# Duke Swamp Wetland and Stream Restoration Mitigation Report – Monitoring Year 0 of 5

## Gates County, North Carolina

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Date Submitted: March 2008

Project Number: D06065-A

USGS Cataloging Unit: 03010203

NCDWQ Sub-basin: 03-01-01

# EXECUTIVE SUMMARY

The Duke Swamp site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the restoration construction and presents as-built monitoring data for the five-year monitoring period. Table 1 summarizes site conditions before and after restoration as well as the conditions predicted in the previously approved site restoration plan. The monitoring plan and as-built data (Year 0 – Baseline) are discussed in detail in Sections 2.1 through 2.5 of this mitigation report.

**Table 1**
**Background Information**

| | | | |
|---|---|---|---|
| **Pre-Construction Site Conditions** | | | |
| **Site** | | | |
| Location | Gates County, NC (see Exhibit 1), approximately nine miles northeast of the town of Gatesville, NC. | | |
| USGS Hydro Unit | 03010203 | | |
| NCDWQ Subbasin | 03-01-01 | | |
| Contract Mitigation Units | **5,000 SMU; 15.0 Riverine WMU** | | |
| **Stream** | | | |
| **Reach** | **Length** | **Condition** | **Drainage Area** |
| UT1a | 2,860 LF | Channelized & Incised E5 | 2.9 $mi^2$ |
| UT1b | 880 LF | Impacted DA system | 0.2 $mi^2$ |
| UT2 | 880 LF | Impacted DA system | 0.03 $mi^2$ |
| **Wetlands** | | | |
| **Wetland Areas** | **Riverine/Non-Riverine** | | **Acreage** |
| Wetland #2 | Riverine | | 2.4 AC |
| Wetland #3 | Riverine | | 5.1 AC |
| **Restoration Plan** | | | |
| **Stream** | | | |
| **Reach** | **Restoration/Enhancement Type** | | **Length** |
| UT1a | Rosgen Priority Level I and II approaches | | 3,983 LF |
| UT1b | Restoration of historic flows throughout remnant channels, flooding functions, and hydrologic connectivity | | 924 LF |
| UT2 | Restoration of historic flows throughout remnant channels, flooding functions, and hydrologic connectivity | | 515 LF |
| **Wetlands** | | | |
| **Wetland Restoration/Enhancement** | **Riverine/Non-Riverine** | | **Acreage** |
| Wetland Restoration (area #1) | Riverine | | 13.1 AC |
| Wetland Enhancement (areas #2 & #3) | Riverine | | 7.5 AC |

| | | | |
|---|---|---|---|
| **Riparian Buffer Acreage** | | | |
| Planted Riparian Buffer Acreage | 17.2 AC | | |
| **Post-Construction Site Conditions** | | | |
| **Stream** | | | |
| **Reach** | **Restoration/Enhancement Type** | **Length** | **SMU** |
| UT1a | Rosgen Priority Level I and II approaches | 4,026 LF | 4,026 |
| UT1b | Restoration of historic flows throughout remnant channels, flooding functions, and hydrologic connectivity | 900 LF | 900 |
| UT2 | Restoration of historic flows throughout remnant channels, flooding functions, and hydrologic connectivity | 515 LF | 515 |
| **Wetland** | | | |
| **Wetland Restoration/Enhancement** | **Riverine/Non-Riverine** | **Acreage** | **WMU** |
| Wetland Restoration (area #1) | Riverine | 12.0 AC | 12.0 |
| Wetland Enhancement (areas #2 & #3) | Riverine | 7.6 AC | 3.8 |

| | |
|---|---|
| **Ecological Benefits** | |
| Water Quality | Nutrient, sediment, and erosion reduction; increased dissolved oxygen concentrations and pollutant retention; and improved stream bank stability. |
| Water Quantity/Flood Attenuation | Increased water storage/flood control; reduced downstream flooding by reconnecting stream with its floodplain; improved groundwater recharge; improved/restored hydrologic connections. |
| Aquatic and Terrestrial Habitat | Improved substrate and in-stream cover; addition of large woody debris; reduced water temperature by increasing shading; restoration of terrestrial habitat; improved aesthetics. |
| **Monitoring Plan** | |
| Success Criteria | Success is measured with permanent cross-sections, vegetation plots, automated groundwater monitoring wells, water level gages, and a longitudinal profile conducted annually for a period of five years. Additionally, photographs and video footage will be used to evaluate channel aggradation or degradation, bank erosion, riparian vegetation, and effectiveness of erosion control measures. |
| Methodology | Cross-sections and longitudinal profile will be surveyed annually and tied to a common benchmark along the restored channel (UT1a). Automated groundwater wells (UT1a) and water level gauges (UT1b & UT2) will monitor flooding frequency and groundwater saturation as compared to pre-restoration conditions. Each tree planted within the 100-square-meter vegetation plots are flagged and identified. Measurements of height and diameter are also taken and annual survival rates are recorded. |
| Remedial Action | N/A |

## Table of Contents



### Tables



### Exhibits



### Appendices

# 1.0 BACKGROUND INFORMATION

The Duke Swamp Site is located in Gates County, NC, approximately nine miles northeast of the town limits of Gatesville, NC, within cataloging unit 03010203, and NC Division of Water Quality (NCDWQ) sub-basin 03-01-01 of the Chowan River Basin (Exhibit 1). To visit the site, take I-95 North to Exit 173, US-158 east towards Gatesville, NC. Follow US-158 through Gatesville and turn left onto NC-32 north, travel approximately 1 mile and turn left onto Kellogg Fork Road (SR 1320). Finally, go approximately 3 miles and turn left at the construction entrance to access the site via a farm access road.

The project involved the proposed restoration and enhancement of riverine wetlands, and restoration of single thread and multi-thread streams. A total of 12.0 acres of riverine wetlands and 5,441 feet of stream were restored, and 7.6 acres of riverine wetlands were enhanced based on the construction as-built survey. Exhibit 2 summarizes the restoration and enhancement areas and quantities on the project site. Selected site photographs are shown in Appendix 1. A conservation easement totaling 25.4 acres has been recorded that protects the streams, wetlands, and riparian buffers in perpetuity.

## 1.1 Restoration Summary

### 1.1.1 Mitigation Goals and Objectives

The specific goals for the Duke Swamp Site Restoration Project were as follows:

- Restore functional stream channels
- Restore riparian wetlands
- Enhance existing riparian wetlands
- Improve water quality within the Duke Swamp watershed by reducing sediment and nutrient inputs
- Improve aquatic and riparian habitat functions by creating deeper pools with in-stream structures
- Establish native stream bank and floodplain vegetation within the agricultural field areas.

### 1.1.2 Project Description and Restoration Approach

After examining the assessment data collected at the site and exploring the site's potential for restoration, an approach to the site was developed that addressed restoration of both stream and wetland functions within the agricultural field areas. The approach also needed to take into account the existing swamp system at the downstream end of the site, which had been impacted in the past by channelization. Topography and soils on the site indicated that the project area most likely functioned in the past as a tributary stream system with associated wetlands, feeding into the larger Duke Swamp system.

Therefore, a design approach was formulated to restore this type of system. First, appropriate stream types for the valley types, slopes, and desired wetland functions were selected and designed to tie in at the upstream road culvert. Then a grading plan was developed to restore the adjacent wetland areas to a "Coastal Plain small stream swamp" as identified by Schafale and Weakley (1990) which had been previously converted to farmland. Finally, a design approach was developed for the downstream swamp area, to remove the past effects of channelization and restore historic flow patterns within the swamp. Special consideration was given to minimizing disturbance to existing wetland and wooded areas.

For analysis and design purposes, Baker Engineering divided the Duke Swamp tributaries into three reaches labeled UT1a, UT1b, and UT2 to Duke Swamp. The reach locations were numbered sequentially from east to west as shown on Exhibit 2. UT1a begins on the upstream side of the project at a culvert under SR 1320, flows west, and ends inside the forested wetland boundary. UT1b continues through the forested area and eventually connects to the Duke Swamp system. UT2 begins at the outlet of a small cypress pond on the northwestern corner of the project site, flows south, and connects with UT1b within the forested wetland area.

**UT1a Channel Restoration**

A stable cross-section was achieved by restoring a single thread, meandering channel across the abandoned floodplain, increasing the width/depth ratio, and raising the streambed to restore a channel that was appropriately sized for its drainage area. Due to the upstream road culvert and the need to not increase flooding conditions of the road, floodplain grading was performed to allow for increased capacity during large storm events. Grading activities were aimed at restoring historic flow patterns and adjacent wetland hydrology by removing past channel spoil and other agricultural land manipulations. The channel was restored to a C-type stream (Rosgen 1994, 1996), and the sinuosity was increased by adding meanders to lengthen the channel and restore bed-form diversity. Minimal grade control was required for the project, due to the low channel slope and low potential for channel incision. In-stream wooden structures, such as log vanes, rootwads, and cover logs were included in the channel design to provide improved aquatic habitat.

**UT1b Channel Restoration**

As discussed in the approved restoration plan, UT1b was channelized through an existing wetland swamp system. The channelization and piling of spoil along the right bank had disrupted the historic flow and flooding patterns of the site, and disconnected the natural confluence of UT1 and UT2. However, historic channel remnants existed within the area adjacent to the existing canal. Restoration of this reach sought to restore historic flow and flooding processes, while avoiding and minimizing disturbance to the existing wetland vegetation. The restoration of UT1a through the farm fields ended at the edge of the jurisdictional wetland system. At this location, the constructed UT1a channel connects with a historic channel remnant which forms the beginning to UT1b. Construction equipment entered the existing wetland area along UT1b by traversing the existing spoil pile, thereby avoiding disturbance to wetland vegetation. The excavator placed the spoil material back into the channel and restored the natural topography in the area of the spoil pile. In this fashion, flows through UT1b are now allowed to follow historic flow patterns and functions as a DA-type stream system as it spreads out through numerous channel remnants, in the same way the system once functioned. The historic connection between UT1 and UT2 was restored.

**UT2 Channel Restoration**

As discussed in the preceding section, restoration in the area of UT1b and UT2 involved removing the existing spoil pile which was affecting the flow of UT2. The UT2 channel was experiencing backwater ponding and damming effects as a result of the spoil pile. By removing the spoil pile and restoring the surrounding topography, the historic flow pattern and flooding regime of UT2 was restored as a transition from a single to multi-thread channel. Rather than ponding and flowing along the spoil pile, the restored UT2 is now able to spread across its floodplain and flows mix with flood flows from UT1.

**Wetland Restoration Area #1**

Wetland functions on the site had been severely impaired as a result of agricultural conversion. The main stream (UT1) flowing through the site was channelized many years ago to reduce flooding and provide drainage for adjacent farm fields. As a result, most of the wetland functions were destroyed within these agricultural field areas.

Wetland restoration of the prior-converted farm fields on the site involved grading areas of the farm fields to resemble natural floodplain topography and raising the local water table to restore a natural flooding regime. Reach UT1a was restored to a stable dimension, pattern, and profile, such that riparian wetland functions were restored to the adjacent hydric soil areas. Drainage ditches and Pond 3 were filled to decrease surface and subsurface drainage and raise the local water table. Native wetland vegetation was planted throughout the riparian buffer areas as shown on the vegetation as-built plan sheets and detailed within Section 2.6.3.

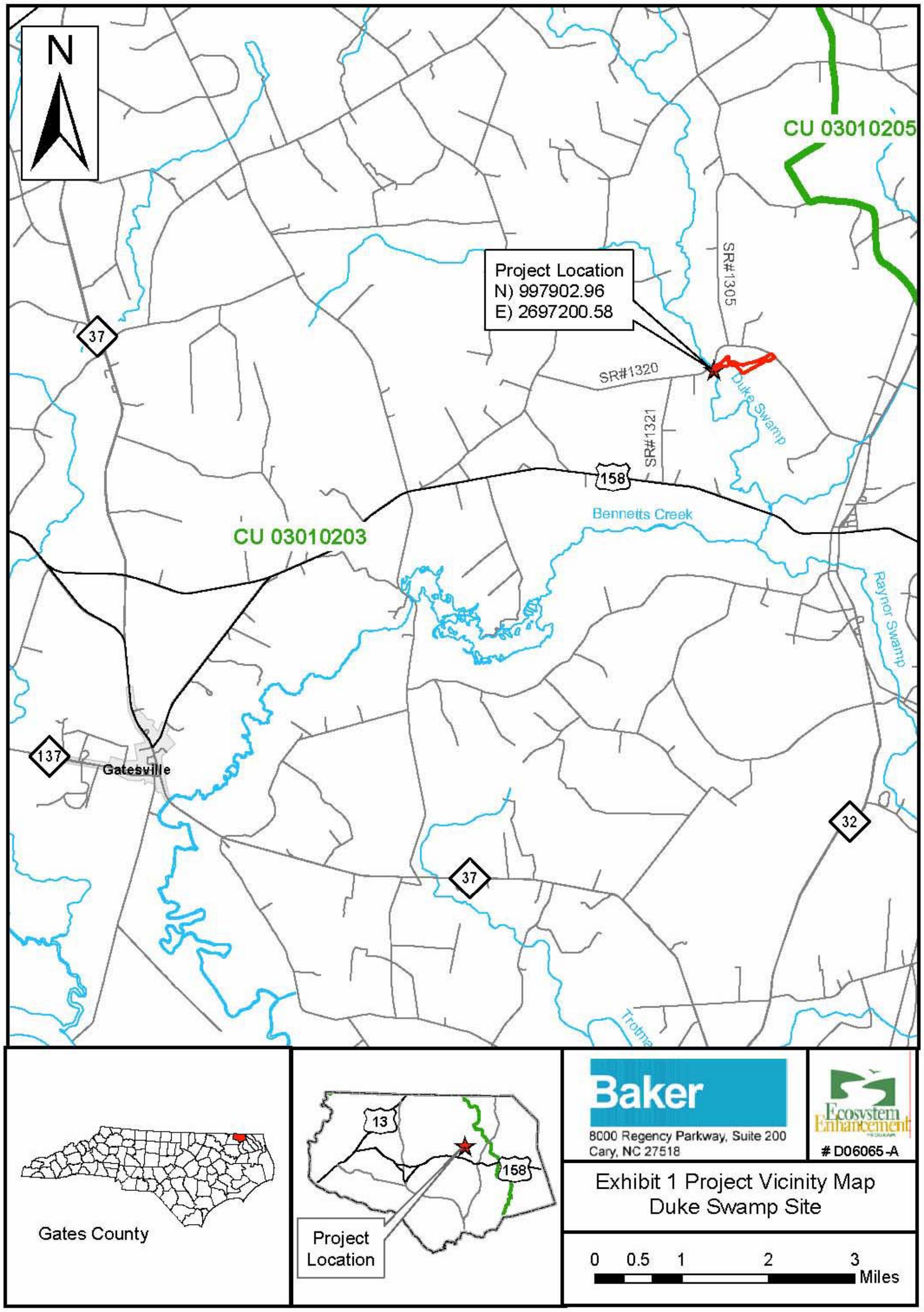
**Wetland Enhancement Area #2**

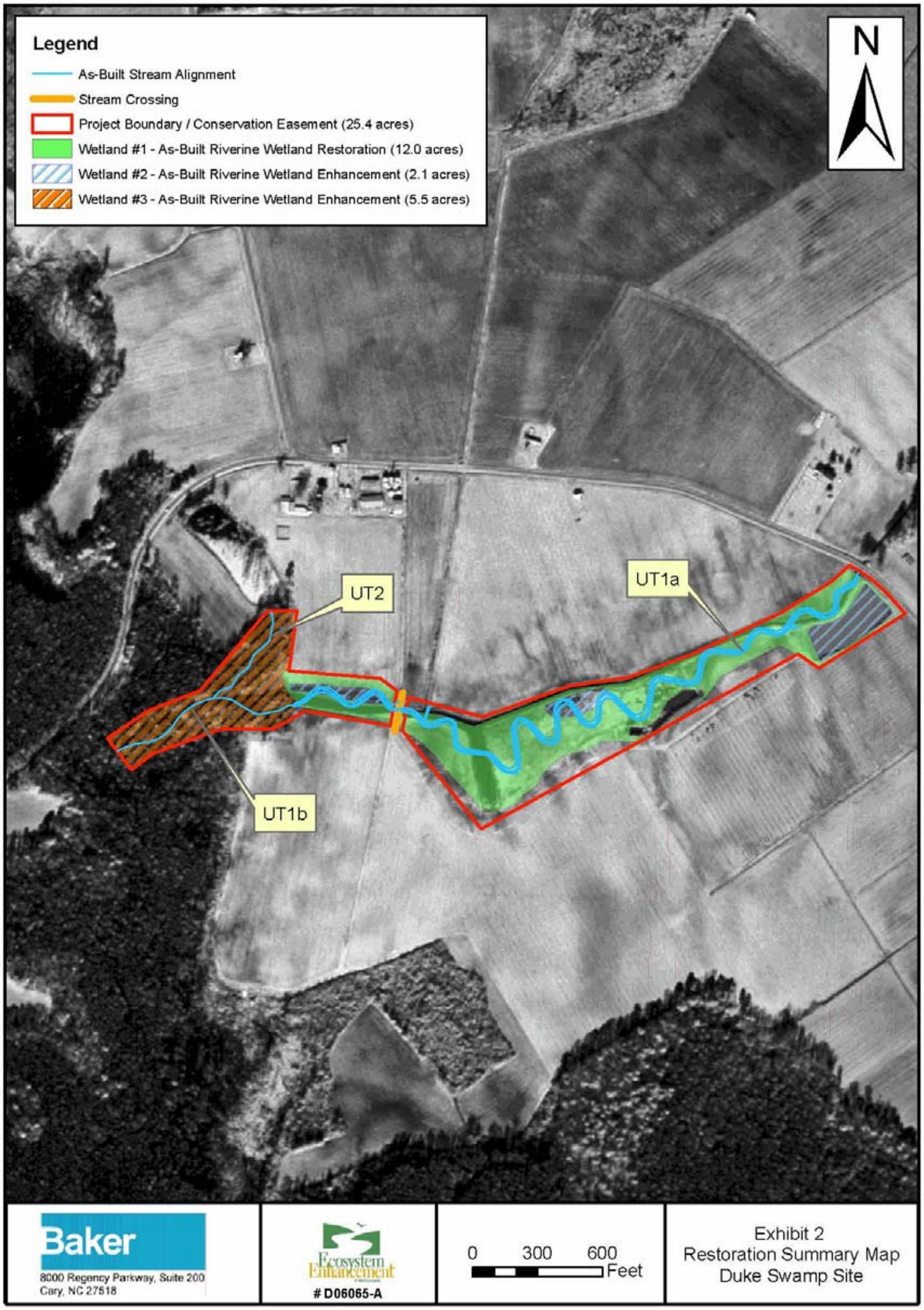
As mentioned above, wetland functions on the site had been severely impaired as a result of agricultural conversion. Wetland enhancement of the existing jurisdictional wetland pockets involved grading areas of the farm fields to resemble natural floodplain topography and raising the local water table to enhance natural flooding regime and hydrology. Drainage ditches and Pond 3 were filled to decrease surface and subsurface drainage and raise the local water table. Additionally, the Pond 1 water level was lowered to function as a wetland. Native wetland vegetation was planted throughout the riparian buffer areas as shown on the vegetation as-built plan sheets and detailed within Section 2.6.3.

**Wetland Enhancement Area #3**

Wetland enhancement of the existing jurisdictional wetlands within the downstream wooded area involved the removal of an existing spoil pile by placing the spoil material back into the channel thereby reestablishing the natural topography in the area. The historic hydrologic connection between UT1 and UT2 was restored. Native vegetation was planted along the spoil pole that was removed as shown on the vegetation as-built plan sheets and detailed within Section 2.6.3.

## 1.2 Project Maps




Legend
As-Built Stream Alignment
Stream Crossing
Project Boundary / Conservation Easement (25.4 acres)
Wetland #1 - As-Built Riverine Wetland Restoration (12.0 acres)
Wetland #2 - As-Built Riverine Wetland Enhancement (2.1 acres)
Wetland #3 - As-Built Riverine Wetland Enhancement (5.5 acres)
N
UT2
UT1a
UT1b
Baker
8000 Regency Parkway, Suite 200
Cary, NC 27518
Ecosystem Enhancement
# D06065-A
0 300 600
Feet
Exhibit 2
Restoration Summary Map
Duke Swamp Site

## 1.3 Construction Summary and Table

Construction activities, in accordance with the approved restoration plan and permits for the site, began in July 2007 near the middle of the project (Reach UT1a, Station 44+00) with site preparation, establishment of the staging areas, haul roads, and stockpile areas. Materials were stockpiled as needed for the initial stages of construction and silt fence was installed per the Sediment and Erosion control plan. Construction stakeout began in July 2007.

Stream and wetland construction began with the installation of a coffer dam and the de-watering of Pond 3 along reach UT1a. A temporary sediment trap was installed near sta. 48+00. Once Pond 3 was drained, benching excavation began both upstream and downstream of Pond 3 (station 39+00) until enough suitable material was available to fill Pond 3. After Pond 3 was filled, excavation of the new design channel and remaining bench began from station 41+00 to 17+00. Log vanes and rootwads were installed per the plans as the channel was constructed. Additional log vanes and rootwads were added and are shown on the as-built plans. Temporary seed and matting were applied as channel excavation was completed. Suitable fill material from bench/channel excavation was then filled into the old ditch. A drainage swale was constructed per the design elevation at Pond 2 to allow for proper drainage and maintaining the existing water level.

The de-watering of Pond 1 was not necessary due to extreme drought conditions. The dam was breached to lower the design water elevation and tied into the new design channel per the drainage berm detail and specifications. The channel was constructed from station 17+00 moving upstream, eventually tying into the culvert at Kellogg Fork Road. Once the upper section of UT1a was complete, construction resumed at station 41+00 tying into the existing ditch as the new channel was formed downstream of the farm crossing and ultimately connecting with reach UT1b immediately within the existing woodline. A constructed riffle was installed near station 49+00 towards the downstream section of UT1a. UT1b was then routed into the remnant channel and the old ditch canal was plugged and filled to the end of the project.

After reach UT1a was connected with the beginning section of UT1b, construction began along UT1b by removing the existing spoil pile and filling the canal until the natural topography was restored. A depressional area was constructed along the filled canal section from station 13+00 to16+00 for the tie to the remnant channel and UT2. After the spoil pile was removed and the ditch was filled along UT1b, UT2 was tied into UT1b by the floodplain to establish connectivity between the two reaches.

The existing pipe culvert crossing was stabilized by removing the failed head walls, fill cover material was added to the road crossing, and rip rap was added to the side slopes. The excess stockpile material was spread evenly throughout upland areas within the limits of disturbance boundaries. Lastly, all disturbed areas were covered with temporary and permanent seed and straw before demobilizing from the site. Planting of bare roots and live stakes was completed in December 2007 and detailed in sections 2.4 and 2.6.3 of this report.

| **Table 2**<br>**Summary of As-built Lengths, Acreages, Mitigation Units, and Restoration Approaches** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Reach Name/Wetland Area** | **As-built Wetland Acreage (acres)** | **Existing Wetland Acreage (acre** | **As-built Length (ft)** | **Existing Length (ft)** | **SMU/ WMU** | **Proposed Credit Ratio** | **Restoration Approach** |
| Reach UT1a | ----- | ----- | 4,026 | 2,860 | 4,026 | 1:1 | Restoration – Priority I & II |
| Reach UT1b | ----- | ----- | 900 | 880 | 900 | 1:1 | Restoration of historic flows throughout remnant channels, flooding functions, and hydrologic connectivity |
| Reach UT2 | ----- | ----- | 515 | 880 | 515 | 1:1 | Restoration of historic flows throughout remnant channels, flooding functions, and hydrologic connectivity |
| Wetland Area #1 | 12.0 | 0 | ----- | ---- | 12.0 | 1:1 | Riverine Wetland Restoration |
| Wetland Areas #2 and #3 | 7.6 | 7.5 | ----- | ---- | 3.8 | 2:1 | Riverine Wetland Enhancement |
| **Total Length / Acreage** | **19.6** | **7.5** | **5,441** | **4,620** | **5,441/ 15.8** | | |

# 2.0 MONITORING PLAN

Channel stability, vegetation survival, and viability of wetland function will all be monitored on the project site. Post-restoration monitoring will be conducted for five years following the completion of construction to document project success. Different monitoring approaches are proposed for the restored stream reaches, based on the restoration approaches that were used. For reach UT1a, which involved a more traditional restoration of a single thread channel, monitoring approaches follow those recommended by the *Stream Mitigation Guidelines* (USACE and NCDWQ 2006). For reaches UT1b and UT2 which involved the restoration of historic flow patterns through an existing mature wetland system, monitoring will focus primarily on visual assessments and documentation. These approaches are described below.

## 2.1 Stream Monitoring – Reach UT1a

Geomorphic monitoring of UT1a will be conducted for five years to evaluate the effectiveness of the restoration practices. Monitored stream parameters include stream dimension (cross-sections), bankfull events, pattern, profile (profile survey), and photographic documentation. The methods used and any related success criteria are described below for each parameter.

### 2.1.1 Bankfull Events

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

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

### 2.1.2 Cross-sections

Seven permanent cross-sections were installed with four located at a riffle cross-section and three located at a pool cross-section. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The annual cross-sectional survey will include points measured at breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in the as-built cross-sections. If changes do take place they should be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

### 2.1.3 Pattern

Annual measurements taken for the plan view of the restoration site will include sinuosity, meander width ratio, and radius of curvature. The radius of curvature measurements will be taken on newly constructed meanders for the first year of monitoring only.

### 2.1.4 Longitudinal Profile

A longitudinal profile will be completed each year of the monitoring period. The profile will be conducted for at least 3,000 feet of the restored channel lengths. Measurements will include thalweg, water surface, inner berm, bankfull, and top of low bank. Each of these measurements will be taken at the head of each feature (e.g., riffle, run, pool, glide) and the maximum pool depth. The survey will be tied to a permanent benchmark.

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

### 2.1.5 Bed Material Analyses

Since the streams through the project site are dominated by sand-size particles, pebble count procedures would not show a significant change in bed material size or distribution over the monitoring period; therefore, bed material analyses will not be conducted for this project.

### 2.1.6 Photo Reference Sites

Photographs will be used to document restoration success visually. Reference stations were photographed before construction and will be continued for at least five years following construction. Reference photos will be taken once per year. Permanent markers were established to ensure that the same locations (and view directions) on the site are monitored during each monitoring period. Selected site photographs are shown in Appendix 1.

#### 2.1.6.1 Lateral Reference Photos

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

#### 2.1.6.2 Structure Photos

Photographs will be taken at each grade control structure along the restored stream. Photographers should make every effort to consistently maintain the same area in each photo over time. Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures subjectively. Lateral photos should not indicate excessive erosion or continuing degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation.

## 2.2 Stream Monitoring – Reaches UT1b and UT2

Geomorphic monitoring of reaches UT1b and UT2 will be conducted for five years to evaluate the effectiveness of the restoration practices. Since restoration of these reaches involved the restoration of historic flow patterns and flooding functions to remnant channel segments in a multi-threaded swamp system, monitoring efforts will focus on visual documentation of stability and the use of water level monitoring gages to document saturation and flooding functions. The methods used and any related success criteria are described below for each parameter.

### 2.2.1 Bankfull Events and Flooding Functions

The occurrence of bankfull events and flooding functions within the monitoring period will be documented by the use of water level monitoring gages and photographs. At least five monitoring gages will be installed within the restored system to document groundwater and flooding levels. Loggers will be programmed to collect data at a minimum of every 12 hours. Installation of monitoring stations will follow the standard methods found in *Stream Mitigation Guidelines* (USACE and NCDWQ 2006).

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years. Gages should document the occurrence of periodic inundation and varying groundwater levels across the restored site. Gages should also document the connectivity of flooding between the restored UT1b and UT2 reaches.

### 2.2.2 Photo and Video Reference Sites

Photographs and video footage will be used to document restoration success visually. Reference stations were photographed before construction and will be continued for at least five years following construction. Reference photos and videos will be taken at least twice per year, and will be taken in enough locations to document the condition of the restored system. Permanent markers will be established to ensure that the same locations (and view directions) on the site are documented in each monitoring period.

The stream systems will be photographed longitudinally beginning at the upstream portion of the restoration reach and moving downstream to the end of the reach. Photographs will be taken looking upstream at delineated locations. Reference photo locations will be marked and described for future reference. Points will be close enough together to provide an overall view of the reach. The angle of the shot will depend on what angle provides the best view and will be noted and continued in future shots. When modifications to photo position must be made due to obstructions or other reasons, the position will be noted along with any landmarks and the same position will used in the future.

Additional photographs and video footage will be taken to document any observed evidence of flooding patterns such as debris, wrack lines, water marks, channel features, etc.

## 2.3 Wetland Monitoring

### 2.3.1 Wetland Hydrologic Monitoring

Groundwater-monitoring stations were installed across the project area to document hydrologic conditions of the restored site. Five groundwater monitoring stations were installed, with all five stations being automated groundwater gauges. Ground water monitoring stations follow the USACE standard methods found in *Stream Mitigation Guidelines* (USACE and NCDWQ 2006).

In order to determine if the rainfall is normal for the given year, rainfall amounts will be tallied using data obtained from the Gates County WETS Station and an onsite rain gage.

The objective is for the monitoring data to show the site is saturated within 12 inches of the soil surface for at least 8 percent of the growing season as indicated by the DRAINMOD model and that the site exhibits an increased frequency of flooding. The restored site's hydrology will be compared to pre-restoration conditions both in terms of groundwater and frequency of overbank events.

## 2.4 Vegetation Monitoring

Successful restoration of the vegetation on a wetland mitigation site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria have been met, vegetation monitoring quadrants were installed across the restoration site, as directed by *Stream Mitigation Guidelines* (USACE and NCDWQ 2006) and the North Carolina Ecosystem Enhancement Program (NCEEP guidelines). The number of quadrants required was based on the species/area curve method, as described in NCEEP monitoring guidance documents. A total of twelve plots were installed, which constitutes approximately 1.5 percent of the total planted area. The size of individual quadrants is 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation.

Vegetation monitoring will occur in the fall, prior to leaf fall. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked such that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period, and 10% mortality in year 4 (288 trees per acre). The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. While measuring species density is the current accepted methodology for evaluating vegetation success on restoration projects, species density alone may be inadequate for assessing plant community health. For this reason, the vegetation monitoring plan will incorporate the evaluation of additional plant community indices to assess overall vegetative success.

Herbaceous vegetation, primarily native grasses, planted at the site shall have at least 80 percent coverage of the seeded/planted area. Any herbaceous vegetation not meeting these criteria shall be replanted. At a minimum, at all times ground cover at the project site shall be in compliance with the North Carolina Erosion and Sedimentation Control Ordinance.

## 2.5 Maintenance and Contingency Plan

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

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

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

## 2.6 Monitoring Results – 2007 As-Built Data

The five-year monitoring plan for the Duke Swamp Site includes criteria to evaluate the success of the vegetation, wetland, and stream components of the project. The specific locations of vegetation plots, wells, permanent cross-sections, crest gauges, and a rainfall gauge are shown on the as-built plan sheets. Photo points, located at each of the grade control structures along the restored stream channel, are also located on the as-built plan sheets in Appendix 3.

### 2.6.1 Morphology

For monitoring wetland and stream success criteria, seven permanent cross-sections, one rain gauge, and one crest gauge were installed. The permanent cross-sections will be used to monitor channel dimension and bank erosion over time. The rain gauge and crest gauge will be used to document the occurrence of bankfull events. In addition, a complete longitudinal survey was completed for the constructed stream channel (reach UT1a) to provide a base-line for evaluating changes in bed conditions over time. The longitudinal profile included the elevations of the grade control structure near sta. 49+00. The permanent cross-section and longitudinal data are provided in Appendix 2. The location of the permanent cross-sections, rain gauge, and the stream gauges are shown on the as-built plan sheets in Appendix 3.

#### 2.6.1.1 Results and Discussion

No monitoring results are available at the submittal of this report. As-built data (Year 0 – Baseline) will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2008.

### 2.6.2 Hydrology

The approved restoration plan for the Duke Swamp Site specified that up to five automated monitoring wells would be established across the restored site. A total of five automated wells were installed in November 2007 to document water table hydrology in all required monitoring locations. The locations of monitoring wells are shown on the as-built plan sheets.

#### 2.6.2.1 Results and Discussion

No monitoring results are available at the submittal of this report. Site hydrology from the first growing season will be discussed in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2008.

### 2.6.3 Vegetation

Bare-root trees were planted within the areas of the conservation easement as shown on the as-built vegetation plan. Riparian buffers at least 50 feet wide were established along the stream reaches, with the exception of three meander bends totaling approximately 437 LF along Reach UT1a, Station 13+50 thru 20+00. These meander bend areas have an average of a 25-foot buffer along the right bank due to landowner agricultural requirements and was confirmed in the approved restoration plan. All buffer areas are protected by a perpetual conservation easement. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern including the spoil pile that was removed and re-graded in the wooded area along UT1b and UT2. Planting of bare-root trees was completed in December 2007. Species planted are summarized in Table 3.

**Table 3**
**Vegetation Species Planted Across the Restoration Site**

| Scientific Name | Common Name | Percent Planted by Species | Total Number of Stems |
|---|---|---|---|
| | **Bare Root Trees Species** | | |
| *Betula nigra* | River Birch | ~15% | 1,800 |
| *Celtis laevigata* | Sugarberry | ~5% | 600 |
| *Fraxinus pennsylvanica* | Green Ash | ~7% | 900 |
| *Nyssa sylvatica* | Swamp Tupelo | ~14% | 1,600 |
| *Platanus occidentalis* | Sycamore | ~19% | 2,300 |
| *Quercus iyrata* | Overcup Oak | ~10% | 1,200 |
| *Quercus michauxii* | Swamp chestnut oak | ~10% | 1,200 |
| *Quercus phellos* | Willow oak | ~8% | 900 |
| *Taxodium distichum* | Bald Cypress | ~12% | 1,400 |
| **Total** | | | **11,900** |
| | **Native Herbaceous Species** | | |
| *Elymus virginicus* | Virginia wild rye | 15% | n/a |
| *Panicum virgatum* | Switchgrass | 15% | n/a |

| Native Herbaceous Species | | | |
|---|---|---|---|
| *Carex vulpinoidea* | Fox Sedge | 15% | n/a |
| *Polygonum pennsylvanicum* | Smartweed | 15% | n/a |
| *Juncus effusus* | Soft rush | 25% | n/a |
| *Carex lupulina* | Hop Sedge | 15% | n/a |
| **Woody Vegetation for Live Stakes** | | | |
| *Cephalanthus occidentalis* | Button bush | 10% | n/a |
| *Salix nigra* | Black Willow | 10% | n/a |
| *Salix sericea* | Silky willow | 40% | n/a |
| *Sambucus canadensis* | Elderberry | 40% | n/a |

The restoration plan for the Duke Swamp site specifies that the number of quadrants required will be based on the species/area curve method, as described in NCEEP monitoring guidance documents, with a minimum of three quadrants. The sizes of individual quadrants are 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of 12 vegetation plots, each 10 by 10 meters in size, were established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table 4. The average density of planted bare root stems, based on the data from the 12 monitoring plots, is 722 stems per acre. The locations of the vegetation plots are shown on the as-built plan sheets.

**Table 4 Initial Stem Counts for Each Species Arranged by Plot**

**Duke Swamp Restoration Site: EEP Contract No. D06065-A**

| | Plots | | | | | | | | | | | | Initial Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Tree Species** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| *Betula nigra* | 4 | 3 | 3 | 4 | 2 | 4 | 3 | 2 | 4 | 0 | 0 | 0 | 29 |
| *Celtis laevigata* | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 8 |
| *Fraxinus pennsylvanica* | 1 | 1 | 0 | 1 | 2 | 1 | 1 | 0 | 3 | 0 | 0 | 0 | 10 |
| *Nussa sylvatica* | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 3 | 0 | 5 | 5 | 9 | 26 |
| *Platanus occidentalis* | 4 | 3 | 4 | 4 | 6 | 4 | 4 | 5 | 8 | 5 | 3 | 0 | 50 |
| *Quercus iyrata* | 2 | 3 | 4 | 2 | 2 | 1 | 3 | 4 | 3 | 2 | 0 | 0 | 26 |
| *Quercus michauxii* | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 5 | 3 | 0 | 3 | 0 | 26 |
| *Quercus phellos* | 2 | 2 | 2 | 1 | 3 | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 16 |
| *Taxodium distichum* | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 2 | 0 | 7 | 4 | 6 | 23 |
| **Stems/plot** | 17 | 15 | 16 | 17 | 19 | 18 | 17 | 21 | 25 | 19 | 15 | 15 | 214 |
| **Stems/acre** | 688.3 | 607.4 | 647.8 | 688.3 | 769.3 | 728.8 | 688.3 | 850.3 | 1012.3 | 769.3 | 607.4 | 607.4 | 722.1 |

#### 2.6.3.1 Results and Discussion

No monitoring results are available at the submittal of this report. As-built data (Year 0 – Baseline) will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2008.

## 2.7 Areas of Concern

No areas of concern have been identified during the first month following completion of the project.

# 3.0 REFERENCES


Rosgen, D. L. 1994. A Classification of Natural Rivers. Catena 22:169-199.

Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colo.

Schafale, Michael P. and Alan S. Weakley. 1990. Classification of the Natural Communities of North Carolina. North Carolina Heritage Program, Raleigh, NC.

US Army Corps of Engineers, Wetland Research Program (WRP), 1997. Technical Note VN-RS-4.1.

US Army Corps of Engineers, WRP, July 2000. Technical Notes ERDC TN-WRAP-00-02.

US Army Corps of Engineers, 2003. Stream Mitigation Guidelines. Prepared with cooperation from US Environmental Protection Agency, NC Wildlife Resources Commission, and the NC Division of Water Quality. www.saw.usace.army.mil/wetlands/Mitigation/Documents/Stream

# APPENDIX 1

## SELECTED PROJECT PHOTOGRAPHS

# Duke Swamp As-built Selected Project Photographs

Flood Gauge 1.JPG

Flood Gauge 2_PP12_view north.JPG

Flood Gauge 3.JPG

Flood Gauge 4.JPG

# Duke Swamp As-built Selected Project Photographs

Flood Gauge 5.JPG

Looking at begining of UT1B.JPG

Looking into woods at end of reach UT1A Station 50+00.jpg

PP1 Riffle Station 11+00.JPG

# Duke Swamp As-built Selected Project Photographs

PP2 Pond 1 tie in UT1A.jpg

PP3 Riffle Station 16+00.JPG

PP4 Riffle Station 20+60.JPG

PP5 Riffle Station 28+00.JPG

# Duke Swamp As-built Selected Project Photographs

PP6 Riffle Staton 33+60.JPG

PP7 Riffle Station 39+52.JPG

PP8 Downstream Culvert Crossing Station 44+50.JPG

PP9 Riffle Station 46+45.JPG

# Duke Swamp As-built Selected Project Photographs


PP10 Constructed Riffle Station 49+40.JPG


PP11 view south.JPG


PP12 view south.JPG


PP13 view north.JPG

# Duke Swamp As-built Selected Project Photographs


PP13 wrack line_view north.JPG


Regraded floodplain near confluence UT1A and UT2.jpg


Upstream culvert crossing under Kellogg Fork Rd Station 10+00.JPG


UT1B looking upstream near Station 15+00.jpg

# Duke Swamp As-built Selected Project Photographs

UT1B Station 13+00.jpg

# APPENDIX 2

## AS-BUILT CROSS-SECTIONS AND LONGITUDINAL PROFILES

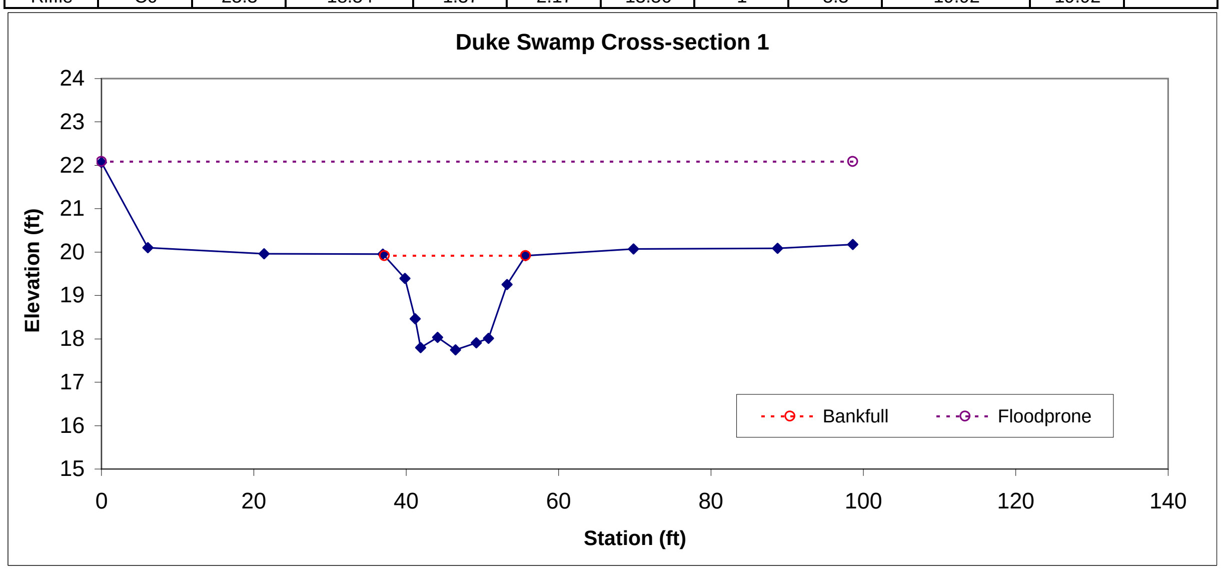
**Permanent Cross-section 1, Station 13+30**

(As-Built Data - collected Oct. 2007)

**Looking at the Left Bank**

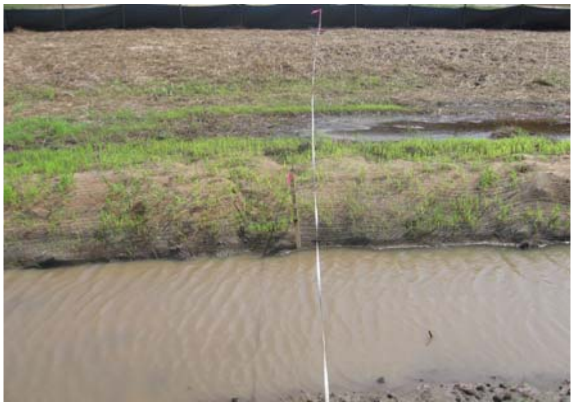
**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | Cc | 25.3 | 18.54 | 1.37 | 2.17 | 13.56 | 1 | 5.3 | 19.92 | 19.92 | |

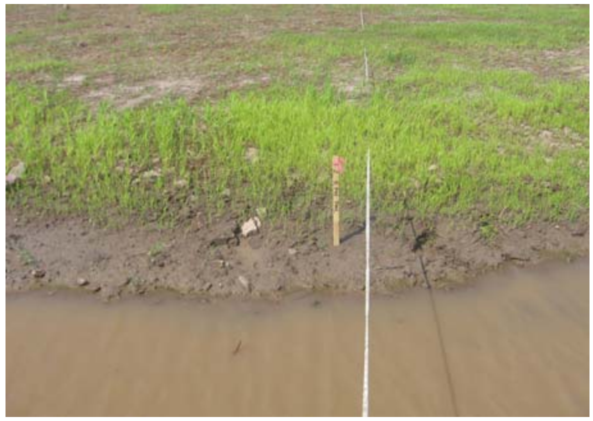


**Permanent Cross-section 2, Station 17+69**

(As-Built Data - collected Oct. 2007)

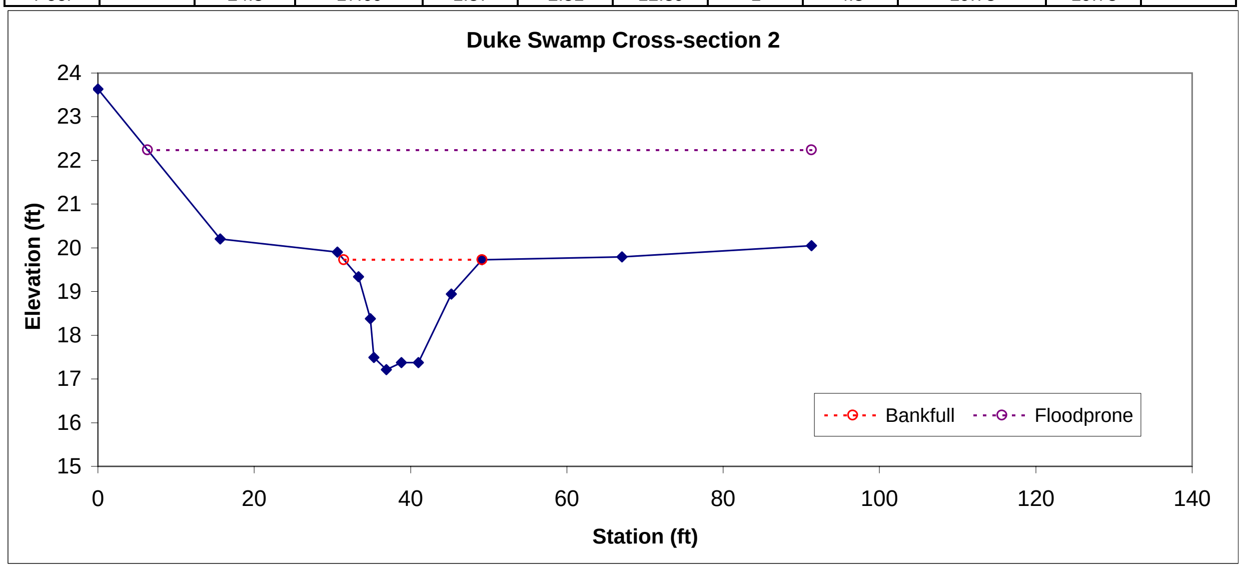


Looking at the Left Bank



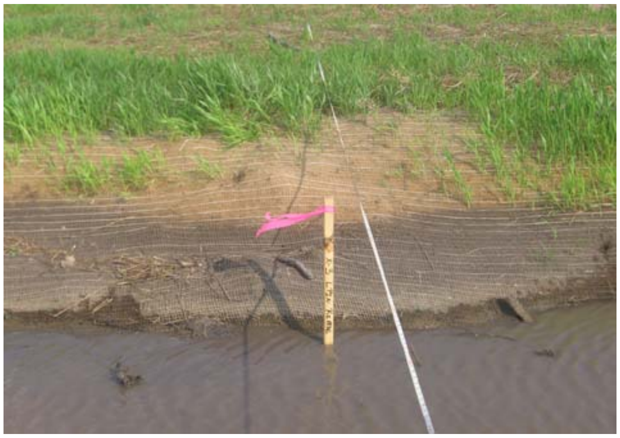
Looking at the Right Bank

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 24.3 | 17.69 | 1.37 | 2.51 | 12.89 | 1 | 4.8 | 19.73 | 19.73 | |



**Permanent Cross-section 3, Station 20+27**

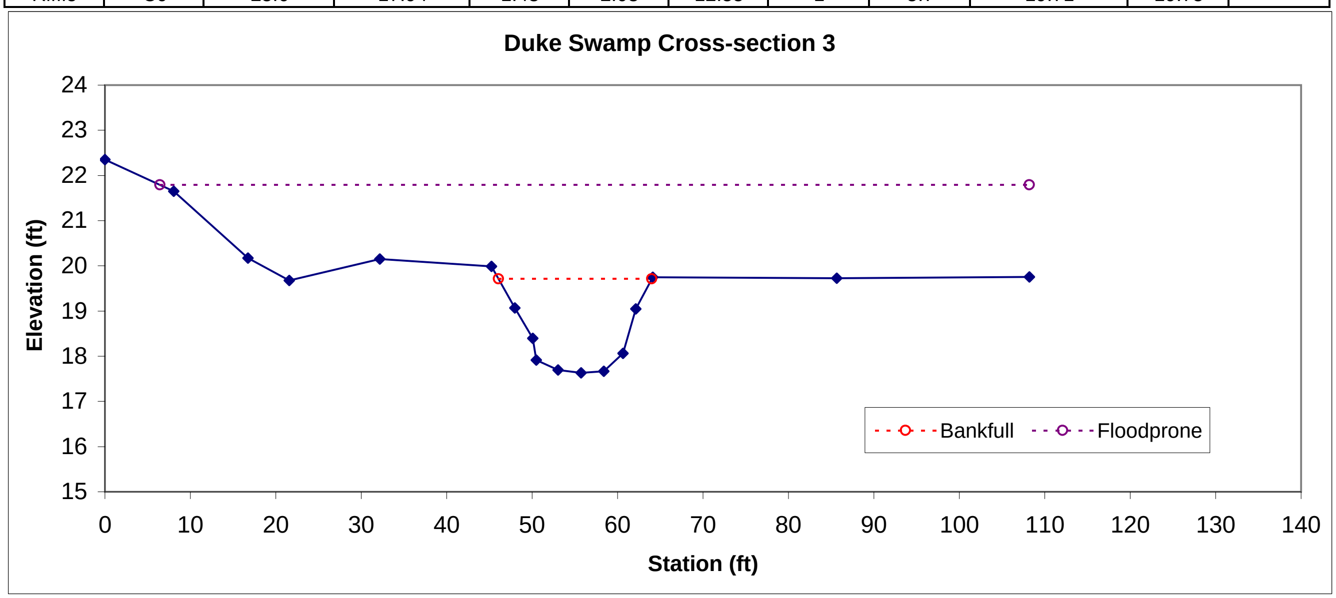
(As-Built Data - collected Oct. 2007)



**Looking at the Left Bank**

**Looking at the Right Bank**

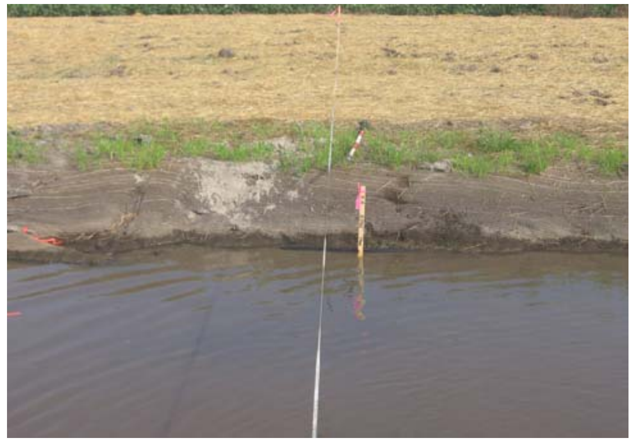
| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | Cc | 25.6 | 17.94 | 1.43 | 2.08 | 12.55 | 1 | 5.7 | 19.71 | 19.75 | |



**Permanent Cross-section 4, Station 26+81**

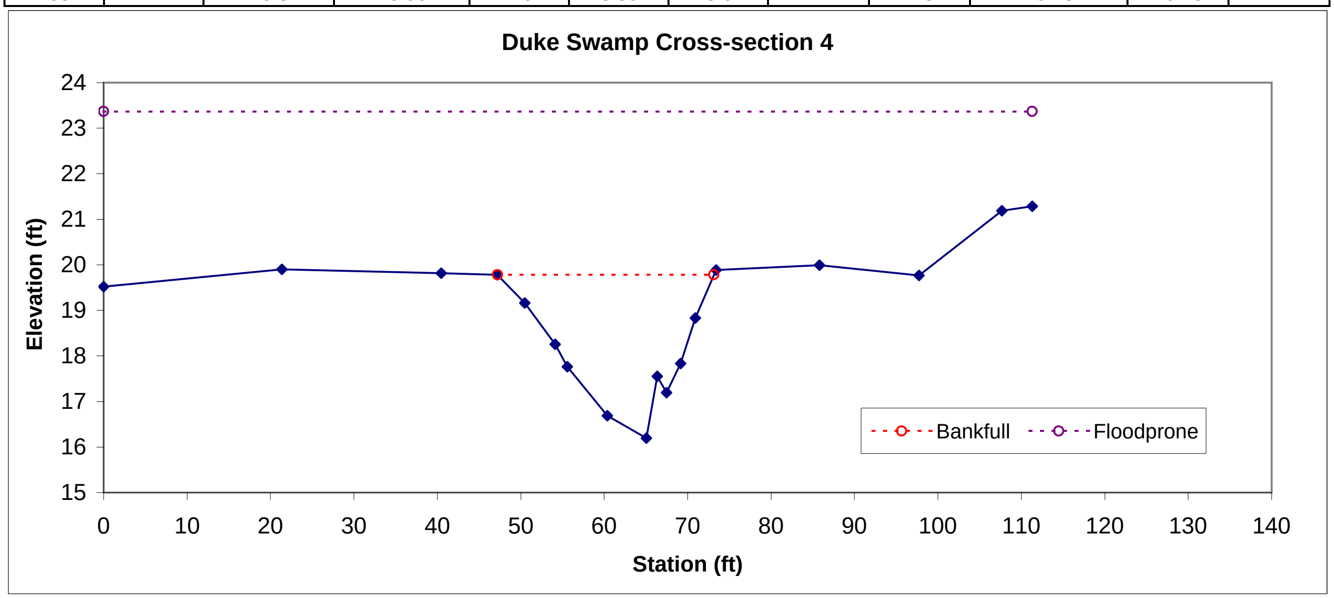
(As-Built Data - collected Oct. 2007)

**Looking at the Left Bank**



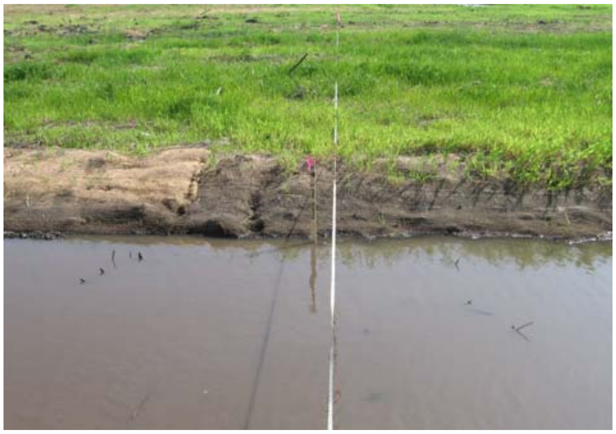
**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 49.3 | 25.96 | 1.9 | 3.59 | 13.67 | 1 | 4.3 | 19.78 | 19.78 | |



**Permanent Cross-section 5, Station 31+47**

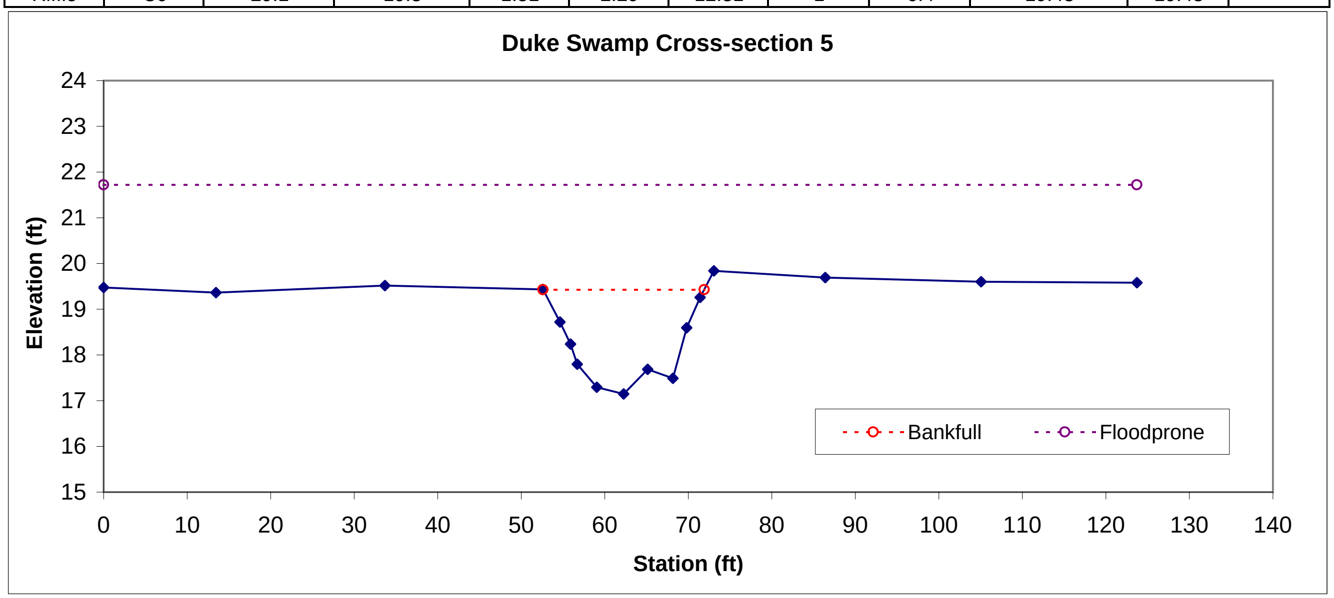
(As-Built Data - collected Oct. 2007)



**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | Cc | 29.1 | 19.3 | 1.51 | 2.29 | 12.81 | 1 | 6.4 | 19.43 | 19.43 | |



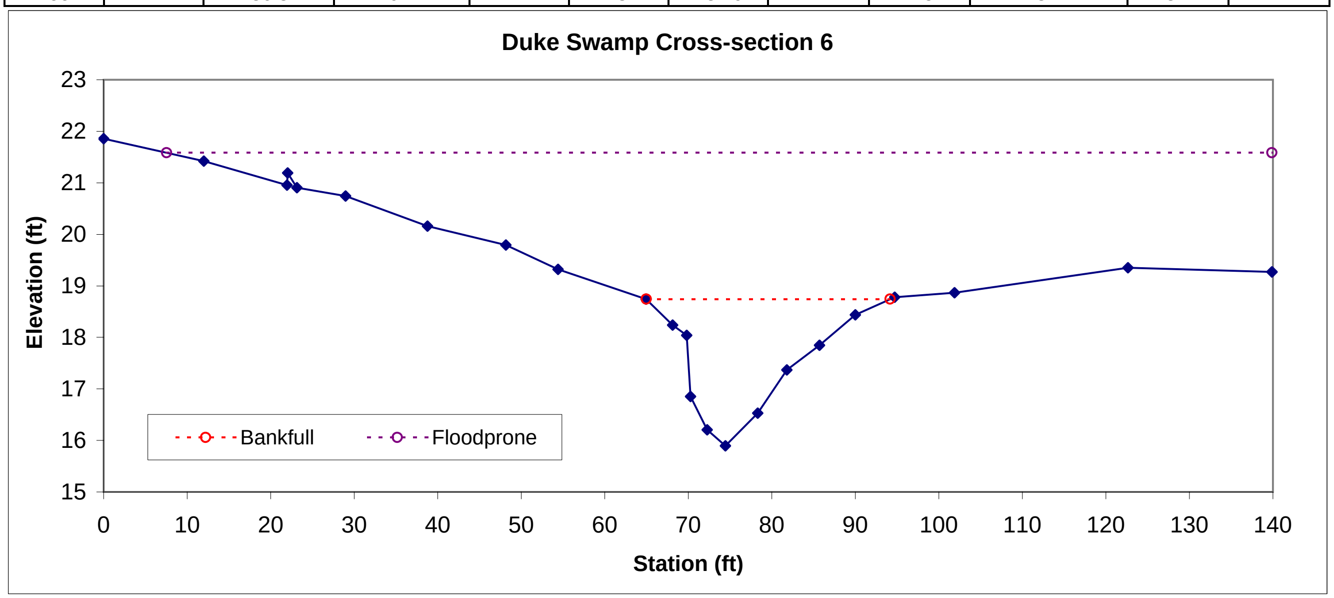
**Permanent Cross-section 6, Station 37+13**

(As-Built Data - collected Oct. 2007)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pool | | 36.3 | 29.22 | 1.24 | 2.84 | 23.49 | 1 | 4.5 | 18.74 | 18.74 | |



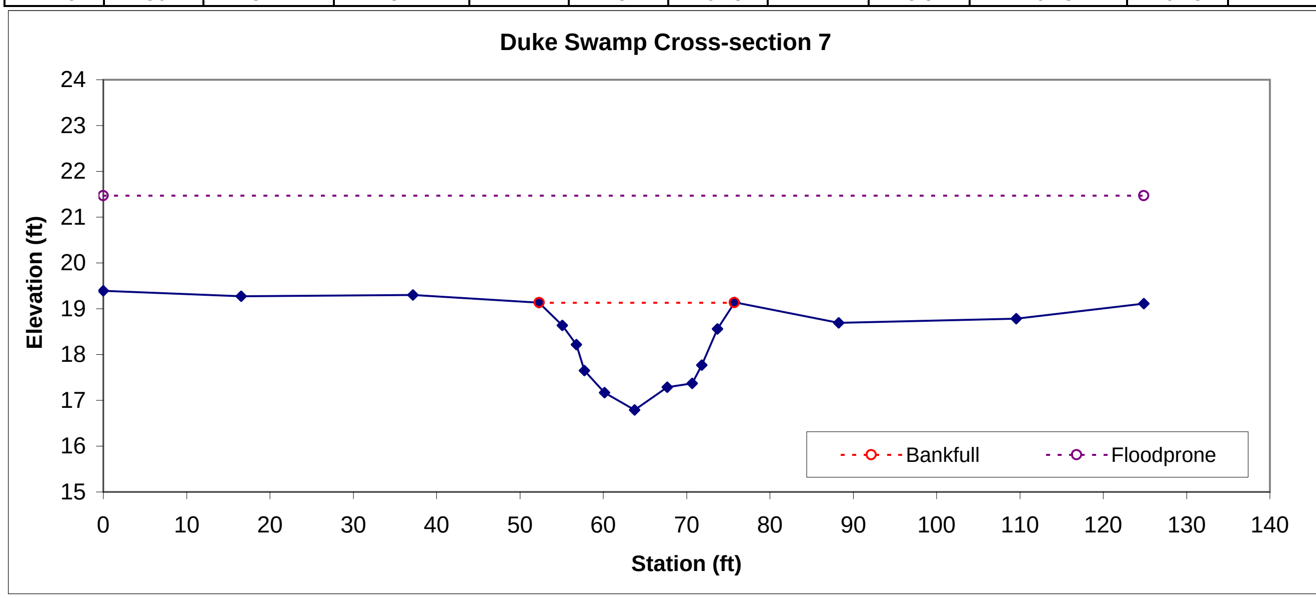
**Permanent Cross-section 7, Station 42+05**

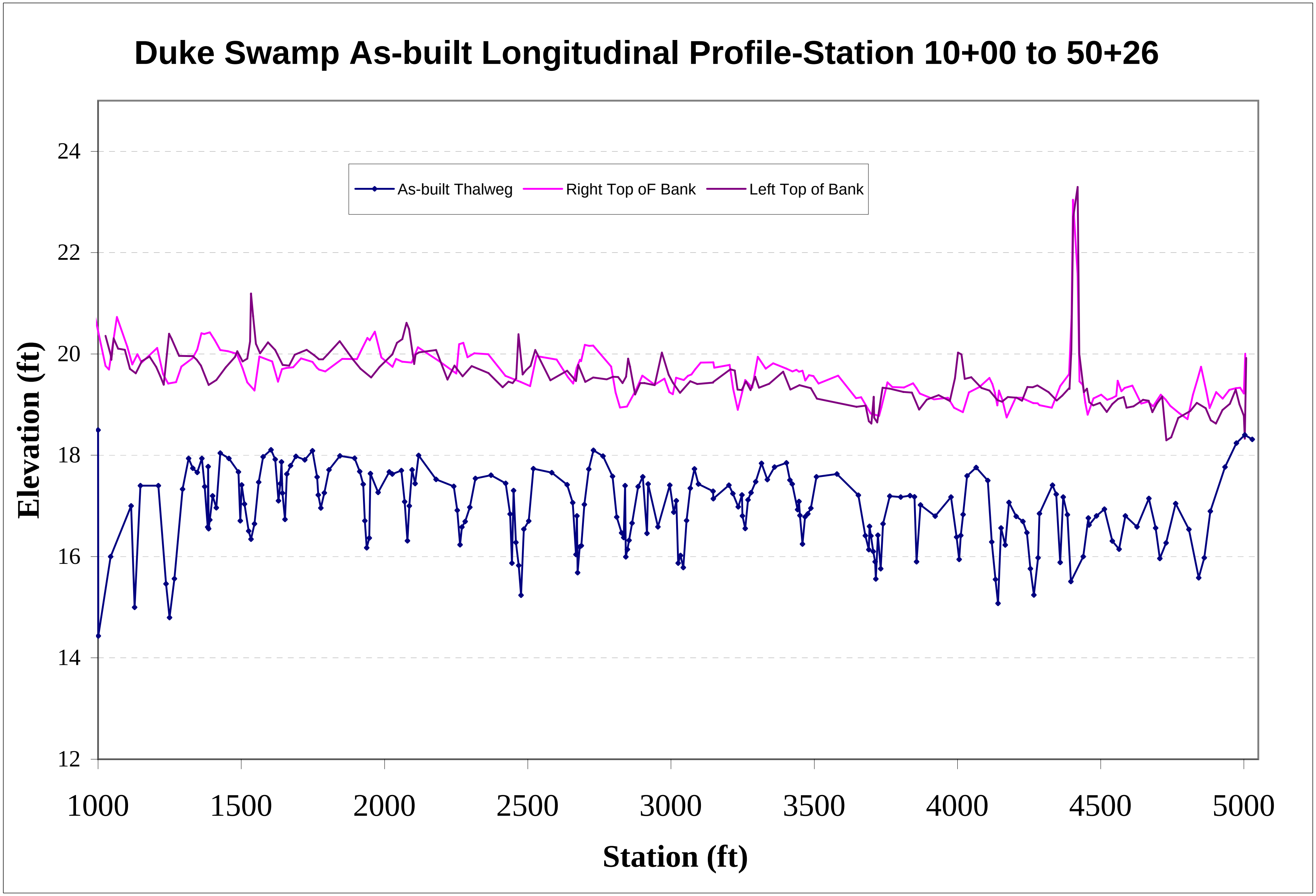
(As-Built Data - collected Oct. 2007)

**Looking at the Left Bank**

**Looking at the Right Bank**

| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev | W-fpa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | Cc | 32.7 | 23.44 | 1.4 | 2.34 | 16.78 | 1 | 5.3 | 19.13 | 19.13 | |




Duke Swamp As-built Longitudinal Profile-Station 10+00 to 50+26
As-built Thalweg
Right Top oF Bank
Left Top of Bank
Elevation (ft)
24
22
20
18
16
14
12
1000
1500
2000
2500
3000
3500
4000
4500
5000
Station (ft)

# APPENDIX 3

## AS-BUILT PLAN SHEETS

PROJECT: 109351 DUKE SWAMP

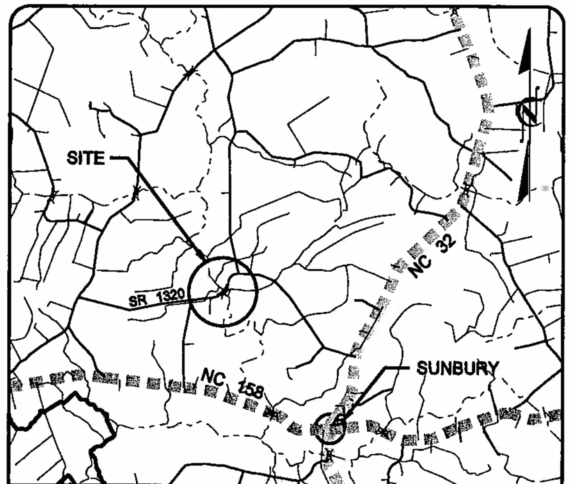
| STATE | BAKER PROJECT REFERENCE NO. | SHEET NO. | TOTAL SHEETS |
|---|---|---|---|
| NC | 109351 | 1 | 11 |
| REVISIONS | | | |
| PER EEP COMMENTS DATED 3/4/08 | | | |

# DUKE SWAMP WETLAND AND STREAM RESTORATION PROJECT
## NC ECOSYSTEM ENHANCEMENT PROGRAM
## PROJECT # D06065-A

# GATES COUNTY

**LOCATION: NINE MILES NORTHEAST OF GATESVILLE OFF SR 1320**

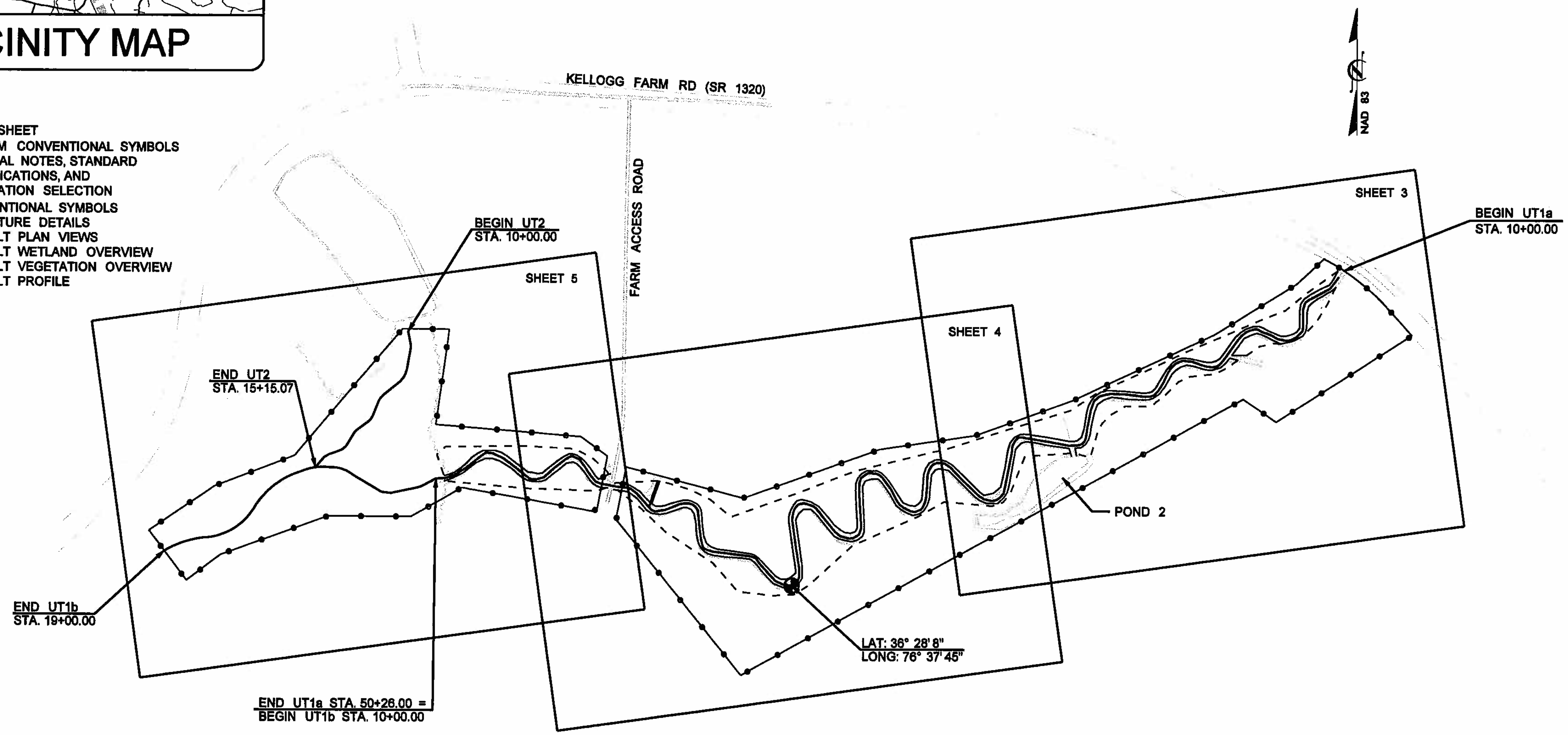
**TYPE OF WORK: AS-BUILT DRAWINGS FOR MITIGATION REPORT**




VICINITY MAP

INDEX OF SHEETS






**GRAPHIC SCALES**

100 25 0 50 100
PLANS

50 25 0 50 100
PROFILE (HORIZONTAL)

5 2.5 0 5 10
PROFILE (VERTICAL)

**AS-BUILT SUMMARY (YEAR 0 – BASELINE DATA)**

| | | |
|---|---|---|
| AS-BUILT UT1A DESIGN STREAM RESTORATION LENGTH (TOTAL) | = | 4,026 FEET |
| AS-BUILT UT1B DESIGN STREAM RESTORATION LENGTH | = | 900 FEET |
| AS-BUILT UT2 DESIGN STREAM RESTORATION LENGTH | = | 515 FEET |
| AS-BUILT RIVERINE WETLAND ENHANCEMENT ACREAGE (AREAS #2 AND #3) | = | 7.6 ACRES |
| AS-BUILT RIVERINE WETLAND RESTORATION ACREAGE (AREA #1) | = | 12.0 ACRES |

**PREPARED FOR THE OFFICE OF:**

Ecosystem Enhancement PROGRAM

NCDENR – ECOSYSTEM ENHANCEMENT PROGRAM
2728 CAPITAL BLVD, SUITE 1H 103
RALEIGH, NC 27604

**NCEEP CONTACT:** GUY PEARCE
*PROJECT CONTACT*

**PREPARED IN THE OFFICE OF:**

Baker

Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490

KEVIN TWEEDY, PE
*PROJECT ENGINEER*

KAYNE VAN STELL
*PROJECT MANAGER*

DECEMBER 2007
*COMPLETION DATE*

**PROJECT ENGINEER**

NORTH CAROLINA PROFESSIONAL SEAL 027337 ENGINEER KEVIN L. TWEEDY

3-24-08

SIGNATURE: P.E.

| BAKER PROJECT REFERENCE NO. | SHEET NO. |
|---|---|
| 109351 | 1-A |

PROJECT ENGINEER

NORTH CAROLINA PROFESSIONAL SEAL 027337 ENGINEER KEVIN L. TWEEDY

APPROVED BY:

2-6-08

DATE:

Baker

Baker Engineering NY, Inc.
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490

# STREAM CONVENTIONAL SYMBOLS

## SUPERCEDES SHEET 1B

- ROCK J-HOOK
- ROCK VANE
- OUTLET PROTECTION
- ROCK CROSS VANE
- DOUBLE DROP ROCK CROSS VANE
- SINGLE WING DEFLECTOR
- DOUBLE WING DEFLECTOR
- TEMPORARY SILT CHECK
- ROOT WAD
- LOG J-HOOK
- LOG VANE
- LOG WEIR
- LOG CROSS VANE
- CONSTRUCTED RIFFLE
- BOULDER CLUSTER
- ROCK STEP POOL
- SAFETY FENCE
- TF — TAPE FENCE
- FP — 100 YEAR FLOOD PLAIN
- CE — CONSERVATION EASEMENT
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- FOOT BRIDGE
- TEMPORARY STREAM CROSSING
- PERMANENT STREAM CROSSING
- TRANSPLANTED VEGETATION
- TREE REMOVAL
- TREE PROTECTION

**NOTE: ALL ITEMS ABOVE MAY NOT BE USED ON THIS PROJECT

# GENERAL NOTES

1. CONSTRUCTION BEGAN IN JULY 2007 AND WAS COMPLETED IN DECEMBER 2007.

# STANDARD SPECIFICATIONS

***EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL DECEMBER 1993***

6.60 TEMPORARY SEDIMENT TRAP

6.06 TEMPORARY GRAVEL CONSTRUCTION ACCESS

6.62 SILT FENCE

6.63 TEMPORARY ROCK DAM

6.70 TEMPORARY STREAM CROSSING

# VEGETATION SELECTION

The following table lists bare-root vegetation selection for the project site. Species were planted at a density of 680 stems per acre. Total planting area was approximately 17 acres. Exact placement of species was determined prior to site planting and based on apparent wetness of planting locations.

| Common Name | Scientific Name | Percent Planted by Species | Total Number of Stems | Wetness Tolerance |
|---|---|---|---|---|
| River Birch | *Betula nigra* | 15% | 1,800 | FACU |
| Sugarberry | *Celtis laevigata* | 5% | 600 | FACW |
| Green Ash | *Fraxinus pennsylvanica* | 7% | 900 | FACW |
| Swamp Tupelo | *Nyssa sylvatica var.biflora* | 14% | 1,600 | FACW+ |
| Sycamore | *Platanus occidentalis* | 19% | 2,300 | FACW |
| Overcup Oak | *Quercus lyrata* | 10% | 1,200 | OBL |
| Swamp Chestnut Oak | *Quercus michauxii* | 10% | 1,200 | FACW- |
| Willow Oak | *Quercus phellos* | 8% | 900 | FACW- |
| Bald Cypress | *Taxodium distichum* | 12% | 1,400 | OBL |
| | | Total | 11,900 | |

The following table temporary seed mix for the project site. All disturbed areas will be stabilized using mulch and temporary seed.

| Common Name | Rate | Dates |
|---|---|---|
| RYE GRAIN (COOL SEASON) | 130 LBS/ACRE | SEPTEMBER TO MARCH |
| MILLET (WARM SEASON) | 40 LBS/ACRE | APRIL TO AUGUST |

Permanent seed mixtures for the restoration site were planted throughout the floodplain and riparian buffer areas. Permanent seed mixtures were applied with temporary seed, as defined in the construction specifications.

| Common Name | Scientific Name | Percent of Mixture | Seeding Density (lbs/acre) | Wetness Tolerance |
|---|---|---|---|---|
| Virginia wildrye | *Elymus virginicus* | 15% | 4 | FAC |
| Switchgrass | *Panicum virgatum* | 15% | 6 | FAC+ |
| Fox sedge | *Carex vulpinoidea* | 15% | 6 | OBL |
| Smart Weed | *Polygonum pennsylvanicum* | 15% | 6 | OBL |
| Soft rush | *Juncus effusus* | 25% | 4 | FACW+ |
| Hop sedge | *Carex lupulina* | 15% | 6 | OBL |

Live staking will be applied to all restored streambanks following the details in this plan set and according to the construction specifications.

| Common Name | Scientific Name | Number of Stems | Wetness Tolerance |
|---|---|---|---|
| Buttonbush | *Cephalanthus occidentalis* | 300 | OBL |
| Black Willow | *Salix nigra* | 300 | OBL |
| Silky Willow | *Salix sericea* | 1,200 | OBL |
| Elderberry | *Sambucus canadensis* | 1,200 | FACW- |

*S.U.E = SUBSURFACE UTILITY ENGINEER

STATE OF NORTH CAROLINA
DIVISION OF HIGHWAYS

# CONVENTIONAL SYMBOLS

## ROADS & RELATED ITEMS

- Edge of Pavement
- Curb
- Prop. Slope Stakes Cut
- Prop. Slope Stakes Fill
- Prop. Woven Wire Fence
- Prop. Chain Link Fence
- Prop. Barbed Wire Fence
- Prop. Wheelchair Ramp
- Curb Cut for Future Wheelchair Ramp
- Exist. Guardrail
- Prop. Guardrail
- Equality Symbol
- Pavement Removal

## RIGHT OF WAY

- Baseline Control Point
- Existing Right of Way Marker
- Exist. Right of Way Line w/Marker
- Prop. Right of Way Line with Proposed R/W Marker (Iron Pin & Cap)
- Prop. Right of Way Line with Proposed (Concrete or Granite) R/W Marker
- Exist. Control of Access Line
- Prop. Control of Access Line
- Exist. Easement Line
- Prop. Temp. Construction Easement Line
- Prop. Temp. Drainage Easement Line
- Prop. Perm. Drainage Easement Line

## HYDROLOGY

- Stream or Body of Water
- River Basin Buffer
- Flow Arrow
- Disappearing Stream
- Spring
- Swamp Marsh
- Shoreline
- Falls, Rapids
- Prop Lateral, Tail, Head Ditches

## STRUCTURES

MAJOR

- Bridge, Tunnel, or Box Culvert
- Bridge Wing Wall, Head Wall and End Wall

MINOR

- Head & End Wall
- Pipe Culvert
- Footbridge
- Drainage Boxes
- Paved Ditch Gutter

## UTILITIES

- Exist. Pole
- Exist. Power Pole
- Prop. Power Pole
- Exist. Telephone Pole
- Prop. Telephone Pole
- Exist. Joint Use Pole
- Prop. Joint Use Pole
- Telephone Pedestal
- U/G Telephone Cable Hand Hold
- Cable TV Pedestal
- U/G TV Cable Hand Hold
- U/G Power Cable Hand Hold
- Hydrant
- Satellite Dish
- Exist. Water Valve
- Sewer Clean Out
- Power Manhole
- Telephone Booth
- Cellular Telephone Tower
- Water Manhole
- Light Pole
- H-Frame Pole
- Power Line Tower
- Pole with Base
- Gas Valve
- Gas Meter
- Telephone Manhole
- Power Transformer
- Sanitary Sewer Manhole
- Storm Sewer Manhole
- Tank; Water, Gas, Oil
- Water Tank With Legs
- Traffic Signal Junction Box
- Fiber Optic Splice Box
- Television or Radio Tower
- Utility Power Line Connects to Traffic Signal Lines Cut Into the Pavement
- Recorded Water Line
- Designated Water Line (S.U.E.*)
- Sanitary Sewer
- Recorded Sanitary Sewer Force Main
- Designated Sanitary Sewer Force Main(S.U.E.*)
- Recorded Gas Line
- Designated Gas Line (S.U.E.*)
- Storm Sewer
- Recorded Power Line
- Designated Power Line (S.U.E.*)
- Recorded Telephone Cable
- Designated Telephone Cable (S.U.E.*)
- Recorded U/G Telephone Conduit
- Designated U/G Telephone Conduit (S.U.E.*)
- Unknown Utility (S.U.E.*)
- Recorded Television Cable
- Designated Television Cable (S.U.E.*)
- Recorded Fiber Optics Cable
- Designated Fiber Optics Cable (S.U.E.*)
- Exist. Water Meter
- U/G Test Hole (S.U.E.*)
- Abandoned According to U/G Record — ATTUR
- End of Information — E.O.I.

## BOUNDARIES & PROPERTIES

- State Line
- County Line
- Township Line
- City Line
- Reservation Line
- Property Line
- Property Line Symbol
- Exist. Iron Pin
- Property Corner
- Property Monument
- Property Number
- Parcel Number
- Fence Line
- Existing Wetland Boundaries
- High Quality Wetland Boundary
- Medium Quality Wetland Boundaries
- Low Quality Wetland Boundaries
- Proposed Wetland Boundaries
- Existing Endangered Animal Boundaries
- Existing Endangered Plant Boundaries

## BUILDINGS & OTHER CULTURE

- Buildings
- Foundations
- Area Outline
- Gate
- Gas Pump Vent or U/G Tank Cap
- Church
- School
- Park
- Cemetery
- Dam
- Sign
- Well
- Small Mine
- Swimming Pool

## TOPOGRAPHY

- Loose Surface
- Hard Surface
- Change in Road Surface
- Curb
- Right of Way Symbol — R/W
- Guard Post — GP
- Paved Walk
- Bridge
- Box Culvert or Tunnel
- Ferry
- Culvert
- Footbridge
- Trail, Footpath
- Light House

## VEGETATION

- Single Tree
- Single Shrub
- Hedge
- Woods Line
- Orchard
- Vineyard — VINEYARD

## RAILROADS

- Standard Gauge — CSX TRANSPORTATION
- RR Signal Milepost — MILEPOST 35
- Switch — SWITCH

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| 109351 | 2 |

PROJECT ENGINEER

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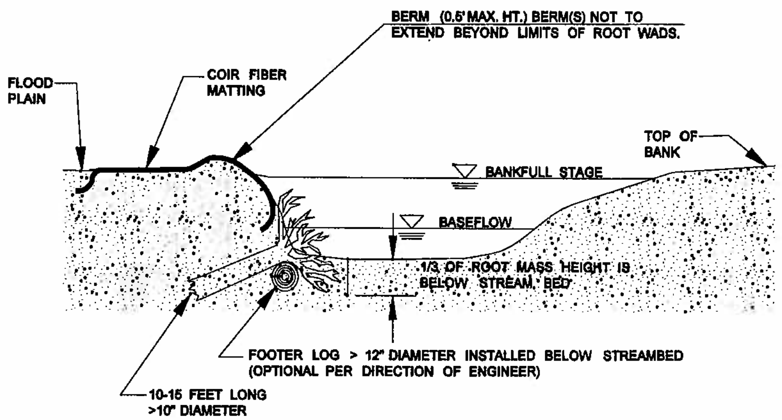
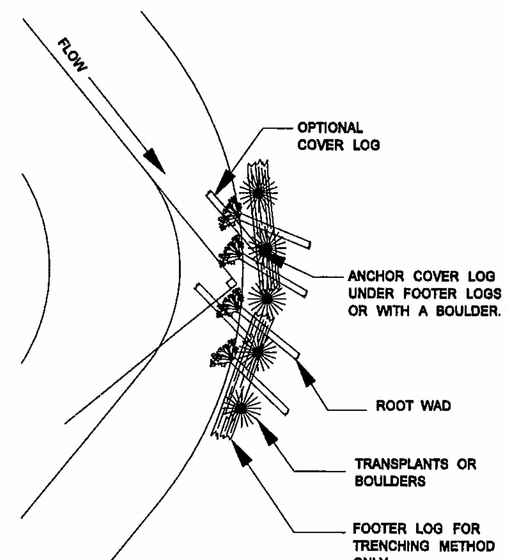
## ROOT WADS WITHOUT TRANSPLANTS

NTS




CROSS SECTION VIEW

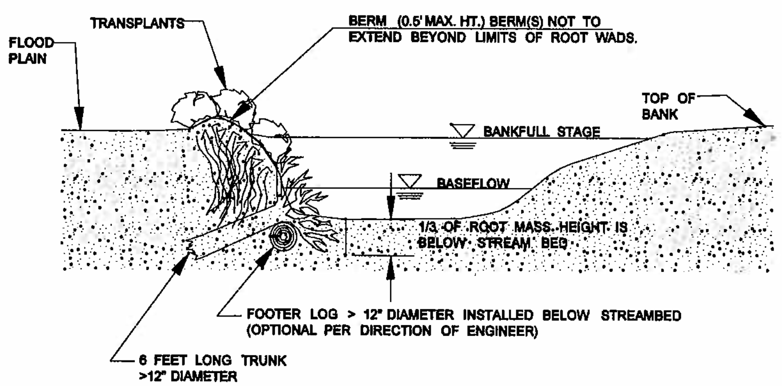
## ROOT WADS




PLAN VIEW

## ROOT WADS WITH TRANSPLANTS

NTS




CROSS SECTION VIEW

NOTES:

TRENCHING METHOD:
IF THE ROOT WAD CANNOT BE DRIVEN INTO THE BANK OR THE BANK NEEDS TO BE RECONSTRUCTED, THE TRENCHING METHOD SHOULD BE USED. THIS METHOD REQUIRES THAT A TRENCH BE EXCAVATED FOR THE LOG PORTION OF THE ROOT WAD. IN THIS CASE, A FOOTER LOG SHOULD BE INSTALLED UNDERNEATH THE ROOT WAD IN A TRENCH EXCAVATED PARALLEL TO THE BANK AND WELL BELOW THE STREAMBED. ONE-THIRD OF THE ROOT WAD SHOULD REMAIN BELOW NORMAL BASE FLOW CONDITIONS.

NOTES:

DRIVE POINT METHOD:
SHARPEN THE END OF THE LOG WITH A CHAINSAW BEFORE "DRIVING" IT INTO THE BANK. ORIENT ROOT WADS UPSTREAM SO THAT THE STREAM FLOW MEETS THE ROOT WAD AT A 90-DEGREE ANGLE, DEFLECTING THE WATER AWAY FROM THE BANK. A TRANSPLANT OR BOULDER SHOULD BE PLACED ON THE DOWNSTREAM SIDE OF THE ROOT WAD IF A BACK EDDY IS FORMED BY THE ROOT WAD. THE BOULDER SHALL BE APPROXIMATELY 4'X 3'X 2'.

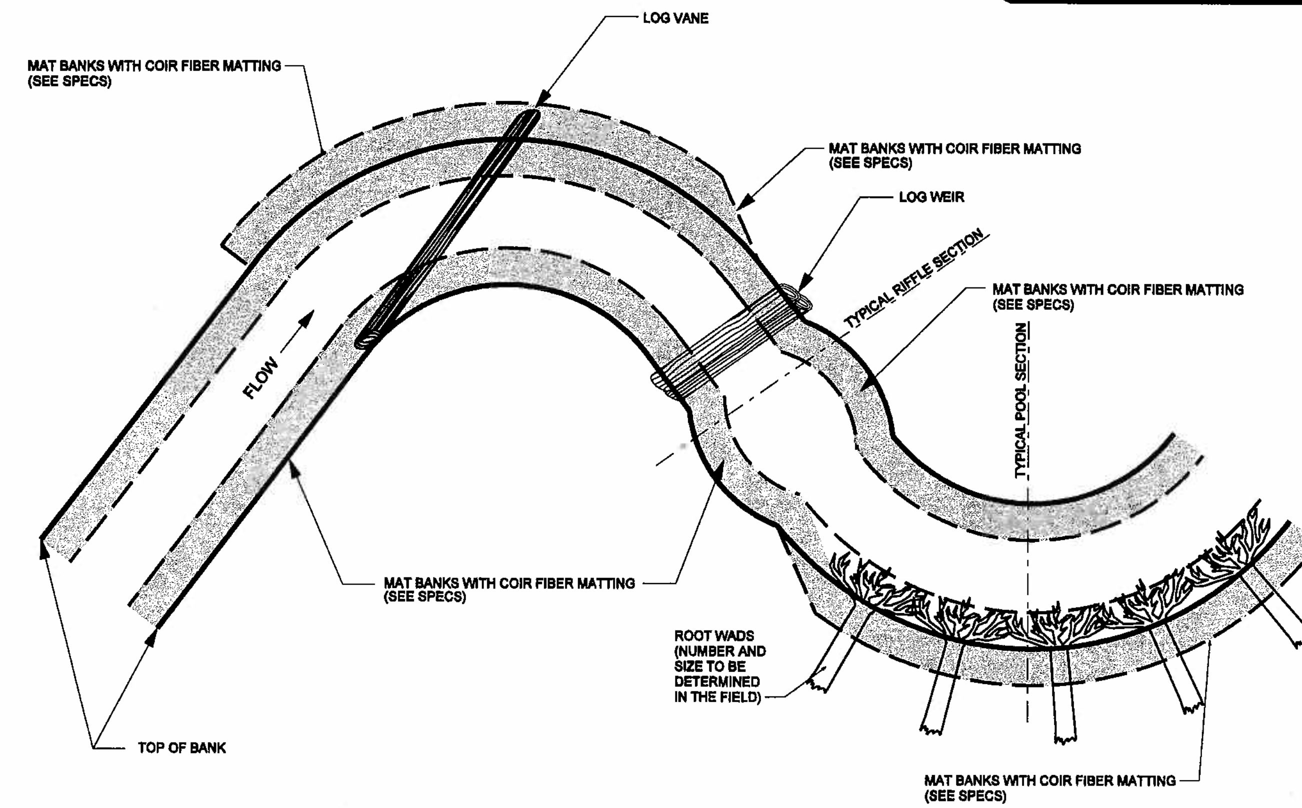
## TYPICAL STRUCTURE PLACEMENT

STRUCTURE NOTES:

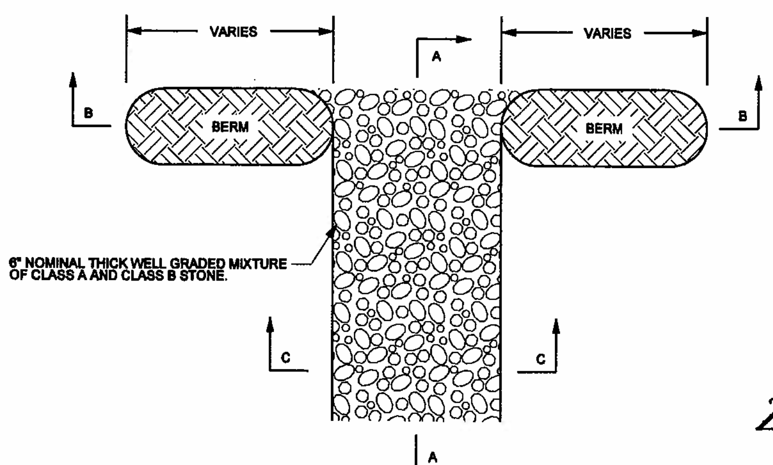
1. GENERALLY LOG WEIRS, ROOT WADS, LOG VANES AND COIR FIBER MATTING WILL BE INSTALLED IN THE LOCATION AND SEQUENCE AS SHOWN.
2. ADDITIONAL STRUCTURES OR CHANGES TO STRUCTURE LOCATIONS MAY BE MADE BY THE DESIGN ENGINEER DURING CONSTRUCTION.

NOTES:

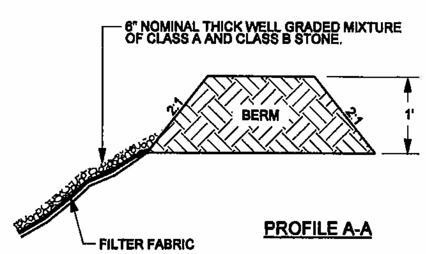
1. COIR FIBER MATTING TO BE INSTALLED ON ALL RESTORED STREAMBANKS.
2. IF ROOT WADS DO NOT COVER ENTIRE SLOPE ON OUTSIDE OF MEANDER BENDS, COIR FIBER MATTING IS NEEDED.



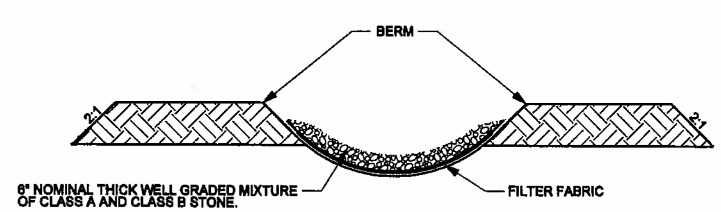

## DRAINAGE BERM



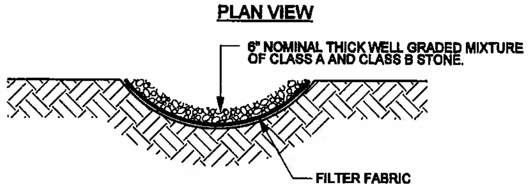

PLAN VIEW




PROFILE A-A




SECTION B-B

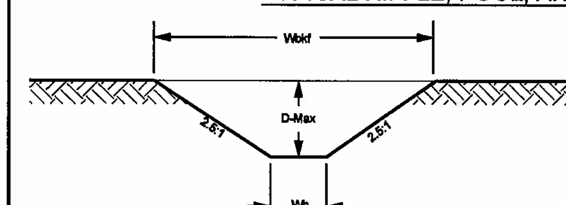



SECTION C-C

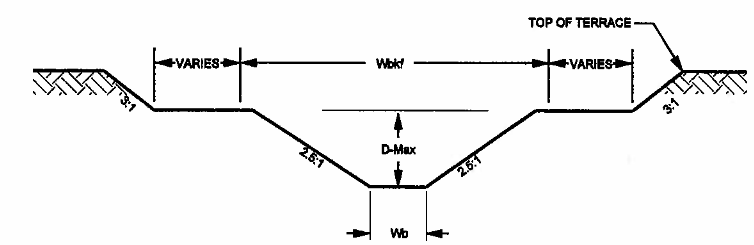
NOTE:

COMPACT BERM USING ON-SITE HEAVY EQUIPMENT IN 6 INCH LIFTS.

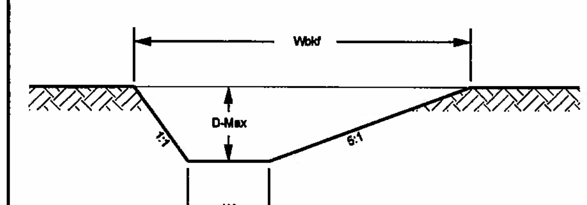
## TYPICAL RIFFLE, POOL, AND BANKFULL BENCH CROSS SECTIONS



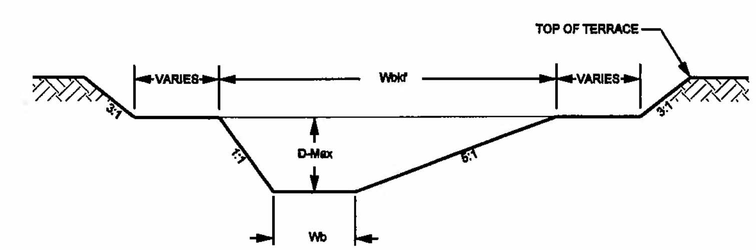

RIFFLE




RIFFLE WITH BANKFULL BENCH




POOL




POOL WITH BANKFULL BENCH

| UT1A | | |
|---|---|---|
| RIFFLE | POOL | |
| 19.4 | 22.0 | WIDTH OF BANKFULL (Wbkf) |
| 1.8 | 3.0 | MAXIMUM DEPTH (D-Max) |
| 14.0 | 11.7 | WIDTH TO DEPTH RATIO (Wbkf / D) |
| 27.0 | 41.3 | BANKFULL AREA (Abkf) |
| 10.4 | 5.5 | BOTTOM WIDTH (Wb) |

NOTES:

1. DURING CONSTRUCTION CORNERS OF DESIGN CHANNEL WILL BE ROUNDED AND A THALWEG WILL BE SHAPED PER DIRECTION OF ENGINEER.
2. POOLS SHOWN ABOVE ARE LEFT POOLS ONLY.

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| 109351 | 2-A |

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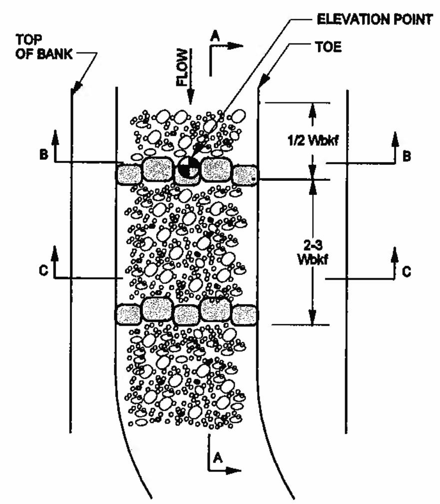
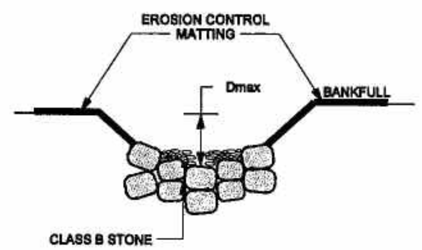
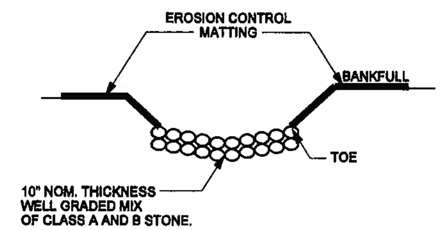
## CONSTRUCTED RIFFLE




PLAN VIEW



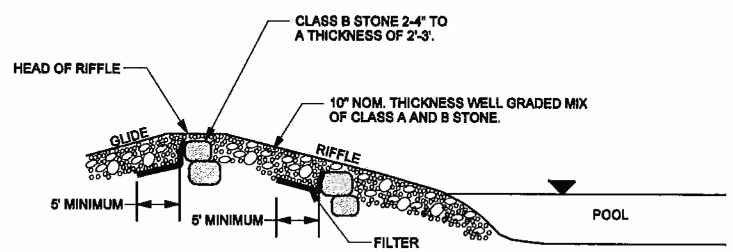

SECTION B - B




SECTION C - C

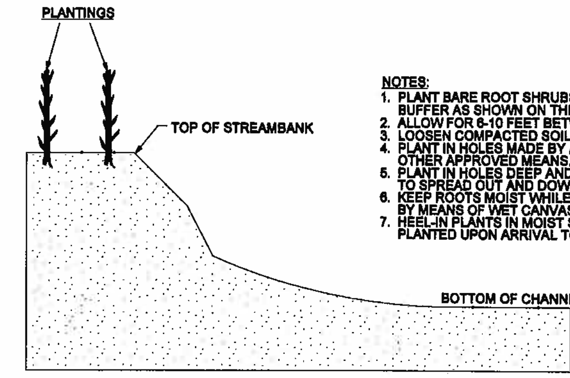
NOTES:

1. DIG A TRENCH BELOW THE BED FOR THE STOCK PILE CUT MATERIAL.
2. DIG A TRENCH FOR THE TAIL OF THE RIFFLE AND INSTALL CLASS B STONE.
3. FOR BOTH INVERTS, INSTALL FILTER FABRIC FOR DRAINAGE BEGINING AT THE MIDDLE OF THE HEADER AND EXTEND DOWNWARD TO THE DEPTH OF THE FOOTER, AND THEN UPSTREAM TO A MINIMUM OF FIVE FEET.
4. FILL IN THE UPSTREAM SIDE OF THE STRUCTURE WITH 2 FOOT MIX OF CLASS A STONE, CLASS B STONE, AND #57 STONE TO THE INVERT ELEVATION OF THE CHANNEL .
5. UNDERCUT RIFFLE BETWEEN INVERTS BY 8 INCHES. ALSO UNDERCUT RIFFLE BY 8 INCHES FOR 4 FEET UPSTREAM OF HEAD OF RIFFLE AND 6 FEET DOWN STREAM OF TAIL OF RIFFLE. BACK FILL ALL UNDERCUT AREAS WITH AN 8 INCH MIX OF CLASS A AND B STONE.



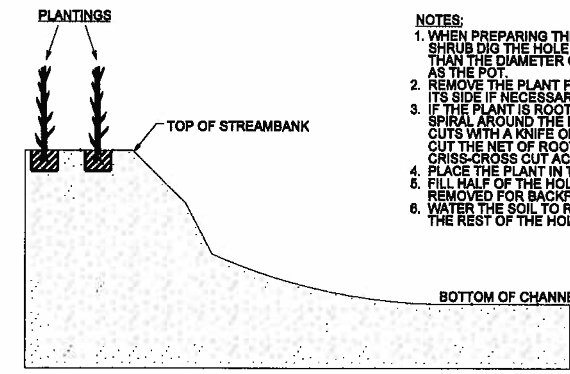

PROFILE A - A

## PLANTING SPECIFICATIONS




CROSS SECTION VIEW OF BARE ROOT PLANTING

NOTES:
1. PLANT BARE ROOT SHRUBS AND TREES TO THE WIDTH OF THE BUFFER AS SHOWN ON THE PLANS.
2. ALLOW FOR 6-10 FEET BETWEEN PLANTINGS, DEPENDING ON SIZE.
3. LOOSEN COMPACTED SOIL.
4. PLANT IN HOLES MADE BY A MATTOCK, DIBBLE, PLANTING BAR, OR OTHER APPROVED MEANS.
5. PLANT IN HOLES DEEP AND WIDE ENOUGH TO ALLOW THE ROOTS TO SPREAD OUT AND DOWN WITHOUT J-ROOTING.
6. KEEP ROOTS MOIST WHILE DISTRIBUTING OR WAITING TO PLANT BY MEANS OF WET CANVAS, BURLAP, OR STRAW.
7. HEEL-IN PLANTS IN MOIST SOIL OR SAWDUST IF NOT PROMPTLY PLANTED UPON ARRIVAL TO PROJECT SITE.

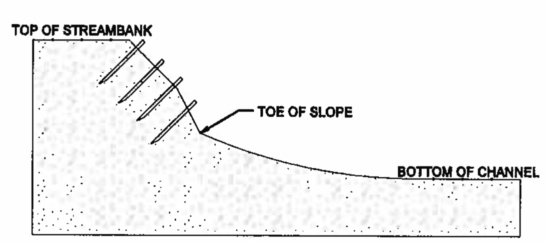



CROSS SECTION VIEW OF CONTAINER PLANTING

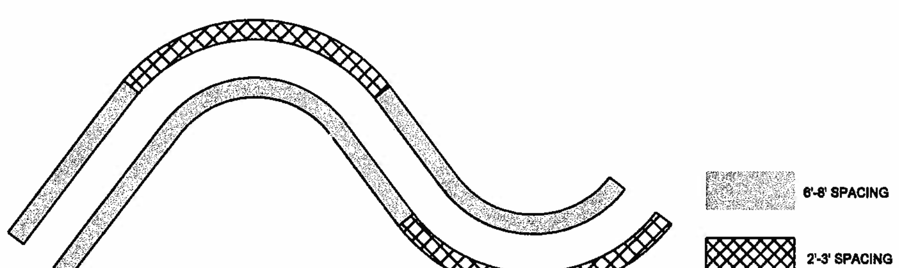
NOTES:
1. WHEN PREPARING THE HOLE FOR A POTTED PLANT OR SHRUB DIG THE HOLE 8 - 12 INCHES LARGER THAN THE DIAMETER OF THE POT AND THE SAME DEPTH AS THE POT.
2. REMOVE THE PLANT FROM THE POT. LAY THE PLANT ON ITS SIDE IF NECESSARY TO REMOVE THE POT.
3. IF THE PLANT IS ROOTBOUND (ROOTS GROWING IN A SPIRAL AROUND THE ROOT BALL), MAKE VERTICAL CUTS WITH A KNIFE OR SPADE JUST DEEP ENOUGH TO CUT THE NET OF ROOTS. ALSO MAKE A CRISS-CROSS CUT ACROSS THE BOTTOM OF THE BALL.
4. PLACE THE PLANT IN THE HOLE.
5. FILL HALF OF THE HOLE WITH SOIL (SAME SOIL REMOVED FOR BACKFILL).
6. WATER THE SOIL TO REMOVE AIR POCKETS AND FILL THE REST OF THE HOLE WITH THE REMAINING SOIL.

## LIVE STAKING SPECIFICATION

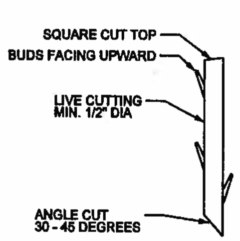
NOTES:
1. STAKES SHOULD BE CUT AND INSTALLED ON THE SAME DAY.
2. DO NOT INSTALL STAKES THAT HAVE BEEN SPLIT.
3. STAKES MUST BE INSTALLED WITH BUDS POINTING UPWARDS.
4. STAKES SHOULD BE INSTALLED PERPENDICULAR TO BANK.
5. STAKES SHOULD BE 1/2 TO 2 INCHES IN DIAMETER AND 2 TO 3 FT LONG.
6. STAKES SHOULD BE INSTALLED LEAVING 1/5 OF STAKE ABOVE GROUND.



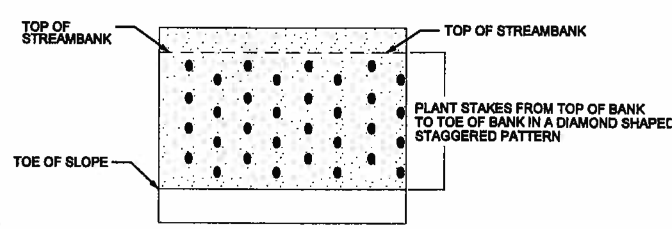

CROSS SECTION VIEW




PLAN VIEW




LIVE STAKE DETAIL

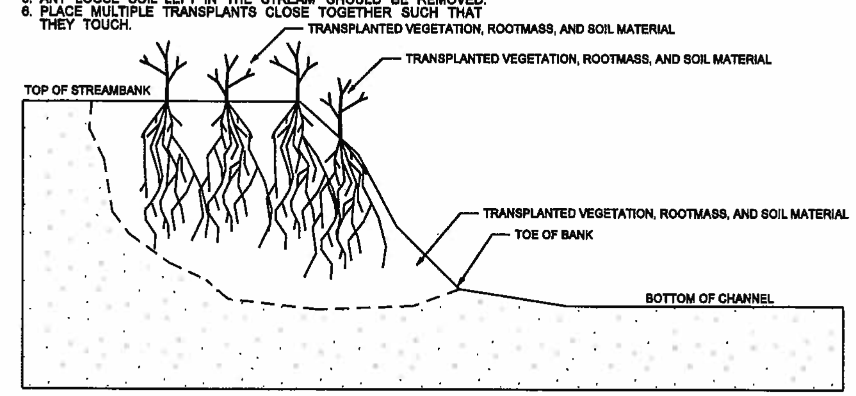



PLAN VIEW

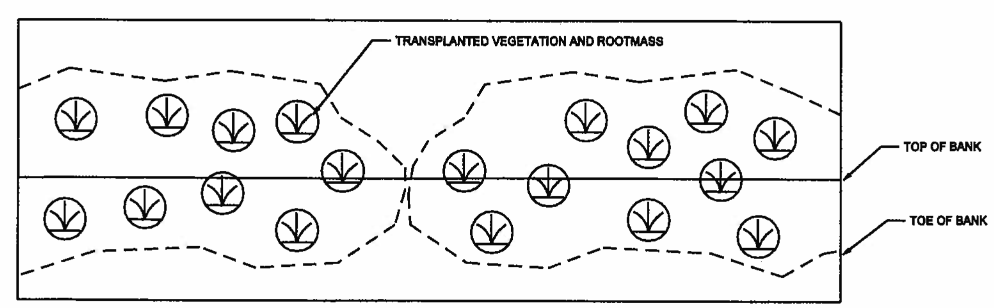
## TRANSPLANTED VEGETATION

NOTES:

1. EXCAVATE A HOLE IN THE BANK TO BE STABILIZED THAT WILL ACCOMMODATE THE SIZE OF TRANSPLANT TO BE PLACED. BEGIN EXCAVATION AT THE TOE OF THE BANK.
2. EXCAVATE TRANSPLANT USING A FRONT END LOADER. EXCAVATE THE ENTIRE ROOT MASS AND AS MUCH ADDITIONAL SOIL MATERIAL AS POSSIBLE. IF ENTIRE ROOT MASS CAN NOT BE EXCAVATE IN ONE BUCKET LOAD, THE TRANSPLANT IS TOO LARGE AND ANOTHER SHOULD BE SELECTED.
3. PLACE TRANSPLANT IN THE BANK TO BE STABILIZED SO THAT VEGETATION IS ORIENTATED VERTICALLY.
4. FILL IN ANY HOLES AROUND THE TRANSPLANT AND COMPACT.
5. ANY LOOSE SOIL LEFT IN THE STREAM SHOULD BE REMOVED.
6. PLACE MULTIPLE TRANSPLANTS CLOSE TOGETHER SUCH THAT THEY TOUCH.

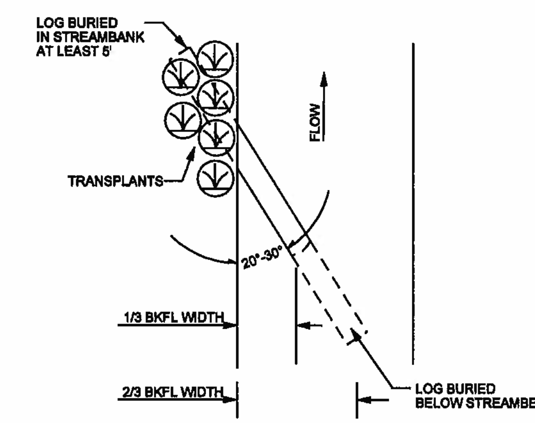



CROSS SECTION VIEW

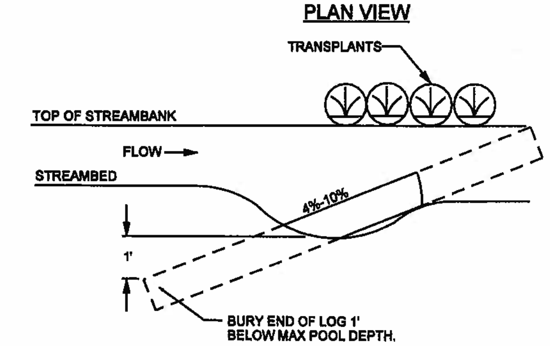



PLAN VIEW

## LOG VANE




PLAN VIEW




PROFILE VIEW

NOTES:

1. LOGS SHOULD BE AT LEAST 12" INCHES IN DIAMETER, RELATIVELY STRAIGHT, HARDWOOD, AND RECENTLY HARVESTED.
2. SOIL SHOULD BE COMPACTED WELL AROUND BURIED PORTIONS OF LOG.
3. TRANSPLANTS ARE PLACED ALONG THE TOP OF THE BANK OVER THE BURIED LOG VANE TO PROTECT AGAINST EROSION DURING HIGH FLOWS.

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| BAKER PROJECT REFERENCE NO. | SHEET NO. |
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PROJECT ENGINEER

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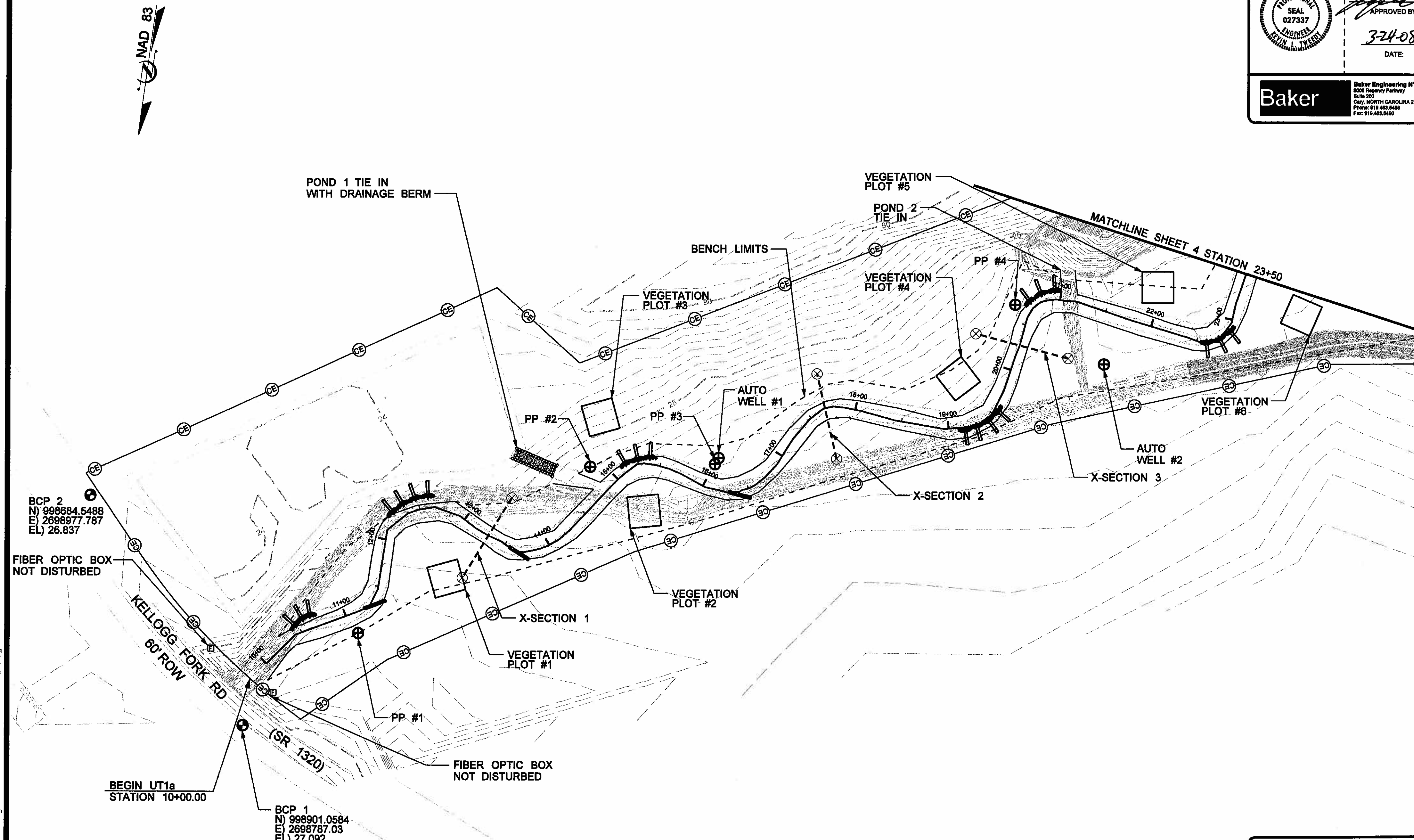


FILLED CHANNEL

DITCH PLUG

NOTE: CONTOURS SHOWN DEPICT PRE-CONSTRUCTION CONDITIONS.

**DUKE SWAMP AS-BUILT PLAN VIEW**

50 25 0 50 100

SCALE (FT)

2/26/03

3/19/2008 r:\109351-duke swamp\design\as-built\109351_BUCK_asb_PSH_03.dgn

| BAKER PROJECT REFERENCE NO. | SHEET NO. |
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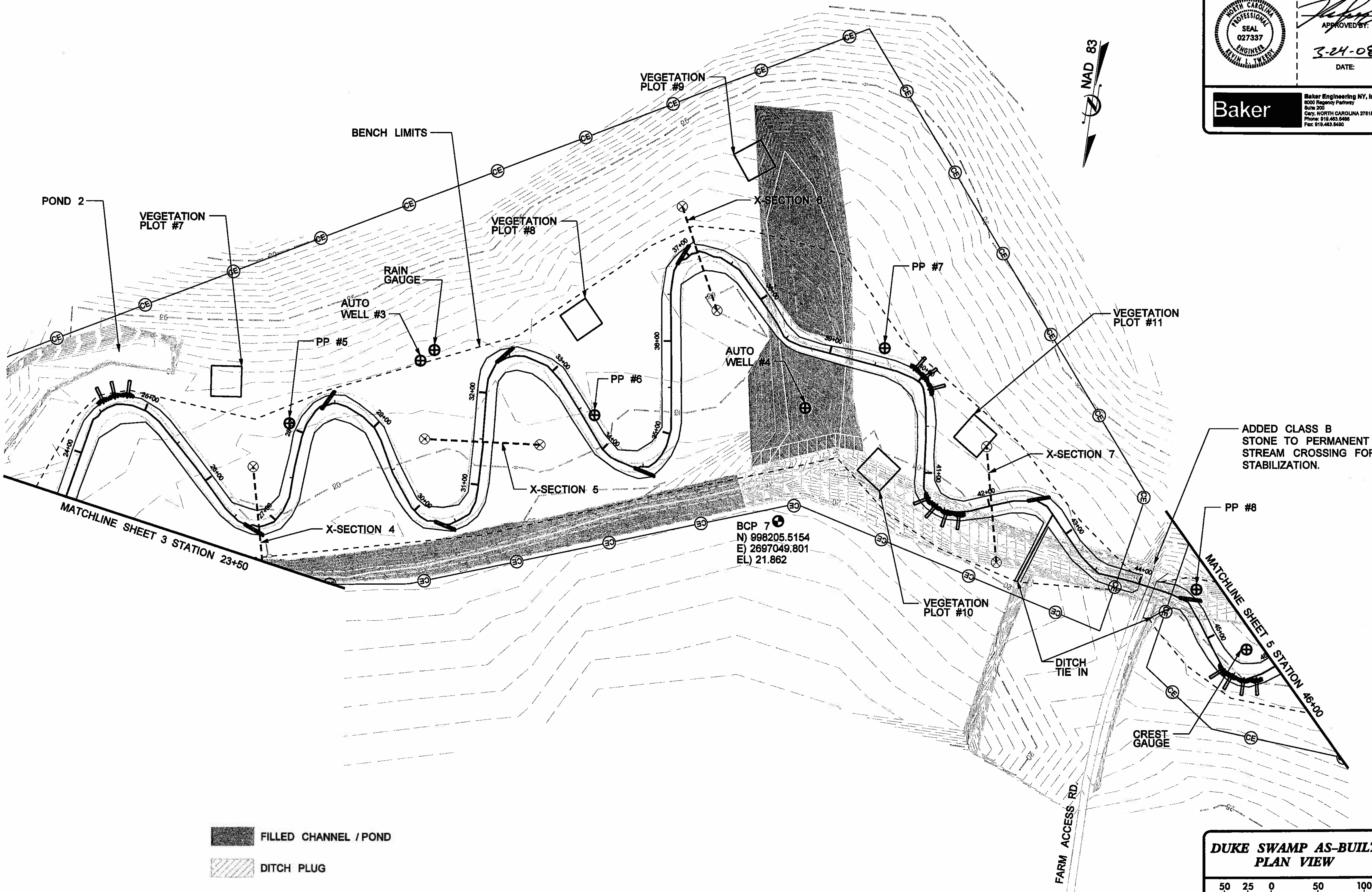


NOTE: CONTOURS SHOWN DEPICT PRE-CONSTRUCTION CONDITIONS.

**DUKE SWAMP AS-BUILT PLAN VIEW**

50 25 0 50 100

SCALE (FT)

2/26/03

3/19/2008
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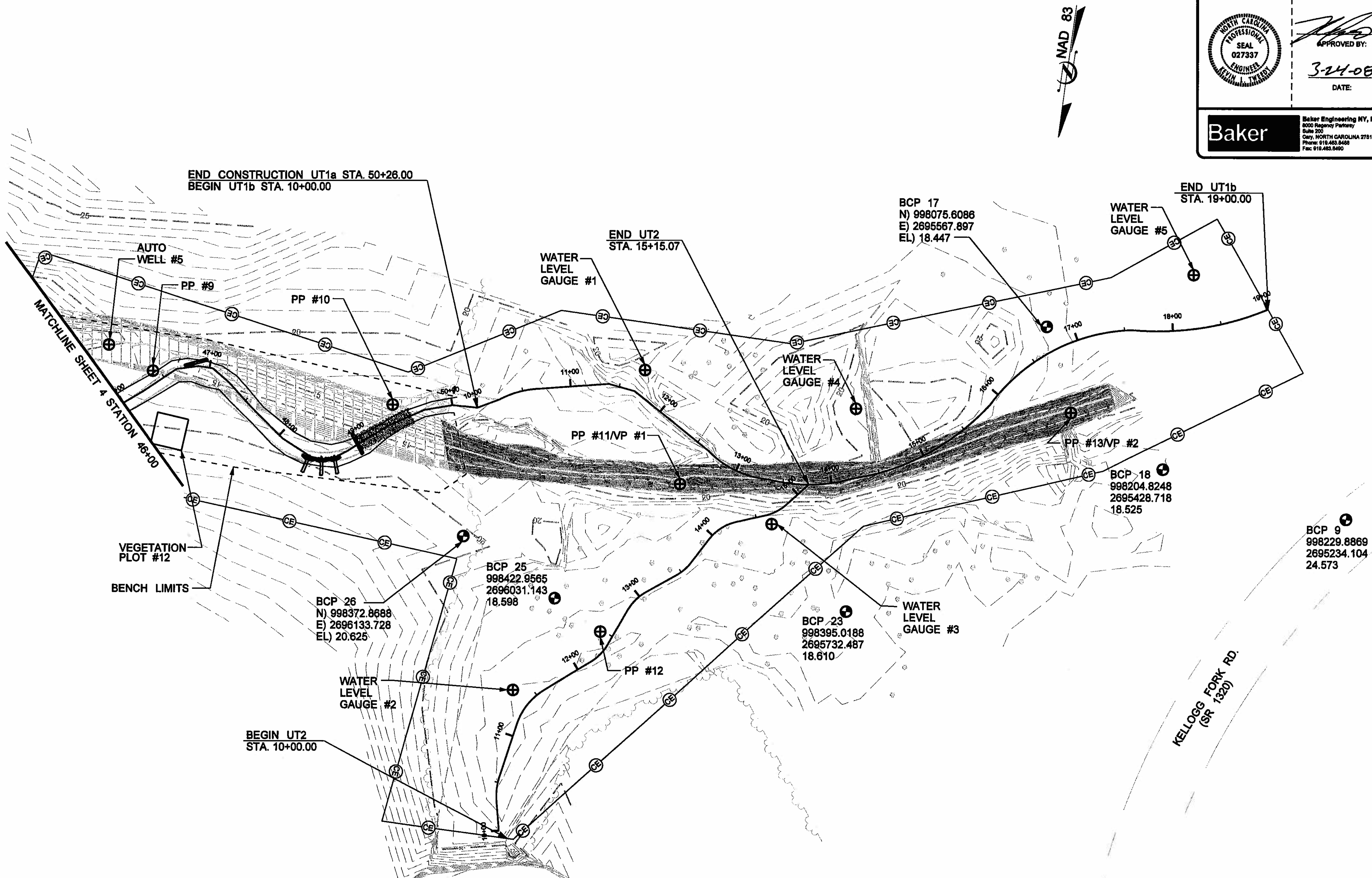


FILLED CHANNEL

DITCH PLUG

NOTE: CONTOURS SHOWN DEPICT PRE-CONSTRUCTION CONDITIONS.

DUKE SWAMP AS-BUILT PLAN VIEW

50 25 0 50 100

SCALE (FT)

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| 109351 | 6 |

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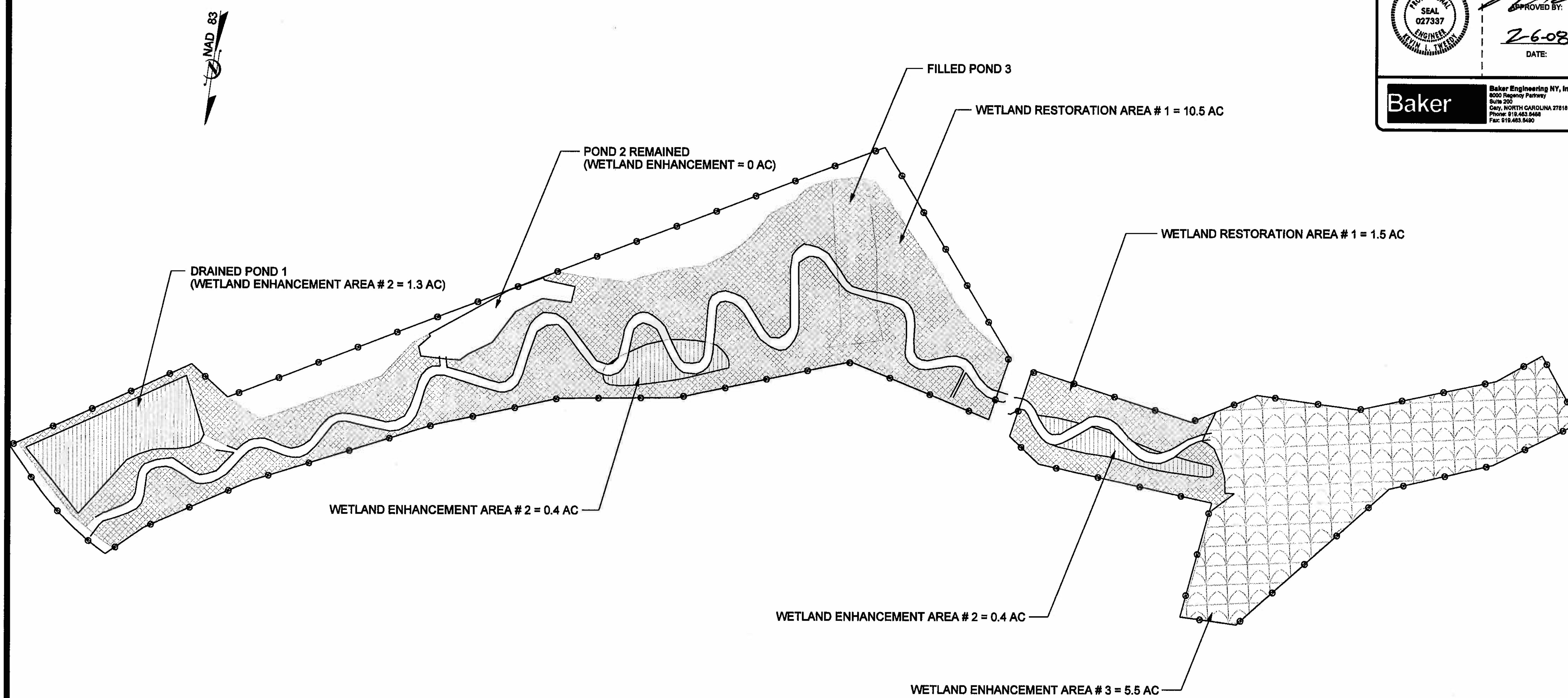


## *AS-BUILT WETLAND SUMMARY*

- AS-BUILT RIVERINE WETLAND RESTORATION ACREAGE (AREA #1) = 12.0 ACRES
- AS-BUILT RIVERINE WETLAND ENHANCEMENT ACREAGE (AREA #2) = 2.1 ACRES
- AS-BUILT RIVERINE WETLAND ENHANCEMENT ACREAGE (AREA #3) = 5.5 ACRES

## *DUKE SWAMP AS-BUILT WETLAND OVERVIEW*

125 0 125 250

SCALE (FT)

2/26/03

2/7/2008

2/26/03

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| 109351 | 7 |

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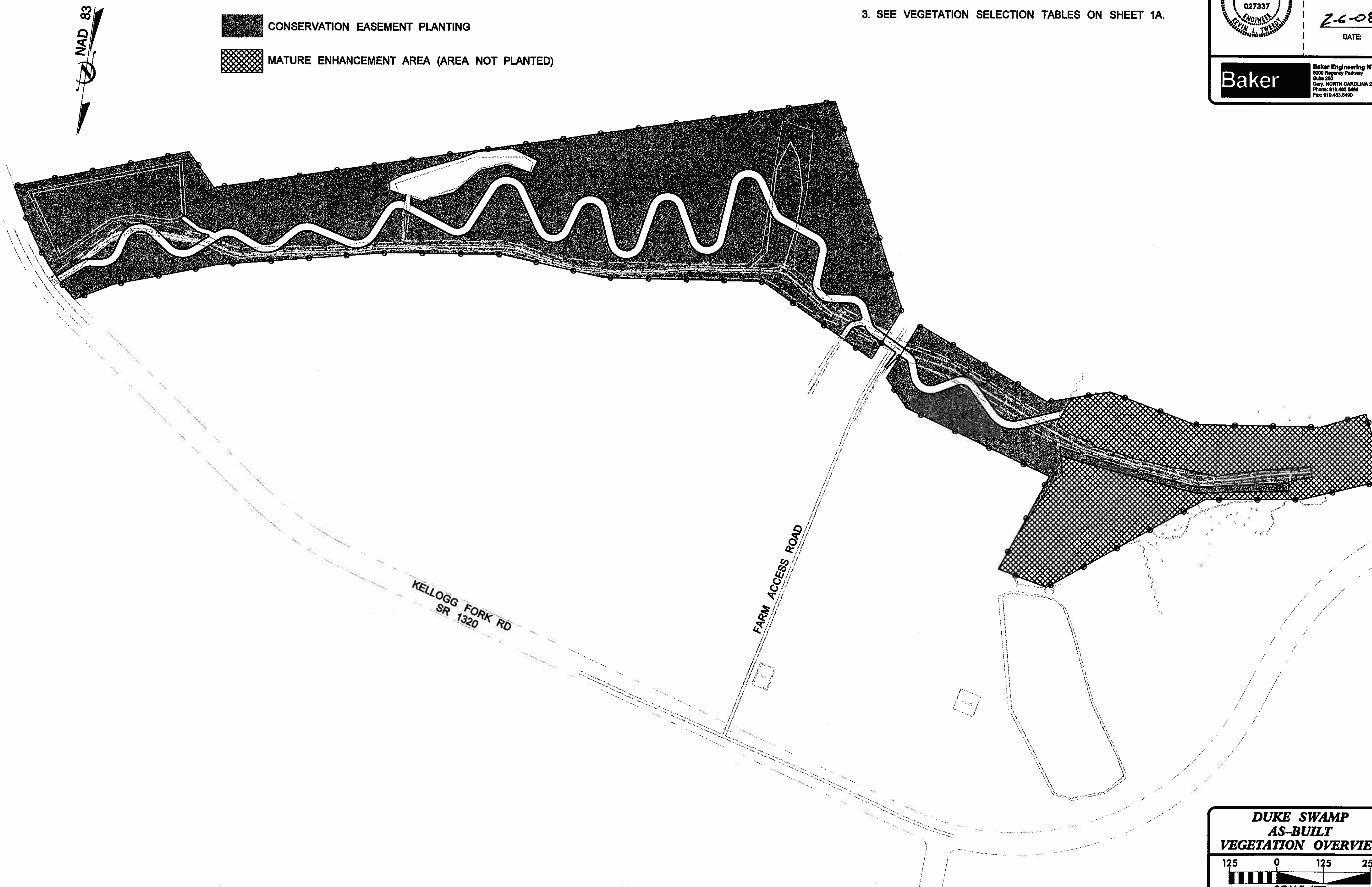
NOTES:

1. TOTAL PLANTING AREA = 17.2 AC.
2. TOTAL CONSERVATION EASEMENT AREA = 25.4 AC.
3. SEE VEGETATION SELECTION TABLES ON SHEET 1A.




# DUKE SWAMP AS-BUILT VEGETATION OVERVIEW

125 0 125 250

SCALE (FT)

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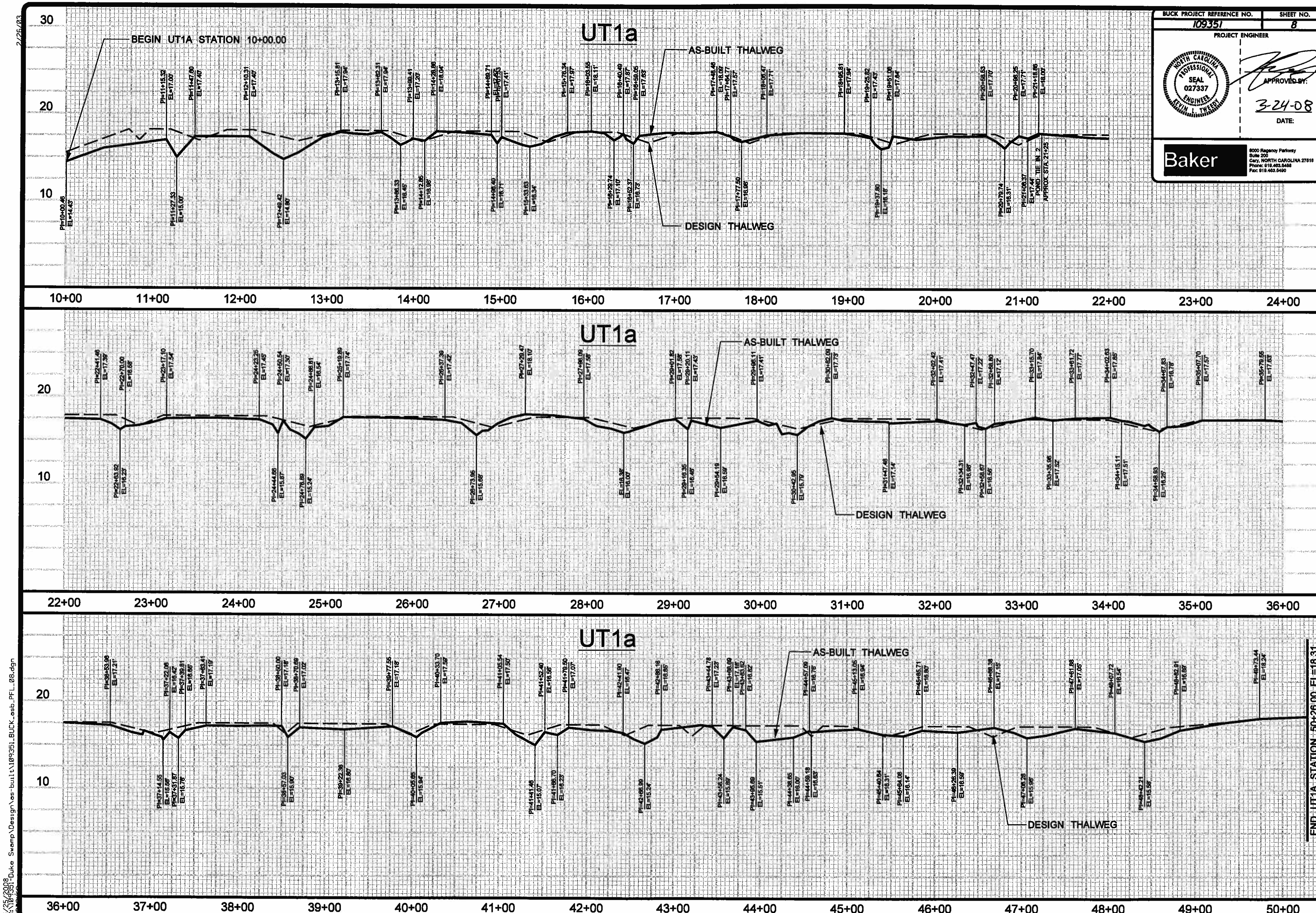


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