mean: | 0.00120 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00000 | Maximum: | 0.00547 | Maximum: | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.00 | Mean: | 0.13 | Mean: | 0.13 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.00 | Maximum: | 0.48 | Maximum: | 0.48 |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| **Variables** | | **Existing Channel** | | **Proposed Reach** | | **Reference Reach** |
| | NAME | R2B | | R2B | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.00000 | Mean: | 0.03587 | Mean: | 0.02837 |
| | Minimum: | 0.00000 | Minimum: | 0.00799 | Minimum: | 0.00632 |
| | Maximum: | 0.00000 | Maximum: | 0.08282 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 0.00 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.00 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 0.00 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00000 | Mean: | 0.03063 | Mean: | 0.02423 |
| | Minimum: | 0.00000 | Minimum: | 0.01142 | Minimum: | 0.00903 |
| | Maximum: | 0.00000 | Maximum: | 0.09990 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 0.00 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.00 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 0.00 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00000 | Mean: | 0.00411 | Mean: | 0.00325 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00000 | Maximum: | 0.01649 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 0.00 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.00 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 0.00 | Mean: | 1.10 | Mean: | 2.88 |
| | Minimum: | 0.00 | Minimum: | 0.83 | Minimum: | 2.17 |
| | Maximum: | 0.00 | Maximum: | 1.27 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 0.00 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 0.00 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 0.00 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 0.00 | Mean: | 0.90 | Mean: | 2.34 |
| | Minimum: | 0.00 | Minimum: | 0.85 | Minimum: | 2.21 |
| | Maximum: | 0.00 | Maximum: | 1.04 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 0.00 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 0.00 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 0.00 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 0.00 | Mean: | 0.80 | Mean: | 2.10 |
| | Minimum: | 0.00 | Minimum: | 0.65 | Minimum: | 1.69 |
| | Maximum: | 0.00 | Maximum: | 0.97 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 0.00 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 0.00 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 0.00 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 0.00 | Mean: | 6.59 | Mean: | 15.33 |
| | Minimum: | 0.00 | Minimum: | 5.21 | Minimum: | 12.11 |
| | Maximum: | 0.00 | Maximum: | 8.13 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | #DIV/0! | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 0.00 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 0.00 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 0.00 | Mean: | 4.73 | Mean: | 28.59 |
| | Minimum: | 0.00 | Minimum: | 3.52 | Minimum: | 21.28 |
| | Maximum: | 0.00 | Maximum: | 6.42 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | #DIV/0! | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 0.00 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 0.00 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 0.00 | Mean: | 33.93 | Mean: | 78.86 |
| | Minimum: | 0.00 | Minimum: | 21.64 | Minimum: | 50.30 |
| | Maximum: | 0.00 | Maximum: | 45.53 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 0.00 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 0.00 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 0.00 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 0.00 | Mean: | 15.10 | Mean: | 35.11 |
| | Minimum: | 0.00 | Minimum: | 7.89 | Minimum: | 18.34 |
| | Maximum: | 0.00 | Maximum: | 27.05 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 0.00 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 0.00 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 0.00 | Maximum: | 3.39 | Maximum: | 3.39 |

**Table IV. Morphological Table**
**Project I.D. No. D06027-B (Little White Oak Stream Restoration Project)**

| Variables | NAME | Existing Channel | | Proposed Reach | | Reference Reach |
|---|---|---|---|---|---|---|
| | | R2D | | R2D | | UT to Ostin Creek |
| 1. Stream Type | | Degraded E6 | | C6 | | C4/1 |
| 2. Drainage Area, sq. mi (acres) | | 0.05 (31.65) | | 0.05 (31.65) | | 0.867(554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 5.50 | | | Mean: | 18.52 |
| | Minimum: | 3.80 | Mean: | 7.97 | Minimum: | 15.97 |
| | Maximum: | 7.20 | | | Maximum: | 20.60 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 0.75 | | | Mean: | 1.64 |
| | Minimum: | 0.70 | Mean: | 0.63 | Minimum: | 1.58 |
| | Maximum: | 0.80 | | | Maximum: | 1.72 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 7.05 | | | Mean: | 11.34 |
| | Minimum: | 5.26 | Mean: | 12.70 | Minimum: | 9.28 |
| | Maximum: | 8.84 | | | Maximum: | 12.72 |
| 6. Bankfull Cross-Sectional Area, sq ft (Abkf) | Mean: | 4.25 | | | Mean: | 30.25 |
| | Minimum: | 2.70 | Mean: | 5.00 | Minimum: | 27.41 |
| | Maximum: | 5.80 | | | Maximum: | 33.37 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 5.3 | Mean: | 4.5 | Mean: | 4.2 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 22 | Mean: | 22 | Mean: | 128 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 1.40 | Mean: | 0.73 | Mean: | 1.90 |
| | Minimum: | 1.15 | Minimum: | 0.59 | Minimum: | 1.54 |
| | Maximum: | 1.65 | Maximum: | 0.90 | Maximum: | 2.36 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.81 | Mean: | 1.16 | Mean: | 1.16 |
| | Minimum: | 1.49 | Minimum: | 0.94 | Minimum: | 0.94 |
| | Maximum: | 2.14 | Maximum: | 1.44 | Maximum: | 1.44 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 3.23 | Mean: | 1.00 | Mean: | 1.23 |
| | Minimum: | 2.47 | Minimum: | 1.00 | Minimum: | 1.01 |
| | Maximum: | 4.01 | Maximum: | 1.00 | Maximum: | 1.42 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 10.49 | Mean: | 30.52 | Mean: | 70.18 |
| | Minimum: | 8.37 | Minimum: | 28.15 | Minimum: | 67.15 |
| | Maximum: | 12.60 | Maximum: | 35.23 | Maximum: | 72.78 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 1.99 | Mean: | 3.83 | Mean: | 3.83 |
| | Minimum: | 1.76 | Minimum: | 3.53 | Minimum: | 3.53 |
| | Maximum: | 2.21 | Maximum: | 4.42 | Maximum: | 4.42 |
| 14. Meander Length, ft (Lm) | Mean: | 0.00 | Mean: | 40.44 | Mean: | 94.00 |
| | Minimum: | 0.00 | Minimum: | 14.20 | Minimum: | 33.00 |
| | Maximum: | 0.00 | Maximum: | 66.68 | Maximum: | 155.00 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 0.00 | Mean: | 5.07 | Mean: | 5.07 |
| | Minimum: | 0.00 | Minimum: | 1.78 | Minimum: | 1.78 |
| | Maximum: | 0.00 | Maximum: | 8.37 | Maximum: | 8.37 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 0.00 | Mean: | 21.08 | Mean: | 49.00 |
| | Minimum: | 0.00 | Minimum: | 8.17 | Minimum: | 19.00 |
| | Maximum: | 0.00 | Maximum: | 49.47 | Maximum: | 115.00 |
| 17. Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 0.00 | Mean: | 2.65 | Mean: | 2.65 |
| | Minimum: | 0.00 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 0.00 | Maximum: | 6.21 | Maximum: | 6.21 |
| 18. Belt Width, ft (Wblt) | Mean: | 0.00 | Mean: | 28.82 | Mean: | 67.00 |
| | Minimum: | 0.00 | Minimum: | 15.49 | Minimum: | 36.00 |
| | Maximum: | 0.00 | Maximum: | 64.53 | Maximum: | 150.00 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 0.00 | Mean: | 3.62 | Mean: | 3.62 |
| | Minimum: | 0.00 | Minimum: | 1.94 | Minimum: | 1.94 |
| | Maximum: | 0.00 | Maximum: | 8.10 | Maximum: | 8.10 |
| 20. Low Bank Height, ft (LBH) | Mean: | 4.34 | Mean: | 0.73 | Mean: | 2.30 |
| | Minimum: | 4.07 | Minimum: | 0.59 | Minimum: | 2.09 |
| | Maximum: | 4.61 | Maximum: | 0.90 | Maximum: | 2.67 |
| 21. Sinuosity (K) | Mean: | 1.12 | Mean: | 1.57 | Mean: | 1.46 |
| 22 Valley Slope (VS) | Mean: | 0.01240 | Mean: | 0.01240 | Mean: | 0.01310 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.01107 | Mean: | 0.00790 | Mean: | 0.00897 |
| 24. Pool Slope (Sp) | Mean: | 0.00000 | Mean: | 0.00106 | Mean: | 0.00120 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00000 | Maximum: | 0.00381 | Maximum: | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.00 | Mean: | 0.13 | Mean: | 0.13 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.00 | Maximum: | 0.48 | Maximum: | 0.48 |

| Table IV. Morphological Table<br>Project I.D. No. D06027-B (Little White Oak Stream Restoration Project) | | | | | | |
|---|---|---|---|---|---|---|
| Variables | | Existing Channel | | Proposed Reach | | Reference Reach |
| | NAME | R2D | | R2D | | UT to Ostin Creek |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.00000 | Mean: | 0.02497 | Mean: | 0.02837 |
| | Minimum: | 0.00000 | Minimum: | 0.00556 | Minimum: | 0.00632 |
| | Maximum: | 0.00000 | Maximum: | 0.05766 | Maximum: | 0.06551 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 0.00 | Mean: | 3.16 | Mean: | 3.16 |
| | Minimum: | 0.00 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 0.00 | Maximum: | 7.30 | Maximum: | 7.30 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.00000 | Mean: | 0.02133 | Mean: | 0.02423 |
| | Minimum: | 0.00000 | Minimum: | 0.00795 | Minimum: | 0.00903 |
| | Maximum: | 0.00000 | Maximum: | 0.06956 | Maximum: | 0.07902 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 0.00 | Mean: | 2.70 | Mean: | 2.70 |
| | Minimum: | 0.00 | Minimum: | 1.01 | Minimum: | 1.01 |
| | Maximum: | 0.00 | Maximum: | 8.81 | Maximum: | 8.81 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.00000 | Mean: | 0.00286 | Mean: | 0.00325 |
| | Minimum: | 0.00000 | Minimum: | 0.00000 | Minimum: | 0.00000 |
| | Maximum: | 0.00000 | Maximum: | 0.01148 | Maximum: | 0.01304 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 0.00 | Mean: | 0.36 | Mean: | 0.36 |
| | Minimum: | 0.00 | Minimum: | 0.00 | Minimum: | 0.00 |
| | Maximum: | 0.00 | Maximum: | 1.45 | Maximum: | 1.45 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 0.00 | Mean: | 1.10 | Mean: | 2.88 |
| | Minimum: | 0.00 | Minimum: | 0.83 | Minimum: | 2.17 |
| | Maximum: | 0.00 | Maximum: | 1.27 | Maximum: | 3.32 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 0.00 | Mean: | 1.76 | Mean: | 1.76 |
| | Minimum: | 0.00 | Minimum: | 1.32 | Minimum: | 1.32 |
| | Maximum: | 0.00 | Maximum: | 2.02 | Maximum: | 2.02 |
| 34. Max Run Depth, ft (drun) | Mean: | 0.00 | Mean: | 0.90 | Mean: | 2.34 |
| | Minimum: | 0.00 | Minimum: | 0.85 | Minimum: | 2.21 |
| | Maximum: | 0.00 | Maximum: | 1.04 | Maximum: | 2.72 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 0.00 | Mean: | 1.43 | Mean: | 1.43 |
| | Minimum: | 0.00 | Minimum: | 1.35 | Minimum: | 1.35 |
| | Maximum: | 0.00 | Maximum: | 1.66 | Maximum: | 1.66 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 0.00 | Mean: | 0.80 | Mean: | 2.10 |
| | Minimum: | 0.00 | Minimum: | 0.65 | Minimum: | 1.69 |
| | Maximum: | 0.00 | Maximum: | 0.97 | Maximum: | 2.54 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 0.00 | Mean: | 1.28 | Mean: | 1.28 |
| | Minimum: | 0.00 | Minimum: | 1.03 | Minimum: | 1.03 |
| | Maximum: | 0.00 | Maximum: | 1.55 | Maximum: | 1.55 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 0.00 | Mean: | 6.59 | Mean: | 15.33 |
| | Minimum: | 0.00 | Minimum: | 5.21 | Minimum: | 12.11 |
| | Maximum: | 0.00 | Maximum: | 8.13 | Maximum: | 18.90 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | #DIV/0! | Mean: | 0.83 | Mean: | 0.83 |
| | Minimum: | 0.00 | Minimum: | 0.65 | Minimum: | 0.65 |
| | Maximum: | 0.00 | Maximum: | 1.02 | Maximum: | 1.02 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 0.00 | Mean: | 4.73 | Mean: | 28.59 |
| | Minimum: | 0.00 | Minimum: | 3.52 | Minimum: | 21.28 |
| | Maximum: | 0.00 | Maximum: | 6.42 | Maximum: | 38.82 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | #DIV/0! | Mean: | 0.95 | Mean: | 0.95 |
| | Minimum: | 0.00 | Minimum: | 0.70 | Minimum: | 0.70 |
| | Maximum: | 0.00 | Maximum: | 1.28 | Maximum: | 1.28 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 0.00 | Mean: | 33.93 | Mean: | 78.86 |
| | Minimum: | 0.00 | Minimum: | 21.64 | Minimum: | 50.30 |
| | Maximum: | 0.00 | Maximum: | 45.53 | Maximum: | 105.84 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 0.00 | Mean: | 4.26 | Mean: | 4.26 |
| | Minimum: | 0.00 | Minimum: | 2.72 | Minimum: | 2.72 |
| | Maximum: | 0.00 | Maximum: | 5.71 | Maximum: | 5.71 |
| 44. Pool Length, ft (Lp) | Mean: | 0.00 | Mean: | 15.10 | Mean: | 35.11 |
| | Minimum: | 0.00 | Minimum: | 7.89 | Minimum: | 18.34 |
| | Maximum: | 0.00 | Maximum: | 27.05 | Maximum: | 62.87 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 0.00 | Mean: | 1.90 | Mean: | 1.90 |
| | Minimum: | 0.00 | Minimum: | 0.99 | Minimum: | 0.99 |
| | Maximum: | 0.00 | Maximum: | 3.39 | Maximum: | 3.39 |

| Table V. BEHI and Sediment Export Estimates for Project Site Streams | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little White Oak Creek Stream Restoration (D06027-B) | | | | | | | | | | | | | | | | |
| Time Point | Segment/Reach | Linear Footage or Acreage | Extreme | | Very High | | High | | Moderate | | Low | | Very Low | | Sediment Export | |
| | | | ft | % | ft | % | ft | % | ft | % | ft | % | ft | % | Yd$^3$/yr | Ton/yr |
| Pre-Construction | R1 | 6530 | | | 5877 | 90 | | | | | | | | | 350 | 455 |
| | R1A | 906.1 | 906.1 | 100 | | | | | | | | | | | 176 | 229 |
| | R1B | 800.4 | 800.4 | 100 | | | | | | | | | | | 128 | 167 |
| | R2 Upper | 3981.9 | 3583.7 | 90 | | | | | | | | | | | 424 | 551 |
| | R2 Lower | 1996.5 | 1796.8 | 90 | | | | | | | | | | | 166 | 216 |
| | R2A | 625 | | | 625 | 100 | | | | | | | | | 25 | 32 |
| | R2B | 1713 | | | | | 1713 | 100 | | | | | | | 93 | 120 |
| | R2C | 1895.5 | 1895.5 | 100 | | | | | | | | | | | 108 | 140 |
| | R2D | 525.9 | 525.9 | 100 | | | | | | | | | | | 193 | 250 |
| | | | | | | | | | | | | | | **Totals** | 1662 | 2161 |

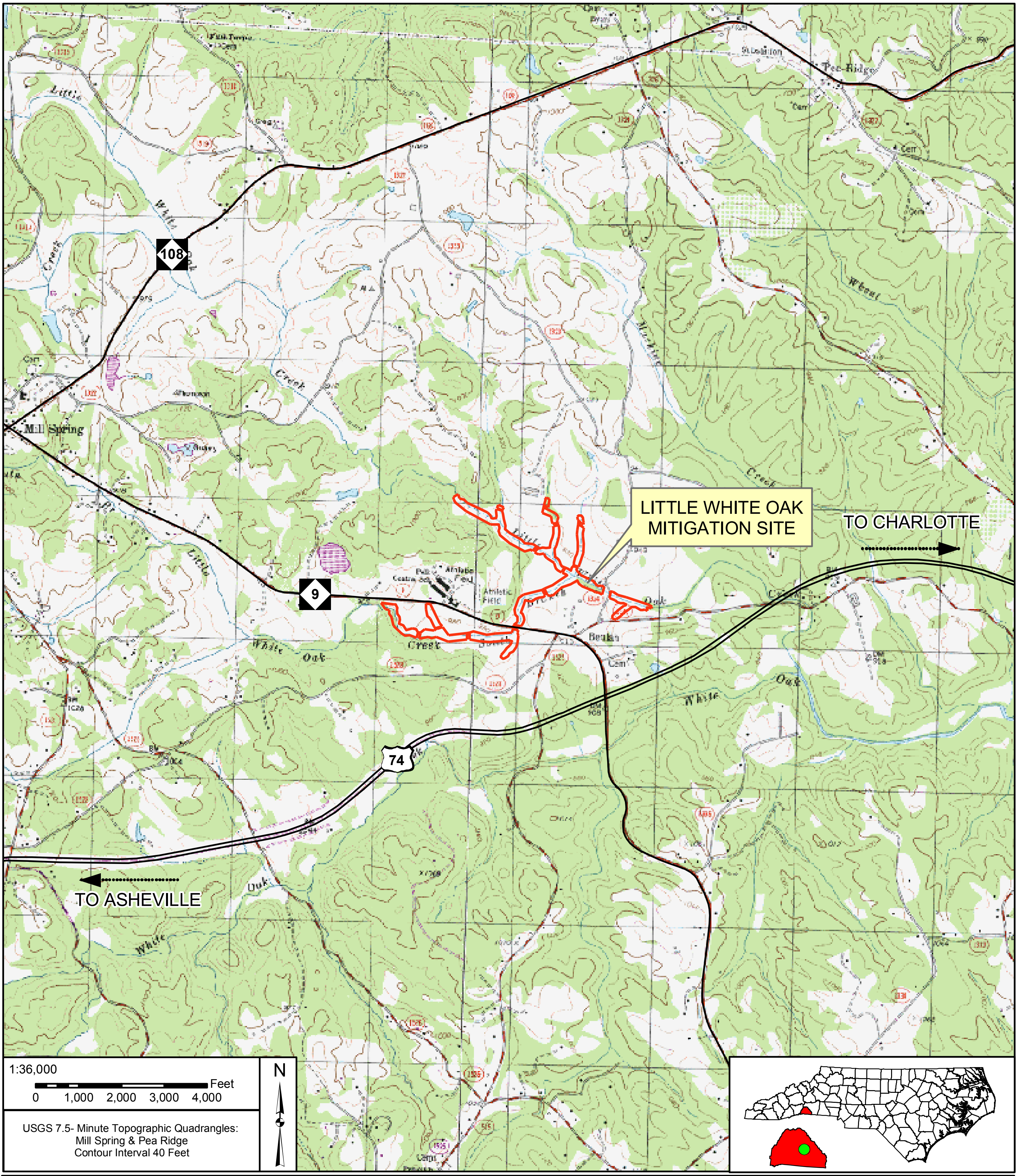
| Table VI. BEHI and Sediment Export Estimates for Reference Reach Streams | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little White Oak Creek Stream Restoration (D06027-B) | | | | | | | | | | | | | | | | |
| Time Point | Segment/Reach | Linear Footage or Acreage | Extreme | | Very High | | High | | Moderate | | Low | | Very Low | | Sediment Export | |
| | | | ft | % | ft | % | ft | % | ft | % | ft | % | ft | % | Yd3/yr | Ton/y |
| Pre-Construction of Little White Oak Site | UT to Ostin Creek | 585 | | | | | | | 585 | 100 | | | | | 32 | 41 |

| Table 7. Pfankuch Summary | | | | | | |
|---|---|---|---|---|---|---|
| **Little White Oak Creek Stream Restoration** | | | | | | |
| **Reach** | **Sediment Supply** | **Stream Bed Stability** | **W/D Condition** | **Stream Type** | **Rating** | **Condition** |
| R1 | High | Degrading | High | E5 | 140 | Poor |
| R1A | High | Degrading | High | B6c | 114 | Poor |
| R1B | High | Degrading | High | B6c | 90 | Poor |
| R2 Upper | High | Degrading | High | E5 | 142 | Poor |
| R2 Lower | High | Degrading | High | E5 | 121 | Poor |
| R2A | Mod | Degrading | Normal | B4c | 95 | Poor |
| R2B | V. High | Degrading | High | G5c | 136 | Poor |
| R2C | High | Degrading | High | G6c | 122 | Poor |
| R2D | High | Degrading | High | B6c | 124 | Poor |

## Table 8. Designed Vegetative Communities

**Project Number D06027-B (Little White Oak Creek Stream Restoration)**

| Planting Zone | Acres | Zone Description | Recommended Plant Species* | |
|---|---|---|---|---|
| | | | **Scientific Name** | **Common Name** |
| 1 | 8.30 | Stream Banks | *Cornus amomum* | Silky dogwood |
| | | | *Salix sericea* | Silky willow |
| | | | *Salix nigra* | Black willow |
| | | | *Cephalanthus occidentalis* | Buttonbush |
| | | | *Alnus serrulata* | Tag alder |
| | | | *Populus deltoides* | Cottonwood |
| | | | | |
| 2 | 14.30 | Riparian Buffer | *Ulmus americana* | American elm |
| | | | *Fraxinus americana* | White ash |
| | | | *Cornus amomum* | silky dogwood |
| | | | *Carpinus caroliniana* | Ironwood |
| | | | *Cephalanthus occidentalis* | Buttonbush |
| | | | *Lindera benzoin* | Spicebush |
| | | | *Alnus serrulata* | Tag alder |
| | | | *Plantanus occidentalis* | Sycamore |
| | | | *Betula nigra* | River birch |
| | | | *Populus deltoides* | Cottonwood |
| | | | *Corylus americana* | American hazelnut |
| | | | Quercus michauxii | Swamp chestnut oak |
| | | | Sambucus canadensis | elderberry |
| | | | | |
| 3 | 0.35 | Wetland Pockets/Oxbows | *Cornus amomum* | Silky dogwood |
| | | | *Salix sericea* | Silky willow |
| | | | *Salix nigra* | Black willow |
| | | | *Cephalanthus occidentalis* | Buttonbush |
| | | | *Alnus serrulata* | Tag alder |
| | | | *Sambucus canadensis* | elderberry |
| | | | | |
| 4 | 32.50 | Upland Buffer | *Pinus strobus* | Eastern white pine |
| | | | *Pinus echinata* | Shortleaf pine |
| | | | *Pinus virginiana* | Virginia Pine |
| | | | *Quercus alba* | White oak |
| | | | *Quercus falcata* | Southern red oak |
| | | | *Quercus stellata* | Post oak |
| | | | *Juniperus virginiana* | Eastern red cedar |
| | | | *Diospyros virginiana* | Common persimmon |
| | | | *Juglans nigra* | Back walnut |
| | | | *Carya tomentosa* | Mockernut hickory |
| | | | *Carya glabra* | Pignut hickory |
| | | | *Ilex opaca* | American holly |
| | | | *Cornus florida* | Flowering dogwood |
| | | | *Juglans nigra* | Black walnut |
| | | | *Fagus grandifolia* | American beech |




PROJECT NO. D06027-B

# VICINITY MAP

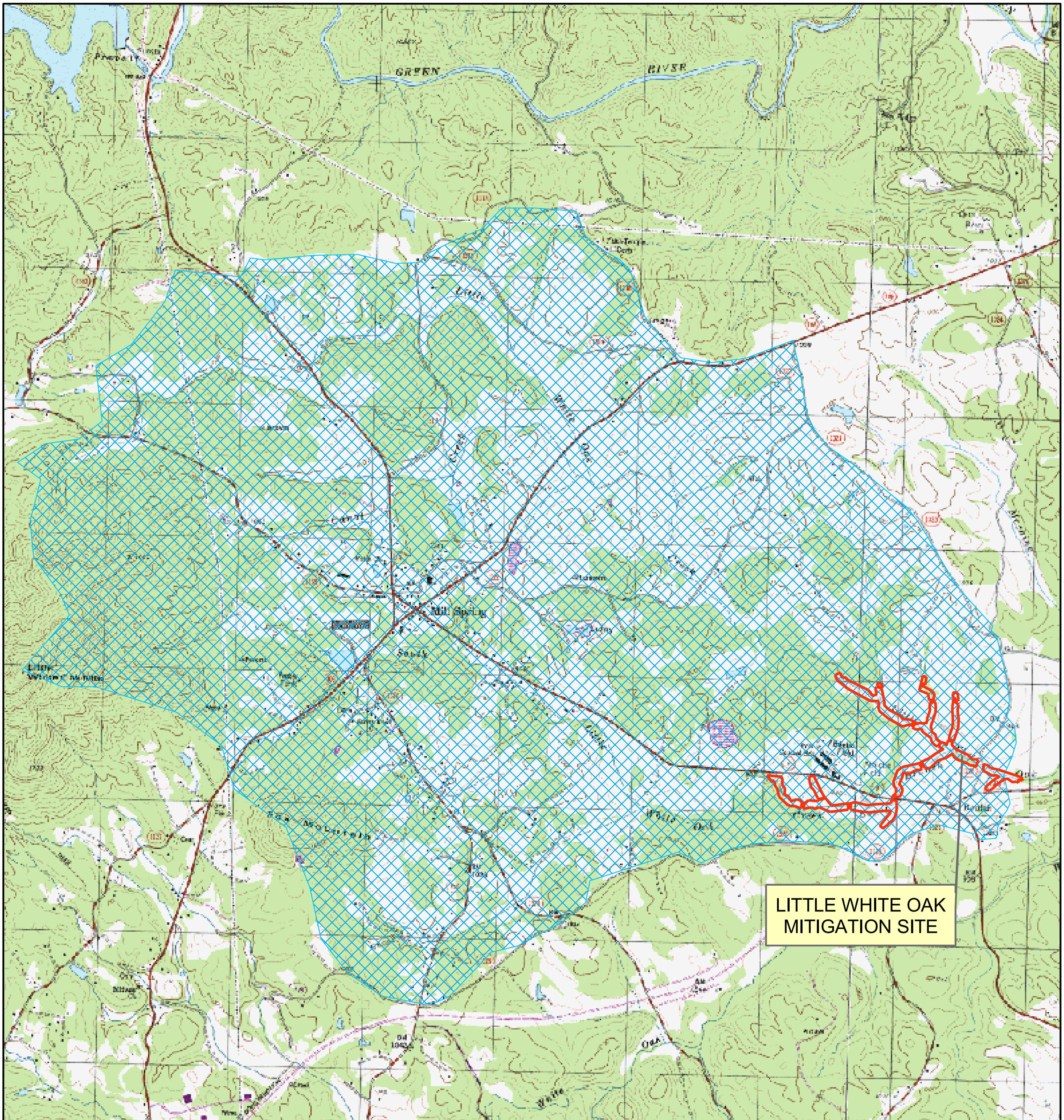
LITTLE WHITE OAK STREAM RESTORATION

POLK COUNTY, NORTH CAROLINA

January 31, 2007

**Figure**

**1**

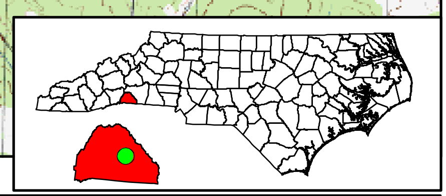



1:39,850

0 1,000 2,000 3,000 4,000 Feet

USGS 7.5- Minute Topographic Quadrangles:
Mill Spring & Pea Ridge
Contour Interval 40 Feet

N



Ecosystem Enhancement PROGRAM

MULKEY ENGINEERS & CONSULTANTS

PROJECT NO. D06027-B

# WATERSHED MAP

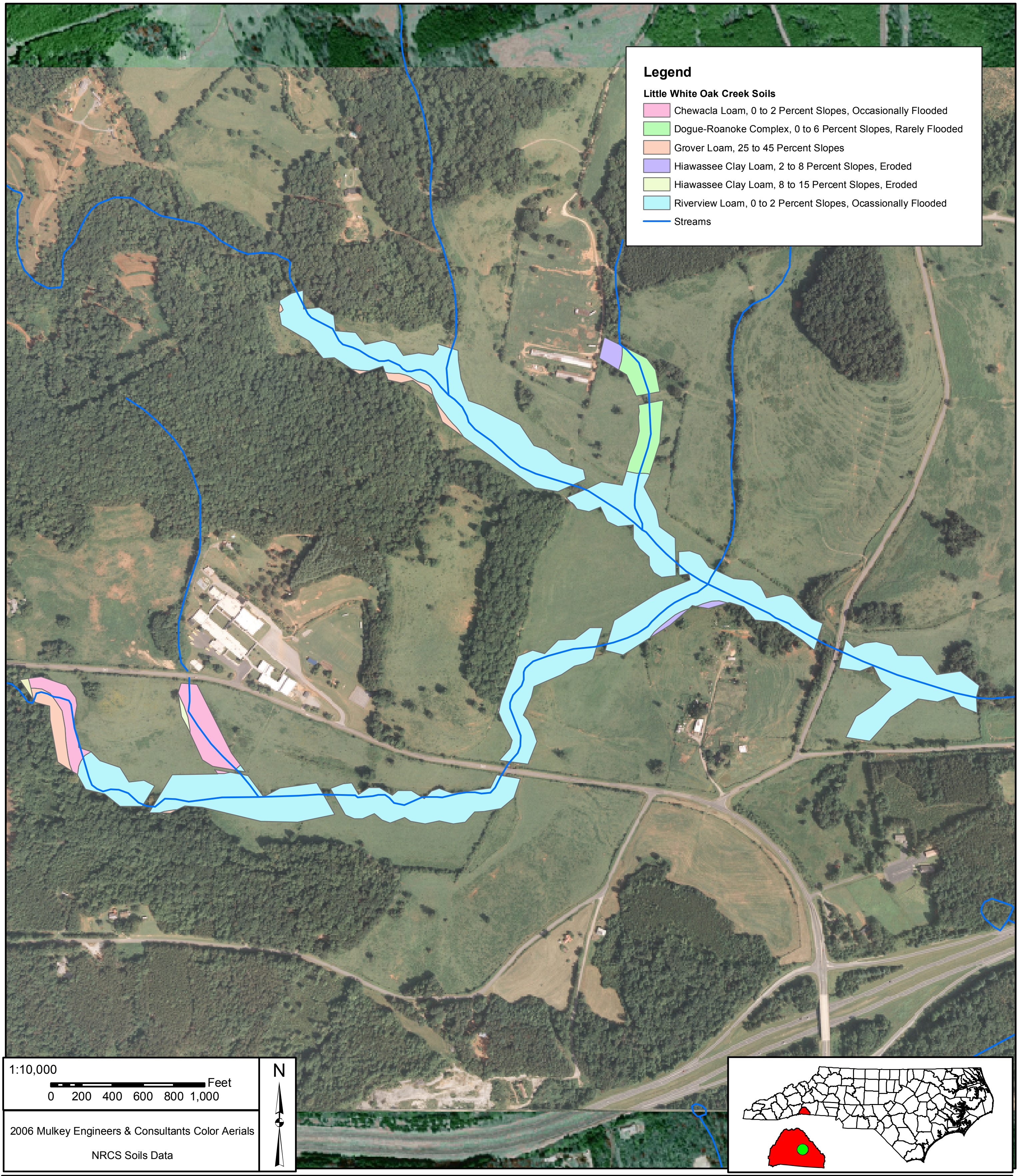
LITTLE WHITE OAK STREAM RESTORATION

POLK COUNTY, NORTH CAROLINA

January 31, 2007

Figure

2




Ecosystem Enhancement Program

MULKEY ENGINEERS & CONSULTANTS

PROJECT NO. D06027-B

# SOILS MAP

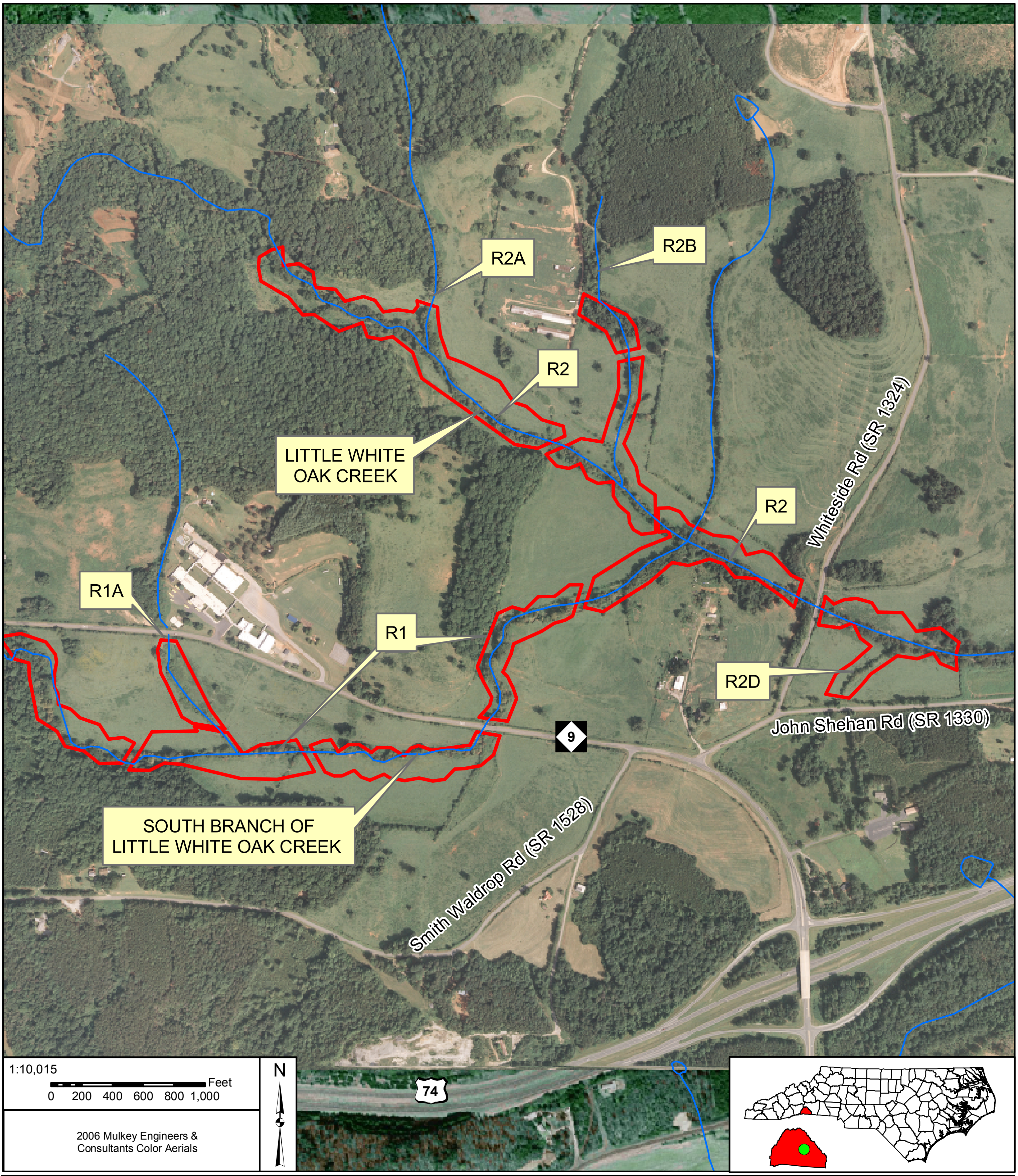
LITTLE WHITE OAK STREAM RESTORATION

POLK COUNTY, NORTH CAROLINA

January 31, 2007

**Figure**

**3**




Ecosystem Enhancement Program

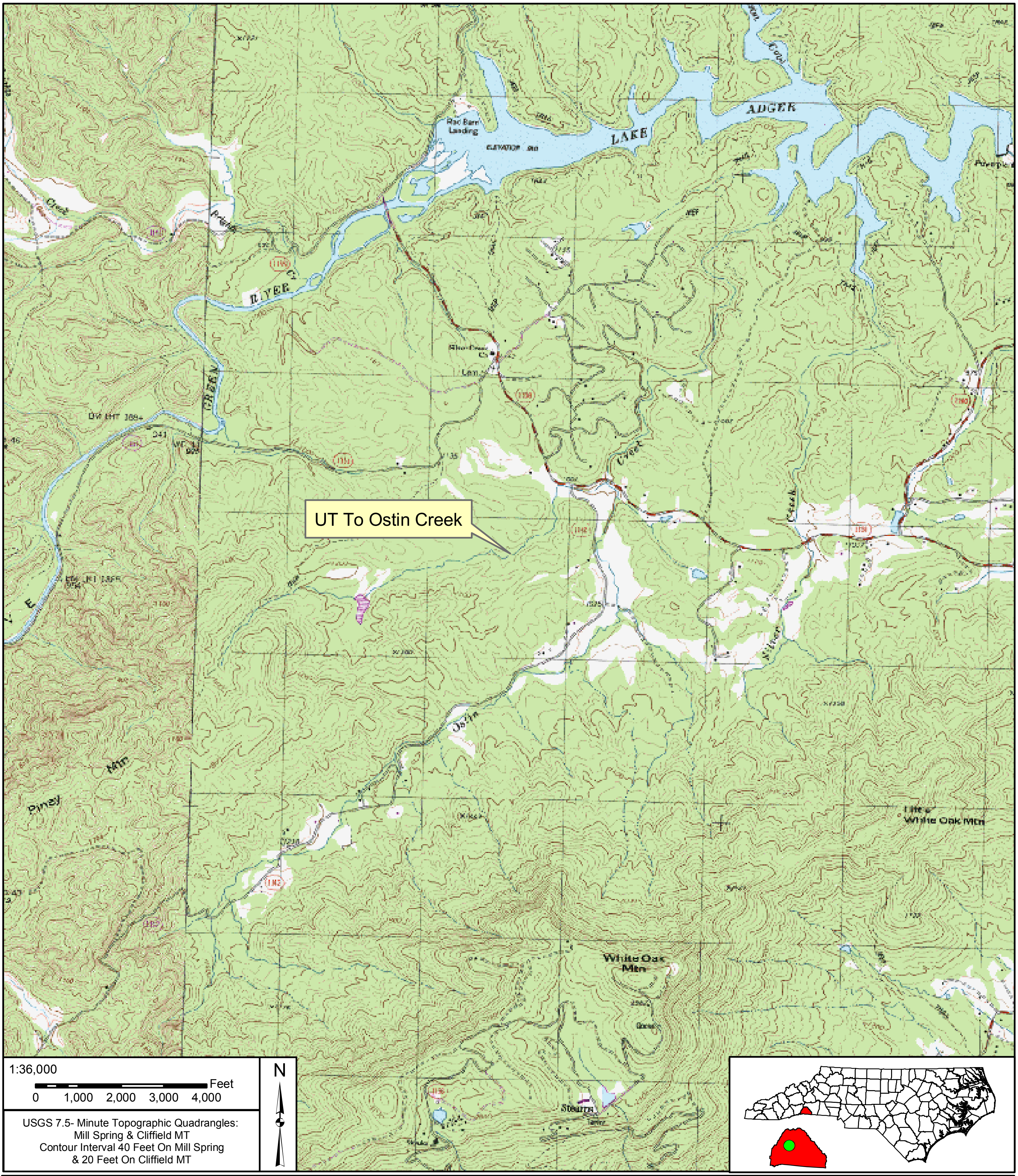
MULKEY ENGINEERS & CONSULTANTS

PROJECT NO. D06027-B

# EXISTING HYDROLOGIC FEATURES

LITTLE WHITE OAK STREAM RESTORATION
POLK COUNTY, NORTH CAROLINA
January 31, 2007

Figure 4




PROJECT NO. D06027-B

# REFERENCE SITE VICINITY MAP

## UT TO OSTIN CREEK

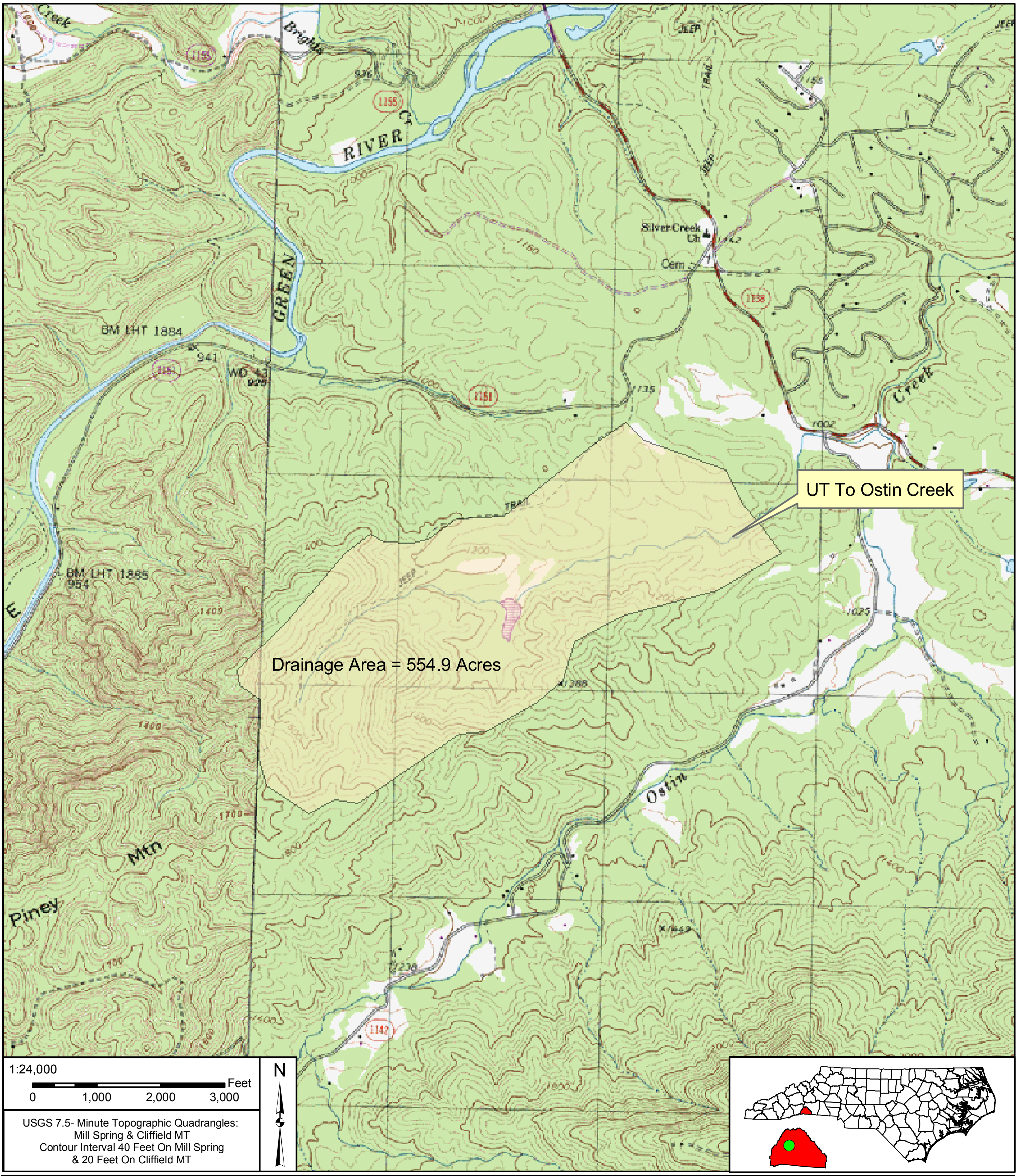
LITTLE WHITE OAK STREAM RESTORATION

POLK COUNTY, NORTH CAROLINA

January 31, 2007

**Figure**

**5**




PROJECT NO. D06027-B

# REFERENCE SITE WATERSHED MAP

## UT TO OSTIN CREEK

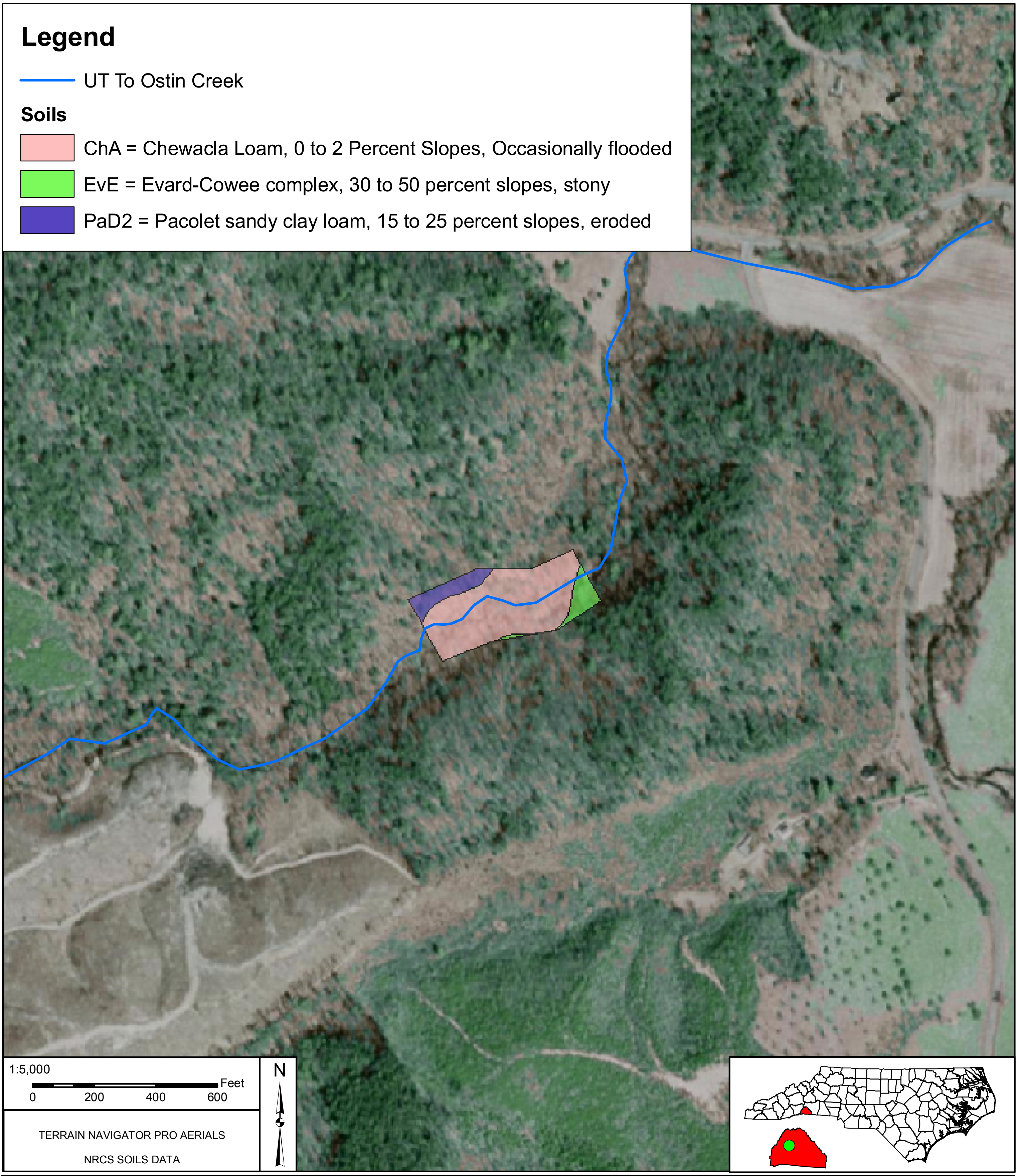
LITTLE WHITE OAK STREAM RESTORATION

POLK COUNTY, NORTH CAROLINA

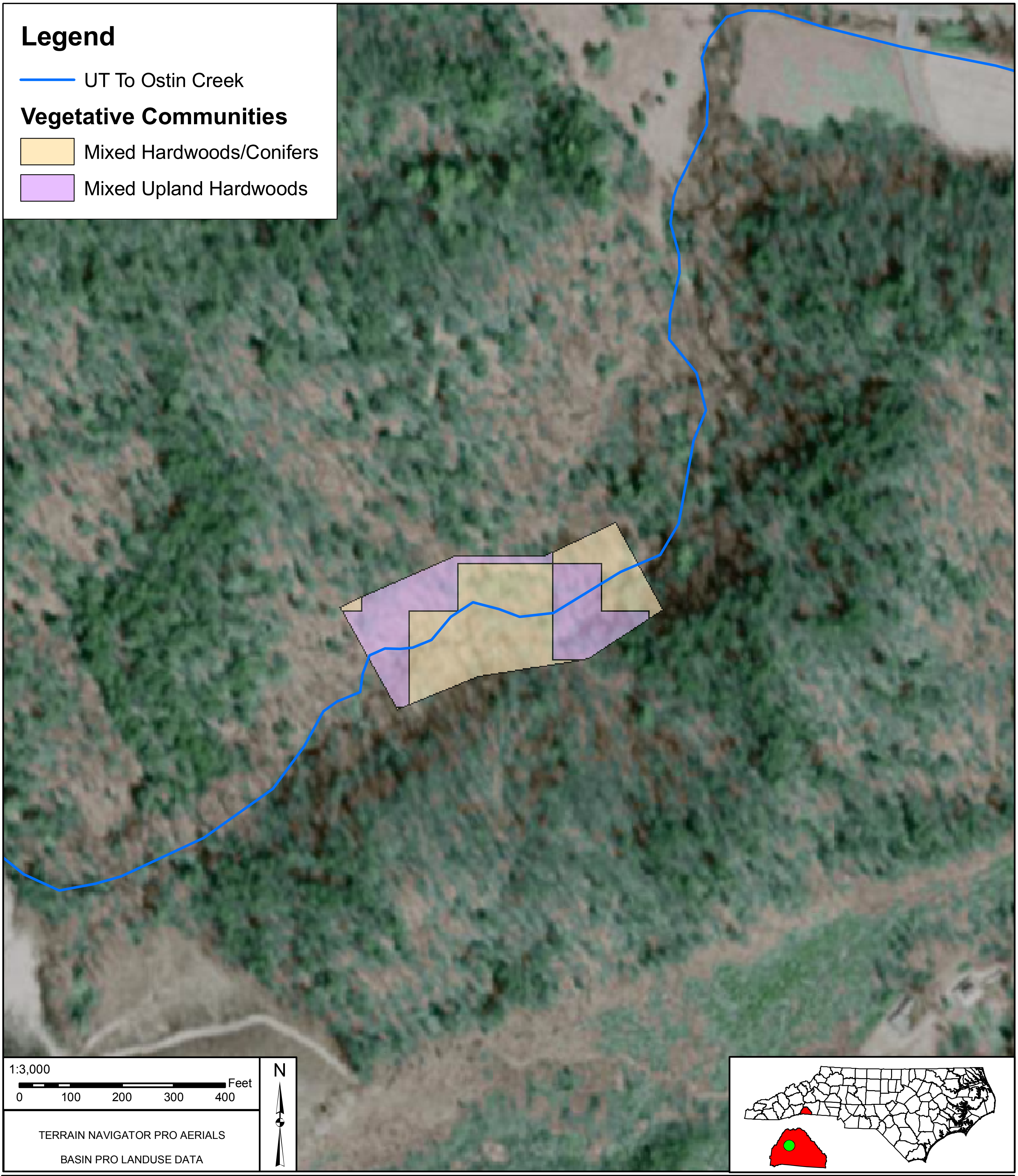
January 31, 2007

**Figure**

**6**




| | | |
|---|---|---|
| PROJECT NO. D06027-B | **REFERENCE SITE SOILS MAP**<br>UT TO OSTIN CREEK<br>LITTLE WHITE OAK STREAM RESTORATION<br>POLK COUNTY, NORTH CAROLINA<br>January 31, 2007 | **Figure**<br>**7** |




PROJECT NO. D06027-B

# REFERENCE SITE VEGETATIVE COMMUNITIES MAP

## UT TO OSTIN CREEK

LITTLE WHITE OAK STREAM RESTORATION

POLK COUNTY, NORTH CAROLINA

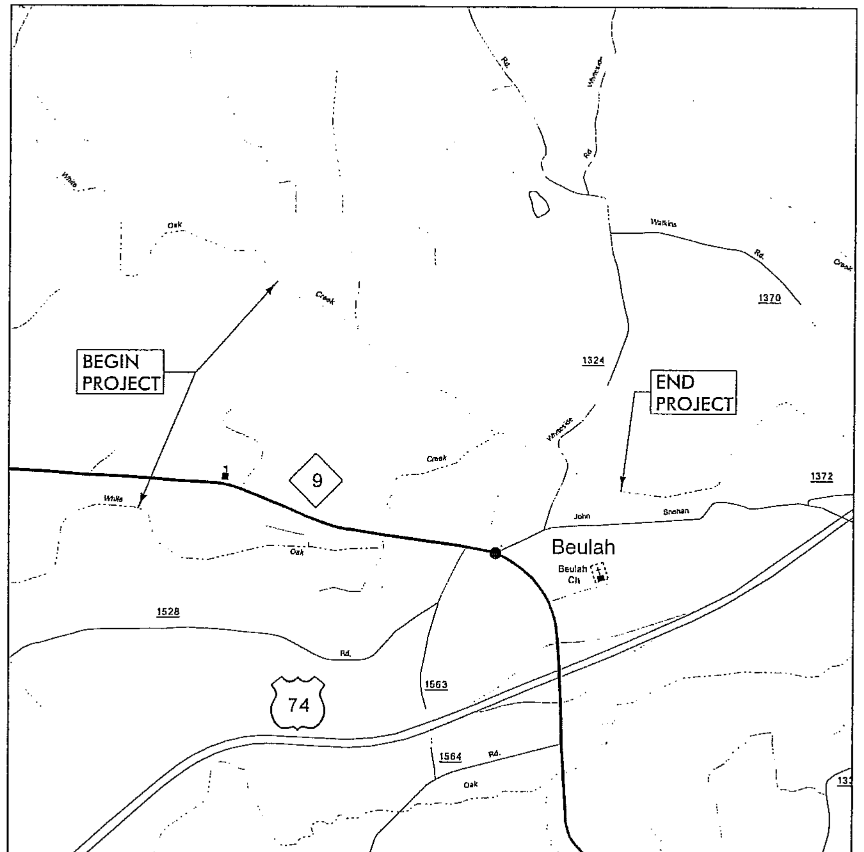
January 31, 2007

**Figure 8**

# POLK COUNTY

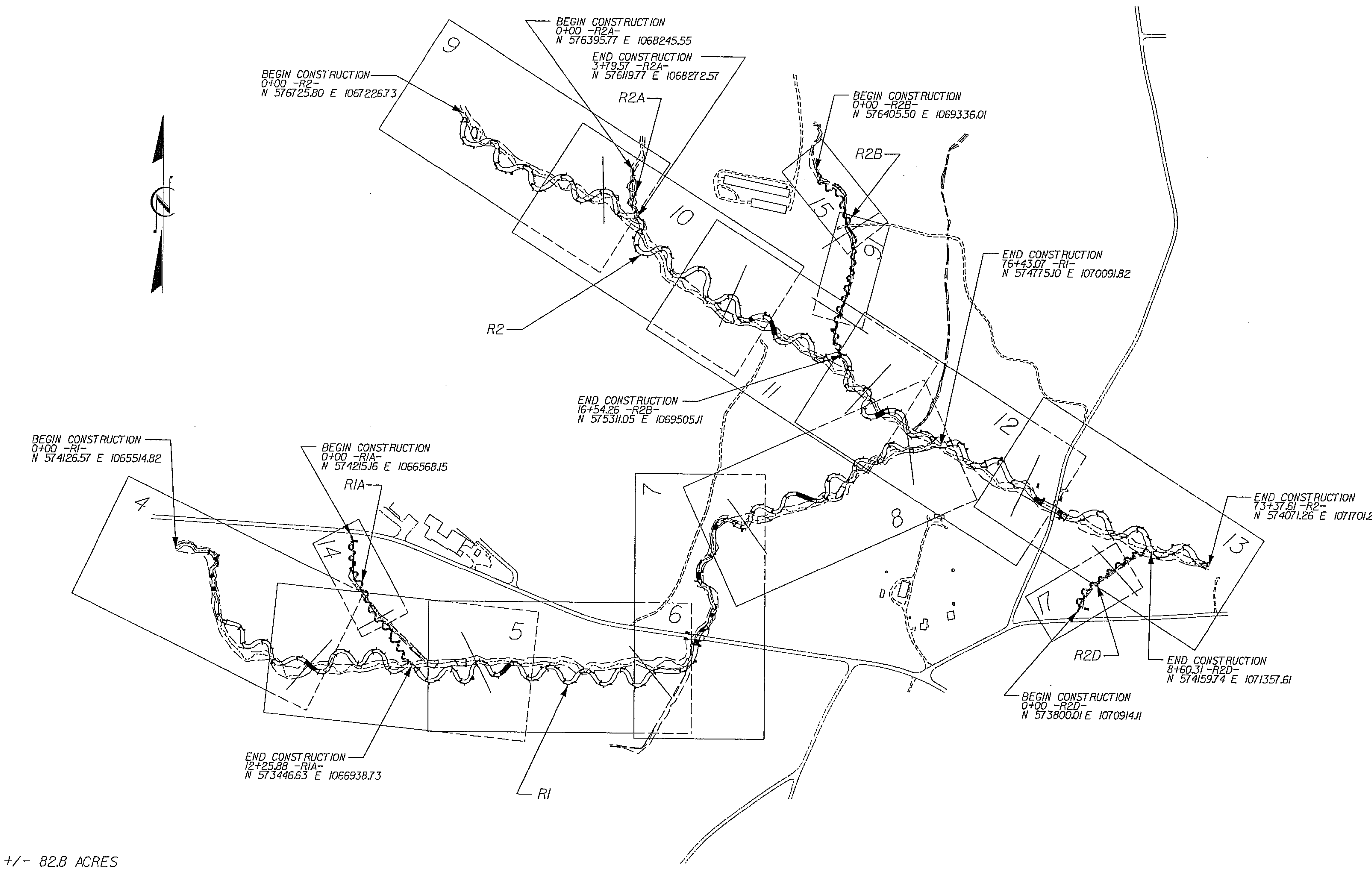
## LITTLE WHITE OAK CREEK STREAM RESTORATION SITE

LOCATION: NORTHEAST OF THE INTERSECTION OF NC 9 AND US 74 (EXIT 167)




VICINITY MAP

NOT TO SCALE




NOT TO SCALE

**INDEX OF SHEETS**

| SHEET NUMBER | SHEET | |
|---|---|---|
| 1 | TITLE SHEET | |
| 1A | LEGEND | |
| 2 | GENERAL NOTES | |
| 2A - 2G | CONSTRUCTION SEQUENCE | |
| 2H | MORPHOLOGICAL TABLES | |
| 2I - 2J | TYPICALS | |
| 2K - 2U | DETAILS | |
| 3 - 3A | PROPOSED PROFILE DATA | |
| 3B - 3D | STRUCTURE TABLES | |
| 4 - 19 | PLAN AND PROFILE | |
| EC-1 - EC-3 | EROSION CONTROL OVERVIEW | (NOT INCLUDED) |
| EC-4 - EC-17 | EROSION CONTROL PLANS | (NOT INCLUDED) |
| PLT-4 - PLT-17 | PLANTING PLANS | |

DISTURBED AREA = +/- 82.8 ACRES

**REVISIONS**

| DATE | BY | DESCRIPTION |
|---|---|---|
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

SCALE AS SHOWN

| | |
|---|---|
| DATE: | 1/31/07 |
| DESIGNED: | WSH |
| DRAWN: | JTL |
| CHECKED: | WSH |
| APPROVED: | WSH |

MULKEY PROJECT NUMBER 2006237.00

PLANS PREPARED BY:

MULKEY ENGINEERS & CONSULTANTS
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Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

MULKEY PROJECT MANAGER
TIM BAUMGARTNER, CPESC

MULKEY SENIOR ENGINEER
WILLIAM SCOTT HUNT, III, PE

MULKEY SENIOR SCIENTIST
THOMAS BARRETT, RF

PROJECT ENGINEER

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**TITLE SHEET**

SHEET 1 OF 76

NOTE: NOT TO SCALE
Not all symbols used in plans

# LEGEND

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT 2/16/07

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 1A |

LEGEND

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## *BOUNDARIES AND PROPERTY:*

- State Line
- County Line
- Township Line
- City Line
- Reservation Line
- Property Line
- Existing Iron Pin (EIP)
- Property Corner
- Property Monument (ECM)
- Temporary Fence
- Proposed Woven Wire Fence
- Proposed Chain Link Fence
- Proposed Barbed Wire Fence
- Tree Protection Fence
- Existing Wetland Boundary (WLB)
- Proposed Oxbow Wetland Boundary (WLB)
- Proposed Conservation Easement
- Construction Limits
- Limits Of Disturbance
- Proposed Gate (G)
- Benchmark

## *BUILDINGS AND OTHER CULTURE:*

- Sign
- Well
- Foundation
- Area Outline
- Building
- School
- Church

## *HYDROLOGY:*

- Stream or Body of Water
- Hydro, Pool or Reservoir
- River Basin Buffer (RBB)
- Flow Arrow
- Disappearing Stream
- Spring
- Thalweg
- Top Of Bank
- Swamp Marsh
- Proposed Lateral, Tail, Head Ditch (FLOW)

## *RAILROADS:*

- Standard Guage (CSX TRANSPORTATION)
- RR Signal Milepost (MILEPOST 35)
- Switch (SWITCH)
- RR Abandoned

## *ROADS AND RELATED FEATURES:*

- Existing Edge of Pavement
- Existing Curb
- Existing Soil Road
- Existing Metal Guardrail
- Existing Cable Guiderail

## *VEGETATION:*

- Single Tree
- Single Shrub
- Hedge
- Woods Line
- Orchard
- Vineyard (Vineyard)

## *EXISTING STRUCTURES:*

MAJOR:

- Bridge, Tunnel or Box Culvert (CONC)
- Bridge Wing Wall, Head Wall and End Wall (CONC WW)

MINOR:

- Head and End Wall (CONC HW)
- Pipe Culvert
- Footbridge
- Drainage Box: Catch Basin, DI or JB (CB)
- Paved Ditch Gutter
- Storm Sewer Manhole
- Storm Sewer

## *UTILITIES:*

POWER:

- Existing Power Pole
- Existing Joint Use Pole
- Power Manhole
- Power Line Tower
- Power Transformer
- U/G Power Cable Hand Hole
- H-Frame Pole
- Recorded U/G Power Line

GAS:

- Gas Valve
- Gas Meter
- Recorded U/G Gas Line
- Above Ground Gas Line (A/G Gas)

TELEPHONE:

- Existing Telephone Pole
- Telephone Manhole
- Telephone Booth
- Telephone Pedestal
- Telephone Cell Tower
- U/G Telephone Cable Hand Hole
- Recorded U/G Telephone Cable
- Recorded U/G Telephone Conduit (TC)
- Recorded U/G Fiber Optics Cable (T FO)

WATER:

- Water Manhole
- Water Meter
- Water Valve
- Water Hydrant
- Recorded U/G Water Line
- Above Ground Water Line (A/G Water)

TV:

- TV Satellite Dish
- TV Pedestal
- TV Tower
- U/G TV Cable Hand Hole
- Recorded U/G TV Cable (TV)
- Recorded U/G Fiber Optic Cable (TV FO)

MISCELLANEOUS:

- Utility Pole
- Utility Pole with Base
- Utility Located Object
- Utility Traffic Signal Box
- Utility Unknown U/G Line (?UTL)
- U/G Tank; Water, Gas, Oil
- A/G Tank; Water, Gas, Oil
- Abandoned According to Utility Records — AATUR
- End of Information — E.O.I.

SANITARY SEWER:

- Sanitary Sewer Manhole
- Sanitary Sewer Cleanout
- U/G Sanitary Sewer Line (SS)
- Above Ground Sanitary Sewer (A/G Sanitary Sewer)
- Recorded SS Forced Main Line (FSS)

## *PROPOSED STREAM WORK:*

STREAM STRUCTURES:

- Rock Crossvane
- Rock Vane
- J Hook Rock Vane
- Double Log Drop
- Rock Step Pool
- Constructed Riffle
- Root Wad
- Structure Number
- Large Specimen Trees

STREAM FEATURES:

- Bankfull
- Vernal Pool
- Proposed Thalweg
- Culvert Pipe

## *EROSION CONTROL FEATURES:*

- Permanent At Grade Stream Crossing (P)
- Temporary Construction Entrance/Exit
- Silt Fence
- Staging Area
- Impervious Dike
- Permanent Improved Gravel Road
- Temporary Gravel Road
- Stone Outlet Sediment Trap
- Impervious Stream Channel Plug
- Fill Existing Stream Channel
- Natural Rock Energy Dissipator Basin Pad

## *PLANTING ZONES:*

- Stream Banks
- Riparian Buffer
- Oxbow Wetland
- Upland

# GENERAL NOTES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 2 |

*GENERAL NOTES*


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1. This plan is based on the principles of natural channel design.

2. Proposed constructed stream features and structures shown on these plans are shown in their approximate location and shall be field located and dimensioned to insure proper channel dimension.

3. All elevations shown on these plans are referenced to NAVD 88.

4. The location of all equipment and material staging areas, haul roads and access points to be located as noted on these plans. Limits of tree protection fencing, silt fencing, construction staging areas and construction access roads shown approximate on plans. Limits and locations to be coordinated with the Designer.

5. Rock will be staged in construction staging areas upon delivery. Existing rock will also be utilized in formation of structures where feasible.

6. Construction activities shall progress downstream, unless otherwise noted on these plans or as directed by the Designer.

7. Equipment will remain outside of channel when feasible during construction. In-stream work is anticipated for successful placement of structures and channel excavation.

8. All mechanized equipment operated in or near the stream or its tributaries shall be inspected regularly and maintained to prevent contamination of stream waters from fuels, lubricants, hydraulic fluids or other toxic materials. Any equipment repairs, maintenance or refueling activities shall not be done while the equipment is in the stream or its tributaries.

9. Contractor to dispose of all waste material offsite in accordance with all federal, state and local regulations.

10. All appropriately sized on-site trees removed during the stream restoration construction to be used on-site as rootwads, footer logs, etc., where feasible and as directed by the Designer.

11. All rootwads shall be installed by driving or pushing them into the streambank, when driving is not feasible, installation through excavation may be acceptable if directed by the Designer.

12. All disturbed areas to be seeded immediately as specified in the project specifications.

13. Apply temporary and permanent seed and erosion control fiber matting to bankfull bench and cut banks daily as excavation progresses. Erosion control fiber matting will be keyed into the top of slope and at the ends of each mat to prevent undercutting from sheet flow. Additional silt fencing will be installed as directed by the Designer.

14. Unless otherwise directed by the Designer or noted on these plans, a 50-foot minimum width permanently vegetated buffer shall be planted.

15. Use rootwads, topsoil and transplant vegetation generated on-site for the proposed stream construction as close as possible to the existing location from where these items are removed in order to minimize hauling distance and storage duration.

16. Unless otherwise directed by the Designer, and where feasible, when beginning construction on a given reach, where clearing is required, use the following sequence:
    A. Remove transplant vegetation and stockpile as specified on the plans.
    B. Remove larger trees that can be used on-site for rootwads, footer logs, log vanes or floodplain habitat structures and stockpile as specified on the plans.
    C. Remove remaining vegetation and dispose of or stockpile as specified on the plans.
    D. Remove topsoil and stockpile as specified on the plans.
    E. Remove remaining soil materials as required and stockpile as specified on the plans.

17. Existing non-native vegetation within the proposed limits of construction to be removed as specified in the project specifications.

18. Contractor to provide temporary plant bedding area on site for temporary storage of vegetation transplants. Transplants to be kept watered, mulched and shaded at all times as specified in the project specifications.

19. Construction staging areas to be of adequate size to provide safe and organized storage for rock, rootwads and logs to be used for in-stream structures, mulch, topsoil and other soil material, temporary plant beds for vegetation transplant material, as well as all other related construction materials and equipment.

20. Construction personnel should park all vehicles within the limits of the designated construction staging areas. All other construction equipment and vehicles should be parked within the construction staging areas when not in use.

21. Contractor to be responsible for repairs to any damage to existing utilities, including but not limited to, overhead and underground utilities, curb and gutter, pavement, sidewalks, storm drainage systems, sanitary sewer systems, access roads, or fencing. Any required repairs to be made in accordance with any and all applicable state and or local municipality standards. The Contractor shall consult with the "Call Before You Dig" Toll Free Number 800-632-4949, and the NC ONE Call Center at least 48 hour prior to beginning any earthwork activities.

22. Contractor shall keep all topsoil stockpiled on site separately from other soil materials.

23. Rock vanes may be installed in lieu of j-hook vanes at the direction of the Designer.

24. Contractor is advised to use caution and to follow the contract documents as well as all applicable regulations with regards to pedestrian and bystander safety.

25. Excess soil materials to be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications. If any excavated soil materials are disposed of off site by the Contractor, the Contractor is responsible for disposal of such soil materials in a permitted area, as well as for providing and implementing an erosion and sedimentation control plan and permit, or any other required permit(s), for the location(s) off site where such materials are disposed.

26. Contractor is responsible for coordinating with the land owner throughout all phases of construction regarding the movement and containment of livestock at the site. The Contractor shall coordinate with the land owner as necessary to insure at all times that livestock are safely and securely moved out of all work areas, that livestock do not escape from the property as a result of construction activities, that livestock are not harmed as a result of construction activities, that livestock are excluded at all times from the active and completed work areas, and that construction activities are not hindered, delayed, or damaged by livestock or the associated movement or containment of livestock.

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT III
02/16/07

# CONSTRUCTION SEQUENCE

| REVISIONS | | | PROJECT ENGINEER |
|---|---|---|---|
| DATE | BY | DESCRIPTION | |
| 1/31/07 | JTL | ISSUED FOR PERMITTING | DO NOT USE FOR CONSTRUCTION |

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 2A |

*CONST. SEQUENCE*

MULKEY ENGINEERS & CONSULTANTS
PO Box 33127
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(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III

## PHASE 1

LIVESTOCK MOVEMENT, MOBILIZATION, AND ESTABLISHMENT OF GENERAL EROSION CONTROL MEASURES

1. Coordinate and complete all necessary livestock movement, exclusion, and containment activities with the landowner.

2. Identify and locate staging areas, stockpile areas, construction entrances, stream crossings required for construction access, limits of silt fencing, limits of tree protection fencing, and construction access roads as shown on plans.

2. Install construction entrances.

3. Install stream crossings required for construction access.

4. Stockpile materials in designated staging areas.

5. Install silt fencing to the limits shown on the plans and at any other locations as directed by the Designer. Silt fencing will be installed around the limits of all staging and stockpile areas.

6. Install tree protection fencing as shown on the plans and at all other locations as directed by the Designer. Flag all vegetation to be transplanted.

NOTE: With approval from the Designer, the Contractor may complete Phases 2 through 13 out of sequence, dependant upon weather and/or site conditions. Regardless of the sequencing of the phases, each phase will be completed prior to beginning work on another phase.

## PHASE 2

REACH R1 FROM BEGINNING OF PROJECT TO CONFLUENCE WITH REACH R1A

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

   i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

   j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 3

REACH R1A

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

CONTINUED ON PAGE 2B

# CONSTRUCTION SEQUENCE

| REVISIONS | | |
|---|---|---|
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DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 2B |

**CONST. SEQUENCE**

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 4

REACH R1 FROM CONFLUENCE WITH REACH R1A TO NC HIGHWAY 9 BRIDGE

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded. amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

   i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

   j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 5

REACH R1 FROM NC HIGHWAY 9 BRIDGE TO CONFLUENCE WITH REACH R2

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

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# CONSTRUCTION SEQUENCE




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NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III 02/16/07


i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 6

REACH R2 FROM BEGINNING OF PROJECT TO CONFLUENCE WITH REACH R2A

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

   i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

   j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 7

REACH R2A

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

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# CONSTRUCTION SEQUENCE

| REVISIONS | | |
|---|---|---|
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| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

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| LITTLE WHITE OAK CREEK | 2D |

**CONST. SEQUENCE**

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

**PHASE 8**

REACH R2 FROM CONFLUENCE WITH REACH R2A TO CONFLUENCE WITH REACH R2B

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

   i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

   j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

**PHASE 9**

REACH R2B

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

   a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

   b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

   c. Perform required clearing and grubbing.

   d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

   e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

   f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

   g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

   h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

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# CONSTRUCTION SEQUENCE

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PROJECT ENGINEER

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NORTH CAROLINA PROFESSIONAL SEAL 22987 ENGINEER WILLIAM SCOTT HUNT, III 02/16/07

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

**PHASE 10**

REACH R2 FROM CONFLUENCE WITH REACH R2B TO CONFLUENCE WITH REACH R1

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

c. Perform required clearing and grubbing.

d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

**PHASE 11**

REACH R2 FROM CONFLUENCE WITH REACH R1 TO SR 1324 BRIDGE

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

c. Perform required clearing and grubbing.

d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

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# CONSTRUCTION SEQUENCE

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

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**CONST. SEQUENCE**

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(919) 851-1918 (FAX)
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i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 12

REACH R2 FROM SR 1324 BRIDGE TO CONFLUENCE WITH REACH R2D

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

c. Perform required clearing and grubbing.

d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 13

REACH R2D

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

c. Perform required clearing and grubbing.

d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel, excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

CONTINUED ON PAGE 2G

# CONSTRUCTION SEQUENCE

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 2G |

*CONST. SEQUENCE*

MULKEY
ENGINEERS & CONSULTANTS
PO Box 33127
Raleigh, N.C. 27636
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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 14

REACH R2 FROM CONFLUENCE WITH REACH R2D TO END OF PROJECT

1. Designer will perform construction staking.

2. Begin pump-around operation at upstream end of reach. Install an impervious dike at upstream and downstream ends of the proposed limit of the area of active construction in order to isolate all work from stream flow. Pump-around operation should be conducted in accordance with the typical pump-around operation detail as shown on the plans. Turbid water between impervious dikes must be pumped with a separate pump into sediment bags to be discharged downstream of the impervious dikes in accordance with the typical pump-around operation detail as shown on the plans. After the pump-around operation is properly initiated, proceed with construction in the sequence noted below:

a. Remove all vegetation transplants, including individual specimens and vegetated mats), stockpile and maintain in accordance with the project specifications.

b. Remove any appropriate trees to be used as rootwads, header logs, footer logs, or logs sills and stockpile in accordance with the project specifications.

c. Perform required clearing and grubbing.

d. Segregate and stockpile topsoil and other soil material in accordance with the project specifications.

e. Beginning at the upstream end of the area of active construction, proceed in the downstream direction with construction of the proposed stream channel. excavating and shaping the channel and installing the required in-stream structures as specified on the plans.

f. Perform all topsoil replacement, vegetation transplanting, seeding (temporary and permanent), soil amendment, mulching, and installation of all erosion control matting as specified on the plans and the project specifications. Stream banks will have permanent and temporary seed, soil amendments, mulch, and erosion control matting applied to them as work progresses and by the end of each day. Erosion control matting will be installed on top of the seeded, amended, and mulched stream banks according to the project specifications.

g. For sections of proposed channel on new alignment, leave the reach of proposed channel on new alignment disconnected (at its upstream end) from the existing active stream channel until construction of the proposed reach of channel on new alignment is completed. Leave such sections of proposed channel disconnected as described as long as possible in order to facilitate the establishment and growth of vegetation prior to activation of the new channel.

h. For sections of proposed channel on new alignment, connect existing channel to the newly constructed channel at its upstream end. Immediately construct the impervious stream channel plug at the upstream end of the reach of existing channel to be abandoned. Haul other soil material produced during construction of this reach back to the abandoned stream reach and use it to begin filling the abandoned channel.

i. Complete all work within the limit of the given pump-around operation before beginning additional work at other locations. After completing all work within the limit of the current pump-around operation, proceed with the next downstream segment of construction.

j. Relocate pump-around operation to next location downstream. Leave impervious dike that was located at the downstream end of the previous pump-around operation in place to serve as the impervious dike at the upstream end of the new pump-around operation. Install an impervious dike at the downstream end of the new pump-around operation. After the new pump-around operation is properly initiated, repeat steps a. through i. along the entire reach until the construction of the reach is completed.

3. Remove and dispose of all unused vegetation materials.

4. All excavated soil materials not utilized will be stockpiled and maintained according to the project specifications. After the completion of construction, all unused soil materials shall be spread on site in active agricultural areas on the properties owned and operated by the Walker Family Trust at the direction of the Designer and the said property owners. Spread soil to be stabilized using seeding per the project specifications.

5. All remaining disturbed areas are to be amended, seeded, matted and/or mulched according to the project specifications.

## PHASE 15

DEMOBILIZATION AND PLANTING

1. Complete remaining minor grading and site planting preparation work, including ripping and/or discing, as specified in the project specifications.

2. All remaining disturbed areas, including areas that have been ripped and/or disced after temporary and/or permanent seeding activities, are to be amended, seeded, matted and/or mulched according to the project specifications.

3. After all construction requiring heavy equipment is completed, remove silt fence and restore construction access roads, staging areas, and stockpile areas. Immediately regrade, replace topsoil, and seed, amend, and mulch as specified in the project specifications.

4. Remove temporary construction entrances. Immediately regrade, seed, amend, and mulch as specified in the project specifications.

5. Remove all tree protection fencing.

6. Complete all remaining proposed permanent vegetation planting per the plans and project specifications.

7. Install permanent fencing and gates for the conservation easement.

8. Remove and dispose of all trash, metal, and debris from the site according to local, state and federal regulations.

# MORPHOLOGICAL TABLES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 2H |

*MORPH. TABLES*

MULKEY
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| Variables | NAME | B1 Existing | B1 Proposed | B1 Reference | B1A Existing | B1A Proposed | B1A Reference | B2 Upper Existing | B2 Upper Proposed | B2 Upper Reference | B2 Lower Existing | B2 Lower Proposed | B2 Lower Reference | B2A Existing | B2A Proposed | B2A Reference | B2B Existing | B2B Proposed | B2B Reference | B2D Existing | B2D Proposed | B2D Reference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Stream Type | | Degraded E5 | C5 | C4/1 | Degraded B6c | C5 | C4/1 | Degraded E5 | C5 | C4/1 | Degraded E5 | C5 | C4/1 | Degraded E4 | C4 | C4/1 | [illegible] | C4 | C4/1 | Degraded E6 | C6 | C4/1 |
| 2. Drainage Area, sq mi (acres) | | 4.46 (2854.4) | 4.46 (2854.4) | 0.867 (554.9) | 0.11 (70.4) | 0.11 (70.4) | 0.867 (554.9) | 6.20 (3966.91) | 6.20 (3966.91) | 0.867 (554.9) | 10.85 (6943.97) | 10.85 (6943.97) | 0.867 (554.9) | 0.55 (351.6) | 0.55 (351.6) | 0.867 (554.9) | 0.12 (76.8) | 0.12 (76.8) | 0.867 (554.9) | 0.05 (31.65) | 0.05 (31.65) | 0.867 (554.9) |
| 3. Bankfull Width, ft (Wbkf) | Mean: | 18.430 | | 18.523 | 7.720 | | 18.523 | 24.385 | | 18.523 | 30.355 | | 18.523 | 11.190 | | 18.523 | 5.475 | | 18.523 | 5.500 | | 18.523 |
| | Minimum: | 16.550 | 25.698 | 15.970 | 4.510 | 7.969 | 15.970 | 24.270 | 31.068 | 15.970 | 28.530 | 35.637 | 15.970 | 11.180 | 11.726 | 15.970 | 4.510 | 7.969 | 15.970 | 3.800 | 7.969 | 15.970 |
| | Maximum: | 20.310 | | 20.600 | 10.950 | | 20.600 | 24.500 | | 20.600 | 32.180 | | 20.600 | 11.200 | | 20.600 | 6.440 | | 20.600 | 7.200 | | 20.600 |
| 4. Bankfull Mean Depth, ft (dbkf) | Mean: | 3.315 | 2.023 | 1.640 | 0.450 | 0.627 | 1.640 | 3.135 | 2.116 | 1.640 | 3.400 | 2.806 | 1.640 | 1.235 | 0.938 | 1.640 | 1.330 | 0.627 | 1.640 | 0.750 | 0.627 | 1.640 |
| | Minimum: | 3.200 | | 1.580 | 0.360 | | 1.580 | 3.130 | | 1.580 | 3.310 | | 1.580 | 0.970 | | 1.580 | 1.310 | | 1.580 | 0.700 | | 1.580 |
| | Maximum: | 3.430 | | 1.720 | 0.540 | | 1.720 | 3.140 | | 1.720 | 3.490 | | 1.720 | 1.500 | | 1.720 | 1.350 | | 1.720 | 0.800 | | 1.720 |
| 5. Width/Depth Ratio (Wbkf/dbkf) | Mean: | 5.547 | 12.700 | 11.342 | 16.384 | 12.700 | 11.342 | 7.778 | 12.700 | 11.342 | 8.948 | 12.700 | 11.342 | 9.496 | 12.500 | 11.342 | 4.107 | 12.700 | 11.342 | 7.050 | 12.700 | 11.342 |
| | Minimum: | 5.172 | | 9.285 | 12.528 | | 9.285 | 7.729 | | 9.285 | 5.175 | | 9.285 | 7.467 | | 9.285 | 3.443 | | 9.285 | 5.260 | | 9.285 |
| | Maximum: | 5.921 | | 12.716 | 20.240 | | 12.716 | 7.827 | | 12.716 | 9.722 | | 12.716 | 11.526 | | 12.716 | 4.770 | | 12.716 | 8.840 | | 12.716 |
| 6. Bankfull Cross Sectional Area, sq ft (Abkf) | Mean: | 61.330 | 52.000 | 30.247 | 3.735 | 5.000 | 30.247 | 76.425 | 76.000 | 30.247 | 103.135 | 100.000 | 30.247 | 13.800 | 11.000 | 30.247 | 7.325 | 5.000 | 30.247 | 4.250 | 5.000 | 30.247 |
| | Minimum: | 52.940 | | 27.410 | 1.620 | | 27.410 | 76.120 | | 27.410 | 99.680 | | 27.410 | 10.820 | | 27.410 | 5.920 | | 27.410 | 2.700 | | 27.410 |
| | Maximum: | 69.720 | | 33.370 | 5.850 | | 33.370 | 76.730 | | 33.370 | 106.590 | | 33.370 | 16.780 | | 33.370 | 8.730 | | 33.370 | 5.800 | | 33.370 |
| 7. Bankfull Mean Velocity, fps (Vbkf) | Mean: | 4.420 | 5.212 | 4.242 | 5.274 | 3.910 | 4.242 | [illegible] | [illegible] | 4.242 | 4.741 | 4.890 | 4.242 | 3.185 | 3.995 | 4.242 | [illegible] | [illegible] | 4.242 | 5.252 | 4.464 | 4.242 |
| 8. Bankfull Discharge, cfs (Qbkf) | Mean: | 271.080 | 271.000 | 128.300 | 19.700 | 19.700 | 128.300 | 310.000 | 310.000 | 128.300 | 489.000 | 489.000 | 128.300 | 43.950 | 43.950 | 128.300 | 31.000 | 31.000 | 128.300 | 22.320 | 22.320 | 128.300 |
| 9. Maximum Bankfull Depth, ft (dmbkf) | Mean: | 3.692 | 2.342 | 1.898 | 0.860 | 0.726 | 1.898 | 4.100 | 2.831 | 1.898 | 3.953 | 3.248 | 1.898 | 1.482 | 1.086 | 1.898 | 1.750 | 0.726 | 1.898 | 1.400 | 0.726 | 1.898 |
| | Minimum: | 2.370 | 1.900 | 1.540 | 0.540 | 0.589 | 1.540 | 3.610 | 2.297 | 1.540 | 3.690 | 2.635 | 1.540 | 0.950 | 0.881 | 1.540 | 1.700 | 0.589 | 1.540 | 1.150 | 0.589 | 1.540 |
| | Maximum: | 5.000 | 2.912 | 2.360 | 1.180 | 0.903 | 2.360 | 4.940 | 3.520 | 2.360 | 4.200 | 4.038 | 2.360 | 2.230 | 1.350 | 2.360 | 1.800 | 0.903 | 2.360 | 1.650 | 0.903 | 2.360 |
| 10. Maximum Riffle Depth/Mean Riffle Depth (dmbkf/dbkf) | Mean: | 1.114 | 1.157 | 1.157 | 1.911 | 1.157 | 1.157 | 1.308 | 1.157 | 1.157 | 1.163 | 1.157 | 1.157 | 1.200 | 1.157 | 1.157 | 1.316 | 1.157 | 1.157 | 1.810 | 1.157 | 1.157 |
| | Minimum: | 0.715 | 0.939 | 0.939 | 1.200 | 0.939 | 0.939 | 1.152 | 0.939 | 0.939 | 1.085 | 0.939 | 0.939 | 0.769 | 0.939 | 0.939 | 1.278 | 0.939 | 0.939 | 1.490 | 0.939 | 0.939 |
| | Maximum: | 1.508 | 1.439 | 1.439 | 2.622 | 1.439 | 1.439 | 1.576 | 1.439 | 1.439 | 1.235 | 1.439 | 1.439 | 1.806 | 1.439 | 1.439 | 1.553 | 1.439 | 1.439 | 2.140 | 1.439 | 1.439 |
| 11. Ratio of Low Bank Height to Maximum Bankfull Depth (LBH/dmbkf) | Mean: | 2.203 | 1.000 | 1.228 | 3.703 | 1.000 | 1.228 | 1.611 | 1.000 | 1.228 | 1.750 | 1.000 | 1.228 | 4.270 | 1.000 | 1.228 | 2.625 | 1.000 | 1.228 | 3.226 | 1.000 | 1.228 |
| | Minimum: | 1.516 | 1.000 | 1.008 | 3.110 | 1.000 | 1.008 | 1.474 | 1.000 | 1.008 | 1.480 | 1.000 | 1.008 | 2.276 | 1.000 | 1.008 | 1.444 | 1.000 | 1.008 | 2.465 | 1.000 | 1.008 |
| | Maximum: | 2.946 | 1.000 | 1.416 | 4.296 | 1.000 | 1.416 | 2.141 | 1.000 | 1.416 | 1.945 | 1.000 | 1.416 | 6.816 | 1.000 | 1.416 | 3.806 | 1.000 | 1.416 | 4.007 | 1.000 | 1.416 |
| 12. Width of Flood Prone Area, ft (Wfpa) | Mean: | 94.085 | 98.413 | 70.180 | 13.825 | 30.516 | 70.180 | 161.025 | 118.975 | 70.180 | 124.560 | 136.474 | 70.180 | 17.520 | 44.905 | 70.180 | 100.350 | 30.516 | 70.180 | 10.485 | 30.516 | 70.180 |
| | Minimum: | 69.590 | 90.792 | 67.150 | 8.580 | 28.153 | 67.150 | 77.050 | 109.762 | 67.150 | 89.480 | 125.906 | 67.150 | 15.990 | 41.428 | 67.150 | 5.420 | 28.153 | 67.150 | 8.370 | 28.153 | 67.150 |
| | Maximum: | 118.580 | 113.623 | 72.780 | 19.070 | 35.233 | 72.780 | 251.000 | 137.363 | 72.780 | 159.640 | 157.566 | 72.780 | 19.050 | 51.846 | 72.780 | 195.280 | 35.233 | 72.780 | 12.600 | 35.233 | 72.780 |
| 13. Entrenchment Ratio (Wfpa/Wbkf) | Mean: | 5.022 | 3.830 | 3.830 | 1.824 | 3.830 | 3.830 | 6.743 | 3.830 | 3.830 | 4.049 | 3.830 | 3.830 | 1.566 | 3.830 | 3.830 | 15.762 | 3.830 | 3.830 | 1.985 | 3.830 | 3.830 |
| | Minimum: | 4.205 | 3.533 | 3.533 | 1.745 | 3.533 | 3.533 | 3.145 | 3.533 | 3.533 | 3.136 | 3.533 | 3.533 | 1.428 | 3.533 | 3.533 | 1.202 | 3.533 | 3.533 | 1.760 | 3.533 | 3.533 |
| | Maximum: | 5.839 | 4.421 | 4.421 | 1.902 | 4.421 | 4.421 | 10.342 | 4.421 | 4.421 | 4.961 | 4.421 | 4.421 | 1.704 | 4.421 | 4.421 | 30.323 | 4.421 | 4.421 | 2.210 | 4.421 | 4.421 |
| 14. Meander Length, ft (Lm) | Mean: | 135.700 | 130.410 | 94.000 | 0.000 | 40.439 | 94.000 | 118.200 | 157.658 | 94.000 | 216.400 | 180.847 | 94.000 | 76.700 | 59.506 | 94.000 | 0.000 | 40.439 | 94.000 | 0.000 | 40.439 | 94.000 |
| | Minimum: | 107.000 | 45.782 | 33.000 | 0.000 | 14.197 | 33.000 | 85.800 | 55.348 | 33.000 | 196.400 | 63.489 | 33.000 | 76.700 | 20.890 | 33.000 | 0.000 | 14.197 | 33.000 | 0.000 | 14.197 | 33.000 |
| | Maximum: | 189.300 | 215.038 | 155.000 | 0.000 | 66.681 | 155.000 | 165.100 | 259.969 | 155.000 | 236.500 | 298.205 | 155.000 | 76.700 | 98.121 | 155.000 | 0.000 | 66.681 | 155.000 | 0.000 | 66.681 | 155.000 |
| 15. Meander Length Ratio (Lm/Wbkf) | Mean: | 7.363 | 5.075 | 5.075 | 0.000 | 5.075 | 5.075 | 4.847 | 5.075 | 5.075 | 7.129 | 5.075 | 5.075 | 6.854 | 5.075 | 5.075 | 0.000 | 5.075 | 5.075 | 0.000 | 5.075 | 5.075 |
| | Minimum: | 5.806 | 1.782 | 1.782 | 0.000 | 1.782 | 1.782 | 3.519 | 1.782 | 1.782 | 6.470 | 1.782 | 1.782 | 6.854 | 1.782 | 1.782 | 0.000 | 1.782 | 1.782 | 0.000 | 1.782 | 1.782 |
| | Maximum: | 10.271 | 8.368 | 8.368 | 0.000 | 8.368 | 8.368 | 6.771 | 8.368 | 8.368 | 7.785 | 8.368 | 8.368 | 6.854 | 8.368 | 8.368 | 0.000 | 8.368 | 8.368 | 0.000 | 8.368 | 8.368 |
| 16. Radius of Curvature, ft (Rc) | Mean: | 37.700 | 67.980 | 49.000 | 0.000 | 21.080 | 49.000 | 45.800 | 62.181 | 49.000 | 57.000 | 94.271 | 49.000 | 21.100 | 31.019 | 49.000 | 0.000 | 21.080 | 49.000 | 0.000 | 21.080 | 49.000 |
| | Minimum: | 23.400 | 26.360 | 19.000 | 0.000 | 8.174 | 19.000 | 19.700 | 31.807 | 19.000 | 30.000 | 36.554 | 19.000 | 8.800 | 12.028 | 19.000 | 0.000 | 8.174 | 19.000 | 0.000 | 8.174 | 19.000 |
| | Maximum: | 63.800 | 159.545 | 115.000 | 0.000 | 49.473 | 115.000 | 124.400 | 192.880 | 115.000 | 79.500 | 221.249 | 115.000 | 31.400 | 72.800 | 115.000 | 0.000 | 49.473 | 115.000 | 0.000 | 49.473 | 115.000 |
| 17. Ratio of Radius of Curvature to Width (Rc/Wbkf) | Mean: | 2.046 | 2.645 | 2.645 | 0.000 | 2.645 | 2.645 | 1.878 | 2.645 | 2.645 | 1.878 | 2.645 | 2.645 | 1.886 | 2.645 | 2.645 | 0.000 | 2.645 | 2.645 | 0.000 | 2.645 | 2.645 |
| | Minimum: | 1.270 | 1.026 | 1.026 | 0.000 | 1.026 | 1.026 | 0.808 | 1.026 | 1.026 | 0.988 | 1.026 | 1.026 | 0.786 | 1.026 | 1.026 | 0.000 | 1.026 | 1.026 | 0.000 | 1.026 | 1.026 |
| | Maximum: | 3.462 | 6.208 | 6.208 | 0.000 | 6.208 | 6.208 | 5.101 | 6.208 | 6.208 | 2.619 | 6.208 | 6.208 | 2.806 | 6.208 | 6.208 | 0.000 | 6.208 | 6.208 | 0.000 | 6.208 | 6.208 |
| 18. Belt Width, ft (Wblt) | Mean: | 39.800 | 92.952 | 67.000 | 0.000 | 28.823 | 67.000 | 32.800 | 112.374 | 67.000 | 42.300 | 128.901 | 67.000 | 20.200 | 42.414 | 67.000 | 0.000 | 28.823 | 67.000 | 0.000 | 28.823 | 67.000 |
| | Minimum: | 22.000 | 49.944 | 36.000 | 0.000 | 15.487 | 36.000 | 15.200 | 60.380 | 36.000 | 16.200 | 69.260 | 36.000 | 20.200 | 22.789 | 36.000 | 0.000 | 15.487 | 36.000 | 0.000 | 15.487 | 36.000 |
| | Maximum: | 61.600 | 208.102 | 150.000 | 0.000 | 64.530 | 150.000 | 48.700 | 251.583 | 150.000 | 69.500 | 288.585 | 150.000 | 20.200 | 94.956 | 150.000 | 0.000 | 64.530 | 150.000 | 0.000 | 64.530 | 150.000 |
| 19. Meander Width Ratio (Wblt/Wbkf) | Mean: | 2.160 | 3.617 | 3.617 | 0.000 | 3.617 | 3.617 | 1.345 | 3.617 | 3.617 | 1.394 | 3.617 | 3.617 | 1.805 | 3.617 | 3.617 | 0.000 | 3.617 | 3.617 | 0.000 | 3.617 | 3.617 |
| | Minimum: | 1.194 | 1.943 | 1.943 | 0.000 | 1.943 | 1.943 | 0.623 | 1.943 | 1.943 | 0.534 | 1.943 | 1.943 | 1.805 | 1.943 | 1.943 | 0.000 | 1.943 | 1.943 | 0.000 | 1.943 | 1.943 |
| | Maximum: | 3.342 | 8.098 | 8.098 | 0.000 | 8.098 | 8.098 | 1.997 | 8.098 | 8.098 | 2.290 | 8.098 | 8.098 | 1.805 | 8.098 | 8.098 | 0.000 | 8.098 | 8.098 | 0.000 | 8.098 | 8.098 |
| 20. Low Bank Height, ft (LBH) | Mean: | 7.683 | 2.342 | 2.296 | 2.995 | 0.726 | 2.296 | 7.533 | 2.831 | 2.296 | 6.913 | 3.248 | 2.296 | 5.644 | 1.086 | 2.296 | 4.535 | 0.726 | 2.296 | 4.338 | 0.726 | 2.296 |
| | Minimum: | 6.320 | 1.900 | 2.090 | 2.320 | 0.589 | 2.090 | 5.940 | 2.297 | 2.090 | 6.040 | 2.635 | 2.090 | 4.210 | 0.881 | 2.090 | 2.600 | 0.589 | 2.090 | 4.067 | 0.589 | 2.090 |
| | Maximum: | 8.900 | 2.912 | 2.670 | 3.670 | 0.903 | 2.670 | 8.930 | 3.520 | 2.670 | 8.170 | 4.038 | 2.670 | 6.680 | 1.350 | 2.670 | 6.470 | 0.903 | 2.670 | 4.608 | 0.903 | 2.670 |
| 21. Sinuosity (K) | Mean: | 1.160 | 1.300 | 1.460 | 1.060 | 1.300 | 1.460 | 1.130 | 1.300 | 1.460 | 1.110 | 1.300 | 1.460 | 1.120 | 1.300 | 1.460 | 1.050 | 1.300 | 1.460 | 1.120 | 1.300 | 1.460 |
| 22. Valley Slope (VS) | Mean: | 0.003 | 0.003 | 0.013 | 0.013 | 0.013 | 0.013 | 0.002 | 0.002 | 0.013 | 0.002 | 0.002 | 0.013 | 0.012 | 0.012 | 0.013 | 0.015 | 0.015 | 0.013 | 0.012 | 0.012 | 0.013 |
| 23. Average Water Surface Slope (S) = (VS/K) | Mean: | 0.003 | 0.003 | 0.009 | 0.012 | 0.010 | 0.009 | 0.002 | 0.002 | 0.009 | 0.002 | 0.002 | 0.009 | 0.011 | 0.009 | 0.009 | 0.014 | 0.012 | 0.009 | 0.011 | 0.010 | 0.009 |
| 24. Pool Slope (Sp) | Mean: | 0.00168 | 0.000339495 | 0.0012 | 0 | 0.001327117 | 0.0012 | 0.00067 | 0.000246905 | 0.0012 | 0.00203 | 0.000216042 | 0.0012 | 0.0026 | 0.001234527 | 0.0012 | 0 | 0.001563735 | 0.0012 | 0 | 0.001275678 | 0.0012 |
| | Minimum: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.00016 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Maximum: | 0.00548 | 0.001225011 | 0.00433 | 0 | 0.00478868 | 0.00433 | 0.00178 | 0.000890917 | 0.00433 | 0.00491 | 0.000779553 | 0.00433 | 0.00891 | 0.004454586 | 0.00433 | 0 | 0.005642476 | 0.00433 | 0 | 0.004603072 | 0.00433 |
| 25. Ratio of Pool Slope to Average Water Slope (Sp/S) | Mean: | 0.590545455 | 0.133740458 | 0.133740458 | 0 | 0.133740458 | 0.133740458 | 0.31825 | 0.133740458 | 0.133740458 | 1.075 | 0.133740458 | 0.133740458 | 0.242666667 | 0.133740458 | 0.133740458 | 0 | 0.133740458 | 0.133740458 | 0 | 0.133740458 | 0.133740458 |
| | Minimum: | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.084571429 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Maximum: | 1.92630303 | 0.482580153 | 0.482580153 | 0 | 0.482580153 | 0.482580153 | 0.8455 | 0.482580153 | 0.482580153 | 2.595285714 | 0.482580153 | 0.482580153 | 0.8316 | 0.482580153 | 0.482580153 | 0 | 0.482580153 | 0.482580153 | 0 | 0.482580153 | 0.482580153 |
| 26. Riffle Slope (water surface facet slope) (Srif) | Mean: | 0.010 | 0.008 | 0.028 | 0.000 | 0.031 | 0.028 | 0.003 | 0.006 | 0.028 | 0.007 | 0.005 | 0.028 | 0.011 | 0.029 | 0.028 | 0.000 | 0.037 | 0.028 | 0.000 | 0.030 | 0.028 |
| | Minimum: | 0.001 | 0.002 | 0.006 | 0.000 | 0.007 | 0.006 | 0.001 | 0.001 | 0.006 | 0.001 | 0.001 | 0.006 | 0.004 | 0.007 | 0.006 | 0.000 | 0.008 | 0.006 | 0.000 | 0.007 | 0.006 |
| | Maximum: | 0.117 | 0.019 | 0.066 | 0.000 | 0.072 | 0.066 | 0.008 | 0.013 | 0.066 | 0.024 | 0.012 | 0.066 | 0.024 | 0.067 | 0.066 | 0.000 | 0.085 | 0.066 | 0.000 | 0.070 | 0.066 |
| 27. Ratio of Riffle Slope to Average Water Slope (Srif/S) | Mean: | 3.677 | 3.162 | 3.162 | 0.000 | 3.162 | 3.162 | 1.658 | 3.162 | 3.162 | 3.504 | 3.162 | 3.162 | 0.996 | 3.162 | 3.162 | 0.000 | 3.162 | 3.162 | 0.000 | 3.162 | 3.162 |
| | Minimum: | 0.432 | 0.704 | 0.704 | 0.000 | 0.704 | 0.704 | 0.442 | 0.704 | 0.704 | 0.423 | 0.704 | 0.704 | 0.395 | 0.704 | 0.704 | 0.000 | 0.704 | 0.704 | 0.000 | 0.704 | 0.704 |
| | Maximum: | 41.159 | 7.301 | 7.301 | 0.000 | 7.301 | 7.301 | 3.900 | 7.301 | 7.301 | 12.511 | 7.301 | 7.301 | 2.262 | 7.301 | 7.301 | 0.000 | 7.301 | 7.301 | 0.000 | 7.301 | 7.301 |
| 28. Run Slope (water surface facet slope) (Srun) | Mean: | 0.004 | 0.007 | 0.024 | 0.000 | 0.027 | 0.024 | 0.003 | 0.005 | 0.024 | 0.008 | 0.004 | 0.024 | 0.008 | 0.025 | 0.024 | 0.000 | 0.032 | 0.024 | 0.000 | 0.026 | 0.024 |
| | Minimum: | 0.001 | 0.003 | 0.009 | 0.000 | 0.010 | 0.009 | 0.001 | 0.002 | 0.009 | 0.001 | 0.002 | 0.009 | 0.003 | 0.009 | 0.009 | 0.000 | 0.012 | 0.009 | 0.000 | 0.010 | 0.009 |
| | Maximum: | 0.011 | 0.022 | 0.079 | 0.000 | 0.087 | 0.079 | 0.005 | 0.016 | 0.079 | 0.019 | 0.014 | 0.079 | 0.014 | 0.081 | 0.079 | 0.000 | 0.103 | 0.079 | 0.000 | 0.084 | 0.079 |
| 29. Ratio Run Slope/Average Water Surface Slope (Srun/S) | Mean: | 1.522 | 2.700 | 2.700 | 0.000 | 2.700 | 2.700 | 1.325 | 2.700 | 2.700 | 3.991 | 2.700 | 2.700 | 0.758 | 2.700 | 2.700 | 0.000 | 2.700 | 2.700 | 0.000 | 2.700 | 2.700 |
| | Minimum: | 0.179 | 1.006 | 1.006 | 0.000 | 1.006 | 1.006 | 0.423 | 1.006 | 1.006 | 0.391 | 1.006 | 1.006 | 0.294 | 1.006 | 1.006 | 0.000 | 1.006 | 1.006 | 0.000 | 1.006 | 1.006 |
| | Maximum: | 3.937 | 8.807 | 8.807 | 0.000 | 8.807 | 8.807 | 2.309 | 8.807 | 8.807 | 10.143 | 8.807 | 8.807 | 1.276 | 8.807 | 8.807 | 0.000 | 8.807 | 8.807 | 0.000 | 8.807 | 8.807 |
| 30. Slope of Glide (water surface facet slope) (Sg) | Mean: | 0.004 | 0.001 | 0.003 | 0.000 | 0.004 | 0.003 | 0.004 | 0.001 | 0.003 | 0.003 | 0.001 | 0.003 | 0.008 | 0.003 | 0.003 | 0.000 | 0.004 | 0.003 | 0.000 | 0.003 | 0.003 |
| | Minimum: | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | Maximum: | 0.006 | 0.004 | 0.013 | 0.000 | 0.014 | 0.013 | 0.007 | 0.003 | 0.013 | 0.010 | 0.002 | 0.013 | 0.010 | 0.013 | 0.013 | 0.000 | 0.017 | 0.013 | 0.000 | 0.014 | 0.013 |
| 31. Ratio Glide Slope/Average Water Surface Slope (Sg/S) | Mean: | 1.304 | 0.362 | 0.362 | 0.000 | 0.362 | 0.362 | 1.667 | 0.362 | 0.362 | 1.818 | 0.362 | 0.362 | 0.763 | 0.362 | 0.362 | 0.000 | 0.362 | 0.362 | 0.000 | 0.362 | 0.362 |
| | Minimum: | 0.629 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.561 | 0.000 | 0.000 | 0.634 | 0.000 | 0.000 | 0.404 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | Maximum: | 2.056 | 1.453 | 1.453 | 0.000 | 1.453 | 1.453 | 3.202 | 1.453 | 1.453 | 5.423 | 1.453 | 1.453 | 0.950 | 1.453 | 1.453 | 0.000 | 1.453 | 1.453 | 0.000 | 1.453 | 1.453 |
| 32. Maximum Pool Depth, ft (dpool) | Mean: | 4.700 | 3.553 | 2.880 | 1.380 | 1.102 | 2.880 | 5.280 | 4.296 | 2.880 | 4.970 | 4.928 | 2.880 | 2.210 | 1.647 | 2.880 | 0.000 | 1.102 | 2.880 | 0.000 | 1.102 | 2.880 |
| | Minimum: | 3.500 | 2.677 | 2.170 | 1.110 | 0.830 | 2.170 | 4.610 | 3.237 | 2.170 | 3.720 | 3.713 | 2.170 | 1.200 | 1.241 | 2.170 | 0.000 | 0.830 | 2.170 | 0.000 | 0.830 | 2.170 |
| | Maximum: | 6.600 | 4.696 | 3.320 | 1.640 | 1.270 | 3.320 | 6.290 | 4.952 | 3.320 | 5.960 | 5.681 | 3.320 | 3.640 | 1.899 | 3.320 | 0.000 | 1.270 | 3.320 | 0.000 | 1.270 | 3.320 |
| 33. Ratio of Maximum Pool Depth to Mean Depth (dpool/dbkf) | Mean: | 1.418 | 1.756 | 1.756 | 3.067 | 1.756 | 1.756 | 1.684 | 1.756 | 1.756 | 1.462 | 1.756 | 1.756 | 1.789 | 1.756 | 1.756 | 0.000 | 1.756 | 1.756 | 0.000 | 1.756 | 1.756 |
| | Minimum: | 1.056 | 1.323 | 1.323 | 2.467 | 1.323 | 1.323 | 1.470 | 1.323 | 1.323 | 1.094 | 1.323 | 1.323 | 0.972 | 1.323 | 1.323 | 0.000 | 1.323 | 1.323 | 0.000 | 1.323 | 1.323 |
| | Maximum: | 1.991 | 2.024 | 2.024 | 3.644 | 2.024 | 2.024 | 2.006 | 2.024 | 2.024 | 1.753 | 2.024 | 2.024 | 2.947 | 2.024 | 2.024 | 0.000 | 2.024 | 2.024 | 0.000 | 2.024 | 2.024 |
| 34. Max Run Depth, ft (drun) | Mean: | 4.150 | 2.887 | 2.340 | 0.000 | 0.895 | 2.340 | 4.440 | 3.490 | 2.340 | 4.140 | 4.004 | 2.340 | 1.780 | 1.338 | 2.340 | 0.000 | 0.895 | 2.340 | 0.000 | 0.895 | 2.340 |
| | Minimum: | 2.690 | 2.727 | 2.210 | 0.000 | 0.846 | 2.210 | 3.910 | 3.297 | 2.210 | 3.360 | 3.781 | 2.210 | 1.640 | 1.264 | 2.210 | 0.000 | 0.846 | 2.210 | 0.000 | 0.846 | 2.210 |
| | Maximum: | 5.790 | 3.356 | 2.720 | 0.000 | 1.041 | 2.720 | 5.530 | 4.057 | 2.720 | 4.620 | 4.654 | 2.720 | 2.650 | 1.556 | 2.720 | 0.000 | 1.041 | 2.720 | 0.000 | 1.041 | 2.720 |
| 35. Ratio Max Run Depth/Bankfull Mean Depth (drun/dbkf) | Mean: | 1.246 | 1.427 | 1.427 | 0.000 | 1.427 | 1.427 | 1.416 | 1.427 | 1.427 | 1.218 | 1.427 | 1.427 | 1.441 | 1.427 | 1.427 | 0.000 | 1.427 | 1.427 | 0.000 | 1.427 | 1.427 |
| | Minimum: | 0.811 | 1.348 | 1.348 | 0.000 | 1.348 | 1.348 | 1.247 | 1.348 | 1.348 | 0.988 | 1.348 | 1.348 | 0.842 | 1.348 | 1.348 | 0.000 | 1.348 | 1.348 | 0.000 | 1.348 | 1.348 |
| | Maximum: | 1.747 | 1.659 | 1.659 | 0.000 | 1.659 | 1.659 | 1.764 | 1.659 | 1.659 | 1.359 | 1.659 | 1.659 | 2.146 | 1.659 | 1.659 | 0.000 | 1.659 | 1.659 | 0.000 | 1.659 | 1.659 |
| 36. Maximum Glide Depth, ft (dg) | Mean: | 4.200 | 2.591 | 2.100 | 0.000 | 0.803 | 2.100 | 4.440 | 3.132 | 2.100 | 4.350 | 3.593 | 2.100 | 1.780 | 1.201 | 2.100 | 0.000 | 0.803 | 2.100 | 0.000 | 0.803 | 2.100 |
| | Minimum: | 2.720 | 2.085 | 1.690 | 0.000 | 0.647 | 1.690 | 3.910 | 2.521 | 1.690 | 3.810 | 2.892 | 1.690 | 0.640 | 0.967 | 1.690 | 0.000 | 0.647 | 1.690 | 0.000 | 0.647 | 1.690 |
| | Maximum: | 5.480 | 3.134 | 2.540 | 0.000 | 0.972 | 2.540 | 5.530 | 3.789 | 2.540 | 4.930 | 4.346 | 2.540 | 2.430 | 1.453 | 2.540 | 0.000 | 0.972 | 2.540 | 0.000 | 0.972 | 2.540 |
| 37. Ratio of Max Glide Depth/Bankfull Mean Depth (dg/dbkf) | Mean: | 1.267 | 1.280 | 1.280 | 0.000 | 1.280 | 1.280 | 1.416 | 1.280 | 1.280 | 1.279 | 1.280 | 1.280 | 1.441 | 1.280 | 1.280 | 0.000 | 1.280 | 1.280 | 0.000 | 1.280 | 1.280 |
| | Minimum: | 0.821 | 1.030 | 1.030 | 0.000 | 1.030 | 1.030 | 1.247 | 1.030 | 1.030 | 1.121 | 1.030 | 1.030 | 0.518 | 1.030 | 1.030 | 0.000 | 1.030 | 1.030 | 0.000 | 1.030 | 1.030 |
| | Maximum: | 1.653 | 1.549 | 1.549 | 0.000 | 1.549 | 1.549 | 1.764 | 1.549 | 1.549 | 1.450 | 1.549 | 1.549 | 1.968 | 1.549 | 1.549 | 0.000 | 1.549 | 1.549 | 0.000 | 1.549 | 1.549 |
| 38. Pool Width, ft (Wbkfp) | Mean: | 25.555 | 21.263 | 15.327 | 5.215 | 6.593 | 15.327 | 31.130 | 25.706 | 15.327 | 44.200 | 29.487 | 15.327 | 11.145 | 9.702 | 15.327 | 0.000 | 6.593 | 15.327 | 0.000 | 6.593 | 15.327 |
| | Minimum: | 25.370 | 16.801 | 12.110 | 3.640 | 5.210 | 12.110 | 30.960 | 20.311 | 12.110 | 34.700 | 23.298 | 12.110 | 7.680 | 7.666 | 12.110 | 0.000 | 5.210 | 12.110 | 0.000 | 5.210 | 12.110 |
| | Maximum: | 25.740 | 26.221 | 18.900 | 6.790 | 8.131 | 18.900 | 31.300 | 31.699 | 18.900 | 53.700 | 36.362 | 18.900 | 14.610 | 11.964 | 18.900 | 0.000 | 8.131 | 18.900 | 0.000 | 8.131 | 18.900 |
| 39. Ratio of Pool Width to Bankfull Width (Wbkfp/Wbkf) | Mean: | 1.387 | 0.827 | 0.827 | 0.676 | 0.827 | 0.827 | 1.277 | 0.827 | 0.827 | 1.456 | 0.827 | 0.827 | 0.996 | 0.827 | 0.827 | 0.000 | 0.827 | 0.827 | 0.000 | 0.827 | 0.827 |
| | Minimum: | 1.377 | 0.654 | 0.654 | 0.472 | 0.654 | 0.654 | 1.270 | 0.654 | 0.654 | 1.145 | 0.654 | 0.654 | 0.686 | 0.654 | 0.654 | 0.000 | 0.654 | 0.654 | 0.000 | 0.654 | 0.654 |
| | Maximum: | 1.397 | 1.020 | 1.020 | 0.880 | 1.020 | 1.020 | 1.284 | 1.020 | 1.020 | 1.769 | 1.020 | 1.020 | 1.306 | 1.020 | 1.020 | 0.000 | 1.020 | 1.020 | 0.000 | 1.020 | 1.020 |
| 40. Pool Cross Sectional Area, sq ft (Apool) | Mean: | 86.535 | 49.158 | 28.593 | 4.660 | 4.727 | 28.593 | 85.300 | 71.846 | 28.593 | 152.195 | 94.534 | 28.593 | 16.990 | 10.399 | 28.593 | 0.000 | 4.727 | 28.593 | 0.000 | 4.727 | 28.593 |
| | Minimum: | 70.480 | 36.585 | 21.280 | 4.620 | 3.518 | 21.280 | 76.250 | 53.470 | 21.280 | 127.990 | 70.355 | 21.280 | 10.430 | 7.739 | 21.280 | 0.000 | 3.518 | 21.280 | 0.000 | 3.518 | 21.280 |
| | Maximum: | 102.590 | 66.739 | 38.820 | 4.700 | 6.417 | 38.820 | 94.350 | 97.512 | 38.820 | 176.400 | 128.345 | 38.820 | 23.550 | 14.118 | 38.820 | 0.000 | 6.417 | 38.820 | 0.000 | 6.417 | 38.820 |
| 41. Ratio of Pool Area to Bankfull Riffle Area (Apool/Abkf) | Mean: | 1.411 | 0.945 | 0.945 | 1.248 | 0.945 | 0.945 | 1.116 | 0.945 | 0.945 | 1.476 | 0.945 | 0.945 | 1.231 | 0.945 | 0.945 | 0.000 | 0.945 | 0.945 | 0.000 | 0.945 | 0.945 |
| | Minimum: | 1.149 | 0.704 | 0.704 | 1.237 | 0.704 | 0.704 | 0.998 | 0.704 | 0.704 | 1.241 | 0.704 | 0.704 | 0.756 | 0.704 | 0.704 | 0.000 | 0.704 | 0.704 | 0.000 | 0.704 | 0.704 |
| | Maximum: | 1.673 | 1.283 | 1.283 | 1.258 | 1.283 | 1.283 | 1.235 | 1.283 | 1.283 | 1.710 | 1.283 | 1.283 | 1.707 | 1.283 | 1.283 | 0.000 | 1.283 | 1.283 | 0.000 | 1.283 | 1.283 |
| 42. Pool to Pool Spacing, ft (p-p) | Mean: | 149.940 | 109.406 | 78.860 | 0.000 | 33.925 | 78.860 | 205.680 | 132.265 | 78.860 | 149.760 | 151.719 | 78.860 | 113.240 | 49.922 | 78.860 | 0.000 | 33.925 | 78.860 | 0.000 | 33.925 | 78.860 |
| | Minimum: | 50.620 | 69.783 | 50.300 | 0.000 | 21.639 | 50.300 | 38.690 | 84.364 | 50.300 | 64.670 | 96.772 | 50.300 | 83.130 | 31.842 | 50.300 | 0.000 | 21.639 | 50.300 | 0.000 | 21.639 | 50.300 |
| | Maximum: | 402.570 | 146.837 | 105.840 | 0.000 | 45.532 | 105.840 | 442.410 | 177.517 | 105.840 | 292.540 | 203.626 | 105.840 | 165.660 | 67.001 | 105.840 | 0.000 | 45.532 | 105.840 | 0.000 | 45.532 | 105.840 |
| 43. Ratio of p-p Spacing to Bankfull Width (p-p/Wbkf) | Mean: | 7.647 | 4.257 | 4.257 | 0.000 | 4.257 | 4.257 | 8.435 | 4.257 | 4.257 | 4.934 | 4.257 | 4.257 | 10.120 | 4.257 | 4.257 | 0.000 | 4.257 | 4.257 | 0.000 | 4.257 | 4.257 |
| | Minimum: | 2.747 | 2.715 | 2.715 | 0.000 | 2.715 | 2.715 | 1.587 | 2.715 | 2.715 | 2.130 | 2.715 | 2.715 | 7.429 | 2.715 | 2.715 | 0.000 | 2.715 | 2.715 | 0.000 | 2.715 | 2.715 |
| | Maximum: | 21.843 | 5.714 | 5.714 | 0.000 | 5.714 | 5.714 | 18.144 | 5.714 | 5.714 | 9.637 | 5.714 | 5.714 | 14.804 | 5.714 | 5.714 | 0.000 | 5.714 | 5.714 | 0.000 | 5.714 | 5.714 |
| 44. Pool Length, ft (Lp) | Mean: | 39.340 | 48.710 | 35.110 | 0.000 | 15.104 | 35.110 | 42.090 | 58.887 | 35.110 | 48.590 | 67.548 | 35.110 | 31.820 | 22.226 | 35.110 | 0.000 | 15.104 | 35.110 | 0.000 | 15.104 | 35.110 |
| | Minimum: | 11.350 | 25.444 | 18.340 | 0.000 | 7.890 | 18.340 | 8.520 | 30.760 | 18.349 | 20.530 | 35.284 | 18.340 | 17.150 | 11.610 | 18.340 | 0.000 | 7.890 | 18.340 | 0.000 | 7.890 | 18.340 |
| | Maximum: | 87.940 | 87.222 | 62.870 | 0.000 | 27.047 | 62.870 | 137.960 | 105.147 | 62.870 | 81.010 | 120.956 | 62.870 | 65.410 | 39.799 | 62.870 | 0.000 | 27.047 | 62.870 | 0.000 | 27.047 | 62.870 |
| 45. Ratio of Pool Length to Bankfull (Lp/Wbkf) | Mean: | 2.135 | 1.895 | 1.895 | 0.000 | 1.895 | 1.895 | 1.722 | 1.895 | 1.895 | 1.601 | 1.895 | 1.895 | 2.844 | 1.895 | 1.895 | 0.000 | 1.895 | 1.895 | 0.000 | 1.895 | 1.895 |
| | Minimum: | 0.616 | 0.990 | 0.990 | 0.000 | 0.990 | 0.990 | 0.349 | 0.990 | 0.990 | 0.676 | 0.990 | 0.990 | 1.553 | 0.990 | 0.990 | 0.000 | 0.990 | 0.990 | 0.000 | 0.990 | 0.990 |
| | Maximum: | 4.772 | 3.394 | 3.394 | 0.000 | 3.394 | 3.394 | 5.621 | 3.394 | 3.394 | 2.768 | 3.394 | 3.394 | 5.845 | 3.394 | 3.394 | 0.000 | 3.394 | 3.394 | 0.000 | 3.394 | 3.394 |

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

# TYPICALS

## NOT TO SCALE

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 8/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

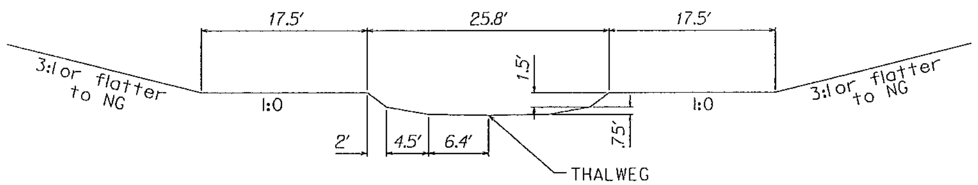
DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 21 |

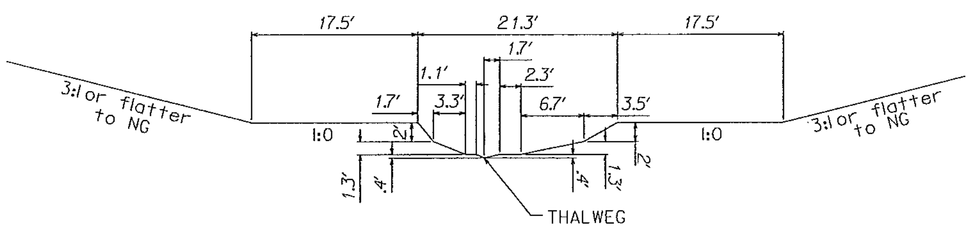
**TYPICALS**

MULKEY ENGINEERS & CONSULTANTS
PO Box 33127
RALEIGH, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

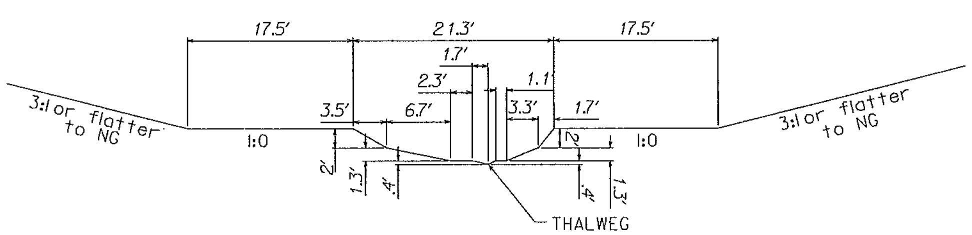
## RI




TYPICAL RIFFLE
BANKFULL CROSS SECTIONAL AREA = 52 SQ.FT.

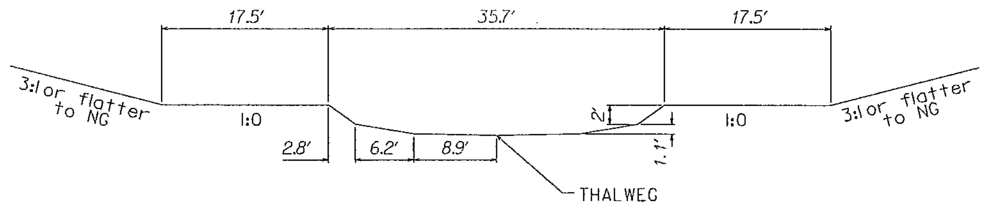



TYPICAL POOL LEFT
BANKFULL CROSS SECTIONAL AREA = 49.2 SQ.FT.

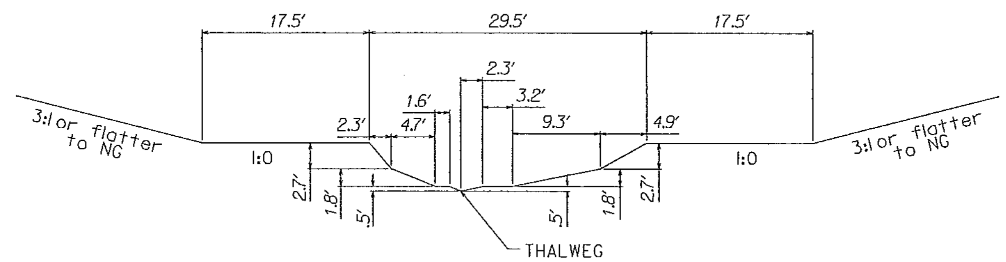



TYPICAL POOL RIGHT
BANKFULL CROSS SECTIONAL AREA = 49.2 SQ.FT.

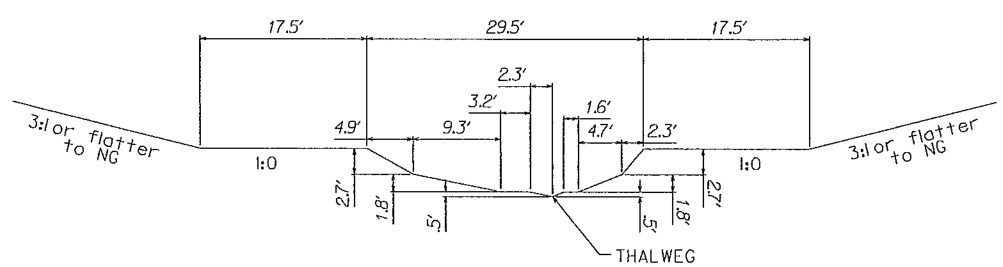
## R2- LOWER REACH




TYPICAL RIFFLE
BANKFULL CROSS SECTIONAL AREA = 100 SQ.FT.

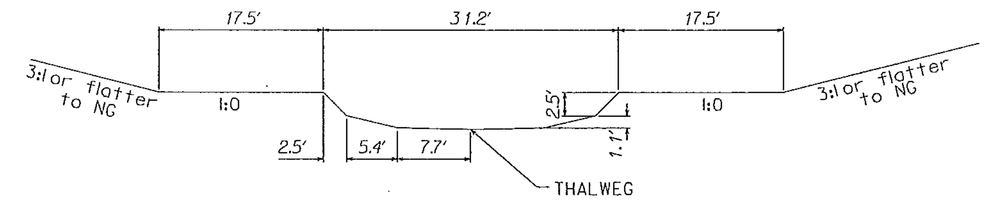



TYPICAL POOL LEFT
BANKFULL CROSS SECTIONAL AREA = 94.5 SQ.FT.

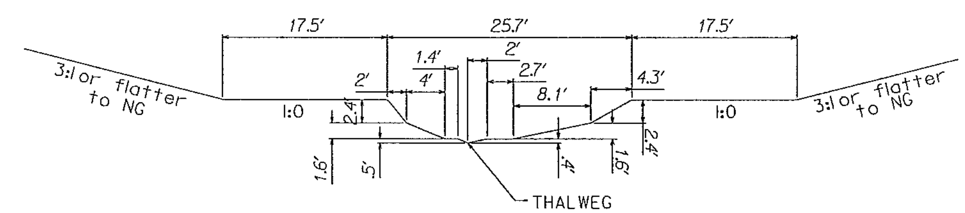



TYPICAL POOL RIGHT
BANKFULL CROSS SECTIONAL AREA = 94.5 SQ.FT.

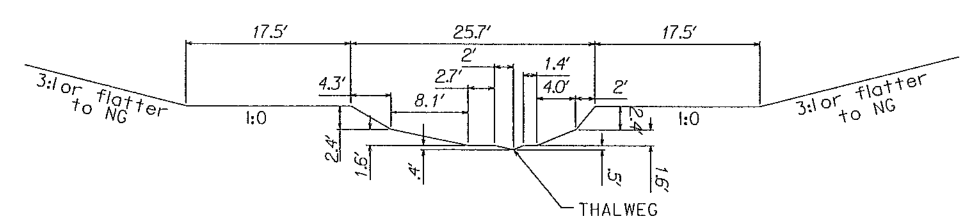
## R2- UPPER REACH




TYPICAL RIFFLE
BANKFULL CROSS SECTIONAL AREA = 76 SQ.FT.




TYPICAL POOL LEFT
BANKFULL CROSS SECTIONAL AREA = 71.9 SQ.FT.




TYPICAL POOL RIGHT
BANKFULL CROSS SECTIONAL AREA = 71.9 SQ.FT.

| PROJECT REFERENCE NO. | SHEET NO. |
| --- | --- |
| LITTLE WHITE OAK CREEK | 2J |

**TYPICALS**

MULKEY
ENGINEERS & CONSULTANTS
PO Box 33127
RALEIGH, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

REVISIONS

| DATE | BY | DESCRIPTION |
| --- | --- | --- |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

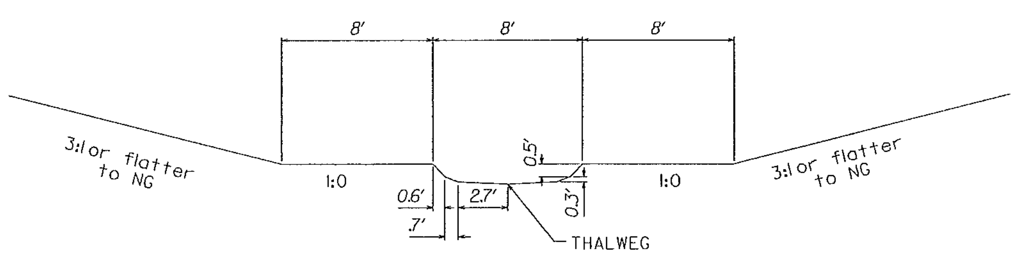
DO NOT USE FOR CONSTRUCTION

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III

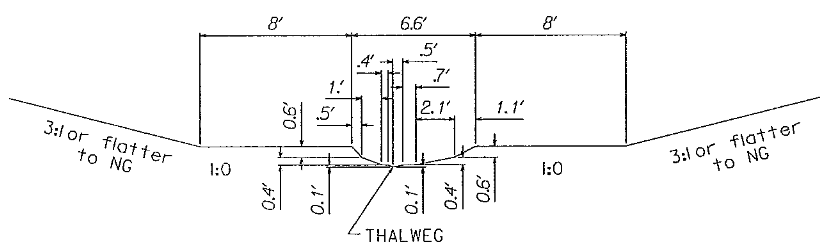
# TYPICALS

## NOT TO SCALE

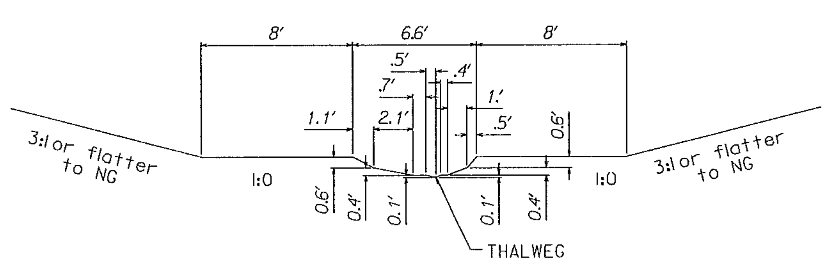
### R1A, R2B, & R2D




TYPICAL RIFFLE
BANKFULL CROSS SECTIONAL AREA = 5 SQ.FT.

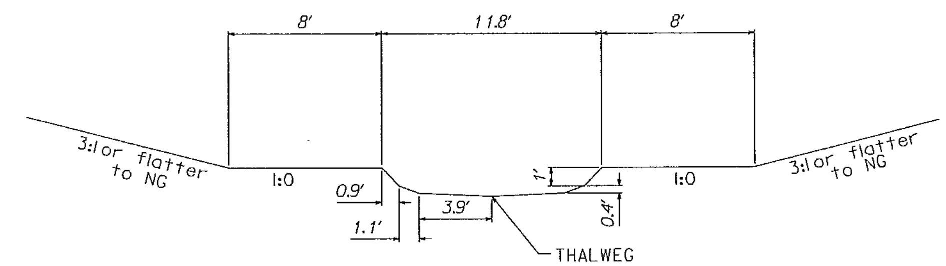



TYPICAL POOL LEFT
BANKFULL CROSS SECTIONAL AREA = 4.7 SQ.FT.

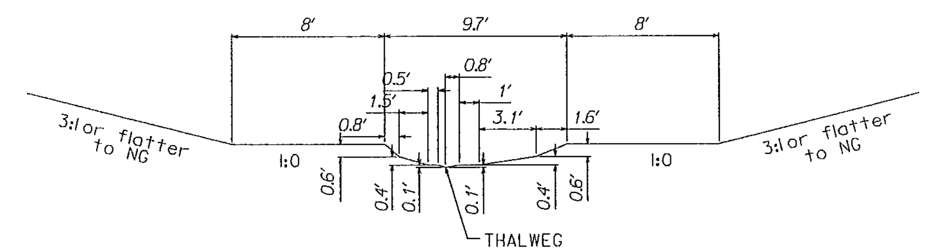



TYPICAL POOL RIGHT
BANKFULL CROSS SECTIONAL AREA = 4.7 SQ.FT.

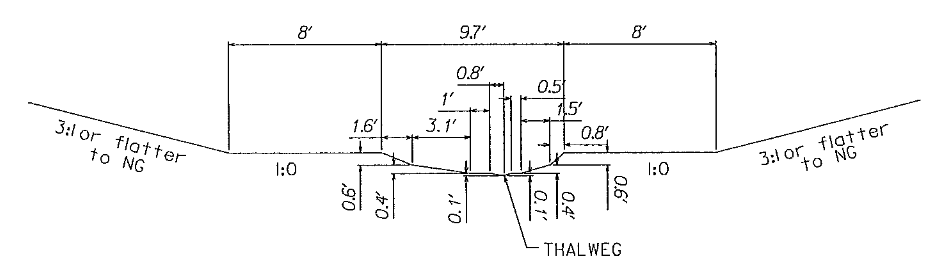
### R2A




TYPICAL RIFFLE
BANKFULL CROSS SECTIONAL AREA = 11 SQ.FT.




TYPICAL POOL LEFT
BANKFULL CROSS SECTIONAL AREA = 10.4 SQ.FT.




TYPICAL POOL RIGHT
BANKFULL CROSS SECTIONAL AREA = 10.4 SQ.FT.

# DETAILS
## NOT TO SCALE

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PROJECT ENGINEER

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***DETAILS***

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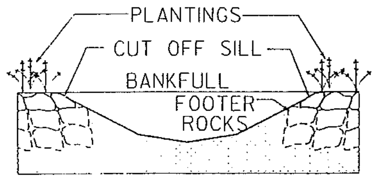
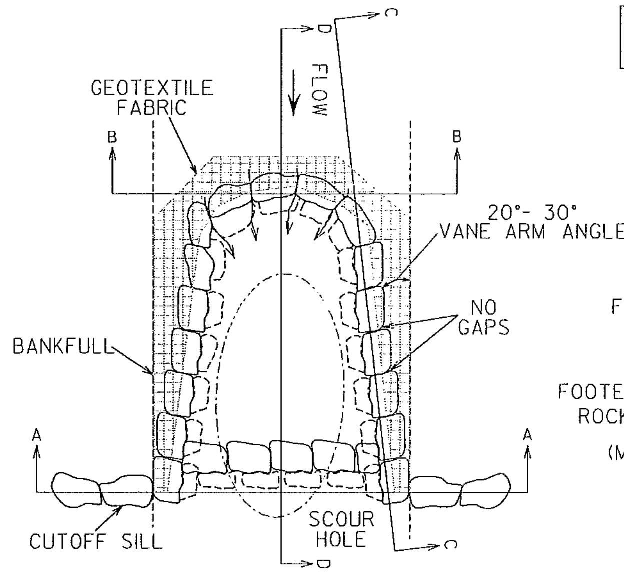
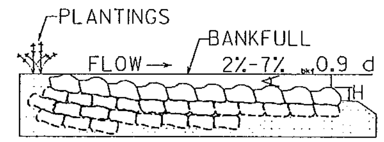
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III

## ROCK CROSS VANE

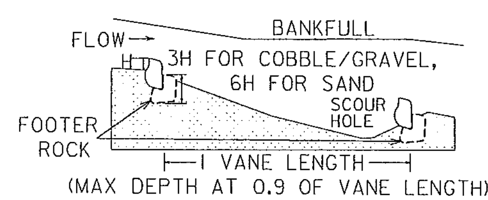



SECTION A-A

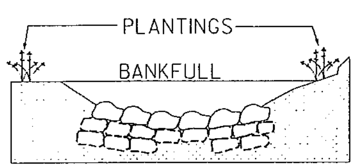


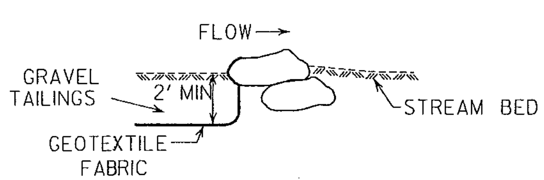

SECTION C-C




SECTION D-D




SECTION B-B

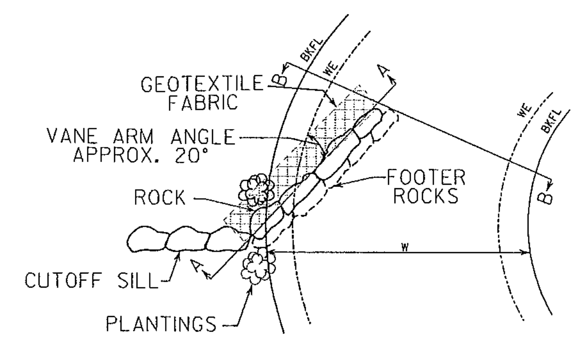


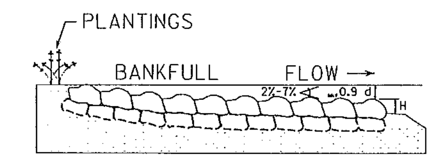

GEOTEXTILE FABRIC

NOTES:

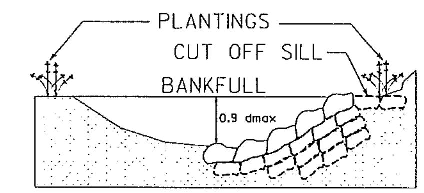
1. ROCKS SHOULD BE NATIVE QUARRIED ROCK OR LOCALLY SHOT ROCK, ANGULAR AND OBLONG. SEE THE PROJECT SPECIFICATIONS FOR ROCK SIZE.
2. ROCKS SHOULD FIT TIGHTLY WITH MINIMAL SPACES.
3. THE TOP OF FOOTER ROCKS SHOULD BE BURIED TO A MINIMUM OF 3 TIMES 'H IN GRAVEL/COBLE BED STREAMS AND 6 TIMES 'H' IN SAND BED STREAMS, WHERE 'H IS THE DISTANCE FROM THE STREAM BED TO THE TOP OF THE HEADER ROCK, OR AS DETERMINED BY THE DESIGNER. H MUST BE A MINIMUM OF 3'.
4. GEOTEXTILE FABRIC SHOULD BE PLACED ON THE UPSTREAM SIDE OF ROCKS. FABRIC SHOULD BE OVERLAIN ON EXPOSED ROCKS AND BURIED TO A MINIMUM DEPTH OF 2 FT. OR AS DIRECTED BY THE DESIGNER. FABRIC SHOULD EXTEND UPSTREAM A MINIMUM LENGTH OF 6 FT. OR AS DIRECTED BY THE DESIGNER. FABRIC SHOULD BE BACKFILLED WITH NATIVE BED MATERIAL OR GRAVEL TAILINGS.
5. AT THE DIRECTION OF THE DESIGNER, THE STRUCTURE ARMS MAY BE CONSTRUCTED UP TO AND TIED INTO AN ELEVATION LESS THAN BANKFULL IN ORDER TO ACHIEVE THE CORRECT STRUCTURE ARM SLOPE.

## ROCK VANE




SECTION A-A




SECTION B-B

NOTES:

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3. THE TOP OF FOOTER ROCKS SHOULD BE BURIED TO A MINIMUM OF 3 TIMES 'H' IN GRAVEL/COBLE BED STREAMS AND 6 TIMES 'H' IN SAND BED STREAMS, WHERE H' IS THE DISTANCE FROM THE STREAM BED TO THE TOP OF THE HEADER ROCK, OR AS DETERMINED BY THE DESIGNER. H MUST BE A MINIMUM OF 3'.
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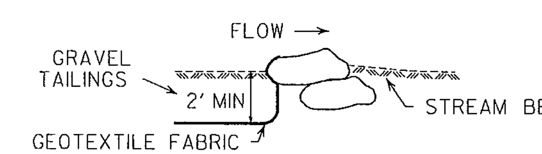


DETAIL OF GEOTEXTILE FABRIC

# DETAILS
## NOT TO SCALE

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| LITTLE WHITE OAK CREEK | 2L |

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PROJECT ENGINEER

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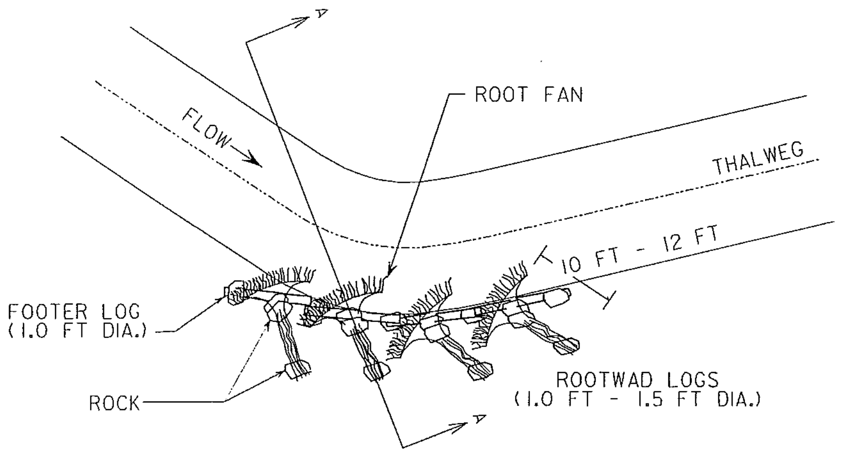
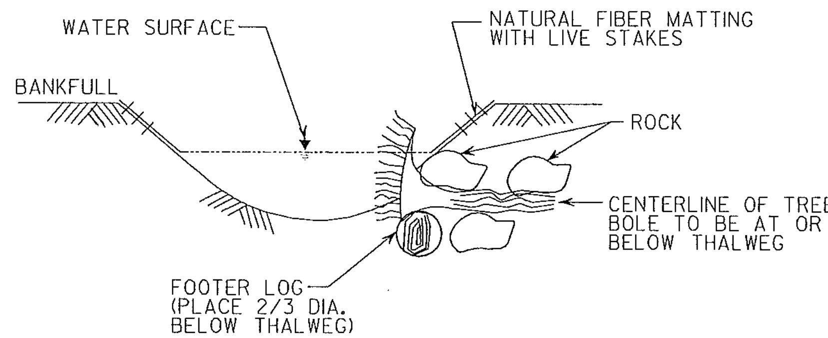
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III

## ROOTWADS




PLAN VIEW

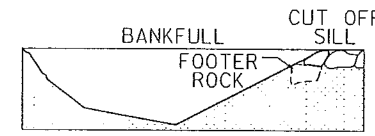



CROSS SECTION VIEW A-A

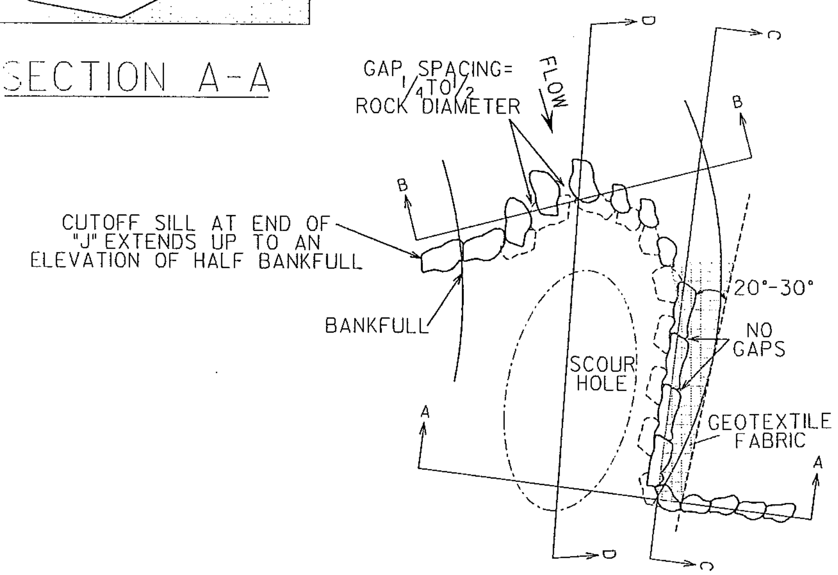
NOTES:

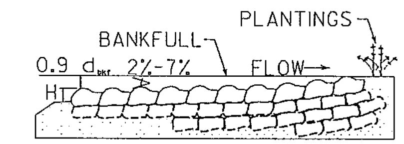
1. A TRENCH SHALL BE DUG ALONG THE TOE OF THE BANK TO A DEPTH EQUAL TO THE DIAMETER OF THE FOOTER LOG. A PRUNED FOOTER LOG SHALL BE PLACED IN THE TRENCH. THE ROOTWAD SHALL BE INSTALLED SUCH THAT IT RESTS ON TOP OF THE FOOTER LOG. THE ROOT MASS SHALL BE ORIENTED IN SUCH A WAY THAT THE VELOCITY VECTORS OF THE WATER ARE DEFLECTED AWAY FROM THE BANK. THERE SHALL BE NO VOIDS BETWEEN THE ROOT MASS AND THE STREAM BANK. A ROCK MAY BE PLACED ON THE DOWNSTREAM SIDE, ON TOP OF, AND/OR ON THE UPSTREAM SIDE BETWEEN THE ROOT MASS AND THE STREAM BANK TO SECURE THE ROOTWAD. ROOT FANS SHALL OVERLAP A MINIMUM OF 2 FEET.
2. ALL DISTURBED OR FILL MATERIAL SHALL BE COMPACTED TO A DENSITY COMPARABLE TO THE ADJACENT UNDISTURBED MATERIAL UNLESS OTHERWISE APPROVED BY THE DESIGNER.
3. ALL MATERIALS FOR THIS STRUCTURE SHALL BE APPROVED BY THE DESIGNER PRIOR TO INSTALLATION.
4. STATIONING OF ROOTWADS SHALL BE AS SHOWN ON THE PLANS OR AS DIRECTED BY THE DESIGNER. THE ACTUAL NUMBER OF ROOTWADS NECESSARY WILL DEPEND ON THE SIZE OF THE ROOT FAN AND THE ACTUAL CONDITION OF THE SITE AT THE TIME OF CONSTRUCTION.

## J-HOOK ROCK VANE

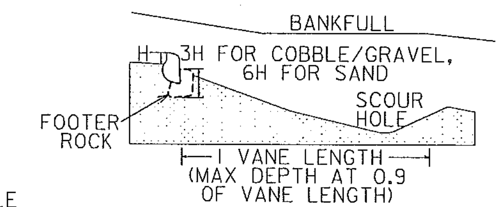



SECTION A-A

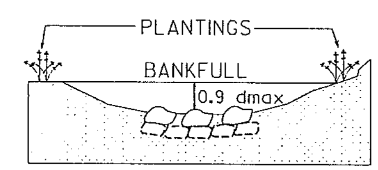


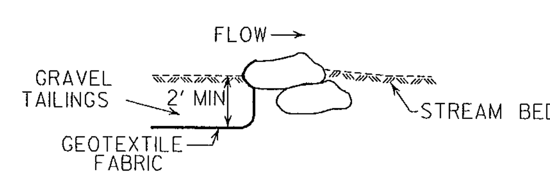

SECTION C-C




SECTION D-D




SECTION B-B




GEOTEXTILE FABRIC

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PROJECT ENGINEER

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# DETAILS

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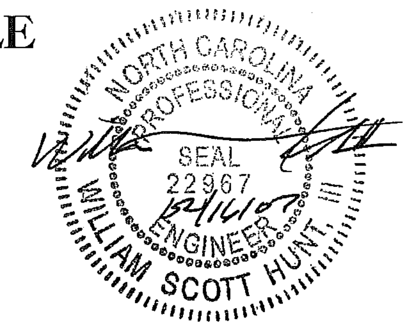
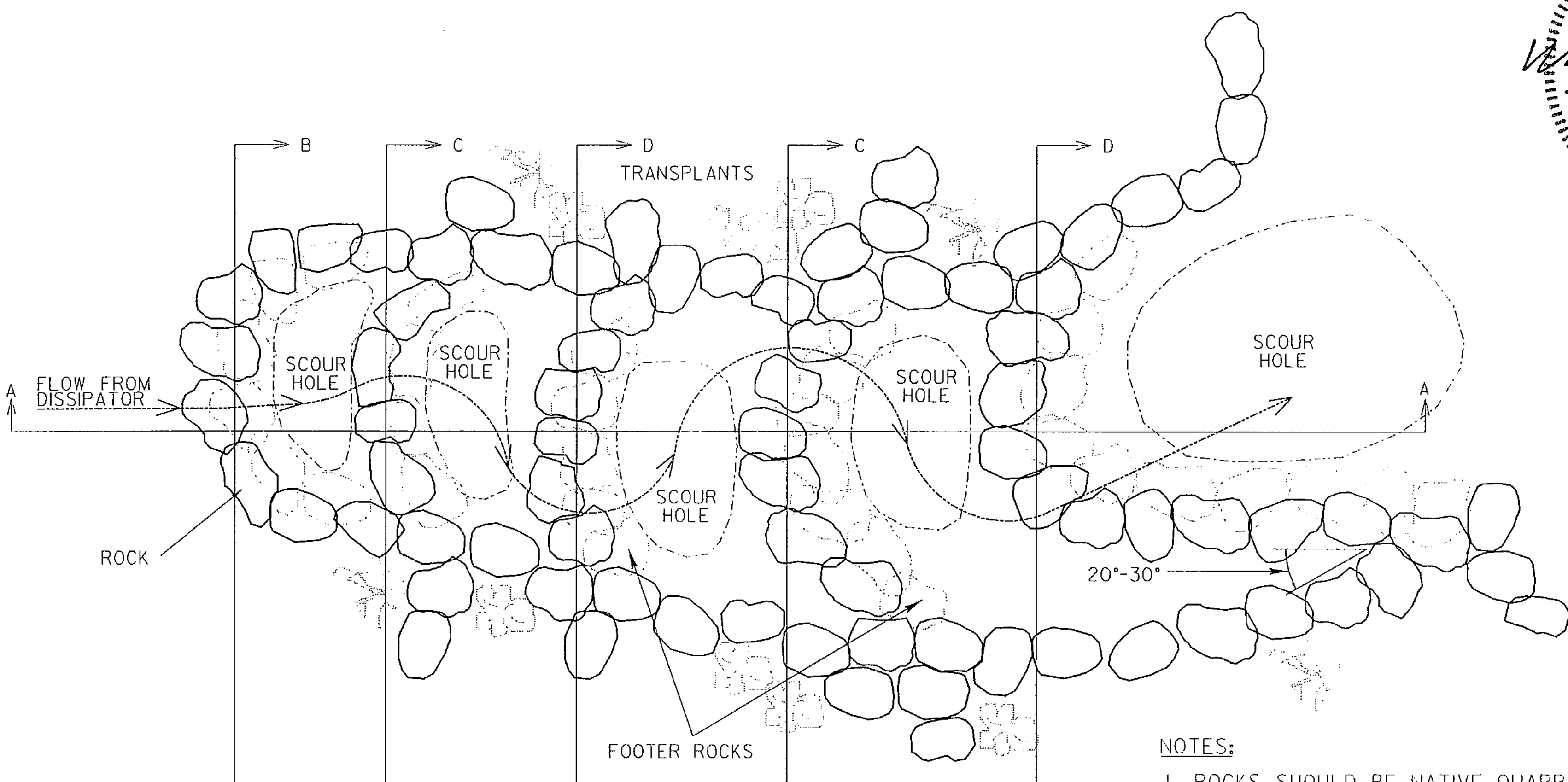
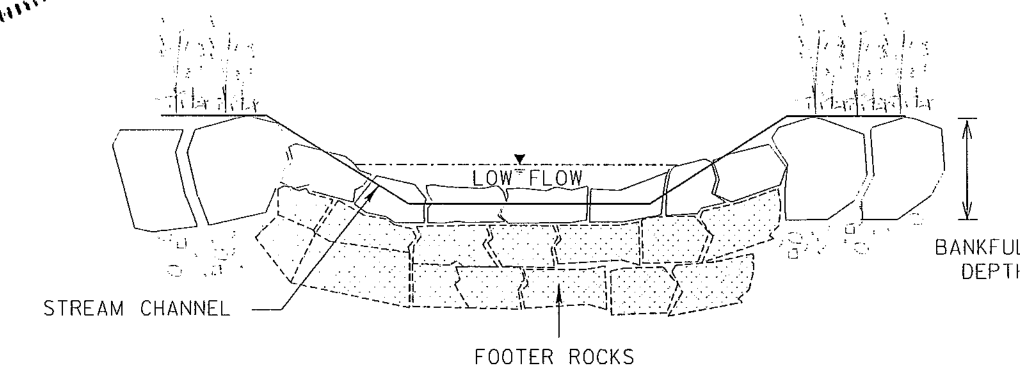
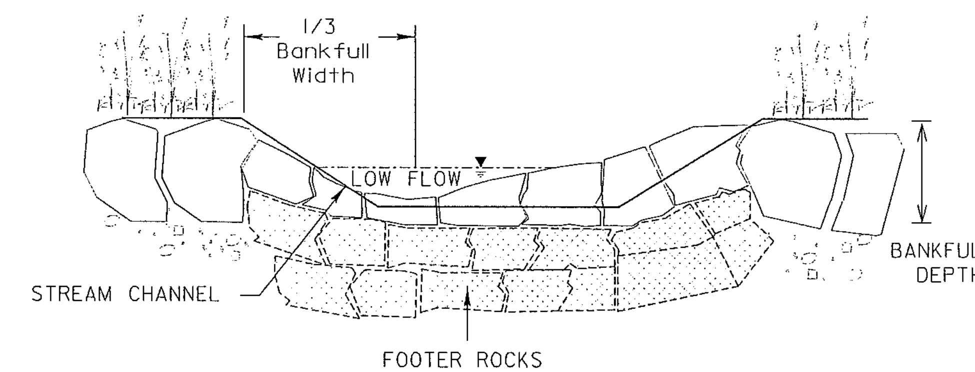



PLAN VIEW




SECTION B-B




SECTION C-C

NOTES:

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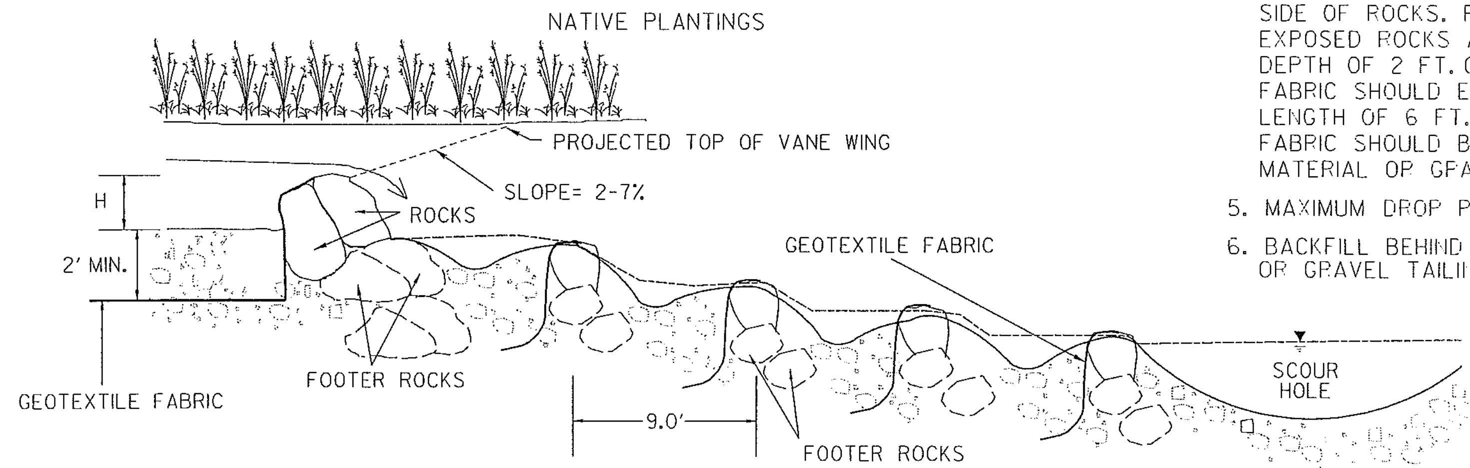
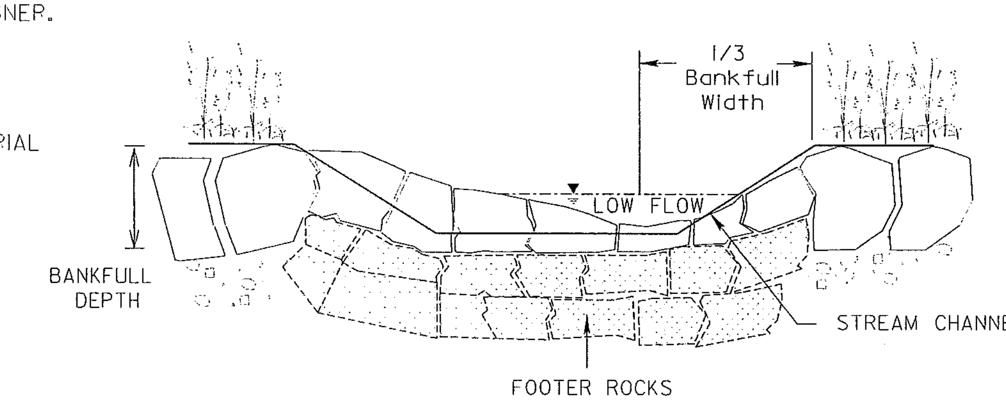
5. MAXIMUM DROP PER STEP = 1.0'.
6. BACKFILL BEHIND STEPS WITH NATIVE BED MATERIAL OR GRAVEL TAILINGS.




SECTION A-A




SECTION D-D

## ROCK STEP POOL

# DETAILS
## NOT TO SCALE

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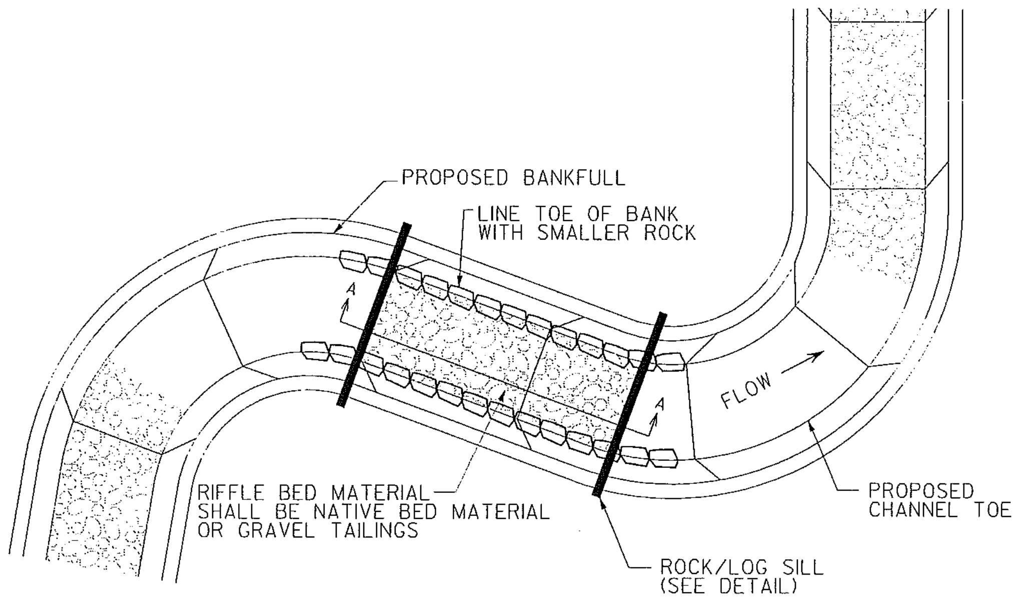
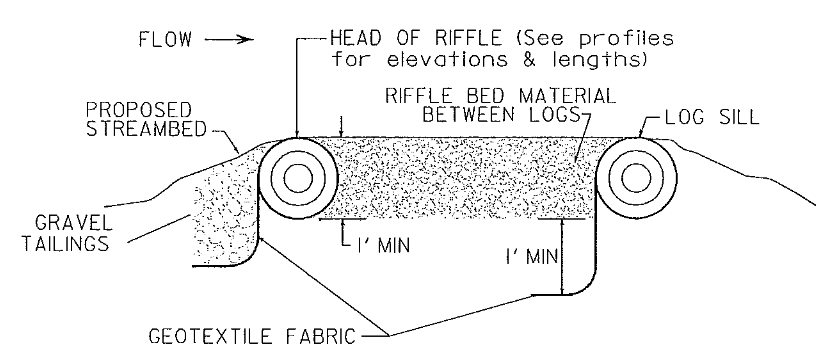
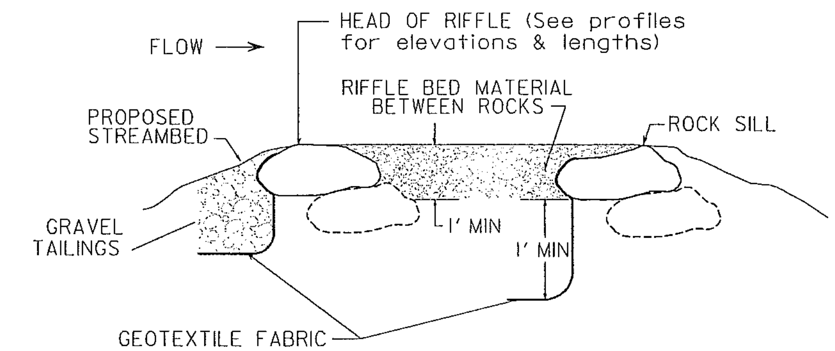
## CONSTRUCTED RIFFLE

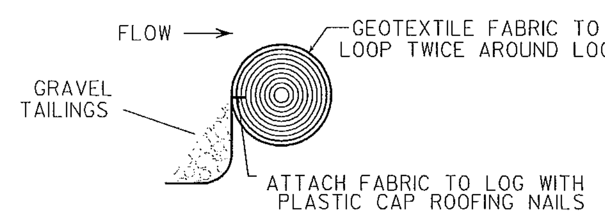


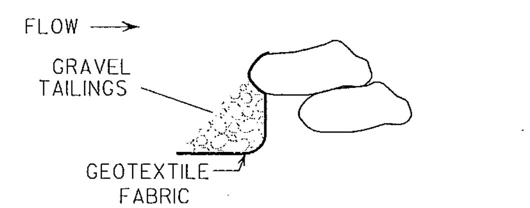

LOG SILL SECTION A-A




ROCK SILL SECTION A-A

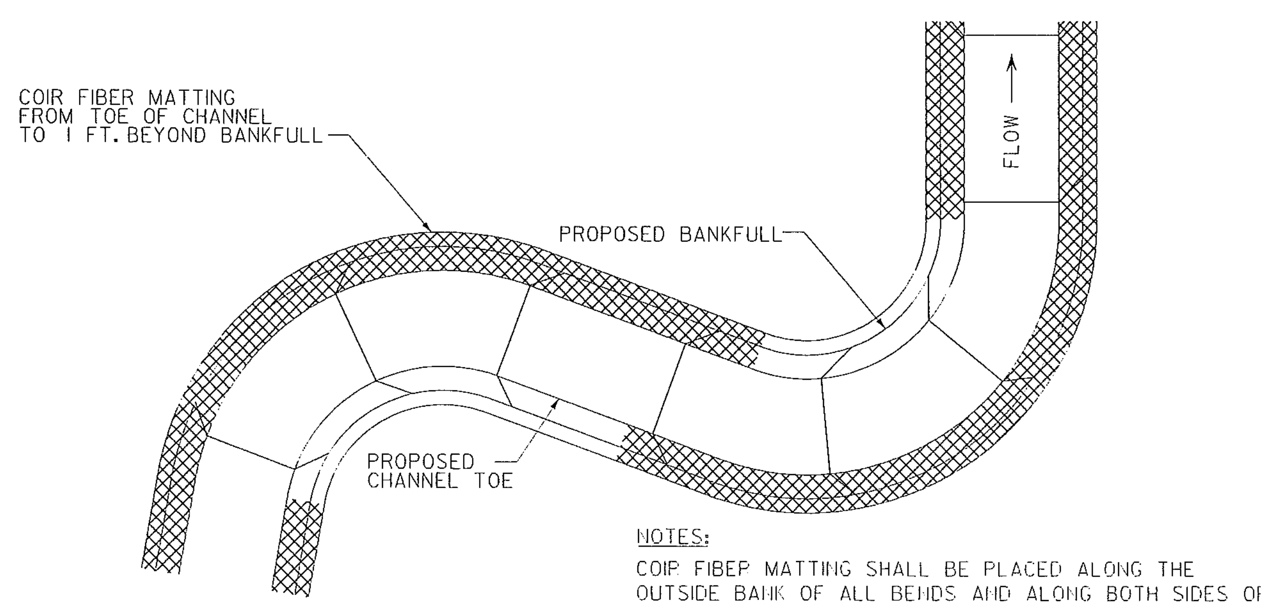



GEOTEXTILE FABRIC



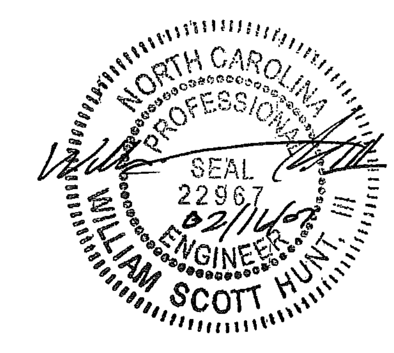

GEOTEXTILE FABRIC

## TYPICAL MATTING LOCATION




NOTES:

COIR FIBER MATTING SHALL BE PLACED ALONG THE OUTSIDE BANK OF ALL BENDS AND ALONG BOTH SIDES OF THE CHANNEL IN TANGENT AREAS.



# DETAILS
NOT TO SCALE

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III 02/16/07

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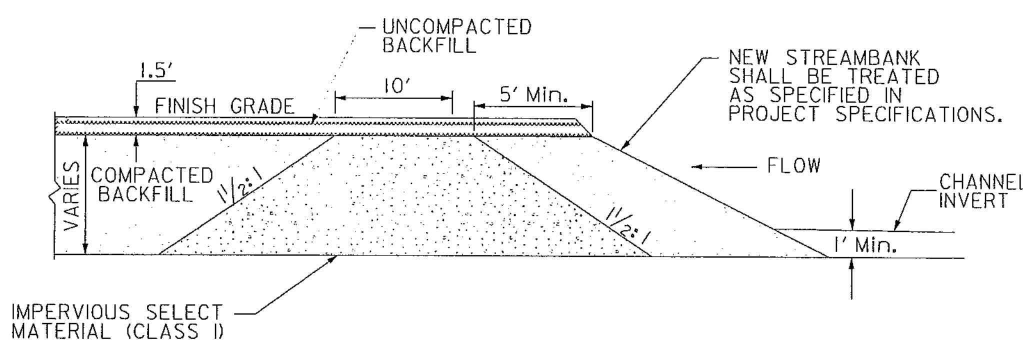
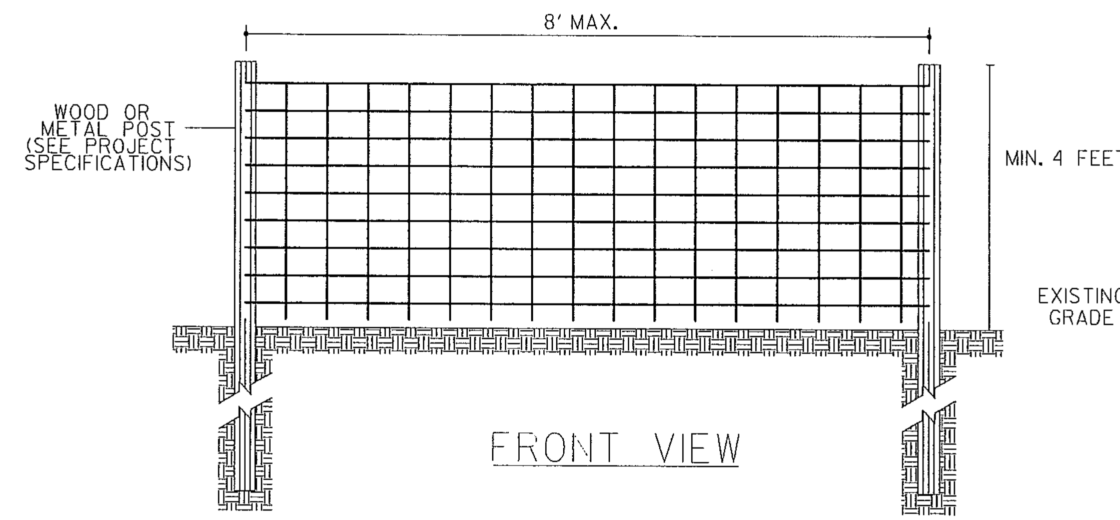
## IMPERVIOUS STREAM CHANNEL PLUG



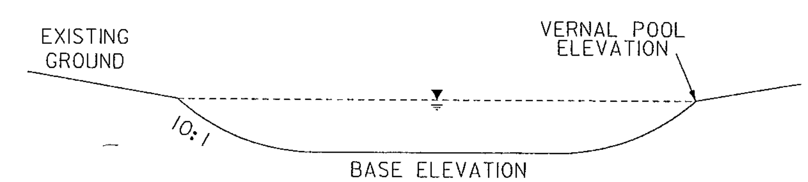

NOTES:

1. CHANNEL PLUGS TO BE LOCATED AS SHOWN ON THE PLANS AND AT OTHER LOCATIONS AS NOTED BY THE DESIGNER.
2. THE CHANNEL PLUG'S SIDE SLOPES THAT IS ADJACENT TO NEW CHANNEL NEEDS TO MATCH PROPOSED CROSS SECTION IN THAT LOCATION.
3. THE CHANNEL PLUG SHALL EXTEND A MINIMUM OF 1 FOOT BELOW THE BOTTOM OF THE EXISTING STREAM BED AND A MINIMUM OF 1 FOOT BEYOND THE LIMITS OF THE EXISITNG STREAM BANKS.

## TREE PROTECTION FENCE




## OXBOW WETLAND




NOTES:

1. EXCAVATE TO WITHIN 0.5 FEET OF RECOMMENDED BASE ELEVATION.
2. CREATE IRREGULAR SHORELINE PATTERN AND MICROTOPOGRAPHY ON THE BOTTOM AS DIRECTED BY DESIGNER.
3. PLACE EXCAVATED MATERIAL IN DESIGNATED STOCK PILE AREAS.

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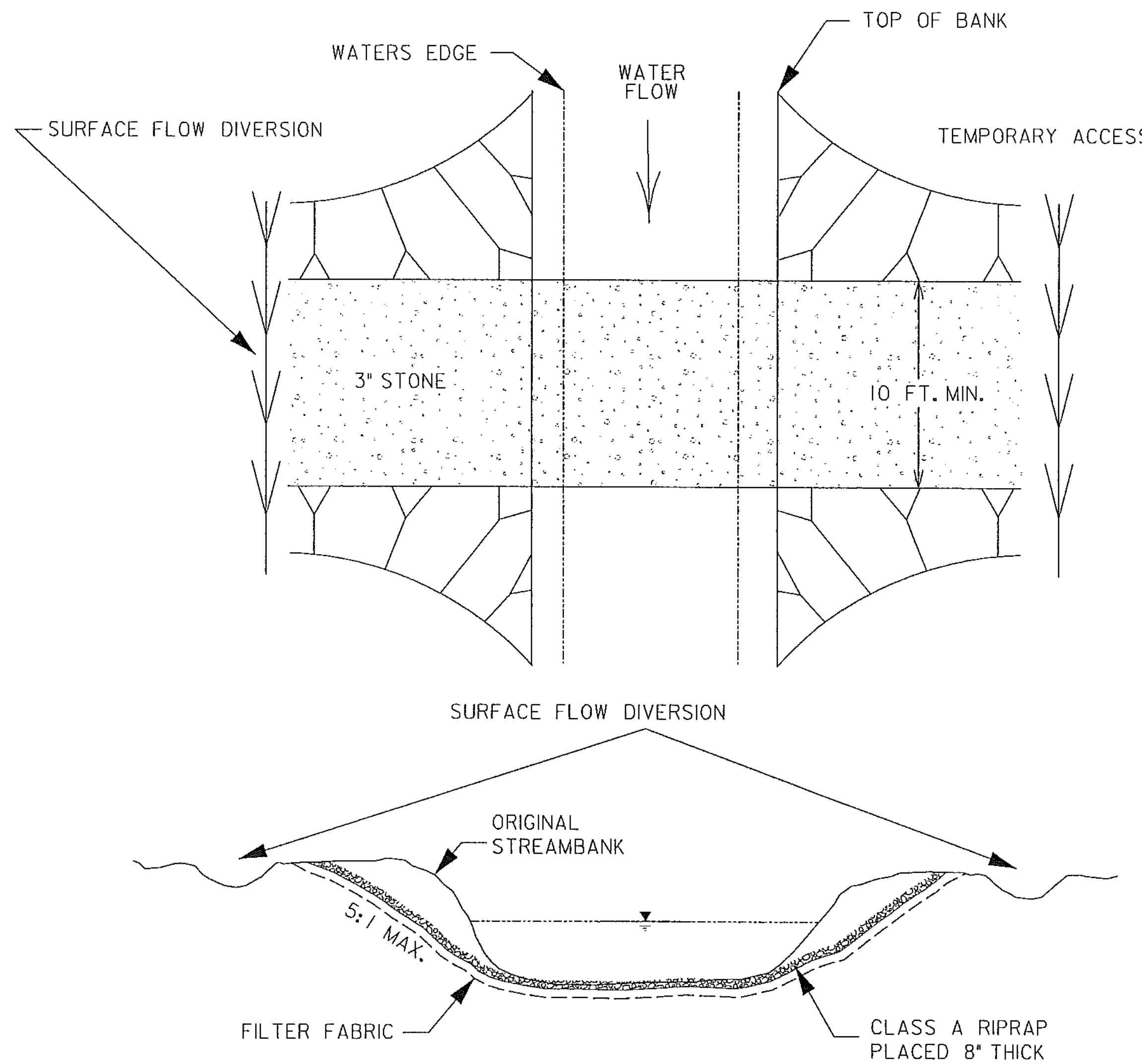
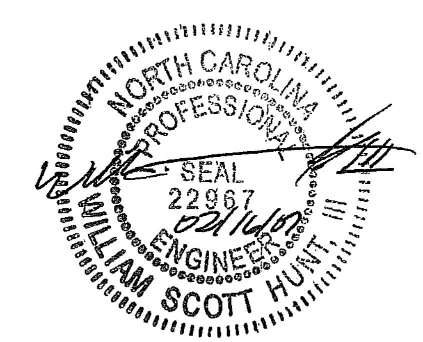
## PERMANENT AT GRADE STREAM CROSSING




NOTES:

1. STONE APPROACH SECTION 5:1 MAXIMUM, SLOPE ON ROAD.
2. KEEP CLEARING AND EXCAVATION OF STREAM BANKS, BED, AND APPROACH SECTIONS TO A MINIMUM.
3. DIVERT ALL SURFACE RUNOFF FROM THE CONSTRUCTION SITE ONTO UNDISTURBED AREAS ADJOINING THE STREAM.
4. KEEP STREAM CROSSINGS AT RIGHT ANGLES TO THE STREAM FLOW.
5. ALIGN ROAD APPROACHES WITH THE CENTER LINE OF THE CROSSING FOR A MINIMUM DISTANCE OF 30 FEET.
6. STABILIZE ALL DISTURBED AREAS SUBJECT TO FLOWING WATER, INCLUDING PLANNED OVERFLOW AREAS.
7. SIDE SLOPES WHERE CROSSING CONNECTS TO EXISTING STREAMBANKS SHOULD BE A MAXIMUM OF 2:1.
8. INSPECT STREAM CROSSINGS AFTER RUNOFF- PRODUCING RAINS TO CHECK FOR BLOCKAGE IN CHANNEL, EROSION OF BANKS, CHANNEL SCOUR, STONE DISPLACEMENT, OR PIPING. MAKE ALL REPAIRS IMMEDIATELY TO PREVENT FURTHER DAMAGE TO THE INSTALLATION.



# DETAILS
NOT TO SCALE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 20 |

*DETAILS*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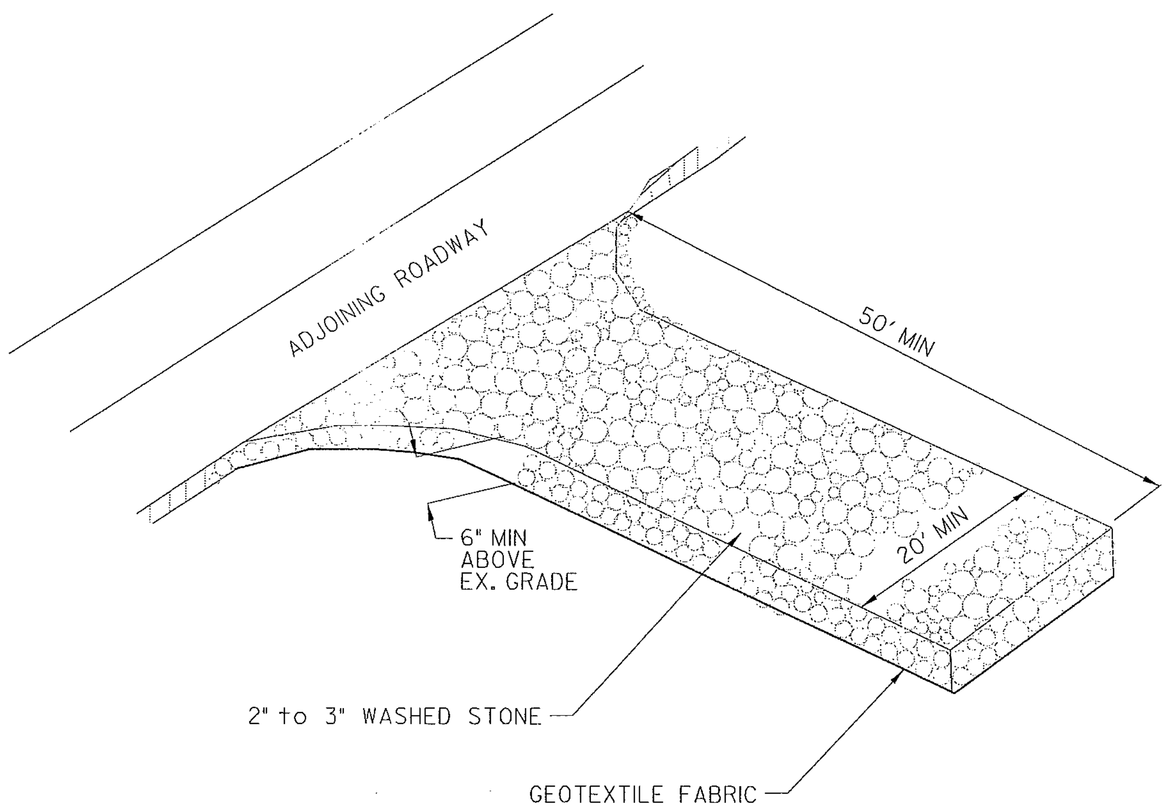
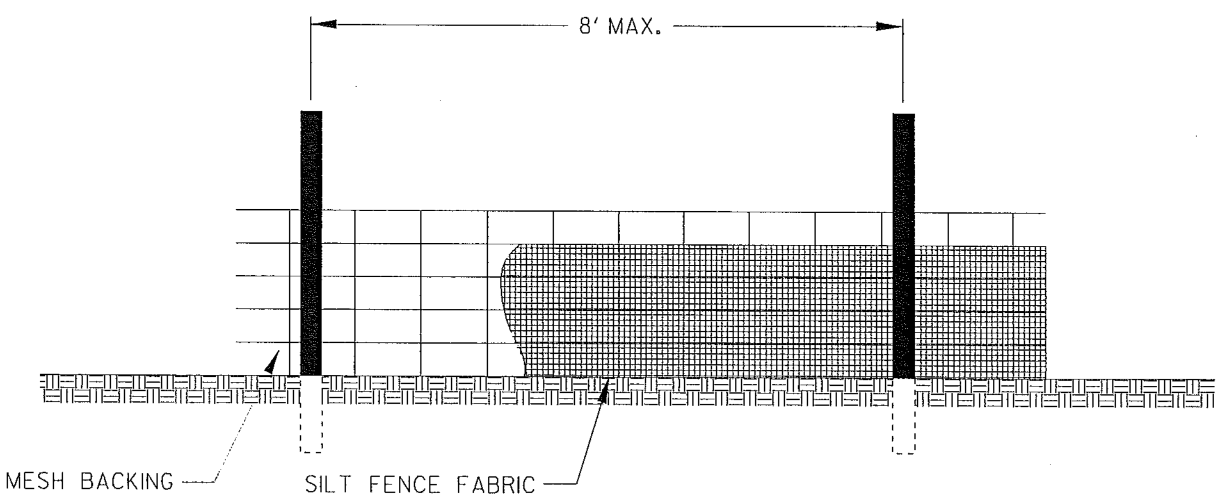
## TEMPORARY CONSTRUCTION ENTRANCE/EXIT

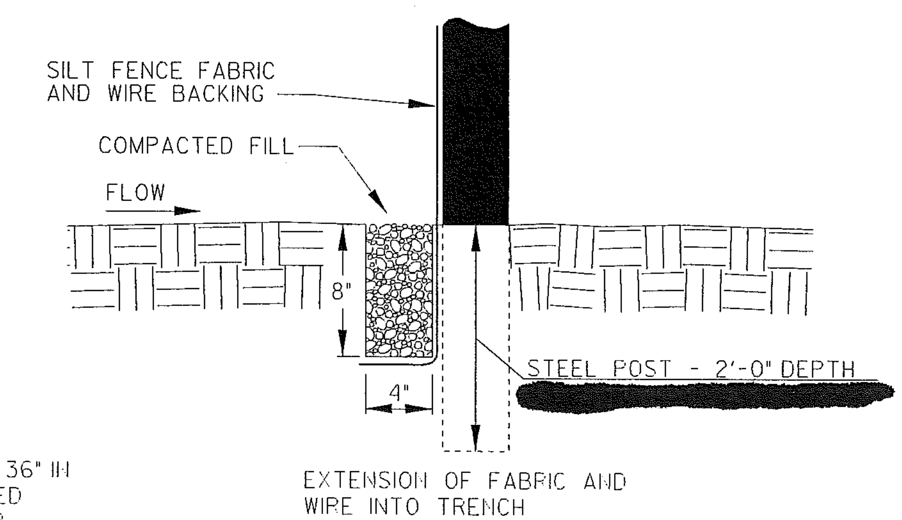



NOTES:

1. 2" TO 3" WASHED COARSE AGGREGATE STONE SAHLL BE USED. PAD TO BE 50' L X 20' W X 6" D AT A MINIMUM.
2. RADII TO BE SUFFICIENT TO ACCOMMODATE TURNING RADII REQUIRED BY LARGE TRUCKS.
3. ENTRANCE(S) SHOULD BE LOCATED TO PROVIDE FOR MAXIMUM UTILITY BY ALL CONSTRUCTION VEHICLES.
4. MUST BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR DIRECT FLOW OF MUD ONTO STREETS. PERIODIC MAINTENANCE, INCLUDING TOPDRESSING WITH STONE WILL BE NECESSARY.
5. ANY SOIL MATERIAL TRACKED ONTO THE ADJOINING ROAD SHALL BE CLEANED UP IMMEDIATELY.

## SILT FENCE




NOTES:

1. WIRE SHALL BE A MINIMUM OF 32" IN HEIGHT.
2. SILT FENCE FABRIC SHALL BE A MINIMUM OF 36" IN HEIGHT AND SHALL BE ADEQUATELY FASTENED TO THE WIRE AS DIRECTED BY THE DESIGNER.

# DETAILS

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PROJECT ENGINEER

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| LITTLE WHITE OAK CREEK | 2R |

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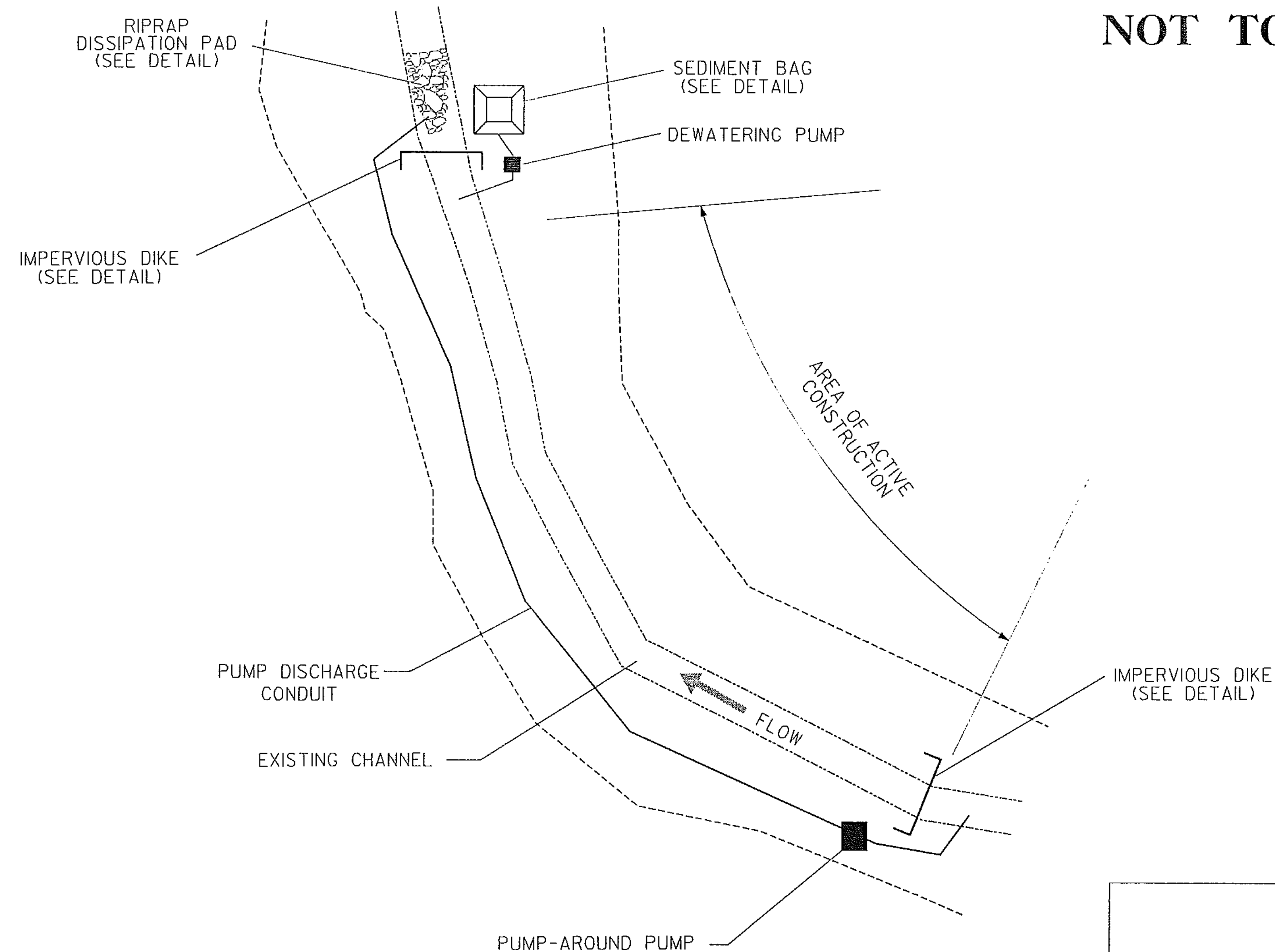


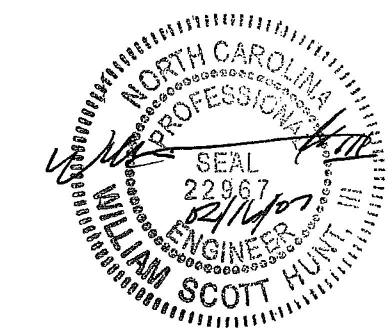

NOTES:

1. ALL EXCAVATION SHALL BE PERFORMED IN ONLY DRY OR ISOLATED SECTIONS OF CHANNEL.
2. IMPERVIOUS DIKES ARE TO BE USED TO ISOLATE WORK FROM STREAM FLOW.
3. PUMPS, IMPERVIOUS DIKES, AND DISCHARGE CONDUITS SHALL BE OF A SUFFICIENT SIZE AND NUMBER TO PUMP AROUND AND TO DEWATER THE WORK AREA.
4. RIPRAP DISSIPATION PAD TO BE INSTALLED DOWNSTREAM OF LOWER IMPERVIOUS DIKE. PUMP DISCHARGE CONDUIT SHALL BE DISCHARGED ONTO PAD AT ALL TIMES.
5. DEWATERING PUMP DISCHARGE CONDUIT SHALL BE DISCHARGED INTO SEDIMENT BAG AT ALL TIMES.
6. SEDIMENT BAG SHALL BE LOCATED OUT OF EXISITNG AND PROPOSED CHANNELS.

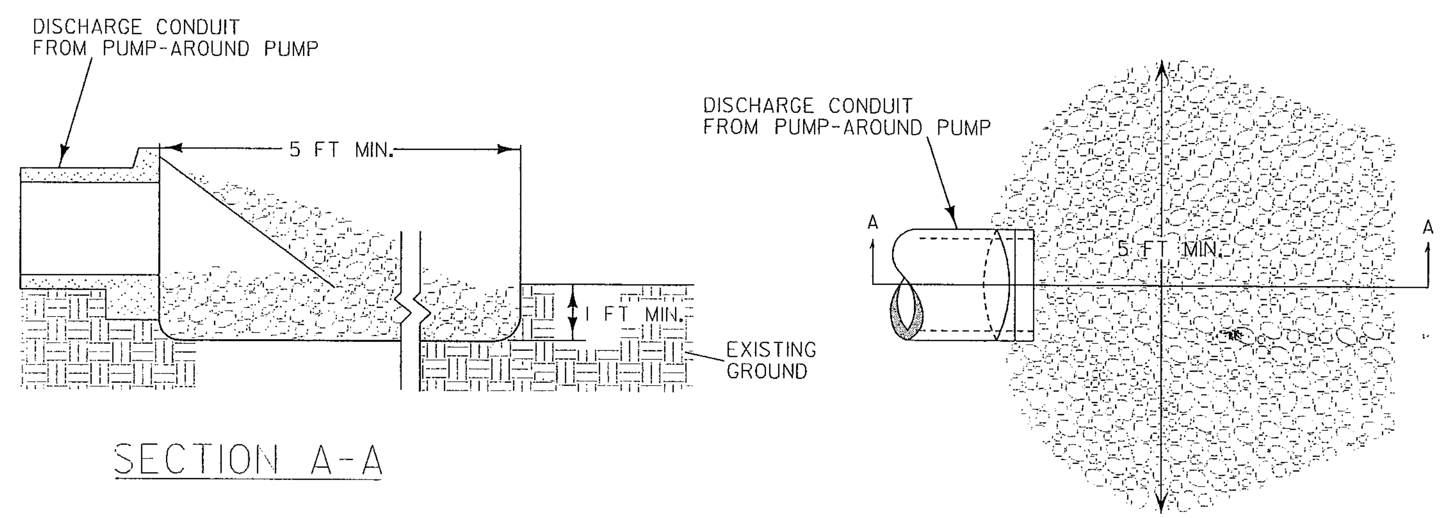
## TYPICAL PUMP-AROUND OPERATION

SEQUENCE OF CONSTRUCTION FOR TYPICAL PUMP-AROUND

1. INSTALL SEDIMENT BAG AND RIPRAP DISSIPATION PAD.
2. INSTALL PUMP AROUND PUMP AND DEWATERING PUMP AND DISCHARGE CONDUIT.
3. PLACE UPSTREAM IMPERVIOUS DIKE AND BEGIN PUMPING OPERATIONS WITH PUMP-AROUND PUMP FOR STREAM DIVERSION.
4. PLACE DOWNSTREAM IMPERVIOUS DIKE AND PUMPING APPARATUS. DEWATER ENTRAPPED AREA USING DEWATERING PUMP.
5. PERFORM STREAM RESTORATION WORK IN ACCORDANCE WITH THE PLANS.
6. EXCAVATE ANY ACCUMULATED SILT AND DEWATER BEFORE REMOVAL OF IMPERVIOUS DIKES. REMOVE IMPERVIOUS DIKES, PUMPS, AND DISCHARGE CONDUIT. (DOWNSTREAM IMPERVIOUS DIKE FIRST)
7. ALL GRADING AND STABILIZATION MUST BE COMPLETED WITHIN THE PUMP AROUND AREAS BETWEEN THE IMPERVIOUS DIKES. THE IMPERVIOUS DIKE LOCATIONS AS SHOWN ON THIS SHEET ONLY SHOW THE UPPER AND LOWER EXTENT OF WORK FOR EACH STREAM SEGMENT. ADDITIONAL DIKES AND/OR PUMPS MAY BE REQUIRED TO ADEQUATLEY DEWATER THE WORK LIMITS.
8. REMOVE SEDIMENT BAG(S) AND BACKFILL, STABILIZE DISTURBED AREA WITH SEED AND MULCH.




## RIPRAP DISSIPATION PAD




SECTION A-A

PLAN VIEW

# DETAILS
## NOT TO SCALE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

| REVISIONS | | |
|---|---|---|
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PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

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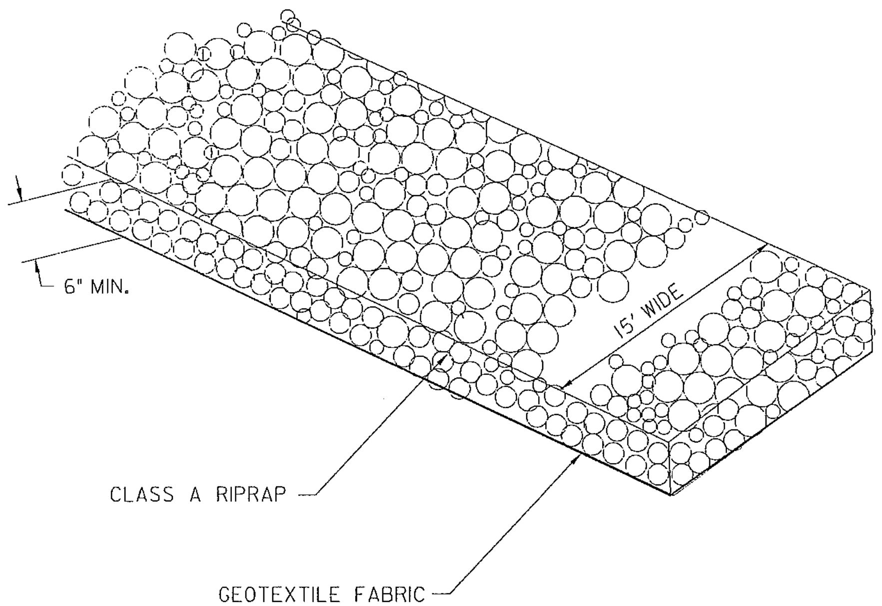
## ACCESS ROADS

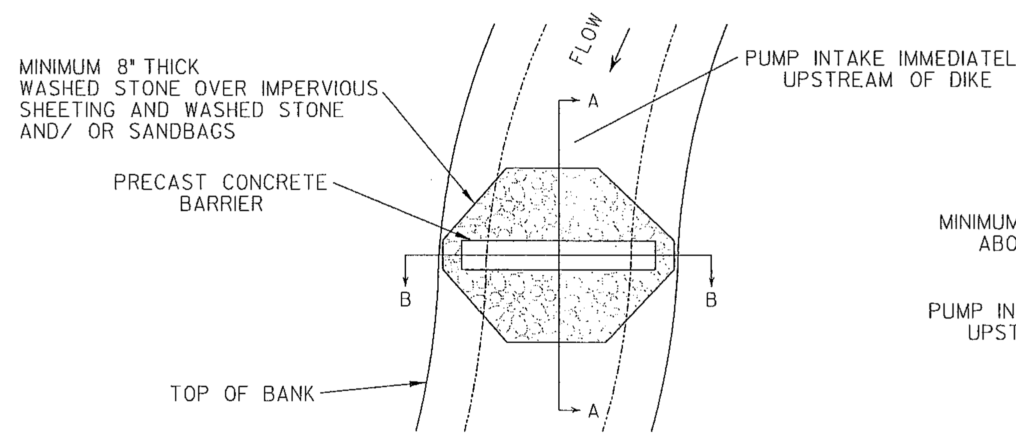



TEMPORARY GRAVEL ROAD

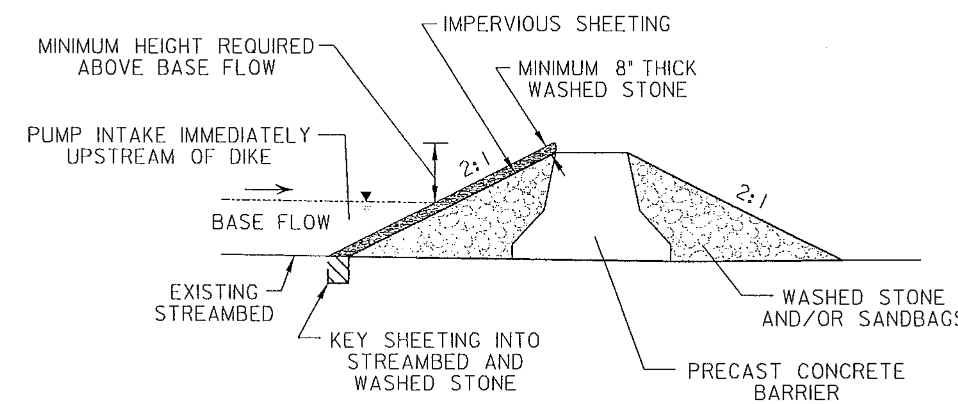
NOTES:

1. CLASS A RIPRAP SHALL BE USED. ROAD TO BE 15' L X 6" D.
2. MUST BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR DIRECT FLOW OF MUD AROUND ROAD. PERIODIC TOPDRESSING WITH STONE WILL BE NECESSARY; KEEP SOME HANDY.
3. ANY MATERIAL WHICH MAKES IT OFF THE ROAD MUST BE CLEANED UP IMMEDIATELY.
4. GRAVEL ROADS ONLY TO BE USED WHEN SITE AND/ OR WEATHER CONDITIONS CAUSE SOIL ROADS TO BE INADEQUATE FOR CONSTRUCTION ACCESS.

## IMPERVIOUS DIKE



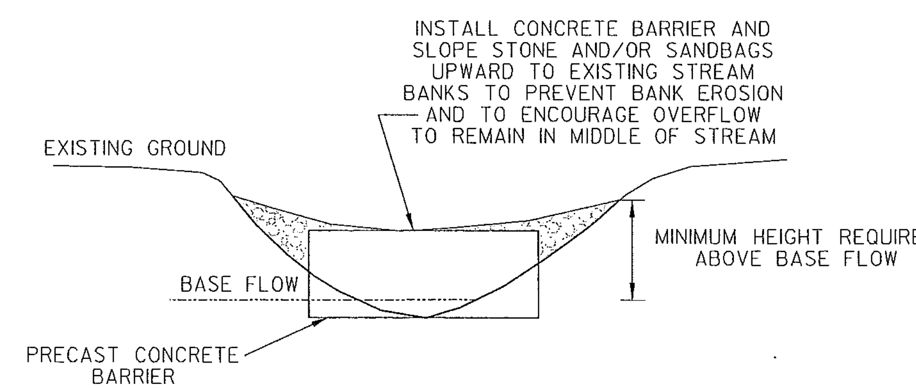

PLAN VIEW




SECTION A-A

NOTES:

1. DIKE IS NOT DESIGNED TO HOLD STORM FLOW. MAY REQUIRE MAINTENACNCE FOLLOWING STORM EVENTS.
2. BASE FLOW TO BE PUMPED EACH DAY FROM UPSTREAM SIDE OF DIKE AND DISCHARGED DOWNSTREAM OF WORK AREA FOR THAT DAY.
3. IF WORK AREA DOWNSTREAM OF DIKE CANNOT BE ADEQUATELY DEWATERED THROUGHT THE USE OF A SINGLE PUMP, ADDITIONAL PUMPING WITHIN THE WORK AREA MAY BE REQUIRED. ALL FLOW PUMPED FROM WITHIN THE WORK AREA TO BE DISCHARGED INTO A DEWATERING BAG PRIOR TO BEING DISCHARGED INTO THE STREAM DOWNSTREAM OF THE WORK AREA.
4. MAXIMUM HEIGHT OF DIKE ABOVE BASE FLOW TO BE MINIMIZED. DIKE HEIGHT TO BE ONLY AS REQUIRED TO PROVIDED ENOUGH BACKWATER FOR ADEQUATE SUCTION AT PUMP INTAKE.
5. WASHED STONE FOR IMPERVIOUS DIKE CONSTRUCTION MAY CONSIST OF CLASS A RIPRAP #5 OR #57 STONE, AND/ OR 2" TO 3" STONE.




SECTION B-B

# DETAILS

## NOT TO SCALE

| REVISIONS | | |
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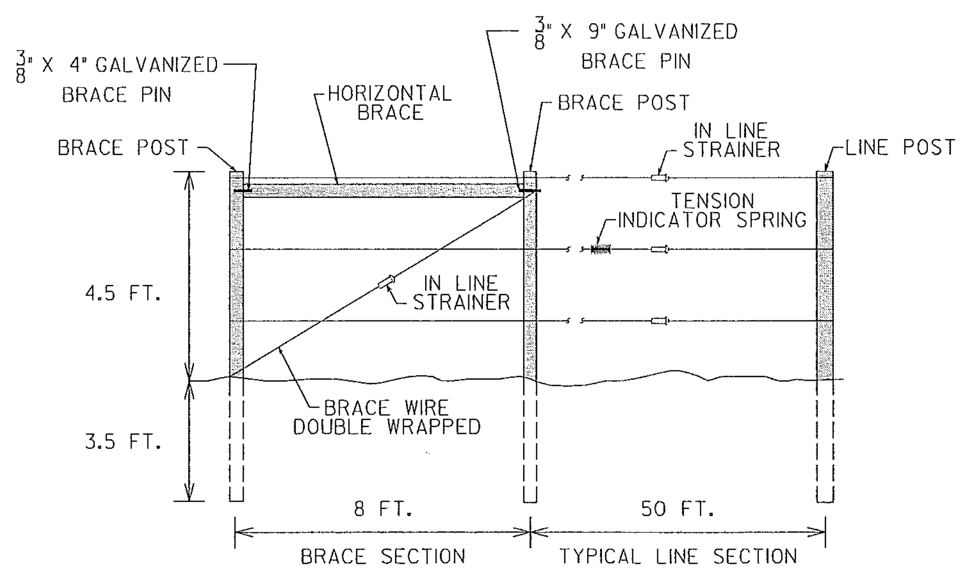
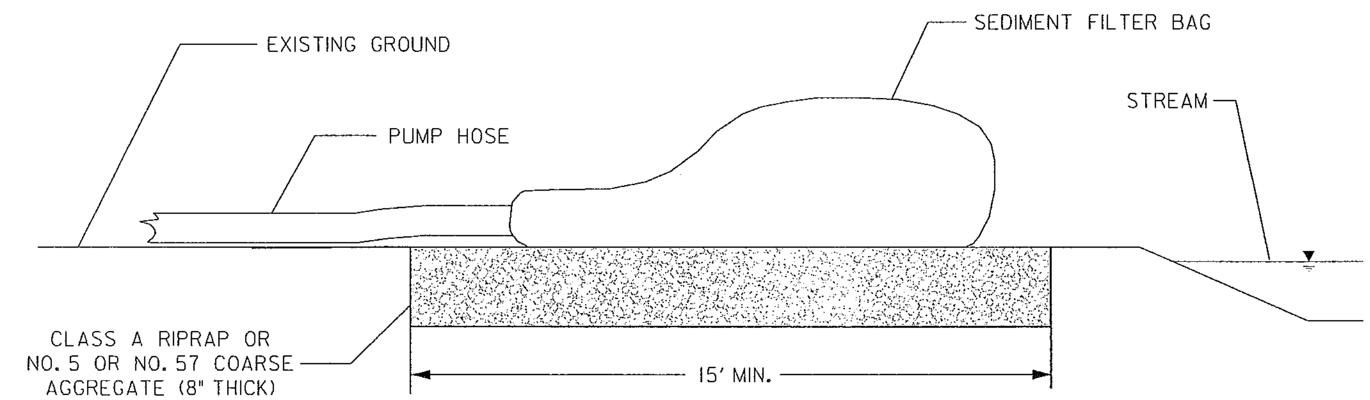
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III

## HIGH-TENSILE ELECTRIC FENCE




## SEDIMENT BAG




NOTES:

1. INSTALL SEDIMENT BAG ON A SLOPE SO INCOMING WATER FLOWS DOWNHILL THROUGH BAG WITHOUT CREATING MORE EROSION. TO INCREASE THE EFFICIENCY OF FILTRATION, PLACE THE BAG ON A GRAVEL BED IN ORDER TO MAXIMIZE WATER FLOW THROUGH THE SURFACE AREA OF THE BAG.

2. BAG IS FULL WHEN IT NO LONGER CAN EFFICIENTLY FILTER SEDIMENT OR ALLOW WATER TO PASS AT A REASONABLE RATE. FLOW RATES WILL VARY DEPENDING ON THE SIZE OF SEDIMENT BAG THE TYPE AND AMOUNT OF SEDIMENT DISCHARGED INTO THE BAG, THE TYPE OF GROUND, ROCK OR OTHER SUBSTANCE UNDER THE BAG AND THE DEGREE OF THE SLOPE ON WHICH THE BAG LIES. AVOID USE OF EXCESSIVE FLOW RATES OR OVERFILLING WITH SEDIMENT TO PREVENT BAG RUPTURE OR FAILURE OF THE HOSE ATTACHMENT STRAPS.

3. DISPOSE SEDIMENT BAG AS DIRECTED BY THE DESIGNER. IF ALLOWED, BAG MAY BE CUT OPEN AND THE CONTENTS SEEDED AFTER REMOVING VISIBLE FABRIC.

# DETAILS
NOT TO SCALE

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III

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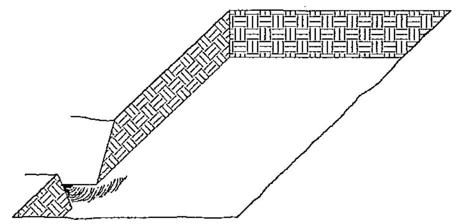
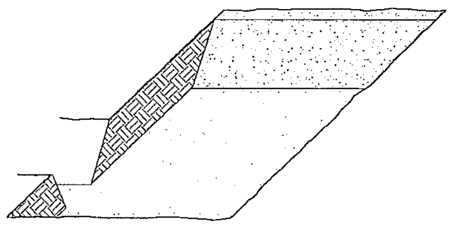
## SEEDLING/LINER BAREROOT PLANTING

HEALING IN

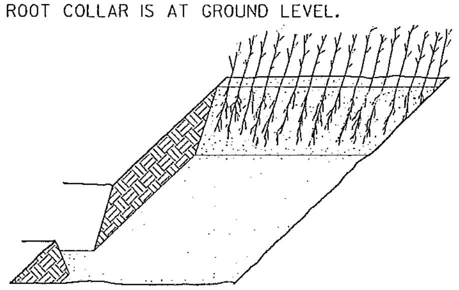
1. LOCATE A HEALING-IN SITE IN A SHADY, WELL PROTECTED AREA.
2. EXCAVATE A FLAT BOTTOM TRENCH 12" DEEP AND PROVIDE DRAINAGE.



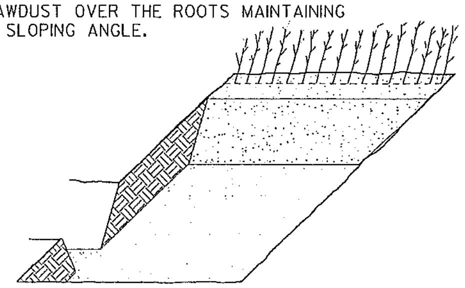
3. BACKFILL THE TRENCH WITH 2" WELL ROTTED SAWDUST. PLACE A 2" LAYER OF WELL ROTTED SAWDUST AT A SLOPING ANGLE AT ONE END OF THE TRENCH.



4. PLACE A SINGLE LAYER OF PLANTS AGAINST THE SLOPING END SO THAT THE ROOT COLLAR IS AT GROUND LEVEL.

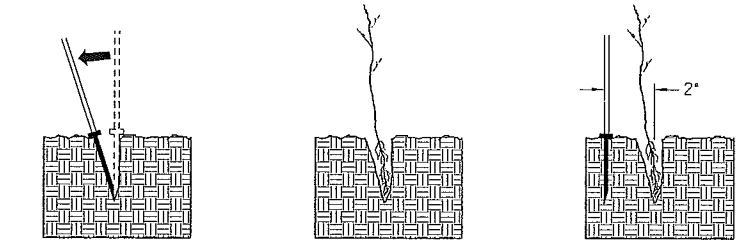


5. PLACE A 2" LAYER OF WELL ROTTED SAWDUST OVER THE ROOTS MAINTAINING A SLOPING ANGLE.

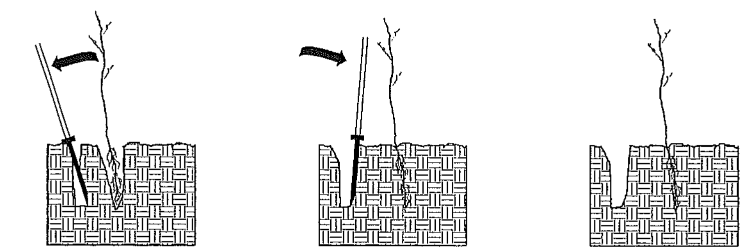


6. REPEAT LAYERS OF PLANTS AND SAWDUST AS NECESSARY AND WATER THOROUGHLY.

DIBBLE PLANTING METHOD
USING THE KBC PLANTING BAR



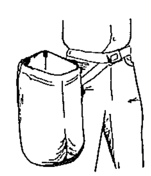

1. INSERT PLANTING BAR AS SHOWN AND PULL HANDLE TOWARD PLANTER.
2. REMOVE PLANTING BAR AND PLACE SEEDLING AT CORRECT DEPTH.
3. INSERT PLANTING BAR 2" TOWARD PLANTER FROM SEEDLING.



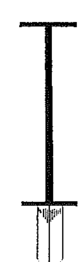
4. PULL HANDLE OF BAR TOWARD PLANTER, FIRMING SOIL AT BOTTOM.
5. PUSH HANDLE FORWARD FIRMING SOIL AT TOP.
6. LEAVE COMPACTION HOLE OPEN. WATER THOROUGHLY.

PLANTING NOTES:

PLANTING BAG
DURING PLANTING, SEEDLINGS SHALL BE KEPT IN A MOIST CANVAS BAG OR SIMILAR CONTAINER TO PREVENT THE ROOT SYSTEMS FROM DRYING.

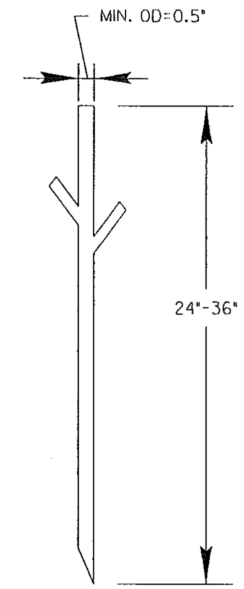


KBC PLANTING BAR**
Planting bar shall have a blade with a triangular cross section, and shall be 12" long, 4" wide and 1" thick at center.

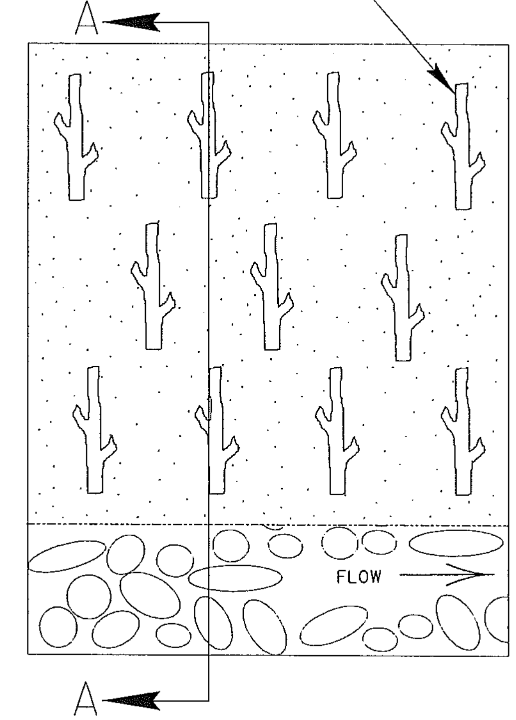


**CONTRACTOR MAY UTILIZE ANY APPROPRIATE PLANTING DEVICE UPON APPROVAL FROM ON-SITE ENGINEER.

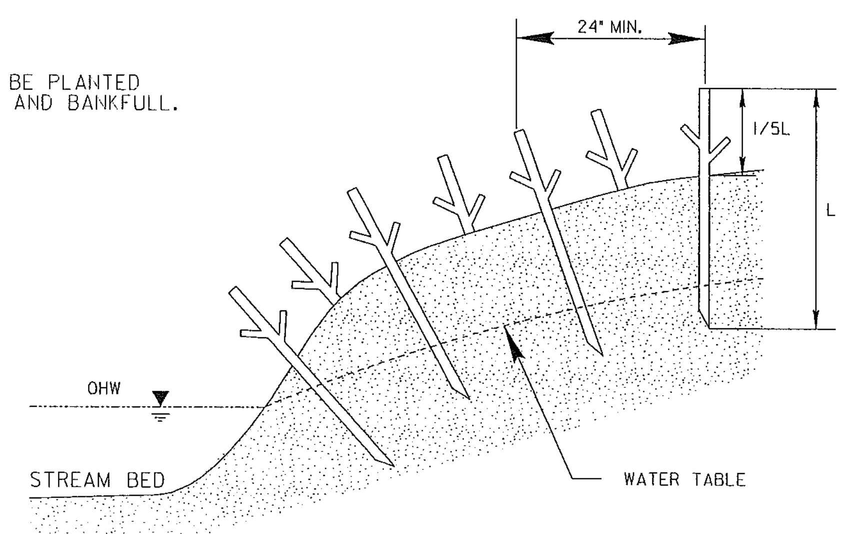
## LIVE STAKE PLANTING




LIVE STAKE




NOTES:
1. LIVE STAKES TO ONLY BE PLANTED BETWEEN WATERS EDGE AND BANKFULL.




SECTION A-A

# PROPOSED PROFILE DATA

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

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| LITTLE WHITE OAK CREEK | 3 |

*PROP. PROFILE DATA*

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NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

## R1

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 0+00 | 884.48' | Riffle |
| 0+25 | 884.06' | Run |
| 0+50 | 883.44' | Pool |
| 0+85 | 882.74' | MaxD |
| 1+25 | 883.92' | Glide |
| 1+47 | 884.06' | Riffle |
| 1+77 | 883.62' | Run |
| 2+12 | 882.97' | Pool |
| 2+42 | 882.29' | Max D |
| 2+72 | 883.50' | Glide |
| 2+92 | 883.64' | Riffle |
| 3+17 | 883.22' | Run |
| 3+42 | 882.60' | Pool |
| 3+72 | 881.92' | Max D |
| 4+02 | 883.13' | Glide |
| 4+17 | 883.29' | Riffle |
| 4+37 | 882.88' | Run |
| 4+57 | 882.27' | Pool |
| 4+72 | 881.63' | Max D |
| 4+87 | 882.89' | Glide |
| 4+97 | 883.06' | Riffle |
| 5+17 | 882.65' | Run |
| 5+37 | 882.04' | Pool |
| 5+62 | 881.37' | Max D |
| 5+87 | 882.60' | Glide |
| 5+96.92 | 882.77' | Riffle |
| 6+21.92 | 882.36' | Run |
| 6+51.92 | 881.75' | Pool |
| 6+86.92 | 881.07' | Max D |
| 7+11.92 | 882.31' | Glide |
| 7+36.92 | 882.46' | Riffle |
| 7+61.92 | 882.05' | Run |
| 7+91.92 | 881.43' | Pool |
| 8+26.92 | 880.75' | Max D |
| 8+56.92 | 881.99' | Glide |
| 8+81.92 | 882.13' | Riffle |
| 9+01.92 | 881.73' | Run |
| 9+26.92 | 881.13' | Pool |
| 9+56.92 | 880.46' | Max D |
| 9+86.92 | 881.69' | Glide |
| 10+06.92 | 881.85' | Riffle |
| 10+31.92 | 881.44' | Run |
| 10+61.92 | 880.82' | Pool |
| 11+01.92 | 880.13' | Max D |
| 11+31.92 | 881.37' | Glide |
| 11+46.92 | 881.53' | Riffle |
| 11+76.92 | 881.12' | Run |
| 12+06.92 | 880.50' | Pool |
| 12+48.92 | 879.80' | Max D |
| 12+90.92 | 881.01' | Glide |
| 13+15.92 | 881.15' | Riffle |
| 13+40.92 | 880.75' | Run |
| 13+70.92 | 880.13' | Pool |
| 14+07.92 | 879.45' | Max D |
| 14+44.92 | 880.66' | Glide |
| 14+80.92 | 880.78' | Riffle |
| 15+48.89 | 880.28' | Run |
| 15+63.89 | 879.70' | Pool |
| 15+98.89 | 879.02' | Max D |
| 16+43.89 | 880.22' | Glide |
| 16+68.89 | 880.36' | Riffle |
| 17+03.89 | 879.93' | Run |
| 17+28.89 | 879.32' | Pool |
| 17+68.89 | 878.63' | Max D |

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 18+13.89 | 879.83' | Glide |
| 18+49.89 | 879.95' | Riffle |
| 18+64.89 | 879.57' | Run |
| 18+84.89 | 878.97' | Pool |
| 19+19.89 | 878.29' | Max D |
| 19+54.89 | 879.52' | Glide |
| 19+79.89 | 879.66' | Riffle |
| 20+04.89 | 879.25' | Run |
| 20+34.89 | 878.64' | Pool |
| 20+74.89 | 877.95' | Max D |
| 21+14.89 | 879.16' | Glide |
| 21+44.89 | 879.29' | Riffle |
| 21+74.89 | 878.87' | Run |
| 22+04.89 | 878.25' | Pool |
| 22+44.89 | 877.56' | Max D |
| 22+89.89 | 878.76' | Glide |
| 23+25.89 | 878.88' | Riffle |
| 23+40.89 | 878.50' | Run |
| 23+60.89 | 877.90' | Pool |
| 23+88.89 | 877.24' | Max D |
| 24+16.89 | 878.48' | Glide |
| 24+28.89 | 878.65' | Riffle |
| 24+63.89 | 878.22' | Run |
| 25+08.89 | 877.57' | Pool |
| 25+48.89 | 876.88' | Max D |
| 25+88.89 | 878.09' | Glide |
| 26+16.89 | 878.23' | Riffle |
| 26+46.89 | 877.81' | Run |
| 26+66.89 | 877.21' | Pool |
| 26+96.89 | 876.55' | Max D |
| 27+31.89 | 877.77' | Glide |
| 27+56.89 | 877.91' | Riffle |
| 27+76.89 | 877.52' | Run |
| 28+01.89 | 876.91' | Pool |
| 28+41.89 | 876.22' | Max D |
| 28+81.89 | 877.43' | Glide |
| 29+01.89 | 877.58' | Riffle |
| 29+36.89 | 877.16' | Run |
| 29+76.89 | 876.52' | Pool |
| 30+16.89 | 875.83' | Max D |
| 30+56.89 | 877.04' | Glide |
| 30+86.89 | 877.17' | Riffle |
| 31+01.89 | 876.78' | Run |
| 31+16.89 | 876.20' | Pool |
| 31+41.89 | 875.54' | Max D |
| 31+69.89 | 876.78' | Glide |
| 31+89.89 | 876.94' | Riffle |
| 32+77.89 | 876.39' | Run |
| 32+87.89 | 875.82' | Pool |
| 33+17.89 | 875.15' | Max D |
| 33+47.89 | 876.38' | Glide |
| 33+62.89 | 876.55' | Riffle |
| 33+92.89 | 876.13' | Run |
| 34+27.89 | 875.50' | Pool |
| 34+57.89 | 874.83' | Max D |
| 34+87.89 | 876.07' | Glide |
| 35+12.89 | 876.21' | Riffle |
| 35+42.89 | 875.79' | Run |
| 35+72.89 | 875.18' | Pool |
| 36+14.89 | 874.48' | Max D |
| 36+56.89 | 875.69' | Glide |
| 36+80.89 | 875.83' | Riffle |
| 37+02.89 | 875.43' | Run |
| 37+29.89 | 874.82' | Pool |

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 37+64.89 | 874.14' | Max D |
| 38+04.89 | 875.35' | Glide |
| 38+24.89 | 875.51' | Riffle |
| 38+49.89 | 875.10' | Run |
| 38+79.89 | 874.48' | Pool |
| 39+14.89 | 873.81' | Max D |
| 39+49.89 | 875.03' | Glide |
| 39+74.89 | 875.17' | Riffle |
| 39+99.89 | 874.76' | Run |
| 40+29.89 | 874.15' | Pool |
| 40+71.89 | 873.45' | Max D |
| 41+13.89 | 874.66' | Glide |
| 41+43.89 | 874.79' | Riffle |
| 41+63.89 | 874.40' | Run |
| 41+88.89 | 873.79' | Pool |
| 42+18.89 | 873.12' | Max D |
| 42+53.89 | 874.34' | Glide |
| 42+78.89 | 874.49' | Riffle |
| 43+08.89 | 874.07' | Run |
| 43+43.89 | 873.44' | Pool |
| 43+73.89 | 872.77' | Max D |
| 44+03.89 | 874.01' | Glide |
| 44+28.89 | 874.15' | Riffle |
| 44+55.89 | 873.74' | Run |
| 44+87.89 | 873.12' | Pool |
| 45+16.89 | 872.45' | Max D |
| 45+51.89 | 873.67' | Glide |
| 45+63.89 | 873.85' | Riffle |
| 46+05.89 | 873.40' | Run |
| 46+53.89 | 872.74' | Pool |
| 47+18.89 | 872.00' | Max D |
| 47+83.89 | 873.15' | Glide |
| 48+18.89 | 873.27' | Riffle |
| 48+82.89 | 872.74' | Run |
| 49+42.89 | 872.03' | Pool |
| 49+49.89 | 871.41' | Max D |
| 49+58.89 | 872.69' | Glide |
| 49+68.89 | 872.86' | Riffle |
| 49+93.89 | 872.44' | Run |
| 50+13.89 | 871.83' | Pool |
| 50+38.89 | 871.16' | Max D |
| 50+68.89 | 872.38' | Glide |
| 50+86.89 | 872.53' | Riffle |
| 51+06.89 | 872.13' | Run |
| 51+36.89 | 871.49' | Pool |
| 51+76.89 | 870.78' | Max D |
| 52+21.89 | 871.96' | Glide |
| 52+56.89 | 872.06' | Riffle |
| 52+81.89 | 871.66' | Run |
| 53+01.89 | 871.07' | Pool |
| 53+21.89 | 870.43' | Max D |
| 53+41.89 | 871.69' | Glide |
| 53+61.89 | 871.85' | Riffle |
| 54+03.89 | 871.41' | Run |
| 54+51.89 | 870.77' | Pool |
| 54+96.89 | 870.08' | Max D |
| 55+38.89 | 871.29' | Glide |
| 55+74.89 | 871.81' | Riffle |
| 55+96.89 | 870.89' | Run |
| 56+21.89 | 869.93' | Pool |
| 56+46.89 | 869.28' | Max D |
| 56+86.89 | 870.49' | Glide |
| 57+02.89 | 870.66' | Riffle |

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 57+37.89 | 870.24' | Run |
| 57+77.89 | 869.60' | Pool |
| 58+12.89 | 868.93' | Max D |
| 58+42.89 | 870.16' | Glide |
| 58+52.89 | 870.34' | Riffle |
| 58+77.89 | 869.94' | Run |
| 59+02.89 | 869.34' | Pool |
| 59+32.89 | 868.67' | Max D |
| 59+62.89 | 869.91' | Glide |
| 59+82.89 | 870.07' | Riffle |
| 60+12.89 | 869.65' | Run |
| 60+47.89 | 869.03' | Pool |
| 60+87.89 | 868.34' | Max D |
| 61+22.89 | 869.57' | Glide |
| 61+47.89 | 869.72' | Riffle |
| 61+72.89 | 869.31' | Run |
| 61+92.89 | 868.72' | Pool |
| 62+27.89 | 868.05' | Max D |
| 62+57.89 | 869.28' | Glide |
| 62+72.89 | 869.45' | Riffle |
| 62+92.89 | 869.06' | Run |
| 63+17.89 | 868.46' | Pool |
| 63+59.89 | 867.77' | Max D |
| 64+04.89 | 868.97' | Glide |
| 64+34.89 | 869.11' | Riffle |
| 65+22.89 | 868.57' | Run |
| 65+52.89 | 867.96' | Pool |
| 65+97.89 | 867.26' | Max D |
| 66+37.89 | 868.48' | Glide |
| 66+62.89 | 868.63' | Riffle |
| 66+87.89 | 868.22' | Run |
| 67+12.89 | 867.62' | Pool |
| 67+52.89 | 866.93' | Max D |
| 67+92.89 | 868.15' | Glide |
| 68+17.89 | 868.30' | Riffle |
| 68+47.89 | 867.88' | Run |
| 68+79.89 | 867.27' | Pool |
| 69+04.89 | 866.61' | Max D |
| 69+29.89 | 867.86' | Glide |
| 69+53.89 | 868.01' | Riffle |
| 69+73.89 | 867.62' | Run |
| 69+93.89 | 867.02' | Pool |
| 70+33.89 | 866.34' | Max D |
| 70+68.89 | 867.56' | Glide |
| 70+83.89 | 867.73' | Riffle |
| 71+18.89 | 867.31' | Run |
| 71+48.89 | 866.69' | Pool |
| 71+83.89 | 866.02' | Max D |
| 72+13.89 | 867.26' | Glide |
| 72+33.89 | 867.41' | Riffle |
| 72+53.89 | 867.02' | Run |
| 72+73.89 | 866.43' | Pool |
| 73+08.89 | 865.76' | Max D |
| 73+38.89 | 866.99' | Glide |
| 73+58.89 | 867.15' | Riffle |
| 73+73.89 | 866.77' | Run |
| 73+88.89 | 866.19' | Pool |
| 74+13.89 | 865.53' | Max D |
| 74+38.89 | 866.78' | Glide |
| 74+73.89 | 866.91' | Riffle |
| 75+15.89 | 866.47' | Run |
| 75+57.89 | 865.83' | Pool |
| 76+43.89 | 865.05' | Max D |

## R2

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 0+00 | 873.78' | Max D |
| 0+10 | 874.50' | Glide |
| 0+35 | 875.42' | Riffle |
| 0+85 | 874.68' | Run |
| 1+35 | 873.99' | Pool |
| 1+85 | 873.33' | Max D |
| 2+35 | 874.80' | Glide |
| 2+60 | 875.06' | Riffle |
| 3+00 | 874.34' | Run |
| 3+40 | 873.67' | Pool |
| 3+80 | 873.02' | Max D |
| 4+20 | 874.51' | Glide |
| 4+40 | 874.78' | Riffle |
| 4+80 | 874.05' | Run |
| 5+20 | 873.38' | Pool |
| 5+60 | 872.73' | Max D |
| 6+00 | 874.22' | Glide |
| 6+20 | 874.49' | Riffle |
| 6+55 | 873.77' | Run |
| 6+90 | 873.11' | Pool |
| 7+35 | 872.45' | Max D |
| 7+80 | 873.93' | Glide |
| 7+90 | 874.22' | Riffle |
| 8+20 | 873.51' | Run |
| 8+50 | 872.85' | Pool |
| 8+90 | 872.21' | Max D |
| 9+35 | 873.68' | Glide |
| 9+60 | 873.94' | Riffle |
| 10+10 | 873.20' | Run |
| 10+60 | 872.51' | Pool |
| 11+10 | 871.85' | Max D |
| 11+50 | 873.34' | Glide |
| 11+70 | 873.61' | Riffle |
| 12+00 | 872.90' | Run |
| 12+35 | 872.23' | Pool |
| 12+75 | 871.59' | Max D |
| 13+15 | 873.08' | Glide |
| 13+35 | 873.34' | Riffle |
| 13+80 | 872.61' | Run |
| 14+25 | 871.93' | Pool |
| 14+75 | 871.27' | Max D |
| 15+25 | 872.74' | Glide |
| 15+45 | 873.01' | Riffle |
| 15+80 | 872.29' | Run |
| 16+15 | 871.63' | Pool |
| 16+35 | 871.01' | Max D |
| 16+55 | 872.53' | Glide |
| 16+67 | 872.81' | Riffle |
| 17+07 | 872.09' | Run |
| 17+47 | 871.41' | Pool |
| 17+97 | 870.75' | Max D |
| 18+47 | 872.22' | Glide |
| 18+62 | 872.50' | Riffle |
| 19+12 | 871.76' | Run |

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 19+62 | 871.07' | Pool |
| 20+12 | 870.41' | Max D |
| 20+62 | 871.88' | Glide |
| 20+92 | 872.13' | Riffle |
| 21+17 | 871.43' | Run |
| 21+42 | 870.78' | Pool |
| 21+82 | 870.14' | Max D |
| 22+22 | 871.62' | Glide |
| 22+42 | 871.89' | Riffle |
| 22+82 | 871.17' | Run |
| 23+22 | 870.49' | Pool |
| 23+72 | 869.83' | Max D |
| 24+17 | 871.31' | Glide |
| 24+42 | 871.57' | Riffle |
| 24+82 | 870.85' | Run |
| 25+22 | 870.17' | Pool |
| 25+72 | 869.51' | Max D |
| 26+22 | 870.98' | Glide |
| 26+42 | 871.25' | Riffle |
| 26+87 | 870.52' | Run |
| 27+32 | 869.84' | Pool |
| 27+82 | 869.18' | Max D |
| 28+32 | 870.65' | Glide |
| 28+44 | 870.93' | Riffle |
| 28+74 | 870.22' | Run |
| 29+04 | 869.56' | Pool |
| 29+54 | 868.90' | Max D |
| 29+99 | 870.38' | Glide |
| 30+14 | 870.66' | Riffle |
| 30+49 | 869.94' | Run |
| 30+84 | 869.28' | Pool |
| 31+24 | 868.63' | Max D |
| 31+59 | 870.13' | Glide |
| 31+71 | 870.41' | Riffle |
| 31+96 | 869.71' | Run |
| 32+21 | 869.06' | Pool |
| 32+66 | 868.40' | Max D |
| 33+06 | 869.89' | Glide |
| 33+21 | 870.17' | Riffle |
| 33+99 | 869.38' | Run |
| 34+34 | 868.72' | Pool |
| 34+69 | 868.08' | Max D |
| 35+04 | 869.57' | Glide |
| 35+19 | 869.85' | Riffle |
| 35+54 | 869.13' | Run |
| 35+89 | 868.47' | Pool |
| 36+39 | 867.81' | Max D |
| 36+89 | 869.28' | Glide |
| 37+09 | 869.55' | Riffle |
| 37+39 | 868.84' | Run |
| 37+69 | 868.18' | Pool |
| 38+14 | 867.53' | Max D |
| 38+59 | 869.01' | Glide |
| 38+74 | 869.28' | Riffle |

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 39+14 | 868.56' | Run |
| 39+54 | 867.88' | Pool |
| 40+06 | 867.22' | Max D |
| 40+58 | 868.69' | Glide |
| 40+88 | 868.94' | Riffle |
| 41+28 | 868.22' | Run |
| 41+68 | 867.54' | Pool |
| 42+03 | 866.91' | Max D |
| 42+38 | 868.40' | Glide |
| 42+53 | 868.68' | Riffle |
| 42+83 | 867.97' | Run |
| 43+13 | 867.31' | Pool |
| 43+58 | 866.66' | Max D |
| 43+98 | 868.14' | Glide |
| 44+18 | 868.41' | Riffle |
| 44+53 | 867.70' | Run |
| 44+88 | 867.03' | Pool |
| 45+23 | 866.39' | Max D |
| 45+63 | 867.88' | Glide |
| 46+03 | 868.12' | Riffle |
| 46+48 | 867.38' | Run |
| 47+03 | 866.69' | Pool |
| 47+53 | 866.03' | Max D |
| 47+98 | 867.50' | Glide |
| 48+13 | 867.78' | Riffle |
| 48+48 | 867.06' | Run |
| 48+83 | 866.40' | Pool |
| 49+18 | 865.76' | Max D |
| 49+53 | 867.26' | Glide |
| 49+68 | 867.36' | Riffle |
| 49+88 | 866.58' | Run |
| 50+08 | 866.00' | Pool |
| 50+33 | 865.26' | Max D |
| 50+58 | 866.86' | Glide |
| 50+70 | 867.20' | Riffle |
| 50+90 | 866.42' | Run |
| 51+10 | 865.83' | Pool |
| 51+46 | 865.08' | Max D |
| 51+76 | 866.67' | Glide |
| 51+89 | 866.76' | Riffle |
| 52+04 | 866.23' | Run |
| 52+19 | 865.66' | Pool |
| 52+64 | 864.88' | Max D |
| 53+09 | 866.44' | Glide |
| 53+29 | 866.60' | Riffle |
| 53+49 | 865.98' | Run |
| 53+69 | 865.40' | Pool |
| 54+29 | 864.60' | Max D |
| 54+89 | 866.13' | Glide |
| 55+09 | 866.43' | Riffle |
| 55+34 | 865.61' | Run |
| 55+59 | 864.98' | Pool |
| 56+09 | 864.13' | Max D |

| Station | Thalweg Elevation | Feature |
|---|---|---|
| 56+54 | 865.41' | Glide |
| 56+74 | 865.69' | Riffle |
| 56+94 | 864.88' | Run |
| 57+14 | 864.17' | Pool |
| 57+44 | 863.36' | Max D |
| 57+69 | 865.06' | Glide |
| 57+82 | 865.36' | Riffle |
| 58+12 | 864.52' | Run |
| 58+42 | 863.78' | Pool |
| 58+82 | 862.94' | Max D |
| 59+22 | 864.60' | Glide |
| 59+42 | 864.90' | Riffle |
| 60+02 | 864.02' | Run |
| 61+05 | 863.14' | Pool |
| 61+05 | 862.42' | Max D |
| 61+05 | 864.20' | Glide |
| 61+05 | 864.54' | Riffle |
| 61+35 | 863.75' | Run |
| 61+70 | 863.05' | Pool |
| 62+10 | 862.27' | Max D |
| 62+45 | 863.99' | Glide |
| 62+60 | 864.31' | Riffle |
| 62+95 | 863.51' | Run |
| 63+30 | 862.81' | Pool |
| 63+90 | 862.00' | Max D |
| 64+50 | 863.69' | Glide |
| 64+70 | 864.00' | Riffle |
| 65+00 | 863.20' | Run |
| 65+30 | 862.51' | Pool |
| 65+75 | 861.72' | Max D |
| 66+20 | 863.43' | Glide |
| 66+40 | 863.74' | Riffle |
| 66+65 | 862.96' | Run |
| 66+90 | 862.27' | Pool |
| 67+40 | 861.48' | Max D |
| 67+90 | 863.18' | Glide |
| 68+10 | 863.49' | Riffle |
| 68+50 | 862.68' | Run |
| 68+90 | 861.97' | Pool |
| 69+52 | 861.16' | Max D |
| 70+07 | 862.86' | Glide |
| 70+32 | 863.16' | Riffle |
| 70+62 | 862.37' | Run |
| 70+92 | 861.67' | Pool |
| 71+32 | 860.89' | Max D |
| 71+72 | 862.61' | Glide |
| 71+87 | 862.93' | Riffle |
| 72+12 | 862.14' | Run |
| 72+37 | 861.46' | Pool |
| 72+62 | 860.70' | Max D |
| 72+92 | 862.43' | Glide |
| 73+22 | 862.73' | Riffle |
| 73+27.13 | 862.78' | END |

# PROPOSED PROFILE DATA

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 3A |

**PROP. PROFILE DATA**

MULKEY
ENGINEERS & CONSULTANTS
PO Box 33127
Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

## R1A

| | Thalweg | | | Thalweg | |
|---|---|---|---|---|---|
| Station | Elevation | Feature | Station | Elevation | Feature |
| 0+00 | 891.79' | Riffle | 6+32 | 886.57' | Riffle |
| 0+34 | 891.25' | Run | 6+42 | 886.36' | Run |
| 0+37 | 891.07' | Pool | 6+52 | 886.18' | Pool |
| 0+42 | 890.96' | Max D | 6+64 | 886.08' | Max D |
| 0+46 | 891.21' | Glide | 6+76 | 886.33' | Glide |
| 0+49 | 891.25' | Riffle | 6+85 | 886.37' | Riffle |
| 0+58 | 890.98' | Run | 6+92 | 886.17' | Run |
| 0+63 | 890.79' | Pool | 7+00 | 886.01' | Pool |
| 0+79 | 890.55' | Max D | 7+09 | 885.91' | Max D |
| 0+91 | 890.72' | Glide | 7+18 | 886.18' | Glide |
| 1+02 | 890.67' | Riffle | 7+24 | 886.23' | Riffle |
| 1+10 | 890.41' | Run | 7+30 | 886.03' | Run |
| 1+19 | 890.18' | Pool | 7+37 | 885.87' | Pool |
| 1+32 | 889.97' | Max D | 7+50 | 885.76' | Max D |
| 1+44 | 890.14' | Glide | 7+63 | 886.01' | Glide |
| 1+53 | 890.11' | Riffle | 7+74 | 886.04' | Riffle |
| 1+63 | 889.83' | Run | 7+82 | 885.84' | Run |
| 1+69 | 889.63' | Pool | 7+91 | 885.67' | Pool |
| 1+80 | 889.45' | Max D | 8+01 | 885.57' | Max D |
| 1+90 | 889.64' | Glide | 8+11 | 885.83' | Glide |
| 1+95 | 889.65' | Riffle | 8+16 | 885.88' | Riffle |
| 2+04 | 889.38' | Run | 8+24 | 885.69' | Run |
| 2+14 | 889.13' | Pool | 8+32 | 885.52' | Pool |
| 2+30 | 888.90' | Max D | 8+43 | 885.41' | Max D |
| 2+41 | 889.08' | Glide | 8+54 | 885.67' | Glide |
| 2+49 | 889.06' | Riffle | 8+65 | 885.70' | Riffle |
| 2+56 | 888.81' | Run | 8+75 | 885.32' | Run |
| 2+64 | 888.59' | Pool | 8+85 | 884.98' | Pool |
| 2+78 | 888.37' | Max D | 8+95 | 884.71' | Max D |
| 2+92 | 888.52' | Glide | 9+06 | 884.78' | Glide |
| 3+03 | 888.47' | Riffle | 9+15 | 884.66' | Riffle |
| 3+12 | 888.20' | Run | 9+42 | 883.93' | Run |
| 3+21 | 887.96' | Pool | 9+53 | 883.56' | Pool |
| 3+32 | 887.78' | Max D | 9+66 | 883.23' | Max D |
| 3+42 | 887.97' | Glide | 9+79 | 883.26' | Glide |
| 3+47 | 887.99' | Riffle | 9+88 | 883.14' | Riffle |
| 3+55 | 887.73' | Run | 9+95 | 882.83' | Run |
| 3+64 | 887.49' | Pool | 10+02 | 882.54' | Pool |
| 3+77 | 887.29' | Max D | 10+14 | 882.23' | Max D |
| 3+90 | 887.45' | Glide | 10+26 | 882.28' | Glide |
| 3+97 | 887.44' | Riffle | 10+32 | 882.23' | Riffle |
| 4+06 | 887.24' | Run | 10+40 | 881.89' | Run |
| 4+15 | 887.06' | Pool | 10+49 | 881.56' | Pool |
| 4+32 | 886.94' | Max D | 10+60 | 881.27' | Max D |
| 4+42 | 887.20' | Glide | 10+71 | 881.34' | Glide |
| 4+53 | 887.23' | Riffle | 10+78 | 881.27' | Riffle |
| 4+60 | 887.04' | Run | 10+87 | 880.91' | Run |
| 4+67 | 886.87' | Pool | 10+96 | 880.58' | Pool |
| 4+79 | 886.76' | Max D | 11+05 | 880.34' | Max D |
| 4+86 | 887.04' | Glide | 11+14 | 880.45' | Glide |
| 4+90 | 887.09' | Riffle | 11+20 | 880.39' | Riffle |
| 4+98 | 886.89' | Run | 11+25 | 880.12' | Run |
| 5+07 | 886.72' | Pool | 11+31 | 879.85' | Pool |
| 5+22 | 886.61' | Max D | 11+43 | 879.54' | Max D |
| 5+37 | 886.85' | Glide | 11+55 | 879.59' | Glide |
| 5+48 | 886.88' | Riffle | 11+62 | 879.52' | Riffle |
| 5+56 | 886.68' | Run | 11+68 | 879.22' | Run |
| 5+65 | 886.51' | Pool | 11+74 | 878.96' | Pool |
| 5+76 | 886.41' | Max D | 11+83 | 878.71' | Max D |
| 5+87 | 886.66' | Glide | 11+92 | 878.82' | Glide |
| 5+92 | 886.72' | Riffle | 11+96 | 878.81' | Riffle |
| 6+01 | 886.51' | Run | 11+99 | 878.58' | Run |
| 6+10 | 886.34' | Pool | 12+03 | 878.36' | Pool |
| 6+19 | 886.25' | Max D | 12+09 | 878.00' | Max D |
| 6+25 | 886.52' | Glide | 12+25.88 | 877.95' | Glide |

## R2A

| | Thalweg | |
|---|---|---|
| Station | Elevation | Feature |
| 0+00 | 876.61' | Riffle |
| 0+21 | 876.13' | Run |
| 0+31 | 875.80' | Pool |
| 0+48 | 875.52' | Max D |
| 0+58 | 875.86' | Glide |
| 0+71 | 875.92' | Riffle |
| 0+81 | 875.47' | Run |
| 0+91 | 875.14' | Pool |
| 1+11 | 874.83' | Max D |
| 1+31 | 875.06' | Glide |
| 1+43 | 875.13' | Riffle |
| 1+53 | 874.68' | Run |
| 1+68 | 874.29' | Pool |
| 1+83 | 874.04' | Max D |
| 2+01 | 874.29' | Glide |
| 2+11 | 874.31' | Riffle |
| 2+21 | 873.79' | Run |
| 2+31 | 873.39' | Pool |
| 2+56 | 872.85' | Max D |
| 2+78 | 872.90' | Glide |
| 2+93 | 872.83' | Riffle |
| 3+03 | 872.31' | Run |
| 3+13 | 871.91' | Pool |
| 3+23 | 871.64' | Max D |
| 3+33 | 871.91' | Glide |
| 3+38 | 872.02' | Riffle |
| 3+45 | 871.56' | Run |
| 3+52 | 871.21' | Pool |
| 3+72 | 870.76' | Max D |
| 3+79.57 | 871.08' | Glide |

## R2B

| | Thalweg | | | Thalweg | | | Thalweg | |
|---|---|---|---|---|---|---|---|---|
| Station | Elevation | Feature | Station | Elevation | Feature | Station | Elevation | Feature |
| 0+00 | 889.14' | Pool | 5+35 | 883.34' | Riffle | 11+17 | 876.42' | Pool |
| 0+08 | 888.99' | Max D | 5+44 | 883.07' | Run | 11+31 | 876.21' | Max D |
| 0+16 | 889.20' | Glide | 5+50 | 882.86' | Pool | 11+41 | 876.39' | Glide |
| 0+19 | 889.24' | Riffle | 5+58 | 882.71' | Max D | 11+49 | 876.37' | Riffle |
| 0+29 | 888.95' | Run | 5+69 | 882.88' | Glide | 11+55 | 876.14' | Run |
| 0+36 | 888.73' | Pool | 5+74 | 882.90' | Riffle | 11+62 | 875.92' | Pool |
| 0+48 | 888.54' | Max D | 6+40 | 881.97' | Run | 11+71 | 875.76' | Max D |
| 0+63 | 888.66' | Glide | 6+55 | 881.66' | Pool | 11+80 | 875.96' | Glide |
| 0+68 | 888.68' | Riffle | 6+72 | 881.41' | Max D | 11+87 | 875.95' | Riffle |
| 0+77 | 888.40' | Run | 6+82 | 881.59' | Glide | 11+95 | 875.69' | Run |
| 0+86 | 888.16' | Pool | 6+90 | 881.57' | Riffle | 12+04 | 875.45' | Pool |
| 1+00 | 887.94' | Max D | 6+95 | 881.35' | Run | 12+19 | 875.22' | Max D |
| 1+10 | 888.13' | Glide | 7+03 | 881.11' | Pool | 12+31 | 875.39' | Glide |
| 1+13 | 888.16' | Riffle | 7+15 | 880.92' | Max D | 12+40 | 875.36' | Riffle |
| 1+23 | 887.88' | Run | 7+28 | 881.07' | Glide | 12+48 | 875.10' | Run |
| 1+30 | 887.66' | Pool | 7+34 | 881.07' | Riffle | 12+56 | 874.87' | Pool |
| 1+40 | 887.48' | Max D | 7+40 | 880.83' | Run | 12+68 | 874.67' | Max D |
| 1+50 | 887.67' | Glide | 7+48 | 880.60' | Pool | 12+80 | 874.84' | Glide |
| 1+58 | 887.65' | Riffle | 7+59 | 880.42' | Max D | 12+86 | 874.84' | Riffle |
| 1+66 | 887.39' | Run | 7+69 | 880.60' | Glide | 12+96 | 874.56' | Run |
| 1+76 | 887.13' | Pool | 7+76 | 880.59' | Riffle | 13+06 | 874.31' | Pool |
| 1+89 | 886.92' | Max D | 7+84 | 880.33' | Run | 13+15 | 874.15' | Max D |
| 2+02 | 887.08' | Glide | 7+93 | 880.09' | Pool | 13+24 | 874.34' | Glide |
| 2+10 | 887.05' | Riffle | 8+05 | 879.89' | Max D | 13+31 | 874.34' | Riffle |
| 2+20 | 886.77' | Run | 8+18 | 880.05' | Glide | 13+38 | 874.09' | Run |
| 2+30 | 886.52' | Pool | 8+24 | 880.05' | Riffle | 13+46 | 873.86' | Pool |
| 2+40 | 886.34' | Max D | 8+31 | 879.80' | Run | 13+59 | 873.65' | Max D |
| 2+50 | 886.53' | Glide | 8+40 | 879.56' | Pool | 13+74 | 873.67' | Glide |
| 2+62 | 886.46' | Riffle | 8+53 | 879.35' | Max D | 13+81 | 873.61' | Riffle |
| 2+72 | 886.18' | Run | 8+64 | 879.52' | Glide | 13+89 | 873.29' | Run |
| 2+82 | 885.92' | Pool | 8+74 | 879.48' | Riffle | 13+96 | 873.02' | Pool |
| 2+87 | 885.81' | Max D | 8+85 | 879.18' | Run | 14+04 | 872.81' | Max D |
| 2+92 | 886.05' | Glide | 8+93 | 878.95' | Pool | 14+13 | 872.94' | Glide |
| 2+96 | 886.07' | Riffle | 9+03 | 878.78' | Max D | 14+20 | 872.88' | Riffle |
| 3+08 | 885.77' | Run | 9+12 | 878.98' | Glide | 14+25 | 872.62' | Run |
| 3+18 | 885.51' | Pool | 9+18 | 878.98' | Riffle | 14+33 | 872.33' | Pool |
| 3+32 | 885.29' | Max D | 9+24 | 878.74' | Run | 14+48 | 871.99' | Max D |
| 3+45 | 885.44' | Glide | 9+34 | 878.49' | Pool | 14+61 | 872.05' | Glide |
| 3+56 | 885.39' | Riffle | 9+43 | 878.32' | Max D | 14+72 | 871.91' | Riffle |
| 3+66 | 885.10' | Run | 9+54 | 878.50' | Glide | 14+80 | 871.59' | Run |
| 3+74 | 884.87' | Pool | 9+62 | 878.48' | Riffle | 14+88 | 871.30' | Pool |
| 3+84 | 884.70' | Max D | 9+73 | 878.18' | Run | 14+97 | 871.07' | Max D |
| 3+96 | 884.86' | Glide | 9+85 | 877.91' | Pool | 15+06 | 871.20' | Glide |
| 4+02 | 884.86' | Riffle | 9+95 | 877.73' | Max D | 15+12 | 871.16' | Riffle |
| 4+12 | 884.58' | Run | 10+07 | 877.90' | Glide | 15+19 | 870.86' | Run |
| 4+18 | 884.37' | Pool | 10+12 | 877.91' | Riffle | 15+29 | 870.53' | Pool |
| 4+26 | 884.22' | Max D | 10+22 | 877.63' | Run | 15+39 | 870.29' | Max D |
| 4+36 | 884.40' | Glide | 10+32 | 877.37' | Pool | 15+52 | 870.34' | Glide |
| 4+41 | 884.42' | Riffle | 10+43 | 877.19' | Max D | 15+59 | 870.28' | Riffle |
| 4+48 | 884.17' | Run | 10+51 | 877.40' | Glide | 15+64 | 870.02' | Run |
| 4+58 | 883.91' | Pool | 10+56 | 877.42' | Riffle | 15+69 | 869.79' | Pool |
| 4+75 | 883.66' | Max D | 10+62 | 877.18' | Run | 15+82 | 869.48' | Max D |
| 4+85 | 883.84' | Glide | 10+70 | 876.95' | Pool | 15+90 | 869.63' | Glide |
| 4+96 | 883.79' | Riffle | 10+83 | 876.74' | Max D | 15+98 | 869.38' | Riffle |
| 5+06 | 883.50' | Run | 10+96 | 876.90' | Glide | 16+13 | 868.96' | Run |
| 5+14 | 883.27' | Pool | 11+03 | 876.89' | Riffle | 16+29 | 868.67' | Pool |
| 5+22 | 883.12' | Max D | 11+10 | 876.64' | Run | 16+54.26 | 867.40' | Max D |
| 5+29 | 883.34' | Glide | | | | | | |

## R2D

| | Thalweg | | | Thalweg | |
|---|---|---|---|---|---|
| Station | Elevation | Feature | Station | Elevation | Feature |
| 0+00 | 871.97' | Riffle | 4+31 | 869.74' | Riffle |
| 0+27 | 871.66' | Run | 4+37 | 869.54' | Run |
| 0+32 | 871.49' | Pool | 4+44 | 869.36' | Pool |
| 0+37 | 871.40' | Max D | 4+54 | 869.25' | Max D |
| 0+42 | 871.68' | Glide | 4+64 | 869.38' | Glide |
| 0+45 | 871.73' | Riffle | 4+69 | 869.36' | Riffle |
| 0+53 | 871.52' | Run | 4+79 | 869.02' | Run |
| 0+64 | 871.32' | Pool | 4+89 | 868.71' | Pool |
| 0+79 | 871.19' | Max D | 4+99 | 868.48' | Max D |
| 0+92 | 871.42' | Glide | 5+10 | 868.59' | Glide |
| 1+02 | 871.44' | Riffle | 5+16 | 868.55' | Riffle |
| 1+11 | 871.22' | Run | 5+25 | 868.23' | Run |
| 1+20 | 871.04' | Pool | 5+35 | 867.92' | Pool |
| 1+30 | 870.92' | Max D | 5+48 | 867.63' | Max D |
| 1+42 | 871.16' | Glide | 5+62 | 867.69' | Glide |
| 1+47 | 871.21' | Riffle | 5+71 | 867.61' | Riffle |
| 1+55 | 871.00' | Run | 5+79 | 867.30' | Run |
| 1+64 | 870.81' | Pool | 5+88 | 867.00' | Pool |
| 1+78 | 870.68' | Max D | 5+96 | 866.81' | Max D |
| 1+92 | 870.90' | Glide | 6+06 | 866.93' | Glide |
| 2+02 | 870.92' | Riffle | 6+11 | 866.92' | Riffle |
| 2+12 | 870.70' | Run | 6+20 | 866.59' | Run |
| 2+22 | 870.51' | Pool | 6+29 | 866.30' | Pool |
| 2+31 | 870.40' | Max D | 6+40 | 866.05' | Max D |
| 2+42 | 870.65' | Glide | 6+52 | 866.14' | Glide |
| 2+47 | 870.69' | Riffle | 6+58 | 866.11' | Riffle |
| 2+53 | 870.49' | Run | 6+65 | 865.82' | Run |
| 2+60 | 870.31' | Pool | 6+73 | 865.54' | Pool |
| 2+70 | 870.20' | Max D | 6+85 | 865.27' | Max D |
| 2+81 | 870.45' | Glide | 6+97 | 865.37' | Glide |
| 2+90 | 870.47' | Riffle | 7+03 | 865.33' | Riffle |
| 3+00 | 870.25' | Run | 7+08 | 865.08' | Run |
| 3+11 | 870.05' | Pool | 7+14 | 864.83' | Pool |
| 3+20 | 869.94' | Max D | 7+26 | 864.57' | Max D |
| 3+29 | 870.20' | Glide | 7+38 | 864.66' | Glide |
| 3+35 | 870.24' | Riffle | 7+45 | 864.61' | Riffle |
| 3+43 | 870.03' | Run | 7+52 | 864.32' | Run |
| 3+51 | 869.84' | Pool | 7+60 | 864.04' | Pool |
| 3+59 | 869.74' | Max D | 7+70 | 863.81' | Max D |
| 3+68 | 870.00' | Glide | 7+81 | 863.92' | Glide |
| 3+72 | 870.05' | Riffle | 7+89 | 863.85' | Riffle |
| 3+81 | 869.83' | Run | 8+02 | 863.46' | Run |
| 3+91 | 869.64' | Pool | 8+16 | 863.08' | Pool |
| 4+06 | 869.50' | Max D | 8+60.31 | 861.65' | Max D |
| 4+21 | 869.72' | Glide | | | |

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III

# STRUCTURE TABLES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 3B |

*STRUCTURE TABLES*

MULKEY
ENGINEERS & CONSULTANTS
PO Box 33127
Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

| R1 (Design) | | | | | R1 (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 1 | J-Hook | 2+36.23 | 882.42 | 886.20 | | | |
| 2 | Rock Vane | 3+12.24 | 883.30 | 885.99 | | | |
| 3 | J-Hook | 6+68.02 | 881.44 | 885.01 | | | |
| 4 | Cross Vane | 7+24.47 | 882.39 | 884.88 | | | |
| 5 | J-Hook | 8+42.83 | 881.41 | 884.62 | | | |
| 6 | J-Hook | 9+48.68 | 880.64 | 884.38 | | | |
| 7 | J-Hook | 10+92.50 | 880.29 | 884.05 | | | |
| 8 | Rock Vane | 11+42.10 | 881.48 | 883.94 | | | |
| 9 | J-Hook | 12+42.53 | 879.91 | 883.72 | | | |
| 10 | Rock Vane | 12+98.82 | 881.05 | 883.59 | | | |
| 11 | J-Hook | 14+12.56 | 879.60 | 883.33 | | | |
| 12 | Cross Vane | 15+48.88 | 880.28 | 883.03 | | | |
| 13 | Rock Vane | 16+50.00 | 880.25 | 882.80 | | | |
| 14 | J-Hook | 17+33.73 | 879.24 | 882.61 | | | |
| 15 | Rock Vane | 18+04.00 | 879.57 | 882.45 | | | |
| 16 | J-Hook | 19+24.63 | 878.46 | 882.18 | | | |
| 17 | J-Hook | 20+63.70 | 878.14 | 881.87 | | | |
| 18 | Rock Vane | 21+13.69 | 879.12 | 881.76 | | | |
| 19 | J-Hook | 22+33.68 | 877.75 | 881.49 | | | |
| 20 | Rock Vane | 22+93.91 | 878.77 | 881.35 | | | |
| 21 | Cross Vane | 24+24.13 | 878.58 | 881.06 | | | |
| 22 | J-Hook | 25+24.35 | 877.30 | 880.83 | | | |
| 23 | Rock Vane | 25+79.06 | 877.79 | 880.71 | | | |
| 24 | J-Hook | 27+24.63 | 877.52 | 880.38 | | | |
| 25 | J-Hook | 28+18.89 | 876.62 | 886.07 | | | |
| 26 | Rock Vane | 28+79.81 | 877.37 | 880.03 | | | |
| 27 | J-Hook | 29+93.92 | 876.23 | 879.78 | | | |
| 28 | Rock Vane | 30+38.67 | 876.49 | 879.68 | | | |
| 29 | J-Hook | 31+53.72 | 876.06 | 879.42 | | | |
| 30 | Cross Vane | 32+77.00 | 876.40 | 879.14 | | | |
| 31 | Rock Vane | 33+26.39 | 875.50 | 879.03 | | | |
| 32 | J-Hook | 34+28.93 | 875.48 | 878.80 | | | |
| 33 | Rock Vane | 34+74.50 | 875.52 | 878.70 | | | |
| 34 | J-Hook | 35+83.73 | 875.00 | 878.45 | | | |
| 35 | Rock Vane | 36+33.70 | 875.02 | 878.34 | | | |
| 36 | J-Hook | 37+43.93 | 874.55 | 878.09 | | | |
| 37 | Rock Vane | 37+90.80 | 874.92 | 877.98 | | | |

| R1 (Design) | | | | | R1 (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 38 | J-Hook | 38+78.90 | 874.50 | 877.79 | | | |
| 39 | Rock Vane | 39+40.58 | 874.71 | 877.65 | | | |
| 40 | J-Hook | 40+38.73 | 874.00 | 877.43 | | | |
| 41 | Rock Vane | 40+83.73 | 873.79 | 877.32 | | | |
| 42 | J-Hook | 42+12.81 | 873.26 | 877.03 | | | |
| 43 | J-Hook | 43+43.92 | 873.44 | 876.74 | | | |
| 44 | Rock Vane | 43+94.19 | 873.61 | 876.63 | | | |
| 45 | J-Hook | 45+18.93 | 872.52 | 876.34 | | | |
| 46 | J-Hook | 46+78.96 | 872.45 | 875.98 | | | |
| 47 | Rock Vane | 47+43.90 | 872.44 | 875.84 | | | |
| 48 | J-Hook | 49+93.89 | 872.44 | 875.19 | | | |
| 49 | J-Hook | 51+33.62 | 871.56 | 874.80 | | | |
| 50 | Rock Vane | 52+46.40 | 872.03 | 874.49 | | | |
| 51 | J-Hook | 53+28.88 | 870.87 | 874.31 | | | |
| 52 | Rock Vane | 54+48.11 | 870.82 | 874.07 | | | |
| 53 | J-Hook | 55+35.00 | 871.18 | 873.89 | | | |
| 54 | Rock Vane | 57+37.03 | 870.25 | 872.99 | | | |
| 55 | J-Hook | 57+83.68 | 869.49 | 872.89 | | | |
| 56 | Cross Vane | 58+45.00 | 870.20 | 872.76 | | | |
| 57 | J-Hook | 59.08.58 | 883.26, | 872.63 | | | |
| 58 | Rock Vane | 59+59.95 | 869.79 | 872.52 | | | |
| 59 | J-Hook | 60+43.89 | 869.10 | 872.34 | | | |
| 60 | Rock Vane | 61+03.96 | 868.90 | 872.21 | | | |
| 61 | J-Hook | 61+93.91 | 868.70 | 872.02 | | | |
| 62 | Rock Vane | 62+64.26 | 869.35 | 871.88 | | | |
| 63 | J-Hook | 63+49.46 | 867.94 | 871.69 | | | |
| 64 | Cross Vane | 65+22.89 | 868.57 | 871.33 | | | |
| 65 | J-Hook | 66+09.96 | 867.63 | 871.14 | | | |
| 66 | J-Hook | 67+18.90 | 867.52 | 870.91 | | | |
| 67 | Rock Vane | 67+79.64 | 867.75 | 870.78 | | | |
| 68 | J-Hook | 68+74.63 | 867.37 | 870.58 | | | |
| 69 | Rock Vane | 69+28.98 | 867.81 | 870.47 | | | |
| 70 | J-Hook | 69+99.54 | 866.92 | 870.32 | | | |
| 71 | Rock Vane | 70+49.56 | 866.89 | 870.21 | | | |
| 72 | J-Hook | 71+68.91 | 866.31 | 869.96 | | | |
| 73 | J-Hook | 73+13.42 | 865.95 | 869.65 | | | |
| 74 | Cross Vane | 74+51.31 | 866.83 | 869.36 | | | |

| R1A (Design) | | | | | R1A (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 147 | Cross Vane | 00+33.14 | 891.26 | 892.16 | | | |
| 148 | Cross Vane | 02+95.00 | 888.51 | 889.29 | | | |
| 149 | Rock Vane | 06+26.00 | 886.53 | 887.32 | | | |
| 150 | Cross Vane | 09+45.28 | 883.82 | 884.76 | | | |
| 151 | Rock Vane | 10+07.63 | 882.39 | 883.46 | | | |
| 152 | Cross Vane | 10+26.00 | 882.28 | 883.08 | | | |
| 153 | Cross Vane | 11+15.00 | 880.44 | 881.23 | | | |
| 154 | Cross Vane | 11+90.00 | 878.80 | 879.67 | | | |

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
02/16/07

# STRUCTURE TABLES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 3C |

*STRUCTURE TABLES*

MULKEY
ENGINEERS & CONSULTANTS
PO Box 33127
RALEIGH, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

| R2 (Design) | | | | | R2 (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 75 | Cross Vane | 00+23.52 | 875.00 | 878.27 | | | |
| 76 | J-Hook | 01+49.66 | 873.80 | 878.07 | | | |
| 77 | Rock Vane | 02+13.33 | 874.16 | 877.97 | | | |
| 78 | J-Hook | 03+54.31 | 873.44 | 877.74 | | | |
| 79 | Rock Vane | 04+25.60 | 874.59 | 877.63 | | | |
| 80 | J-Hook | 05+14.71 | 873.47 | 877.49 | | | |
| 81 | Rock Vane | 05+73.93 | 873.25 | 877.39 | | | |
| 82 | J-Hook | 07+09.33 | 872.83 | 877.18 | | | |
| 83 | Rock Vane | 07+76.24 | 873.81 | 877.07 | | | |
| 84 | J-Hook | 08+49.69 | 872.86 | 876.95 | | | |
| 85 | Rock Vane | 09+13.60 | 872.98 | 876.85 | | | |
| 86 | J-Hook | 10+70.17 | 872.38 | 876.60 | | | |
| 87 | Rock Vane | 11+48.95 | 873.30 | 876.47 | | | |
| 88 | J-Hook | 12+64.66 | 871.76 | 876.29 | | | |
| 89 | Rock Vane | 13+25.17 | 873.21 | 876.19 | | | |
| 90 | J-Hook | 14+29.53 | 871.87 | 876.02 | | | |
| 91 | Rock Vane | 15+09.58 | 872.29 | 875.90 | | | |
| 92 | J-Hook | 16+39.65 | 871.36 | 875.69 | | | |
| 93 | J-Hook | 17+70.21 | 871.10 | 875.48 | | | |
| 94 | Cross Vane | 18+50.00 | 872.28 | 875.35 | | | |
| 95 | J-Hook | 19+59.48 | 871.10 | 875.18 | | | |
| 96 | Rock Vane | 20+29.52 | 870.93 | 875.06 | | | |
| 97 | J-Hook | 21+59.23 | 870.50 | 874.86 | | | |
| 98 | Rock Vane | 22+24.88 | 871.66 | 874.75 | | | |
| 99 | J-Hook | 23+34.52 | 870.32 | 874.58 | | | |
| 100 | Rock Vane | 23+99.67 | 870.74 | 874.47 | | | |
| 101 | J-Hook | 25+34.51 | 870.00 | 874.26 | | | |
| 102 | Rock Vane | 26+04.53 | 870.47 | 874.14 | | | |
| 103 | J-Hook | 27+54.41 | 869.54 | 873.90 | | | |
| 104 | Rock Vane | 28+28.00 | 870.53 | 873.79 | | | |
| 105 | J-Hook | 29+20.28 | 869.35 | 873.64 | | | |
| 106 | Rock Vane | 29+89.76 | 870.08 | 873.53 | | | |
| 107 | J-Hook | 30+95.35 | 869.10 | 873.36 | | | |
| 108 | Rock Vane | 31+34.35 | 869.07 | 873.30 | | | |
| 109 | J-Hook | 32+64.81 | 868.42 | 873.09 | | | |
| 110 | Cross Vane | 34+07.71 | 869.22 | 872.86 | | | |

| R2 (Design) | | | | | R2 (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 111 | Rock Vane | 34+70.38 | 868.14 | 872.76 | | | |
| 112 | J-Hook | 36+14.74 | 868.13 | 872.53 | | | |
| 113 | Rock Vane | 36+70.29 | 868.73 | 872.44 | | | |
| 114 | J-Hook | 37+99.71 | 867.74 | 872.23 | | | |
| 115 | Cross Vane | 38+63.00 | 869.08 | 872.13 | | | |
| 116 | J-Hook | 39+74.75 | 867.62 | 871.95 | | | |
| 117 | Cross Vane | 40+71.15 | 868.80 | 871.80 | | | |
| 118 | J-Hook | 41+95.42 | 867.05 | 871.60 | | | |
| 119 | J-Hook | 43+29.22 | 867.08 | 871.39 | | | |
| 120 | Rock Vane | 43+86.88 | 867.73 | 871.29 | | | |
| 121 | J-Hook | 44+79.29 | 867.20 | 871.15 | | | |
| 122 | Rock Vane | 45+39.61 | 867.01 | 871.05 | | | |
| 123 | Cross Vane | 46+60.98 | 867.22 | 870.86 | | | |
| 124 | J-Hook | 47+29.70 | 866.34 | 870.75 | | | |
| 125 | J-Hook | 49+04.39 | 866.01 | 870.47 | | | |
| 126 | Rock Vane | 49+39.70 | 866.69 | 870.41 | | | |
| 127 | Cross Vane | 50+64.65 | 867.05 | 870.21 | | | |
| 128 | Cross Vane | 51+87.94 | 866.75 | 870.00 | | | |
| 129 | J-Hook | 52+65.40 | 864.93 | 869.85 | | | |
| 130 | J-Hook | 54+23.55 | 864.67 | 869.55 | | | |
| 131 | Cross Vane | 54+89.07 | 866.13 | 869.42 | | | |
| 132 | J-Hook | 56+08.34 | 864.14 | 869.08 | | | |
| 133 | J-Hook | 57+66.20 | 864.87 | 868.63 | | | |
| 134 | Cross Vane | 61+35.03 | 863.75 | 867.75 | | | |
| 135 | Rock Vane | 62+45.47 | 864.00 | 867.58 | | | |
| 136 | J-Hook | 63+73.77 | 862.22 | 867.39 | | | |
| 137 | Rock Vane | 64+43.30 | 863.50 | 867.29 | | | |
| 138 | J-Hook | 65+43.46 | 862.27 | 867.14 | | | |
| 139 | Rock Vane | 66+10.36 | 863.06 | 867.04 | | | |
| 140 | J-Hook | 67+33.23 | 861.59 | 866.85 | | | |
| 141 | Rock Vane | 68+12.67 | 863.44 | 866.74 | | | |
| 142 | J-Hook | 69+23.58 | 861.53 | 866.57 | | | |
| 143 | Rock Vane | 70+20.80 | 863.03 | 866.43 | | | |
| 144 | J-Hook | 71+28.57 | 860.96 | 866.27 | | | |
| 145 | Rock Vane | 72+29.84 | 861.65 | 866.12 | | | |
| 146 | Cross Vane | 72+91.92 | 862.43 | 866.02 | | | |

| R2A (Design) | | | | | R2A (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 155 | Cross Vane | 00+22.05 | 876.10 | 877.45 | | | |
| 156 | Rock Vane | 00+54.17 | 875.73 | 877.09 | | | |
| 157 | Rock Vane | 01+07.44 | 874.89 | 876.48 | | | |
| 158 | Rock Vane | 01+29.46 | 875.04 | 876.23 | | | |
| 159 | Rock Vane | 01+79.49 | 874.10 | 875.67 | | | |
| 160 | Cross Vane | 02+02.00 | 874.29 | 875.41 | | | |
| 161 | Rock Vane | 02+49.50 | 872.99 | 874.62 | | | |
| 162 | Cross Vane | 02+82.00 | 872.88 | 874.03 | | | |
| 163 | Cross Vane | 03+35.00 | 871.95 | 873.08 | | | |

NORTH CAROLINA PROFESSIONAL SEAL 22867 ENGINEER WILLIAM SCOTT HUNT, III
02/16/07

# STRUCTURE TABLES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 3D |

STRUCTURE TABLES

MULKEY
ENGINEERS & CONSULTANTS
PO Box 33127
Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM

| R2B (Design) | | | | | R2B (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 164 | Cross Vane | 00+17.49 | 889.22 | 889.98 | | | |
| 165 | Rock Vane | 01+37.39 | 887.53 | 888.61 | | | |
| 166 | Cross Vane | 04+90.00 | 883.82 | 884.58 | | | |
| 167 | Rock Vane | 05+54.57 | 882.77 | 883.85 | | | |
| 168 | Cross Vane | 06+39.85 | 881.97 | 882.87 | | | |
| 169 | Cross Vane | 07+30.23 | 881.07 | 881.84 | | | |
| 170 | Cross Vane | 09+54.00 | 878.5 | 879.30 | | | |
| 171 | Cross Vane | 10+09.32 | 877.9 | 878.67 | | | |
| 172 | Rock Vane | 11+24.57 | 876.31 | 877.38 | | | |
| 173 | Cross Vane | 12+32.00 | 875.39 | 876.17 | | | |
| 174 | Rock Vane | 13+12.92 | 874.19 | 875.27 | | | |
| 175 | Cross Vane | 13+27.49 | 874.34 | 875.10 | | | |
| 176 | Rock Vane | 14+43.46 | 872.09 | 873.17 | | | |
| 177 | Cross Vane | 14+66.52 | 871.98 | 872.74 | | | |
| 178 | Cross Vane | 15+55.15 | 870.31 | 871.08 | | | |
| 179 | Cross Vane | 16+20.21 | 868.83 | 869.87 | | | |

| R2D (Design) | | | | | R2D (Construct) | | |
|---|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Thalweg Elevation (ft) | Bankfull Elevation (ft) | Constructed Elevation (ft) | Constructed Arm Angle ( ° ) | Constructed Arm Slope (%) |
| 180 | Cross Vane | 00+25.94 | 871.67 | 872.57 | | | |
| 181 | J-Hook | 00+39.11 | 871.52 | 872.50 | | | |
| 182 | Rock Vane | 02+25.50 | 870.47 | 871.53 | | | |
| 183 | Rock Vane | 03+97.60 | 869.48 | 870.64 | | | |
| 184 | Cross Vane | 04+22.07 | 869.72 | 870.52 | | | |
| 185 | Rock Vane | 04+92.72 | 868.62 | 869.68 | | | |
| 186 | Rock Vane | 05+88.51 | 866.99 | 868.04 | | | |
| 187 | Cross Vane | 06+06.00 | 866.93 | 867.74 | | | |
| 188 | Cross Vane | 06+95.00 | 865.35 | 866.21 | | | |
| 189 | Rock Vane | 07+23.05 | 864.63 | 865.73 | | | |
| 190 | Cross Vane | 07+82.00 | 863.91 | 864.71 | | | |
| 191 | Rock Vane | 08+12.92 | 863.16 | 864.18 | | | |

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
02/16/07

## Constructed Riffles

| R1 (Design) | | | | | R1 (Construct) | |
|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Beginning Elevation (ft) | Ending Elevation (ft) | Beginning Elevation (ft) | Ending Elevation (ft) |
| 1 | C. RIFFLE | 2+92 | 883.64 | 883.22 | | |
| 2 | C. RIFFLE | 4+17 | 883.29 | 882.88 | | |
| 3 | C. RIFFLE | 4+97 | 883.06 | 882.65 | | |
| 4 | C. RIFFLE | 14+71.42 | 880.78 | 880.28 | | |
| 5 | C. RIFFLE | 31+96.69 | 876.94 | 876.39 | | |
| 6 | C. RIFFLE | 48+76.94 | 873.27 | 872.74 | | |
| 7 | C. RIFFLE | 49+69.17 | 872.86 | 872.44 | | |
| 8 | C. RIFFLE | 50+87 | 872.53 | 872.13 | | |
| 9 | C. RIFFLE | 53+62 | 871.85 | 871.41 | | |
| 10 | C. RIFFLE | 57+03 | 870.66 | 870.24 | | |
| 11 | C. RIFFLE | 64+21.28 | 869.11 | 868.57 | | |

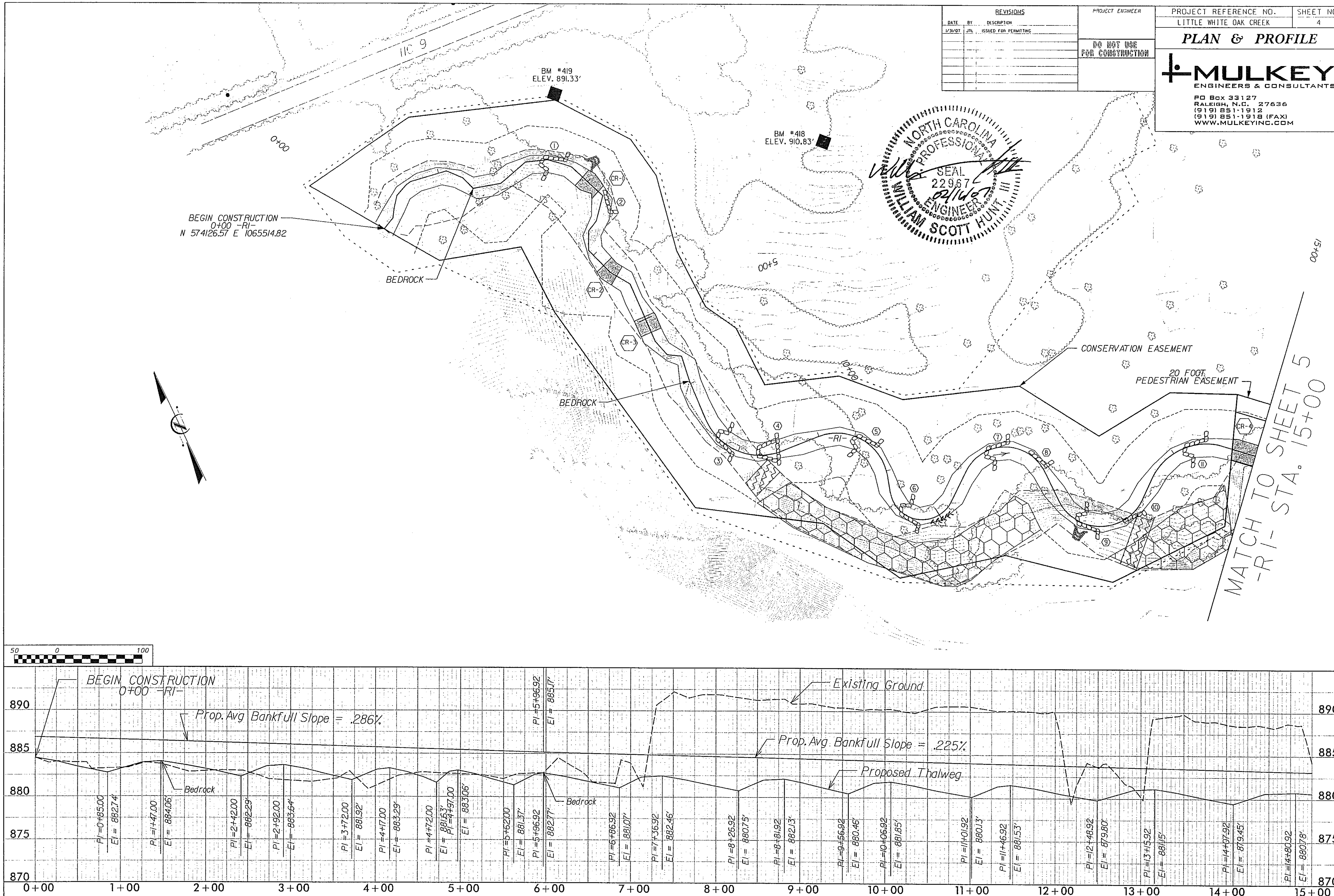
| R2 (Design) | | | | | R2 (Construct) | |
|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Beginning Elevation (ft) | Ending Elevation (ft) | Beginning Elevation (ft) | Ending Elevation (ft) |
| 12 | C. RIFFLE | 31+71 | 870.41 | 869.71 | | |
| 13 | C. RIFFLE | 33+21 | 870.17 | 869.38 | | |
| 14 | C. RIFFLE | 46+03 | 868.12 | 867.38 | | |
| 15 | C. RIFFLE | 59+42 | 864.90 | 864.02 | | |
| 16 | C. RIFFLE | 61+05 | 864.54 | 863.75 | | |

| R1A (Design) | | | | | R1A (Construct) | |
|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Beginning Elevation (ft) | Ending Elevation (ft) | Beginning Elevation (ft) | Ending Elevation (ft) |
| 17 | C. RIFFLE | 0+00 | 891.79 | 891.25 | | |
| 18 | C. RIFFLE | 2+49 | 889.06 | 888.81 | | |
| 19 | C. RIFFLE | 4+90 | 887.09 | 886.89 | | |
| 20 | C. RIFFLE | 8+65 | 885.70 | 885.32 | | |
| 21 | C. RIFFLE | 9+15 | 884.66 | 883.93 | | |

| R2A (Design) | | | | | R2A (Construct) | |
|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Beginning Elevation (ft) | Ending Elevation (ft) | Beginning Elevation (ft) | Ending Elevation (ft) |
| 22 | C. RIFFLE | 0+00 | 876.61 | 876.13 | | |
| 23 | C. RIFFLE | 0+71 | 875.92 | 875.47 | | |

| R2B (Design) | | | | | R2B (Construct) | |
|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Beginning Elevation (ft) | Ending Elevation (ft) | Beginning Elevation (ft) | Ending Elevation (ft) |
| 24 | C. RIFFLE | 0+68 | 888.68 | 888.40 | | |
| 25 | C. RIFFLE | 4+41 | 884.42 | 884.17 | | |
| 26 | C. RIFFLE | 5+75.50 | 882.90 | 881.97 | | |
| 27 | C. RIFFLE | 8+24 | 880.05 | 879.80 | | |
| 28 | C. RIFFLE | 9+18 | 878.98 | 878.74 | | |
| 29 | C. RIFFLE | 10+56 | 877.42 | 877.18 | | |

| R2D (Design) | | | | | R2D (Construct) | |
|---|---|---|---|---|---|---|
| Structure Number | Type | Station | Beginning Elevation (ft) | Ending Elevation (ft) | Beginning Elevation (ft) | Ending Elevation (ft) |
| 30 | C. RIFFLE | 0+00 | 871.97 | 871.66 | | |
| 31 | C. RIFFLE | 3+35 | 870.24 | 870.03 | | |
| 32 | C. RIFFLE | 5+16 | 868.55 | 868.23 | | |



REVISIONS
DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO. LITTLE WHITE OAK CREEK
SHEET NO. 4
PLAN & PROFILE
MULKEY ENGINEERS & CONSULTANTS
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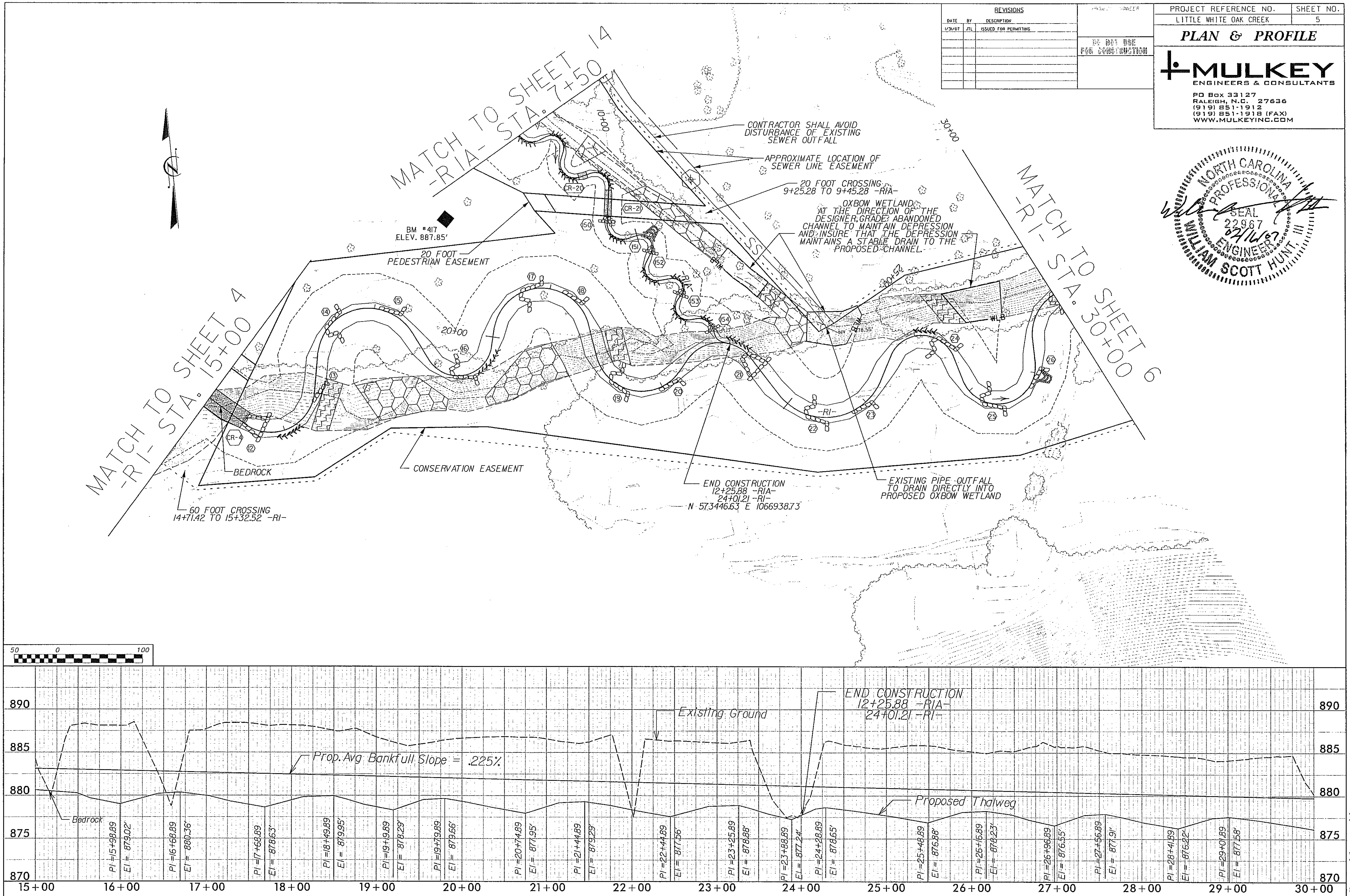
Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III
NC 9
BM #419 ELEV. 891.33'
BM #418 ELEV. 910.83'
0+00
5+00
10+00
15+00
BEGIN CONSTRUCTION 0+00 -RI- N 574126.57 E 1065514.82
BEDROCK
CR-1
CR-2
CR-3
CR-4
-RI-
CONSERVATION EASEMENT
20 FOOT PEDESTRIAN EASEMENT
MATCH TO SHEET 5 -RI- STA. 15+00
50 0 100
BEGIN CONSTRUCTION 0+00 -RI-
Prop. Avg Bankfull Slope = .286%
Prop. Avg. Bankfull Slope = .225%
Existing Ground
Proposed Thalweg
Bedrock
PI =0+85.00 El = 882.74'
PI =1+47.00 El = 884.06'
PI =2+42.00 El = 882.29'
PI =2+92.00 El = 883.64'
PI =3+72.00 El = 881.92'
PI =4+17.00 El = 883.29'
PI =4+72.00 El = 881.63'
PI =4+97.00 El = 883.06'
PI =5+62.00 El = 881.37'
PI =5+96.92 El = 885.17'
PI =5+96.92 El = 882.77'
PI =6+86.92 El = 881.07'
PI =7+36.92 El = 882.46'
PI =8+26.92 El = 880.75'
PI =8+81.92 El = 882.13'
PI =9+56.92 El = 880.46'
PI =10+06.92 El = 881.85'
PI =11+01.92 El = 880.13'
PI =11+46.92 El = 881.53'
PI =12+48.92 El = 879.80'
PI =13+15.92 El = 881.15'
PI =14+07.92 El = 879.45'
PI =14+80.92 El = 880.78'
890
885
880
875
870
0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00 14+00 15+00



PROJECT REFERENCE NO.
SHEET NO.
LITTLE WHITE OAK CREEK
5
PLAN & PROFILE
MULKEY
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PO Box 33127
RALEIGH, N.C. 27636
(919) 851-1912
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REVISIONS
DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
NOT USE FOR CONSTRUCTION
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III
MATCH TO SHEET 14 -RIA- STA. 7+50
MATCH TO SHEET 4 -RI- STA. 15+00
MATCH TO SHEET 6 -RI- STA. 30+00
CONTRACTOR SHALL AVOID DISTURBANCE OF EXISTING SEWER OUTFALL
APPROXIMATE LOCATION OF SEWER LINE EASEMENT
20 FOOT CROSSING 9+25.28 TO 9+45.28 -RIA-
OXBOW WETLAND AT THE DIRECTION OF THE DESIGNER, GRADE ABANDONED CHANNEL TO MAINTAIN DEPRESSION AND INSURE THAT THE DEPRESSION MAINTAINS A STABLE DRAIN TO THE PROPOSED CHANNEL.
BM #417
ELEV. 887.85'
20 FOOT PEDESTRIAN EASEMENT
BEDROCK
CONSERVATION EASEMENT
60 FOOT CROSSING 14+71.42 TO 15+32.52 -RI-
END CONSTRUCTION 12+25.88 -RIA- 24+01.21 -RI- N 573446.63 E 1066938.73
EXISTING PIPE OUTFALL TO DRAIN DIRECTLY INTO PROPOSED OXBOW WETLAND
CR-20
CR-21
CR-4
-RI-
-RIA-
20+00
30+00
10+00
50 0 100
890
885
880
875
870
Existing Ground
END CONSTRUCTION 12+25.88 -RIA- 24+01.21 -RI-
Prop. Avg Bankfull Slope = .225%
Proposed Thalweg
Bedrock
PI =15+98.89 El = 879.02'
PI =16+68.89 El = 880.36'
PI =17+68.89 El = 878.63'
PI =18+49.89 El = 879.95'
PI =19+19.89 El = 878.29'
PI =19+79.89 El = 879.66'
PI =20+74.89 El = 877.95'
PI =21+44.89 El = 879.29'
PI =22+44.89 El = 877.56'
PI =23+25.89 El = 878.88'
PI =23+88.89 El = 877.24'
PI =24+28.89 El = 878.65'
PI =25+48.89 El = 876.88'
PI =26+16.89 El = 878.23'
PI =26+96.89 El = 876.55'
PI =27+56.89 El = 877.91'
PI =28+41.89 El = 876.22'
PI =29+01.89 El = 877.58'
15+00
16+00
17+00
18+00
19+00
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00
28+00
29+00
30+00

| PROJECT REFERENCE NO. | SHEET NO. |
| --- | --- |
| LITTLE WHITE OAK CREEK | 6 |

REVISIONS

| DATE | BY | DESCRIPTION |
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PROJECT ENGINEER

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## PLAN & PROFILE


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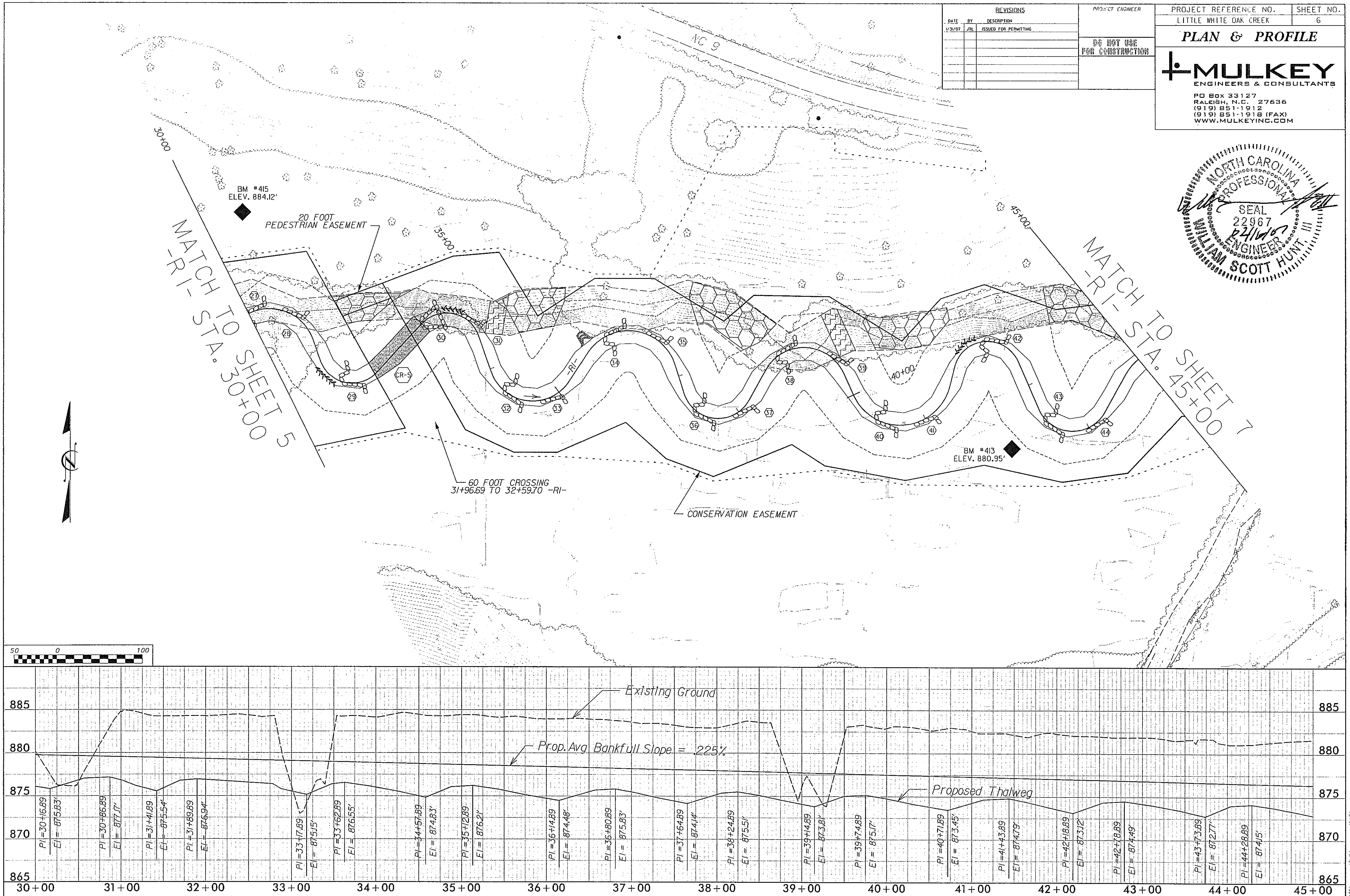
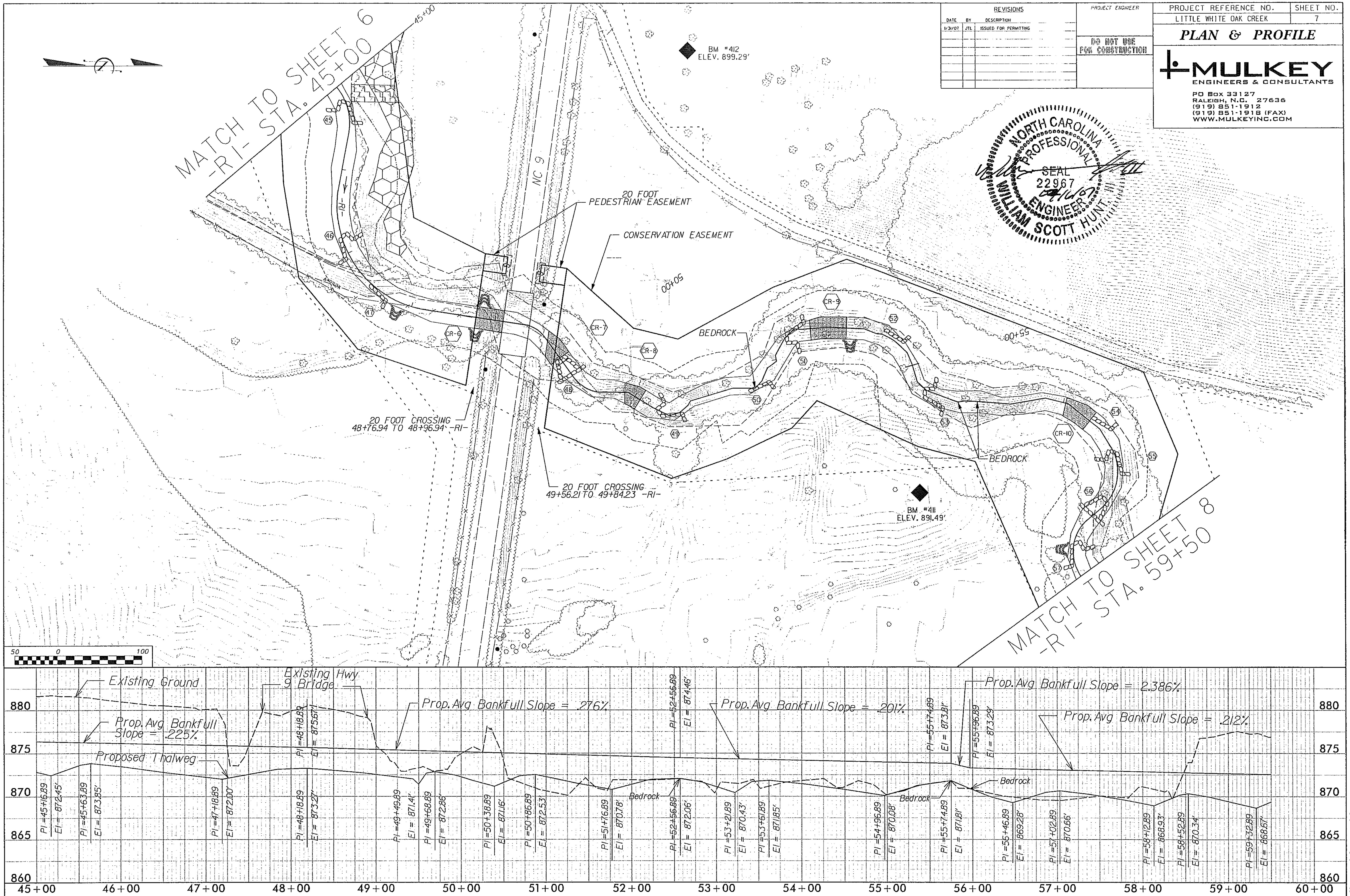
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III





REVISIONS
DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO.
LITTLE WHITE OAK CREEK
SHEET NO. 7
PLAN & PROFILE
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(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM
NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT III
MATCH TO SHEET 6 -R I- STA. 45+00
MATCH TO SHEET 8 -R I- STA. 59+50
BM #412 ELEV. 899.29'
BM #411 ELEV. 891.49'
NC 9
20 FOOT PEDESTRIAN EASEMENT
CONSERVATION EASEMENT
BEDROCK
20 FOOT CROSSING 48+76.94 TO 48+96.94 -RI-
20 FOOT CROSSING 49+56.21 TO 49+84.23 -RI-
CR-6
CR-7
CR-8
CR-9
CR-10
50+00
55+00
45+00
50 0 100
Existing Ground
Existing Hwy 9 Bridge
Prop. Avg Bankfull Slope = .225%
Proposed Thalweg
Prop. Avg Bankfull Slope = .276%
Prop. Avg Bankfull Slope = .201%
Prop. Avg Bankfull Slope = 2.386%
Prop. Avg Bankfull Slope = .212%
Bedrock
PI =45+16.89 El = 872.45'
PI =45+63.89 El = 873.85'
PI =47+18.89 El = 872.00'
PI =48+18.89 El = 873.27'
PI =48+18.89 El = 875.67'
PI =49+49.89 El = 871.41'
PI =49+68.89 El = 872.86'
PI =50+38.89 El = 871.16'
PI =50+86.89 El = 872.53'
PI =51+76.89 El = 870.78'
PI =52+56.89 El = 874.46'
PI =52+56.89 El = 872.06'
PI =53+21.89 El = 870.43'
PI =53+61.89 El = 871.85'
PI =54+96.89 El = 870.08'
PI =55+74.89 El = 873.81'
PI =55+74.89 El = 871.81'
PI =55+96.89 El = 873.29'
PI =56+46.89 El = 869.28'
PI =57+02.89 El = 870.66'
PI =58+12.89 El = 868.93'
PI =58+52.89 El = 870.34'
PI =59+32.89 El = 868.67'
860 865 870 875 880
45+00 46+00 47+00 48+00 49+00 50+00 51+00 52+00 53+00 54+00 55+00 56+00 57+00 58+00 59+00 60+00

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

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|---|---|
| LITTLE WHITE OAK CREEK | 8 |

**PLAN & PROFILE**


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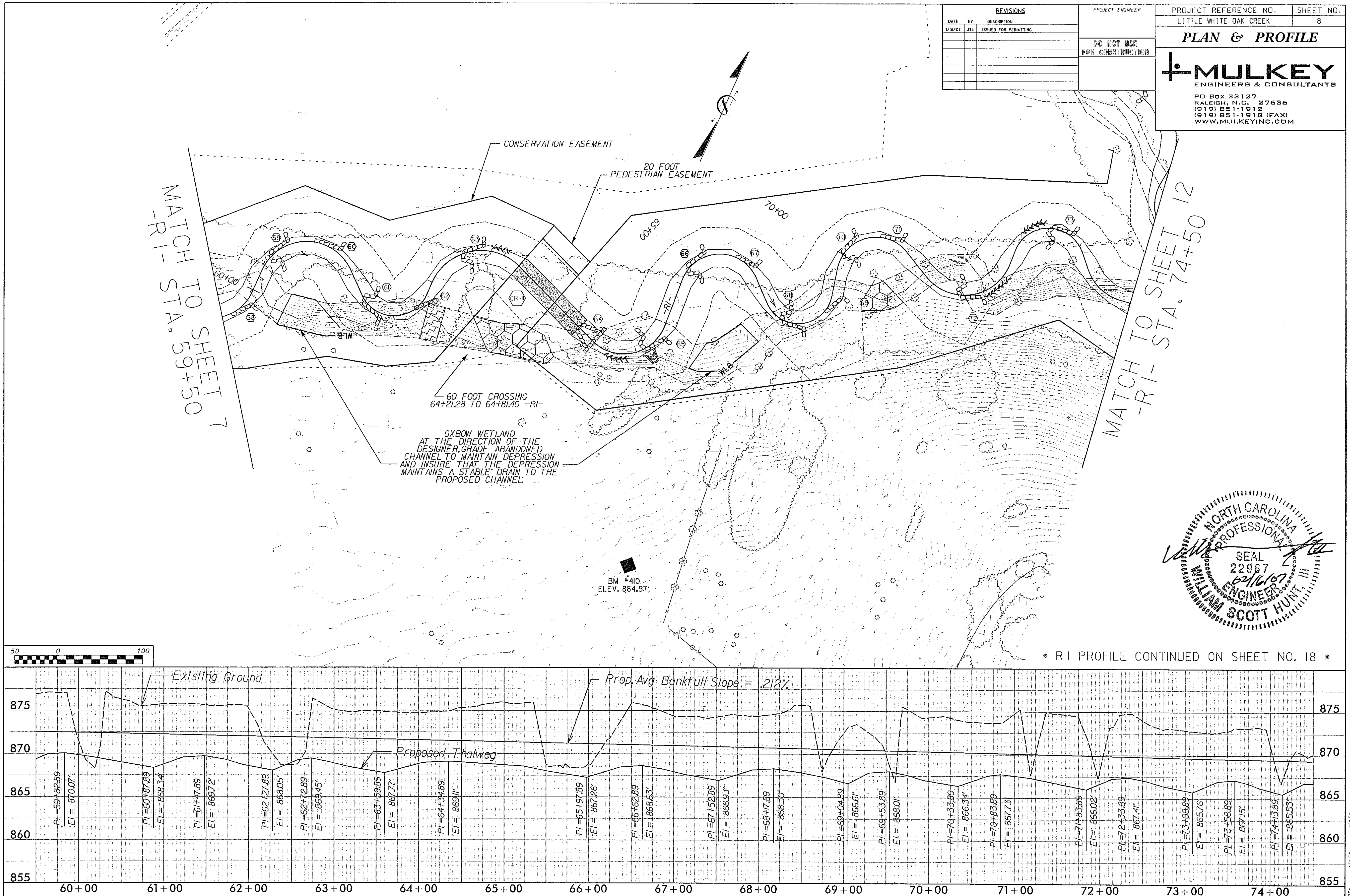


* RI PROFILE CONTINUED ON SHEET NO. 18 *

| REVISIONS | | | PROJECT ENGINEER | PROJECT REFERENCE NO. | SHEET NO. |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | | LITTLE WHITE OAK CREEK | 9 |
| 1/31/07 | JTL | ISSUED FOR PERMITTING | DO NOT USE FOR CONSTRUCTION | | |

## PLAN & PROFILE


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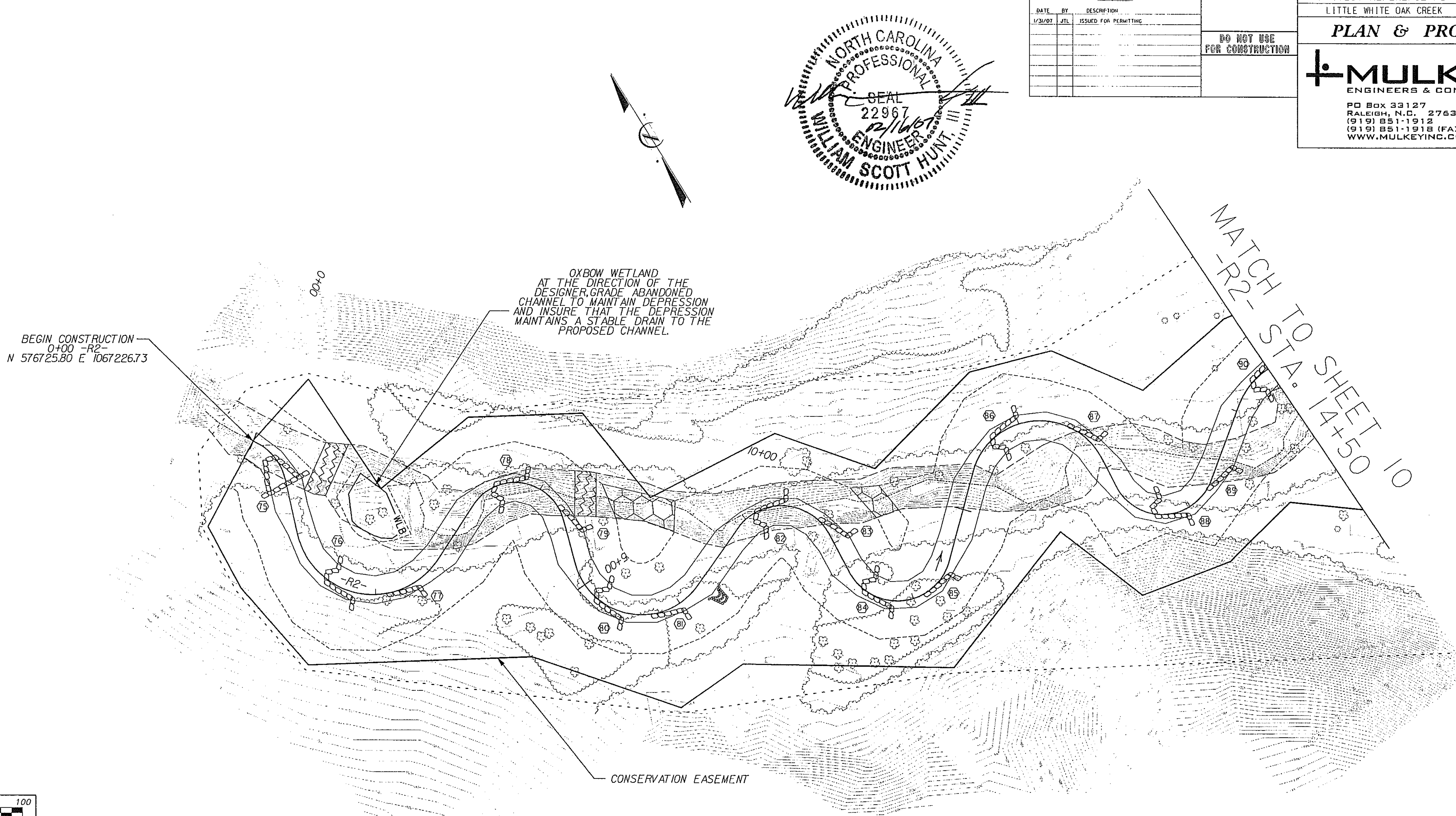


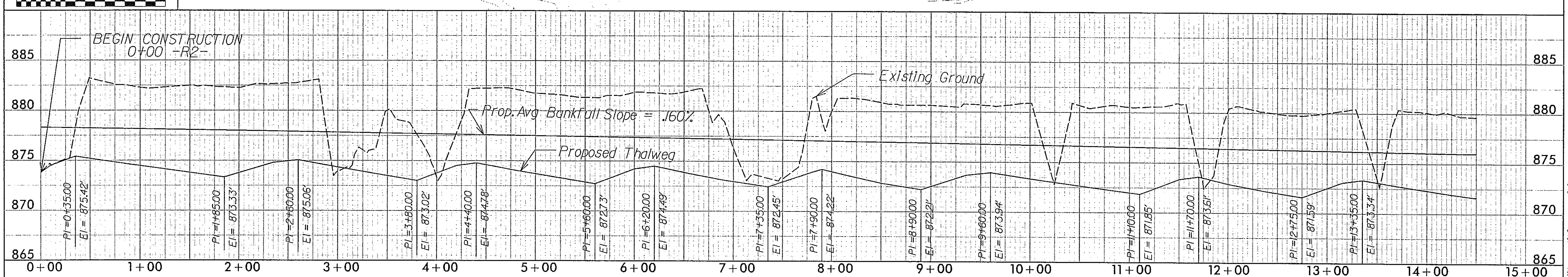

| PROJECT REFERENCE NO. | SHEET NO. |
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| LITTLE WHITE OAK CREEK | 10 |

## PLAN & PROFILE

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| REVISIONS | | |
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| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

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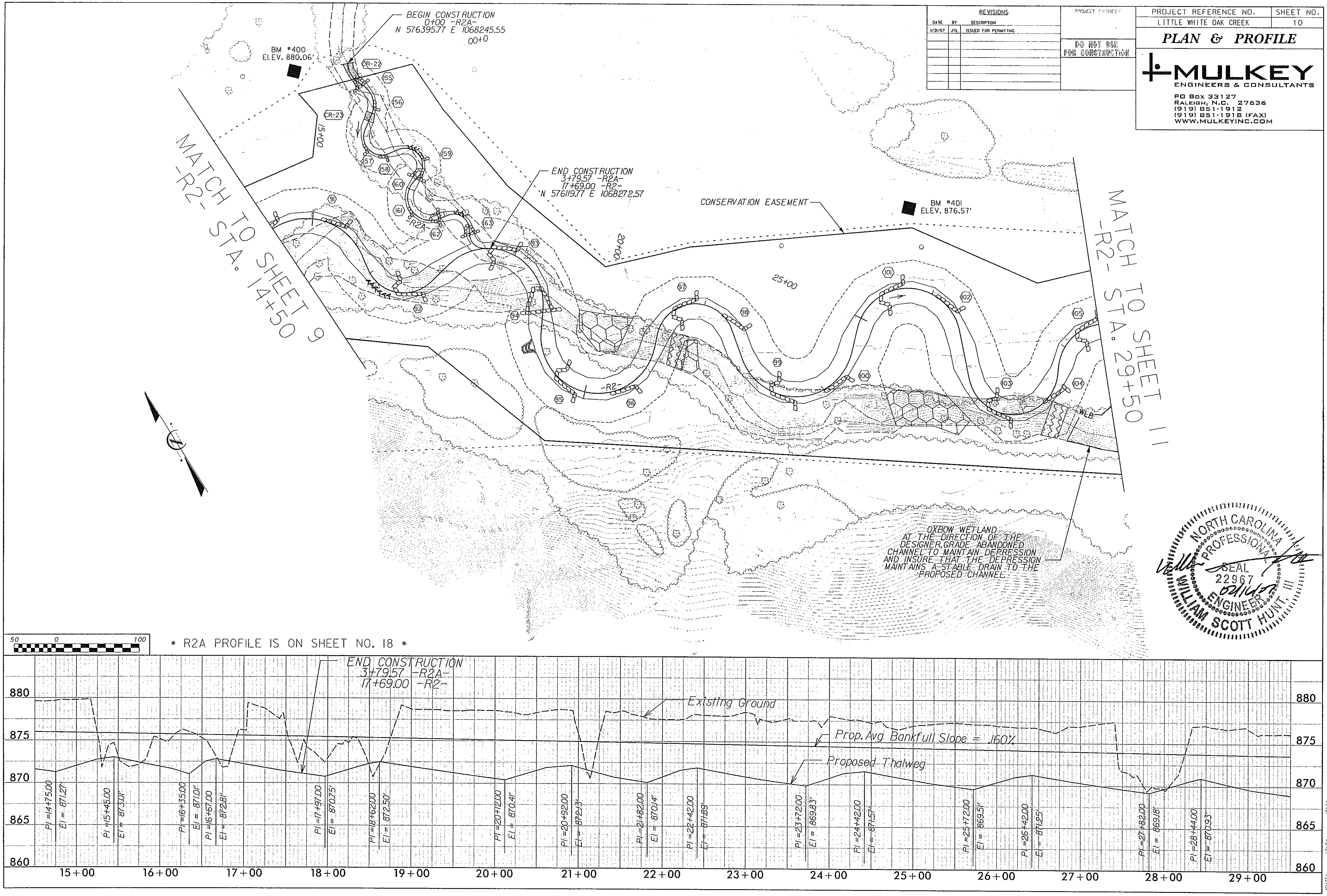

| REVISIONS | | | PROJECT ENGINEER | PROJECT REFERENCE NO. | SHEET NO. |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | | LITTLE WHITE OAK CREEK | 11 |
| 1/31/07 | JTL | ISSUED FOR PERMITTING | DO NOT USE FOR CONSTRUCTION | | |

**PLAN & PROFILE**


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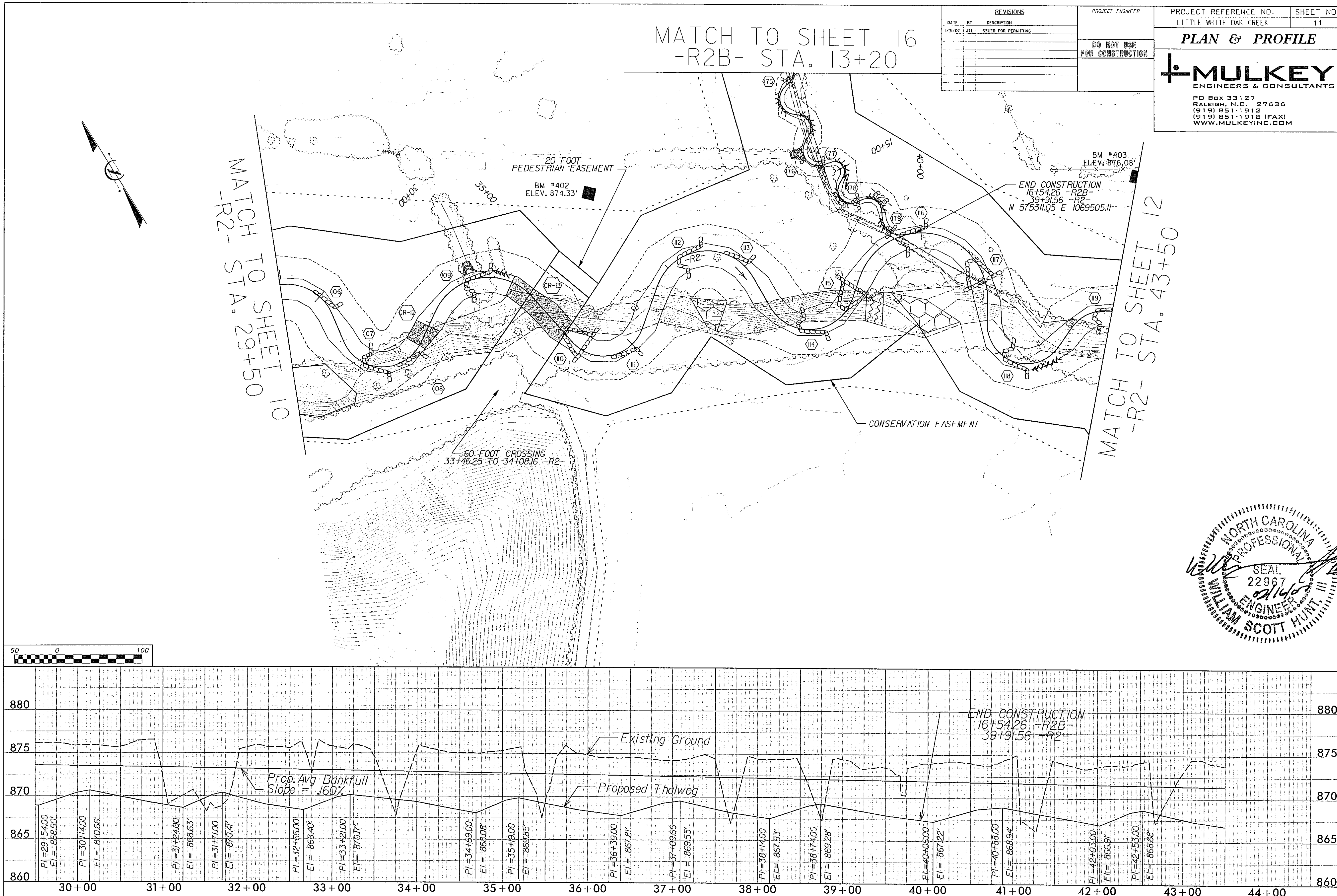

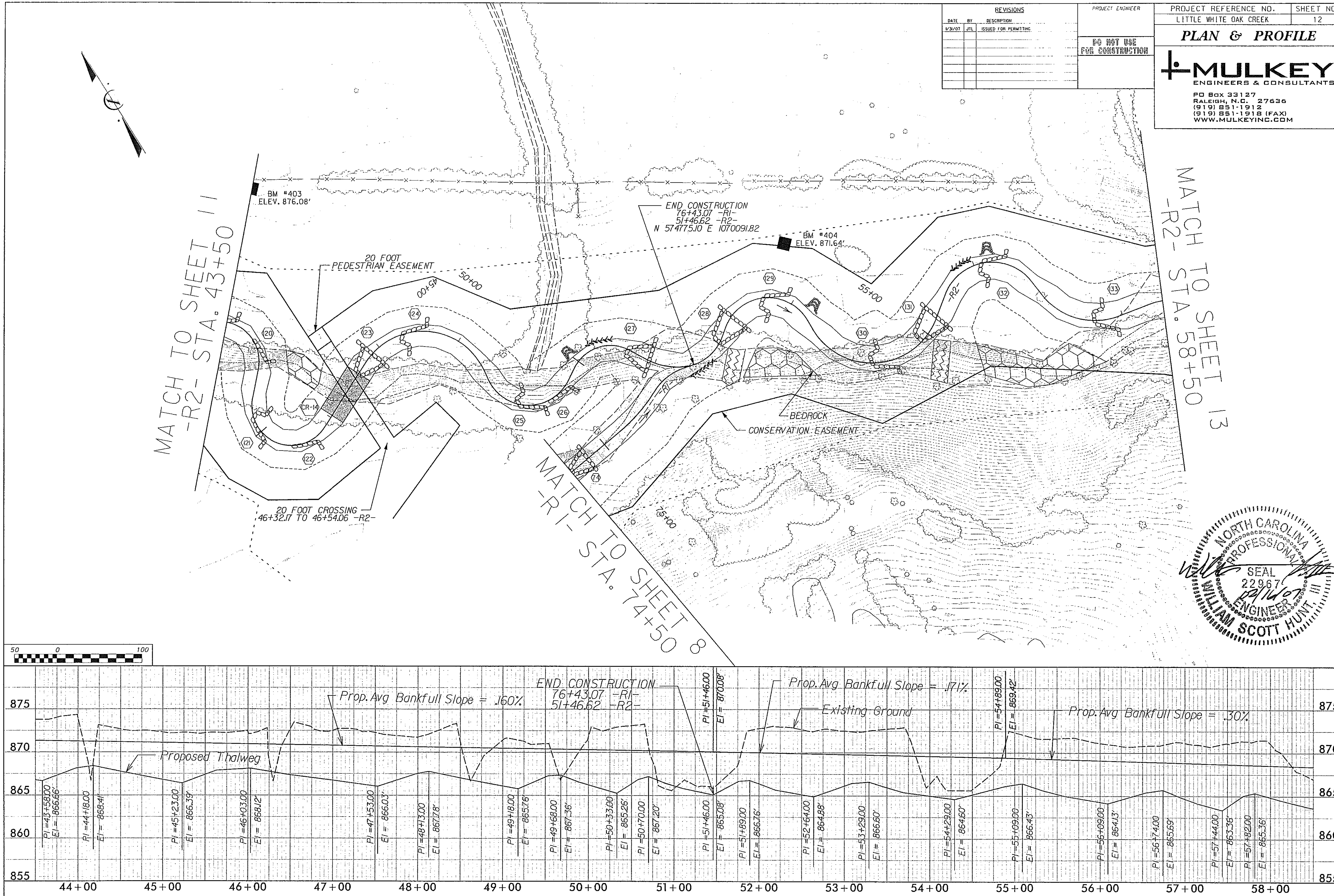
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DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO.
SHEET NO.
LITTLE WHITE OAK CREEK
12
PLAN & PROFILE
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ENGINEERS & CONSULTANTS
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(919) 851-1918 (FAX)
WWW.MULKEYINC.COM
BM #403 ELEV. 876.08'
MATCH TO SHEET 11 -R2- STA. 43+50
20 FOOT PEDESTRIAN EASEMENT
END CONSTRUCTION 76+43.07 -R1- 51+46.62 -R2- N 574775.10 E 1070091.82
BM #404 ELEV. 871.64'
MATCH TO SHEET 13 -R2- STA. 58+50
45+00
50+00
55+00
75+00
CR-14
BEDROCK
CONSERVATION EASEMENT
20 FOOT CROSSING 46+32.17 TO 46+54.06 -R2-
MATCH TO SHEET 8 -R1- STA. 74+50
NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
50 0 100
END CONSTRUCTION 76+43.07 -R1- 51+46.62 -R2-
Prop. Avg Bankfull Slope = .160%
Prop. Avg Bankfull Slope = .171%
Prop. Avg Bankfull Slope = .30%
Existing Ground
Proposed Thalweg
PI =43+58.00 El = 866.66'
PI =44+18.00 El = 868.41'
PI =45+23.00 El = 866.39'
PI =46+03.00 El = 868.12'
PI =47+53.00 El = 866.03'
PI =48+13.00 El = 867.78'
PI =49+18.00 El = 865.76'
PI =49+68.00 El = 867.36'
PI =50+33.00 El = 865.26'
PI =50+70.00 El = 867.20'
PI =51+46.00 El = 865.08'
PI =51+46.00 El = 870.08'
PI =51+89.00 El = 866.76'
PI =52+64.00 El = 864.88'
PI =53+29.00 El = 866.60'
PI =54+29.00 El = 864.60'
PI =54+89.00 El = 869.42'
PI =55+09.00 El = 866.43'
PI =56+09.00 El = 864.13'
PI =56+74.00 El = 865.69'
PI =57+44.00 El = 863.36'
PI =57+82.00 El = 865.36'
875
870
865
860
855
44+00
45+00
46+00
47+00
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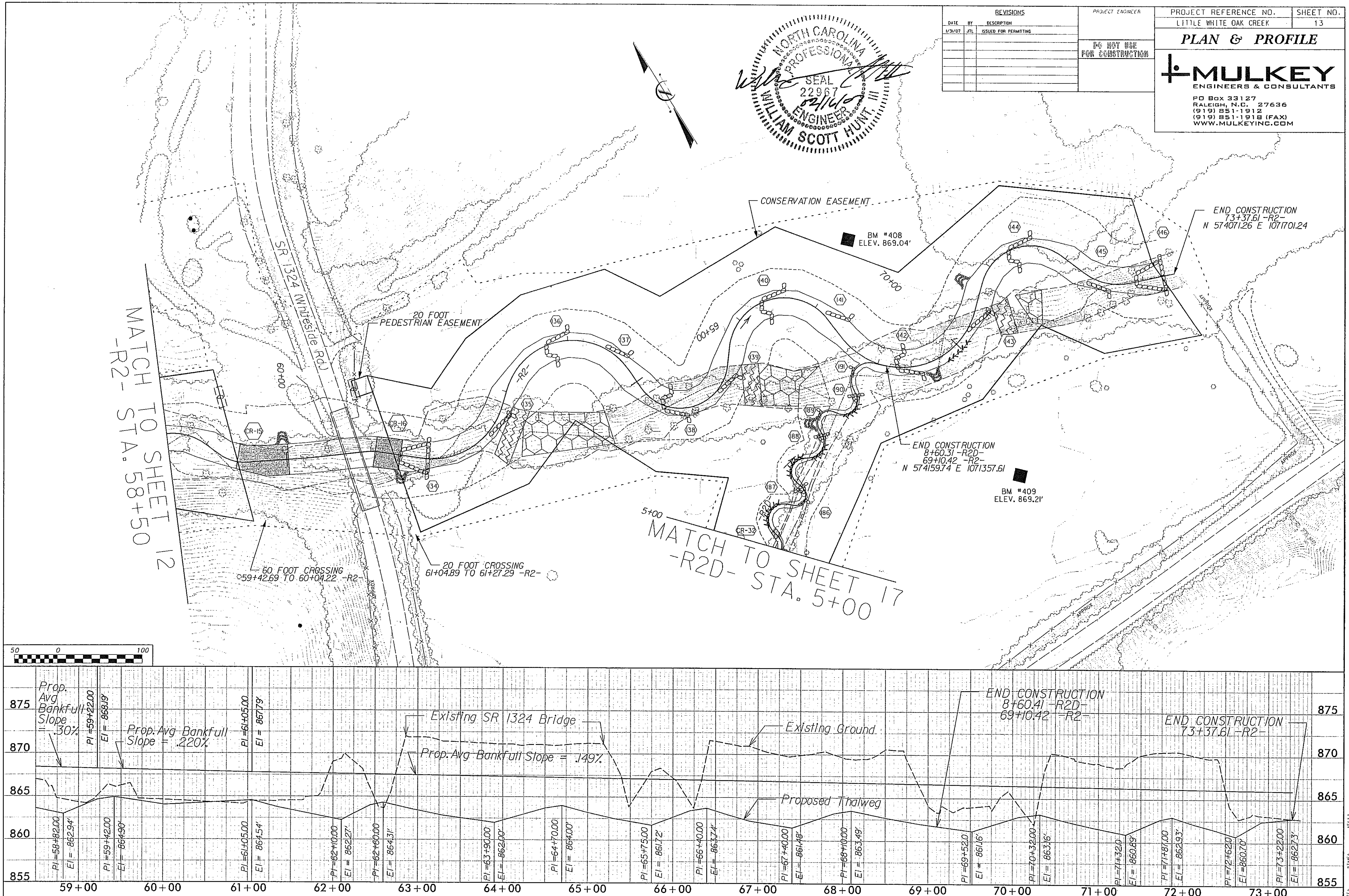
56+00
57+00
58+00

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| DATE | BY | DESCRIPTION |
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PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 13 |

## PLAN & PROFILE

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|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | | LITTLE WHITE OAK CREEK | 14 |
| 1/31/07 | JTL | ISSUED FOR PERMITTING | DO NOT USE FOR CONSTRUCTION | PLAN & PROFILE | |

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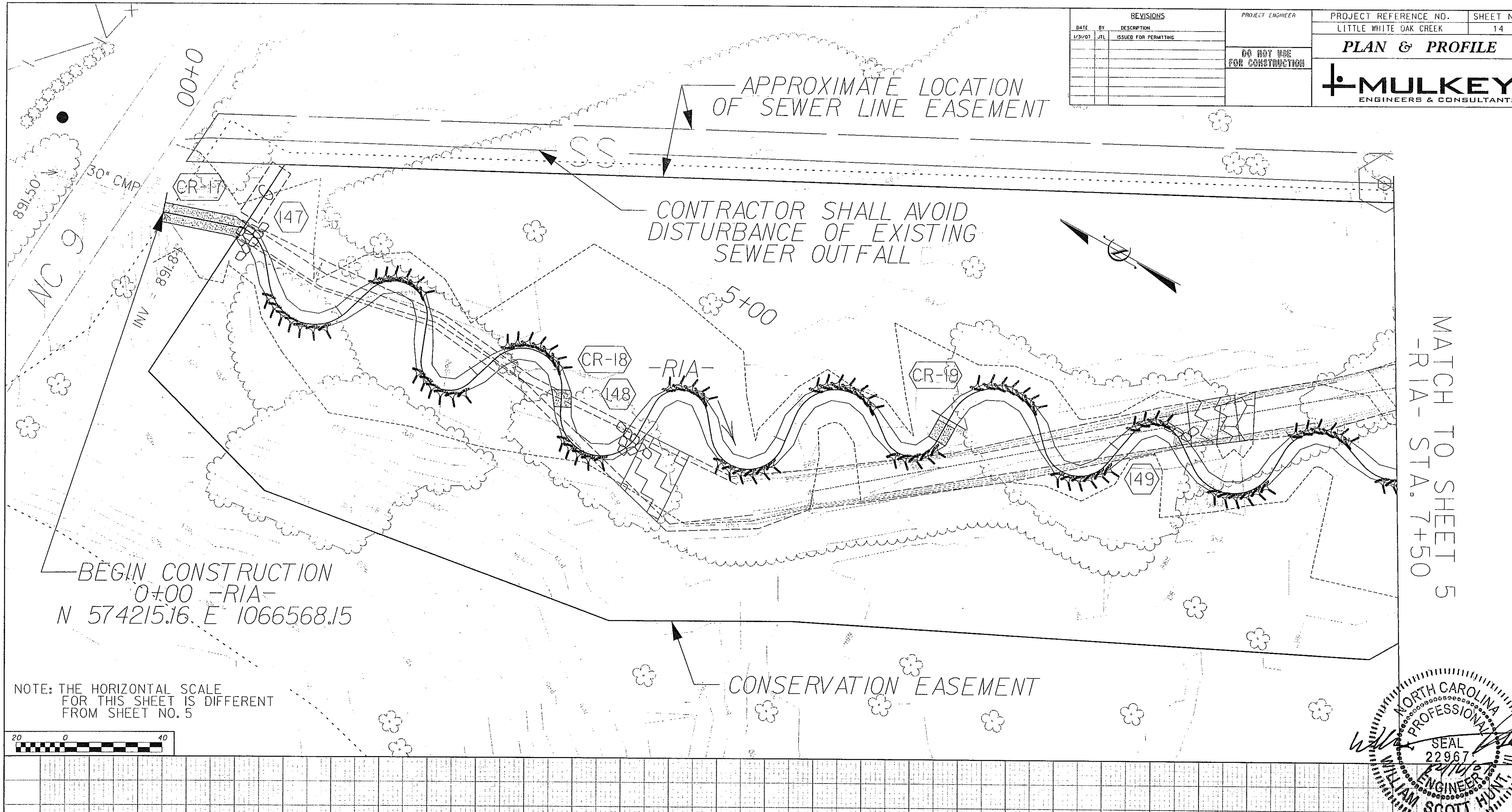



NOTE: THE HORIZONTAL SCALE FOR THIS SHEET IS DIFFERENT FROM SHEET NO. 5

20 0 40

SEE SHEET NO. 18 FOR -RIA- PROFILE

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

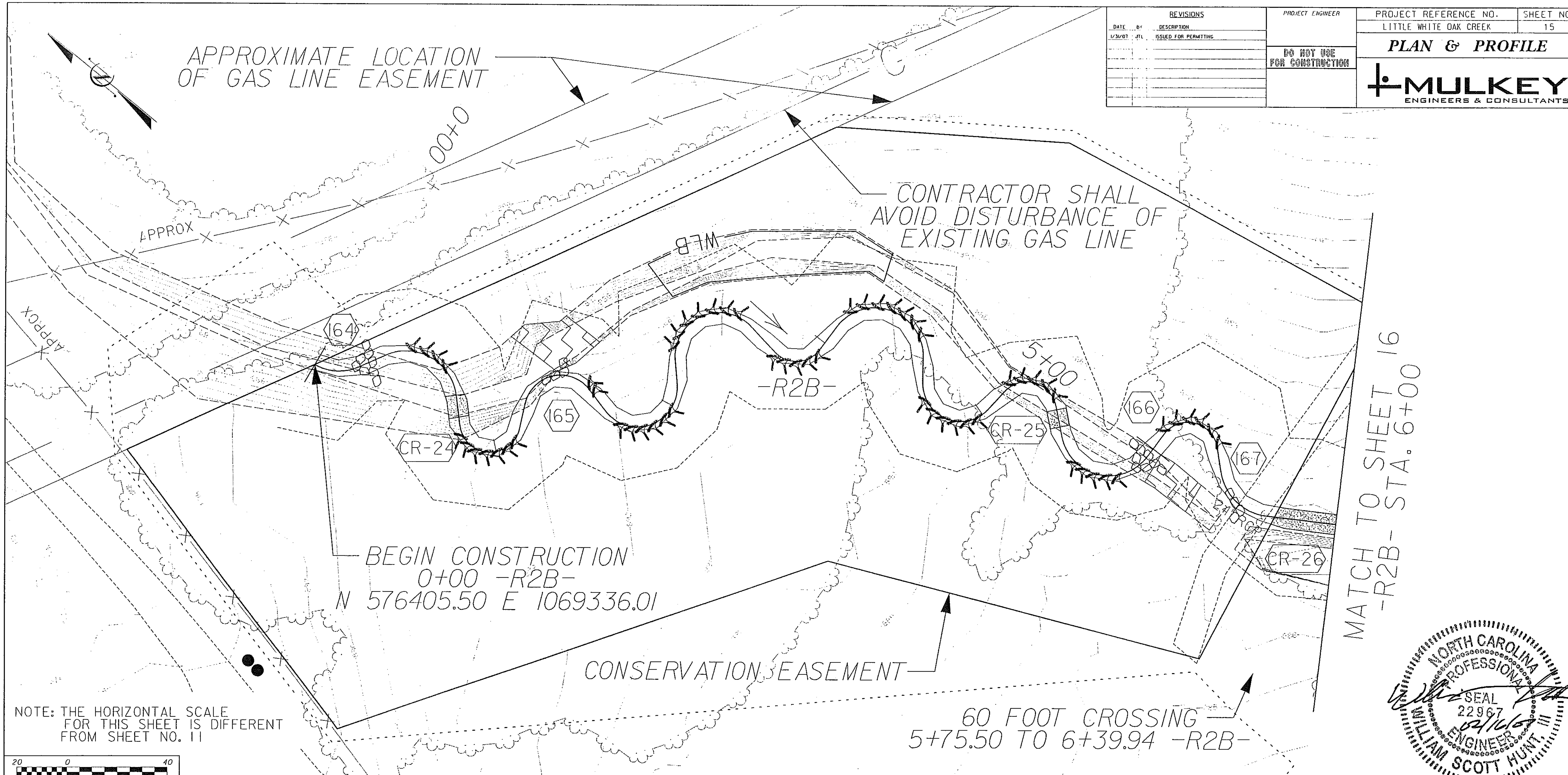
PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 15 |

# PLAN & PROFILE

MULKEY ENGINEERS & CONSULTANTS




NOTE: THE HORIZONTAL SCALE FOR THIS SHEET IS DIFFERENT FROM SHEET NO. 11

20 0 40

SEE SHEET NO. 19 FOR -R2B- PROFILE

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
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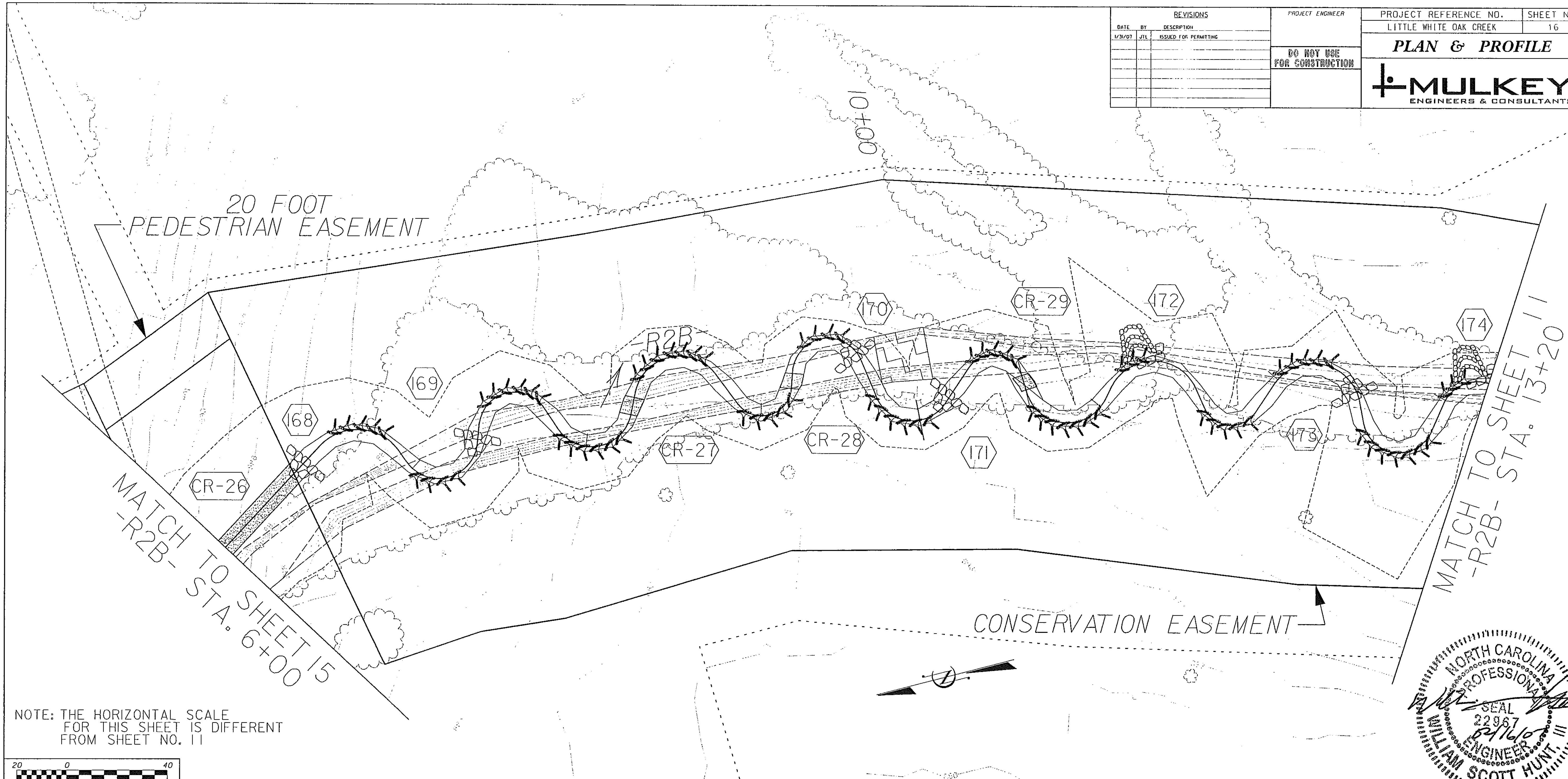
| LITTLE WHITE OAK CREEK | 16 |

## *PLAN & PROFILE*

MULKEY ENGINEERS & CONSULTANTS




NOTE: THE HORIZONTAL SCALE FOR THIS SHEET IS DIFFERENT FROM SHEET NO. 11

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SEE SHEET NO. 19 FOR -R2B- PROFILE

| REVISIONS | | | PROJECT ENGINEER | PROJECT REFERENCE NO. | SHEET NO. |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | | LITTLE WHITE OAK CREEK | 17 |
| 1/31/07 | JTL | ISSUED FOR PERMITTING | DO NOT USE FOR CONSTRUCTION | PLAN & PROFILE | |

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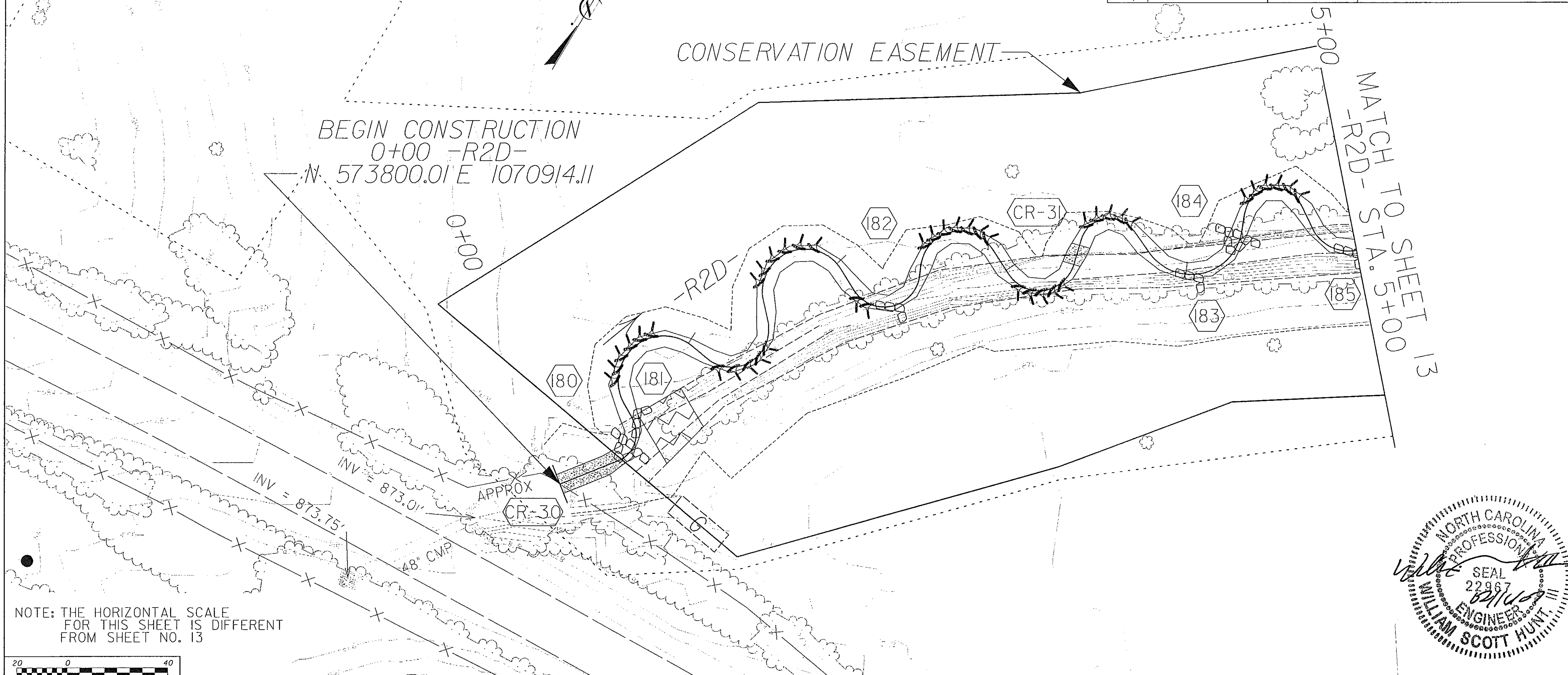



SEE SHEET NO. 19 FOR -R2D- PROFILE

# PROPOSED PROFILES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 18 |

*PROPOSED PROFILES*

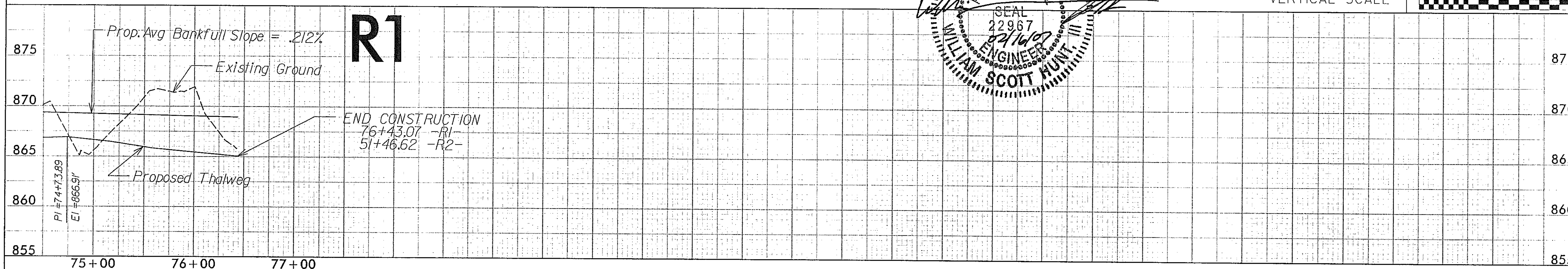
MULKEY ENGINEERS & CONSULTANTS

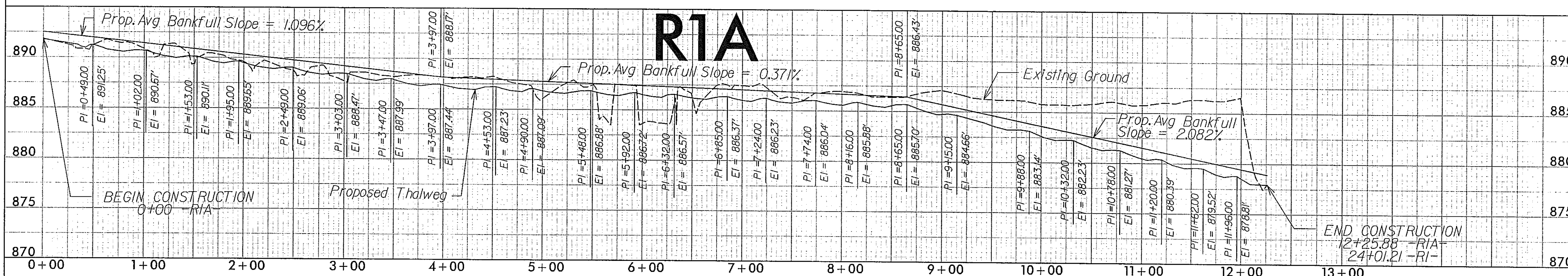
HORIZONTAL SCALE 50 0 100

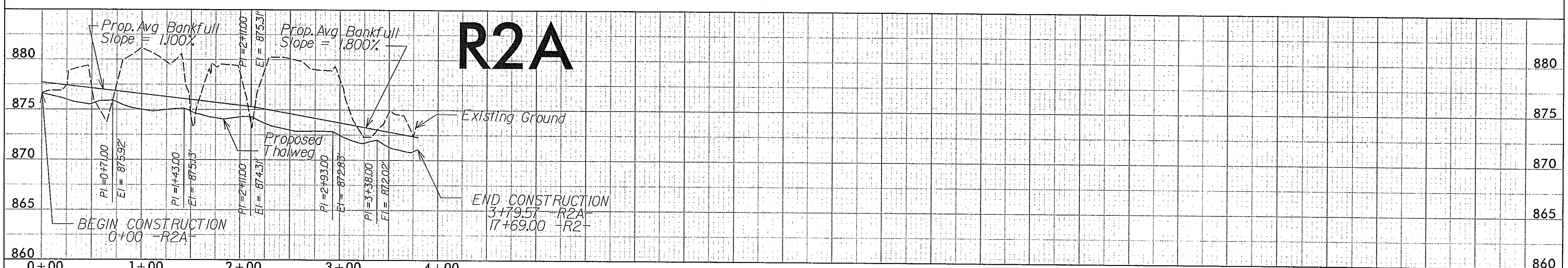
VERTICAL SCALE 5 0 10

NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III

2/16/07



# PROPOSED PROFILES

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | 19 |

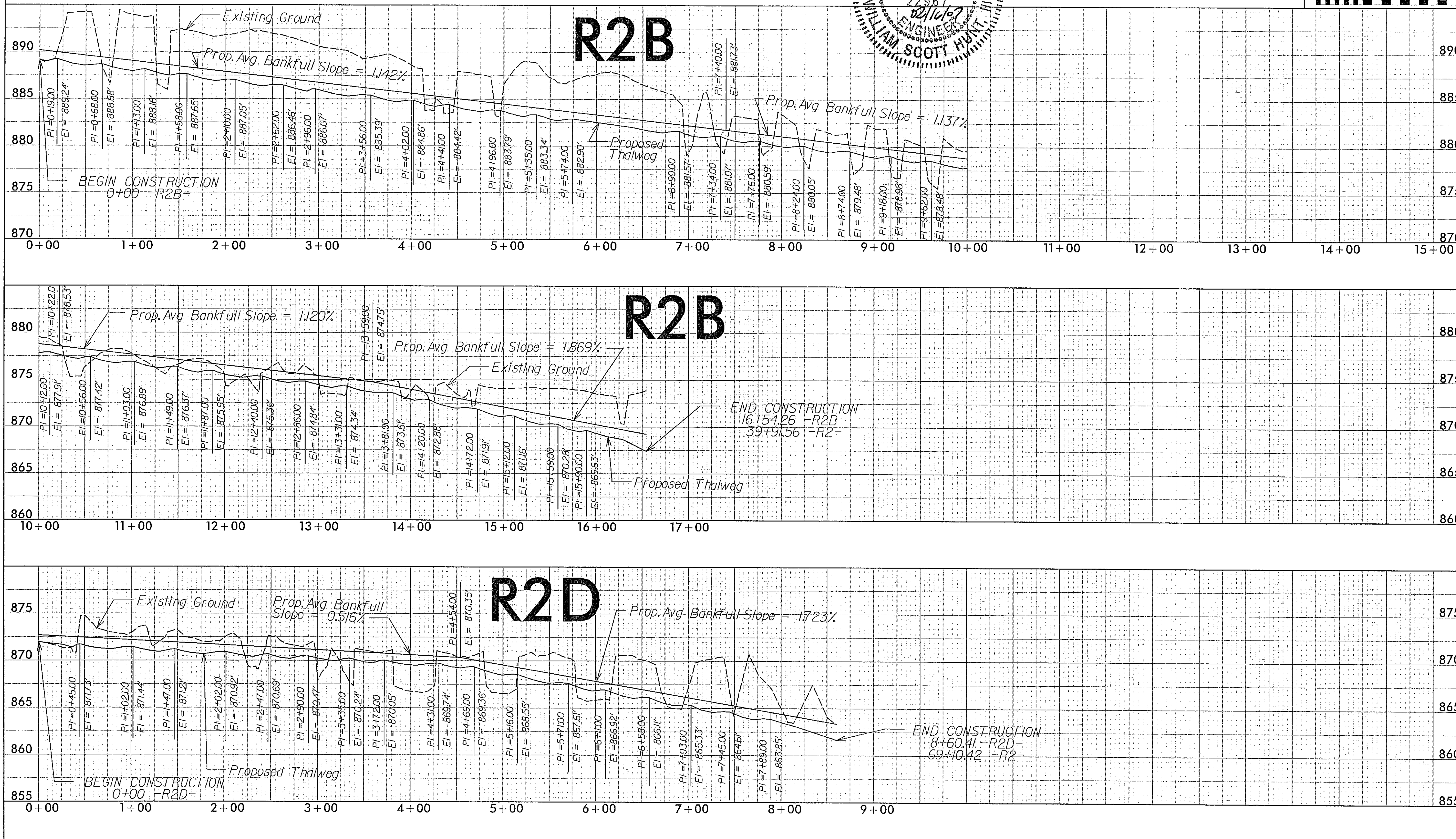
**PROPOSED PROFILES**

MULKEY ENGINEERS & CONSULTANTS

HORIZONTAL SCALE 50 0 100

VERTICAL SCALE 5 0 10

NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07



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PROJECT ENGINEER

DO NOT USE FOR CONSTRUCTION

| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | PLT-4 |

## PLANTING

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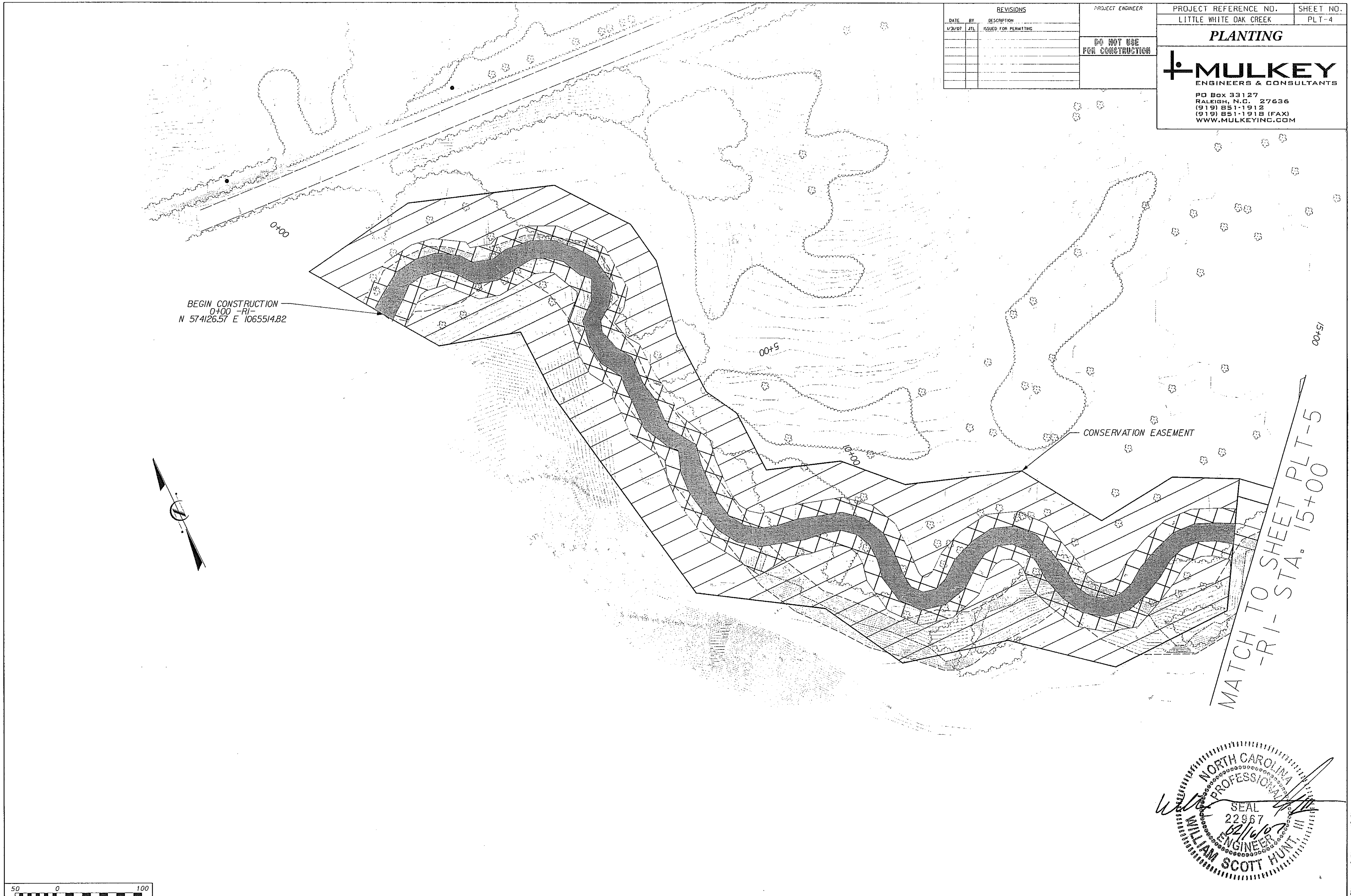

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PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
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| LITTLE WHITE OAK CREEK | PLT-5 |

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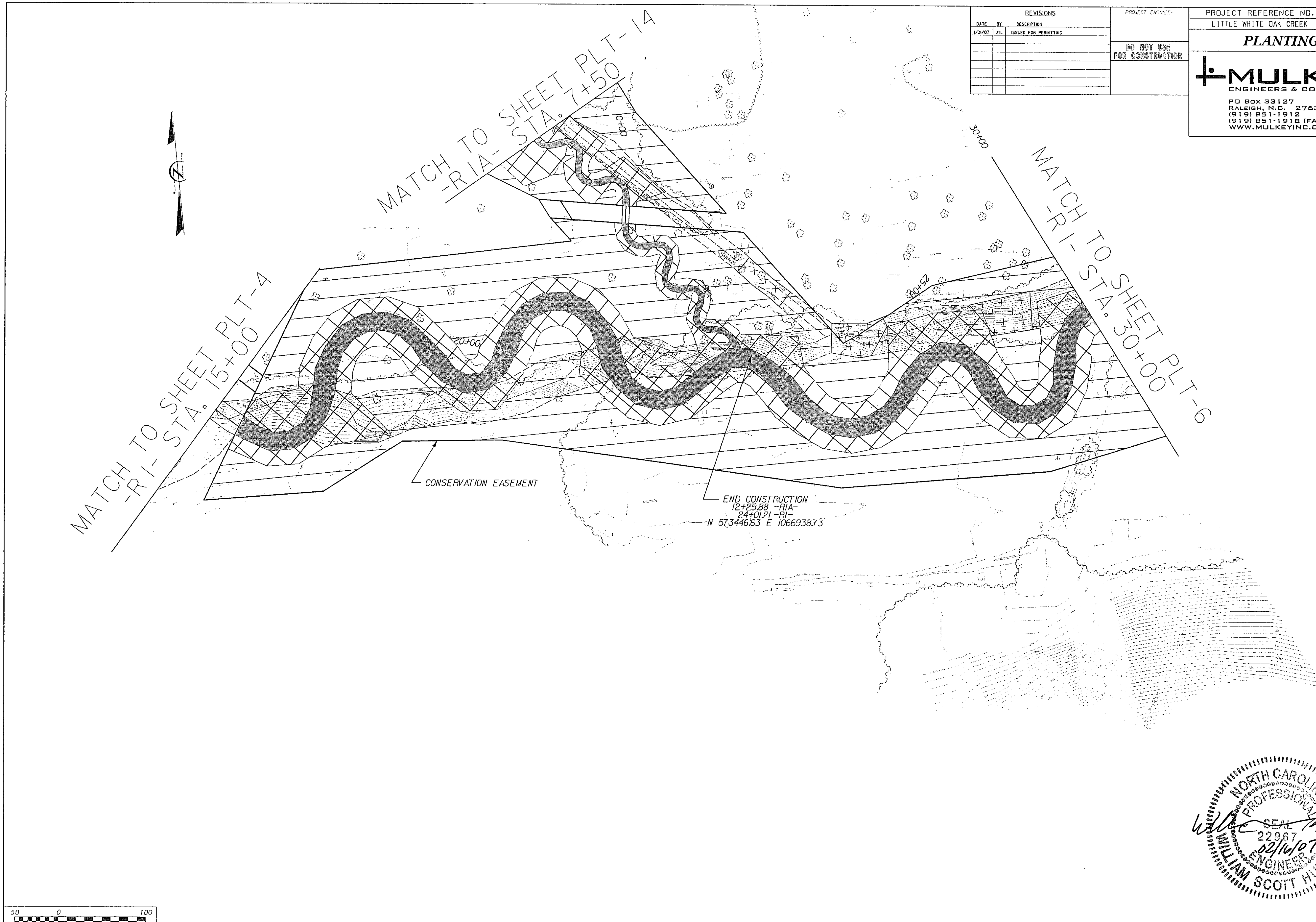
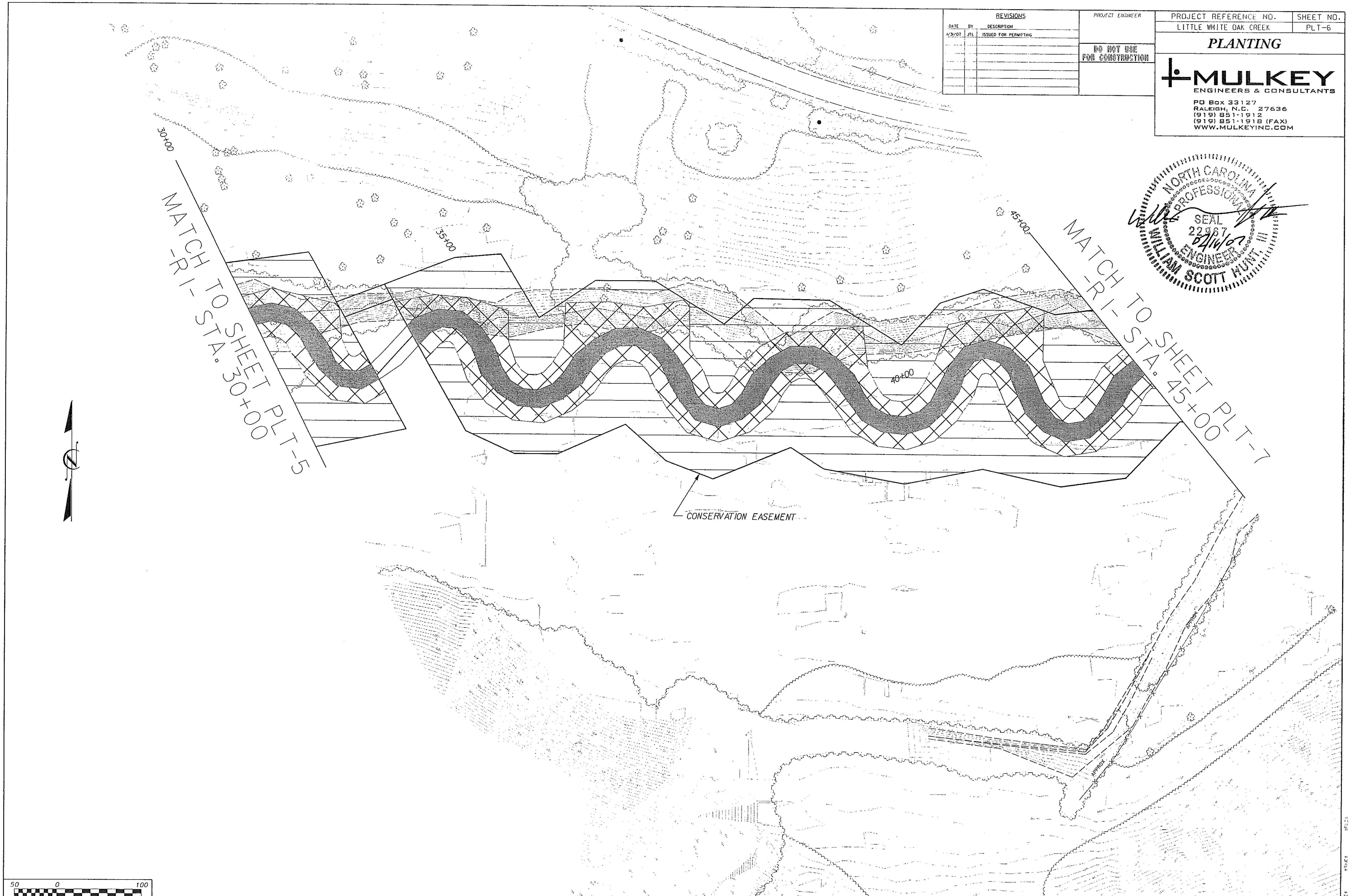



NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
02/16/07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DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO.
LITTLE WHITE OAK CREEK
SHEET NO.
PLT-6
PLANTING
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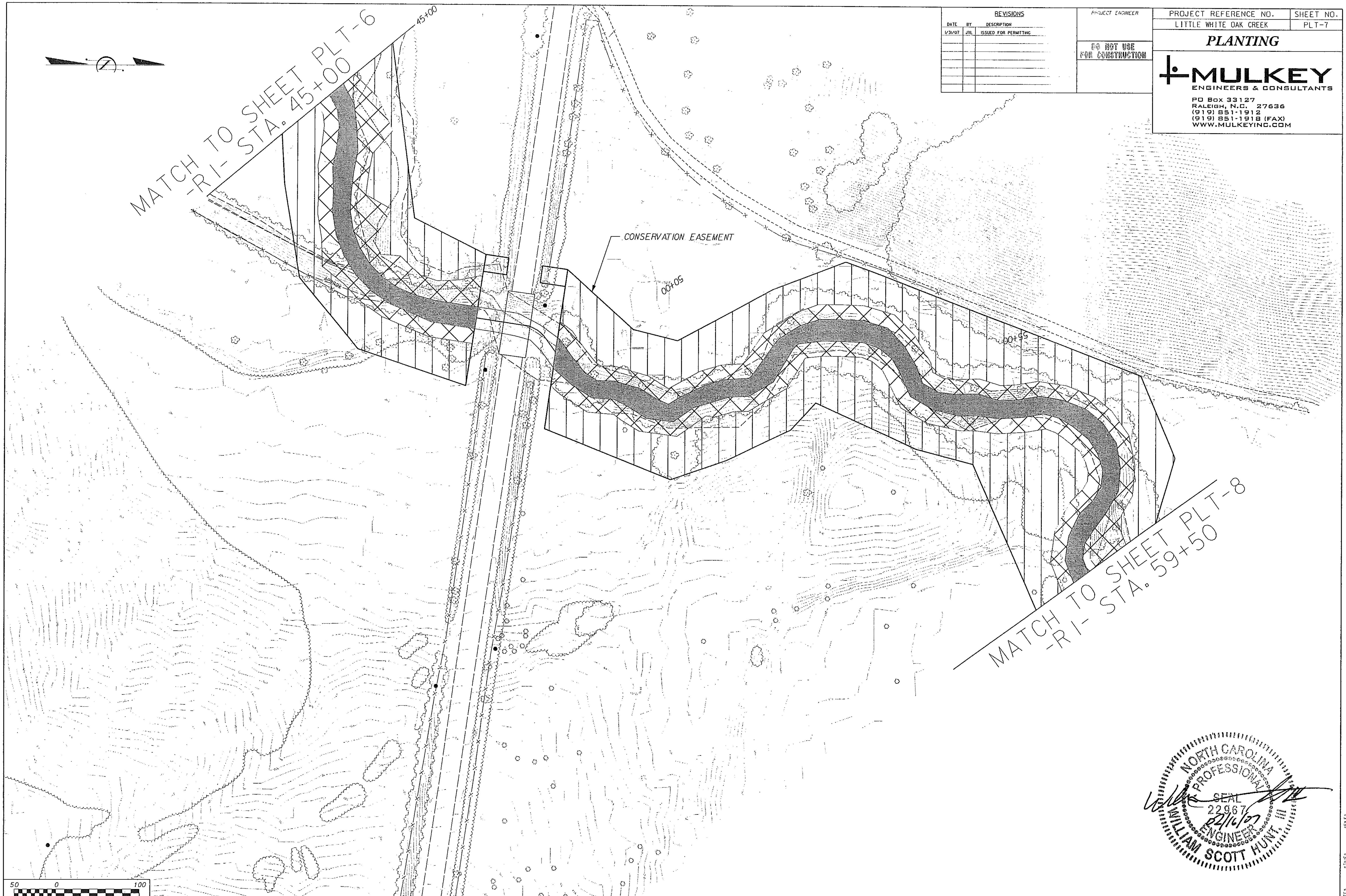
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM
NORTH CAROLINA
PROFESSIONAL
SEAL
22987
ENGINEER
WILLIAM SCOTT HUNT, III
MATCH TO SHEET PLT-5
-R1- STA. 30+00
MATCH TO SHEET PLT-7
-R1- STA. 45+00
30+00
35+00
40+00
45+00
CONSERVATION EASEMENT
APPROX
50
0
100

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PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
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| LITTLE WHITE OAK CREEK | PLT-7 |

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| PROJECT REFERENCE NO. | SHEET NO. |
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| LITTLE WHITE OAK CREEK | PLT-8 |

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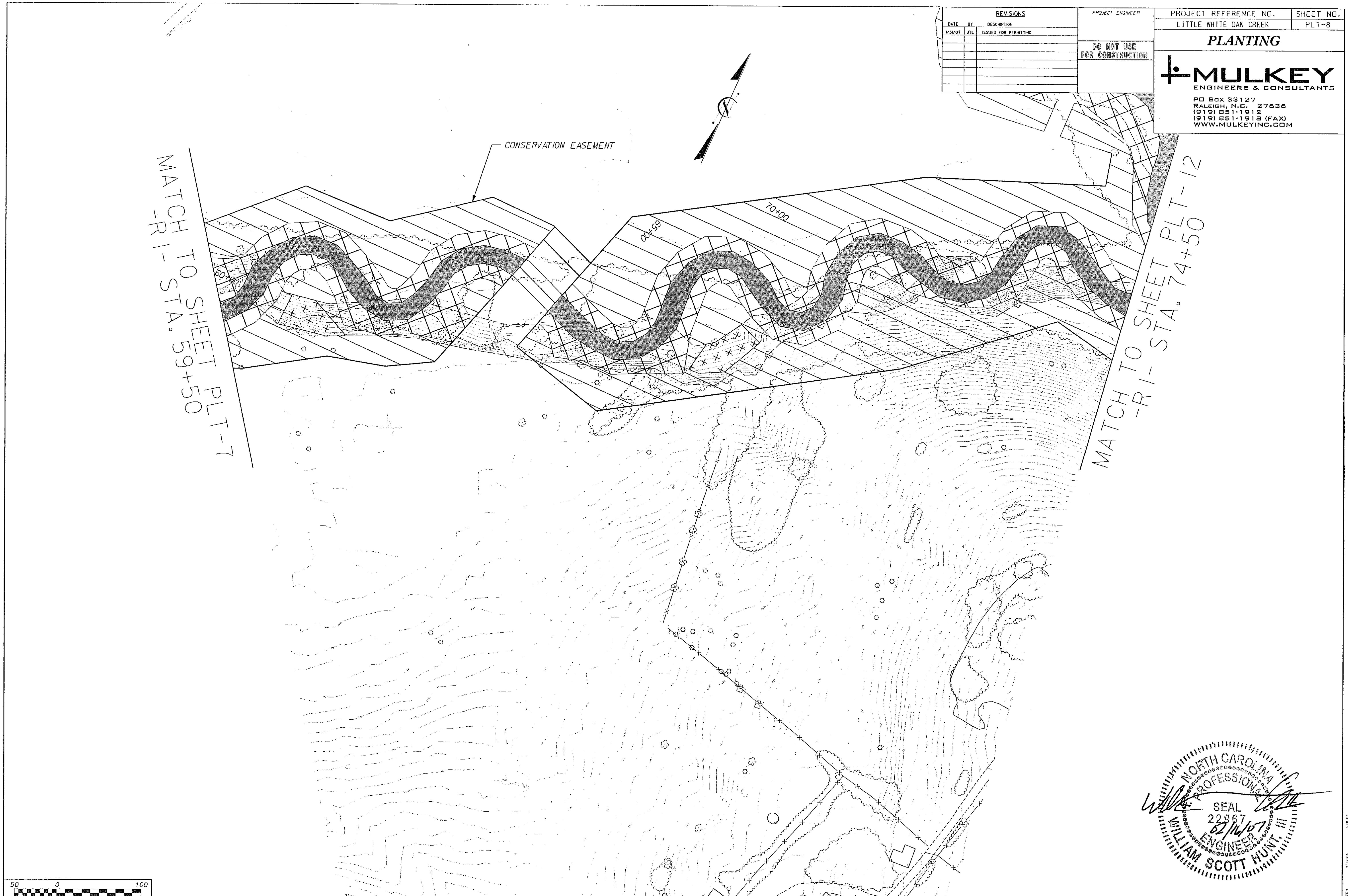

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PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
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| LITTLE WHITE OAK CREEK | PLT-9 |

# PLANTING

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(919) 851-1912
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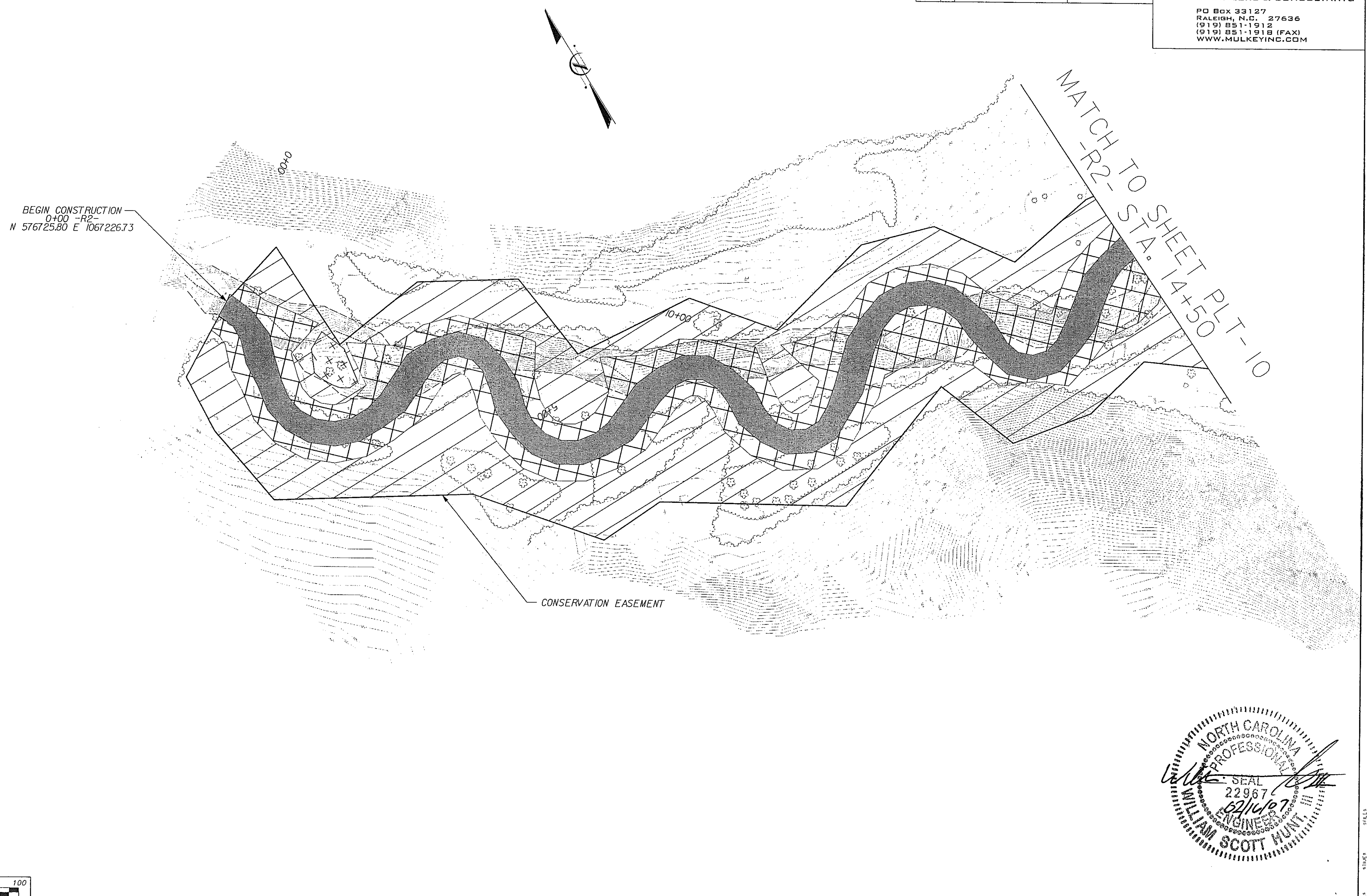

| PROJECT REFERENCE NO. | SHEET NO. |
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| LITTLE WHITE OAK CREEK | PLT-10 |

# PLANTING

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| DATE | BY | DESCRIPTION |
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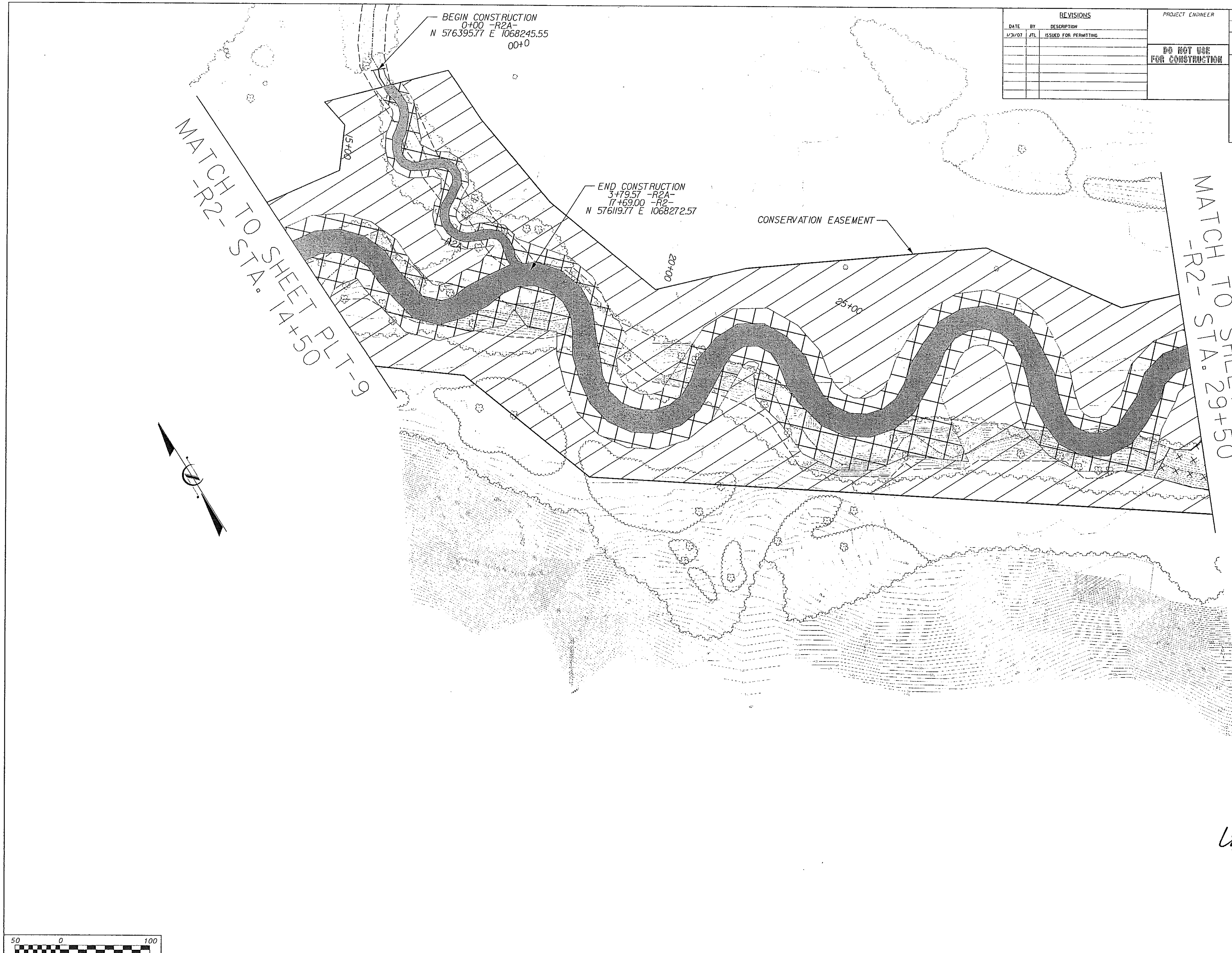


NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
02/16/07

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
| 1/31/07 | JTL | ISSUED FOR PERMITTING |

PROJECT ENGINEER

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| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | PLT-11 |

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PO Box 33127
Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
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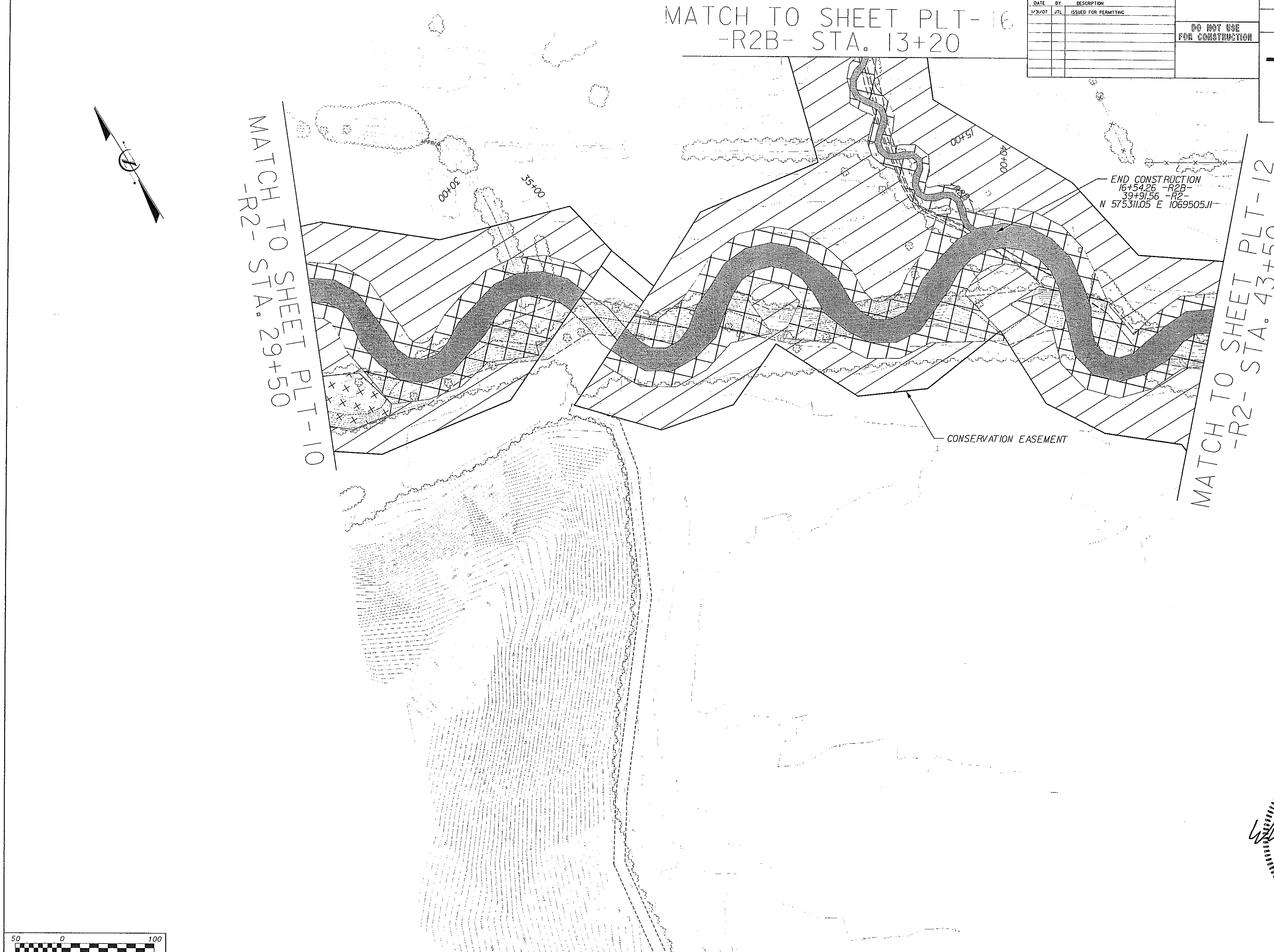


NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 22967 WILLIAM SCOTT HUNT, III 02/16/07

| REVISIONS | | |
|---|---|---|
| DATE | BY | DESCRIPTION |
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| PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| LITTLE WHITE OAK CREEK | PLT-12 |

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(919) 851-1918 (FAX)
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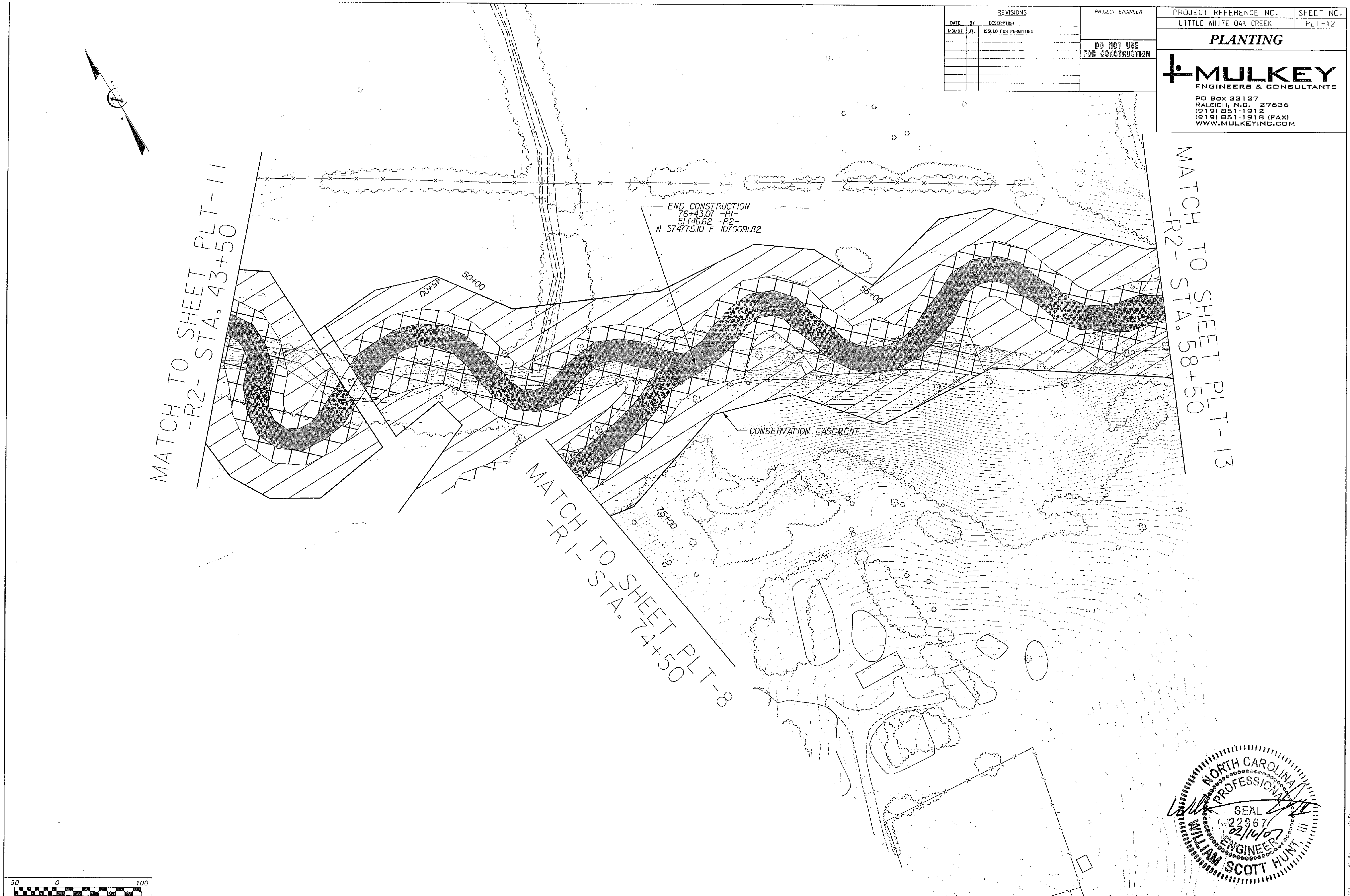

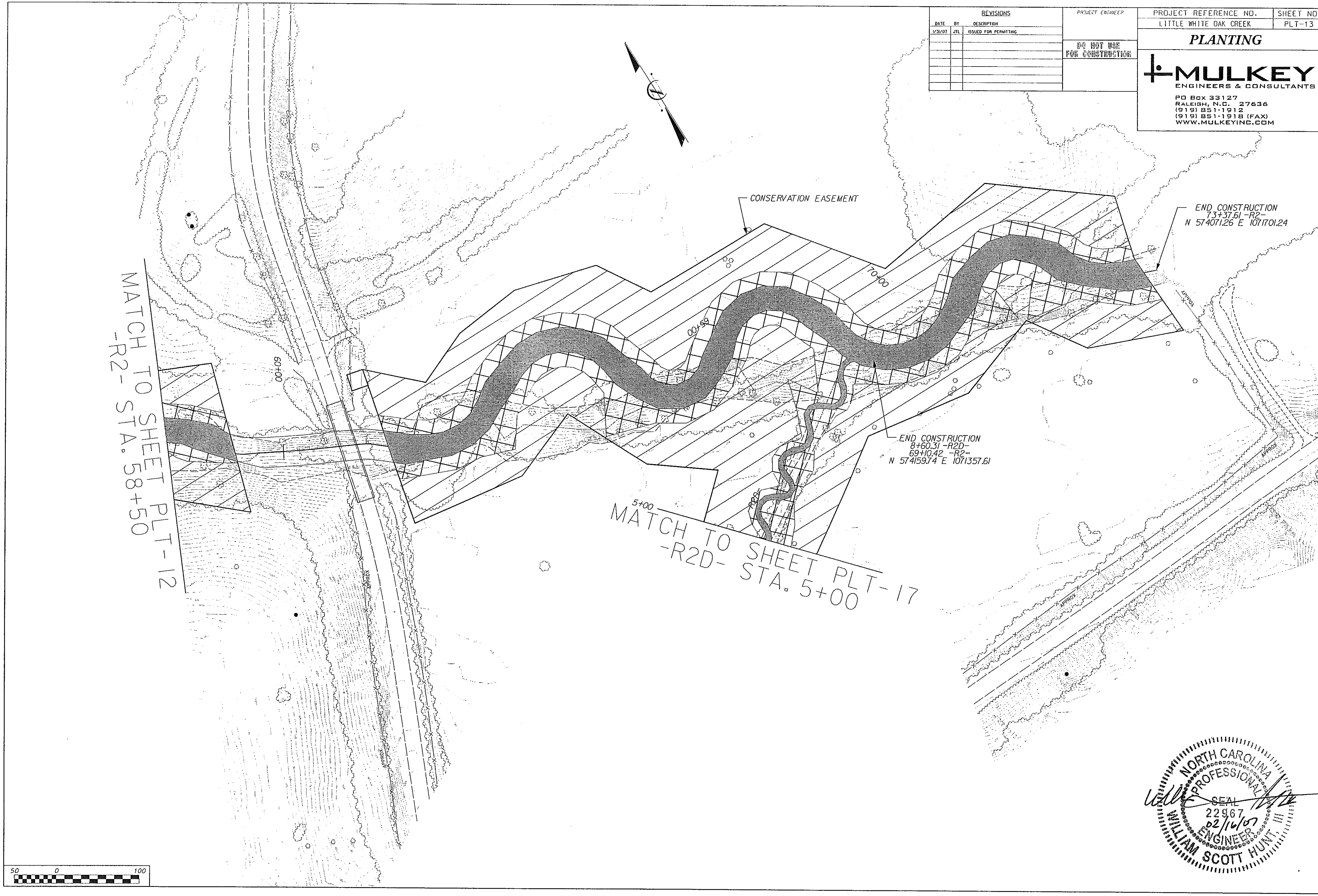
REVISIONS
DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO.
LITTLE WHITE OAK CREEK
SHEET NO.
PLT-13
PLANTING
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ENGINEERS & CONSULTANTS
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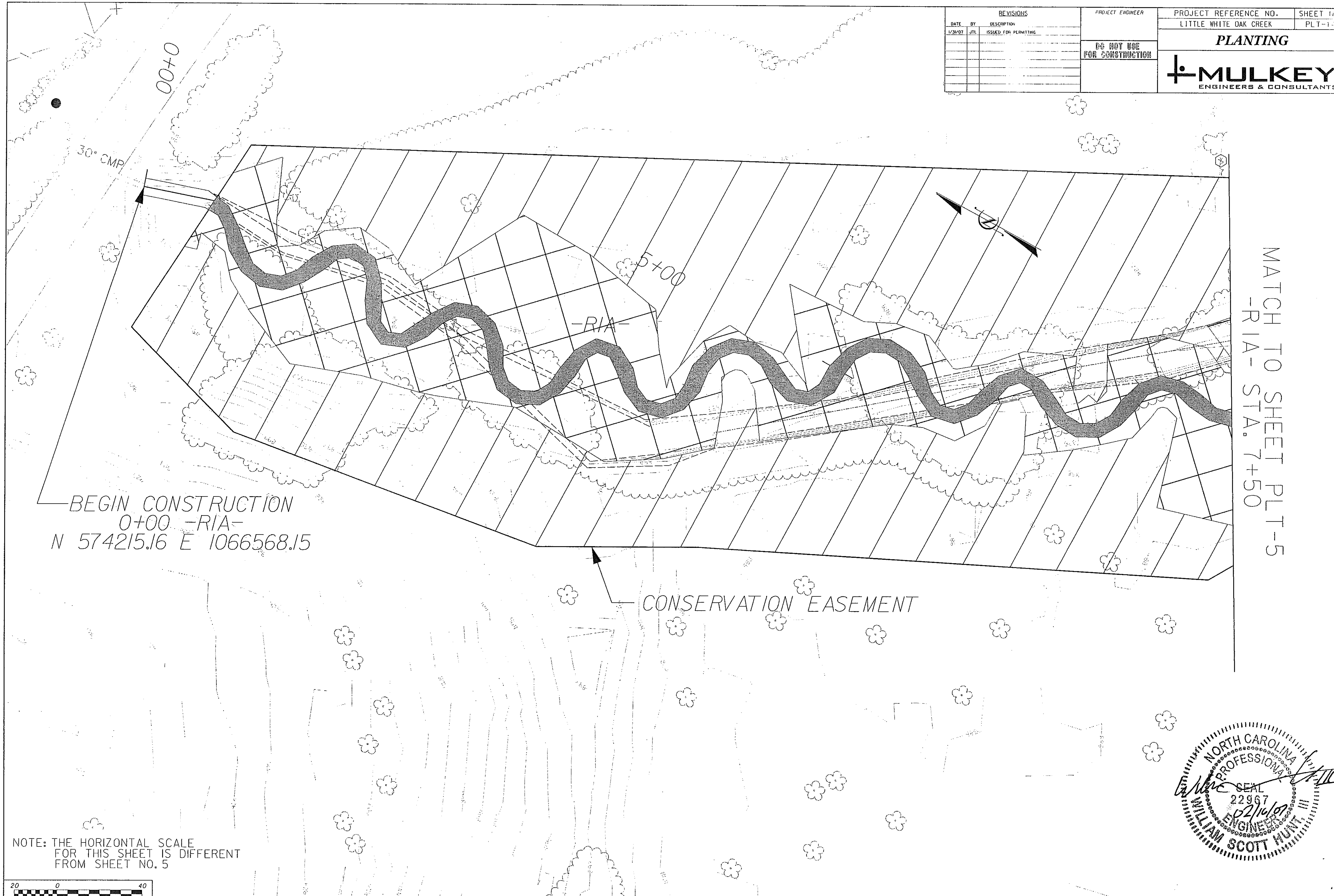
Raleigh, N.C. 27636
(919) 851-1912
(919) 851-1918 (FAX)
WWW.MULKEYINC.COM
CONSERVATION EASEMENT
END CONSTRUCTION
73+37.61 -R2-
N 574071.26 E 1071701.24
70+00
65+00
60+00
END CONSTRUCTION
8+60.31 -R2D-
69+10.42 -R2-
N 574159.74 E 1071357.61
MATCH TO SHEET PLT-12
-R2- STA. 58+50
5+00
MATCH TO SHEET PLT-17
-R2D- STA. 5+00
APPROX
50 0 100
NORTH CAROLINA
PROFESSIONAL
SEAL
22967
ENGINEER
WILLIAM SCOTT HUNT, III
02/16/07



REVISIONS
DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO.
LITTLE WHITE OAK CREEK
SHEET NO.
PLANTING
MULKEY
ENGINEERS & CONSULTANTS
0+00
30" CMP
5+00
-RIA-
MATCH TO SHEET PLT-5
-RIA- STA. 7+50
BEGIN CONSTRUCTION
0+00 -RIA-
N 574215.16 E 1066568.15
CONSERVATION EASEMENT
NORTH CAROLINA
PROFESSIONAL
SEAL
22967
ENGINEER
WILLIAM SCOTT HUNT, III
NOTE: THE HORIZONTAL SCALE FOR THIS SHEET IS DIFFERENT FROM SHEET NO. 5
20 0 40

| REVISIONS | | | PROJECT ENGINEER | PROJECT REFERENCE NO. | SHEET NO. |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | | LITTLE WHITE OAK CREEK | PLT-15 |
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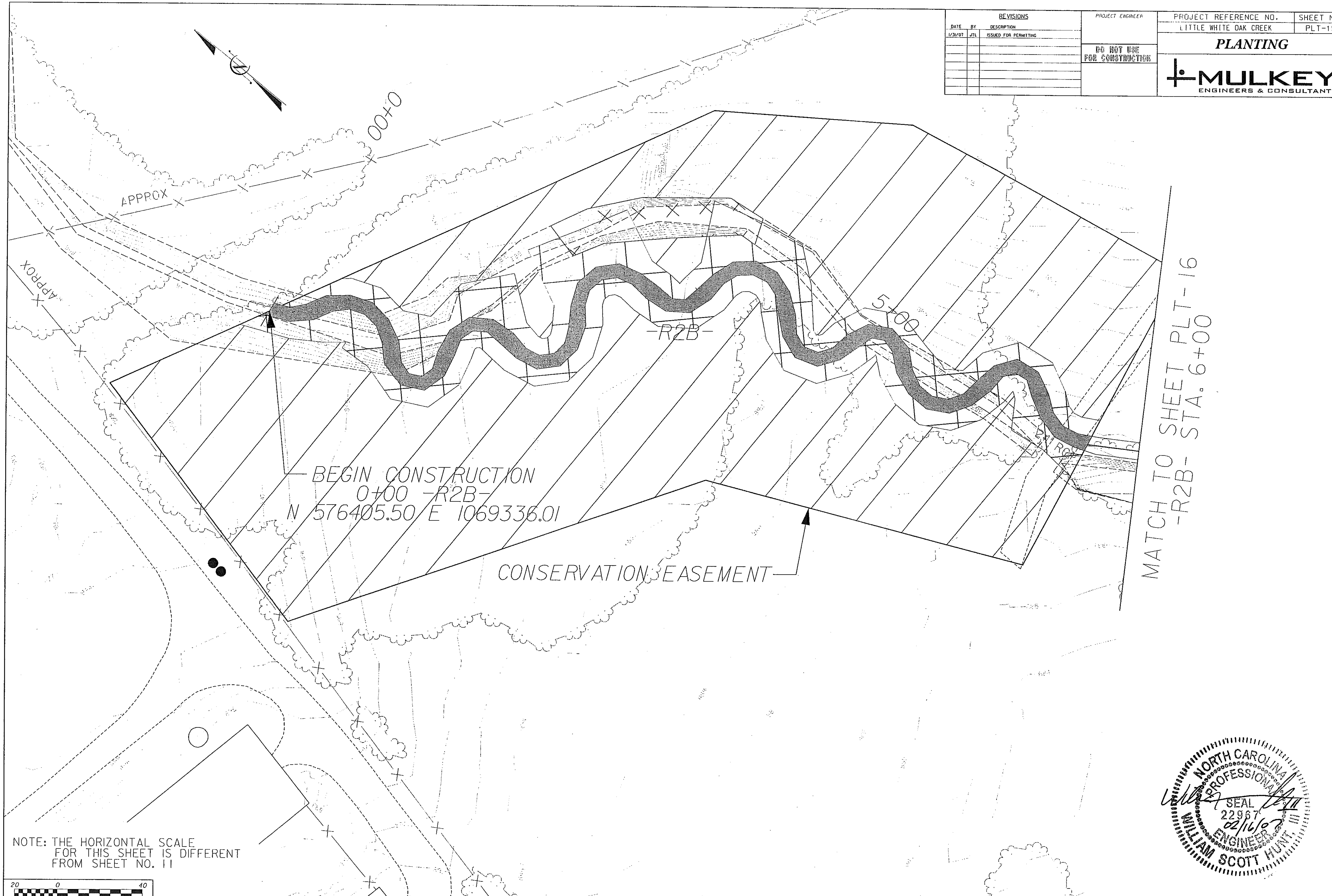
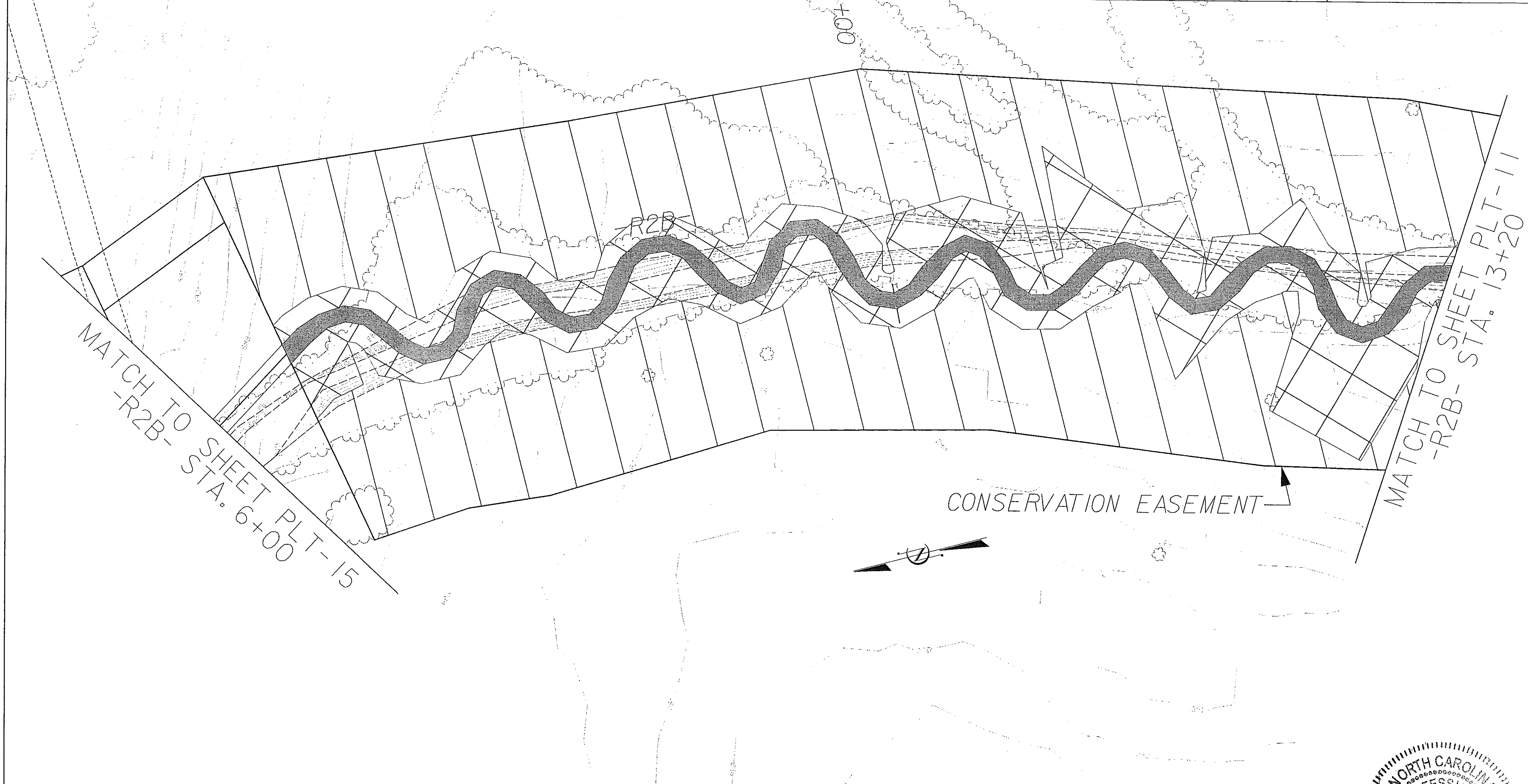



NOTE: THE HORIZONTAL SCALE FOR THIS SHEET IS DIFFERENT FROM SHEET NO. 11

| REVISIONS | | | PROJECT ENGINEER | PROJECT REFERENCE NO. | SHEET NO. |
|---|---|---|---|---|---|
| DATE | BY | DESCRIPTION | | LITTLE WHITE OAK CREEK | PLT-16 |
| 1/31/07 | JTL | ISSUED FOR PERMITTING | DO NOT USE FOR CONSTRUCTION | PLANTING | |

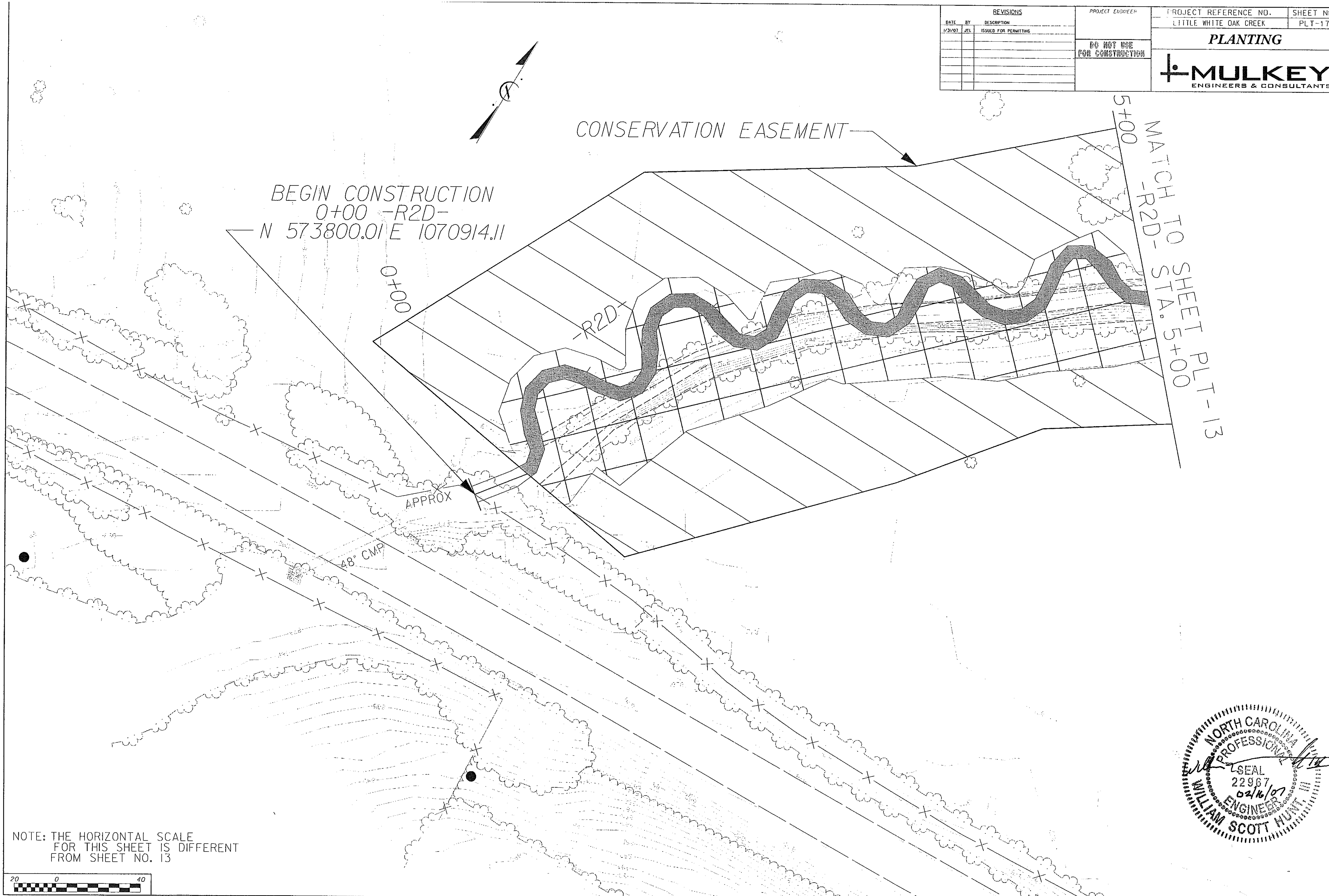
MULKEY ENGINEERS & CONSULTANTS




NORTH CAROLINA PROFESSIONAL SEAL 22967 ENGINEER WILLIAM SCOTT HUNT, III
02/16/07

NOTE: THE HORIZONTAL SCALE FOR THIS SHEET IS DIFFERENT FROM SHEET NO. 11

20 0 40



REVISIONS
DATE BY DESCRIPTION
1/31/07 JTL ISSUED FOR PERMITTING
PROJECT ENGINEER
DO NOT USE FOR CONSTRUCTION
PROJECT REFERENCE NO.
LITTLE WHITE OAK CREEK
SHEET NO.
PLT-17
PLANTING
MULKEY
ENGINEERS & CONSULTANTS
CONSERVATION EASEMENT
BEGIN CONSTRUCTION
0+00 -R2D-
N 573800.01 E 1070914.11
0+00
-R2D-
5+00
MATCH TO SHEET PLT-13
-R2D- STA. 5+00
APPROX
48" CMP
NORTH CAROLINA
PROFESSIONAL
SEAL
22967
02/16/07
ENGINEER
WILLIAM SCOTT HUNT, III
NOTE: THE HORIZONTAL SCALE
FOR THIS SHEET IS DIFFERENT
FROM SHEET NO. 13
20 0 40

# Reach R1 and Tributaries

Cattle exiting Reach R1.

Photo facing downstream of Reach R1 at cross section 3.

Cattle crossing on R1A.

Photo representative of the condition of R1A and was taken upstream of the confluence with R1.

View of Reach R1A at a cross section location.

# Reach R2 and Tributaries

Southeast portion of Reach R2 facing up stream.


Northwest portion of Reach R2 facing southeast.

Reach R2 Upper facing down stream, downstream of the confluence with R2B.

Reach R2 Lower below the confluence of R2D.

Reach R2A upstream of the confluence with R2.


Southern portion of Reach R2B facing north up stream.


Northwest portion of R2B facing downstream.


R2D facing down stream.


R2D facing west perpendicular to the stream.

WSH QC 01/05/07

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

| | | |
|---|---|---|
| **Date:** 7/20/06 | **Project:** Little White Oak | **Latitude:** |
| **Evaluator:** TMB | **Site:** R1 | **Longitude:** |
| **Total Points:** *Stream is at least intermittent if ≥19 or perennial if ≥30* 54.5 | **County:** Polk | **Other** *e.g. Quad Name:* Mill Springs |

| A. Geomorphology (Subtotal = 29) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | **3** |
| 2. Sinuosity | 0 | 1 | **2** | 3 |
| 3. In-Channel structure: riffle-pool sequence | 0 | **1** | 2 | 3 |
| 4. Soil texture or stream substrate sorting | 0 | 1 | **2** | 3 |
| 5. Active/relic floodplain | 0 | 1 | 2 | **3** |
| 6. Depositional bars or benches | 0 | 1 | 2 | **3** |
| 7. Braided channel | **0** | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | 1 | 2 | **3** |
| 9[a]. Natural levees | 0 | 1 | 2 | **3** |
| 10. Headcuts | 0 | 1 | 2 | **3** |
| 11. Grade controls | 0 | 0.5 | 1 | **1.5** |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | **1.5** |
| 13. Second or greater order channel on existing USGS or NRCS map or other documented evidence. | No = 0 | | **Yes = 3** | |

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

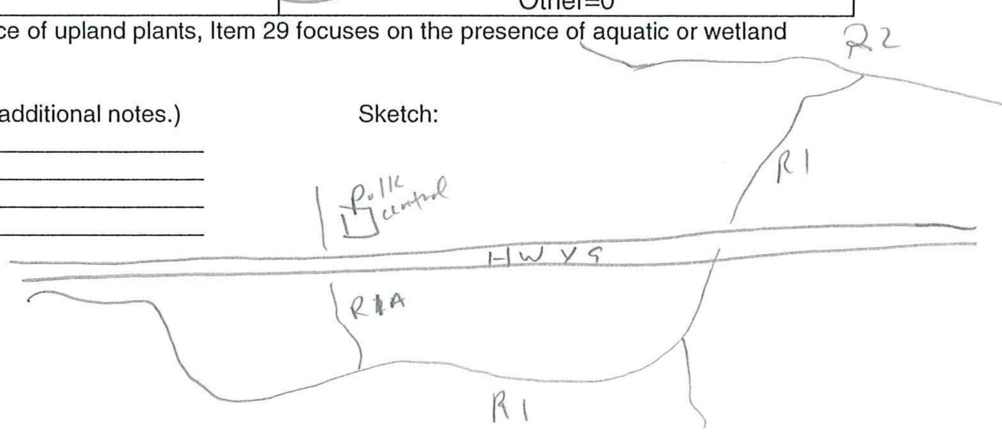
| B Hydrology (Subtotal = 11) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | 2 | **3** |
| 15. Water in channel and > 48 hrs. since rain, or Water in channel – dry or growing season | 0 | 1 | 2 | **3** |
| 16. Leaflitter | 1.5 | 1 | **0.5** | 0 |
| 17. Sediment on plants or debris | 0 | 0.5 | 1 | **1.5** |
| 18. Organic debris lines or piles (Wrack lines) | 0 | 0.5 | 1 | **1.5** |
| 19. Hydric soils (redoximorphic features) present? | No = 0 | | **Yes = 1.5** | |

| C. Biology (Subtotal = 14.5) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | **3** | 2 | 1 | 0 |
| 21[b]. Rooted plants in channel | **3** | 2 | 1 | 0 |
| 22. Crayfish | 0 | 0.5 | 1 | **1.5** |
| 23. Bivalves | 0 | **1** | 2 | 3 |
| 24. Fish | 0 | 0.5 | 1 | **1.5** |
| 25. Amphibians | 0 | 0.5 | 1 | **1.5** |
| 26. Macrobenthos (note diversity and abundance) | 0 | 0.5 | **1** | 1.5 |
| 27. Filamentous algae; periphyton | 0 | **1** | 2 | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | **0.5** | 1 | 1.5 |
| 29[b]. Wetland plants in streambed | **FAC=0.5**; FACW=0.75; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



WSH QC 01/05/07
TMB QC 01/08/07

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

| | | |
|---|---|---|
| **Date:** 7/20/06 | **Project:** Little White Oak | **Latitude:** |
| **Evaluator:** TMB | **Site:** R1A | **Longitude:** |
| **Total Points:** 43<br>*Stream is at least intermittent If ≥19 or perennial if ≥30* | **County:** Polk | **Other** *e.g. Quad Name:* Mill Springs |

| A. Geomorphology (Subtotal = 26) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | **3** |
| 2. Sinuosity | 0 | 1 | 2 | **3** |
| 3. In-Channel structure: riffle-pool sequence | 0 | 1 | 2 | **3** |
| 4. Soil texture or stream substrate sorting | 0 | **1** | 2 | 3 |
| 5. Active/relic floodplain | 0 | 1 | **2** | 3 |
| 6. Depositional bars or benches | 0 | **1** | 2 | 3 |
| 7. Braided channel | 0 | 1 | 2 | **3** |
| 8. Recent alluvial deposits | 0 | 1 | 2 | **3** |
| 9[a]. Natural levees | 0 | 1 | **2** | 3 |
| 10. Headcuts | 0 | 1 | **2** | 3 |
| 11. Grade controls | 0 | 0.5 | 1 | **1.5** |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | **1.5** |
| 13. Second or greater order channel on existing USGS or NRCS map or other documented evidence. | **No = 0** | | Yes = 3 | |

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

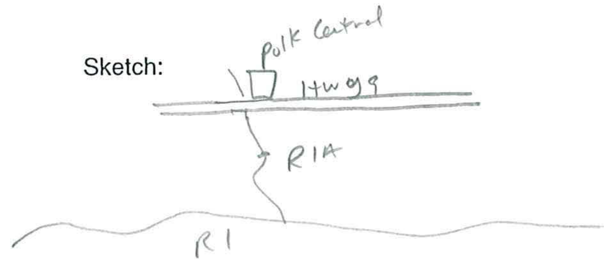
| B Hydrology (Subtotal = 8) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | **2** | 3 |
| 15. Water in channel and > 48 hrs. since rain, or Water in channel – dry or growing season | 0 | 1 | 2 | **3** |
| 16. Leaflitter | 1.5 | **1** | 0.5 | 0 |
| 17. Sediment on plants or debris | 0 | 0.5 | **1** | 1.5 |
| 18. Organic debris lines or piles (Wrack lines) | 0 | 0.5 | **1** | 1.5 |
| 19. Hydric soils (redoximorphic features) present? | **No = 0** | | Yes = 1.5 | |

| C. Biology (Subtotal = 9) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | 3 | **2** | 1 | 0 |
| 21[b]. Rooted plants in channel | 3 | **2** | 1 | 0 |
| 22. Crayfish | 0 | 0.5 | **1** | 1.5 |
| 23. Bivalves | **0** | 1 | 2 | 3 |
| 24. Fish | 0 | **0.5** | 1 | 1.5 |
| 25. Amphibians | 0 | 0.5 | 1 | **1.5** |
| 26. Macrobenthos (note diversity and abundance) | 0 | **0.5** | 1 | 1.5 |
| 27. Filamentous algae; periphyton | **0** | 1 | 2 | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | 0.5 | **1** | 1.5 |
| 29[b]. Wetland plants in streambed | **FAC=0.5**; FACW=0.75; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



W514 QC 01/05/07

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

| | | |
|---|---|---|
| **Date:** 7/20/06 | **Project:** LWO | **Latitude:** |
| **Evaluator:** TMB | **Site:** R2 | **Longitude:** |
| **Total Points:** 54 ✓<br>*Stream is at least intermittent If ≥19 or perennial if ≥30* | **County:** Polk | **Other** Mill Springs<br>*e.g. Quad Name:* |

(Circled ratings are shown in bold.)

| A. Geomorphology (Subtotal = 29 ✓) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | **3** |
| 2. Sinuosity | 0 | 1 | **2** | 3 |
| 3. In-Channel structure: riffle-pool sequence | 0 | **1** | 2 | 3 |
| 4. Soil texture or stream substrate sorting | 0 | 1 | **2** | 3 |
| 5. Active/relic floodplain | 0 | 1 | 2 | **3** |
| 6. Depositional bars or benches | 0 | 1 | 2 | **3** |
| 7. Braided channel | **0** | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | 1 | 2 | **3** |
| 9[a]. Natural levees | 0 | 1 | 2 | **3** |
| 10. Headcuts | 0 | 1 | 2 | **3** |
| 11. Grade controls | 0 | 0.5 | 1 | **1.5** |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | **1.5** |
| 13. Second or greater order channel on existing USGS or NRCS map or other documented evidence. | No = 0 | | **Yes = 3** | |

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

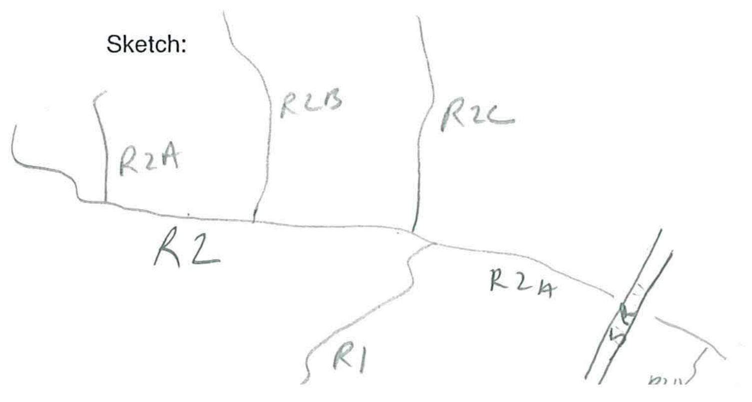
| B Hydrology (Subtotal = 10.5 ✓) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | 2 | **3** |
| 15. Water in channel and > 48 hrs. since rain, or Water in channel – dry or growing season | 0 | 1 | 2 | **3** |
| 16. Leaflitter | 1.5 | 1 | 0.5 | **0** |
| 17. Sediment on plants or debris | 0 | 0.5 | 1 | **1.5** |
| 18. Organic debris lines or piles (Wrack lines) | 0 | 0.5 | 1 | **1.5** |
| 19. Hydric soils (redoximorphic features) present? | No = 0 | | **Yes = 1.5** | |

| C. Biology (Subtotal = 14.5 ✓) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | **3** | 2 | 1 | 0 |
| 21[b]. Rooted plants in channel | **3** | 2 | 1 | 0 |
| 22. Crayfish | 0 | 0.5 | 1 | **1.5** |
| 23. Bivalves | 0 | **1** | 2 | 3 |
| 24. Fish | 0 | 0.5 | 1 | **1.5** |
| 25. Amphibians | 0 | 0.5 | 1 | **1.5** |
| 26. Macrobenthos (note diversity and abundance) | 0 | 0.5 | **1** | 1.5 |
| 27. Filamentous algae; periphyton | 0 | **1** | 2 | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | **0.5** | 1 | 1.5 |
| 29[b]. Wetland plants in streambed | **FAC=0.5**; FACW=0.75; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



WSHQC 01/05/07
TMBQC 01/08/07

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

| | | |
|---|---|---|
| **Date:** 7/20/06 | **Project:** Little White Oak | **Latitude:** |
| **Evaluator:** TMB | **Site:** R2A | **Longitude:** |
| **Total Points:** 46<br>*Stream is at least intermittent If ≥19 or perennial if ≥30* | **County:** Polk | **Other** *e.g. Quad Name:* Mill Springs |

| A. Geomorphology (Subtotal = 23 ) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | **3** |
| 2. Sinuosity | 0 | **1** | 2 | 3 |
| 3. In-Channel structure: riffle-pool sequence | 0 | 1 | **2** | 3 |
| 4. Soil texture or stream substrate sorting | 0 | 1 | **2** | 3 |
| 5. Active/relic floodplain | 0 | 1 | 2 | **3** |
| 6. Depositional bars or benches | 0 | 1 | **2** | 3 |
| 7. Braided channel | **0** | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | 1 | **2** | 3 |
| 9[a]. Natural levees | 0 | 1 | **2** | 3 |
| 10. Headcuts | 0 | 1 | 2 | **3** |
| 11. Grade controls | 0 | 0.5 | 1 | **1.5** |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | **1.5** |
| 13. Second or greater order channel on existing USGS or NRCS map or other documented evidence. | **No = 0** | | Yes = 3 | |

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

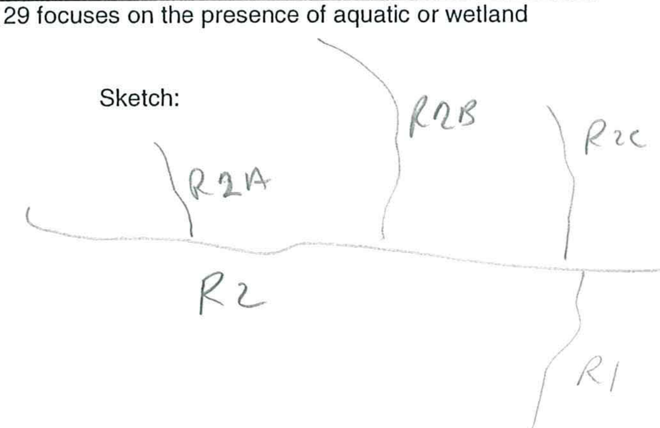
| B Hydrology (Subtotal = 10 ) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | 2 | **3** |
| 15. Water in channel and > 48 hrs. since rain, or Water in channel – dry or growing season | 0 | 1 | 2 | **3** |
| 16. Leaflitter | 1.5 | 1 | **0.5** | 0 |
| 17. Sediment on plants or debris | 0 | 0.5 | **1** | 1.5 |
| 18. Organic debris lines or piles (Wrack lines) | 0 | 0.5 | **1** | 1.5 |
| 19. Hydric soils (redoximorphic features) present? | No = 0 | | **Yes = 1.5** | |

| C. Biology (Subtotal = 13 ) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | **3** | 2 | 1 | 0 |
| 21[b]. Rooted plants in channel | **3** | 2 | 1 | 0 |
| 22. Crayfish | 0 | 0.5 | **1** | 1.5 |
| 23. Bivalves | **0** | 1 | 2 | 3 |
| 24. Fish | 0 | 0.5 | 1 | **1.5** |
| 25. Amphibians | 0 | 0.5 | 1 | **1.5** |
| 26. Macrobenthos (note diversity and abundance) | 0 | 0.5 | **1** | 1.5 |
| 27. Filamentous algae; periphyton | 0 | **1** | 2 | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | **0.5** | 1 | 1.5 |
| 29[b]. Wetland plants in streambed | **FAC=0.5**; FACW=0.75; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



WSH QC 01/05/07

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

| | | |
|---|---|---|
| **Date:** 7/20/06 | **Project:** LWO | **Latitude:** |
| **Evaluator:** JMB | **Site:** R2B | **Longitude:** |
| **Total Points:** *Stream is at least intermittent If ≥19 or perennial if ≥30* 44.5 ✓ | **County:** Polk | **Other** *e.g. Quad Name:* Mill Springs |

| A. Geomorphology (Subtotal = 23 ✓) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | (3) |
| 2. Sinuosity | 0 | (1) | 2 | 3 |
| 3. In-Channel structure: riffle-pool sequence | 0 | (1) | 2 | 3 |
| 4. Soil texture or stream substrate sorting | 0 | 1 | (2) | 3 |
| 5. Active/relic floodplain | 0 | 1 | (2) | 3 |
| 6. Depositional bars or benches | 0 | 1 | 2 | (3) |
| 7. Braided channel | (0) | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | 1 | 2 | (3) |
| 9[a]. Natural levees | 0 | 1 | (2) | 3 |
| 10. Headcuts | 0 | 1 | 2 | (3) |
| 11. Grade controls | 0 | 0.5 | 1 | (1.5) |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | (1.5) |
| 13. Second or greater order channel on <u>existing</u> USGS or NRCS map or other documented evidence. | (No = 0) | | Yes = 3 | |

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

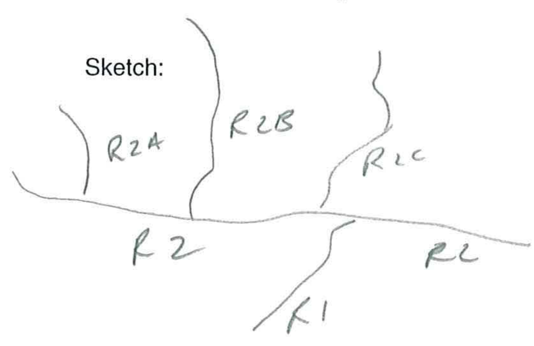
| B Hydrology (Subtotal = 9 ✓) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | 2 | (3) |
| 15. Water in channel and > 48 hrs. since rain, **or** Water in channel – dry or growing season | 0 | 1 | 2 | (3) |
| 16. Leaflitter | 1.5 | (1) | 0.5 | 0 |
| 17. Sediment on plants or debris | 0 | 0.5 | (1) | 1.5 |
| 18. Organic debris lines or piles (Wrack lines) | 0 | 0.5 | (1) | 1.5 |
| 19. Hydric soils (redoximorphic features) present? | (No = 0) | | Yes = 1.5 | |

| C. Biology (Subtotal = 12.5 ✓) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | (3) | 2 | 1 | 0 |
| 21[b]. Rooted plants in channel | (3) | 2 | 1 | 0 |
| 22. Crayfish | 0 | 0.5 | (1) | 1.5 |
| 23. Bivalves | (0) | 1 | 2 | 3 |
| 24. Fish | (0) | 0.5 | 1 | 1.5 |
| 25. Amphibians | 0 | 0.5 | 1 | (1.5) |
| 26. Macrobenthos (note diversity and abundance) | 0 | (0.5) | 1 | 1.5 |
| 27. Filamentous algae; periphyton | 0 | 1 | (2) | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | 0.5 | (1) | 1.5 |
| 29[b]. Wetland plants in streambed | (FAC=0.5); FACW=0.75; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



WSH QC 01/08/0
TMB QC 01/08/0

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

| | | |
|---|---|---|
| **Date:** 7/20/06 | **Project:** LWO | **Latitude:** |
| **Evaluator:** TMB | **Site:** R2D | **Longitude:** |
| **Total Points:** 35.25<br>*Stream is at least intermittent if ≥19 or perennial if ≥30* | **County:** Polk | **Other** Mill Spring<br>*e.g. Quad Name:* |

| A. Geomorphology (Subtotal = 17) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | **3** |
| 2. Sinuosity | 0 | **1** | 2 | 3 |
| 3. In-Channel structure: riffle-pool sequence | 0 | **1** | 2 | 3 |
| 4. Soil texture or stream substrate sorting | 0 | 1 | **2** | 3 |
| 5. Active/relic floodplain | 0 | 1 | **2** | 3 |
| 6. Depositional bars or benches | 0 | **1** | 2 | 3 |
| 7. Braided channel | **0** | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | **1** | 2 | 3 |
| 9[a]. Natural levees | 0 | 1 | **2** | 3 |
| 10. Headcuts | 0 | 1 | **2** | 3 |
| 11. Grade controls | 0 | 0.5 | **1** | 1.5 |
| 12. Natural valley or drainageway | 0 | 0.5 | **1** | 1.5 |
| 13. Second or greater order channel on <u>existing</u> USGS or NRCS map or other documented evidence. | **No = 0** | | Yes = 3 | |

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

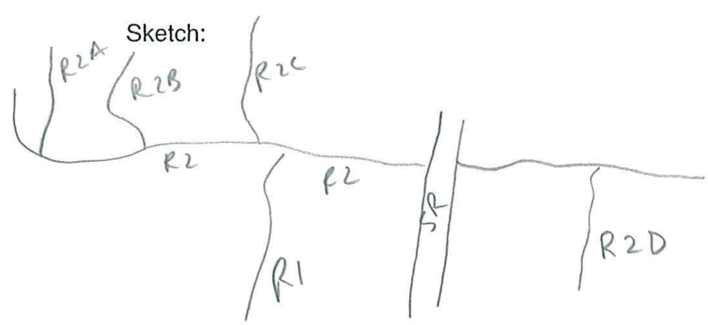
| B Hydrology (Subtotal = 9) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | 2 | **3** |
| 15. Water in channel and > 48 hrs. since rain, <u>or</u> Water in channel – dry or growing season | 0 | 1 | 2 | **3** |
| 16. Leaflitter | 1.5 | 1 | **0.5** | 0 |
| 17. Sediment on plants or debris | 0 | **0.5** | 1 | 1.5 |
| 18. Organic debris lines or piles (Wrack lines) | 0 | **0.5** | 1 | 1.5 |
| 19. Hydric soils (redoximorphic features) present? | No = 0 | | **Yes = 1.5** | |

| C. Biology (Subtotal = 9.25) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | 3 | **2** | 1 | 0 |
| 21[b]. Rooted plants in channel | 3 | 2 | **1** | 0 |
| 22. Crayfish | 0 | 0.5 | 1 | **1.5** |
| 23. Bivalves | **0** | 1 | 2 | 3 |
| 24. Fish | 0 | **0.5** | 1 | 1.5 |
| 25. Amphibians | 0 | 0.5 | 1 | **1.5** |
| 26. Macrobenthos (note diversity and abundance) | 0 | **0.5** | 1 | 1.5 |
| 27. Filamentous algae; periphyton | 0 | **1** | 2 | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | **0.5** | 1 | 1.5 |
| 29[b]. Wetland plants in streambed | FAC=0.5; **FACW=0.75**; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



# Reference Site Photographs
# UT to Ostin Creek

Beginning of the surveyed reach of the UT to Ostin Creek facing downstream.

UT to Ostin Creek approximately 172 linear feet from the start of the reference reach survey.

UT to Ostin Creek facing downstream approximately 400 feet from the start of reference reach survey.

Photo taken facing downstream at the end of the reference reach survey approximately 590 linear feet downstream of the start of the survey.

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

| | | |
|---|---|---|
| **Date:** 9/28/06 | **Project:** UT to Ostin Creek | **Latitude:** |
| **Evaluator:** TMB | **Site:** Reference Reach | **Longitude:** |
| **Total Points:** 53.5<br>*Stream is at least intermittent If ≥19 or perennial if ≥30* | **County:** Polk | **Other**<br>*e.g. Quad Name:* |

| A. Geomorphology (Subtotal = 27) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1[a]. Continuous bed and bank | 0 | 1 | 2 | **3** |
| 2. Sinuosity | 0 | 1 | 2 | **3** |
| 3. In-Channel structure: riffle-pool sequence | 0 | 1 | 2 | **3** |
| 4. Soil texture or stream substrate sorting | 0 | 1 | 2 | **3** |
| 5. Active/relic floodplain | 0 | 1 | 2 | **3** |
| 6. Depositional bars or benches | 0 | 1 | 2 | **3** |
| 7. Braided channel | **0** | 1 | 2 | 3 |
| 8. Recent alluvial deposits | 0 | 1 | 2 | **3** |
| 9[a]. Natural levees | 0 | 1 | **2** | 3 |
| 10. Headcuts | 0 | **1** | 2 | 3 |
| 11. Grade controls | 0 | 0.5 | 1 | **1.5** |
| 12. Natural valley or drainageway | 0 | 0.5 | 1 | **1.5** |
| 13. Second or greater order channel on existing USGS or NRCS map or other documented evidence. | **No = 0** | | Yes = 3 | |

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

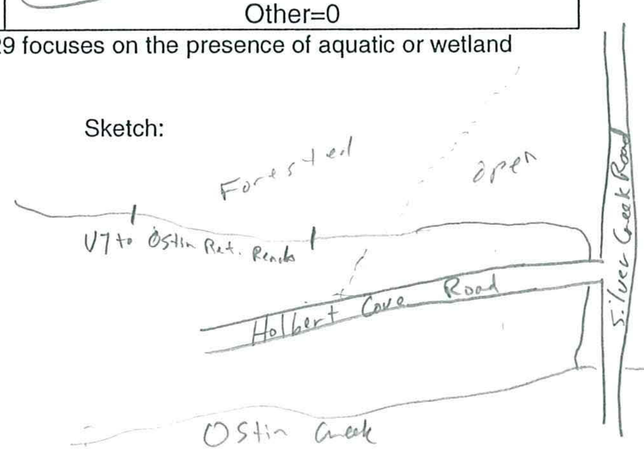
| B Hydrology (Subtotal = 11.5) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 14. Groundwater flow/discharge | 0 | 1 | 2 | **3** |
| 15. Water in channel and > 48 hrs. since rain, or Water in channel – dry or growing season | 0 | 1 | 2 | **3** |
| 16. Leaflitter | 1.5 | **1** | 0.5 | 0 |
| 17. Sediment on plants or debris | 0 | 0.5 | 1 | **1.5** |
| 18. Organic debris lines or piles (Wrack lines) | 0 | 0.5 | 1 | **1.5** |
| 19. Hydric soils (redoximorphic features) present? | No = 0 | | **Yes = 1.5** | |

| C. Biology (Subtotal = 15) | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 20[b]. Fibrous roots in channel | **3** | 2 | 1 | 0 |
| 21[b]. Rooted plants in channel | **3** | 2 | 1 | 0 |
| 22. Crayfish | 0 | 0.5 | 1 | **1.5** |
| 23. Bivalves | 0 | **1** | 2 | 3 |
| 24. Fish | 0 | 0.5 | 1 | **1.5** |
| 25. Amphibians | 0 | 0.5 | 1 | **1.5** |
| 26. Macrobenthos (note diversity and abundance) | 0 | 0.5 | 1 | **1.5** |
| 27. Filamentous algae; periphyton | 0 | **1** | 2 | 3 |
| 28. Iron Oxidizing bacteria/fungus | 0 | **0.5** | 1 | 1.5 |
| 29[b]. Wetland plants in streambed | **FAC=0.5**; FACW=0.75; OBL=1.5; SAV=2.0; Other=0 | | | |

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

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

Sketch:



## Flood Analysis for the 10 Year Event

| | | | | Water Surface Elevations (ft) | | |
|---|---|---|---|---|---|---|
| River | Reach | River Station | Discharge (cfs) | Existing Conditions | Proposed Conditions | Difference |
| SB Little White | R1-1 | 240 | 1450 | 891.2 | 889.0 | -2.2 |
| SB Little White | R1-1 | 230 | 838 | 890.1 | 887.5 | -2.6 |
| SB Little White | R1-1 | 220 | 838 | 889.9 | 887.0 | -2.9 |
| SB Little White | R1-1 | 210 | 838 | 888.0 | 886.5 | -1.5 |
| SB Little White | R1-1 | 200 | 838 | 887.1 | 885.6 | -1.5 |
| SB Little White | R1-1 | 190 | 838 | 886.3 | 884.8 | -1.5 |
| SB Little White | R1-1 | 170 | 838 | 885.0 | 882.8 | -2.2 |
| SB Little White | R1-1 | 160 | 870 | 884.3 | 882.2 | -2.1 |
| SB Little White | R1-1 | 150 | 870 | 883.4 | 880.6 | -2.7 |
| SB Little White | R1-1 | 140 | 870 | 881.8 | 879.8 | -2.0 |
| SB Little White | R1-1 | 130 | 870 | 881.5 | 879.3 | -2.2 |
| SB Little White | R1-1 | 120 | 870 | 881.7 | 878.9 | -2.7 |
| SB Little White | R1-1 | 110 | 884 | 881.5 | 878.6 | -3.0 |
| SB Little White | R1-1 | 100 | 884 | 881.5 | 878.5 | -3.0 |
| SB Little White | R1-1 | 90 | **Bridge** | | | |
| SB Little White | R1-1 | 80 | 884 | 880.5 | 878.1 | -2.4 |
| SB Little White | R1-1 | 70 | 884 | 879.9 | 878.0 | -1.9 |
| SB Little White | R1-1 | 60 | 884 | 879.5 | 877.6 | -1.9 |
| SB Little White | R1-1 | 50 | 884 | 877.9 | 875.3 | -2.5 |
| SB Little White | R1-1 | 40 | 884 | 877.6 | 875.6 | -1.9 |
| SB Little White | R1-1 | 30 | 884 | 877.0 | 875.4 | -1.6 |
| SB Little White | R1-1 | 20 | 884 | 876.5 | 874.5 | -2.0 |
| SB Little White | R1-1 | 10 | 884 | 873.7 | 873.9 | 0.1 |
| Little White Oak | R2-1 | 260 | 1000 | 882.5 | 879.7 | -2.8 |
| Little White Oak | R2-1 | 250 | 1000 | 881.9 | 879.5 | -2.4 |
| Little White Oak | R2-1 | 240 | 1000 | 881.7 | 879.2 | -2.5 |
| Little White Oak | R2-1 | 230 | 1000 | 881.1 | 878.6 | -2.5 |
| Little White Oak | R2-1 | 220 | 1000 | 881.1 | 878.4 | -2.7 |
| Little White Oak | R2-1 | 210 | 1000 | 879.5 | 877.7 | -1.8 |
| Little White Oak | R2-1 | 200 | 1080 | 879.3 | 877.1 | -2.2 |
| Little White Oak | R2-1 | 190 | 1080 | 878.1 | 876.6 | -1.5 |
| Little White Oak | R2-1 | 180 | 1080 | 876.5 | 875.7 | -0.8 |
| Little White Oak | R2-1 | 170 | 1080 | 876.3 | 874.8 | -1.5 |
| Little White Oak | R2-1 | 160 | 1080 | 873.9 | 874.2 | 0.3 |
| Little White Oak | R2-1 | 150 | 1100 | 874.6 | 873.8 | -0.9 |
| Little White Oak | R2-1 | 140 | 1100 | 874.6 | 873.6 | -1.0 |
| Little White Oak | R2-1 | 130 | 1100 | 874.6 | 873.5 | -1.1 |
| Little White Oak | R2-1 | 120 | 1600 | 874.4 | 872.8 | -1.6 |
| Little White Oak | R2-5 | 110 | 1600 | 874.3 | 872.5 | -1.8 |
| Little White Oak | R2-5 | 100 | 1600 | 874.1 | 872.2 | -1.9 |
| Little White Oak | R2-5 | 90 | 1600 | 873.6 | 871.8 | -1.9 |
| Little White Oak | R2-5 | 80 | 1600 | 873.6 | 871.6 | -1.9 |
| Little White Oak | R2-5 | 70 | **Bridge** | | | |
| Little White Oak | R2-5 | 60 | 1600 | 873.2 | 871.0 | -2.2 |
| Little White Oak | R2-5 | 50 | 1600 | 870.8 | 870.7 | 0.0 |
| Little White Oak | R2-5 | 40 | 1620 | 870.7 | 870.5 | -0.2 |
| Little White Oak | R2-5 | 30 | 1620 | 870.5 | 870.4 | -0.1 |
| Little White Oak | R2-5 | 10 | 1620 | 870.2 | 870.2 | 0.0 |

## Flood Analysis for the 50 Year Event

| | | | | Water Surface Elevations (ft) | | |
|---|---|---|---|---|---|---|
| River | Reach | River Station | Discharge (cfs) | Existing Conditions | Proposed Conditions | Difference |
| SB Little White | R1-1 | 240 | 1450 | 892.9 | 890.4 | -2.5 |
| SB Little White | R1-1 | 230 | 1450 | 891.7 | 889.1 | -2.6 |
| SB Little White | R1-1 | 220 | 1450 | 891.6 | 888.6 | -2.9 |
| SB Little White | R1-1 | 210 | 1450 | 889.3 | 888.2 | -1.2 |
| SB Little White | R1-1 | 200 | 1450 | 888.5 | 887.2 | -1.3 |
| SB Little White | R1-1 | 190 | 1450 | 887.0 | 886.4 | -0.6 |
| SB Little White | R1-1 | 170 | 1450 | 886.8 | 884.4 | -2.4 |
| SB Little White | R1-1 | 160 | 1510 | 885.7 | 883.9 | -1.8 |
| SB Little White | R1-1 | 150 | 1510 | 885.0 | 882.4 | -2.6 |
| SB Little White | R1-1 | 140 | 1510 | 881.9 | 881.5 | -0.4 |
| SB Little White | R1-1 | 130 | 1510 | 882.6 | 880.9 | -1.7 |
| SB Little White | R1-1 | 120 | 1510 | 882.6 | 880.6 | -2.0 |
| SB Little White | R1-1 | 110 | 1530 | 882.4 | 880.2 | -2.3 |
| SB Little White | R1-1 | 100 | 1530 | 882.4 | 880.1 | -2.3 |
| SB Little White | R1-1 | 90 | **Bridge** | | | |
| SB Little White | R1-1 | 80 | 1530 | 881.6 | 879.6 | -2.0 |
| SB Little White | R1-1 | 70 | 1530 | 881.1 | 879.5 | -1.6 |
| SB Little White | R1-1 | 60 | 1530 | 880.9 | 878.9 | -2.0 |
| SB Little White | R1-1 | 50 | 1530 | 879.1 | 876.8 | -2.3 |
| SB Little White | R1-1 | 40 | 1530 | 879.4 | 877.0 | -2.4 |
| SB Little White | R1-1 | 30 | 1530 | 879.1 | 876.8 | -2.3 |
| SB Little White | R1-1 | 20 | 1530 | 875.4 | 875.5 | 0.1 |
| SB Little White | R1-1 | 10 | 1530 | 875.9 | 875.2 | -0.7 |
| Little White Oak | R2-1 | 260 | 1730 | 883.8 | 881.4 | -2.4 |
| Little White Oak | R2-1 | 250 | 1730 | 882.4 | 881.3 | -1.1 |
| Little White Oak | R2-1 | 240 | 1730 | 882.5 | 880.9 | -1.6 |
| Little White Oak | R2-1 | 230 | 1730 | 881.9 | 880.4 | -1.5 |
| Little White Oak | R2-1 | 220 | 1730 | 881.5 | 880.1 | -1.4 |
| Little White Oak | R2-1 | 210 | 1730 | 880.3 | 879.2 | -1.1 |
| Little White Oak | R2-1 | 200 | 1850 | 879.5 | 878.5 | -1.0 |
| Little White Oak | R2-1 | 190 | 1850 | 878.4 | 877.9 | -0.5 |
| Little White Oak | R2-1 | 180 | 1850 | 877.2 | 876.7 | -0.5 |
| Little White Oak | R2-1 | 170 | 1850 | 876.0 | 875.6 | -0.4 |
| Little White Oak | R2-1 | 160 | 1850 | 876.0 | 875.1 | -0.9 |
| Little White Oak | R2-1 | 150 | 1890 | 876.0 | 875.0 | -1.0 |
| Little White Oak | R2-1 | 140 | 1890 | 876.0 | 875.0 | -1.0 |
| Little White Oak | R2-1 | 130 | 1890 | 876.0 | 874.9 | -1.0 |
| Little White Oak | R2-1 | 120 | 2710 | 875.8 | 874.5 | -1.3 |
| Little White Oak | R2-5 | 110 | 2710 | 875.7 | 874.3 | -1.4 |
| Little White Oak | R2-5 | 100 | 2710 | 875.5 | 873.9 | -1.6 |
| Little White Oak | R2-5 | 90 | 2710 | 874.9 | 873.1 | -1.7 |
| Little White Oak | R2-5 | 80 | 2710 | 874.8 | 872.9 | -1.8 |
| Little White Oak | R2-5 | 70 | **Bridge** | | | |
| Little White Oak | R2-5 | 60 | 2710 | 873.1 | 872.0 | -1.1 |
| Little White Oak | R2-5 | 50 | 2710 | 872.3 | 871.6 | -0.8 |
| Little White Oak | R2-5 | 40 | 2740 | 871.5 | 871.4 | -0.1 |
| Little White Oak | R2-5 | 30 | 2740 | 871.3 | 871.3 | 0.0 |
| Little White Oak | R2-5 | 10 | 2740 | 871.0 | 871.0 | 0.0 |

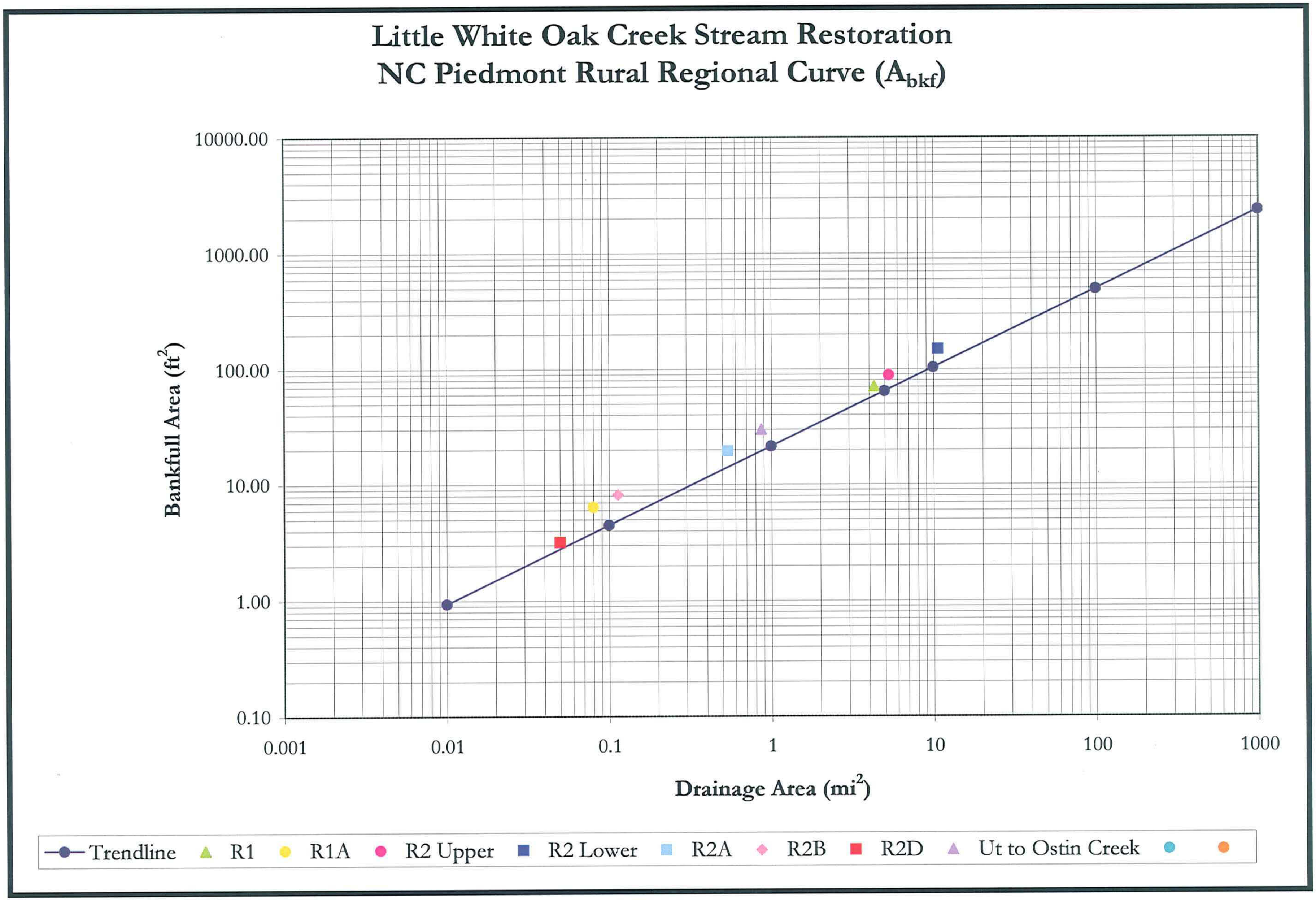
## Flood Analysis for the 100 Year Event

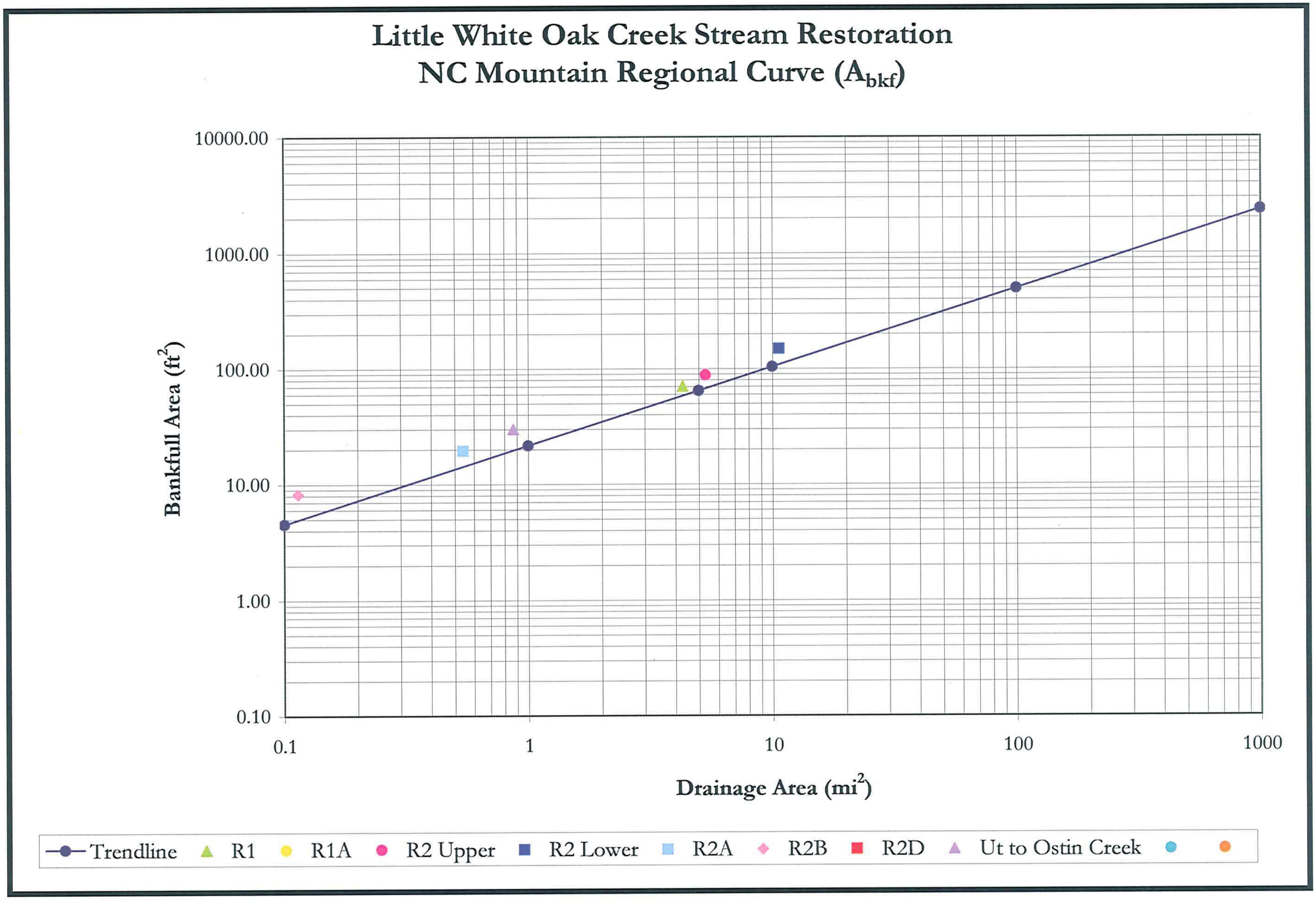
| | | | | Water Surface Elevations (ft) | | |
|---|---|---|---|---|---|---|
| River | Reach | River Station | Discharge (cfs) | Existing Conditions | Proposed Conditions | Difference |
| SB Little White | R1-1 | 240 | 1770 | 893.5 | 891.0 | -2.5 |
| SB Little White | R1-1 | 230 | 1770 | 892.4 | 889.8 | -2.6 |
| SB Little White | R1-1 | 220 | 1770 | 892.3 | 889.3 | -3.0 |
| SB Little White | R1-1 | 210 | 1770 | 889.7 | 888.9 | -0.8 |
| SB Little White | R1-1 | 200 | 1770 | 889.1 | 888.0 | -1.1 |
| SB Little White | R1-1 | 190 | 1770 | 887.2 | 887.1 | 0.0 |
| SB Little White | R1-1 | 170 | 1770 | 886.6 | 885.1 | -1.5 |
| SB Little White | R1-1 | 160 | 1840 | 886.2 | 884.6 | -1.6 |
| SB Little White | R1-1 | 150 | 1840 | 884.5 | 883.0 | -1.5 |
| SB Little White | R1-1 | 140 | 1840 | 883.1 | 882.0 | -1.1 |
| SB Little White | R1-1 | 130 | 1840 | 882.9 | 881.6 | -1.3 |
| SB Little White | R1-1 | 120 | 1840 | 882.8 | 881.3 | -1.6 |
| SB Little White | R1-1 | 110 | 1870 | 882.7 | 881.0 | -1.7 |
| SB Little White | R1-1 | 100 | 1870 | 882.6 | 880.9 | -1.7 |
| SB Little White | R1-1 | 90 | **Bridge** | | | |
| SB Little White | R1-1 | 80 | 1870 | 881.9 | 880.3 | -1.6 |
| SB Little White | R1-1 | 70 | 1870 | 881.2 | 880.2 | -1.1 |
| SB Little White | R1-1 | 60 | 1870 | 881.0 | 879.6 | -1.4 |
| SB Little White | R1-1 | 50 | 1870 | 879.8 | 877.5 | -2.3 |
| SB Little White | R1-1 | 40 | 1870 | 879.7 | 877.8 | -2.0 |
| SB Little White | R1-1 | 30 | 1870 | 878.9 | 877.4 | -1.5 |
| SB Little White | R1-1 | 20 | 1870 | 876.7 | 875.8 | -0.9 |
| SB Little White | R1-1 | 10 | 1870 | 876.4 | 875.8 | -0.6 |
| Little White Oak | R2-1 | 260 | 2110 | 884.5 | 882.1 | -2.4 |
| Little White Oak | R2-1 | 250 | 2110 | 882.5 | 882.0 | -0.4 |
| Little White Oak | R2-1 | 240 | 2110 | 882.9 | 881.7 | -1.2 |
| Little White Oak | R2-1 | 230 | 2110 | 882.2 | 881.0 | -1.2 |
| Little White Oak | R2-1 | 220 | 2110 | 881.7 | 880.7 | -1.0 |
| Little White Oak | R2-1 | 210 | 2110 | 880.5 | 879.6 | -0.9 |
| Little White Oak | R2-1 | 200 | 2250 | 879.7 | 878.9 | -0.8 |
| Little White Oak | R2-1 | 190 | 2250 | 878.7 | 878.2 | -0.5 |
| Little White Oak | R2-1 | 180 | 2250 | 877.4 | 877.1 | -0.3 |
| Little White Oak | R2-1 | 170 | 2250 | 876.5 | 875.9 | -0.6 |
| Little White Oak | R2-1 | 160 | 2250 | 876.5 | 875.7 | -0.8 |
| Little White Oak | R2-1 | 150 | 2300 | 876.5 | 875.6 | -0.9 |
| Little White Oak | R2-1 | 140 | 2300 | 876.4 | 875.6 | -0.9 |
| Little White Oak | R2-1 | 130 | 2300 | 876.4 | 875.5 | -0.9 |
| Little White Oak | R2-1 | 120 | 3280 | 876.3 | 875.2 | -1.1 |
| Little White Oak | R2-5 | 110 | 3280 | 876.2 | 875.0 | -1.2 |
| Little White Oak | R2-5 | 100 | 3280 | 876.0 | 874.5 | -1.4 |
| Little White Oak | R2-5 | 90 | 3280 | 875.1 | 873.6 | -1.5 |
| Little White Oak | R2-5 | 80 | 3280 | 875.0 | 873.4 | -1.6 |
| Little White Oak | R2-5 | 70 | **Bridge** | | | |
| Little White Oak | R2-5 | 60 | 3280 | 873.4 | 872.4 | -1.0 |
| Little White Oak | R2-5 | 50 | 3280 | 872.5 | 871.9 | -0.6 |
| Little White Oak | R2-5 | 40 | 3310 | 871.9 | 871.8 | -0.1 |
| Little White Oak | R2-5 | 30 | 3310 | 871.6 | 871.6 | 0.0 |
| Little White Oak | R2-5 | 10 | 3310 | 871.4 | 871.4 | 0.0 |

## Flood Analysis for the 500 Year Event

| | | | | Water Surface Elevations (ft) | | |
|---|---|---|---|---|---|---|
| River | Reach | River Station | Discharge (cfs) | Existing Conditions | Proposed Conditions | Difference |
| SB Little White | R1-1 | 240 | 1450 | 894.6 | 893.2 | -1.5 |
| SB Little White | R1-1 | 230 | 2690 | 893.3 | 891.3 | -2.0 |
| SB Little White | R1-1 | 220 | 2690 | 893.3 | 890.8 | -2.5 |
| SB Little White | R1-1 | 210 | 2690 | 891.5 | 890.3 | -1.2 |
| SB Little White | R1-1 | 200 | 2690 | 890.4 | 889.0 | -1.4 |
| SB Little White | R1-1 | 190 | 2690 | 887.3 | 888.4 | 1.1 |
| SB Little White | R1-1 | 170 | 2690 | 887.0 | 886.3 | -0.7 |
| SB Little White | R1-1 | 160 | 2780 | 886.8 | 886.0 | -0.7 |
| SB Little White | R1-1 | 150 | 2780 | 885.1 | 884.1 | -0.9 |
| SB Little White | R1-1 | 140 | 2780 | 883.5 | 883.5 | 0.0 |
| SB Little White | R1-1 | 130 | 2780 | 883.5 | 883.4 | -0.1 |
| SB Little White | R1-1 | 120 | 2780 | 883.5 | 883.4 | -0.1 |
| SB Little White | R1-1 | 110 | 2820 | 883.2 | 883.2 | 0.0 |
| SB Little White | R1-1 | 100 | 2820 | 883.1 | 883.1 | 0.0 |
| SB Little White | R1-1 | 90 | **Bridge** | | | |
| SB Little White | R1-1 | 80 | 2820 | 882.7 | 881.5 | -1.1 |
| SB Little White | R1-1 | 70 | 2820 | 882.2 | 881.4 | -0.7 |
| SB Little White | R1-1 | 60 | 2820 | 881.9 | 881.1 | -0.8 |
| SB Little White | R1-1 | 50 | 2820 | 880.5 | 878.2 | -2.4 |
| SB Little White | R1-1 | 40 | 2820 | 880.5 | 878.7 | -1.8 |
| SB Little White | R1-1 | 30 | 2820 | 879.6 | 877.8 | -1.9 |
| SB Little White | R1-1 | 20 | 2820 | 878.1 | 878.2 | 0.1 |
| SB Little White | R1-1 | 10 | 2820 | 878.0 | 878.1 | 0.1 |
| Little White Oak | R2-1 | 260 | 3170 | 885.0 | 883.1 | -1.9 |
| Little White Oak | R2-1 | 250 | 3170 | 883.7 | 883.1 | -0.6 |
| Little White Oak | R2-1 | 240 | 3170 | 883.8 | 882.9 | -0.9 |
| Little White Oak | R2-1 | 230 | 3170 | 883.2 | 882.0 | -1.2 |
| Little White Oak | R2-1 | 220 | 3170 | 882.2 | 881.6 | -0.6 |
| Little White Oak | R2-1 | 210 | 3170 | 881.1 | 880.4 | -0.7 |
| Little White Oak | R2-1 | 200 | 3390 | 880.1 | 879.6 | -0.5 |
| Little White Oak | R2-1 | 190 | 3390 | 879.2 | 879.0 | -0.1 |
| Little White Oak | R2-1 | 180 | 3390 | 878.4 | 878.4 | 0.0 |
| Little White Oak | R2-1 | 170 | 3390 | 878.1 | 878.1 | 0.0 |
| Little White Oak | R2-1 | 160 | 3390 | 878.0 | 878.1 | 0.0 |
| Little White Oak | R2-1 | 150 | 3460 | 878.0 | 878.1 | 0.0 |
| Little White Oak | R2-1 | 140 | 3460 | 878.0 | 878.1 | 0.0 |
| Little White Oak | R2-1 | 130 | 3460 | 878.0 | 878.0 | 0.0 |
| Little White Oak | R2-1 | 120 | 4870 | 877.9 | 877.9 | 0.0 |
| Little White Oak | R2-5 | 110 | 4870 | 877.8 | 877.8 | 0.0 |
| Little White Oak | R2-5 | 100 | 4870 | 877.6 | 877.5 | -0.1 |
| Little White Oak | R2-5 | 90 | 4870 | 876.8 | 876.9 | 0.2 |
| Little White Oak | R2-5 | 80 | 4870 | 876.6 | 876.6 | 0.0 |
| Little White Oak | R2-5 | 70 | **Bridge** | | | |
| Little White Oak | R2-5 | 60 | 4870 | 874.0 | 873.1 | -0.9 |
| Little White Oak | R2-5 | 50 | 4870 | 873.0 | 872.8 | -0.2 |
| Little White Oak | R2-5 | 40 | 4910 | 872.8 | 872.7 | -0.1 |
| Little White Oak | R2-5 | 30 | 4910 | 872.5 | 872.5 | 0.0 |
| Little White Oak | R2-5 | 10 | 4910 | 872.2 | 872.2 | 0.0 |

| Data Entry for New Reach | | | |
|---|---|---|---|
| **No.** | **Reach Name** | **Drainage Area ($mi^2$)** | **$A_{bkf}$ ($ft^2$)** |
| 1 | R1 | 4.3 | 70.4 |
| 2 | R1A | 0.08 | 6.4 |
| 3 | R2 Upper | 5.33 | 88 |
| 4 | R2 Lower | 10.656 | 148.5 |
| 5 | R2A | 0.54 | 19.5 |
| 6 | R2B | 0.114 | 8.2 |
| 7 | R2D | 0.05 | 3.2 |
| 8 | Ut to Ostin Creek | 0.87 | 30 |
| 9 | | | |
| 10 | | | |


Little White Oak Creek Stream Restoration
NC Piedmont Rural Regional Curve ($A_{bkf}$)
10000.00
1000.00
100.00
10.00
1.00
0.10
Bankfull Area (ft²)
0.001
0.01
0.1
1
10
100
1000
Drainage Area (mi²)
Trendline
R1
R1A
R2 Upper
R2 Lower
R2A
R2B
R2D
Ut to Ostin Creek


Little White Oak Creek Stream Restoration
NC Mountain Regional Curve ($A_{bkf}$)
10000.00
1000.00
100.00
10.00
1.00
0.10
Bankfull Area ($ft^2$)
0.1
1
10
100
1000
Drainage Area ($mi^2$)
Trendline
R1
R1A
R2 Upper
R2 Lower
R2A
R2B
R2D
Ut to Ostin Creek

# Entrainment Calculation Form

Project: 2006237.00 | Location: Polk County
Stream: Little White Oak Creek | Reach: R1 XS #2 (Existing)
Date: 12/1/2006 | Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | # Choose one |
| 7.87 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# |
| 2.9 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 27 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.089 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.00284 | S (ft/ft) | Bankfull Water Surface Slope |
| 3.43 | d (ft) | Bankfull Mean Depth |
| 69.72 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 25.36 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 2.71 | $D_{50}/\hat{D}_{50}$ | Range 3-7 Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 3.43 | $D_i/D_{50}$ | Range 1.3-3.0 Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.035 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress Equation Used: 1 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 1.797 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 1.909 | $d/d_r$ | **Stability:** **Degrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.001 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 1.909 | $S/S_r$ | **Stability:** **Degrading** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 2.75 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.487 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 90 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.095 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 1/19/2007
Location: Polk County
Reach: R1 XS #2 Proposed (Actual Designed Slope)
Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 7.87 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 2.9 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 27 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.089 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.00286 | S (ft/ft) | Bankfull Water Surface Slope | |
| 2 | d (ft) | Bankfull Mean Depth | |
| 52 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 29.7 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| | | | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 2.71 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 3.43 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.035 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

| | | |
|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 1.785 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 1.121 | $d/d_r$ | **Stability:** **Degrading** |

| | | |
|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.003 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 1.121 | $S/S_r$ | **Stability:** **Degrading** |

| | | |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 1.75 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.312 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 65 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.095 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

## Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/1/2006

Location: Polk County
Reach: R1 XS #2 Proposed (iteration 1)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 7.87 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# (# Choose one) |
| 2.9 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 27 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.089 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0025 | S (ft/ft) | Bankfull Water Surface Slope |
| 2.3 | d (ft) | Bankfull Mean Depth |
| 61 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 31.1 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 2.71 | $D_{50}/\hat{D}_{50}$ | Range 3-7 Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 3.43 | $D_i/D_{50}$ | Range 1.3-3.0 Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.035 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 1 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 2.042 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 1.127 | $d/d_r$ | **Stability:** Degrading |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.002 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 1.127 | $S/S_r$ | **Stability:** Degrading |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 1.96 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.306 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 64 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.095 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/1/2006

Location: Polk County
Reach: R1 XS #2 Proposed (iteration 2)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 7.87 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# (# Choose one) |
| 2.9 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 27 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.089 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0025 | S (ft/ft) | Bankfull Water Surface Slope |
| 2.1 | d (ft) | Bankfull Mean Depth |
| 52 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 28.7 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 2.71 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 3.43 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.035 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 1 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 2.042 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 1.029 | $d/d_r$ | **Stability:** Degrading |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.002 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 1.029 | $S/S_r$ | **Stability:** Degrading |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 1.81 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.283 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 60 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.095 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

| | | | |
|---|---|---|---|
| Project: | 2006237.00 | Location: | Polk County |
| Stream: | Little White Oak Creek | Reach: | R1 XS #2 Proposed (iteration 3) |
| Date: | 12/1/2006 | Observers: | EMP TMB |

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 7.87 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 2.9 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 27 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.089 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.0025 | S (ft/ft) | Bankfull Water Surface Slope | |
| 2 | d (ft) | Bankfull Mean Depth | |
| 52 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 29.5 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 2.71 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 3.43 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.035 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

| Value | Variable | Definition | |
|---|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| 2.042 | $d_r$ | Required Bankfull Mean Depth (ft) | $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 0.980 | $d/d_r$ | **Stability:** | Aggrading |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| 0.003 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) | $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 0.980 | $S/S_r$ | **Stability:** | Aggrading |

| Value | Variable | Definition |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 1.76 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.275 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 59 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.095 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

## Entrainment Calculation Form

| | | | |
|---|---|---|---|
| Project: | 2006237.00 | Location: | Polk County |
| Stream: | Little White Oak Creek | Reach: | R1A XS #4 (Existing) |
| Date: | 12/4/2006 | Observers: | EMP TMB |

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | # Choose one |
| 9.17 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 22 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.072 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.01219 | S (ft/ft) | Bankfull Water Surface Slope | |
| 0.36 | d (ft) | Bankfull Mean Depth | |
| 1.62 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 4.72 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

**Calculation of Critical Dimensionless Shear Stress**

| Value | Variable | Definition | |
|---|---|---|---|
| 91.70 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.40 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.018 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 2 |

**Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle**

| Value | Variable | Definition |
|---|---|---|
| 0.173 | $d_r$ | Required Bankfull Mean Depth (ft) |
| | | $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 2.085 | $d/d_r$ | Stability: Degrading |

**Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle**

| Value | Variable | Definition |
|---|---|---|
| 0.006 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) |
| | | $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 2.085 | $S/S_r$ | Stability: Degrading |

**Sediment Transport Validation - Bankfull Shear Stress**

| Value | Variable | Definition |
|---|---|---|
| 0.34 | R | Hydraulic Radius (ft) |
| | | $R = A/W_p$ |
| 0.261 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) |
| | | $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 57 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.072 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00 | Location: Polk County
Stream: Little White Oak Creek | Reach: R1A XS #4 Proposed (Actual Designed Slope)
Date: 1/19/2007 | Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | # Choose one |
| 9.17 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 22 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.072 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0196 | S (ft/ft) | Bankfull Water Surface Slope |
| 0.63 | d (ft) | Bankfull Mean Depth |
| 5 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 9.3 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 91.70 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.40 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.018 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 2 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 0.107 | $d_r$ | Required Bankfull Mean Depth (ft): $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 5.868 | $d/d_r$ | **Stability: Degrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.003 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft): $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 5.868 | $S/S_r$ | **Stability: Degrading** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.54 | R | Hydraulic Radius (ft): $R = A/W_p$ |
| 0.658 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$): $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 112 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.072 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

| | | | |
|---|---|---|---|
| Project: | 2006237.00 | Location: | Polk County |
| Stream: | Little White Oak Creek | Reach: | R1A XS #4 Proposed (iteration 1) |
| Date: | 12/5/2006 | Observers: | EMP TMB |

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | # Choose one |
| 9.17 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 22 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.072 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0099 | S (ft/ft) | Bankfull Water Surface Slope |
| 0.66 | d (ft) | Bankfull Mean Depth |
| 5 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 8.92 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |

## Calculation of Critical Dimensionless Shear Stress

| Value | Variable | Definition |
|---|---|---|
| 91.70 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.40 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.018 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 2 |

## Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle

| Value | Variable | Definition |
|---|---|---|
| 0.213 | $d_r$ | Required Bankfull Mean Depth (ft) $$d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$$ |
| 3.105 | $d/d_r$ | **Stability:** **Degrading** |

## Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle

| Value | Variable | Definition |
|---|---|---|
| 0.003 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $$S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$$ |
| 3.105 | $S/S_r$ | **Stability:** **Degrading** |

## Sediment Transport Validation - Bankfull Shear Stress

| Value | Variable | Definition |
|---|---|---|
| 0.56 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.346 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 70 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.072 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/5/2006

Location: Polk County
Reach: R1A XS #4 Proposed (iteration 2)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | # Choose one |
| 9.17 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 22 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.072 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0099 | S (ft/ft) | Bankfull Water Surface Slope |
| 0.63 | d (ft) | Bankfull Mean Depth |
| 5 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 9.16 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |

| Value | Variable | Definition |
|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 91.70 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.40 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.018 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 2 |

| Value | Variable | Definition |
|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 0.213 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 2.964 | $d/d_r$ | **Stability:** **Degrading** |

| Value | Variable | Definition |
|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.003 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 2.964 | $S/S_r$ | **Stability:** **Degrading** |

| Value | Variable | Definition |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.55 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.337 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 68 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.072 | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006

Location: Polk County
Reach: R2 Upper XS #1 (Existing)
Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 13.96 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 3.87 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 37 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.121 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.00211 | S (ft/ft) | Bankfull Water Surface Slope | |
| 3.14 | d (ft) | Bankfull Mean Depth | |
| 76.12 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 28 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

**Calculation of Critical Dimensionless Shear Stress**

| | | | |
|---|---|---|---|
| 3.61 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.65 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.027 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

**Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle**

| | | |
|---|---|---|
| 2.586 | $d_r$ | Required Bankfull Mean Depth (ft) |
| | | $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 1.214 | $d/d_r$ | Stability: Degrading |

**Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle**

| | | |
|---|---|---|
| 0.002 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) |
| | | $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 1.214 | $S/S_r$ | Stability: Degrading |

**Sediment Transport Validation - Bankfull Shear Stress**

| | | |
|---|---|---|
| 2.72 | R | Hydraulic Radius (ft)<br>$R = A/W_p$ |
| 0.358 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$)<br>$\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous?<br>Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 71 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.146 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 1/19/2007
Location: Polk Co
Reach: R2 Upper Proposed (Actual Designed Slope)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 13.96 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# — # Choose one |
| 3.87 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 37 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.121 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.00171 | S (ft/ft) | Bankfull Water Surface Slope |
| 2.4 | d (ft) | Bankfull Mean Depth |
| 76 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 35.9 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 3.61 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.65 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.027 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 1 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 3.191 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 0.752 | $d/d_r$ | **Stability:** **Aggrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.002 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 0.752 | $S/S_r$ | **Stability:** **Aggrading** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 2.12 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.226 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 51 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.146 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006

Location: Polk Co
Reach: R2 Upper Proposed (iteration 1)
Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | # Choose one |
| 13.96 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | |
| 3.87 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 37 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.121 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.0018 | S (ft/ft) | Bankfull Water Surface Slope | |
| 2.6 | d (ft) | Bankfull Mean Depth | |
| 76 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 34.7 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| | | | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 3.61 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.65 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.027 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

| | | |
|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 3.032 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 0.858 | $d/d_r$ | **Stability:** **Aggrading** |

| | | |
|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.002 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 0.858 | $S/S_r$ | **Stability:** **Aggrading** |

| | | |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 2.19 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.246 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 54 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.146 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00 | Location: Polk Co
Stream: Little White Oak Creek | Reach: R2 Upper Proposed (iteration 2)
Date: 12/4/2006 | Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | # Choose one |
| 13.96 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# |
| 3.87 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 37 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.121 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0018 | S (ft/ft) | Bankfull Water Surface Slope |
| 2.5 | d (ft) | Bankfull Mean Depth |
| 76 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 35.8 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 3.61 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.65 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.027 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 1 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 3.032 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 0.825 | $d/d_r$ | **Stability:** Aggrading |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.002 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 0.825 | $S/S_r$ | **Stability:** Aggrading |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 2.12 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.238 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 53 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.146 | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

## Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006

Location: Polk County
Reach: R2 Lower XS #4 (Existing)
Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | # Choose one |
| 4.25 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 21 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.069 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.001889 | S (ft/ft) | Bankfull Water Surface Slope | |
| 3.49 | d (ft) | Bankfull Mean Depth | |
| 99.68 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 32.87 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| | | | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 42.50 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 4.94 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.009 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 2 |

| | | |
|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 0.560 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 6.230 | $d/d_r$ | **Stability:** **Degrading** |

| | | |
|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.000 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 6.230 | $S/S_r$ | **Stability:** **Degrading** |

| | | |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 3.03 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.357 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 71 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.068 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 1/19/2007

Location: Polk Co
Reach: Proposed R2 Lower (Actual Designed Slope)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 4.25 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# (# Choose one) |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 21 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.069 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.00149 | S (ft/ft) | Bankfull Water Surface Slope |
| 2.8 | d (ft) | Bankfull Mean Depth |
| 100 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 41.2 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 42.50 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 4.94 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| N/A | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: N/A |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| N/A | $d_r$ | Required Bankfull Mean Depth (ft): $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| N/A | $d/d_r$ | **Stability:** N/A |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| N/A | $S_r$ | Required Bankfull Water Surface Slope (ft/ft): $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| N/A | $S/S_r$ | **Stability:** N/A |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 2.43 | R | Hydraulic Radius (ft): $R = A/W_p$ |
| 0.226 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$): $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 51 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.068 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

## Entrainment Calculation Form

| | |
|---|---|
| Project: 2006237.00 | Location: Polk Co |
| Stream: Little White Oak Creek | Reach: Proposed R2 Lower (iteration 1) |
| Date: 12/4/2006 | Observers: EMP TMB |

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 4.25 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 21 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.069 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.0016 | S (ft/ft) | Bankfull Water Surface Slope | |
| 3 | d (ft) | Bankfull Mean Depth | |
| 105 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 40.7 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| | | | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 42.50 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 4.94 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| N/A | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: N/A |

| | | |
|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| N/A | $d_r$ | Required Bankfull Mean Depth (ft) $$d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$$ |
| N/A | $d/d_r$ | **Stability:** N/A |

| | | |
|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| N/A | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $$S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$$ |
| N/A | $S/S_r$ | **Stability:** N/A |

| | | |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 2.58 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.258 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 56 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.068 | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006
Location: Polk Co
Reach: Proposed R2 Lower (iteration 2)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| **4.25** | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement#    # Choose one |
| **0.1** | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| **21** | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| **0.069** | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| **0.0016** | S (ft/ft) | Bankfull Water Surface Slope |
| **2.8** | d (ft) | Bankfull Mean Depth |
| **100** | A ($ft^2$) | Bankfull Cross Sectional Area |
| **41** | $W_p$ (ft) | Wetted Perimeter |
| **1.65** | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| **62.4** | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| **42.50** | $D_{50}/\hat{D}_{50}$ | Range 3-7   Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| **4.94** | $D_i/D_{50}$ | Range 1.3-3.0   Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| **N/A** | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress   Equation Used: **N/A** |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| **N/A** | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| **N/A** | $d/d_r$ | **Stability:** **N/A** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| **N/A** | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| **N/A** | $S/S_r$ | **Stability:** **N/A** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| **2.44** | R | Hydraulic Radius (ft) $R = A/W_p$ |
| **0.244** | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| **N** | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| **N/A** | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| **N/A** | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| **54** | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| **0.068** | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006

Location: Polk County
Reach: R2A XS #3 (Existing)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 20.68 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# — # Choose one |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 55 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.180 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.01069 | S (ft/ft) | Bankfull Water Surface Slope |
| 1.5 | d (ft) | Bankfull Mean Depth |
| 16.78 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 13.16 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 206.80 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.66 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.016 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 2 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 0.449 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 3.340 | $d/d_r$ | **Stability:** **Degrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.003 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 3.340 | $S/S_r$ | **Stability:** **Degrading** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 1.28 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.851 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 135 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.251 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

## Entrainment Calculation Form

| | | | |
|---|---|---|---|
| Project: | 2006237.00 | Location: | Polk County |
| Stream: | Little White Oak Creek | Reach: | R2A XS #3 Proposed (Actual Designed Slope) |
| Date: | 1/19/2007 | Observers: | EMP TMB |

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| **20.68** | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| **0.1** | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| **55** | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| **0.180** | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| **0.011** | S (ft/ft) | Bankfull Water Surface Slope | |
| **0.94** | d (ft) | Bankfull Mean Depth | |
| **11** | A ($ft^2$) | Bankfull Cross Sectional Area | |
| **13.6** | $W_p$ (ft) | Wetted Perimeter | |
| **1.65** | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| **62.4** | $\gamma$ (lbs/$ft^3$) | Density of Water (62.4) | |
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| **206.80** | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| **2.66** | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| **0.016** | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: **2** |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| **0.436** | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ | |
| **2.154** | $d/d_r$ | **Stability:** | **Degrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| **0.005** | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ | |
| **2.154** | $S/S_r$ | **Stability:** | **Degrading** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | | |
| **0.81** | R | Hydraulic Radius (ft) $R = A/W_p$ | |
| **0.555** | $\tau_c$ | Bankfull Shear Stress (lb/$ft^2$) $\tau_c = \gamma RS$ | |
| **N** | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. | |
| **N/A** | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. | |
| **N/A** | lb/$ft^2$* | Predicted Shear Stress (lbs/$ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. | |
| **99** | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. | |
| **0.251** | lb/$ft^2$* | Predicted Shear Stress (lbs/$ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. | |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

| | | | |
|---|---|---|---|
| Project: | 2006237.00 | Location: | Polk County |
| Stream: | Little White Oak Creek | Reach: | R2A XS #3 Proposed (iteration 1) |
| Date: | 12/5/2006 | Observers: | EMP TMB |

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 20.68 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 55 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.180 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.0107 | S (ft/ft) | Bankfull Water Surface Slope | |
| 1.1 | d (ft) | Bankfull Mean Depth | |
| 14 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 14.9 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| | | | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 206.80 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.66 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.016 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 2 |

| | | | |
|---|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| 0.449 | $d_r$ | Required Bankfull Mean Depth (ft) | $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 2.451 | $d/d_r$ | **Stability:** | **Degrading** |

| | | | |
|---|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| 0.004 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) | $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 2.451 | $S/S_r$ | **Stability:** | **Degrading** |

| | | |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.94 | R | Hydraulic Radius (ft)<br>$R = A/W_p$ |
| 0.627 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$)<br>$\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous?<br>Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 108 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.251 | $lb/ft^{2*}$ | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/5/2006
Location: Polk County
Reach: R2A XS #3 Proposed (iteration 2)
Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 20.68 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 55 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.180 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.0107 | S (ft/ft) | Bankfull Water Surface Slope | |
| 1.1 | d (ft) | Bankfull Mean Depth | |
| 14 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 15.4 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| Value | Variable | Definition | | |
|---|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | | |
| 206.80 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ | |
| 2.66 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ | |
| 0.016 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: | 2 |

| Value | Variable | Definition | |
|---|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| 0.449 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ | |
| 2.451 | $d/d_r$ | **Stability:** | **Degrading** |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| 0.004 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ | |
| 2.451 | $S/S_r$ | **Stability:** | **Degrading** |

| Value | Variable | Definition |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.91 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.607 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 105 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.251 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/5/2006

Location: Polk County
Reach: R2A XS #3 Proposed (iteration 3)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 20.68 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# (# Choose one) |
| 0.1 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 55 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.180 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.0107 | S (ft/ft) | Bankfull Water Surface Slope |
| 0.9 | d (ft) | Bankfull Mean Depth |
| 11 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 13.5 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 206.80 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.66 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.016 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 2 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 0.449 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 2.006 | $d/d_r$ | **Stability:** **Degrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.005 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 2.006 | $S/S_r$ | **Stability:** **Degrading** |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.81 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.544 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 97 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.251 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006

Location: Polk County
Reach: R2B XS# 1 (Existing)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| 24.98 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# (# Choose one) |
| 4.86 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| 70 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| 0.230 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| 0.01443 | S (ft/ft) | Bankfull Water Surface Slope |
| 1.31 | d (ft) | Bankfull Mean Depth |
| 5.92 | A ($ft^2$) | Bankfull Cross Sectional Area |
| 6.36 | $W_p$ (ft) | Wetted Perimeter |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |
| **Calculation of Critical Dimensionless Shear Stress** | | |
| 5.14 | $D_{50}/\hat{D}_{50}$ | Range 3-7 — Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.80 | $D_i/D_{50}$ | Range 1.3-3.0 — Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.020 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress — Equation Used: 1 |
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | |
| 0.525 | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 2.493 | $d/d_r$ | Stability: Degrading |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | |
| 0.006 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 2.493 | $S/S_r$ | Stability: Degrading |
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.93 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.838 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 134 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.348 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00 — Location: Polk County
Stream: Little White Oak Creek — Reach: R2B XS# 1 Proposed (Actual Designed Slope)
Date: 1/19/2007 — Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 24.98 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 4.86 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 70 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.230 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.01142 | S (ft/ft) | Bankfull Water Surface Slope | |
| 0.63 | d (ft) | Bankfull Mean Depth | |
| 5 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 9.26 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

**Calculation of Critical Dimensionless Shear Stress**

| Value | Variable | Range | Definition |
|---|---|---|---|
| 5.14 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.80 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.020 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

**Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle**

| Value | Variable | Definition |
|---|---|---|
| 0.664 | $d_r$ | Required Bankfull Mean Depth (ft) |
| | | $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 0.949 | $d/d_r$ | **Stability:** Aggrading |

**Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle**

| Value | Variable | Definition |
|---|---|---|
| 0.012 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) |
| | | $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 0.949 | $S/S_r$ | **Stability:** Aggrading |

**Sediment Transport Validation - Bankfull Shear Stress**

| Value | Variable | Definition |
|---|---|---|
| 0.54 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.385 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 75 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.348 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

## Entrainment Calculation Form

| | | | |
|---|---|---|---|
| Project: | 2006237.00 | Location: | Polk County |
| Stream: | Little White Oak Creek | Reach: | R2B XS# 1 Proposed (iteration 1) |
| Date: | 12/4/2006 | Observers: | EMP TMB |

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 24.98 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 4.86 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 70 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.230 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.012 | S (ft/ft) | Bankfull Water Surface Slope | |
| 0.78 | d (ft) | Bankfull Mean Depth | |
| 7 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 10.56 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 5.14 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.80 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.020 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

| Value | Variable | Definition | |
|---|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| 0.632 | $d_r$ | Required Bankfull Mean Depth (ft) | $d_r = \frac{\tau^*_{ci}\gamma_s D_i}{S}$ |
| 1.235 | $d/d_r$ | Stability: | Degrading |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| 0.010 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) | $S_r = \frac{\tau^*_{ci}\gamma_s D_i}{d}$ |
| 1.235 | $S/S_r$ | Stability: | Degrading |

| Value | Variable | Definition |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.66 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.496 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 91 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.348 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00
Stream: Little White Oak Creek
Date: 12/4/2006
Location: Polk County
Reach: R2B XS# 1 Proposed (iteration 2)
Observers: EMP TMB

| Value | Variable | Definition |
|---|---|---|
| **Required Information for Entrainment Analysis** | | |
| **24.98** | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# |
| **4.86** | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# |
| **70** | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# |
| **0.230** | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) |
| **0.012** | S (ft/ft) | Bankfull Water Surface Slope |
| **0.75** | d (ft) | Bankfull Mean Depth |
| **7** | A ($ft^2$) | Bankfull Cross Sectional Area |
| **10.9** | $W_p$ (ft) | Wetted Perimeter |
| **1.65** | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) |
| **62.4** | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) |

# Choose one

| Value | Variable | Definition | | |
|---|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | | |
| **5.14** | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ | |
| **2.80** | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ | |
| **0.020** | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: | **1** |

| Value | Variable | Definition | |
|---|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| **0.632** | $d_r$ | Required Bankfull Mean Depth (ft) $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ | |
| **1.187** | $d/d_r$ | **Stability:** | **Degrading** |
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| **0.010** | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ | |
| **1.187** | $S/S_r$ | **Stability:** | **Degrading** |

| Value | Variable | Definition |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| **0.64** | R | Hydraulic Radius (ft) $R = A/W_p$ |
| **0.481** | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| **N** | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| **N/A** | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| **N/A** | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| **89** | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| **0.348** | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey

# Entrainment Calculation Form

Project: 2006237.00 — Location: Polk County
Stream: Little White Oak Creek — Reach: R2B XS# 1 Proposed (iteration 3)
Date: 12/4/2006 — Observers: EMP TMB

| Value | Variable | Definition | |
|---|---|---|---|
| **Required Information for Entrainment Analysis** | | | |
| 24.98 | $D_{50}$ (mm) | $D_{50}$ from Riffle or Pavement# | # Choose one |
| 4.86 | $\hat{D}_{50}$ (mm) | $D_{50}$ from Bar Sample or Subpavement# | |
| 70 | $D_i$ (mm) | Largest Particle from Bar Sample or Pavement# | |
| 0.230 | $D_i$ (ft) | Di (mm) / 304.8 (mm/ft) | |
| 0.012 | S (ft/ft) | Bankfull Water Surface Slope | |
| 0.63 | d (ft) | Bankfull Mean Depth | |
| 5 | A ($ft^2$) | Bankfull Cross Sectional Area | |
| 9.16 | $W_p$ (ft) | Wetted Perimeter | |
| 1.65 | $\gamma_s$ | Submerged Specific Weight of Sediment (1.65) | |
| 62.4 | $\gamma$ ($lbs/ft^3$) | Density of Water (62.4) | |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculation of Critical Dimensionless Shear Stress** | | | |
| 5.14 | $D_{50}/\hat{D}_{50}$ | Range 3-7 | Use Equation 1: $\tau^*_{ci} = 0.0834(D_{50}/\hat{D}_{50})^{-0.872}$ |
| 2.80 | $D_i/D_{50}$ | Range 1.3-3.0 | Use Equation 2: $\tau^*_{ci} = 0.0384(D_i/\hat{D}_{50})^{-0.887}$ |
| 0.020 | $\tau^*_{ci}$ | Critical Dimensionless Shear Stress | Equation Used: 1 |

| Value | Variable | Definition | |
|---|---|---|---|
| **Caculate Bankfull Mean Depth Required for Entrainment of Largest Particle** | | | |
| 0.632 | $d_r$ | Required Bankfull Mean Depth (ft) | |
| | | $d_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{S}$ | |
| 0.997 | $d/d_r$ | Stability: | Aggrading |

| Value | Variable | Definition | |
|---|---|---|---|
| **Calculate Bankfull Water Surface Slope Required for Entrainment of Largest Particle** | | | |
| 0.012 | $S_r$ | Required Bankfull Water Surface Slope (ft/ft) | |
| | | $S_r = \dfrac{\tau^*_{ci}\gamma_s D_i}{d}$ | |
| 0.997 | $S/S_r$ | Stability: | Aggrading |

| Value | Variable | Definition |
|---|---|---|
| **Sediment Transport Validation - Bankfull Shear Stress** | | |
| 0.55 | R | Hydraulic Radius (ft) $R = A/W_p$ |
| 0.409 | $\tau_c$ | Bankfull Shear Stress ($lb/ft^2$) $\tau_c = \gamma RS$ |
| N | Y or N | Is the Bed Material Homogeneous? Determine from reach wide pebble count distribution. If homogeneous use "Leopold et al" Curve Data, if heterogeneous use "Colorado" Curve Data. |
| N/A | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| N/A | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Leopold, Wolman, & Miller 1964 Power-trendline. |
| 79 | mm* | Movable Particle Size (mm) At Bankfull Shear Stress predicted by the Colorado Data Power-trendline. |
| 0.348 | $lb/ft^2$* | Predicted Shear Stress ($lbs/ft^2$) Required To Move $D_i$ predicted by the Colorado Data Power-trendline. |

*Taken from *The Reference Reach Field Book*, 2005 by Rosgen and Silvey