Haw Branch Wetland and Stream Restoration Project – Mitigation Plan Report

Onslow County, North Carolina

Prepared for:

EBX NEUSE - I, LLC
10055 RED RUN BLVD.
OWINGS MILL, MD 21117-4860

EBX

Report Prepared by Buck Engineering PC

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EXECUTIVE SUMMARY

The Haw Branch site was restored through a contract with EBX Neuse - I, LLC (EBX). The goals and objectives of this project were as follows:

- Restore 25 acres of small stream swamp riverine wetlands;
- Restore dimension, pattern, and profile to 10,005 linear feet (LF) of streams;
- Improve floodplain functionality by matching floodplain elevation with bankfull stage;
- Establish native wetland and floodplain vegetation within the permanent conservation easement;
- Improve water quality by reducing bank erosion, reducing inputs of nutrients to the stream system, and providing for improved retention of flood waters; and
- Improve wildlife habitat functions of the site.

This report is being submitted to document completion of the project and to present base-line, as-built monitoring data for the five-year monitoring period. The stream and wetland mitigation units developed on the project meet or exceed the number of units that EBX contracted with EEP to provide as shown in Table 1.

Table 1 **Background Information**	
Project	Haw Branch Wetland and Stream Restoration Project
Designer	Buck Engineering (Cary Office)
Contractor	RG Construction
Project County	Onslow County
Directions to Project Site	From Raleigh, take I-40 east to HWY 24 west Go through Beuleaville, turn right onto Haw Branch Road, turn right into the project about two miles down the road on the right.
Drainage Area	UT1 = 246 acres (0.38 square miles) UT2 = 91 acres (0.14 square miles) UT3 = 174 acres (0.27 square miles)
USGS Hydro Unit	03030007-080010
NCDWQ Subbasin	03-06-22
Contract Mitigation Units	10,000 SMUs; 25 Riverine WMUs
Project Length	10,005 LF (As-built); 10,005 SMUs
Project Area	25 acres coastal plain small stream swamp (As-built); 25.0 Riverine WMUs
Restoration Approach	Restore channel dimension, pattern and profile to three separate stream reaches
	Restore wetland functions to riverine wetlands
Date of Earthwork Completion	August 2005
Date of Planting Completion	December 2005
Monitoring Dates	Monthly through each growing season for 5 years

TABLE OF CONTENTS

1.0 BACKGROUND INFORMATION 1

1.1 Goals and Objectives 1
1.2 Project Location 1
1.3 Project Description 1
1.4 Construction 4

2.0 MONITORING RESULTS – 2005 AS-BUILT DATA 6

2.1 Vegetation 6
2.1.1 Results and Discussion 8
2.2 Morphology 8
2.2.1 Results and Discussion 8
2.3 Hydrology 8
2.4 Areas of Concern 8

3.0 SUPPLEMENTAL INFORMATION 9

3.1 Pre-Construction Site Conditions 9
3.2 Restoration Plan 9
3.3 Design Modifications Made During Construction 10
3.4 Post Construction Site Conditions 10
3.5 Ecological Benefits 10
3.6 Monitoring Plan 11
3.7 Success Criteria 13
3.8 Maintenance and Contingency Plans 14
3.9 References 14

Tables and Exhibits

Table 1 Background Information i
Table 2 Summary of As-built Lengths and Restoration Approaches 5
Table 3 Vegetation Species Planted Across the Restoration Site 6
Table 4 Initial Planted Density of Trees for the Five Vegetation Sampling Plots 7

Figure 1 Project Vicinity Map 3

Appendices

Appendix 1 Selected Project Photographs
Appendix 2 As-Built Cross-sections and Longitudinal Profiles
Appendix 3 As-Built Plan Sheets

1.0 BACKGROUND INFORMATION

The Haw Branch Wetland and Stream Restoration Project is located near the town of Richlands in Onslow County, North Carolina (Figure1). The site has a recent history of row crop production. Ditches were used to increase land use and improve drainage when the land was under crop production. The streams on the project site were channelized and riparian vegetation was cleared in most locations. Stream and riparian functions on the site had been severely impacted as a result of agricultural conversion.

The project involved the restoration of 25 acres of riverine wetlands and 10,005 linear feet (LF) of stream along several unnamed tributaries to Back Swamp. The project restored channel dimension, pattern and profile to all 10,005 LF of stream channel.

1.1 Goals and Objectives

The specific goals for the Haw Branch Restoration Project were as follows:

- Restore approximately 25 acres (design acreage) of small stream swamp riverine wetlands;
- Restore dimension, pattern, and profile to approximately 10,005 LF (design length) of streams;
- Improve floodplain functionality by matching floodplain elevation with bankfull stage;
- Establish native wetland and floodplain vegetation within the permanent conservation easement;
- Improve water quality by reducing bank erosion, reducing inputs of nutrients to the stream system, and providing for improved retention of flood waters; and
- Improve wildlife habitat functions of the site.

1.2 Project Location

The Haw Branch Restoration Project is located near the town of Richlands in Onslow County, North Carolina. Directions to the site are included in the Executive Summary.

1.3 Project Description

For analysis and design purposes, the on-site streams were divided into three reaches. The reaches were numbered sequentially, moving from north to south, with unnamed tributaries carrying a "UT" designation. UT1 begins off site, flows into the project area from the north, and flows out of the project site to the south. UT2 begins off site, flows into the project area from the northeast, and ends at its confluence with UT1. UT3 begins off site, flows into the project area from the east, and ends at its confluence with UT1. For design purposes, UT1 was further divided into UT1a, upstream of its confluence with UT2, and UT1b, downstream of the confluence. UT1 ultimately drains into Back Swamp, approximately 4,000 LF south of the project site.

Wetland functions on the site had been severely impaired as a result of agricultural conversion. Streams flowing through the site were channelized many years ago to reduce flooding and provide drainage for adjacent farm fields. As a result, nearly all wetland functions were destroyed within the project area. The channelized streams flowing through the site functioned more as drainage ditches and canals than Coastal Plain streams, with areas of active bank erosion and an overall poor habitat condition.

The design for the restored stream involved the construction of a new meandering channel across the agricultural fields. The stream type for the restored stream was a Rosgen "C" channel with design dimensions based on those of reference parameters. Wetland restoration of the prior-converted farm fields on the site involved raising the local water table to restore a natural flooding regime. The streams through the site were restored to a stable dimension, pattern, and profile, such that riverine wetland functions were restored to the adjacent hydric soil areas. Drainage ditches within the restoration areas were filled to decrease surface and subsurface drainage and raise the local water table. Total stream length across the Haw Branch Restoration Project was increased from approximately 4,370 LF to 10,005 LF.

The design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. The in-stream structures consisted of root wads, log vanes, and log weirs, which promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles or rock cross vanes were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, and transplants. Transplants provide living root mass to increase streambank stability and create holding areas for fish and aquatic biota. The purpose of the project is to restore wetland functions to prior-converted crop fields on the site and to restore stream functions to the impaired stream channels that flow through it. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

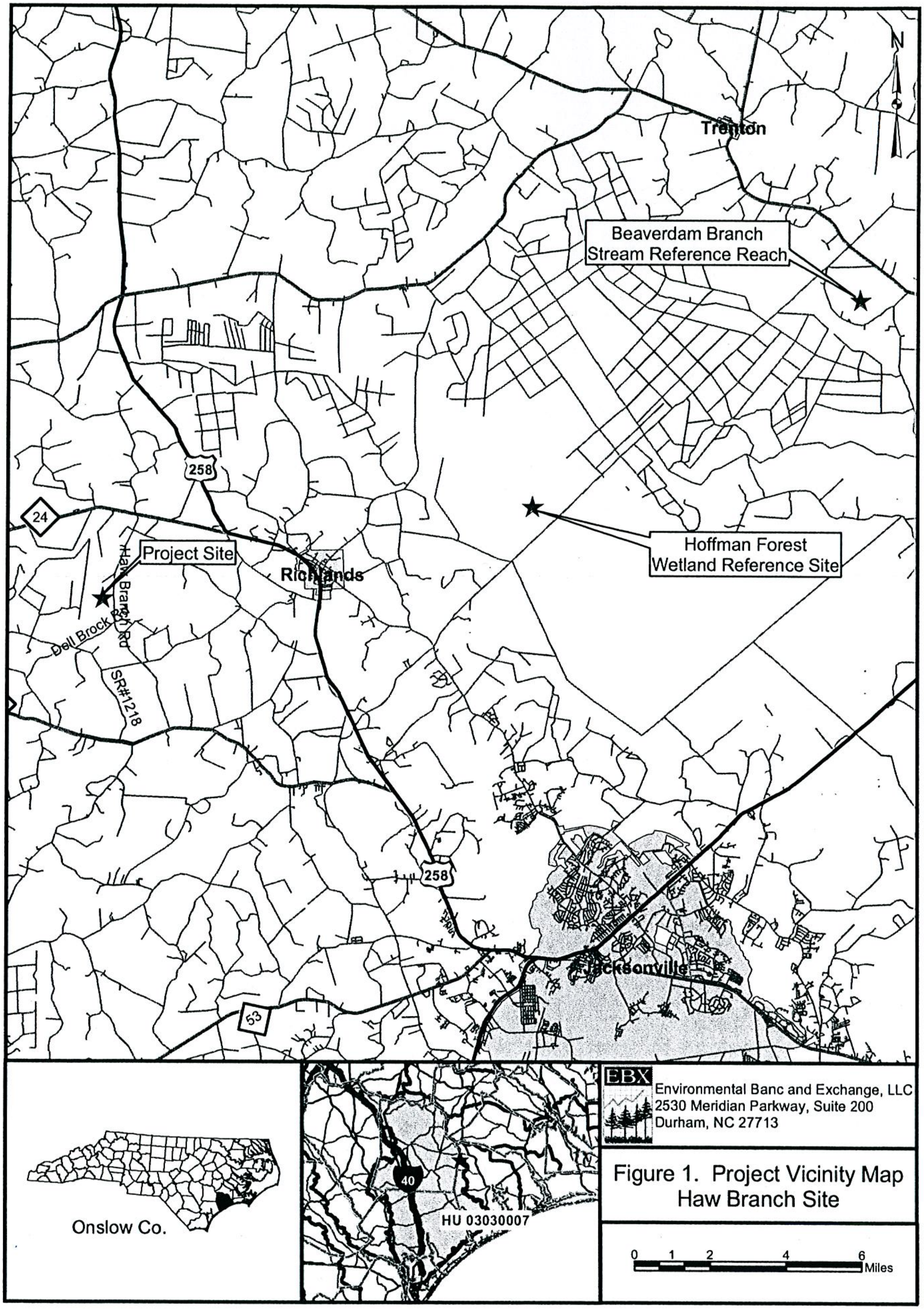


Figure 1. Project Vicinity Map
Haw Branch Site

1.4 Construction

Construction activities, in accordance with the approved restoration plan for the site, began in May 2005 with construction stakeout. This was followed immediately by the establishment of access sites and stockpile areas. Materials were stockpiled as needed for the initial stages of construction.

The next step was the grading of the floodplain and wetland areas to reach design grades across the site. Grade stakes were installed along design contours to direct the grading activities. The excavated material was stockpiled in specified areas near field ditches and existing channels that were to be filled. Soil was also used to construct a farm path to allow the landowner continued access to several fields. Where necessary, silt fencing was installed between stockpiles and the active ditches to prevent erosion of sediment into the channel.

Once the design floodplain and wetland grades were achieved, the new stream channels were sculpted and constructed. Construction of the stream channels began at the downstream end of UT1 and proceeded upstream. After completing UT1, construction continued from the confluence of UT2 with UT1 and moved in upstream along UT2. After completion of these reaches, construction was completed on UT3. Upon completion of each new channel segment, in-stream structures, matting, and transplants were installed, and the channel was prepared to accept flow from the old channel. Once fully prepared, temporary sediment traps at the downstream ends of the channels were removed, and water was directed into the newly constructed channels. Abandoned field ditches and remnant channels were immediately filled. Prior to planting of the site, wetland areas were disked to scarify the surface and break any hard pans. Disking of the site created micro topography which helps hold surface water onsite.

Conditions on the site were dry during construction, making site access and constructability straightforward. The dry conditions were a result of the drought experienced through much of North Carolina in 2005. No major delays were experienced and construction proceeded with few changes to the proposed restoration plan. Minor modifications made during construction involved the location and selection of in-stream structures and bank stabilization practices. Substitutions were made based on availability of materials and professional judgment. These changes are documented in the attached as-built drawings.

The final as-built stream length for the project, as indicated on Sheet 1 in Appendix 3, was 10,005 LF, as compared to the 10,060 LF predicted in the restoration plan. The final as-built wetland acreage for the project was 25.0 acres as predicted in the restoration plan. Table 2 summarizes the as-built reach lengths and restoration approaches.

UT1 and UT2 were dry immediately following construction as evidenced in the cross-section photos (Appendix 2) for several reasons. As previously mentioned, construction was completed during drought conditions, which resulted in dry streams throughout the region. Secondly, the water table at the site has been artificially low at the site since the excavation of the main drainage ditches on the site. Average rainfall throughout the fall of 2005 raised the water table on the site and UT1 and UT2 have exhibited perennial flow since September.

Early observations also indicate that the vegetation treatments were effective at quickly establishing herbaceous ground cover. Temporary seeding (rye grain and German millet) applied to streambanks, beneath the erosion matting, sprouted within two weeks of application and have provided good ground coverage.

In the several months following construction completion (prior to site planting), conditions have been very wet on the site. More normal rainfall patterns have led to several observed out of bank events and significant areas of shallow standing water across the site. The reduced drainage capability and increased surface storage have resulted in significantly wetter conditions on the site than were observed prior to wetland restoration activities. These visual observations indicate that site hydrology has been restored to a naturally functioning wetland system.

Table 2
Summary of As-built Lengths, Acreages and Restoration Approaches

Reach Name	Wetland Acreage (acres)	WMU	As-built Length (ft)	SMU	Restoration Approach
Riverine Wetland Restoration	25	25	---	---	Plug ditch network, increase surface storage, and restore flooding functions through stream restoration
Stream Reach UT1	---	---	6,115 LF	6,115	Restoration of dimension, pattern, and profile
Stream Reach UT2	---	---	2,964 LF	2,964	Restoration of dimension, pattern, and profile
Stream Reach UT3	---	---	926 LF	926	Restoration of dimension, pattern, and profile
Total Length	**25**	**25**	**10,005 LF**	**10,005**	---------

2.0 MONITORING RESULTS – 2005 AS-BUILT DATA

The five-year monitoring plan for the Haw Branch site includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, wells, permanent cross-sections, crest gauges, and the rainfall gauge are shown on the as-built drawing sheets. Photo points are located at each of the grade control structures along the restored stream channel.

2.1 Vegetation

Bare-root trees were planted within all areas of the conservation easement. A minimum 50-foot buffer was established along all restored stream reaches. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in December 2005. 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
Trees for Buffer Planting			
Quercus phellos	Willow oak	15%	4,869
Quercus michauxii	Swamp chestnut oak	3%	1,020
Quercus lyrata	Overcup oak	17%	5,472
Platanus occidentalis	Sycamore	3%	1,020
Taxodium distichum	Bald cypress	9%	2,736
Fraxinus pennsylvanica	Green ash	2%	765
Betula nigra	River Birch	17%	5,472
Celtis laevigata	Sugarberry	15%	4,869
Juglans nigra	Black walnut	2%	765
Nyssa sylvatica var. biflora	Swamp tupelo	17%	5,472
Native Grass Species for Restored Stream Banks			
Carex vulpinoidea	Fox sedge	38%	n/a
Carex lupulina	Hop sedge	37%	n/a
Juncus effusus	Soft rush	25%	n/a
Native Grass Species for Floodplain and Buffer Areas			
Elymus virginica	Virginia wild rye	25%	n/a
Panicum virgatum	Switchgrass	38%	n/a
Carex vulpinoidea	Fox sedge	37%	n/a

Woody Vegetation for Live Stakes			
Salix nigra	Black willow	41%	3,690
Salix sericea	Silky willow	19%	1,700
Cephalanthus occidentalis	Buttonbush	40%	3,530

The restoration plan for the Haw Branch Site specifies that the number of quadrants required will be based on the species/area curve method, as described in North Carolina Ecosystem Enhancement Program (NCEEP) monitoring guidance documents, with a minimum of three quadrants. The size of individual quadrants will be 100 square meters for woody tree species, 25 square meters for shrubs, and 1 square meter for herbaceous vegetation. A total of 20 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 5 monitoring plots, is 698 stems/acre. The locations of the vegetation plots are shown on the as-built plan sheets.

Table 4
Initial Planted Density of Trees for the Twenty Vegetation Sampling Plots for Haw Branch

Sampling Plot No.	Counted Stems per Plot	Stems per Acre (extrapolated)
HW1	18	720
HW2	16	640
HW3	20	800
HW4	17	680
HW5	17	680
HW6	17	680
HW7	16	640
HW8	17	680
HW9	18	720
HW10	18	720
HW11	17	680
HW12	18	720
HW13	18	720
HW14	18	720
HW15	18	720
HW16	17	680
HW17	18	720
HW18	16	640

HW19	17	680
HW20	18	720

2.1.1 Results and Discussion

No monitoring results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during November 2006.

2.2 Morphology

For monitoring wetland and stream success criteria, 6 wells (3 automated and 3 manual), 21 permanent cross-sections, 1 rain gauge, and 3 crest gauges were installed. The permanent cross-sections will be used to monitor channel dimension and bank erosion over time. The rain gauge and crest gauges will be used to document the occurrence of bankfull events. In addition, a complete longitudinal survey was completed for the restored stream channels to provide a base-line for evaluating changes in bed conditions over time. The longitudinal profiles included the elevations of all grade control structures. 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.

2.2.1 Results and Discussion

No results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during November 2005.

2.3 Hydrology

The restoration plan for the Haw Branch Site specifies that six monitoring wells (three automated and three manual) would be established across the restored site. Wells were installed during mid-December 2005 to document water table hydrology in all required monitoring locations. The locations of monitoring wells are shown on the as-built plan sheets

2.4 Areas of Concern

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

3.0 SUPPLEMENTAL INFORMATION

The information provided in this section is intended to supplement as-built information as indicated in current NCEEP format guidelines for mitigation plan reports.

3.1 Pre-Construction Site Conditions

Streams

The streams on the project site include unnamed tributaries to Back Swamp. These streams had been channelized, and riparian vegetation had been cleared in the field areas such that row crops are planted up to the top of the streambanks. Drainage ditches were excavated in parts of the site to provide additional drainage for agricultural production. The ditches and channelized streams on the site transported surface and shallow, subsurface drainage from the prior-converted crop fields, lowering the water table and keeping soil conditions favorable for agricultural production.

Wetlands

Wetland functions on the site were severely impaired as a result of agricultural conversion. Field areas were graded to promote rapid surface drainage, and additional drainage ditches were excavated to improve sub-surface drainage. As a result, nearly all wetland functions were destroyed within the project area. Data collected in October and November of 2004 indicated that the site exhibited hydrologic conditions drier than jurisdictional wetland conditions. Even though the data were collected in the dormant season, when the water table is typically at its highest for the year, jurisdictional wetland hydrology did not exist across the project fields during the existing condition phase of the project.

3.2 Restoration Plan

Restoration Overview		
Wetland Type / Project Feature	**Size**	**Approach**
Riverine Wetland/ Coastal Plain Small Stream Swamp	25 AC	Plug ditch network, restore flooding functions through stream restoration
Stream Reach UT1	6,138 LF	Restoration of dimension, pattern, and profile
Stream Reach UT2	2,928 LF	Restoration of dimension, pattern, and profile
Stream Reach UT3	994 LF	Restoration of dimension, pattern, and profile

3.3 Design Modifications Made During Construction

No major modifications were made to the design plans during construction of the site. Minor modifications made involved the location and selection of in-stream structures and bank stabilization practices. Substitutions were made based on availability of materials and professional judgment. These changes are documented in the as-built drawings.

3.4 Post Construction Site Conditions

The Haw Branch Restoration Project restored a "Coastal Plain small stream swamp" system, as described by Schafale and Weakley (1990). Wetland restoration of the prior-converted farm fields on the site involved raising the local water table and restoring a natural flooding regime. The streams through the site were restored to a stable dimension, pattern, and profile, such that riverine wetland functions were restored to the adjacent hydric soil areas. Drainage ditches within the restoration areas were filled to decrease surface and subsurface drainage and raise the local water table. In addition, scarification of the fields and breaking of the local plow pan provides increased surface storage of water and provides favorable conditions for a variety of native wetland plant species.

Summary of As-built Lengths, Acreages and Restoration Approaches

Reach Name	Wetland Acreage (acres)	WMU	As-built Length (LF)	SMU	Restoration Approach
Riverine Wetland Restoration	25	25	---	---	Plug ditch network, increase surface storage, and restore flooding functions through stream restoration
Stream Reach UT1	---	---	6,115	6,115	Restoration of dimension, pattern, and profile
Stream Reach UT2	---	---	2,964	2,964	Restoration of dimension, pattern, and profile
Stream Reach UT3	---	---	926	926	Restoration of dimension, pattern, and profile
Total Length	**25**	**25**	**10,005**	**10,005**	---------

3.5 Ecological Benefits

The topography of the restored site was patterned after natural floodplain wetland reference sites, and included the restoration of minor depressions and tip mounds (microtopography) that promote diversity of hydrologic conditions and habitats common to natural wetland areas. These techniques were instrumental to the restoration of site hydrology by promoting surface ponding and infiltration, decreasing drainage capacity, and imposing higher water table conditions across the restoration site. In order to improve drainage and increase agricultural production, farmed wetland soils are often graded to a smooth surface and crowned to enhance runoff (Lilly, 1981). Microtopography contributes to the properties of forest soils and to the diversity and patterns of plant communities (Lutz, 1940; Stephens, 1956; Bratton, 1976; Ehrnfeld, 1995). Stream restoration components of the project improve water quality by reducing bank erosion, reducing inputs of nutrients to the stream system, and providing for improved retention of flood waters.

3.6 Monitoring Plan

<u>Streams</u>

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

Cross Sections - Two permanent cross sections will be installed per 1,000 linear feet of stream restoration work, with one located at a riffle cross-section and one located at a pool cross-section. Each cross section will be marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross sections and consistently used to facilitate easy comparison of year-to-year data. The annual cross-section survey will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross sections will be classified using the Rosgen Stream Classification System. There should be little change in as-built cross sections. If changes do take place they should be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross sections shall be classified using the Rosgen Stream Classification System, and all monitored cross sections should fall within the quantitative parameters defined for channels of the design stream type.

Longitudinal Profile - A longitudinal profile will be completed in years one, three, and five of the monitoring period. The profile will be conducted for the entire length of the project or for at least 3,000 feet of restored channel. 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 profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed for channels of the design stream type.

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 are not recommended for this project.

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

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

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

Wetlands

Wetland Hydrologic Monitoring - Groundwater monitoring stations will be installed across the project area to document hydrologic conditions of the restored site. Six groundwater monitoring stations will be installed, with three automated groundwater gauges and three manually-read stations. In order to determine if the rainfall is normal for the given year, rainfall amounts will be tallied using data obtained from the nearest automated weather station, located within Hoffman State Forest, approximately 15 miles east of the project site (UCAN: 14151, COOP: 314144). The monitoring data will show the site has been saturated within 12 inches of the soil surface for at least 8% of the growing season and that the site has exhibited an increased frequency of flooding. This criterion is based on the modeling analysis presented in the restoration plan. For the Hoffman Forest reference site, the Wide Open location exhibits conditions similar to those expected for the restoration site. At the Wide Open location, the average hydroperiod documented over five years of monitoring data has been approximately 8%. The restored site will be compared to the reference site data during normal or drier then normal years.

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 are achieved, vegetation-monitoring quadrants will be installed across the restoration site, as directed by EEP monitoring guidance. The number of quadrants required will be based on the species/area curve method, as described in EEP monitoring guidance documents, with a minimum of three quadrants. The size of individual quadrants will be 100 square meters for woody tree species, 25 square meters for shrubs, and 1 square meter for herbaceous vegetation. Vegetation monitoring will occur after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked 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. At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between July and November. The interim measure of vegetative success for the site will be the survival of at least 320 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260 5-year old, planted trees per acre at the end of year five of the monitoring period.

3.7 Success Criteria

Streams

The stream restoration success criteria for the site include the following:

Bankfull Events - Two bankfull flow events must be documented within the five-year monitoring period.

Cross-sections - There should be little change in as-built cross-sections. Cross-sections shall be classified using the Rosgen stream classification method and all monitored cross-sections should fall within the quantitative parameters defined for "E" or "C" type channels.

Longitudinal Profiles - The longitudinal profiles should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. Bedforms observed should be consistent with those observed in "E" and "C" type channels.

Photo Reference Stations - Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures.

Benthic Macroinvertebrate - Sampling of benthic macroinvertebrates within the restored stream channel shall be conducted for the first three years of post-restoration monitoring. No success criteria are applied to the sampling data that will be collected.

Wetlands

Wetland Hydrologic Monitoring - As stated in the approved Restoration Plan, the hydrologic success criteria for the site are to restore the water table so that it will remain within 12 inches of the soil surface for at least 8 percent of the growing season continuously (approximately 19 days). The day counts are based on the growing season for Onslow County, which is 243 days long, beginning on March 18 and ending November 16, as calculated from National Weather Service Wetlands Determination Tables (WETS) for Onslow County. As specified in the approved Restoration Plan, data are collected from three automated and three manual groundwater gauges.

The Mitigation Plan further specified that in order for the hydrologic data to be considered successful it must demonstrate wetland conditions are present in normal or drier than normal conditions. Monitoring data from the Wide Open reference site in Hoffman Forest will be used to demonstrate positive correlations between the restoration site and the natural hydrology of the target system during normal and drier than normal monitoring years.

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

3.8 Maintenance and Contingency Plans

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

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

Maintenance issues and recommended remediation measures will be detailed and documented in the yearly monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. Remedial Action will be approved prior to any action is taken.

3.9 References

Bratton, S. P. 1976. Resource division in an understory herb community: responses to temporal and microtopographic gradients. The American Naturalist 110 (974):679-693.

Ehrnfield, J. G. 1995. Microsite differences in surface substrate characteristics in Chamaecyparis swamps of the New Jersey pinelands. Wetlands 15(2):183-189.

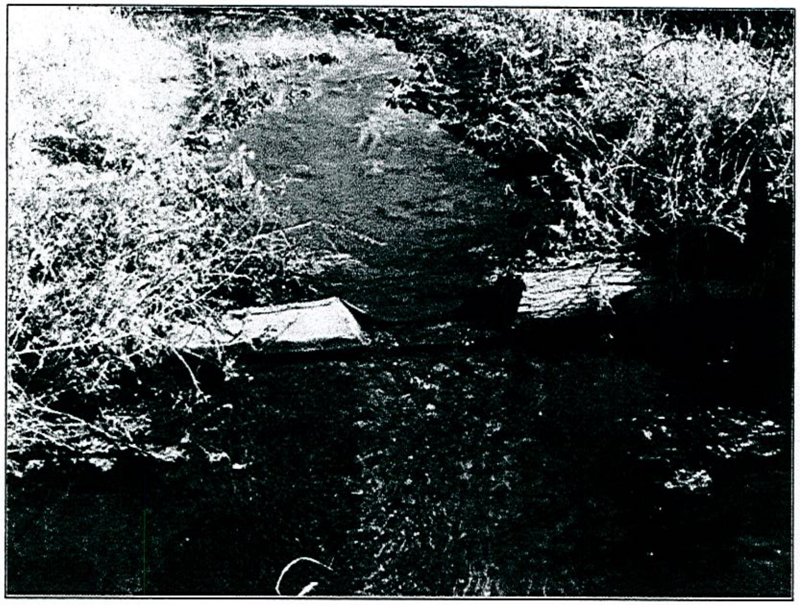
Lilly, J. P. 1981. The blackened soils of North Carolina: Their characteristics and management for agriculture. North Carolina Agricultural Research Service Technical Bulletin No. 270.

Lutz, H. J. 1940. Disturbance of forest soil resulting from the uprooting of trees. Yale University School of Forestry Bulletin No. 45.

Stephens, E. P. 1956. The uprooting of trees: a forest process. Soil Science Society of America Proceedings 20:113-116.

APPENDIX 1

SELECTED PROJECT PHOTOGRAPHS



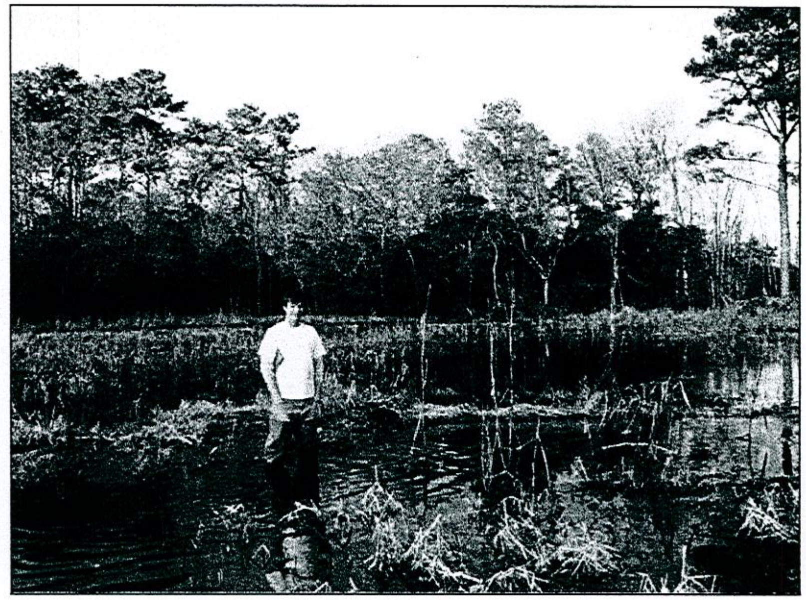
Log Weir - UT1

Constructed Riffle – UT2

Culvert – UT1

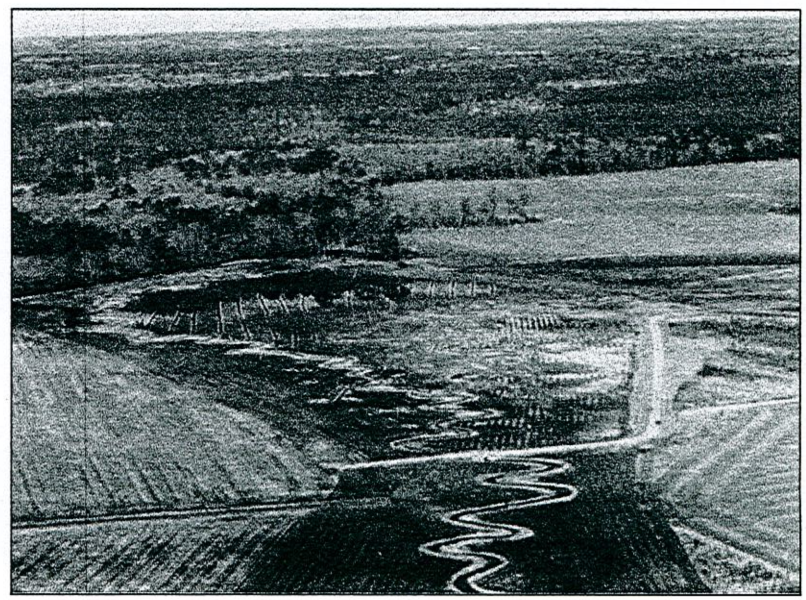
Rootwads – UT1

Microtopography in Wetland Areas

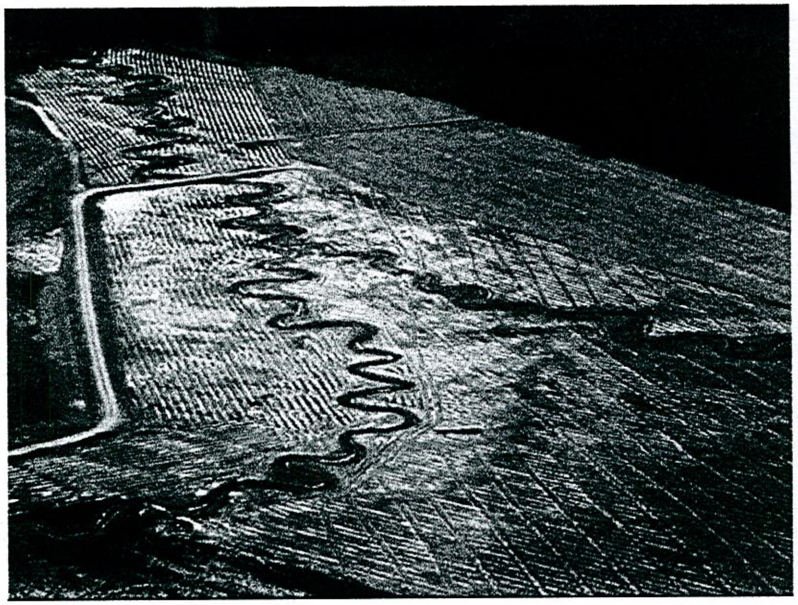


Flooded Conditions – UT1

Aerial Photo – UT3



Aerial Photo – UT1, UT2, & Wetlands



Aerial Photo – UT1, UT2, & Wetlands

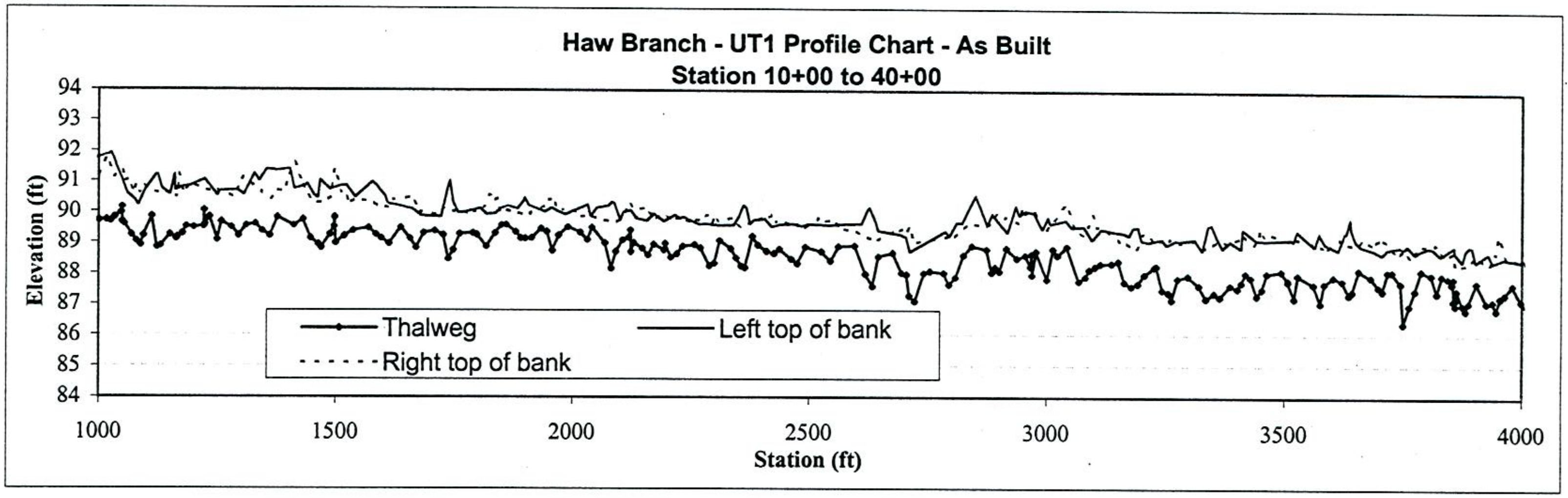
Flooded Conditions – UT2 & UT1

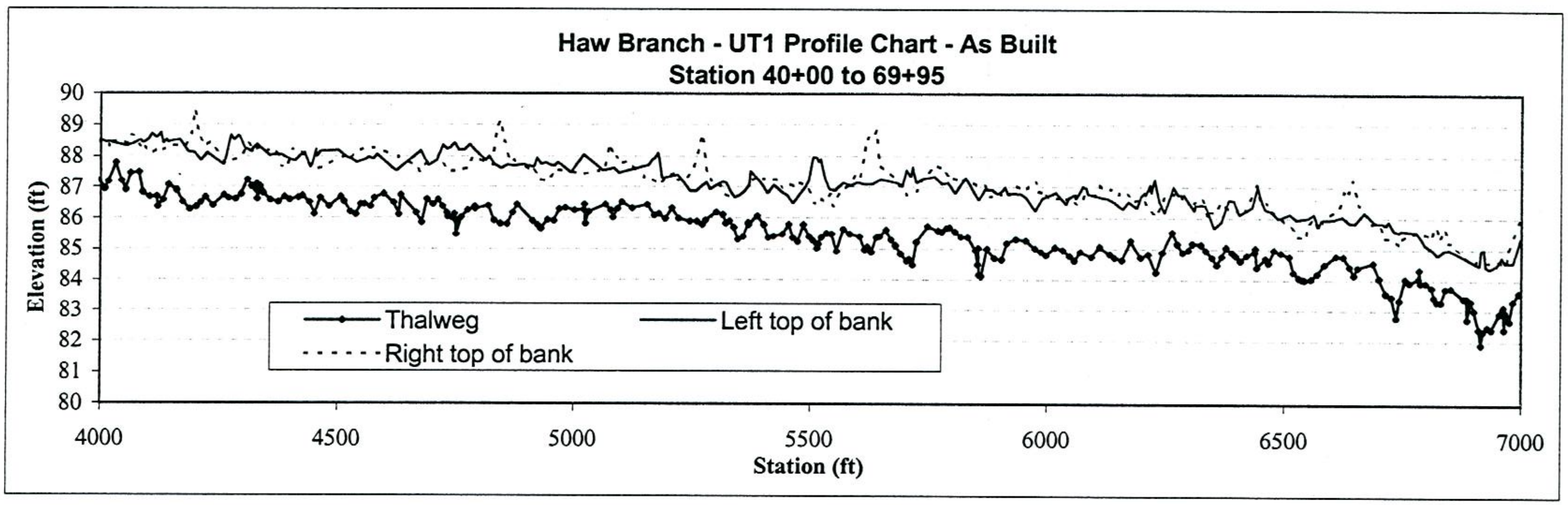
Stream Pattern – UT1

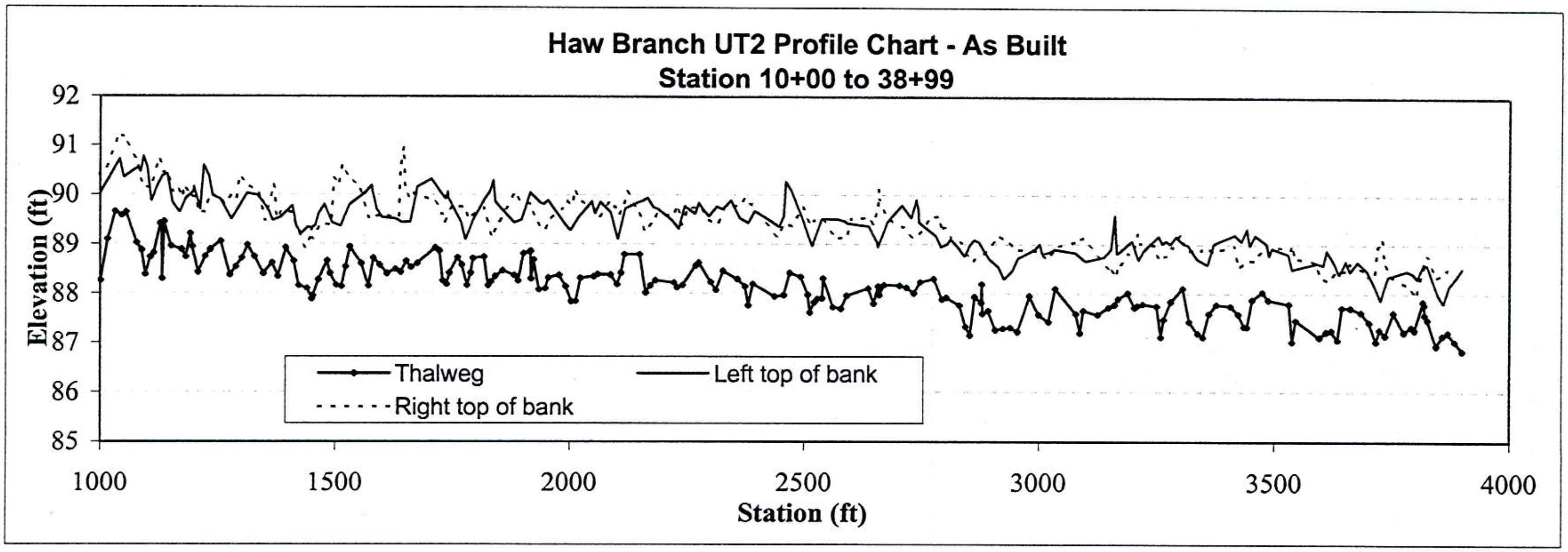
Bedload Movement – UT3

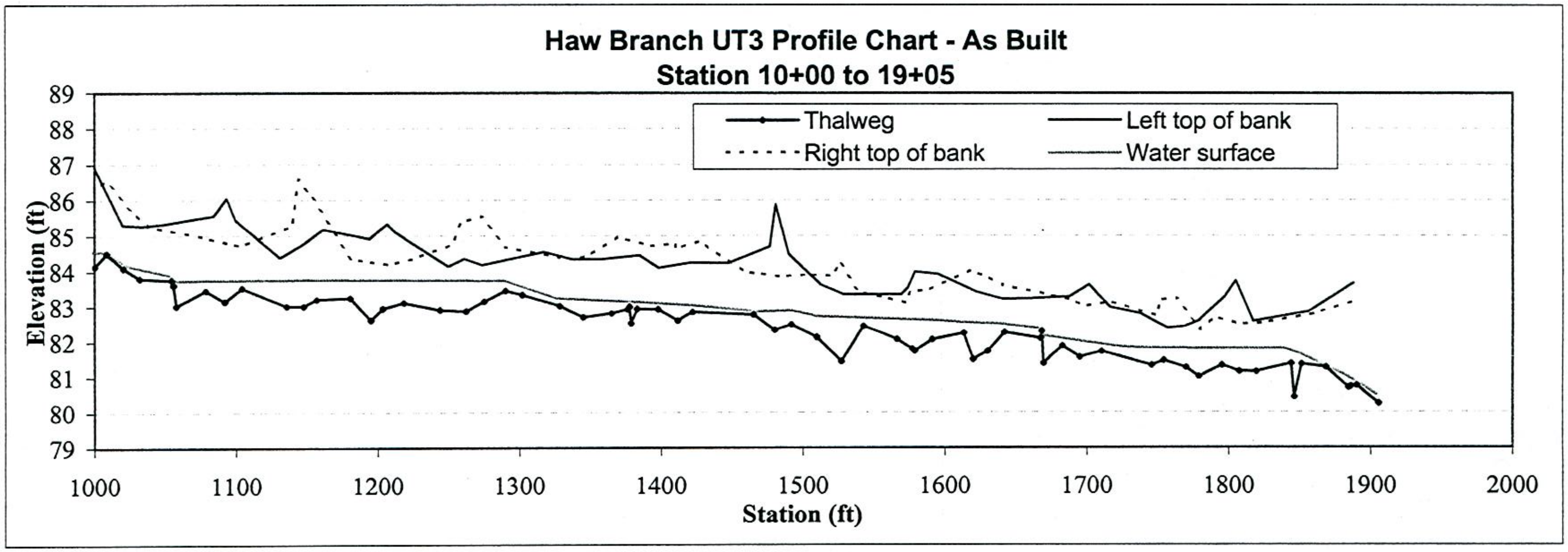
APPENDIX 2

AS-BUILT CROSS-SECTIONS AND LONGITUDINAL PROFILES

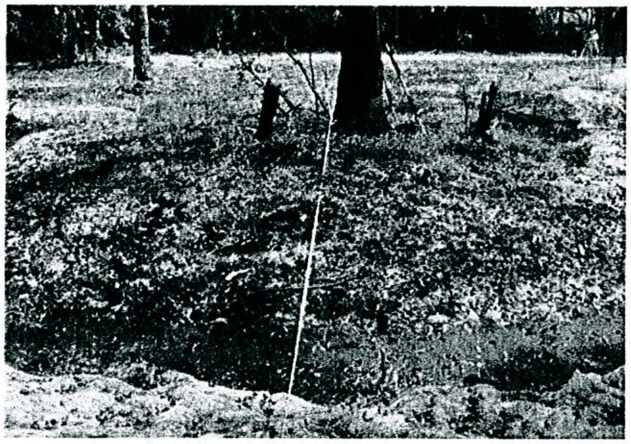

Haw Branch - UT1 Profile Chart - As Built
Station 10+00 to 40+00
Elevation (ft)
94
93
92
91
90
89
88
87
86
85
84
1000
1500
2000
2500
3000
3500
4000
Station (ft)
Thalweg
Left top of bank
Right top of bank

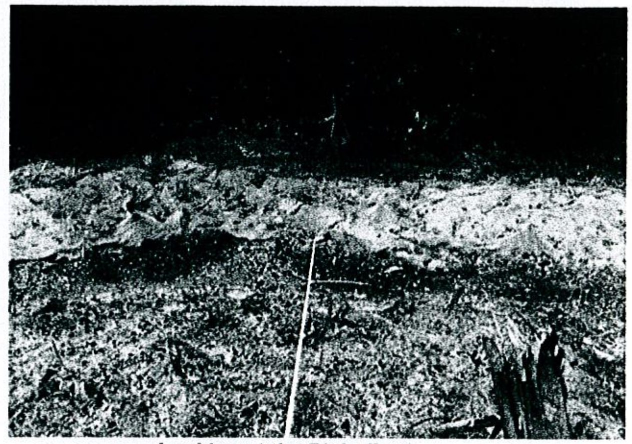

Haw Branch - UT1 Profile Chart - As Built
Station 40+00 to 69+95
Elevation (ft)
90
89
88
87
86
85
84
83
82
81
80
4000
4500
5000
5500
6000
6500
7000
Station (ft)
Thalweg
Left top of bank
Right top of bank


Haw Branch UT2 Profile Chart - As Built
Station 10+00 to 38+99
92
91
90
89
88
87
86
85
Elevation (ft)
1000
1500
2000
2500
3000
3500
4000
Station (ft)
Thalweg
Left top of bank
Right top of bank

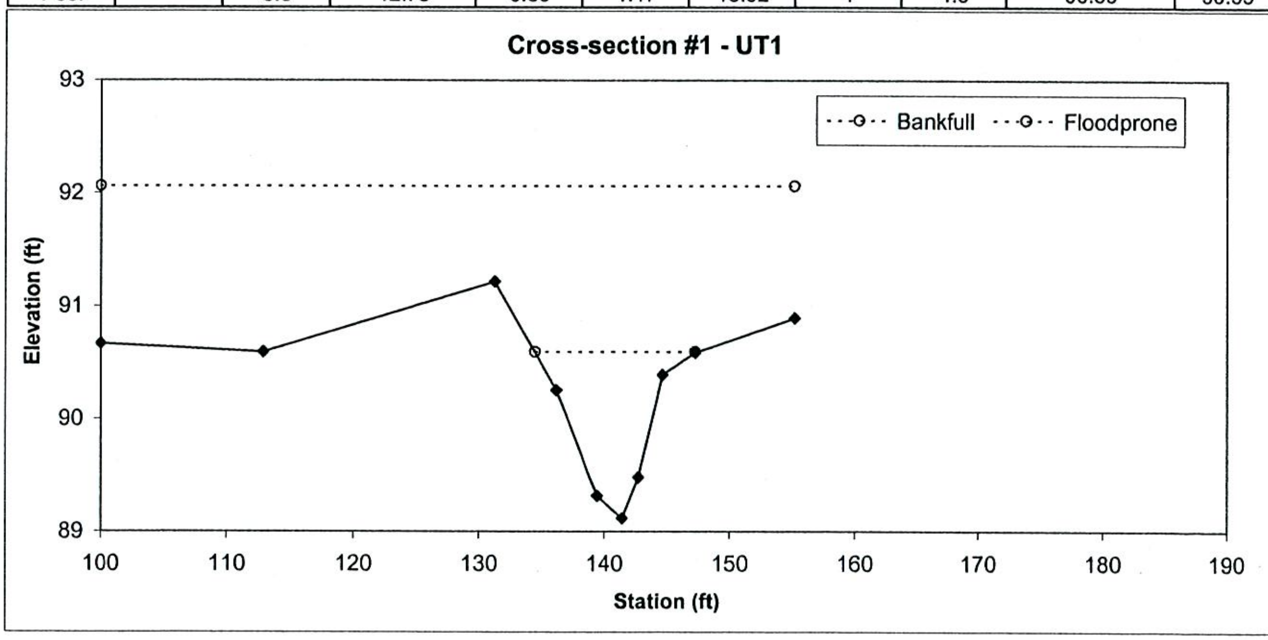

Haw Branch UT3 Profile Chart - As Built
Station 10+00 to 19+05
Thalweg
Right top of bank
Left top of bank
Water surface
Elevation (ft)
89
88
87
86
85
84
83
82
81
80
79
Station (ft)
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000

Permanent Cross-section #1
(As-Built Data - collected Aug. 2005)


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
Pool	---	8.8	12.78	0.69	1.47	18.52	1	4.3	90.59	90.59



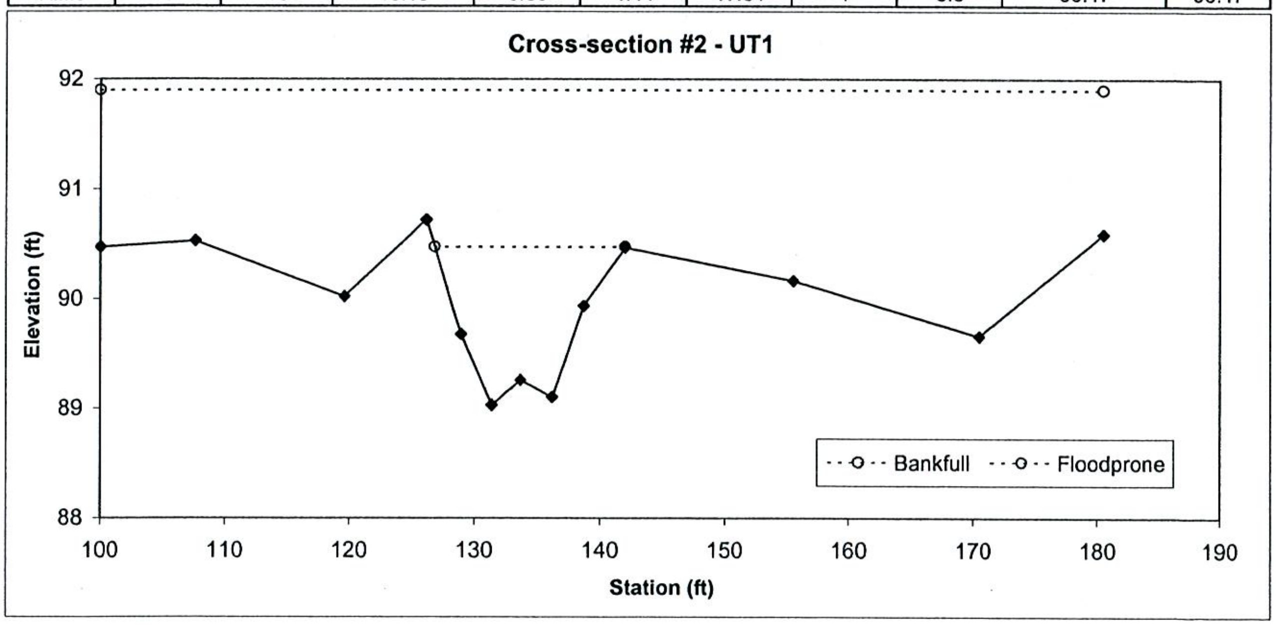
Permanent Cross-section #2

(As-Built Data - collected Aug. 2005)

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
Riffle	C	13	15.13	0.86	1.44	17.54	1	5.3	90.47	90.47



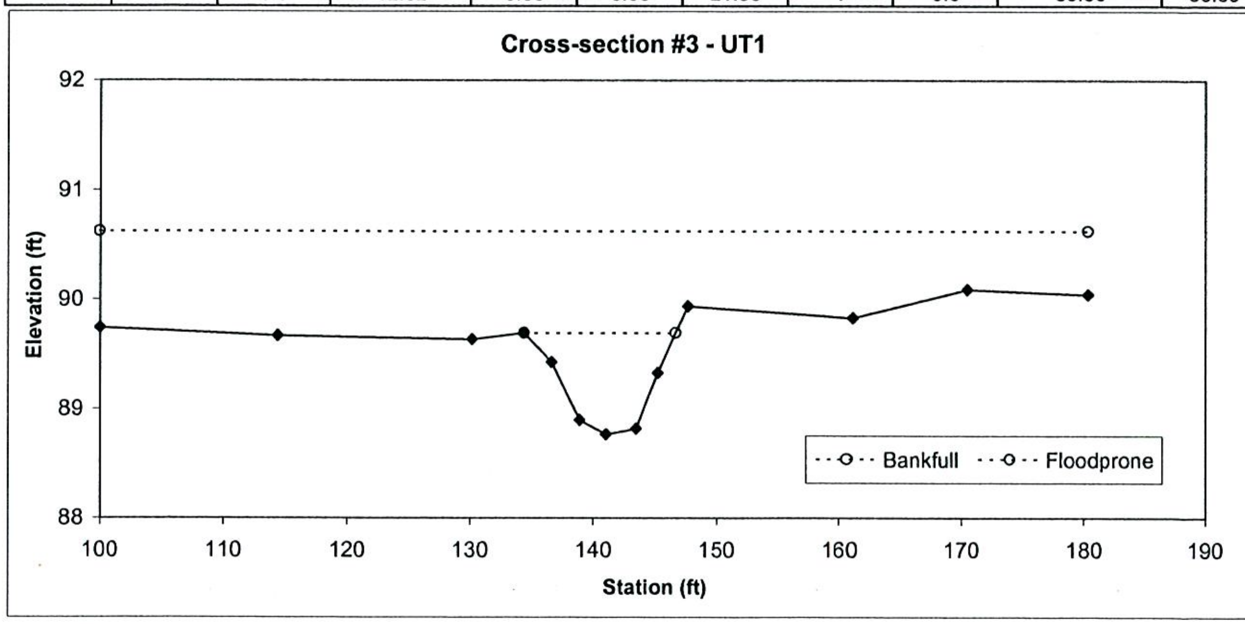
Permanent Cross-section #3

(As-Built Data - collected Aug. 2005)

Looking at the Left Bank

Looking at the Right Bank

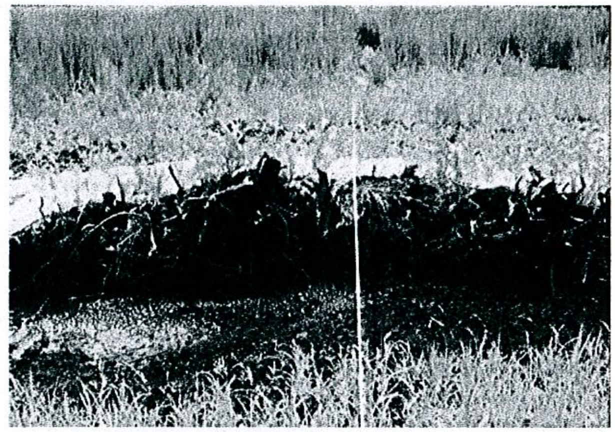
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	6.9	12.32	0.56	0.93	21.98	1	6.5	89.69	89.69



Permanent Cross-section #4

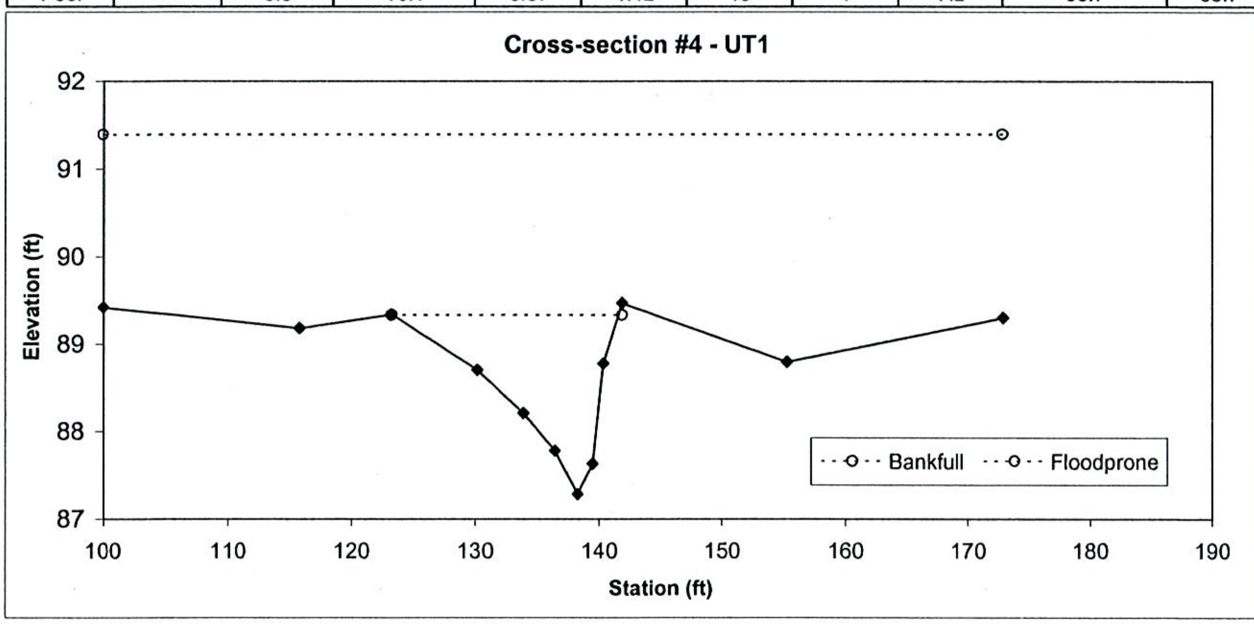
(As-Built Data - collected Aug. 2005)

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
Pool	---	6.8	10.1	0.67	1.42	15	1	7.2	88.7	88.7

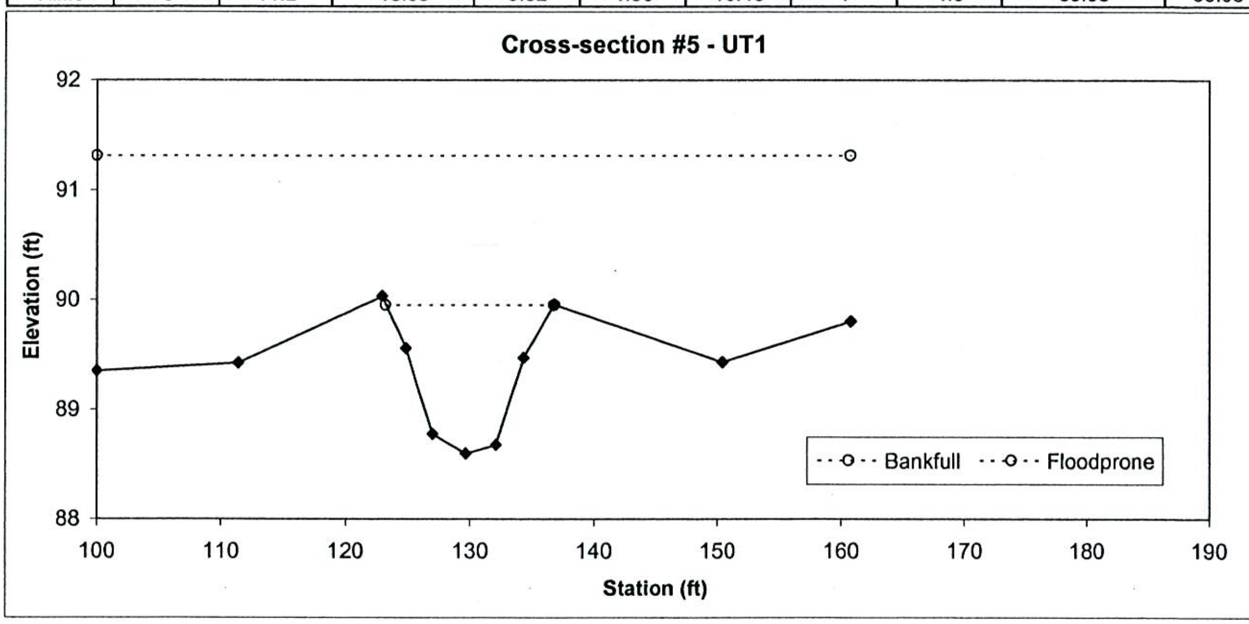


Permanent Cross-section #5
(As-Built Data - collected Aug. 2005)

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
Riffle	C	11.2	13.59	0.82	1.36	16.48	1	4.5	89.95	89.95



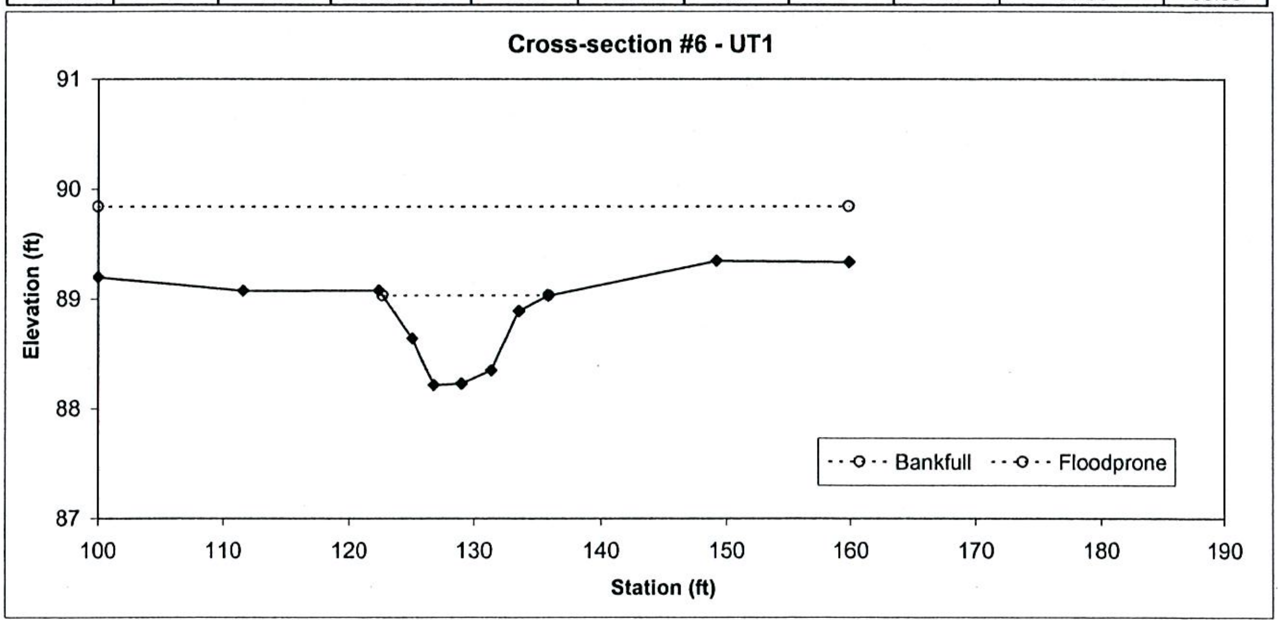
Permanent Cross-section #6

(As-Built Data - collected Aug. 2005)

Looking at the Left Bank

Looking at the Right Bank

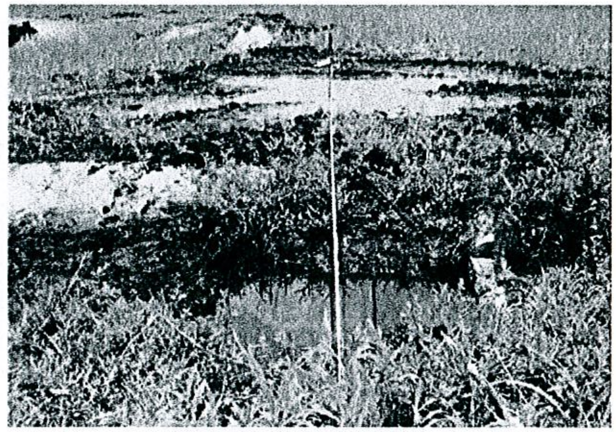
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	6.1	13.24	0.46	0.81	28.7	1	4.5	89.03	89.03



Permanent Cross-section #7

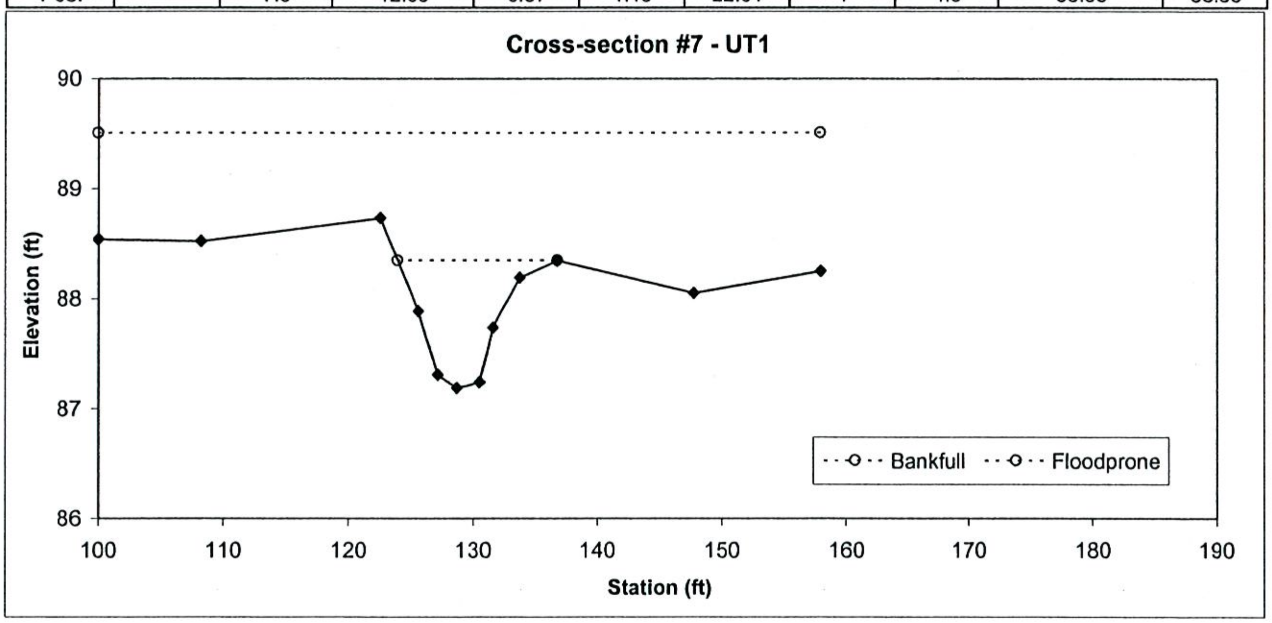
(As-Built Data - collected Aug. 2005)

Looking at the Left Bank



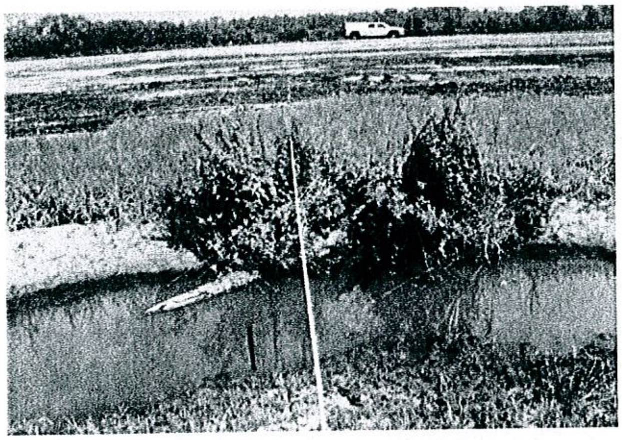
Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	---	7.3	12.86	0.57	1.16	22.61	1	4.5	88.35	88.35



Permanent Cross-section #8

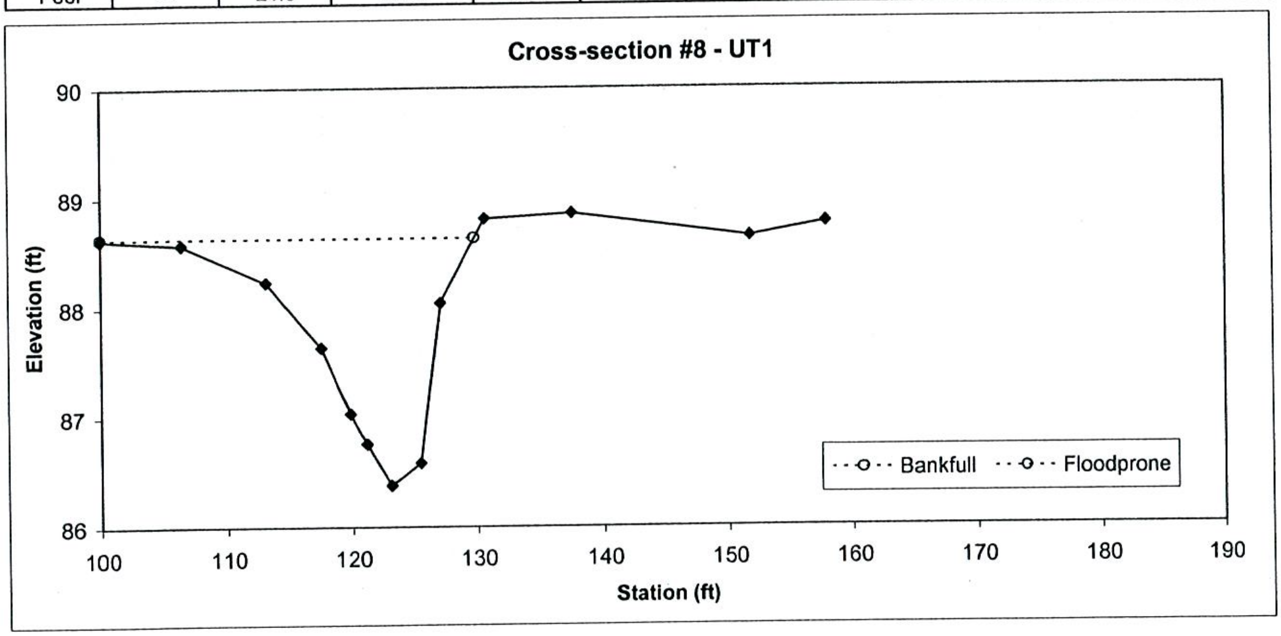
(As-Built Data - collected Aug. 2005)



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
Pool	---	21.9	29.79	0.74	2.25	40.53	1	1.9	88.63	88.63



Permanent Cross-section #9

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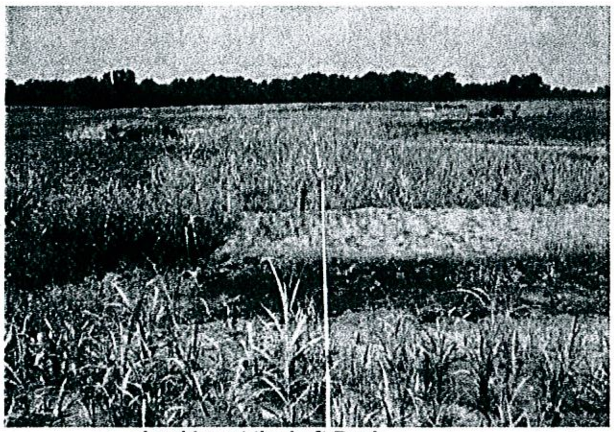
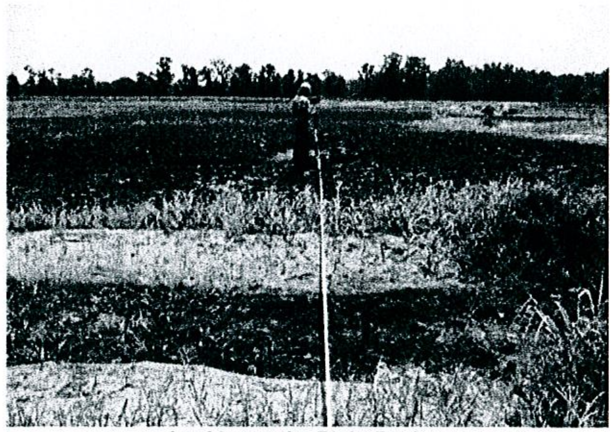
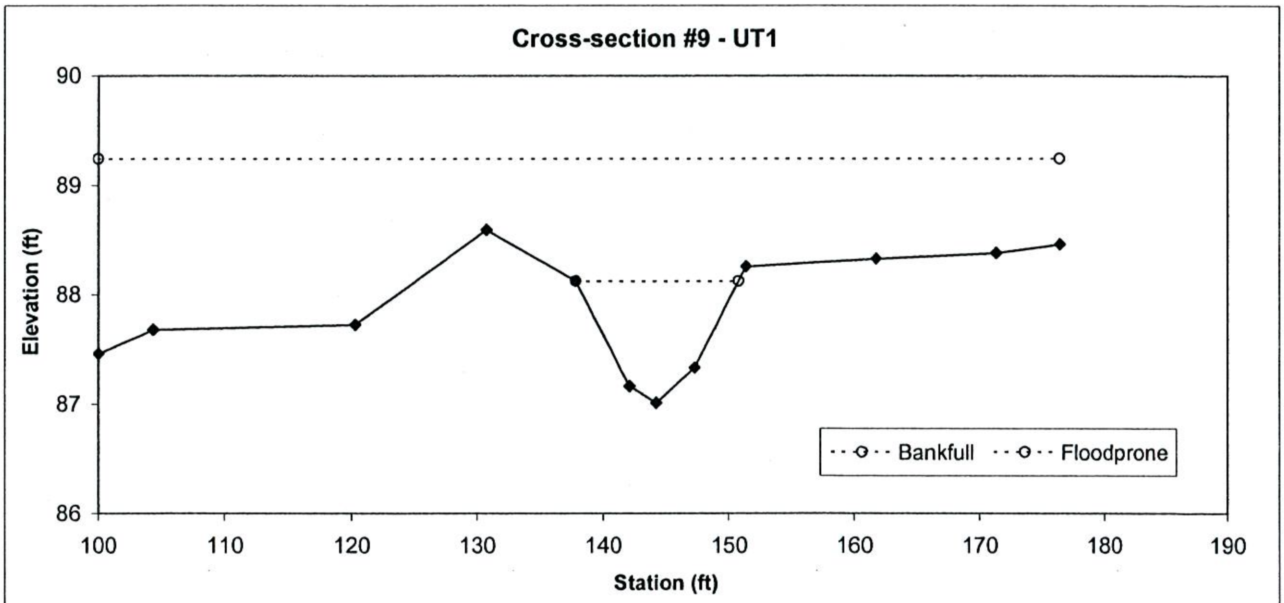


Looking at the Left Bank



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
Riffle	C	8.6	12.96	0.66	1.12	19.61	1	5.9	88.12	88.12

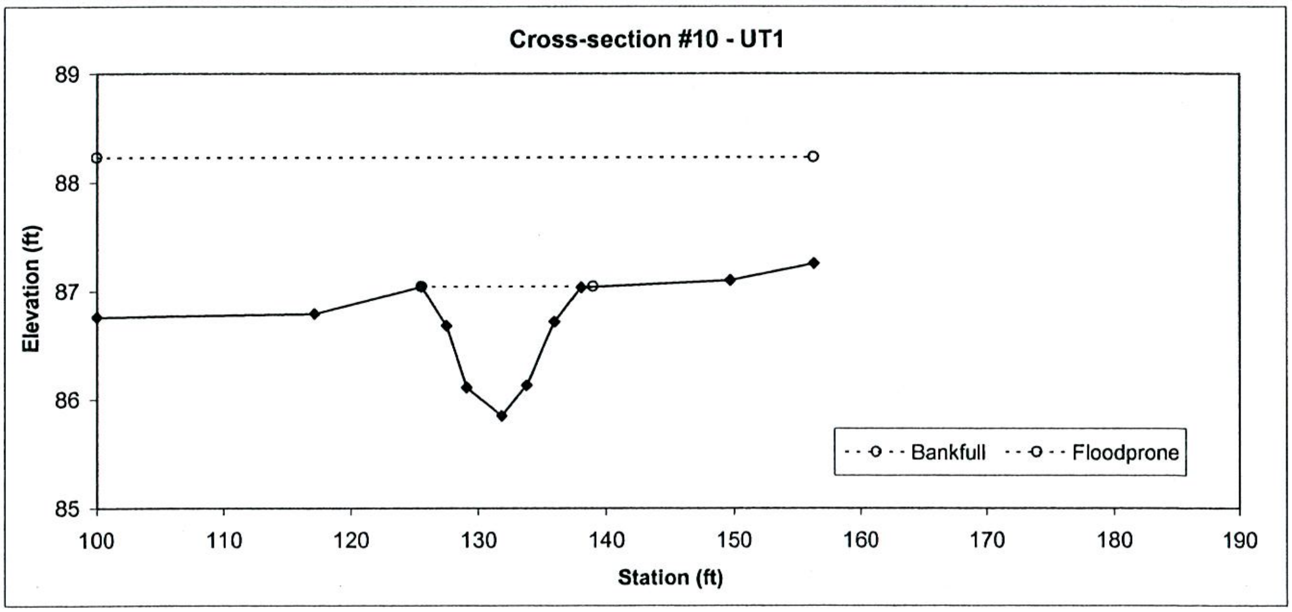


Permanent Cross-section #10
(As-Built Data - collected Aug. 2005)

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
Riffle	C	8	13.43	0.6	1.19	22.55	1	4.2	87.04	87.04

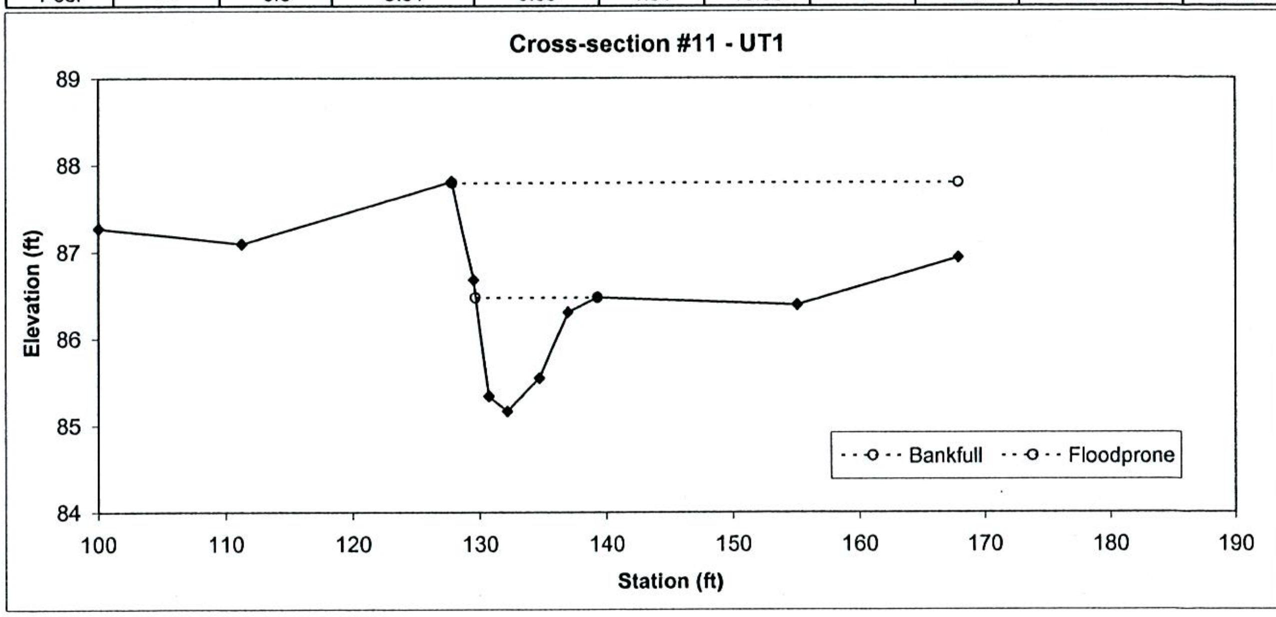


Permanent Cross-section #11
(As-Built Data - collected Aug. 2005)

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
Pool	---	6.6	9.64	0.69	1.31	13.98	1	4.2	86.47	86.47



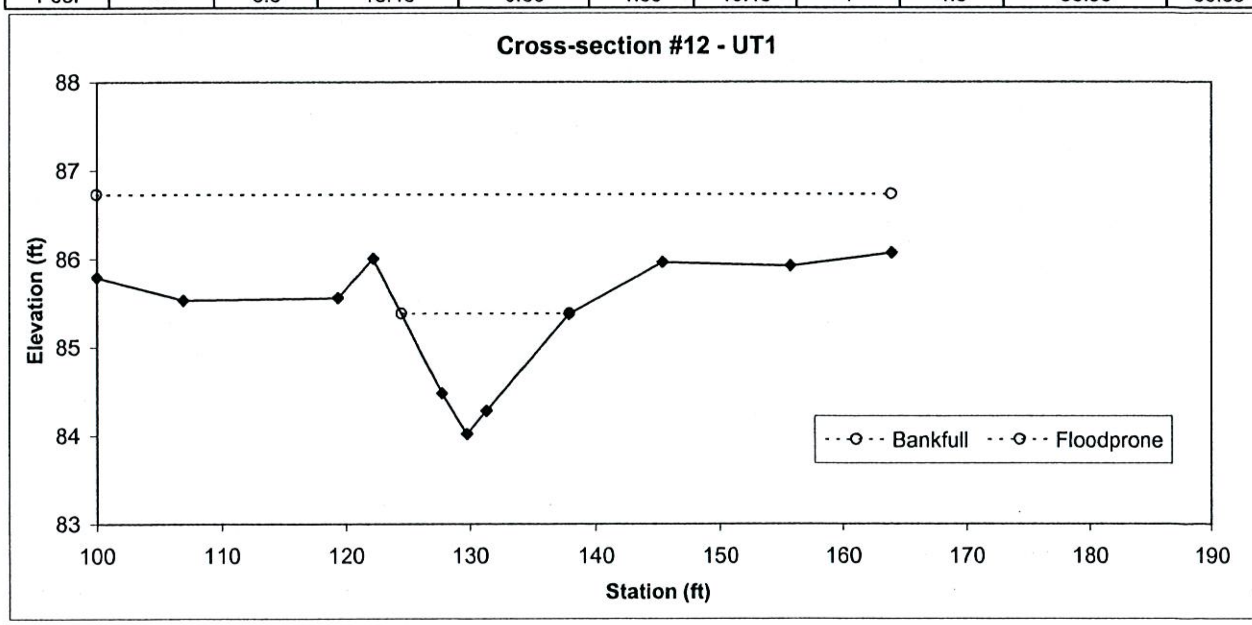
Permanent Cross-section #12

(As-Built Data - collected Aug. 2005)

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
Pool	---	9.3	13.43	0.69	1.36	19.48	1	4.8	85.38	85.38

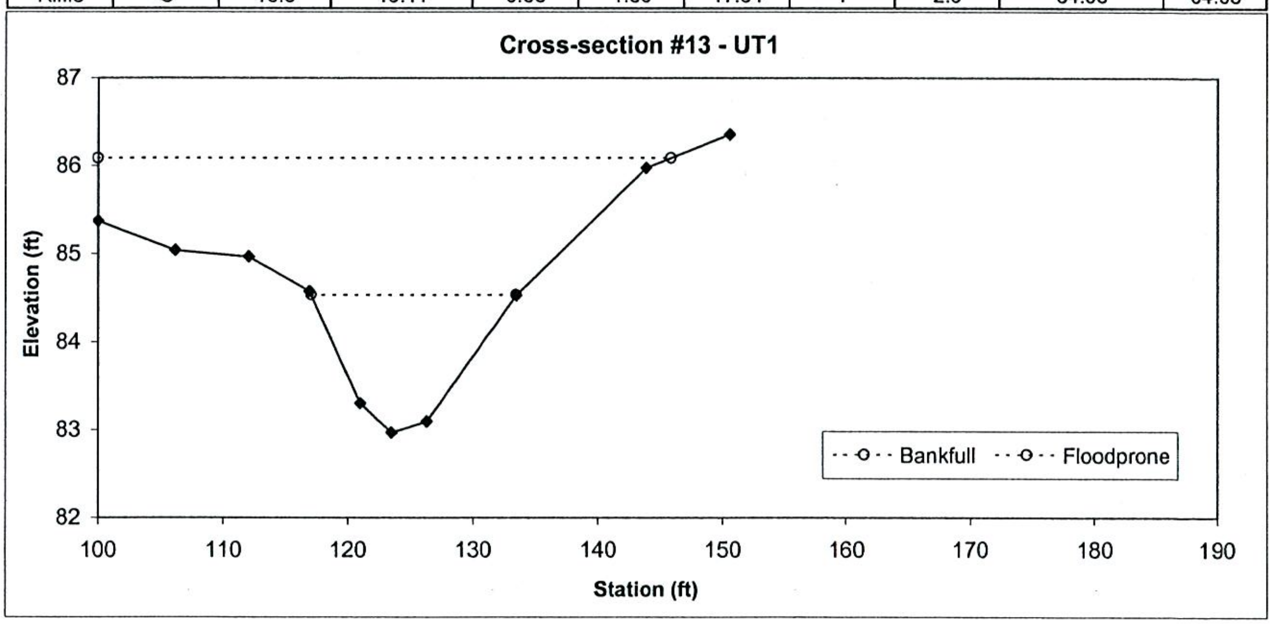


Permanent Cross-section #13
(As-Built Data - collected Aug. 2005)

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
Riffle	C	15.3	16.41	0.93	1.56	17.64	1	2.8	84.53	84.53

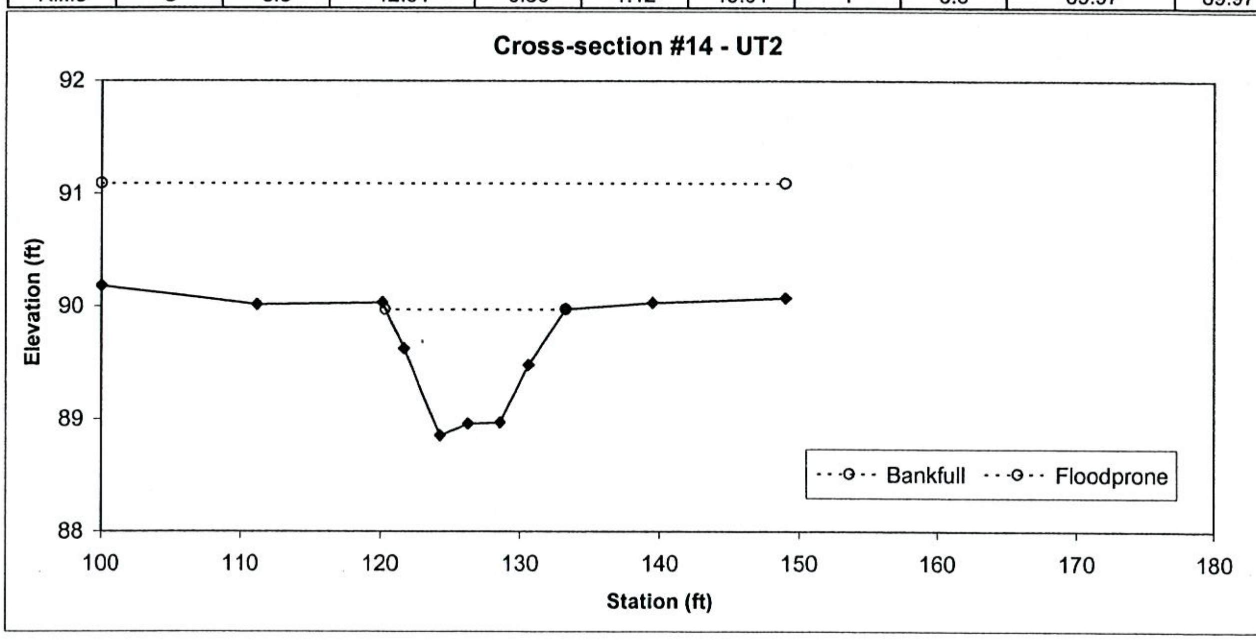


Permanent Cross-section #14
(As Built Data - collected Aug. 2005)

Looking at the Left Bank

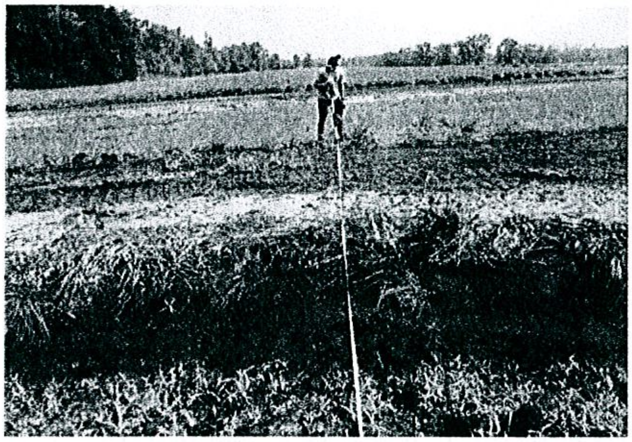
Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	8.8	12.94	0.68	1.12	19.01	1	3.8	89.97	89.97

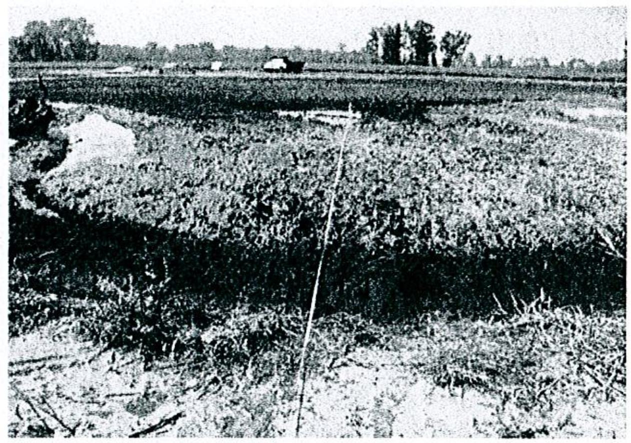


Permanent Cross-section #15

(As Built Data - collected Aug. 2005)

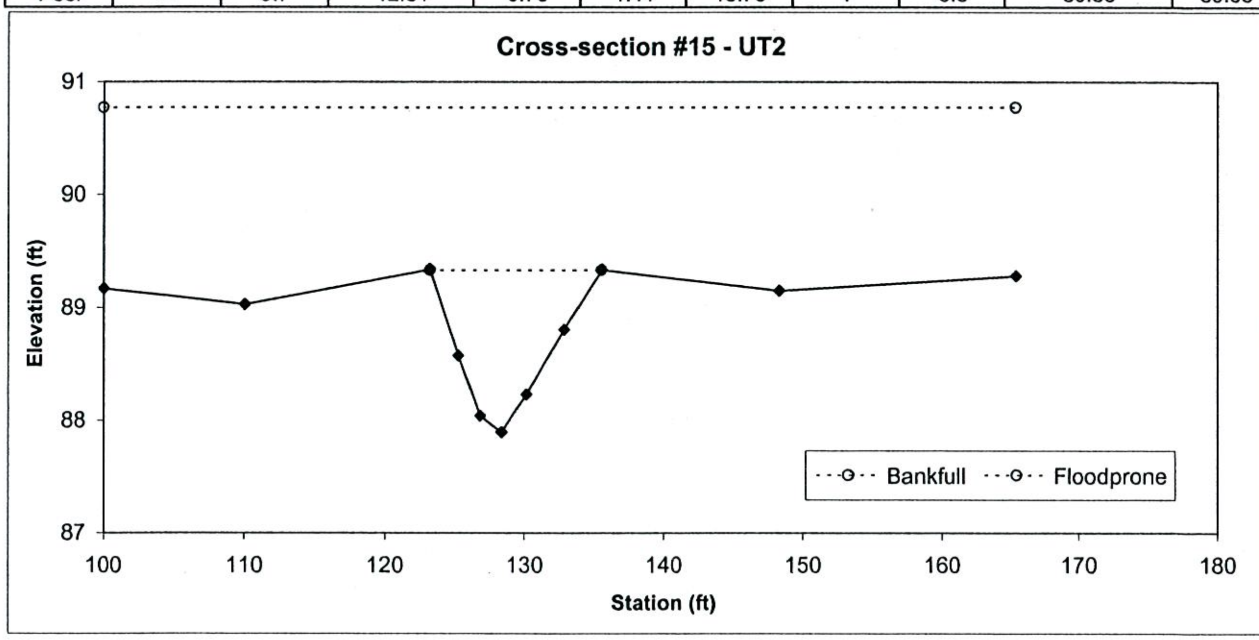


Looking at the Left Bank



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
Pool	---	9.7	12.34	0.78	1.44	15.75	1	5.3	89.33	89.33



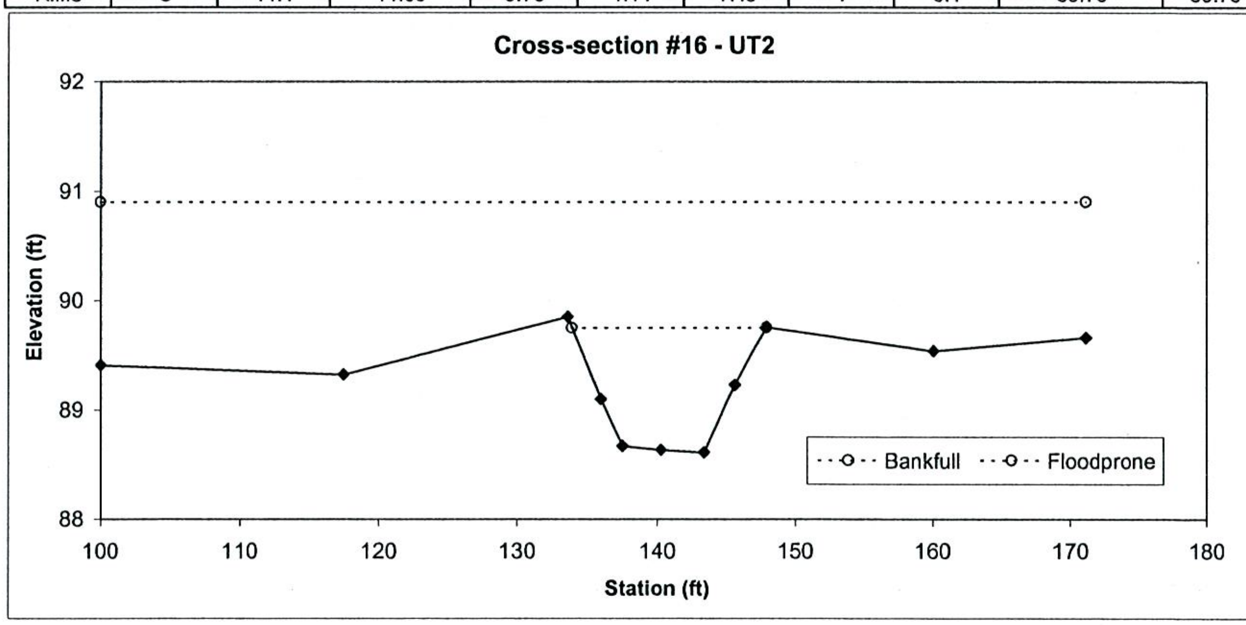
Permanent Cross-section #16

(As Built Data - collected Aug. 2005)

Looking at the Left Bank

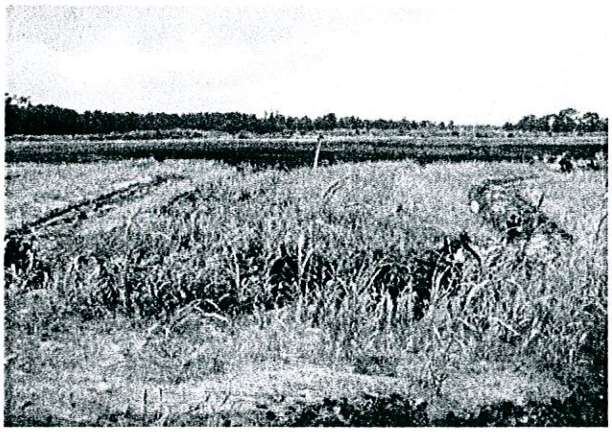
Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	11.1	14.06	0.79	1.14	17.8	1	5.1	89.75	89.75



Permanent Cross-section #17

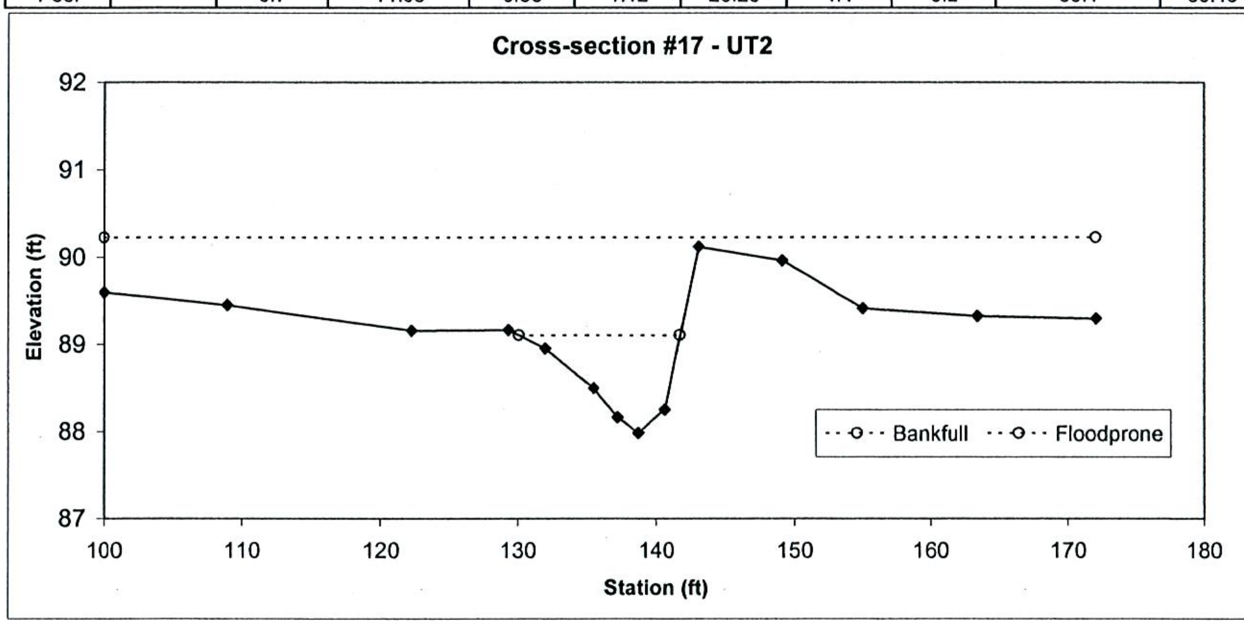
(As Built Data - collected Aug. 2005)



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
Pool	---	6.7	11.66	0.58	1.12	20.26	1.1	6.2	89.1	89.16



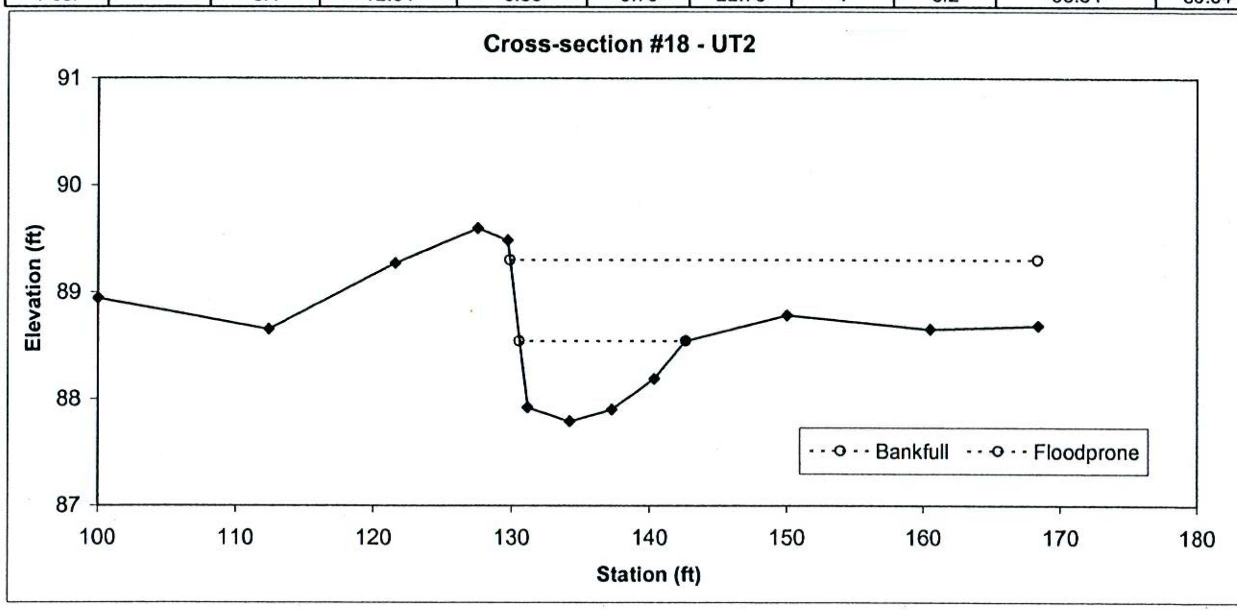
Permanent Cross-section #18

(As Built Data - collected Aug. 2005)

Looking at the Left Bank

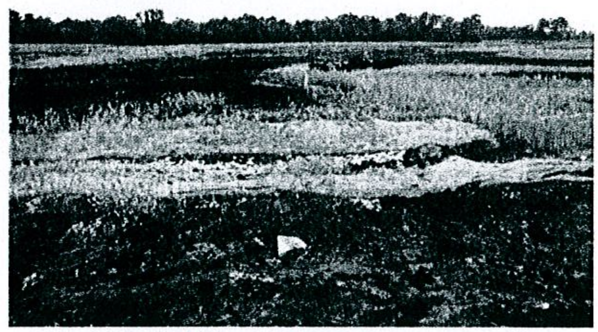
Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	---	6.4	12.04	0.53	0.76	22.76	1	3.2	88.54	88.54



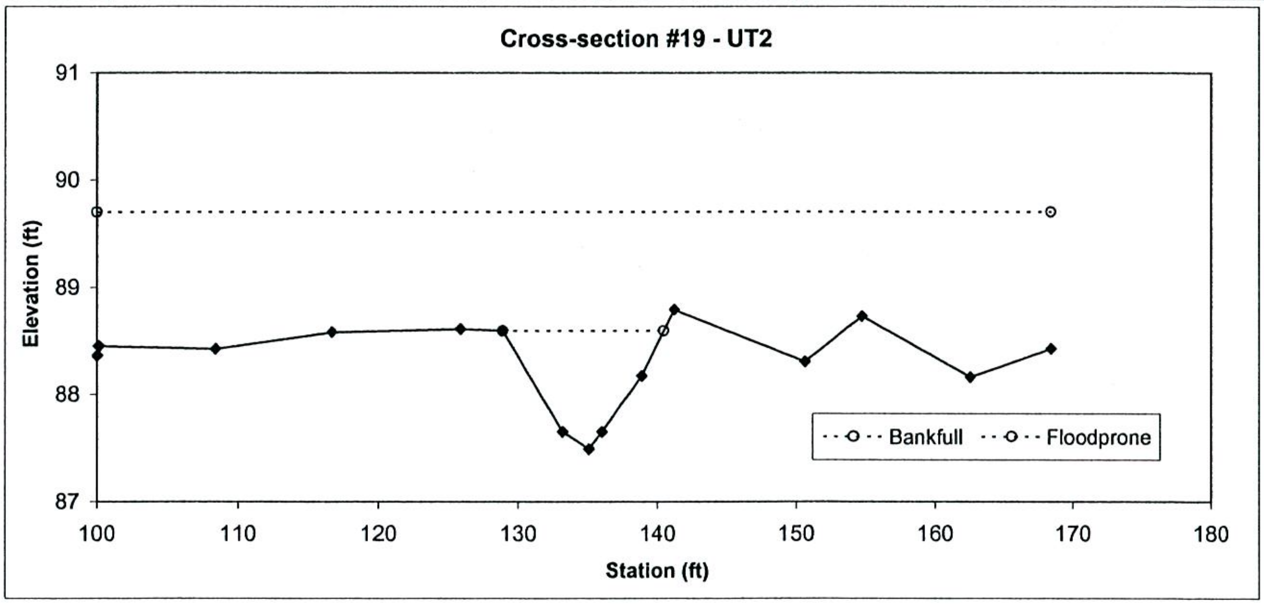
Permanent Cross-section #19
(As Built Data - collected Aug. 2005)

Looking at the Left Bank



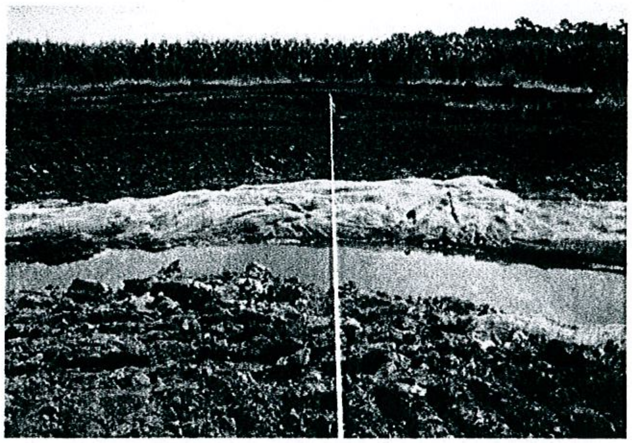
Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	7.2	11.56	0.62	1.11	18.59	1	5.9	88.59	88.59

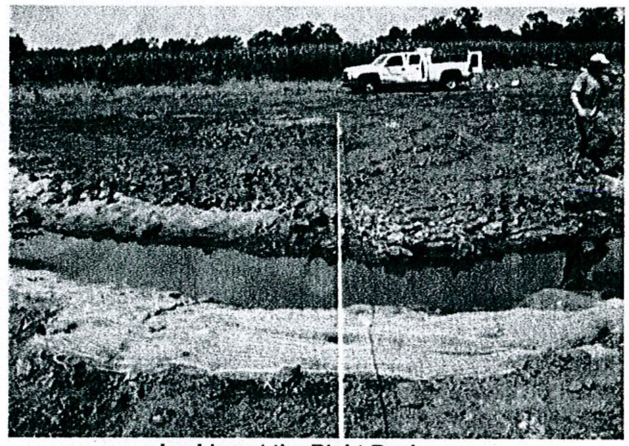


Permanent Cross-section #20

(As Built Data - collected Aug. 2005)

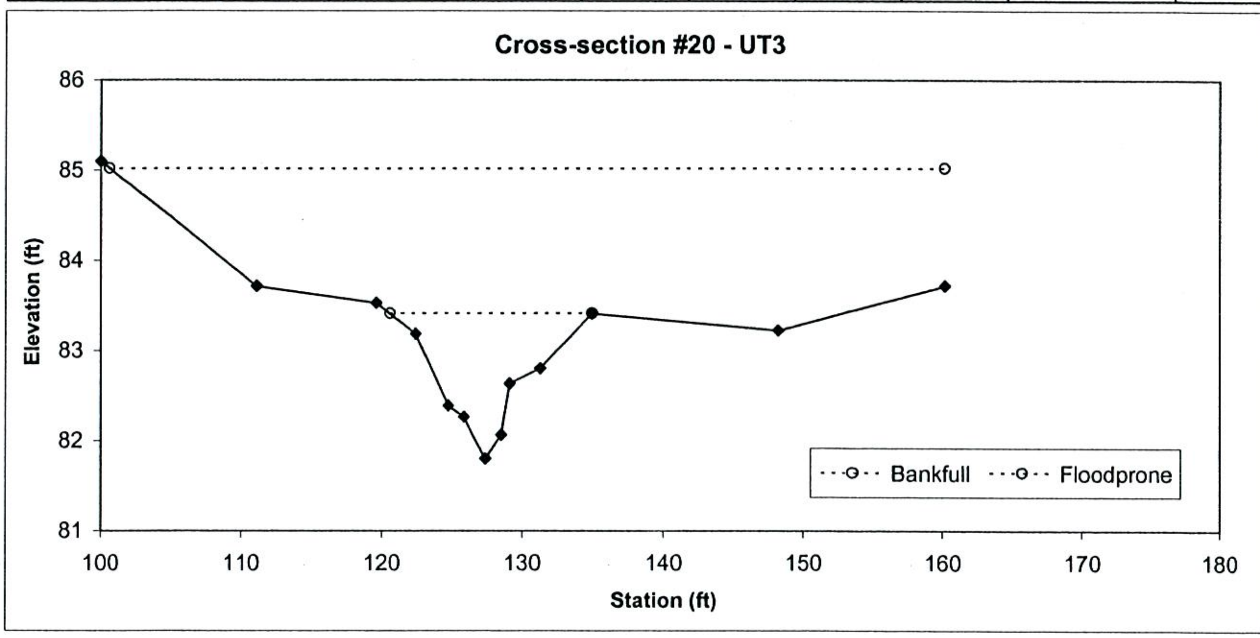


Looking at the Left Bank



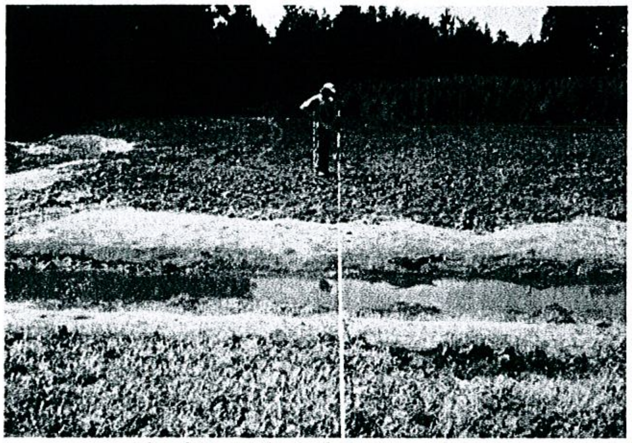
Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	---	9.9	14.36	0.69	1.61	20.87	1	4.1	83.41	83.41



Permanent Cross-section #21

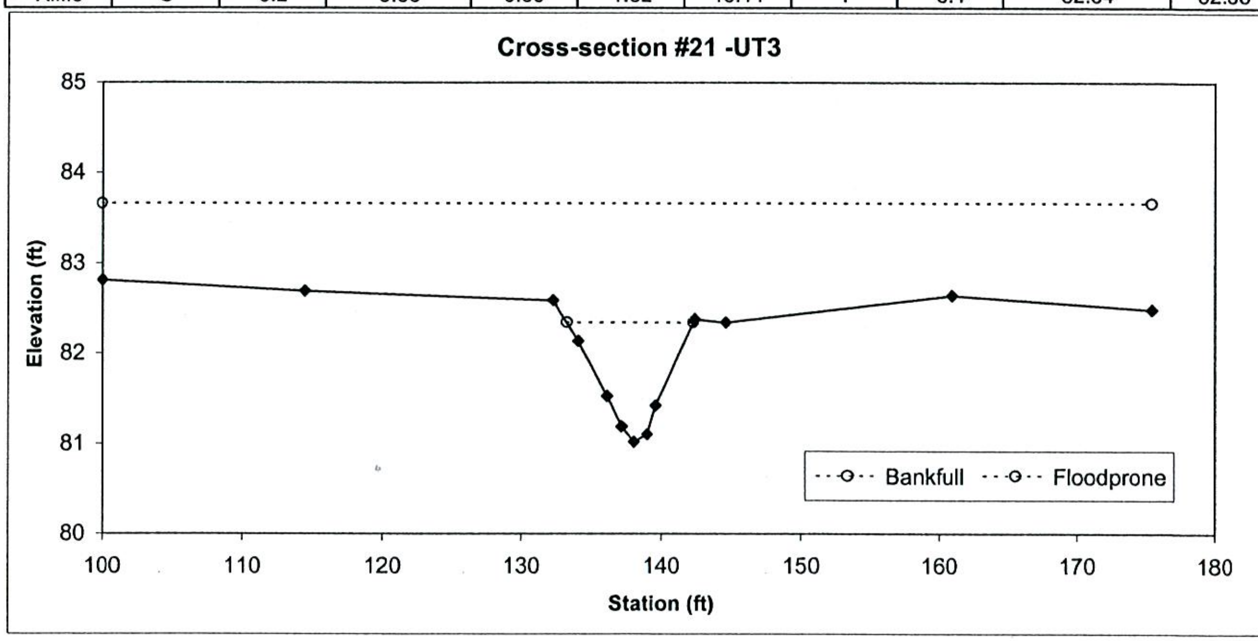
(As Built Data - collected Aug. 2005)



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
Riffle	C	6.2	9.03	0.69	1.32	13.11	1	8.4	82.34	82.38



Appendix 3

As-Built Plan Sheets