Restoration Plan

Dutch Buffalo Creek Stream Restoration
Cabarrus County, North Carolina
Catalog Unit 03040105

Draft Submission Date: May 2007
Revised Draft Submission Date: June 2007
Final Submission Date: September 2007

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EXECUTIVE SUMMARY

Executive Summary

Dutch Buffalo Creek is located in Cabarrus County, North Carolina, northeast of the City of Concord. The restoration effort will occur along the main reach of Dutch Buffalo Creek and along one unnamed tributary near the central portion of the site. The project area is generally oriented east to west. The downstream end of the project begins southeast of an existing wetland. The project area extends upstream for approximately 10,050 feet along Dutch Buffalo Creek and terminates adjacent to a former wetland area currently planted in switch grass (*Panicum virgatum*). The majority of the wetland areas are located along the upstream half of the project. One wetland area is located at the downstream terminus of the project. The North Carolina Ecosystem Enhancement Program (NCEEP) has a 30-foot easement along both banks of the creek for the majority of its length within the project area. In the areas with adjacent wetlands, the associated easement boundary extends approximately 400 feet out from Dutch Buffalo Creek. All stream and wetland restoration, enhancement, and preservation efforts will be implemented within the established conservation easement limits.

i. Project Goals and Objectives

The following goals have been established for the Dutch Buffalo Creek Stream and Wetland Restoration project.

- Stabilize and protect degraded or vulnerable stream banks along the main reach of Dutch Buffalo Creek.
- Enhance the upper project reach of Dutch Buffalo Creek by fencing out the livestock and vegetating streambanks where necessary.
- Restore a natural, stable dimension, pattern, and profile along one unnamed tributary using natural channel design techniques.
- Improve stable habitat for macroinvertebrate and fish communities.
- Restore and/or enhance the natural hydrology, vegetation, and soil composition in adjacent wetlands.
- Provide alternate cattle watering sources and road access across Dutch Buffalo Creek.
- Improve the aesthetics of the stream.

To meet these goals, the following objectives have been established for the Dutch Buffalo Creek Stream and Wetland Restoration project.

- Enhancing approximately 3,611 linear feet in the main channel's upper reach.
- Preserving approximately 4,678 linear feet in the main channel's lower and upper reaches.
- Relocating approximately 608 linear feet of an unnamed tributary into a Rosgen C/E stream type.
- Preserving approximately 1.67 acres, enhancing approximately 4.26 acres, and restoring approximately 7.29 acres of wetland area.
- Constructing access crossings across the main channel and the unnamed tributary of Dutch Buffalo Creek.

- Creating an alternative livestock watering source that prevents livestock from accessing the stream.

ii. Existing Amount of Streams and Wetlands

The existing streams and wetlands within the easement limits of Dutch Buffalo Creek available for restoration, enhancement, or preservation consist of the following components.

- 10,050 linear feet along the main reach of Dutch Buffalo Creek.
- 464 linear feet along an unnamed tributary of Dutch Buffalo Creek.
- 19.3 acres of wetlands adjacent to Dutch Buffalo Creek (approximately 3.5 of the 19.3 acres are located outside the conservation easement).

iii. Amount of Streams and Wetlands Designed

Along the main channel of Dutch Buffalo Creek, the downstream portions of the stream appear stable, consisting of bedrock and cobble substrates. Overbank flooding indicators were also observed along the project reach which reveals that the stream may not be as incised as initially thought. Any type of channel grading or excavation of a bankfull bench along the main reach would require a large amount of land and tree disturbance in which the negative results would far outweigh the benefits. Therefore, restoration efforts along the main channel of Dutch Buffalo Creek will consist of planting native vegetation on streambanks where necessary and constructing a fence that will prevent livestock from accessing the stream. Sections of the stream where livestock do not access the stream appear stable; therefore, once the livestock impacts are removed and the vegetation establishes, the stream should develop into a stable system over time.

The unnamed tributary of Dutch Buffalo Creek will be restored using natural channel design procedures. This restoration effort will consist of returning the appropriate dimension, pattern, and profile to the stream. The restoration effort will include both Priority 1 and 2 approaches. The incised upper reach of the unnamed tributary will be replaced with a new, stable stream at a higher elevation which follows the Priority 1 approach. A rock cross-vane will be used at the upstream end of the project to raise the stream to its original floodplain. The bankfull stage of the new channel will be located at the ground surface of the original floodplain. The middle section of the new channel will be restored using a Priority 2 approach by creating a new bankfull bench at the existing channel elevation, and then grading the banks at a gentle 3:1 slope until it ties in with the original floodplain. Constructed riffles will be installed to provide grade control, stabilization, and habitat. Step-Pools will be used in the downstream reach of the unnamed tributary upstream of the confluence with Dutch Buffalo Creek to join the elevations of the unnamed tributary and the main reach.

Adjacent stream banks and riparian zones of the main channel and unnamed tributary will be replanted using native species appropriate to the area. Bare root, live stakes, and container plants will be used to replant the riparian zone using native vegetation, such as silky dogwood *(Cornus* *amomum)*, willow (*Salix sp.)*, elderberry *(Sambucus sp.)*, and ninebark *(Physocarpus sp.)*. Indigenous plant species will be planted at elevations according to their ability to be saturated.

The project will also include riparian wetland restoration and enhancement. The primary wetland restoration area is within the field at the western end of the project that is currently planted in switch grass. Ditches draining this field will be plugged, and the area will be planted with native tree and shrub species. Other wetland restoration opportunities include plugging/filling ditches in existing forested wetlands and returning hydrology to the wetland adjacent to the stream restoration reach. There will be 0.23 acres of temporary wetland impact as a result of wetland enhancement work within in the wetland and establishing temporary access across two existing wetlands. Refer to Table 1.1 below for a summary of project restoration structure and objectives included within the scope of work.

Table 1.1
Project Restoration Structure and Objectives

Dutch Buffalo Creek						
Segment/Reach	**Stationing**	**Restoration Type**	**Priority Approach**	**Existing Linear Footage or Acres**	**Design Linear Footage or Acres**	**Comments**
Dutch Buffalo Creek-Upper Reach	0+00 – 17+61	NA	NA	NA	NA	Fencing one side of stream in conservation easement.
	17+61 - 53+72	Enhancement II	P4	3,611 lf	3611 lf	Replanting of native vegetation.* Easement will be fenced.
Dutch Buffalo Creek-Lower Reach	53+72 – 100+50	Preservation	NA	4,678 lf	NA	Fencing of conservation easement.
Unnamed Tributary	0+00 – 6+08	Restoration	P1,2	527 lf	608 lf	Channel restoration, relocation with use of grade control and bank protection structures.
Wetland Area A	NA	Preservation	NA	1.67 ac	NA	Fencing of conservation easement.
Wetland Area B	NA	Enhancement	NA	9.93 ac	2.47 ac	Plugging/filling ditches, replanting vegetation.
		Restoration	NA		1.97 ac	
Wetland Area C	NA	Enhancement	NA	4.64 ac	1.79 ac	Plugging/filling ditches, replanting vegetation.
		Restoration	NA		5.32 ac	
* Efforts will consist of enhancing degraded sections along the right and left banks.						

SECTION 1
PROJECT SITE IDENTIFICATION AND LOCATION

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PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Directions to Project Site

To access the site from Interstate 85, take exit 63 (Lane Road) and turn east off the exit. Take Lane Road for approximately 0.8 miles to Old Salisbury-Concord Road and turn left. Take Old Salisbury-Concord Road for 0.5 miles and turn right onto Irish Potato Road (heading east). Follow Irish Potato Road for 5.0 miles, and where it intersects with Gold Hill Road, turn left (heading north-east). Take this to 6200 Gold Hill Road (approximately 2 miles), home of L. Suther. Refer to Figure 1.1 for a location map of the project site.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

Dutch Buffalo Creek and its unnamed tributary are located in Cabarrus County, North Carolina approximately 9 miles northeast of the City of Concord. The project is located in the Yadkin-Pee Dee River Basin, Catalog Unit 03040105, DWQ Subbasin 30712. Dutch Buffalo Creek is a third order stream with an approximate drainage area of 23 square miles at the farthest downstream point of the project. The unnamed tributary to Dutch Buffalo Creek is a first order stream with an approximate drainage area of 0.3 square miles. Dutch Buffalo Creek drains into the Pee Dee River and is listed as WS-II class waters.

1.3 Project Site Vicinity Map

Refer to Figure 1.1 for a location map of the project site.

SECTION 2
WATERSHED CHARACTERIZATION

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2.1 Drainage Area

Dutch Buffalo Creek drains approximately 23 square miles at the farthest downstream point of the NCEEP project easement. The upper portion of the Dutch Buffalo Creek drainage basin is situated in Rowan County, NC and the lower portion lies within Cabarrus County, NC. In general, Dutch Buffalo Creek flows north to south through its watershed. Landscape within the watershed is comprised of steep to strongly sloping upland ridges near headwater streams to gently sloping to broad, flat areas along the floodplain of Dutch Buffalo Creek. Elevations range between 850 ft near the watershed's headwaters to approximately 635 ft at the farthest downstream point of the NCEEP project easement. The project will be conducted within a 66-acre conservation easement along Dutch Buffalo Creek. This acreage excludes the two proposed road easements that the current landowner will retain. Refer to Figure 2.1, USGS Quad Map and Figure 2.2, Project Site Watershed Map for details of the NCEEP project easement's drainage area. Table 2.1 summarizes the drainage areas for each project reach.

Table 2.1
Drainage Areas

Dutch Buffalo Creek		
Reach	**Drainage Area (acres)**	**Drainage Area (square miles)**
Dutch Buffalo Creek-Upper Reach (Enhancement Level II)	13,605	21.26
Dutch Buffalo Creek-Lower Reach (Preservation)	14,910	23.29
Unnamed Tributary (Restoration)	199	0.31

Surface drainage to Dutch Buffalo Creek within the project easement follows two main pathways:

- Drainage directly to Dutch Buffalo Creek via several unnamed tributaries.
- Sheet/overland flow drainage into adjacent riparian wetlands, which eventually contribute to groundwater seepage and baseflow to Dutch Buffalo Creek.

Seeps at the outer edge of the floodplain, overland flow draining into adjacent riparian buffer areas, frequent flooding of Dutch Buffalo Creek and its tributaries, and rainfall appear to be the main contributors to riparian wetland hydrology for the site. This unique combination of hydrology results in scattered zones of inundation typically following the natural micro-topography of the floodplain. As a result of this zonation, the existing riparian wetlands provide a diverse wildlife habitat and high floral species richness.

2.2 Surface Water Classification/Water Quality

The segments of Dutch Buffalo Creek in the project reach have been classified by the North Carolina Department of Environment and Natural Resources (NC DENR) Division of Water Quality as WS-II and HQW. The WS-II classification is described as "Water Supply Level II – Undeveloped", and the HQW classification is described as "High Quality Waters". Although not currently classified, the unnamed tributary draining to Dutch Buffalo Creek in the project reach is also assumed to be WS-II.

2.3 Physiography, Geology and Soils

The Dutch Buffalo Creek project site is located in the Piedmont Physiographic Region. The Piedmont is characterized by broad, gently rolling interstream areas and by steeper slopes along drainage ways. Elevations in the Piedmont range from 300 to 600 feet above mean sea level near its border with the Coastal Plain to 1,500 feet at the foot of the Blue Ridge. More specifically, the project site lies within the Charlotte Belt and is comprised primarily of foliated to weakly foliated, locally migmatic metamorphosed granite rocks (NCGS, 1991). These rocks are estimated to be 300 to 500 million years old and have undergone several deformations over time resulting in folding, fracturing, crushing, and shearing. In addition to these processes, chemical and physical weathering of these rocks has generated deep soil profiles generally referred to as saprolite. Saprolite develops on igneous and metamorphic rocks. Saprolite comprises compact clayey to sandy soil, with original bedrock textures and features preserved (Cady, 1950).

The project site resides in a Valley Type VIII. These valley types are characterized by wide, gentle valley slopes with well-developed floodplains adjacent to river terraces. Stream types "C" and "E", which are slightly entrenched and meandering channels that develop a riffle/pool bedform, normally develop in the Type VIII Valley (Rosgen, 1996).

The *Soil Survey of Cabarrus County, North Carolina* (USDA, 1988) was consulted to determine soil-mapping units within the study area. According to the soil data, nine soil-mapping units occur within the proposed project area. These soil mapping units were compared to the *Hydric Soils of the United States* (USDA-SCS, 1991) to determine if hydric soils are known to occur within the study area. One soil series (Chewacla) appears on the *Hydric Soils of the United States* and is designated 2B3 hydric criterion (USDA-SCS, 1991). Hydric soil unit types denoted by a letter B indicate map units with inclusions of hydric soils or that have wet spots. In Cabarrus County, the Chewacla sandy loam, frequently flooded (Ch) map unit contains approximately 5% hydric inclusions. According to the USDA-SCS *Hydric Soils of the United States*, inclusions consist of the Wehadkee soil types, which is designated an A hydric criterion (100% hydric) and typically occur on adjoining upland side slopes of streams.

In addition to the above, the Altavista soil series is also listed on the *Hydric Soils of North Carolina* (http://soils.usda.gov/use/hydric/lists/state.html) for Cabarrus County and is designated 2B3, 3 hydric criterion (USDA-SCS, 1991). Inclusions within the Altavista soil series consist of 1% Wehadkee soil types. Inclusions of the Wehadkee soil type within Cabarrus County typically occur within depressions along the floodplains and terraces of streams (USDA-SCS, 1991).

Since Chewacla and Altavista soils have a hydric B status, field observations were performed to determine areas within the easement as having hydric conditions. Throughout the easement area, soil samples were collected to determine the hydromorphic condition. In general, field observations of reduced chroma and aquic moisture regime were used in determining if a particular area was hydric. Indicators of wetland hydrology included saturated soils within the upper 12 inches, areas of inundation, oxidized rhizospheres, and water-stained vegetation. Additional hydrologic indicators included crayfish burrows and multi-trunked tree species.

Field observations reveal that soils within the project area formed in sandy, loamy alluvium inside and along the Dutch Buffalo Creek levee within the project area. However, farther away from Dutch Buffalo Creek within the floodplain and adjacent terraces, soils appear to have formed in a clayey, loamy alluvium. Field observations suggest that hydric soils likely have developed within these areas due to the poor drainage and slow permeability of clayey, loamy alluvium. In addition, areas beyond the natural levee are lower in elevation and are typically ponded during significant flood events; therefore, the upper soil pedon is saturated long enough in some of these floodplain areas during the winter and spring for aquic conditions to develop.

Several floodplain areas surrounding Dutch Buffalo Creek are being drained and no longer develop aquic conditions. Natural levees along an incised Dutch Buffalo Creek and severely incised and down-cut backwater ditches/channels within the floodplain now remove surface water and have altered the hydrology and soils. The morphology of much of these soils, however, indicates that aquic conditions were present prior to anthropogenic modification of the hydrology. Typically, the upper 12 inches of soils identified as hydric exhibited soil matrix colors of 10YR 5/2 or 10YR 3/2. Iron concentrations were typically 10YR 4/4.

Of the total nine mapping units which occur within the project area, all are considered as prime farmland soils or farmland of statewide importance. Refer to Figure 2.3 for a Soil Map of the site. Below is a brief description of soil mapping units that occur within the project area.

- **Altavista sandy loam, 2 to 6 percent slopes (AaB) -** The Altavista series consists of very deep, moderately well-drained, moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed from loamy fluvial sediments.

- **Cecil sandy clay loam, 2 to 8 percent slopes (CcB2) -** The Cecil series consists of very deep, well-drained moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed in residuum weathered from felsic, igneous and high-grade metamorphic rocks of the Piedmont uplands.

- **Cecil sandy clay loam, 8 to 15 percent slopes eroded (CcD2) -** The Cecil series consists of very deep, well-drained moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed in residuum weathered from felsic, igneous and high-grade metamorphic rocks of the Piedmont uplands.

- **Chewacla sandy loam, frequently flooded (Ch) -** The Chewacla series consists of very deep, moderately permeable, somewhat poorly drained soils on floodplains. They formed in recent alluvium washed largely from soils formed in residuum from schist, gneiss, granite, phyllite, and other metamorphic and igneous rocks.

- **Cullen clay loam, 2 to 8 percent slopes eroded (CuD2) -** Soils of the Cullen series are very deep and well-drained with moderate permeability. They formed in residuum from mixed mafic and felsic crystalline rocks. These soils are on upland ridge tops and side slopes of the Piedmont Plateau.

- **Enon sandy loam, 8 to 15 percent slopes (EnD) -** The Enon series consists of very deep, well-drained, slowly permeable soils on ridge tops and side slopes in the Piedmont. They have formed in residuum weathered from mafic or intermediate igneous and high-grade metamorphic rocks such as diorite, gabbro, diabase, or hornblende gneiss or schist.

- **Pacolet sandy loam, 15 to 35 percent slopes (PaF) -** The Pacolet series consists of very deep, well-drained, moderately permeable soils that formed in residuum weathered mostly from felsic igneous and metamorphic rocks of the Piedmont uplands.

- **Mecklenburg loam, 2 to 8 percent slopes (MeB) -** The Mecklenburg series consists of very deep, well-drained, slowly permeable soils that formed in residuum weathered from intermediate and mafic crystalline rocks of the Piedmont uplands.

- **Mecklenburg loam, 8 to 15 percent slopes (MeD) -** The Mecklenburg series consists of very deep, well-drained, slowly permeable soils that formed in residuum weathered from intermediate and mafic crystalline rocks of the Piedmont uplands.

In addition to the above map soil units, a brief description of the Wehadkee soil type, which is a hydric soil inclusion sometimes found within Ch and AaB mapped soil units, is provided below.

- **Wehadkee loam frequently flooded (We) -** The Wehadkee series consists of poorly drained, moderately permeable soils on floodplains of major creeks and streams with a seasonal high water table at or near the surface. These soils formed in schist, gneiss, granite, and other metamorphic and igneous rock. Mapped areas range from nearly level to slight depressions and are generally narrow and long. In addition, the *Soil Survey of Cabarrus County* (1988) lists a typical pedon of this soil type existing one mile east of Concord on state highway 73 to Gold Hill Road to Dutch Buffalo Creek, 400 yards north from bridge, in a wooded area.

2.4 Historical Land Use and Development Trends

The watershed land use is dominated by rural pasture land and forest. The surrounding land use of the project site is primarily agricultural with activities ranging from cattle grazing to row crops. The majority of the site has been historically disturbed due to past and current management for cattle grazing and rearing.

Past site land use includes livestock grazing, removal of riparian vegetation, dredging and straightening of drainage channels to Dutch Buffalo Creek and its tributary, and ditching of wetlands to drain them for conversion to crop fields.

The Cabarrus County GIS land use coverage has the entire drainage area of the project reach characterized as Open Space. The County zoning ordinance defines Open Space as primarily agricultural with some undeveloped or forested areas. Residences and businesses are typically related to or support agriculture. A land use summary is provided in Table 2.2.

Table 2.2
Land Use of Watershed

Land Use*	Acres (ac)	Percentage (%)
Agriculture**	9,225	**61.98**
Cleared	*2,668*	**-**
Forested	*2,154*	**-**
Commercial	141	**0.95**
Public/Institutional	7	**0.05**
Residential	5,135	**34.50**
Transportation	379	**2.53**
Total	**14,884**	**100.00**

***** Source: Cabarrus County (2007) and Rowan County (2007)

****** The forested lands classification shown in Table 2.2 includes areas within Cabarrus County only, because no data were available for specific forested areas within Rowan County. The Cabarrus County data are more detailed than the Rowan County data, so we were able to process the agricultural and forested areas within Cabarrus County into separate classifications of Cleared and Forested land uses. However, the Agriculture classification for Rowan County includes both cleared lands and any extant forested lands within the drainage basin, as there was no information available for processing these land uses separately.

2.5 Endangered / Threatened Species

Under terms of Section 7 of the Endangered Species Act, federal agencies shall "*ensure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary to be critical…*" The USACE requires protected species surveys for project sites that involve a Section 404 of the Clean Water Act permit.

Prior to the field studies, an office review of available resources was performed to develop a list of potential federal- and state-listed species for Cabarrus County, North Carolina. The tentative list of known protected species was compiled by review of the United States Fish and Wildlife Service (USFWS) county database (http://www.fws.gov/nc-es/es/es.html, 2006).

Prior to the field survey, a letter was submitted to the North Carolina Ecological Services field office of USFWS to obtain information regarding the listed species within Cabarrus County, North Carolina. The letter requests any information of known occurrence within the vicinity of the project area. To date (September 2007), no response has been issued from the USFWS.

Field studies were conducted to determine the presence of suitable protected species habitat and the potential occurrence of these species. There were no protected species identified within the proposed project study area; however, there is suitable habitat for one of the listed species: Carolina creekshell (*Villosa vaughaniana*). The project may effect, but is not likely to adversely affect this species. Furthermore, due to stringent use of BMPs implemented during construction, sedimentation and erosion will be minimized. As a result of these practices, this project is not likely to adversely affect this species or its overall habitat. A detailed discussion of protected species studies is included in the Threatened and Endangered Species Section of this report.

Table 2.3 provides a summary of federal- and state-listed species for Cabarrus County, North Carolina as reported by the U.S. Fish and Wildlife Service's (USFWS) Region 4 North Carolina Ecological Services field office website. A species/habitat matrix included in Table 2.4 provides information on listed species and their preferred habitat. Brief descriptions of the federal and state protected species are provided in Tables 2.3 and 2.4.

Table 2.3
Summary of Federal- and State-Listed Species for Cabarrus County

Species	Vernacular Name	Federal Rank	Preferred Habitat	Habitat Present
Faunal				
Anguilla rostrata	American eel	FSC	The American eel occurs most often in moderate or large rivers with continuous flow and moderately clear water.	No
Etheostoma collis collis	Carolina darter	FSC	The Carolina darter inhabits muddy and rocky pools and backwaters of sluggish headwaters and creeks.	No
Villosa vaughaniana	Carolina creekshell	FSC	The Carolina creekshell is usually found in silty sand or clay along the banks of small streams. In areas of abundance, they have also been found occupying substrates of mixed sand and gravel.	Yes
Lasmigona decorata	Carolina heelsplitter	E*	The Carolina heelsplitter inhabits streams or small rivers and is usually found in mud, muddy sand, or muddy gravel substrates along stable, well-shaded stream banks.	No
Floral				
Lotus unifoliolatus var. *helleri*	Prairie bird's foot-trefoil	FSC	The Prairie bird's foot-trefoil inhabits dry woods and clearings of the Piedmont Physiographic Region.	No
Helianthus schweinitzii	Schweinitz's sunflower	E	Occurs in clearings and edges of upland woods on moist to dryish clays, clay-loams, or sandy clay-loams; Schweinitz's sunflower usually grows in open habitats such as roadsides, powerline right-of-ways, and fallow pastures.	No
Isoetes virginica	Virginia quillwort	FSC	Shallow soils within vernal pools approximately one inch deep on granite outcrops.	No
E = Endangered; FSC = Federal Species of Concern * There are only 6 known populations of this species left; none of which occur in Cabarrus County, North Carolina				

Table 2.4
Species/Habitat Matrix

Habitat	Sub-Habitat	Species
Terrestrial	Dry woods and clearings.	Prairie bird's foot-trefoil, Schweinitz's sunflower
	Clearings and edges of upland woods on moist to dry clay soils.	Schweinitz's sunflower
	Shallow soils in vernal pools on granite outcrops.	Virginia quillwort
Aquatic	Moderate or large rivers with continuous flow and moderately clear water.	American eel
	Inhabits muddy and rocky pools and backwaters of sluggish headwaters and creeks.	Carolina darter
	Silty sand or clay along the banks of small streams. In areas of abundance, they have also been found occupying substrates of mixed sand and gravel.	Carolina creekshell
	Streams or small rivers and is usually found in mud, muddy sand, or muddy gravel substrates along stable, well-shaded stream banks.	Carolina heelsplitter

Species Description

American eel – American eels are brownish in color with a slender snake-like body and a small pointed head. The dorsal fin is long, extending more than half the length of the body and joins the tail and anal fins. They have short rounded pectoral fins and no pelvic fins. They occur most often in moderate or large rivers with continuous flow and moderately clear water (USFWS, 2001). Suitable habitat for this species was not observed; therefore, this project will have no affect on this species or its habitat.

Carolina darter – The Carolina darter has eyes almost on top of its head, rounded tail fin, and an elongated to somewhat compressed body. The fish's body is yellowish-brown with dark blotches and speckles on its body. The dorsal fin is usually a rusty color and its remaining fins are pale yellow to clear. The darter has a green to yellow iridescence around its head. The Carolina darter inhabits muddy and rocky pools and backwaters of sluggish headwaters and creeks. The fish is generally found only in the Atlantic Piedmont from Roanoke River drainage of Virginia to Santee River drainage of South Carolina (Page & Burr, 1991). Suitable habitat for this species was not observed; therefore, this project will have no affect on this species or its habitat.

Carolina creekshell – The Carolina creekshell is sexually dimorphic. In males, the shell is generally elliptical in shape and, in females the shell shape is somewhat trapezoidal. The inner shell is white to bluish-white and iridescent; some shells may have a salmon wash along the ventral margin.

The range of the Carolina creekshell includes the Catawba and Yadkin-Pee Dee River Basins in North and South Carolina, and Upper Cape Fear River Basin in North Carolina (NatureServe, 2005).

The Carolina creekshell is usually found in silty sand or clay along the banks of small streams. In areas of abundance, they have also been found occupying substrates of mixed sand and gravel (NCAMEF, 2006). Suitable habitat for this species was observed; however, no specimens were observed during field studies. A mussel survey was conducted on Dutch Buffalo Creek in 2002 by The Catena Group. No specimens of Carolina creekshell were found. Furthermore, sedimentation and erosion will be minimized due to stringent use of BMPs implemented during construction. As a result of these practices, this project may affect, but is not likely to adversely affect this species or its overall habitat.

Carolina heelsplitter – The Carolina heelsplitter has an ovate, trapezoid-shaped, unsculptured shell. The shell's outer surface varies from greenish brown to dark brown in color, and shells from younger specimens have faint greenish brown or black rays. The nacre (inside surface) is often pearly white to bluish white, grading to orange in the area of the umbo (Keferl 1991 as reported in USFWS, 2006 A). Historically, the Carolina heelsplitter was known from several locations within the Catawba and Pee Dee River systems in North Carolina and the Pee Dee and Savannah River systems, and possibly the Saluda River system, in South Carolina. Recent collection records indicate that the Carolina heelsplitter has been eliminated from all but one of the streams from which it was known to have been originally collected. Only six populations of the species are known to exist. All of these are within Union County, North Carolina (Keferl and Shelly 1988, Keferl 1991, Alderman 1995 and 1998 as reported in USFWS, 2006). Due to the extirpation of the species throughout North Carolina, the species is not likely to be present. Also, a mussel survey was conducted on Dutch Buffalo Creek in 2002 by The Catena Group and no specimens of Carolina heelsplitter were found. Furthermore, the area proposed for restoration doe not provide suitable habitat for the Carolina heelsplitter. As a result of these findings, this project will have no affect on this species or its overall habitat.

Prairie bird’s foot-trefoil – The prairie bird’s foot-trefoil is erect annual herb with branches and stems approximately 8 to 20 inches in height. The leaflets are narrowly elliptic to linear shape. The plant generally inhabits dry woods or clearings. The distribution for this species ranges from Georgia to Virginia; however, it only is known to occur in a few counties of each state (Radford, 1968). Suitable habitat for this species was not observed; therefore, this project will have no affect on this species or its habitat.

Schweinitz’s sunflower –The Schweinitz’s sunflower grows from three to six feet in height from a cluster of carrot-like tuberous roots. Stems are usually solitary, branching only at or above mid-stem, with the branches departing from the stem at about a 45-degree angle. The purplish stem is usually pubescent but can be nearly glabrous. The leaves are opposite on the lower stem, changing to alternate above. The leaves are lance-shaped with entire leaf margins. The lower leaves are approximately four to eight inches in length and approximately 0.5 to 1 inch in width. The upper leaves are smaller and approximately two inches in length.

From September to frost, Schweinitz's sunflower blooms with comparatively small heads of yellow flowers. Schweinitz's sunflower is endemic to the Piedmont of the Carolinas, where it is currently known in 12 counties in North Carolina, including Cabarrus. This plant is a prairie species that occurs in clearings and edges of upland woods on moist to dry clays, clay loams, or sandy clay loams that often have high gravel content. Schweinitz's sunflower usually grows in open habitats such as roadsides, powerline right-of-ways, and fallow pastures (USFWS, 2006B). The majority of the project area is a moist, forested floodplain surrounded by agricultural fields for cattle grazing. Botanical studies have been conducted in the wet prairie located in the eastern end of the Suther property south of the preservation area. This prairie provides no habitat due to the wetter conditions, and no specimens were found (Barden, L.S., 2007). Furthermore, the heavy grazing and frequent mowing of the surrounding pasture land results in unsuitable habitat for this species. As a result of these findings and conditions, suitable habitat for this species is not located within the project area; therefore, this project will have no affect on this species or its habitat.

Virginia quillwort – The Virginia quillwort is a granite outcrop species that develops in shallow soils within vernal pools on rock outcrops. The leaves are 15 to 50 in number and are generally five to seven inches in length. The leaves are slender, brown at the base; leaf septa are coarse; peripheral strands four or six in number, or entirely lacking; sporangia oblong, brown, with narrow velum (USDA, 2006). Suitable habitat for this species was not observed; therefore, this project will have no affect on this species or its habitat.

Biological Conclusion

Field surveys were conducted in December 2006, and no observations were made of any listed species. However, suitable habitat was observed for one species listed as a Federal species of concern: Carolina creekshell. No specimens of Carolina creekshell were observed or found during the survey. Furthermore, a mussel survey was conducted on Dutch Buffalo Creek in 2002 by The Catena Group, and no listed species were found during the survey. Furthermore, sedimentation and erosion will be minimized due to stringent use of BMPs implemented during construction. As a result of these practices, this project may affect, but is not likely to adversely affect this species or its overall habitat. In addition, no specimens of the federally-protected Carolina heelsplitter were found and there is no evidence that a viable population has occurred in Dutch Buffalo Creek. Furthermore, the survey report states that it is unlikely that non-reproducing individuals inhabit Dutch Buffalo Creek. This project will have no affect on the Carolina heelsplitter or its habitat. Habitat was not observed for any other species; therefore, this project will have no affect on any of the other listed species.

Federal Designated Critical Habitat

Habitat Description

The project area is not designated as Federal Critical Habitat. The project area has been impacted from past and present land use (agricultural practices).

Biological Conclusion

Since the project area has not been designated as Federal Critical Habitat, the project will not have an affect on a critical habitat area.

USFWS Concurrence

Prior to the field survey a letter (dated December, 2006) was submitted to the North Carolina Ecological Services office of USFWS to obtain information regarding the listed species within Cabarrus County, North Carolina. The letter requests any information of known occurrence within the vicinity of the project area. To date (September 2007), no response has been received. A response was requested in 30 days. Since no response has been received, it is presumed that the USFWS has no comments on the project.

2.6 Cultural Resources

Site Evaluation Methodology

A review of the National Register of Historic Places database (http://www.nr.nps.gov/) indicates that there are no records of any historic places within the proposed project area. No known archeological resources will be affected by the proposed project and no historic properties will be affected. Should cultural resources be identified during construction, the USACE and State Historic Preservation Officer would be contacted.

Field Evaluation

Potential for Historic Architectural Resources

Impacts to any historical structures are not anticipated as a result of the construction of this project. There is a low probability of intact architectural resources occurring within the project area, and no standing structures over 50 years old were observed during surveys.

The majority of the site has been previously disturbed due to past and current management for cattle grazing and rearing. The current landowners' father also raised cattle on this property (L. Suther, 2006). As a result of this history of disturbance, grazing, and trampling, it is unlikely that disturbances resulting from temporary construction access and channel work would result in impacts to potential areas of archaeological significance. No archeological artifacts have been observed or noted during preliminary surveys of the site for restoration purposes. The landowner has identified an existing inundated ditch located in the eastern-most wetland as a former raceway for a gristmill (L. Suther, 2006). No remains of the gristmill have been observed. Furthermore, during verbal correspondence with John Minth of State Historic Preservation Office (SHPO) regarding the feature, Mr.Minth stated that the feature was not of concern (JJG, 2007).

SHPO/THPO Concurrence

A letter was submitted to the State Historic Preservation Office regarding the cultural resource information. Subsequent to verbal correspondence with Mr. Minth, SHPO submitted a letter of response stating that SHPO is not aware of any historic resources that would be affected by the project. Therefore, SHPO has no comment on the project.
There are no other compliance issues known at this time.

2.7 Potential Constraints

The Federal Highway Administration (FHWA), in cooperation with NCEEP and various state and federal agencies, has developed environmental screening and documentation guidelines for NCEEP projects to be processed as a Categorical Exclusion (CE). The CE was prepared and approved as a part of the Environmental Resources Technical Report (ERTR) (JJG, 2007).

The CE confirmed that the site has not been designated as Federal Critical Habitat; therefore, the project will not have an effect on any endangered species or habitat. Concerns were raised by the North Carolina Wildlife Resources Commission (NCWRC) regarding potential impacts to listed mussels in correspondence dated January 5, 2007. A conference call was held on February 20, 2007 with the NCEEP and the FHWA to discuss the concerns of the NCWRC and the findings of the mussel survey. The participants concluded that the finding of “no effect” on the Carolina heelsplitter is correct (JJG, 2007).

In regards to the Farm Practices Protection Act (FPPA), the Natural Resources Conservation Service (NRCS) has determined that the Dutch Buffalo Creek project area contains prime farmland soils. The USDA was contacted and a completed AD-1006 (Farmland Conversion Impact Rating) Form was submitted to the NRCS for review. This documentation allows the project to comply with the FPPA (JJG, 2007).

There are no existing structures within the areas proposed for restoration or enhancement; furthermore, no architectural structures or archeological artifacts have been observed or noted during preliminary surveys of the site for restoration purposes. In addition, the majority of the site has historically been disturbed due to past and current management for cattle grazing and rearing.

2.7.1 Property Ownership and Boundary

The parcels that the proposed Dutch Buffalo Creek restoration/enhancement will occur on are owned by Messrs Louis and John Suther. Restoration will occur within conservation easement limits maintained by NCEEP. NCEEP has a conservation easement that extends 30 feet from the existing top of bank along both banks of the creek for the majority of its length within the project area. With the exception of areas necessary for access, the proposed disturbance will occur within these limits. In three reaches, NCEEP only has an easement along one side of Dutch Buffalo Creek. NCEEP also owns the conservation easements associated with the wetland areas involved in the proposed restoration and enhancement. NCEEP Restoration Project criteria states that proposed stream segment sites must include permanent easements (at a minimum) from land owners on both sides of the stream channel; therefore, segments with an easement on only one side of bank will not be included in the stream restoration/enhancement and/or preservation scope.

2.7.2 Site Access

Communication with the Suthers indicates that construction access should not be a major project concern and can occur beyond the conservation easement limits. A construction access plan is included in the restoration plan. Please refer to Section 7.8 for a summary of proposed access.

2.7.3 Utilities

There are no utilities or utility easements within the project site.

2.7.4 FEMA Hydrological Trespass

JJG will evaluate the existing flooding regime of the streams and factors affecting site hydrology (e.g. structures, ditches, and topographic alterations). A Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) (effective date Nov 2, 1994) has been obtained for the project area. According to the FEMA 100-year (has a 1% chance of being equaled or exceeded in any given year) floodplain, the entire project conservation easement occurs within the floodplain. A hydraulic model (HEC-RAS) has been produced to determine the possible flooding effects due to potential topographic changes associated with enhancing/restoring streams and wetlands. Both existing and proposed stream geometries were modeled in HEC-RAS and the 100-year floodplain water surface elevations were compared for the two conditions. The model indicates that there will not be a rise in the water surface elevation for 100-year floodplain due to the proposed conditions; therefore, there will be no hydrological trespass associated with proposed project.

SECTION 3

PROJECT SITE STREAMS (EXISTING CONDITIONS)

SECTION 3

PROJECT SITE STREAMS (EXISTING CONDITIONS)

Existing conditions within the project reach indicate a departure from a stable system due to various land use activities. The main reach of Dutch Buffalo Creek is slightly incised. Bedrock outcroppings throughout the existing stream bed provide grade control and prevent the stream from further incision and entrenchment. Indicators of over-bank flows (wrack lines, flood debris, and sediment deposition) were observed several times during JJG's field surveys between November 2006 and March 2007. This evidence indicates that the stream is not deeply incised and is connected to its floodplain. However, the upper reach has actively eroding, unstable banks. Many trees have fallen into the stream due to the streambank erosion and instability. Areas of mass wasting, bank slumping, and sediment deposition are evident throughout the upstream project reach. In some areas, excess sediment from the eroding banks has deposited within the stream and covered the native substrate. These sediment deposits have likely reduced in-stream habitat for fish and macroinvertebrates. In certain areas, the sediment has formed sandbars, and these sandbars, as well as the fallen trees, tend to re-direct the stream flow into the banks exacerbating potential erosion. The substrate in the upper reach of the project appears to be dominated by fine sand. Further downstream, the banks appear to be more stable and vegetated, resulting in a cobble dominated substrate. Several active beaver dams were observed throughout the middle portion of the main channel. Overall, the instability of the stream is contributing to stream bank loss, increased sedimentation, and less viable biological habitat.

A small unnamed tributary flows into the main channel just upstream of an existing cattle crossing. This tributary is deeply incised and appears to have been modified or straightened in the past. The majority of the substrate in the tributary is fine sand. The stream banks have high angles, with little to no vegetation. Near the bottom of the reach a chute forms and flows into the main channel. This area is over-widened with highly erosive banks. In some areas, excess sediment from the eroding banks has deposited within the stream and covered the native substrate. Overall, the instability of the stream is contributing to stream bank loss, increased sedimentation, and less viable biological habitat.

3.1 Channel Classification

Dutch Buffalo Creek and the unnamed tributary were classified using the Rosgen stream classification system, based on surveyed morphological measurements (Rosgen, 1996).

The existing surveyed reach of Dutch Buffalo Creek was classified as a C5e. Typically, a C5 stream is slightly entrenched, meandering, and has a well-developed floodplain and point bars. C5 streams also tend to have gentle gradients, slight sinuosity, and a relatively high width/depth (W/D) ratio. The stream bed morphology typically consists of a riffle-pool sequence, with a sand-dominated substrate.

Morphological bed features, such as ripples, dunes, and anti-dunes are usually prevalent in these sandy stream systems. C5 stream banks are usually composed of erodible, sandy material; therefore, the banks are susceptible to accelerated bank erosion with a high to very high sediment supply rate. Rates of erosion and the level of stability in these types of streams are directly influenced by the presence or lack of vegetation. C5 stream types are also very susceptible to shifts in both lateral and vertical stability (Rosgen, 1996). The "little e" designation was added to the stream classification, because the project reach of Dutch Buffalo Creek has a lower W/D ratio that resembles more of an E- type channel than a C-type channel.

The unnamed tributary to Dutch Buffalo Creek was classified as a G5c. Streams within this classification are considered entrenched, have a moderate gradient, deeply incised with highly erosive banks, and a sandy substrate (Rosgen, 1996). These "sandy gully" stream types transport great amounts of sediment due to the ease of particle detachment and fluvial entrainment (Rosgen, 1996). Channel sinuosity is usually low as are the W/D ratios. The "little c" designation was added to the classification because the slope/gradient of the tributary resembles more of a C-type stream and than a G-type stream. These stream types are extremely sensitive to disturbance and tend to make significant adverse channel adjustments to changes in flow regime and sediment supply from the surrounding watershed. G-type streams are considered unstable and a prime candidate for stream restoration efforts.

3.2 Discharge (bankfull, trends)

Using USGS rural regression equations for North Carolina's Blue Ridge Piedmont hydrologic area (2001), peak flows for the 2-, 5-, 10-, 25-, 50- and 100-year storms were calculated for the main channel and the unnamed tributary of Dutch Buffalo Creek to determine the existing discharges. The main channel peak flows for the 2-, 5-, 10-, 25-, 50- and 100-year storms were also modeled using Hydrologic Engineering Centers River Analysis System (HEC-RAS). Table 3.1 presents the discharge trends calculated for the main channel and the unnamed tributary. A typical cross-section for the main channel and unnamed tributary were modeled in Bentley Flowmaster to determine bankfull discharge (the water surface at which flow reached the bankfull indicator) (Table 3.2). Refer to Section 3.5 for information on regional curve bankfull discharge and crest gauge results.

Table 3.1
Peak Discharges (Q) from Regression Equations

Reach	Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)
Main Channel	1220	2022	2662	3597	4409	5287
Unnamed Tributary	59	110	154	224	286	358

Table 3.2
Bankfull Discharges (Qbkf) from Bentley Flowmaster

Reach	Qbkf -Calculated (cfs)
Main Channel	423
Unnamed Tributary	39

3.3 Channel Morphology (pattern, dimension, profile)

Existing stream morphological conditions for the main channel and the unnamed tributary of Dutch Buffalo Creek are summarized in Table 3.3. Additional morphological data is provided in Appendix 9. All geomorphic assessments (cross-section, longitudinal, and pebble counts) were performed following guidelines outlined in the Stream Channel Reference Sites: An Illustrated Guide to Field Techniques (Harrelson et al., 1994). A topographic survey of the project site was completed by R.J. Harris. The survey consisted of collecting detailed data for all stream, wetland, and floodplain areas, and the location of trees within the established conservation easement.

Currently, the main channel of Dutch Buffalo Creek is slightly incised (Bank Height Ratio of 1.22 – 1.25) with highly erosive banks. The channel has down-cut slightly and widened over the course of time. The stream's vertical stability is maintained due to bedrock knick points throughout the reach; however, lateral stability varies depending upon tree rooting and existing rocks within the soil. There are a number of large trees along the bank that provide good bank protection and appear stable. Channel widening and lack of stability have affected the stream pattern. The channel pattern is slightly sinuous in the middle to lower sections (1.4), but within the enhancement project limits, the channel is straight due to previous channel alterations, resulting in a sinuosity of 1.18.

The mean cross-sectional area of the main reach is currently smaller than what is predicted in the North Carolina Regional Curves for Rural Piedmont streams (146.68-158.41 ft^2). The W/D ratio (6.47-16.27) of the existing main channel is also lower than would be expected according to the North Carolina Regional Curve for Rural Piedmont streams. The lower W/D ratio could be due to the channel over-widening in areas, and adjusting to re-establish a dynamic equilibrium. The average water surface slope of the main reach is 0.0014 ft/ft. Both the low slope and in-stream bank failure are factors in the high sediment deposition rate occurring within the channel. Typically, upstream bank failure leads to downstream aggradation. These areas of aggradation are also indicating a shift in stream bed form; some of the areas where riffles are expected are flat, filled with sediment, and evolving into runs. The main channel is characterized by a mean riffle D50 of 3.52 millimeters (mm), and a mean pool D50 of 0.39 mm, indicating a channel substrate dominated by gravel and sand-sized particles. The stream was probably once characterized by a cobble substrate before land disturbance activities and instability of the stream banks shifted the substrate to a sandy substrate.

The unnamed tributary to Dutch Buffalo Creek is incised with vertical banks (Bank Height Ratio of 2.53). This instability is probably due to historic land use, channelization, and removal of riparian vegetation. The channel pattern has a slight sinuosity, resulting in a sinuosity of 1.24. The average water surface slope is 0.0078 ft/ft. A steeper slope is typical for these stream types that have been historically straightened. High shear stresses and discharge volumes contained within the channel are greater, because the stream is disconnected from its floodplain.

This leaves the stream vulnerable to bank erosion and failure. The bed features vary from a riffle-pool sequence in the upper reach of the tributary to a continuous run with sporadic pools located within the lower reach. The channel is characterized by a mean reach-wide D50 of 2.18 mm, indicating a channel substrate dominated by sand-sized particles. The stream was probably once characterized by gravel substrate before the land disturbance and instability of the stream banks shifted the substrate to a sandy substrate.

Table 3.3
Existing Morphology

	Parameter	Main Reach		Unnamed Tributary	
		MIN	MAX	MIN	MAX
General	Drainage Area (sq mi)	21.3		0.31	
	Stream Type (Rosgen)	C5e*		G5c*	
	Valley Type	VIII		VIII	
Dimension	BKF Mean Velocity (Vbkf) (ft/s), n=10	3.31	3.58	3.8	
	Bankfull Discharge (Qbkf)(cfs)	423**		39.04**	
	Bankfull XSEC Area, Abkf (sq ft), n=10	146.68	158.41	10.17	
	Bankfull Width, Wbkf (ft), n=10	32.02	49.31	8.68	
	Bankfull Mean Depth, dbkf (ft), n=10	3.03	4.95	1.17	
	Width to Depth Ratio, W/D (ft/ft), n=10	6.47	16.27	7.42	
	Width Floodprone Area, Wfpa (ft)	>150		9.8	
	Entrenchment Ratio, Wfpa/Wbkf) (ft/ft), n=10	3.04	4.68	1.13	
	Max Depth @ bkf, Dmax (ft), n=10	5.48	6.67	1.49	
	Max Depth Ratio, Dmax/dbkf, n=10	1.81	1.35	1.27	
	Max Depth @ tob, Dmaxtob (ft), n=10	6.68	8.37	3.77	
	Bank Height Ratio, Dtob/Dmax (ft/ft), n=10	1.22	1.25	2.53	
	Pool Max Depth, Dmaxpool (ft), n=7	6.02	6.86	1.79	
	Pool Max Depth Ratio, Dmaxpool/dbkf, n=7	1.99	1.39	1.53	
	Pool Area, Apool (sqft), n=7	158.50	189.50	10.26	
	Pool Area Ratio, Apool/Abkf, n=7	1.08	1.20	5.73	
	Pool Width, Wpool (ft), n=7	32.89	40.76	10.16	
	Pool Width Ratio, Wpool/Wbkf, n=7	1.03	0.83	1.17	
	Pool Length, Lpool (ft), n=7	52.47	194.86	5.89	37.56
	Pool Length Ratio, Lpool/Wbkf, n=7	1.64	3.95	0.68	4.33
	Pool-Pool Spacing, Lps (ft), n=7	45.06	238.08	17.35	125.66
	Pool-Pool Spacing Ratio, Lps/Wbkf, n=7	1.41	4.83	2.00	14.48
Pattern	Meander Length, Lm (ft), n=50	84.59	965.64	43.00	109.00
	Meander Length Ratio, Lm/Wbkf, n=50	2.64	19.58	4.98	21.90
	Radius of Curvature, Rc (ft), n=76	39.25	153.4212	10.38	37.99
	Rc Ratio, Rc/Wbkf, n=76	1.23	3.11	1.20	4.38
	Belt Width, Wblt (ft), n=46	11.07	660.68	2.50	19.40
	Meander Width Ratio, Wblt/Wbkf (ft), n=46	0.35	13.40	0.29	2.24
	Sinuosity, K	1.18^	1.4	1.24	
Profile	Valley Slope, Sval (ft/ft)	0.0011		0.0093	
	Channel Slope, Schan (ft/ft)	0.0014		0.0078	
	Slope Riffle, Srif (ft/ft), n=4	0.0016	0.0071	0.0031	0.0386
	Riffle Slope Ratio, Srif/Schan, n=4	1.14	5.05	0.39	4.95
	Riffle Length, Rlength (ft), n=4	8.31	106.24	6.76	41.57
	Riffle Length Ratio, Rlength/Wbkf, n=4	0.26	2.15	0.78	4.79
	Slope Pool, Spool (ft/ft), n=7	0.0004	0.0036	0.0000	0.0051
	Pool Slope Ratio, Spool/Schan, n=7	0.29	2.59	0.00	0.65
	Slope Run, Srun (ft/ft), n=3	0.0003	0.0022	0.0010	0.0264
	Run Slope Ratio, Srun/Schan, n=3	0.22	1.55	0.13	3.38
	Slope Glide, Sglide (ft/ft)			0.0026	0.0899
	Glide Slope Ratio, Sglide/Schan			0.33	11.52
Substrate	d16 (mm)	0.05	0.36	0.12	
	d35 (mm)	0.25	4.53	0.83	
	d50 (mm)	0.63	10.06	2.36	
	d84 (mm)	2.8	39.41	11.03	
	d95 (mm)	4.85	75.69	22.6	

Cells noted with a (*) have been classified using a typical cross-section within each reach, Cells noted with a (**) were calculated using Flowmaster, Cells noted with a (^) were calculated within enhancement reach limits.
n=number of data points.

3.4 Channel Stability Assessment

3.4.1 Channel Evolution

Any change within and around a channel typically results in a period of instability and adjustments to re-establish a state of dynamic equilibrium with the sediment load and discharge of the stream (Leopold et al., 1992, Simon, 1989, and Rosgen, 2004a). The sequence of adjustments that a channel undergoes can be predicted using Simon's (1989) conceptual evolution model. Determining the stream type evolution can be predicted using Rosgen's (2006a) successional stages of channel evolution.

Simon's (1989) model predicts that following some type of disturbance, such as straightening or channelization, degradation occurs, resulting in an incised channel with vertical banks. When critical bank heights of a channel are exceeded, extensive bank failure and mass wasting occurs beginning the widening stage of the channel evolution process (Simon, 1989). As the widening and bank failure continue upstream, aggradation will occur downstream. The final stage of the channel evolution process results in the development of a new channel within the alluvium deposits downstream. The new channel is now at a lower elevation and typically has similar dimension and pattern to that of the pre-modified channel (Simon, 1989). Rosgen (2006a) describes nine different stream type channel evolution scenarios to assist the observer in determining the appropriate stage and evolution direction of a stream.

The process for a channel to naturally evolve through these stages to re-establish a state of dynamic equilibrium typically occurs over a long period of time depending upon channel inputs and channel substrate characteristics (10's to 1000's of years). This evolution can result in excessive stream bank erosion rates, which is a major cause of non-point source pollution (Rosgen, 2001). Using the stream evolution prediction models, the current trends in a disturbed stream can be identified, and the direction in which the stream is moving can be predicted. The current and future stage of evolution of a stream should be assessed before selecting appropriate restoration action to undertake. For this study, both concepts were applied to the main channel and unnamed tributary to assess current conditions and provide guidance for future trends.

According to Rosgen's stream channel succession scenarios, (Rosgen, 2006b), the main reach of Dutch Buffalo Creek generally falls under Scenario 9, which follows a stream type evolution from C→G→F→C. Using Simon's conceptual channel evolution model, the main channel is in two different levels within stage V; aggradation and widening. The upper reach, which is above the unnamed tributary, appears to be in the early stage of the aggradation and widening process. However, within the lower reach below the unnamed tributary, the stream appears to be in the later part of stage V, where it has been aggrading and widening for a longer period. At the very end of the project, the stream appears to be approaching stage VI, where the stream is reaching a state of dynamic equilibrium. The tributary to Dutch Buffalo Creek seems to be following the stream type evolution scenario from an E→Gc→F→C→E, which is Scenario 5 according to Rosgen's predicted channel evolution scenario. The stream channel is most likely in stage IV of Simon's channel evolution model, a state of degradation and widening.

3.4.2 Stream Bed and Bank Stability

Stream bed and bank composition provide indicators for changes in channel form, hydraulics, erosion rate and sediment supply (Doll et al., 2003). Streambank erosion rate (lateral erosion rate) and sediment supply (tons/yr) is a very important variable in the river stability assessment. One consequence of a disturbed stream is streambank erosion and associated land-loss and sediment supply to the system. Extensive streambank erosion rates tend to create a loss of in-stream habitats, leaving a homogenized environment due to extensive sedimentation (Waters, 1995 and Brooks et al., 2002).

Rosgen (2001) developed a channel stability assessment using the channel dimension relationships, river profile and bed features, vertical stability (degradation/aggradation), lateral stability, degree of confinement, degree of incision, channel enlargement, channel evolution, and near bank velocity stresses along the channel. Two prediction methodologies are used in Rosgen's channel stability assessment to determine the potential for bank erosion: Bank Erodibility Hazard Index (BEHI) and Near-Bank Stress (NBS). BEHI assesses the physical properties of the streambank to determine the possible sources of bank instability, such as removal of vegetation, livestock access, high bank height ratios, bank angle, lack of vegetative or rock surface protection, and poor, non-cohesive bank/soil material type.

The second factor in channel stability assessment is NBS, which assesses the bank with respect to the stress associated with the velocity in that portion of the channel. Using these methodologies, the expected annual sediment load produced from a stream system is estimated.

Tables 3.4 and 3.5 summarize the BEHI/NBS results and sediment export estimates for the Dutch Buffalo main reach and the tributary. Both the existing main channel and tributary of Dutch Buffalo Creek are showing signs of aggradation and degradation. This instability could be a result of livestock accessing the stream as their water source and possible historic channelization. Trampling of the banks creates a loss in riparian vegetation, exposing raw soil resulting in excessive sedimentation within the channel. Straightening a stream channel typically results in an increase in slope, which increases velocity resulting in potential down-cutting and incision. The main channel and the unnamed tributary of Dutch Buffalo Creek are contributing large amounts of sediment from within the stream channel. Refer to Appendix 9 for further details on BEHI/NBS assessment and calculations.

Table 3.4
BEHI and Sediment Export Estimates for Project Site Streams

Reach	Bank	Linear Footage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export*
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Tons/yr
Main Reach	Left	1,160	85	*7*	105	*9*	945	*82*	25	*2*	0	*N/A*	0	*N/A*	650
Main Reach	Right	1,210	0	*N/A*	200	*17*	670	*55*	340	*28*	0	*N/A*	0	*N/A*	352
Tributary	Left	480	0	*N/A*	160	*33*	150	*31*	170	*35*	0	*N/A*	0	*N/A*	54
Tributary	Right	480	0	*N/A*	90	*19*	215	*45*	175	*36*	0	*N/A*	0	*N/A*	63
Project Total		**3,330**	**85**	***3***	**555**	***17***	**1,980**	***59***	**710**	***21***					**1,118**

*Sediment export estimates were calculated as follows (ft^3/yr): (Section Length*Bank Height*Erosion Rate (ft/yr)) and converted to tons/year as follows: $(ft^3/yr)*(1yd^3/27\ ft^3)*(1.8\ tons/yd^3)$.

Table 3.5
Near Bank Stress Estimates for Project Site Streams

Reach	Bank	Linear Footage	Extreme		Very High		High		Moderate		Low		Very Low	
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%
Main Reach	Left	1,160	155	*13*	300	*26*	176	*15*			504	*44*	25	*2*
Main Reach	Right	1,210	285	*23*	250	*21*	100	*8*	105	*9*	470	*39*		
Tributary	Left	480	20	*4*	140	*29*			60	*13*	210	*44*	50	*10*
Tributary	Right	480			190	*40*					240	*50*	50	*10*
Project Total		**3,330**	**460**	***14***	**880**	***26.4***	**276**	***8.3***	**165**	***5***	**1,424**	***43***	**125**	***4***

3.5 Bankfull Verification

Visual bankfull indicators were difficult to identify in the field, because the existing main channel and tributary of Dutch Buffalo Creek are incised. Within the existing main channel, Cross-section 5 is stable and has developed a bankfull bench within the incised channel. Refer to Appendix 9 for Cross-section 5 morphological measurements. Since it appeared stable, the surveyed data from Cross-section 5 was used in Bentley Flowmaster to determine the existing bankfull discharge of the main channel, which was assumed to be the flow associated with the water surface level on the bankfull bench feature of the cross-section. Since there were no visual bankfull indicators in the unnamed tributary, bankfull cross-sectional area was determined using regional curves developed by North Carolina State University Stream Restoration Institute (Harman, et al., 1999). Bentley Flowmaster was then used to determine the discharge that was associated with this cross-sectional area, and this was assumed to be the bankfull discharge of the unnamed tributary. The discharges were calculated and compared to the North Carolina Regional Curves for Rural Piedmont streams. The calculated bankfull discharge for the main reach is lower than the regional curves associated with the drainage area predicted. A possible reason for the calculated discharge being lower than the predicted discharge on the main channel could be due to the low gradient of the stream (0.0014 ft/ft).

Table 3.6 illustrates calculated and verified bankfull discharges for the main channel and the unnamed tributary of Dutch Buffalo Creek.

Table 3.6
Existing Bankfull Discharge (Qbkf)

Reach	Drainage Area (sq miles)	Qbkf -Calculated (cfs)	Qbkf-Regional Curve (cfs)		
			Mid	**UCL**	**LCL**
Main Reach	21.3	423	804	2000	300
Tributary	0.31	39	40	250	12

UCL: Upper Confidence Limit from NC Regional Curve for Rural Piedmont Streams
LCL: Lower Confidence Limit from NC Regional Curve for Rural Piedmont Streams

Indicators of over-bank flows (wrack lines, flood debris, and sediment deposition) were visually observed several times during JJG's field surveys between November 2006 and March 2007, and were photo-documented on March 8, 2007. The storms that produced these over-bank flows indicate a bankfull flow occurred at least twice between January and April.

Approximately midway along the main channel of Dutch Buffalo Creek a crest-gauge was installed to record stage during high flow events. Also, above Cross-section 11 on the unnamed tributary, a stream gauge was installed to record water levels on a more precise level (every four hours). These stream gauges were installed to assist in verifying that a bankfull discharge or greater is occurring within the project.

At least one recorded bankfull event occurred during the month of February, with a high water mark 8 ft above the thalweg within the main channel. Other high water stages have been observed after the storm events *via* wrack lines and sediment deposition. These events were not recorded with the crest gauge due to malfunction. Within the unnamed tributary, approximately four bankfull or greater events have been recorded from January through April 2007. Refer to Appendix 1 for photographs of storm event wrack lines and sedimentation (photographs 5 – 7) and Appendix 7 for surface gauge data for the unnamed tributary.

3.6 Vegetation

The project site is located within a riverine bottomland between two topographic ridgelines surrounded by agricultural properties. Dutch Buffalo Creek traverses through an existing secondary successional riparian forest with limited disturbance.

Beginning from the upstream area of the project, the south side of the stream consists of cleared floodplain pasture planted in switch grass (*Panicum virgatum*). An approximate 25-foot intact buffer remains between Dutch Buffalo Creek and the switch grass field. Typical species found within the 25-foot buffer are box-elder (*Acer negundo*), American sycamore (*Platanus occidentalis*), tulip poplar (*Liriodendron tulipifera*), sweet-gum (*Liquidambar styraciflua*), and river birch (*Betula nigra*).

Immediately downstream of the switch grass areas, the extensive forested riparian zone on both sides of the stream for this upper reach (Stations 17+00 to 30+00) consist of an intact Piedmont/Mountain Bottomland Forest community (Schafale and Weakley, 1990). Species identified within the canopy layer of the riparian zone include tulip polar, sweet-gum, river birch, swamp chestnut oak (*Quercus michauxii*), American elm (*Ulmus americana*), eastern cottonwood (*Populus deltoides*) and green ash (*Fraxinus pennsylvanica*).

The understory primarily includes American hornbeam (*Carpinus caroliana)*, red maple (*Acer rubrum*), American holly (*Ilex opaca*), red buckeye (*Aesculus sylvatica*), and thickets of giant cane (*Arundinaria gigantea*). Herbaceous plants identified within this riparian area include false nettle (*Boehmeria cylindrica*), sedge species (*Carex* spp.), and Christmas fern (*Polystichium acrostichoides*).

The middle to lower reaches (downstream of 30+00) of the Dutch Buffalo Creek project consists of an intact riparian zone along both banks of the stream. The riparian forest community is more typical of a Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley, 1990). The Piedmont/Low Mountain Alluvial Forest community is distinguished from the Bottomland Forest community by the absence of thick areas of giant cane and the increasing number of floodplain species such as box-elder and river birch. Species identified within the canopy layer of the riparian zone include river birch, tulip polar, sweet-gum, American elm, green ash, box-elder and black walnut (*Juglans nigra*). The understory primarily includes American hornbeam, red maple, American holly, red buckeye, silky dogwood (*Cornus amomum*), and spice bush (*Lindera benzion*). In addition, herbaceous plants identified within this riparian area include false nettle (*Boehmeria cylindrica*), sedge species, Christmas fern, and goldenrod species (*Solidago* sp). Please refer to Figure 3.1 for a map of vegetative communities.

SECTION 4
REFERENCE STREAMS

SECTION 4

REFERENCE STREAMS

Natural channel design methodology employs the characteristics of stable streams as a template for designing restored streams. Selection of a (Rosgen) stream type identifies the broad characteristics for the restored stream but does not provide sufficient design parameters to develop stream restoration plans. Additional geomorphic measurements must be collected from stable streams that fully detail the characteristics of a stable stream's cross section, pattern, and profile. A stream possessing stable characteristics is termed a "reference reach." The geomorphic characteristics of the reference reach are used as a template for designing stream restoration projects. The primary requirement of a reference reach is that the stream reach is stable; often reference reach streams are not pristine. A suitable reference reach should possess similar hydrologic, geologic, and physiographic characteristics to the reach that is to be restored. The shape of a particular stream presents the balance between erosive forces applied to a stream by water flowing down a slope and the resistive forces supplied by the native stream substrate and stream banks. Streams formed in differing types of alluvium or rock respond differently to the same hydrology. Likewise, streams of the same lithology and geology exhibit differing forms if subjected to differing hydrologic regimes.

Finding reference reaches within the same watershed for stream restoration can be difficult; therefore, streams from different locations but with similar physiographic conditions may be used as an adequate reference stream. JJG assessed stream reaches within the watershed and segments of Dutch Buffalo Creek upstream and downstream of the project reach, but none of them appeared stable. According to Rosgen, proximity of the reference reach to the project reach is less important than being stable, being in the same physiographic region, and having similar valley type, topography, and drainage area. For this project, JJG collected data from two North Carolina Department of Transportation (NCDOT) reference reach sites located in Orange and Wake Counties, North Carolina with similar physiographic conditions as those found in the Dutch Buffalo Creek watershed. The following two reference reach sites were selected.

- Morgan Creek: Located in Orange County, North Carolina is a C4 stream type (NCDOT Stream ID 5).
- Sal's Branch: Located in Wake County, North Carolina is an E4 stream type (NCDOT Stream ID 18).

4.1 Watershed Characterization

Both Morgan Creek and Sal's Branch are located in the Piedmont Physiographic Province. Both reference reach sites consist of broad areas of level to gently sloping terrain. According to the Generalized Geologic Map of North Carolina, Morgan Creek and Sal's Branch reference reach sites are underlain by sedimentary and metamorphic rocks of the Carolina Slate Belt and Raleigh Belt, respectively (NCGS, 1991). Chemical and physical weathering of these rocks has generated deep soil profiles (saprolite) very similar to those found in the Charlotte Belt.

Morgan Creek is located in Orange County, North Carolina, west of the City of Chapel Hill. The surveyed reference reach is located within the Neuse River Basin, USGS Hydrologic Unit 03020002, subbasin 03-06-06, Stream Index No. 16-41-2 (5). Morgan Creek is a third order stream with an approximate drainage area of 8.35 square miles. According to the Generalized Geologic Map of North Carolina, the area surrounding Morgan Creek is underlain by foliated to weakly foliated, locally magmatic, metamorphosed, granite rocks of the Carolina Slate Belt (NCGS, 1991). The project vicinity consists of broad areas of level to gently sloping terrain.

Sal's Branch is situated within William B. Umstead State Park in Wake County, North Carolina, west of the City of Raleigh. The surveyed reference reach is located within the Neuse River Basin, USGS Hydrologic Unit 03020201, subbasin 03-04-02. Sal's Branch is a first order stream with an approximate drainage area of 0.3 square miles.

Refer to Figures 4.1 and 4.2 for site location maps and Figures 4.3 and 4.4 for watershed maps of Morgan Creek and Sal's Branch.

4.2 Channel Classification

Morgan Creek and Sal's Branch reference reaches were classified using the Rosgen stream classification system, based on surveyed morphological measurements (Rosgen, 1996).

The Morgan Creek reference reach is classified as a C4. Typically, C4 stream types are slightly entrenched, meandering, and have a well-developed floodplain. C4 streams also tend to have gentle gradients, a slight sinuosity, and a relatively high W/D ratio. The stream bed morphology typically consists of a riffle-pool sequence, with a gravel-dominated substrate.

Sal's Branch is classified as an E4 stream type. Typically, E4 stream types are riffle/pool systems, exhibit low channel W/D ratios and display moderate to high channel sinuosities, which result in the high meander width ratio values. E4 channels exhibit predominantly gravel-sized bed substrates, with channel slopes usually less than 2% (Rosgen, 1996). By and large, E4 channel stream banks are composed of materials finer than that of the dominant channel bed materials. These finer streambank materials are usually stabilized with extensive riparian or wetland vegetation that forms densely rooted sod mats from grasses, sedges, and rushes, as well as woody species (Rosgen, 1996). These channels are considered hydraulically efficient maintaining a high sediment transport capacity. E4 stream channels are very stable streams but can become vulnerable to erosion if stream banks are disturbed, and/or significant changes in sediment supply and streamflow occur.

4.3 Discharge (bankfull, trends)

For both reference reaches, the bankfull cross-sectional area and velocity were previously determined and reported in the NCDOT Reference Reach Database. JJG visited each site and surveyed the reach to verify the bankfull cross-sectional area and discharge using regional curves developed by North Carolina State University Stream Restoration Institute (Harman, et al., 1999). Table 4.1 presents the bankfull discharge estimates for Sal's Branch and Morgan Creek.

Table 4.1
Reference Bankfull Discharge (Qbkf)

Reach	Drainage Area (sq miles)	Qbkf -NCDOT (cfs)	Qbkf-Regional Curve (cfs)		
			Mid	**UCL**	**LCL**
Morgan Creek	8.35	524	400	1010	160
Sal's Branch	0.30	38	38	120	13
UCL: Upper Confidence Limit from NC Regional Curve for Rural Piedmont Streams LCL: Lower Confidence Limit from NC Regional Curve for Rural Piedmont Streams					

4.4 Channel Morphology (pattern, dimension, profile)

A reference reach survey was conducted on Morgan Creek and Sal's Branch following methods described in Stream Channel Reference Sites: An Illustrated Guide to Field Technique (Harrelson et al., 1994). Table 4.2 summarizes the results from the reference reach survey.

4.5 Channel Stability Assessment

The reference reaches were walked to visually assess the channel stability. Both reference reaches appeared to be stable at the time of the survey and did not illustrate any signs of lateral or vertical instability. The stream bed features also appeared to be stable and not showing signs of migration. The sediment deposition appeared to be normal for each the stream type; no heavy sediment deposition or degradation was occurring.

4.6 Bankfull Verification

For both reference reaches, the bankfull cross-sectional area and velocity were previously determined and reported in the North Carolina Department of Transportation (NCDOT) Reference Reach Database (http://www.ncdot.org/doh/preconstruct/highway/hydro/Stream/). JJG visited each site and surveyed the reach to verify the bankfull cross-sectional area using regional curves developed by North Carolina State University Stream Restoration Institute (Harman, et al., 1999).

Table 4.2
Reference Reach Morphology

	Parameter	Morgan Creek		Sal's Branch	
		MIN	MAX	MIN	MAX
General	Drainage Area (sq mi)	8.35		0.3	
	Stream Type (Rosgen)	C4		E4	
	Valley Type	-		-	
Dimension	BKF Mean Velocity (Vbkf) (ft/s)	6.6		3.5	
	Bankfull Discharge (Qbkf) (cfs)	524		38	
	Bankfull XSEC Area, Abkf (sq ft)	75.1	79.8	10.95	
	Bankfull Width, Wbkf (ft)	33.2	33.5	8.3	
	Bankfull Mean Depth, dbkf (ft)	2.26	2.38	1.3	
	Width to Depth Ratio, W/D (ft/ft)	14.69	14.08	6.4	
	Width Floodprone Area, Wfpa (ft)	77.5	86.8	130	
	Entrenchment Ratio, Wfpa/Wbkf) (ft/ft)	2.33	2.59	15.66	
	Max Depth @ bkf, Dmax (ft)	2.80	2.90	1.90	
	Max Depth Ratio, Dmax/dbkf	1.24	1.22	1.46	
	Max Depth @ tob, Dmaxtob (ft)	2.80	2.90	2.28	
	Bank Height Ratio, Dtob/Dmax (ft/ft)	1.00	1.00	1.20	
	Pool Max Depth, Dmaxpool (ft)	4.10		2.40	
	Pool Max Depth Ratio, Dmaxpool/dbkf	1.81		1.00	1.8
	Pool Area, Apool (sqft)	88.90		26.00	
	Pool Area Ratio, Apool/Abkf	1.18		2.40	
	Pool Width, Wpool (ft)	25.90		14.00	
	Pool Width Ratio, Wpool/Wbkf	0.78		1.70	
	Pool Length, Lpool (ft)	-		7.80	35
	Pool Length Ratio, Lpool/Wbkf	-		0.90	4.2
	Pool-Pool Spacing, Lps (ft)	4.38	8.31	40.30	60
	Pool-Pool Spacing Ratio, Lps/Wbkf	0.13	0.25	4.90	7.2
Pattern	Meander Length, Lm (ft)	-		60.00	69
	Meander Length Ratio, Lm/Wbkf	-		7.20	8.3
	Radius of Curvature, Rc (ft)	-		12.00	19
	Rc Ratio, Rc/Wbkf	-		1.4	2.3
	Belt Width, Wblt (ft)	-		33	69
	Meander Width Ratio, Wblt/Wbkf (ft)	-		4	8.3
	Sinuosity, K	-		1.8	
Profile	Valley Slope, Sval (ft/ft)	-		0.012	
	Channel Slope, Schan (ft/ft)	0.007		0.005	
	Slope Riffle, Srif (ft/ft)	0.014	0.024	0.016	0.024
	Riffle Slope Ratio, Srif/Schan	2.00	3.43	3.2	4.8
	Riffle Length, Rlength (ft)	-		5.4	23
	Riffle Length Ratio, Rlength/Wbkf	-		0.7	2.8
	Slope Pool, Spool (ft/ft)	0		0	
	Pool Slope Ratio, Spool/Schan	0		0	
	Slope Run, Srun (ft/ft)	0.0026		-	
	Run Slope Ratio, Srun/Schan	0.37		-	
	Slope Glide, Sglide (ft/ft)	0.006		-	
	Glide Slope Ratio, Sglide/Schan	0.86		-	
Substrate	d16 (mm)			-	
	d35 (mm)	1.2		-	
	d50 (mm)	3		16.00	
	d84 (mm)	77		-	
	d95 (mm)	800		-	

Cells noted with a (-), data was not provided. (http://www.ncdot.org/doh/preconstruct/highway/hydro/Stream/) and NCSU used as verification for reference data collected at these streams.

4.7 Vegetation

Reference vegetative communities must be established for stream and wetland restoration sites. Streambank, riparian, and floodplain restoration should be based on reference areas found within close proximity of the project site and should be based on initial riparian assessments of the proposed restoration area. Reference vegetative communities are areas on which to model restoration efforts of the restoration site in relation to soils, topography, hydrology, and vegetation. Reference sites should represent pre-disturbed conditions and be as pristine as possible (i.e., undisturbed areas which are free of exotic vegetation).

Reference vegetative surveys were conducted along the existing onsite channels by JJG ecologists. The survey was used to guide plant community restoration and is presented in Section 7.7). In general, riparian areas along the middle to lower reaches (downstream of Station 30+00) of the Dutch Buffalo Creek Restoration project area most closely resemble that of a Piedmont Low Mountain Alluvial Forest Community (Schafale and Weakley, 1990). This community type displays the following characteristics.

- Soils: Various alluvial soils, most typically Chewacla (Fluvaquentic Dystrochrepts) or Congaree (Typic Udifluvent).
- Hydrology: Palustrine, seasonally or intermittently flooded.
- Vegetation: Forest with open to dense understory or shrub layer and sparse to dense diverse herb layer. Canopy a mixture of bottomland and mesophytic trees (Schafale and Weakley, 1990).

Immediately downstream of the switch grass areas, the extensive forested riparian zone on both sides of the stream for this upper reach (Stations 17+00 to 30+00) consist of an intact Piedmont/Mountain Bottomland Forest community (Schafale and Weakley, 1990). This community type displays the following characteristics.

- Soils: Various alluvial soils, generally Chewacla (Fluvaquentic Dystrochrepts) and Congaree (Typic Udifluvents).
- Hydrology: Palustrine, intermittently flooded.
- Vegetation: Forest with open to dense understory or shrub layer and sparse to dense diverse herb layer. Canopy a mixture of bottomland and mesophytic trees (Schafale and Weakley, 1990).

SECTION 5

PROJECT SITE WETLANDS (EXISTING CONDITIONS)

SECTION 5

PROJECT SITE WETLANDS (EXISTING CONDITIONS)

5.1 Jurisdictional Wetlands

Jurisdictional wetlands were identified by JJG ecologists and located with Trimble Pro XH Global Positioning System (GPS) surveying equipment. The GPS is designed to collect remote positions on the ground without the need for survey traverse lines. The GPS unit has submeter accuracy with a 95% confidence rating on each point. The Trimble Pro XH receiver uses Satellite Based Augmentation Systems (SBAS) correction messages to improve the accuracy and integrity of the data. The data can be differentially corrected with desktop software provided with the unit. The Pathfinder software allows the data to be exported from the data collector and used in GIS or other design programs.

Field studies identified the presence of six wetlands within the NCEEP easement areas identified for wetland restoration or enhancement. The wetlands were classified as palustrine forested, palustrine forested-emergent, or palustrine scrub-shrub systems. Several data points were collected within each wetland polygon. Upland data points were also collected within areas adjacent to the wetland features to establish the difference between upland and wetland characteristics. Wetlands were marked with pink flagging marked "Wetland Boundary" and located with a Trimble Pro XH Global Positioning Unit (GPS). The locations of the wetlands and streams are shown on Figure 5.1a. Please refer to Table 5.1 for a summary of wetland features.

Table 5.1
Summary of Wetland Features

Jurisdictional Area	USGS Stream Association	Classification	Community Type	Approximate Acreage (ac)	Restoration/ Enhancement
WL A-1	Dutch Buffalo Creek	PSS1B	Scrub-shrub	1.39	Associated areas proposed for preservation
WL A-2	Dutch Buffalo Creek	PSS1B/E	Scrub-shrub	0.12	Associated areas proposed for preservation
WL A-3	Dutch Buffalo Creek	PSS1B	Scrub-shrub	0.16	Associated areas proposed for preservation
WL B-1	Dutch Buffalo Creek	PFO1B/E	Forested	12.78	Associated areas proposed for enhancement

Jurisdictional Area	USGS Stream Association	Classification	Community Type	Approximate Acreage (ac)	Restoration/ Enhancement
WL B-2	Dutch Buffalo Creek	PFO1A/B	Forested	0.55	Associated areas proposed for enhancement
WL C-1	Dutch Buffalo Creek	PFO1B/E PEM1B/E	Forested-emergent	4.34	Associated areas proposed for restoration
			Total Wetland Acreage Delineated	**19.34**	

5.1.1 Wetland Characteristics

Wetland A-1 – The wetland is classified as a palustrine, scrub-shrub system with a saturated hydrologic regime. The dominant community in Wetland A-1 consists of a young Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley, 1990). Dominant vegetation associated with A-1 includes the species listed below. The vegetation criterion was satisfied with 100 percent of the species being facultative, facultative wetland, or obligates wetland.

Scientific Name	Common Name	Indicator Status
Ulmus americana	American elm	FACW
Alnus serrulata	brookside alder	FACW
Liquidambar styraciflua	sweet-gum	FAC+
Scirpus cyperinus	wool grass	OBL
Typha latifolia	broad-leaved cattail	OBL
Cornus amomum	silky dogwood	FACW+
Salix nigra	black willow	OBL
Betula nigra	river birch	FACW
Platanus occidentalis	American sycamore	FACW-
Carex sp.	sedge species	FAC - OBL
Juncus effusus	soft rush	FACW+
Eleocharis obtusa	blunt spike rush	OBL

Indicators of wetland hydrology included saturated soils within the upper 12 inches, areas of inundation, oxidized rhizospheres, and water-stained vegetation. Additional hydrologic indicators include crayfish burrows and multi-trunked tree species. Soil samples were taken from a depth of 0 to 12 inches. Soils at a depth of 0 to 12 inches had a matrix color of 10YR 5/2 with mottles of 10YR 4/4. The soil texture throughout the wetland area is clay loam. Hydric soil indicators included reducing conditions and low chroma.

Wetland A-2 – The wetland is classified as a palustrine, scrub-shrub system with a saturated to seasonally flooded, hydrologic regime. Similar to Wetland A-1, the dominant community in Wetland A-2 consists of a young Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley, 1990). Dominant vegetation associated with A-2 includes the species listed below. The vegetation criterion was satisfied with 100 percent of the species being facultative, facultative wetland, or obligate wetland. This wetland area is an incised ditch feature that is trapping hydrology. Shrub and sapling wetland plants are growing along banks of the feature and also have herbaceous plants developing within the feature.

Scientific Name	**Common Name**	**Indicator Status**
Ulmus americana	American elm	FACW
Alnus serrulata	brookside alder	FACW
Liquidambar styraciflua	sweet-gum	FAC+
Carex sp.	sedge species	FAC+ - OBL
Juncus effusus	soft rush	FACW+
Eleocharis obtusa	blunt spike rush	OBL

Indicators of wetland hydrology included saturated soils within the upper 12 inches and inundation. Soil samples were taken from a depth of 0 to 12 inches at the end of the ditch feature. Soils were not collected within the inundated portion of this feature. Soils at a depth of 0 to 12 inches had a matrix color of 10YR 3/2 with a soil texture of sandy clay loam. Hydric soil indicators included reducing conditions and a low chroma.

Wetland A-3 – The wetland is classified as a palustrine, scrub-shrub system with a saturated hydrologic regime. Like Wetlands A-1 and A-2, the dominant community in Wetland A-3 consists of a young Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley, 1990). Dominant vegetation associated with A-3 includes the species listed below. The vegetation criterion was satisfied with 100 percent of the species being facultative, facultative wetland, or obligates wetland.

Scientific Name	**Common Name**	**Indicator Status**
Ulmus americana	American elm	FACW
Alnus serrulata	brookside alder	FACW
Liquidambar styraciflua	sweet-gum	FAC+
Cornus amomum	silky dogwood	FACW+
Salix nigra	black willow	OBL
Betula nigra	river birch	FACW
Platanus occidentalis	American sycamore	FACW-
Scirpus cyperinus	wool grass	OBL
Carex sp.	sedge species	FAC - OBL
Juncus effusus	soft rush	FACW+
Eleocharis obtusa	blunt spike rush	OBL

Indicators of wetland hydrology included saturated soils within the upper 12 inches, oxidized rhizospheres, and water-stained vegetation. Additional hydrologic indicators include crayfish burrows, and multi-trunked tree species. Soil samples were taken from a depth of 0 to 12 inches. Soils at a depth of 0 to 12 inches had a matrix color of 10YR 5/2 with mottles of 10YR 4/4. The soil texture throughout the wetland area is clay loam. Hydric soil indicators included reducing conditions and low chroma.

Wetland B-1 – The wetland is classified as a palustrine forested system with a saturated to seasonally flooded hydrologic regime. The dominant community type within Wetland B-1 is a Piedmont/Mountain Bottomland Forest (Schafale and Weakley, 1990); however, it transitions into a Piedmont/Mountain Alluvial Forest (Schafale and Weakley, 1990) along its eastern edge. Dominant vegetation associated with B-1 includes the species listed below. The vegetation criterion was satisfied with 100 percent of the species being facultative, facultative wetland, or obligates wetland.

Scientific Name	Common Name	Indicator Status
Ulmus americana	American elm	FACW
Quercus michauxii	swamp chestnut oak	FACW-
Quercus phellos	willow oak	FACW-
Quercus bicolor	swamp white oak	FACW+
Liquidambar styraciflua	sweet-gum	FAC+
Lindera benzoin	spice bush	FACW
Cornus amomum	silky dogwood	FACW+
Betula nigra	river birch	FACW
Platanus occidentalis	American sycamore	FACW-
Arundinaria gigantea	giant cane	FACW
Carex spp.	sedge species	FAC - OBL
Juncus effusus	soft rush	FACW+
Boehmeria cylindrica	false nettle	FACW+

Indicators of wetland hydrology included saturated soils within the upper 12 inches, areas of inundation, oxidized rhizospheres, drift lines, sediment deposition, and water-stained vegetation. Additional hydrologic indicators include crayfish burrows, buttressed tree trunks, and shallow root systems. Soil samples were taken from a depth of 0 to 12 inches throughout the outer limits of the wetland system. Typically, soils at a depth of 0 to 12 inches had a matrix color of 10YR 5/2 with mottles of 10YR 4/4. Within the central portions of the wetland feature, soils from a depth of 0 to 12 inches had a matrix color of 10YR 3/2. The soil texture throughout the wetland area is clay loam. Hydric soil indicators included reducing conditions and low chroma.

Wetland B-2 – The wetland is classified as a palustrine forested system with a saturated to temporarily flooded hydrologic regime. The dominant community type within Wetland B-2 is a Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley, 1990). Dominant vegetation associated with B-2 includes the species listed below. The vegetation criterion was satisfied with 100 percent of the species being facultative, facultative wetland, or obligate wetland. Please refer to Appendix 1b for a representative photograph.

Scientific Name	Common Name	Indicator Status
Ulmus americana	American elm	FACW
Platanus occidentalis	American sycamore	FACW-
Acer negundo	box elder	FACW
Arundinaria gigantea	giant cane	FACW
Fraxinus pennsylvanica	green ash	FACW
Carex sp.	sedge species	FAC+ - OBL
Eleocharis obtusa	blunt spike rush	OBL

Indicators of wetland hydrology included saturated soils within the upper 12 inches, drift lines, sediment deposition, and water-stained vegetation. Soil samples were taken from a depth of 0 to 12 inches throughout the wetland area. Soils at a depth of 0 to 12 inches had a matrix color of 10YR 6/2 with mottles of 10YR 4/6. The soil texture is sandy clay loam. Hydric soil indicators included reducing conditions and a low chroma.

Wetland C-1 – The wetland is classified as a palustrine forested-emergent system with a saturated to seasonally flooded hydrologic regime. A portion of this forest-dominated system abuts a larger area that was cleared, planted in switch grass, and periodically mowed. The majority of the planted area is not jurisdictional wetland; however, small inclusions of emergent wetlands occur within the switch grass area. The forested area consists of a Piedmont/Low Mountain Bottomland Forest (Schafale and Weakley, 1990). Dominant vegetation associated with Wetland C-1 includes the species listed below. The vegetation criterion was satisfied with 100 percent of the species being facultative, facultative wetland, or obligate wetland. Please refer to Appendix 1b for a representative photograph.

Scientific Name	Common Name	Indicator Status
Forested area of system		
Ulmus americana	American elm	FACW
Betula nigra	river birch	FACW
Platanus occidentalis	American sycamore	FACW-
Liquidambar styraciflua	sweet-gum	FAC+
Alnus serrulata	brookside alder	FACW
Cornus amomum	silky dogwood	FACW+
Lindera benzion	spice bush	FACW
Betula nigra	river birch	FACW
Platanus occidentalis	American sycamore	FACW-
Emergent area of system		
Panicum virgatum	switch grass	FAC+
Carex sp.	sedge species	FAC+ - OBL
Juncus effusus	soft rush	FACW+

Indicators of wetland hydrology included saturated soils within the upper 12 inches, oxidized rhizospheres, drainage patterns, and small inundation portions. Soils at a depth of 0 to 12 inches had a matrix color of 10YR 6/2 with mottles of 10YR 4/6. The soil texture throughout the wetland system is clay loam. Hydric soil indicators included reducing conditions and a low chroma.

5.1.2 Upland Characteristics

Data Points - Data were also collected for the upland areas adjacent to the wetland areas. The dominant vegetation found in the upland area includes the following species.

Scientific Name	Common Name	Indicator Status
Adjacent to Wetlands A1-A3		
Pinus taeda	loblolly pine	FAC
Ulmus alata	winged elm	FACU+
Liquidambar styaciflua	sweet-gum	FAC+
Rubus argutus	serrate-leaf blackberry	FACU+
Acer saccharum	sugar maple	FACU-
Adjacent to Wetlands B1-B2		
Cornus florida	flowering dogwood	FACU
Liriodendron tulipifera	tulip poplar	FAC+
Fagus grandifolia	American beech	FACU
Juglans nigra	black walnut	FACU
Juniperus virginiana	Eastern red cedar	FACU-
Liquidamabar styraciflua	sweet-gum	FAC+
Acer saccharum	sugar maple	FACU-
Ilex opaca	American holly	FAC-
Adjacent to Wetland C-1		
Fagus grandifolia	American beech	FACU
Juniperus virginiana	Eastern red-cedar	FACU-
Liquidambar styraciflua	sweet-gum	FAC+
Ligustrum sinense	Chinese privet	FAC+
Panicum virgatum	switch grass	FAC+

Upland habitats have insufficient indicators of wetland hydrology or hydric soils. Soil samples taken from a depth of 0 to 12 inches exhibited a matrix color of 10YR 4/4 to 10YR 4/6. For the upland areas, the data points were determined to be outside of the wetland area, because all three wetland parameters were not met. The vegetation was dominated by facultative to facultative upland species, and soils are oxidized; therefore, adequate hydrology indicators were not observed.

5.2 Hydrological Characterization

Wetland hydrology is the driving force for the creation of hydric soils and the development of hydrophytic vegetative communities; observing field indicators can assess hydrology. Research suggests that the most influential factor for plant community development is the duration of soil saturation or inundation, rather than the frequency of the event

In addition, the presence of wetland hydrology is essential during the growing season. The growing season is defined as the period in which soil temperatures are above 5°C (41.5°F) or as the period between the last frost of spring and the first frost of winter.

A classification system of wetland hydrology for non-tidal areas, developed by the Department of the Army Waterways Experiment Station, is presented in Table 5.2 (*Federal Manual*, 1987*).*

Table 5.2
Hydrologic Zones - Non-Tidal Areas

Zone	Name	Duration*	Comments
I†	Permanently inundated	100%	Inundation > 6.6 feet mean water depth
II	Semi permanently to nearly permanently inundated or saturated	> 75% - < 100%	Inundation defined as ≤ 6.6 feet mean water depth
III	Regularly inundated or saturated	> 25% - 75%	
IV	Seasonally inundated or saturated	> 12.5% - 25%	
V	Irregularly inundated or saturated	≤ 5% - 12.5%	Many areas having these hydrologic characteristics are not wetlands
VI	Intermittently or never inundated or saturated	< 5%	Areas with these hydrologic characteristics are not wetlands

* Refers to duration of inundation and/or soil saturation during the growing season.
† This defines an aquatic habitat zone.

Analysis of the hydrology parameter for a Routine Determination involves reviewing a study area for indicators of extended periods of hydrology. Some indicators of wetland hydrology are identified in the 1987 *Federal Manual.* These indicators include recorded data, visual observation of inundation, visual observation of soil saturation, watermarks, drift lines, sediment deposits, drainage patterns within the wetlands, oxidized rhizospheres by live roots within the soil profile, and water-stained leaves. In addition, the presence of wetland hydrology may be inferred from certain morphological, physiological, and reproductive adaptations of plants to an anaerobic environment. Only the morphological adaptations can be field determined. Examples of morphological adaptations include buttressed tree trunks, pneumatophores, adventitious roots, shallow root systems, inflated vegetative structures, polymorphic leaves, floating leaves and stems, hypertrophied lenticels, and multi-trunks or stooling. The facultative-neutral option also can be used as a secondary indicator of wetland hydrology. Refer to Section 5.1.1 for descriptions of hydrologic indicators found within each wetland area. Documented hydrologic data are described in Section 5.2.1.

5.2.1 Groundwater Modeling

Ten groundwater monitoring gauges, one surface gauge, and one rain gauge were installed on January 5, 2007 throughout the project area surrounding Dutch Buffalo Creek. Groundwater gauges were set to a depth immediately above the top of clay subsurface layer, approximately 25 to 40 inches below the surface. The monitoring gauges record groundwater levels daily and are downloaded monthly. Current data reflect the period of January to May to capture hydrologic data. The target hydrologic characteristics range from saturation to periodic inundation. Six of the site's ten groundwater monitoring gauges (Gauges 4, 5, 6, 8, 9, and 10) are located within upland areas once believed to be palustrine forested wetland systems found within Piedmont/Low Mountain Bottomland communities. Within these areas, groundwater levels generally averaged between 4 and 20 inches below the ground surface. Field surveys determined these areas are currently underlain by relict hydric soils that have been impacted by ditching of fields, channel incision, vegetative clearing, and earth movement associated with the dredging/straightening of Dutch Buffalo Creek and its tributaries.

In addition, cattle grazing and trampling of riparian areas have exacerbated channel incision of drainage features once found within these historic wetlands. Incision of linear features and the aforementioned impacts have lowered the hydraulic gradient within these historic riparian wetland areas.

Four of the site's ten groundwater monitoring wells are located within Wetlands B-1 and C-1, which are included in the Piedmont/Low Mountain Bottomland Forest community type. In order to attain hydrologic success, groundwater levels must be within 12 inches of the ground surface for 29 consecutive days during the growing season. The growing season in Cabarrus County averages 232 days beginning March 23 and ending November 10. Groundwater monitoring gauges 1 and 2, located within Wetland B-1, confirmed that continuous daily groundwater elevations were within the upper 12 inches of the soil profile for duration greater than 29 consecutive days during the growing season. Daily groundwater elevations were within the upper 12 inches of the soil profile between March 23 and May 31 (70 days) and between March 23 and May 16 (55 days) for gauges 1 and 2, respectively. Average groundwater levels during this period were approximately 5 and 6 inches below the surface for gauges 1 and 2, respectively. Groundwater monitoring gauge 7 (Wetland C-1) revealed continuous daily groundwater levels were within the upper twelve inches of the soil profile between March 23 and May 18 (57 days, which also exceeds the target hydrological characteristics for wetland systems. Average groundwater levels during the monitoring period for gauge 7 were approximately 5 inches below the surface during this period. Refer to Appendix 7 for Hydrologic Gauge Data Summary, Groundwater and Rainfall Information.

In summary, gauges 1, 2, and 7 suggest that existing wetland hydrology is at or near the surface for portions of Wetlands B-1 and C-1 during the winter and the early growing season. Although these areas have been designated as reference wetlands, and gauges 1, 2, and 7 reflect functioning hydrology, higher evapotranspiration rates experienced during the month of May have substantially lowered groundwater levels (approximately 2-3 ft below the surface) at gauges 2, 3, and 7. This is evident from groundwater data observed at gauges 2, 3 and 7 during the month of May. However, it should also be noted that the project area and surrounding Concord region is currently experiencing a drought for the monitoring period with precipitation totals approximately 3.63 inches below the 60-year average. JJG will continue to monitor existing wetland areas throughout the growing season in order to accurately determine wetland hydrology. Refer to Section 6 for more details on the reference wetland areas.

Gauge 3 is located in a degraded portion of Wetland B-1 and reflects hydrology in the areas proposed for enhancement. Refer to Figure 5.1b for mapped locations of groundwater gauges.

5.2.2 Hydrologic Budget for Restoration Site

Water inputs to existing riparian wetlands consist of the following primary sources: seeps at the outer edge of the floodplain, overland flow draining into adjacent riparian areas, frequent flooding of Dutch Buffalo Creek and its tributaries, and direct precipitation. This unique combination of hydrology results in scattered zones of inundation typically following the natural micro-topography of the floodplain. Water outputs from the site include evapotranspiration, deep infiltration, and surface water outflow *via* Dutch Buffalo Creek, tributaries to Dutch Buffalo Creek, and ditches draining riparian wetlands.

A site water budget was estimated for existing wetland areas for the period of January through April 2007. The water budget demonstrates that significant hydrologic inputs are currently being depleted from existing wetland and upland areas (likely former wetlands). Review of site topographic maps and field evaluations indicate that two natural drainage features within Wetland B-1 have experienced severe incision or “down-cutting” and/or channel excavation resulting in an overall increase in the normal hydraulic gradient. Currently, these two drainage features remove most hydrologic inflow above the 644-ft contour line into Dutch Buffalo Creek. In addition, incised ditches that have resulted from “down-cutting” and/or channel excavation function to both decrease depressional water storage and groundwater levels.

In addition, the site water budget demonstrates that sufficient hydrologic inputs are available for restoration of the surrounding riparian areas which are currently losing hydrology due to the drainage ditches. Hydrologic inputs and outputs were estimated for Wetland B-1 (~12.8 acres) from site precipitation data and regional potential evapotranspiration (PET) data provided by the State Climate Office of North Carolina (SCONC, 2007). In addition, historical climatological data obtained from Concord and Salisbury, NC was used to calculate a water budget for an average year (SCONC, 2007).

Average precipitation data suggest that existing riparian wetlands may have been experiencing a slight water deficit between January and April. Precipitation data for the site were approximately 1.4 inches below average for all four months during the monitoring period. However, existing riparian wetlands appeared to display sufficient hydrologic storage during this period with an overall surplus of 0.01 inches for the study period. Refer to Appendix 7 for Dutch Buffalo Creek rainfall data and the State Climate Office of North Carolina 56-year monthly average rainfall for Concord, NC. Refer to Table 5.3. for a summary of the existing site wetlands water budget. An explanation of water inputs and outputs, calculations, and climatological data collection used for the water budget is located in Appendix 9.

Table 5.3
Water Budget

Climatic Period	Precip. (in)	Surface Inflow (in)	Over TOB influx (in)	GW Net (in)	PET (in)	Surface Outflow (in)	Infiltration (in)	Change in Storage (in)
Jan-April Average	15.2	28.4	36.0	0	12.1	63.4	4.1	0.01
Jan-April 2007	13.8	9.8	72.0	0	12.8	78.7	4.1	0.01

5.3 Soil Characterization

The soil parameter is the least reliable for determining the current status of a community. Because of the time required for formation of hydric soils, which is estimated to take from 15 to 50 years by some accounts, review of the soil parameter more reliably reveals historical data. Hydric soils that have been drained and fail to support hydrophytic vegetation do not meet the criteria of the soil parameter. Hydric soils are formed during periods of saturation or inundation. These periods create an anaerobic environment within the upper horizons of the soil profile. According to the *1987 Federal Manual*, the following criteria apply to hydric soils:

- All histosols except folists;
- Soils in aquic suborders, aquic subgroups, albolls suborder, salorthids great group, or pell great groups of vertisols that are:
  - Somewhat poorly drained and have a water table less than 0.5 feet from the surface for a significant period (usually a week or more) during the growing season; or
  - Poorly drained or very poorly drained and have either:
    - A water table at less than 1.0 foot from the surface for a significant period (usually a week or more) during the growing season if permeability is less than 6 inches in any layer within 20 inches; or
    - A water table at less than 1.5 feet from the surface for a significant period (usually a week or more) during the growing season if permeability is less than 6 inches in any layer within 20 inches; or
- Soils that are ponded for a long or very long duration during the growing season; or
- Soils that frequently flood for long or very long durations during the growing season.

Soils may be determined to be hydric by using regional indicators in addition to referencing the *Hydric Soils of the United States* (USDA, 1991). Several criteria are listed in the 1987 *Federal Manual,* each of which indicates the presence of hydric soils.

Non-Sandy Soils:

- **Organic soils (histosols)** - Organic soils are saturated for long periods of time and commonly are called muck. Soils are determined to be organic if more than 50 percent of the upper 12 inches of soil is composed of organic material or if organic material lies directly over bedrock.

- **Histic epipedons** - Histic epipedons are soils with an 8- to 16-inch layer of soil that is sufficiently saturated to prevent aerobic decomposition of the organic surface. Histic epipedons must be saturated for 30 consecutive days or more for soils containing a minimum of 20 percent organic matter when no clay is present or a minimum of 30 percent organic matter when the clay content is 60 percent or higher.

- **Sulfidic material** - Sulfidic material is determined to be present within the soils when waterlogged and permanently saturated soils emit an odor of rotten eggs. This odor is an indication of the presence of hydrogen sulfide created from a reducing environment.

- **Aquic or peraquic moisture regime** - An aquic moisture regime essentially is free of dissolved oxygen due to strong reducing conditions. The soil is saturated by groundwater, and dissolved oxygen is removed from the soil by soil fauna and root systems. The soil temperature must be above 5 degrees Celsius (°C) at some point while the soil is saturated. A peraquic soil regime requires the presence of groundwater always at or near the soil surface.

- **Reducing soil conditions** - During periods of prolonged inundation or saturation, soils will begin to undergo reducing conditions. These conditions result in iron being reduced from the ferric state to the ferrous state. In the field, this can be confirmed by a qualitative test using alpha, alpha dipyridil and a chemical reagent. If the iron in the soil has been reduced, a pink color would occur when the alpha, alpha dipyridil is added to the soil sample.

- **Soil colors** - When anaerobic conditions result in soil reduction, mineral soils often will produce gray or very dark colors. These colors are a direct result of the reduction of iron, manganese, and other elements in the soil. Soils that are saturated for a long duration usually exhibit bluish- to greenish-gray colors. This effect is referred to as gleying. The Munsell Color Charts can be used to determine gleyed soils. Mineral soils that are saturated (but not for prolonged periods) will develop a low chroma matrix that may or may not contain mottles. Under these conditions, the mottles often will be "bright" Munsell colors. As a general rule, mineral hydric soils will exhibit one of the following conditions: 1) matrix chroma of 2 or less in mottled soils; or 2) matrix color of 1 or less in unmottled soils.

- **Soil appearing on hydric soils list** - The National Technical Committee for Hydric Soils maintains an updated list of soil types that are known to be hydric or to have hydric inclusions. This list can be referenced to determine if a soil type is hydric. Many NRCS offices also maintain a list of known hydric soils that can be more beneficial on a regional basis.

Sandy Soils:

- **High organic matter content in surface horizon** - Sandy soils that are inundated or saturated for prolonged periods usually develop a layer of organic matter near the surface horizon. This can be attributed to anaerobic conditions that greatly reduce decomposition of the organic matter.

- **Streaking of subsurface horizons by organic matter** - As the water table fluctuates in sandy soils, organic material is carried through the soil profile. The movement of the organics through the soil profile often results in organic streaking in certain portions of the soil profile that are subject to water table fluctuation. Areas of organic streaking can be observed visually with the assistance of a sharpshooter shovel.

- **Organic pans** - As stated above, organic material moves within the soil profile as the water table fluctuates. The organics have a tendency to accumulate in the area that represents the average depth of the water table. The presence of elemental aluminum can result in the soils becoming hardened at the average depth of groundwater. This hardened layer often is referred to as a spodic horizon. Soil pits must be excavated to determine if spodic horizons are present.

Along with the 1987 *Federal Manual*, several other publications are available that provide guidance in the identification of hydric soils. These publications are available for use at both the regional and national levels. Examples include *Redoximorphic Features for Identifying Aquic Conditions* (Vepraskas, 1995) and *Field Indicators of Hydric Soils in the United States* (United States Department of Agriculture, 1995). These resources often provide detailed information on the identification of hydric soils. The USACE district in which the work would be performed should be contacted to ensure that the usage of hydric soil indicators other than those in the 1987 *Federal Manual* is acceptable.

Mapped Soils within the Study Area

The *Soil Survey of Cabarrus County, North Carolina* (USDA, 1988) was consulted prior to conducting field surveys to assess the potential for wetland areas on site. Soil mapping units were compared to the *Hydric Soils of the United States* (USDA-SCS, 1991) to determine if hydric soils are known to occur within the study area. According to the soil data, nine soil-mapping units occur within the proposed project area. One soil series (Chewacla) is listed on the *Hydric Soils of the United States* as a Class B hydric soil, which includes hydric inclusions (USDA-SCS, 1991). In addition, the Altavista soil mapping unit is listed on the *Hydric Soils of North Carolina* for Cabarrus County (http://soils.usda.gov/use/hydric/lists/state.html). Like Chewacla, the Altavista soil mapping unit is listed as a Class B hydric soil. The delineated wetland areas were found to be within the soil mapping units designated as Altavista or Chewacla. Refer to Section 2.3 for a complete description of Chewacla and Altavista soil mapping units within the project area. Refer to Figure 2.3 for a display of soil mapping units that comprise the project area. Please refer to Sections 2.3 and 5.1.1 for evidence of hydric soils identified during wetland delineation surveys. Field soil samples were taken to a minimum depth of 12 inches. The soils were studied for examples of hydric properties (i.e., oxidized rhizospheres, mottling, low chroma, concretions, and water saturation). *Munsell Soil Color Charts* (GretagMacbeth, 2000) were used to determine hue, value, and chroma of both the matrix and the mottle colors of each horizon. Hue indicates the relationship to the primary colors in the spectrum of white light; value indicates the lightness of the color; and chroma represents the strength. A low chroma soil with bright mottles or gleyed soil indicates a hydric soil, if the low chroma is a result of a reducing environment rather than natural color or parent materials. A low chroma soil generally has a matrix chroma of 2 or less in mottled soils or a matrix chroma of 1 or less in unmottled soils. Refer to Section 5.1.1 for a description of hydric soils found within each identified wetland.

5.4 Plant Community Characterization

In both the Routine and Comprehensive Determinations, all dominant plants should be identified to species. The vegetation parameter is the strongest, most reliable parameter in undisturbed wetland communities. Following identification, the *National List of Plant Species that Occur in Wetlands - Southeast Region* (Reed, 1988) should be consulted to determine the wetland indicator status of each species. The indicator status of a plant may fall into one of the categories listed in Table 5.4.

Table 5.4
Plant Indicator Status Categories (adopted from the *Federal Manual*)*

Indicator Category	Indicator Symbol	Definition
Obligate Wetland Plants	OBL	Plants that occur almost always (estimated probability > 99%) in wetlands under natural conditions, but also may rarely occur (estimated probability < 1%) in non-wetlands. Examples: *Spartina alterniflora, Taxodium distichum*.
Facultative Wetland Plants	FACW	Plants that usually occur (estimated probability > 67% to 99%) in wetlands, but also occur (estimated probability 1% to 33%) in non-wetlands. Examples: *Fraxinus pennsylvanica, Cornus amomum*.
Facultative Plants	FAC	Plants with a similar probability (estimated probability 33% to 67%) of occurring in both wetlands and non-wetlands. Examples: *Acer rubrum, Smilax rotundifolia*.
Facultative Upland Plants	FACU	Plants that occur sometimes (estimated probability 1% to > 33%) in wetlands but occur more often (estimated probability > 67% to > 99%) in non-wetlands. Examples: *Quercus rubra, Andropogon virginica*.
Obligate Upland Plants	UPL	Plants that rarely occur (estimated probability > 1%) in wetlands, but almost always occur (estimated probability > 99%) in non-wetlands under natural conditions. Examples: *Pinus echinata, Bromus mollis*.

* Categories were originally developed and defined by the USFWS National Wetlands Inventory and subsequently modified by the National Plant List Panel. The three facultative categories are subdivided by (+) and (-) modifiers.

Analysis of the vegetation parameter in a Comprehensive Determination involves detailed sampling of various strata to establish plant dominance. In a Routine Determination, dominance may be based on visual observations of each strata. For the vegetation parameter to be satisfied, a plant community should have greater than 50 percent of the dominant species with a rating of facultative, facultative wetland, or obligate wetland. An alternative to the 50 percent dominance criteria is the facultative-neutral option. This option may be used when a district questions the indicator status of a dominant species. When dominant species with an indicator of facultative occur with facultative upland or facultative wetland dominant plant species, the facultative species may be considered neutral; therefore, the jurisdictional status of the parameter would be based on the greater number of facultative wetland species versus facultative upland species. Should the facultative wetland dominant species equal the facultative upland species, then associate species are considered. Should the number still be equal, then the jurisdictional status is determined by the soil and hydrology parameters. The final step within the vegetation parameter is to identify the type of vegetation community and wetland system following the *Classification of Wetlands and Deepwater Habitats* (Cowardin *et al.,* 1979). Refer to Section 5.1.1 for a list of plants found in delineated wetlands.

SECTION 6
REFERENCE WETLANDS

SECTION 6
REFERENCE WETLANDS

Reference wetlands are minimally impaired sites that are representative of the expected ecological conditions, functions, and values of other wetlands of the same type and region (USEPA, 2000). The north portion of Wetland B-1 (Reference Wetland B) and the south portion of Wetland C-1 (Reference Wetland C) were selected as the best reference wetlands, since they are subject to the same conditions as the sites proposed for restoration and enhancement. The species diversity within these areas is a result of the on-site conditions and the appropriate wetland functions in terms hydrology and soil biogeochemistry. Due to site variability in the wetland functions of a mature forested wetland, off-site reference wetlands are typically limited for comparison, and on-site comparison for species composition and comparable function are typically recommended (Clewell and Lea, 1990)

6.1 Hydrological Characterization

Dutch Buffalo Creek generally flows west to east through the project area and drains approximately 23 square miles at the farthest downstream point of the NCEEP project easement. In general, the project easement encompasses a relatively wide floodplain. Elevations within the project easement floodplain appear to be gently sloping to flat and ranging between 650 feet near the upper end to approximately 645 feet at the lower end. Surface drainage to Dutch Buffalo Creek within the project easement follows two main pathways.

- Drainage directly to Dutch Buffalo Creek *via* several unnamed tributaries.
- Sheet/overland flow drainage into adjacent riparian wetlands, which eventually contribute to groundwater seepage and baseflows to Dutch Buffalo Creek.

Seeps at the outer edge of the floodplain, overland flow draining into adjacent riparian buffer areas, frequent flooding of Dutch Buffalo Creek and its tributaries, and rainfall appear to be the main contributors to wetland hydrology for the site. This unique combination of hydrology results in scattered zones of inundation typically following the natural micro-topography of the floodplain. As a result of this zonation, the existing wetlands provide a diverse habitat and high species richness.

Some portions of the Dutch Buffalo Creek project easement underlain by hydric soil have been impacted by ditching of fields, channel incision, vegetative clearing, cattle grazing and trampling, and earth movement associated with the dredging/straightening of Dutch Buffalo Creek and its tributaries. Unfortunately these land disturbances have resulted in an overall loss in hydrology to several adjacent riparian wetlands, and in some cases, total loss of wetlands.

Field studies identified the presence of one area within Wetland B-1 and one area within Wetland C-1 as adequate reference wetlands to be used as models for the proposed restoration and enhancement areas. Reference Wetlands B and C are classified as a palustrine forested systems. Several data points were collected within these wetland areas. Upland data points were also collected within areas adjacent to the wetland features but not within the wetland boundary. The reference wetland areas were marked with white and blue-striped flagging labeled "Reference Wetland Boundary" and located with a Trimble Pro XH GPS. The location of the reference wetlands is shown on Figure 6.1.

6.1.1 Gauge Data Summary

Three of the site's ten groundwater monitoring wells are located within Reference Wetlands B and C which are included in the Piedmont/Low Mountain Bottomland Forest community type. Refer to Figure 6.1 for a map of gauge locations within reference wetland areas. Refer to Section 5.2.1 for more information on the monitoring and download intervals and the success criteria established for all groundwater gauges on site. Groundwater monitoring gauges 1 and 2 (Reference Wetland B) confirmed that continuous daily groundwater elevations were within the upper 12 inches of the soil profile for duration of greater than 29 consecutive days during the growing season. Daily groundwater elevations were within the upper 12 inches of the soil profile between March 23 and May 31 (70 days) and between March 23 and May 16 (55 days) for gauges 1 and 2, respectively. Average groundwater levels during this period were approximately 5 and 6 inches below the surface for gauges 1 and 2, respectively. Groundwater monitoring gauge 7 (Reference Wetland C) revealed continuous daily groundwater levels were within the upper twelve inches of the soil profile between March 23 and May 18 (57 days), which also exceeds the NCEEP target hydrological characteristics for wetland systems. In summary, reference wetland groundwater levels suggest that normal wetland hydrological conditions should be at a minimum at or near the surface with scattered pockets of inundation during the winter and early growing season. However, as previously stated in Section 5.2.1, higher evapotranspiration rates experienced during the month of May and precipitation totals approximately 3.63 inches below the 60-year average have substantially lowered groundwater levels (approximately 2-3 ft below the surface) within some portions of reference wetlands. JJG will continue to monitor reference wetland areas throughout the growing season in order to accurately determine wetland hydrology for proposed restoration areas. Refer to Appendix 7 for Hydrologic Gauge Data Summary, Groundwater and Rainfall Information.

6.2 Soil Characterization

6.2.1 Taxonomic Classification (including series)

The dominant soil type within the Reference Wetlands B and C is the Chewacla sandy loam, frequently flooded (Ch) series (USDA, 1988). The Chewacla series is listed as a Class B hydric soil (USDA-SCS, 1991). Refer to Section 2.3 for a complete description of the Chewacla soil mapping unit within the project area. Refer to Figure 6.2 for a map of soil mapping units within reference wetland areas.

Chewacla sandy loam, frequently flooded (Ch) - The Chewacla series consists of very deep, moderately permeable, somewhat poorly drained soils on floodplains. These soils formed in recent alluvium washed largely from soils formed in residuum from schist, gneiss, granite, phyllite, and other metamorphic and igneous rocks. Typically, the surface layer is dark brown loam approximately 6 inches in depth. The upper subsoil layer is a reddish-brown sandy clay loam with grayish mottles from a depth of 6 inches to approximately 20 inches. The middle of the subsoil layer is a sandy clay loam with grayish-brown to yellowish-brown colors. The middle of the subsoil layer also has many grayish mottles at a depth of approximately 20 inches to 40 inches or more. The lower subsoil layer is yellowish-brown to brown with light grayish mottles from approximately 40 inches to the maximum depth of approximately 60 inches. Field soil samples were taken to a minimum depth of 12 inches. The soils were studied for examples of hydric properties (i.e., oxidized rhizospheres, mottling, low chroma, concretions, and water saturation). *Munsell Soil Color Charts* (GretagMacbeth, 2000) were used to determine hue, value, and chroma of both the matrix and the mottle colors of each horizon. The profile for the Chewacla soil series found within the project corridor typically displays the following profile.

- A horizon = 0 to 6 inches depth; brown loam. Hue is 10YR, value is 3 or 4, and chroma is 2.

- B1 Horizon = 6 to 15 inches depth; reddish-brown sandy clay loam. Hue is 7.5YR, value is 4, and chroma is 2.

- B2 Horizon = 15 to 35 inches depth; grayish-brown to yellowish-brown sandy clay loam. Hue is 10YR, value is 5, and chroma is 2.

- B3 Horizon = 36 to 60 inches depth; light grayish brown sandy clay loam. Its hue is 10YR, value is 5 or 6, and chroma is 2.

The Chewacla sandy loam soils within the project corridor are frequently flooded with a typical water table depth at approximately 15 inches below the ground surface. Chewacla sandy loam soils are medium in percent organic matter and natural fertility. Furthermore, these soils are moderately suited for farming due to frequent flooding or saturation. Chewacla soils are well suited for farming, if drainage ditches are present. Permeability is moderate, and the available water capacity is high. Therefore, the infiltration rate is moderate when wet.

The susceptibility of sheet or rill erosion by water (K-Factor) within Chewacla sandy loam is moderate. These numbers present the percentages of silt, sand, and organic matter relative to soil structure and permeability. The T factor is the estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity. Table 6.1 provides a brief summary of the physical properties for the Chewacla sandy loam soil within the project corridor.

Table 6.1
Summary of Physical Properties for the Chewacla Soil Series

Soil Series	Max Depth (in)	Percent Clay	Percent Sand	Percent Silt	% Organic Matter	K Factor (% silt, sand, organic matter)	T Factor (tons/ac/yr)	Bulk Density (g/cm^3)
Chewacla	60	22.5	39.8	37.7	2.5	0.32	5	0.36

6.3 Plant Community Characterization

6.3.1 Community Description(s) All Strata

Reference Wetlands B and C are classified as a palustrine forested system with a saturated to seasonally flooded hydrologic regime. The dominant community type within the reference area is a Piedmont/Mountain Bottomland Forest community (Schafale and Weakley, 1990). Dominant vegetation associated with these areas includes the species listed below. The vegetation criterion was satisfied with 90 percent of the species being facultative, facultative wetland, or obligates wetland. Refer to Figure 6.3 for a map of vegetative communities within reference wetland areas.

Table 6.3
Dominant Vegetation within Reference Wetlands B and C

Scientific Name	Common Name	Strata	Indicator Status
Ulmus americana	American elm	Upper Canopy	FACW
Quercus michauxii	swamp chestnut oak	Upper Canopy	FACW-
Quercus phellos	willow oak	Upper Canopy	FACW-
Liriodendron tulipifera	tulip poplar	Upper Canopy	FAC+
Quercus bicolor	swamp white oak	Upper Canopy	FACW+
Liquidambar styraciflua	sweet-gum	Upper Canopy	FAC+
Betula nigra	river birch	Upper Canopy	FACW
Platanus occidentalis	American sycamore	Upper Canopy	FACW-
Quercus rubra	red oak	Upper Canopy	FACU
Carpinus caroliniana	American hornbeam	Upper Canopy	FAC
Celtis laevigata	hackberry/sugarberry	Upper Canopy	FACW
Acer negundo	box elder	Upper Canopy	FACW
Eleocharis obtusa	blunt spike rush	Upper Canopy	OBL
Lindera benzoin	spice bush	Sub-Canopy	FACW
Cornus florida	flowering dogwood	Sub-Canopy	FACU
Cornus amomum	silky dogwood	Sub-Canopy	FACW+
Arundinaria gigantea	giant cane	Herbaceous	FACW
Carex spp.	sedge species	Herbaceous	FAC - OBL
Juncus effusus	soft rush	Herbaceous	FACW+
Juncus spp.	rush species	Herbaceous	FACW - OBL
Impatiens capensis	jewel weed	Herbaceous	FACW

6.3.2 Basal Area

The dominant size class within the reference wetlands is 12 to 18 inch diameter at breast height (DBH). This size converts to a dominant basal area of 0.11 to 0.32 ft^2 (.01 to .03 m^2). Several specimen trees of American sycamore are greater than 18 inches DBH.

SECTION 7
PROJECT SITE RESTORATION PLAN

SECTION 7

PROJECT SITE RESTORATION PLAN

The primary stream restoration effort will consist of Enhancement Level II along the main reach of Dutch Buffalo Creek and Restoration along the unnamed tributary. The restoration plan will also include wetland restoration and enhancement, the re-establishment of native riparian areas, and preservation of native vegetation, wetlands, and reaches of Dutch Buffalo Creek.

7.1 Restoration Project Goals and Objectives

The following goals have been established for the Dutch Buffalo Creek Stream and Wetland Restoration project.

- Stabilize and protect degraded or vulnerable stream banks along the main reach of Dutch Buffalo Creek.
- Enhance the upper project reach of Dutch Buffalo Creek by fencing out the livestock and vegetating streambanks where necessary.
- Restore a natural, stable dimension, pattern, and profile along one unnamed tributary using natural channel design techniques.
- Improve stable habitat for macroinvertebrate and fish communities.
- Restore and/or enhance the natural hydrology, vegetation, and soil composition in adjacent wetlands.
- Provide alternate cattle watering sources and road access across Dutch Buffalo Creek.
- Improve the aesthetics of the stream.

To meet these goals, the following objectives have been established for the Dutch Buffalo Creek Stream and Wetland Restoration project.

- Enhancing approximately 3,611 linear feet in the main channel's upper reach.
- Preserving approximately 4,678 linear feet in the main channel's lower and upper reaches.
- Relocating approximately 608 linear feet of an unnamed tributary into a Rosgen C/E stream type.
- Preserving approximately 1.67 acres, enhancing approximately 4.26 acres, and restoring approximately 7.29 acres of wetland area.
- Constructing access crossings across the main channel and the unnamed tributary of Dutch Buffalo Creek.
- Creating an alternative livestock watering source that prevents livestock from accessing the stream.

7.1.1 Designed Channel Classification

Upstream Main Reach (station 17+61 – 53+72)

After investigating the project reach of Dutch Buffalo Creek, JJG believes that the stream is not as impaired as initially thought. Indicators of overbank flooding have been observed several times within the last year. These occurrences indicate that the stream may not be as incised as originally thought and that it is somewhat connected to its floodplain. There are also several bedrock outcrops within the stream that act as grade control and will limit the potential for further incision. Select stable areas with plentiful tree and root cover also exist along the reach. The majority of instability along the main reach results from livestock's grazing and trampling of the streambanks. The restoration effort for the main reach consists of Enhancement Level II which can be accomplished by fencing the stream and associated wetland areas to prevent livestock grazing and trampling, and vegetating vulnerable streambanks and riparian areas where necessary. An alternative watering source will also be developed to prevent the livestock from accessing the stream. Sections of the stream where livestock are not provided access appear stable; therefore, once the livestock impacts are removed and the vegetation establishes, the stream should develop into a stable system over time. Any type of channel grading or excavation of a bankfull bench along the main reach would require such a large amount of land and tree disturbance that the negative results would far outweigh the benefits.

Trash, fallen trees, and debris will be removed from the stream to improve habitat, water quality, and aesthetics. All of the proposed work will occur within the conservation easement.

Refer to Design Sheets in Section 11 for a more detailed plan of the stream and wetland restoration site, and Table 7.1 for the design values and dimensionless ratios. Components of this restoration plan may be modified based on construction and access constraints.

Downstream Main Reach (station 53+72 – 100+50)

The downstream portion of the easement will be placed in preservation. Also, an electric fence will be constructed along the easement boundary to prevent livestock access.

Unnamed Tributary (station 0+00 – 6+08)

The restoration effort for the unnamed tributary was determined to be Restoration, using a combination of Priority Levels 1 & 2 approach. Stream dimension, pattern and profile have been designed so the new stream will maintain stability while conveying its watershed's runoff and transporting its sediment load. The proposed stream type includes an upstream section that was designed as a C/E channel, and a downstream section that was designed as a B-type step-pool channel. The purpose of the downstream section was to transition the tributary from its elevation to the elevation of Dutch Buffalo Creek at their confluence. The proposed relocation of the channel will utilize the existing floodplain within the project site. Meanders will be introduced into the proposed channel to mimic the natural sinuosity pattern and establish riffle/pool sequences that occur in typical Piedmont streams. The ratio of radius of curvature to bankfull width is designed to be 2.5 to 3.0, which provides a moderate to very low potential for bank erosion to occur (Rosgen, 2006b). The meandering will also allow the stream to dissipate energy and decrease shear stress. Typical riffle and pool cross-sections have been designed to reconnect the channel with its floodplain. Where a Priority 1 approach is used, the bankfull stage of the new channel will be established at the ground surface of the existing floodplain. In the middle section of the reach where a Priority 2 approach is used, a bankfull bench will be built to act as a floodplain. The designed channel will provide a stable bedform with riffle, run, pool, and glide features and will also improve in-stream habitat for macroinvertebrates. Adjacent stream banks and riparian zones of the unnamed tributary will be replanted using native species appropriate to the area.

A rock cross-vane will be used at the upstream end of the project to raise the streambed and connect it to its original floodplain. Constructed riffles will be installed to provide grade control, stabilization, and habitat. Riffle material from the existing stream will be used to build the constructed riffles where possible. Step-Pools will be used at the confluence with Dutch Buffalo Creek to join the elevations of the unnamed tributary and the main reach.

The designed dimensions were based on a combination of the dimensionless ratios from the reference reach Sal's Branch, the NC Regional Curve for Rural Piedmont Streams, Rosgen's stable reference reach data ranges (Rosgen, 2004a) and existing conditions.

Refer to Design Sheets in Section 11 for a more detailed plan of the stream and wetland restoration site, and Table 7.1 for the design values and dimensionless ratios. Components of this restoration plan may be modified based on construction and access constraints.

Table 7.1
Design Values for Proposed Conditions

	Parameter	Proposed UT MIN	Proposed UT MAX
General	Drainage Area (sq mi)	0.31	
	Stream Type (Rosgen)	C/E4	
	Valley Type	VIII	
Dimension	BKF Mean Velocity (Vbkf) (ft/s)	3.65	
	Bankfull Discharge (Qbkf)(cfs)	32.83***	
	Bankfull XSEC Area, Abkf (sq ft)	9.00	
	Bankfull Width, Wbkf (ft)	9.00	
	Bankfull Mean Depth, dbkf (ft)	1.00	
	Width to Depth Ratio, W/D (ft/ft)	9.00	
	Width Floodprone Area, Wfpa (ft)	150.00	
	Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	16.67	
	Max Depth @ bkf, Dmax (ft)	1.50	
	Max Depth Ratio, Dmax/dbkf	1.50	
	Max Depth @ tob, Dmaxtob (ft)	1.50	
	Bank Height Ratio, Dtob/Dmax (ft/ft)	1.00	
	Pool Max Depth, Dmaxpool (ft)	1.00	1.80
	Pool Max Depth Ratio, Dmaxpool/dbkf	1.00	1.80
	Pool Area, Apool (sqft)	11.30	
	Pool Area Ratio, Apool/Abkf	1.26	
	Pool Width, Wpool (ft)	11.70	
	Pool Width Ratio, Wpool/Wbkf	1.30	
	Pool Length, Lpool (ft)	21.1	54.1
	Pool Length Ratio, Lpool/Wbkf	2.34	6.01
	Pool-Pool Spacing, Lps (ft)	34.6	67.9
	Pool-Pool Spacing Ratio, Lps/Wbkf	3.84	7.54
Pattern	Meander Length, Lm (ft)	57.60	126
	Meander Length Ratio, Lm/Wbkf	6.40	14.00
	Radius of Curvature, Rc (ft)	22.50	27.00
	Rc Ratio, Rc/Wbkf	2.50	3.00
	Belt Width, Wblt (ft)	33.30	81.00
	Meander Width Ratio, Wblt/Wbkf (ft)	3.70	9.00
	Sinuosity, K	1.13	
Profile	Valley Slope, Sval (ft/ft)	0.0062	
	Channel Slope, Schan (ft/ft)	0.0055	
	Slope Riffle, Srif (ft/ft)	.014	.024
	Riffle Slope Ratio, Srif/Schan	2.55	4.36
	Riffle Length, Rlength (ft)	10.00	41.20
	Riffle Length Ratio, Rlength/Wbkf	1.11	4.58
	Slope Pool, Spool (ft/ft)	0	0
	Pool Slope Ratio, Spool/Schan	0	0
	Slope Run, Srun (ft/ft)	-	
	Run Slope Ratio, Srun/Schan	-	
	Slope Glide, Sglide (ft/ft)	-	
	Glide Slope Ratio, Sglide/Schan	-	

Cells noted with a (-), data was not provided.
Cells noted with a (***) were calculated using Bentley Flowmaster.

7.1.2 Target Wetland Communities/Buffer Communities

The proposed wetland communities will be similar to the existing surrounding wetlands and the reference wetland identified on-site. These palustrine forested wetlands are classified as Piedmont/Mountain Bottomland Forest community (Schafale and Weakley, 1990). Typical overstory vegetation associated with these wetlands includes American elm, sweet-gum, river birch, swamp white oak, green ash, hackberry (*Celtis laevigata*), and American sycamore. Typical understory vegetation includes silky dogwood and American hornbeam (*Carpinus caroliniana*). Wetland hydrology is achieved by overbank flooding and a seasonally high groundwater table resulting in periodic inundation and seasonal saturation. Alluvial, hydric soils are present consisting of the Chewacla soil series.

7.2 Sediment Transport Analysis

Sediment transport competency and capacity analyses were conducted on the main channel and the unnamed tributary of Dutch Buffalo Creek to ensure that the design stream will move its sediment load without significant potential for aggradation or degradation. Stream competency was analyzed to determine what sediment particle sizes are typically available for mobility at bankfull flows. Characterizing the streambed sediment stratification also provided the means to calculate and verify the channels' existing and proposed critical dimensionless shear stress, target design slope, and the required minimum mean depth needed for channel stability. Channel capacity was evaluated to determine bedload transport through the channel. This metric is typically analyzed using a sediment transport model to verify and assess whether or not the proposed design channel has the potential to aggrade or degrade.

7.2.1 Methodology

Entrainment data were collected within the main channel and the unnamed tributary of Dutch Buffalo Creek. Pavement and subpavement samples were collected at a riffle cross-section, and a wetted pebble count was conducted at each cross-section to calculate entrainment and velocity. Calculated fields consist of critical dimensionless shear stress (cdss), mean depth of bankfull (d_{BKF}), and water surface/bankfull slope. Using Shields and Rosgen Colorado curve, maximum grain diameter and shear stresses were determined to verify entrainment calculations (Rosgen, 2006). Shields and Rosgen Colorado curve can be used to predict two stream parameters. Shear stress can be predicted using the largest particle size (Di) from a bar or subpavement sample, or the Di can be predicted using a calculated shear stress. Field collection and calculations followed methods described by Rosgen (2004 a, b), and North Carolina Stream Restoration Institute (Doll et. al., 2003). Lab procedures for processing pavement and subpavement samples followed methods described by Bunte et. al. (2001).

A BAGS model (2006) was developed for the main channel and the unnamed tributary using typical channel cross-sections to calculate bedload transport rates for the existing and proposed channels. The different model equations used in this program are based upon the following data: channel cross-section, average water surface slope of each reach, discharge measurements, and grain size distribution from bed samples. The following model equations were used for the

Dutch Buffalo Creek sediment transport analysis: Wilcock and Crowe (2003), Parker-Klingeman (1982), and Parker-Klingeman-McLean (1982). Wilcock and Crowe is a surface-based equation that models transport relations based on the grain size distribution of the bed-surface (pavement layer). Parker-Klingeman is a substrate-based equation that models transport relations based on size fraction of the subsurface bed (subpavement layer). Parker-Klingeman-McLean is a substrate-based equation that models transport relations based on a single grain size (median grain size) of the substrate (subpavement), $D50_{sub}$.

7.2.2 Calculations and Discussion

Tables 7.2 and 7.3 summarize the results of the sediment transport analysis for Dutch Buffalo Creek.

Table 7.2
Entrainment Calculations

Parameter	Main Channel	Unnamed Tributary
	Design-C5e	**Design-E4**
Existing Bankfull Slope (ft/ft)	0.0014	0.0060
Median particle size-wetted pebble count, D50 (mm)	2.84	15.06
Median particle size subpavement, D50^ (mm)	2.25	2.01
D50/D50^	1.26	7
Largest Particle Size from Subpavement, Di (mm)	60.00	93.00
Critical Dimensionless Shear Stress, cdss	0.0705	0.0149
Minimum Mean Bankfull Depth, dBKF (ft)	*	1.25
Minimum Bankfull/Water Surface Slope (ft/ft)	*	0.0060
* Data were not necessary to present since profile and pattern were not altered in design.		

Table 7.3
Sediment Transport Validation

Parameter		Main Channel		Unnamed Tributary	
		Existing-C5e	**Design-C5e**	**Existing-G5c**	**Design-E4**
Bankfull Shear Stress (lbs/sqft):	*γRS*	0.33	0.27	0.51	0.33
Grain Diameter (mm)*	*Using Bankfull Shear Stress*	17.76	14.78	27.19	18.00
Grain Diameter (mm)**		66.31	58.40	91.87	68.32
Predicted Shear Stress (lbs/sqft)*	*Using Di*	0.88	0.88	1.13	1.13
Predicted Shear Stress (lbs/sqft)**		0.29	0.29	0.51	0.51
* Results using Shields Curve, ** Results using Rosgen CO curve Source for Curve Data from Watershed Assessment of River Stability and Sediment Supply (Rosgen, 2006b)					

7.2.3 Results

Main Channel

Competency

- Using Shields and Rosgen CO Curves, the largest particle available for transport is respectively, 17.76 and 66.31 mm for the existing channel, and 14.78 and 58.40 mm for the design.
- The critical dimensionless shear stress required to mobilize and transport the Di is 0.0705.
- To entrain the Di, the minimum bankfull depth and slope required for the design are 15.89 ft, and 0.0055 ft/ft, respectively. These were disregarded in our design, since there are no proposed changes to the profile or pattern on the main channel.
- The calculated existing bankfull shear stress is 0.33 lbs/ft^2. The calculated design bankfull shear stress is 0.27 lbs/ft^2. Shields predicted a shear stress value of 0.88 lbs/ft^2, which is much greater than the calculated shear stress, and indicates a potential for aggradation. However, the Rosgen CO curve predicted a shear stress value of 0.29 lbs/ft^2, which is similar to the calculated value, indicating neither aggradation, nor degradation is likely to occur.

Capacity

The sediment transport rating curves for the main channel are relatively the same for the existing and the design channel for flows greater than 100 cubic feet per second (cfs). Within the main channel, a 100 cfs storm event has a 100% probability to occur once a year within a typical riffle cross-section. The max depth for the 100 cfs discharge is approximately 2.76 feet, which results in a stage within the upper two-thirds of the bankfull discharge elevation. Flows between two-thirds of the bankfull discharge and the bankfull discharge typically transport a large percentage of the total annual bedload sediment in gravel bed streams (Pitlick et. al., 2006).

The results produced from the Wilcock and Crowe (2003) model when compared to the Parker-Klingeman (1982), and Parker-Klingeman-McLean (1982) models illustrate a similar sediment transport trend for discharges greater than 100 cfs, but illustrate a significant difference for discharges less than 100 cfs. Pitlick et. al. (2006) suggest that there may not be an absolute lower limit to bed load transport in-stream, but there is a point where extremely small loads can be considered negligible. Therefore, since a large percentage of the data points for the main channel of Dutch Buffalo Creek have similar trends for discharges greater than 100 cfs, the data output below the upper two-thirds of the channel bankfull discharge is considered negligible and too small to be of significance. The similarity of the existing and design curves demonstrates that with higher discharge the design will maintain and perhaps improve sediment transport within the main channel. The proposed enhancement efforts will aid in decreasing the amount of in-stream bank erosion, therefore, decreasing in-stream sediment. Please refer to Appendix 9 for graphical results from the BAGS model.

Unnamed Tributary

Competency

- Using Shields and Rosgen CO Curves, the largest particle available for transport is 27.19 and 91.87 mm respectively for the existing channel, and 18 and 65 mm for the designed channel.
- The critical dimensionless shear stress required to mobilize and transport the Di is 0.0144.
- To entrain the Di, the minimum bankfull depth and slope required for the design are 1.25 ft, and 0.006 ft/ft, respectively. These parameters are met within our design.
- The calculated existing bankfull shear stress is 0.51 lbs/ft^2. The calculated design bankfull shear stress is 0.33 lbs/ft^2. Shields curve predicted shear stress values of 1.13 lbs/ft^2, which are much greater than the calculated shear stress, and indicates a potential for aggradation in the design channel. However, the Rosgen CO curve predicted a shear stress value of 0.51 lbs/ft^2, which is closer to the calculated values, indicating neither aggradation nor degradation will occur.
- In the transition zone (B4 stream type) for the unnamed tributary to Dutch Buffalo Creek, bankfull shear stress was calculated as 0.82 lbs/ft^2. This value exceeds the calculated design shear stress, 0.31 lbs/ft^2; therefore, the high shear stresses will be reduced and controlled over a 0.016 ft/ft slope using step-pool rock structures. Shields Curve predicted the largest particle available for transport in the transition zone to be 54.47 mm; however, Rosgen CO curve predicts a larger particle size of 129.22 mm. This value will be used to determine the size of boulders used to build the step-pool structures.

Capacity

The sediment transport curves indicate similar trends between the existing and proposed channel design for all three models evaluated. Therefore, it can be assumed that the curves predict that there is not a significant potential for aggradation or degradation to occur within the proposed channel design. Please refer to Appendix 9 for graphical results from the BAGS model.

Summary

The similarities between the existing and design curves for the main channel and unnamed tributary to Dutch Buffalo Creek demonstrate that the proposed Enhancement and Restoration efforts will aid in decreasing the amount of in-stream bank erosion thereby, decreasing in-stream sediment. Therefore, it can be assumed there is not a significant potential for aggradation or degradation to occur within the main channel or unnamed tributary for the proposed channel designs.

7.3 HEC-RAS Analysis

A hydraulic model was developed for the project reach of the main channel of Dutch Buffalo Creek using HEC-RAS software to determine water surface elevations along the project reach and to identify the extent of flooding for both the existing stream geometry and proposed stream geometry. Peak flow rates discussed in section 3.2 were used in the model. The model was also used to verify that the proposed enhancement will not increase the water surface elevation of the FEMA 100-year floodplain. The model indicates that there will not be a rise in the water surface elevation for the 100-year floodplain due to the proposed conditions. These results can be seen in the following table. Refer to Table 7.4 for the 100-year water surface elevations for the existing and proposed conditions.

Table 7.4
100-year Water Surface Elevations (WSE) for Existing and Proposed Conditions

Cross-Section Station (ft)	Existing Conditions 100-yr WSE (ft)	Proposed Conditions 100-yr WSE (ft)	Difference in WSE from Existing to Proposed (ft)
4,996.65	655.04	654.6	-0.44
4,359.03	653.85	653.28	-0.57
4,034.23	653.24	652.79	-0.45
3,468.53	652.73	652.33	-0.40
3,175.13	652.5	652.07	-0.43
2,835.6	652.22	651.81	-0.41
2,217.61	651.47	651.03	-0.44
1,923.54	651.12	650.77	-0.35
1,758.49	650.9	650.58	-0.32
1,437.81	650.54	650.31	-0.23
1,304.85	650.42	650.25	-0.17
927.73	649.86	649.83	-0.03

7.3.1 No-Rise, LOMR, CLOMR

A No-Rise Certification is being submitted to Cabarrus County to verify that the project will not increase the water surface elevation of the 100-year floodplain. A copy of the No-Rise Certification will be submitted to the EEP once received from the county. LOMR and CLOMR will not be required.

7.3.2 Hydrologic Trespass

The proposed restoration project was designed to avoid hydrologic trespass. Hydrologic trespass occurs when there is a rise in the 100-year storm floodplain (water surface elevation) when compared to the published FEMA FIRM map. According to the FEMA FIRM map of the project area (effective date November 2, 1994), approximately all of the project conservation easement is in the 100-year floodplain. The HEC-RAS model of the proposed restoration/enhancement reaches indicates that the 100-year floodplain elevations on adjacent properties will not increase.

7.4 Stormwater Best Management Practices

Stormwater Best Management Practices (BMPs) will be implemented within the Dutch Buffalo Creek project following guidelines outlined in the North Carolina Department of Environment and Natural Resources (NCDENR) Erosion and Sediment Control Planning and Design Manual (2006) and the NCDENR Stormwater Best Management Practices (1999). Through the use of non-structural controls, runoff will be treated, therefore, limiting the potential for pollutant runoff. The existing streams and wetlands will be protected from erosion and sedimentation problems before, during, and following construction. The easement will be completely fenced to prevent potential cattle and land use management impacts following stream and wetland construction. All on-site stormwater discharge will flow in the form of sheet flow. The existing riparian area and easement will provide sufficient filtering of any nutrient and sediment runoff *via* cattle or other farming practices. No other significant stormwater concerns are prevalent within the project limits.

7.4.1 Narrative of Site-Specific Stormwater Concerns

During construction, all disturbed areas, access roads, and stock piles within the project site will have appropriate prevention methods installed to avoid erosion and sedimentation impacts on the existing streams and wetlands of Dutch Buffalo Creek.

7.4.2 Device Description and Application

Erosion and sedimentation control measures will consist of installing silt fencing around disturbed areas prior to disturbance, and maintaining throughout the construction phases. All newly constructed stream banks will be matted and staked at the end of each work day.

7.5 Hydrological Modifications (for wetland restoration or enhancement)

7.5.1 Wetland Restoration Area C

The area adjacent to Wetland C-1 (referred to as Wetland Restoration Area C) has been managed for a number of years as a pasture planted in switch grass. An existing drainage ditch is cut through the southern edge of the switch grass field and drains to Dutch Buffalo Creek. Similarly, there are also several side ditches off of this ditch. The drainage ditch was dug by the landowner's father (L. Suther, 2006.). The linear nature of the ditch is indicative of a typical agricultural drainage ditch. Representative photographs of this channel are shown in Appendix 1.

These channelized ditches effectively drain surface water and shallow groundwater from the switch grass area by providing a drainage way at an elevation lower than potential groundwater levels. The first 100 feet of this channel (from convergence with Dutch Buffalo Creek and up-channel) will be partially filled and then restored with shallow log vane step-pools. The step-pools will facilitate some drainage from the wetlands and provide a step-down change in elevation to Dutch Buffalo Creek. The remainder of these channelized ditches will be "plugged" with earth material (95% Standard Proctor) to restore the ditches to current grade and restore groundwater to its "pre-ditched" level. Construction materials will consist of clay plug material, native fill material (from grading the stream bank), and natural fiber erosion control fabric. A schematic of this technique is provided in Appendix 7. Currently, the elevation of the ditch is 648 feet above mean sea level (ft), whereas the stream is at 644 ft. Similar to an unaltered wetland area, inundation and saturation levels will vary with seasonal and climatological variability. In droughts, groundwater will be at a lower elevation; therefore, groundwater in these areas will be at a lower elevation and may not inundate or saturate proposed restoration areas.

7.5.2 Wetland Enhancement Area B-1

Similar to Wetland Restoration Area C, the area adjacent to Reference Wetland B-1 (referred to as Wetland Enhancement Area B) has been altered by an existing drainage ditch cut through the southeastern edge of Wetland B-1 and drains to Dutch Buffalo Creek. Similarly, there are also several side ditches off of this ditch. The drainage ditch was dug by the landowner's father (L. Suther, 2006.). Over time, the ditches have incised due to the elevation of Dutch Buffalo Creek and cattle activity. Cattle have been allowed to trample this area and graze on vegetation, which has resulted in reduced vegetation and increased runoff. These stresses have likely exacerbated the incision of the streams. Representative photographs of this channel are shown in Appendix 1.

These channelized ditches effectively drain surface water and shallow groundwater from the surrounding area by providing a drainage way at an elevation lower than potential groundwater levels. Two approaches will be used in these areas. The more incised portions of these channels will be partially filled and then restored with shallow log vane step-pools.

The function of the step-pools will be to step the channel down to Dutch Buffalo Creek (thereby preventing a headcut), catch sediment, and detain surface flow. These restored shallow drainage swales will enhance the surrounding wetland habitat and provide good amphibian habitat in wetter seasons of the year. Also, these swales will facilitate drainage from the wetland. These features are designed based on the wetter swales identified in Reference Wetland B. The fill will consists of compacted earth material (90% Standard Proctor). Construction materials will consist of clay plug material, native fill material (from grading the stream bank), and natural fiber erosion control fabric. Filling the ditch shall be accomplished in similarity to dike construction to prevent seepage and erosion. The central portion of this ditch shall be filled with a clay plug of high plasticity and compacted to fill voids and reduce permeability (Spigolon, 2000). Currently, the elevation of the ditch is 643 ft whereas the stream is at 641 ft. Similar to an unaltered wetland area, inundation and saturation levels will vary with seasonal and climatological variability. In droughts, groundwater will be at a lower elevation; therefore, groundwater in these areas will be at a lower elevation and may not inundate or saturate proposed restoration areas.

7.5.3 Wetland Enhancement Area B-2

The area surrounding the tributary proposed for restoration is proposed for wetland enhancement. Currently, there are two small wetland areas surrounding the existing tributary. The tributary is incised and drains its surrounding floodplain and groundwater sources due to its vertical instability and incision. The existing stream may have been previously channelized and straightened for drainage which increased its slope resulting in an increase in velocity and vertical incision. By relocating the channel to the east at a higher elevation, the channel will be reconnected with its floodplain reducing drainage of the floodplain and increasing the elevation of the groundwater table. By increasing the sinuosity of the channel, the slope is decreased, resulting in a lower velocity. Currently, the elevation of the existing channel and the relocated channel are similar extending from 644 ft (at the point where the channel relocation begins) to 641 ft at the convergence with Dutch Buffalo Creek. However, the elevation of the floodplain surrounding the relocated channel is approximately 647 ft which is one foot lower than the elevation of floodplain area (approximately 648 ft) surrounding the existing channel. As a result, the relocated channel is designed to more frequently flood as well as raise the surrounding groundwater. Representative photographs of this channel are shown in Appendix 1.

7.5.4 Proposed Wetland Impacts

Wetlands will be temporarily impacted as a result of required construction access across Wetland Area B-1 and Wetland Area C-1. The proposed temporary impact area is estimated to be 0.055 acres in Wetland B-1 and 0.172 acres in Wetland C-1. Construction mats will be used to minimize impacts. Any fill material required for access stability will be removed and the area will be restored to pre-existing contours. Furthermore, the proposed disturbances in Wetland B-1 and Wetland C-1 are in areas proposed for enhancement. Currently, the area in Wetland B-1 consists of degraded wetland due to the presence of a cleared area which was probably used as an unimproved road. Also, there is evidence of active cattle trampling of the soils and grazing of the vegetation. This area, as well as the area of impact in Wetland C-1, is proposed for enhancement, so utilizing these areas for access will minimize the overall impact to existing wetlands. Please refer to Figure 7.1 for an exhibit of the proposed impact areas.

7.6 Soil Restoration

Typically, the soils of the Piedmont/Mountain Bottomland Forest community are prime farm and planting soils due to their fertility and periodic flooding (Schafale and Weakely, 1990). The existing soils within the proposed wetland restoration and enhancement areas consist of Chewacla soils which are naturally fertile and well-suited for planting (USDA, 1988). The area that will be planted most heavily will be the existing switch grass field. This field has not been regularly plowed and replanted, so it is unlikely to have been over utilized for agriculture. The switch grass field will be harvested by the landowner, if he chooses to do so prior to disturbance. Subsequently, the remaining culms will be disked into the soil to work additional organic matter into the soil. Disking the soil prior to planting will not only add organic manner, but also diminish any compaction and increase the rooting volume (Clewel and Lea, 1990). In addition, disking will ensure adequate drainage and beneficial microtopography for planting and drainage. Prior to planting, soil analysis for the switch grass area will be performed by the Contractor to determine what, if any, soil amendments need to be added to establish correct soil conditions for the trees/shrubs to be planted.

With the exception of the drainage ditches, minimal grading (fill or cut) is proposed for the wetland restoration and enhancement areas. Top soil taken from cut areas along the stream will be reserved for the top soil dressing utilized for ditch filling. The soil along the stream banks is naturally fertile due to its alluvial nature, so this top soil should be well suited for planting.

7.7 Natural Plant Community Restoration

7.7.1 Narrative & Plant Community Restoration

The wetland restoration area and the areas of disturbance associated with the ditch filling will be planted with species similar to those found in reference wetlands (Wetlands B-1 and C-1) to achieve a Piedmont/Mountain Bottomland Forest as described in Schafale and Weakely (1990). The reference wetlands, surrounding forest, and Schafale and Weakley's species descriptions are used to develop a species list as shown in Table 7.5. Similarly, the stream banks and immediately adjacent riparian areas associated with disturbance due to bank stabilization will be planted with species similar to those currently found there to maintain a Piedmont/Low Mountain Alluvial Forest (Schafale and Weakely 1990). The species list found in Table 7.6 is developed based on on-site inventories and Schafale and Weakley's species descriptions. Species selected for live staking are based on on-site inventories, past experience, and results of field trials reported by Calabria *et al.* (2006). Refer to Table 7.6 for a list of live staking material. A map of proposed communities is provided in Figure 7.2.

Table 7.5
Piedmont/Mountain Bottomland Forest Community
Wetland Planting List - Woody Species

Common Name	Scientific Name	Wetl Ind. Stat.	Size	Spacing	Quantity
Trees					
Blackgum	*Nyssa sylvatica*	FAC	24" or > b.r.	10-feet O.C. random	436
Tulip tree	*Liriodendron tulipifera*	FAC	24" or > b.r.	10-feet O.C. random	436
Swamp chesnut oak	*Quercus michauxii*	FACW-	24" or > b.r.	10-feet O.C. random	218
Green ash	*Fraxinus pennsylvanica*	FACW	24" or > b.r.	10-feet O.C. random	1,307
American elm	*Ulmus americana*	FACW	24" or > b.r.	10-feet O.C. random	871
River birch	*Betula nigra*	FACW	24" or > b.r.	10-feet O.C. random	436
Willow oak	*Quercus phellos*	FACW-	24" or > b.r.	10-feet O.C. random	218
Hackberry	*Celtis laevigata*	FACW	24" or > b.r.	10-feet O.C. random	218
Swamp white oak	*Quercus bicolor*	FACW	24" or > b.r.	10-feet O.C. random	218
Total Trees					4,358
Shrubs					
Flowering dogwood	*Cornus florida*	FACU	24" or > b.r.	6-feet O.C. random	75
Spicebush	*Lindera benzoin*	FACW	24" or > b.r.	6-feet O.C. random	87
Pawpaw	*Asimina triloba*	FAC	24" or > b.r.	6-feet O.C. random	87
Silky dogwood	*Cornus amomum*	FACW	24" or > b.r.	6-feet O.C. random	273
American hornbeam	*Carpinus caroliniana*	FAC	24" or > b.r.	6-feet O.C. random	87
Arrow-wood	*Viburnum dentatum*	FAC	24" or > b.r.	6-feet O.C. random	87
Alder	*Alnus serrulata*	FACW	24" or > b.r.	6-feet O.C. random	174
Total shrubs					870

Table 7.6
Piedmont/Mountain Alluvial Forest Community
Stream banks and Adjacent Riparian Planting List - Woody Species

Zone(s)	Common Name	Scientific Name	Wetl Ind. Stat.	Size	Spacing	Quantity
Trees/Overstory						
3	Eastern cottonwood	*Populus deltoids*	FAC+	24” or > b.r.	10-feet O.C. random	40
3	Tulip tree	*Liriodendron tulipifera*	FAC	24” or > b.r.	10-feet O.C. random	80
3	Hackberry	*Celtis laevigata*	FACW	24” or > b.r.	10-feet O.C. random	80
3	Green ash	*Fraxinus pennsylvanica*	FACW	24” or > b.r.	10-feet O.C. random	159
3	American sycamore	*Platanus occidentalis*	FACW-	24” or > b.r.	10-feet O.C. random	80
3	American elm	*Ulmus americana*	FACW	24” or > b.r.	10-feet O.C. random	119
3	River birch	*Betula nigra*	FACW	24” or > b.r.	10-feet O.C. random	80
3	Willow oak	*Quercus phellos*	FAC	24” or > b.r.	10-feet O.C. random	40
	Total Trees					678
Shrubs/Understory						
3	Flowering dogwood	*Cornus florida*	FACU	24” or > b.r.	6-feet O.C. random	129
3	American holly	*Ilex opaca*	FAC-	24” or > b.r.	6-feet O.C. random	129
3/2	Alder	*Alnus serrulata*	FACW	24” or > b.r.	6-feet O.C. random	110 / 172
2	Silky dogwood	*Cornus amomum*	FACW	24” or > b.r.	6-feet O.C. random	172
3/2	Spicebush	*Lindera benzoin*	OBL	24” or > b.r.	6-feet O.C. random	110 / 86
3/2	Ironwood	*Carpinus caroliniana*	FAC	24” or > b.r.	6-feet O.C. random	110 / 86
3	Arrow-wood	*Viburnum dentatum*	FAC	24” or > b.r.	6-feet O.C. random	86
	Total shrubs					330 / 860
Live Stakes						
1	Black willow	*Salix nigra*	FACW	36” or >	3-feet O.C. random	2,024
1	Ninebark	*Physiocarpus opulifolius*	FAC-	36” or >	3-feet O.C. random	1,964
1	Silky dogwood	*Cornus amomum*	FACW	36” or >	3-feet O.C. random	1,964
	Total stakes					5,952

On-site Invasive Species Management

Existing invasive species is minimal due to the age of the forest, the existing canopy cover, and the minimal amount of understory. There are some specimens of Nepal grass *(Microstegium vimineum)*, multiflora rose *(Rosa multiflora)*, Japanese honeysuckle *(Lonicera japonica)*, and Chinese privet *(Ligustrum sinense)*, but coverage is sparse. Invasive species are not expected to be a problem. If invasive species appear to be deterring growth of planted species during monitoring, the use of an herbicide approved for use in aquatic areas will be explored.

7.8 Construction Access Plan

To access the site, temporary construction easements are located off two public roads: Gold Hill Road and Saint Johns Church Road. Access points from public roads shall be protected with a construction entrance according to Details Sheets of the Construction Plans. Wetland Restoration Area C shall be accessed from the temporary construction easement located off Saint Johns Church Road. Construction mats shall be used to cross the existing wetland area. Access to Wetland Enhancement Area B and the Stream Enhancement area shall be gained *via* the temporary construction access easement off Gold Hill Road near the land owner’s residence. This will provide access to the north side of the stream. To access the south side of the stream and the Stream Restoration Area, the contractor shall establish crossings at Stations 32+00 and 41+00. The latter crossing is the location of a proposed permanent rock crossing. The crossing at Station 32+00 is to be removed after construction. These locations can be found on Sheet 9.

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SECTION 8
PERFORMANCE CRITERIA

SECTION 8
PERFORMANCE CRITERIA

8.1 Streams

To evaluate the success of the stream restoration and enhancement efforts on Dutch Buffalo Creek, morphological and biological monitoring should be conducted. Specific morphological and biological monitoring requirements to evaluate the success of this project will be determined by NCEEP accordingly.

8.1.1 Dimension, Pattern, and Profile

An initial as-built longitudinal profile and permanent cross-sections will be established and surveyed for both the main channel and the unnamed tributary, which will serve as base-line data for future monitoring years. Each assessment following the initial as-built survey should include re-surveying the same longitudinal profile and permanent cross-sections. Geomorphologic data (profile, pattern, and dimension) will be collected and evaluated to determine whether the stream is stable or unstable. The surveyed data collected will be assessed to determine whether the stream channel is indicating a lateral and/or vertical migration. Reach-wide and cross-sectional pebble counts will also be collected to monitor changes in channel substrate composition. Determining success on the Dutch Buffalo Creek project should include, but not be limited to, evaluating any significant change in the dimension, pattern, profile, and substrate criteria, such as the following parameters:

- Width to depth ratio
- Cross-sectional area
- Bank height ratio
- Substrate composition (D50)
- Bankfull verification (occurs at least twice within 5-year monitoring period)
- Transporting sediment: neither aggradation nor degradation occurring
- Survivability of planted riparian vegetation

8.2 Stormwater Management Devices

All stormwater management devices will be removed once construction has concluded; therefore, describing performance criteria is not necessary.

8.3 Wetlands

As described by the USACE Wilmington District, success criteria must be SMART (specific, measurable, attainable, reasonable, and trackable). Wetland restoration success criteria are normally addressed in terms of the three parameters (vegetation, soils, and hydrology) (USACE, 2007).

Hydrology

Wetland restoration success is largely dictated by the hydrology of the site. Factors considered in establishing wetlands hydrologic success criteria include knowledge of existing and/or relic hydric soil types and target wetland systems, as well as relevant scientific literature. Hydrology will be monitored through the use of Ecotone Water Level Loggers during each growing season for the first five years of monitoring, or until the success criteria have been met, whichever occurs later. The USACE 1987 *Manual* defines an area as wetland if the soil is ponded, flooded, or saturated within 12 inches of the surface for at least 8% (19 consecutive days) of the growing season. NCEEP target hydrological characteristics include saturation or inundation within 12 inches of the surface for 29 consecutive days of the growing season (~12.5%). The growing season in Cabarrus County averages 232 days beginning in late March and continuing through early to mid-November. In addition to the aforementioned criteria, JJG will also use groundwater gauges within the reference wetlands as a target for hydrological success criteria of restored wetland areas. Data for restored and enhanced areas will be compared to data with gauges located in reference areas. An Infinity Rain Gauge will be downloaded monthly in order to compare the groundwater levels to precipitation levels. Tables and charts will be prepared to illustrate the groundwater levels and precipitation totals for the entire growing season. Hydrologic success criteria is reviewed for each well (29 consecutive days within 12 inches) and presented in the report. Once all wells have reached this criterion, then the site has reached success.

Groundwater monitoring wells will be installed by the “Monitoring Team” in each post-restoration community type. Groundwater gauges will be provided and maintained by the NCEEP. Groundwater monitoring well installation will follow the USACE standard methods found in Technical Notes ERDC TNWRAP- 00-02 (July 2000).

Precipitation data collected by the State Climate Office of North Carolina for Concord, NC will be used to determine “normal/average” precipitation for months within the growing season. In the event that there are years of “normal/average” precipitation during the monitoring period and the data for those years does not show that the site has been inundated or saturated for the appropriate hydroperiod during the normal precipitation year, the review agencies may require remedial action. The “Monitoring Team” will provide any required remedial action and continue to monitor hydrology on the site until it demonstrates that the site has been inundated or saturated for the appropriate hydroperiod.

8.4 Vegetation

Successful restoration of the wetland vegetation on a restoration site is dependent upon hydrologic restoration, active planting of native vegetative community species, and volunteer regeneration of the native plant communities. Vegetative success at the restoration site will be measured by survivability over a five-year monitoring period. Success for the site will be based on the survival of at least 320 planted woody stems per acre at the end of year three, 290 planted woody stems per acre at the end of year four, and 260 planted woody stems per acre at the end of year five of the monitoring period.

In addition to the above-listed success criteria, noxious/invasive species will be identified and controlled so that none become dominant or alter the desired community structure of the site. If noxious plants are identified as problematic on the site, the "Monitoring Team" will develop and implement a species-specific control plan. During the five-year monitoring period, the "Monitoring Team", where necessary, will remove, treat, or otherwise manage undesirable plant or animal species, including physical removal and use of herbicides.

Monitoring will also include photo documentation of vegetative communities within monitoring plots. Photographs will be taken from the monument control (southwest corner of the plot). Site specific vegetation monitoring protocol will be developed and finalized by the NCEEP.

8.5 Schedule/Reporting

Monitoring, scheduling, and reporting will be finalized by NCEEP. Typically, there is an initial as-built monitoring survey and a monitoring plan established immediately following construction. The establishment of monitoring features and the collection and summarization of monitoring data shall be conducted in accordance with the most current EEP document entitled "Content, Format, and Data Requirements for EEP Monitoring Reports." Subsequently, the site will be monitored and reported on annually for five years, or until success criteria are met, whichever occurs last.

SECTION 9
REFERENCES

SECTION 9
REFERENCES

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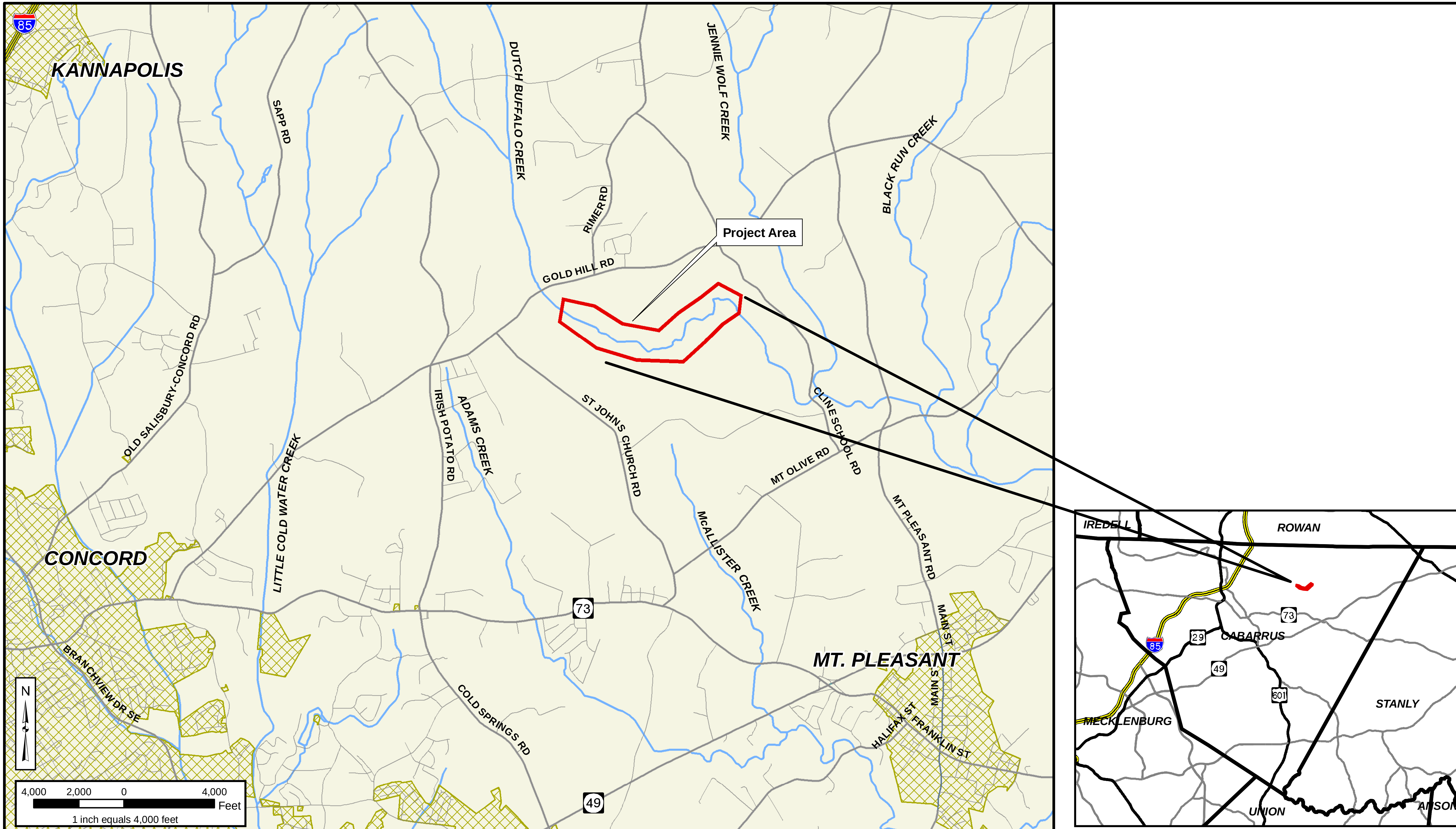
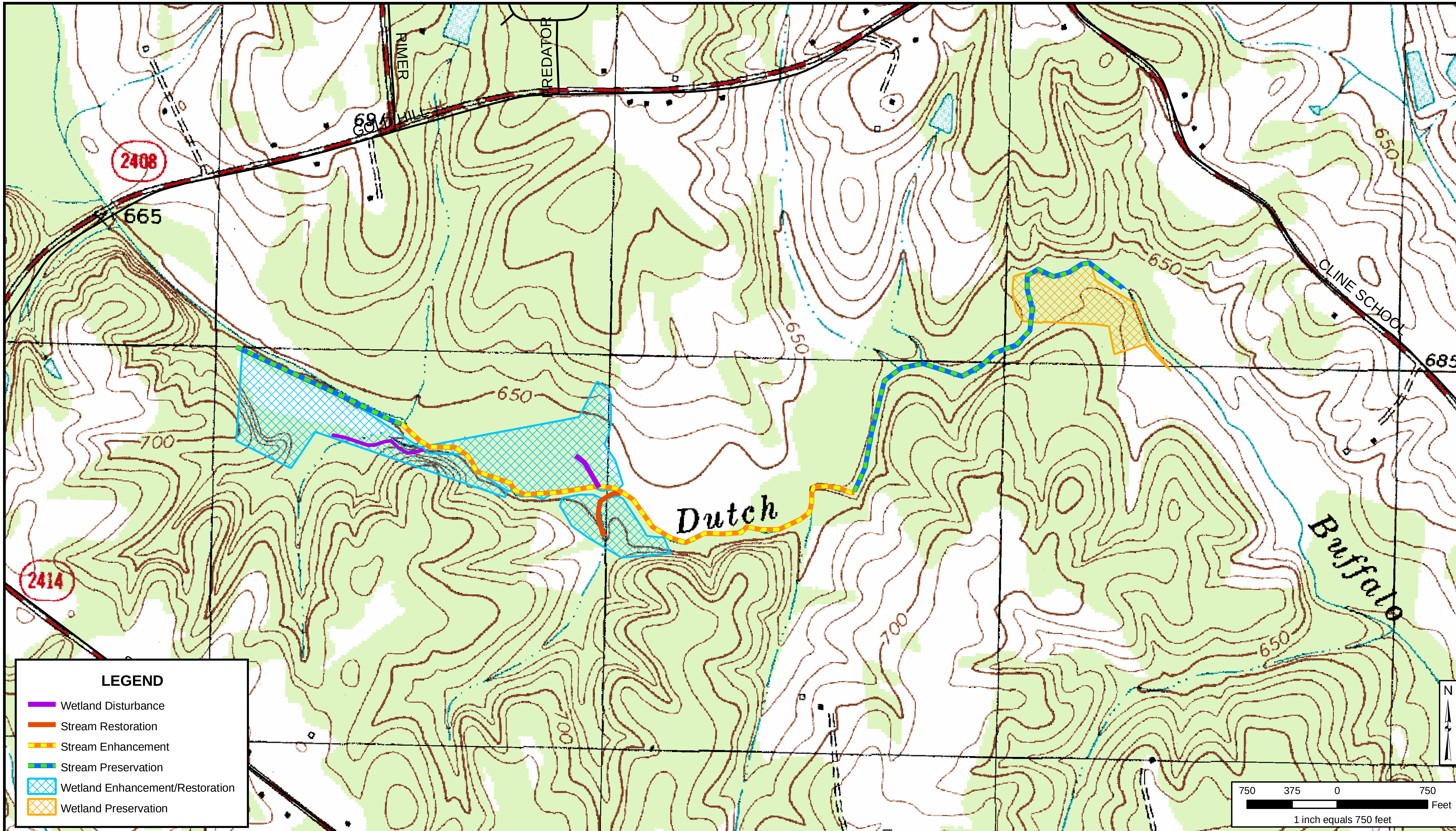
SECTION 10
FIGURES



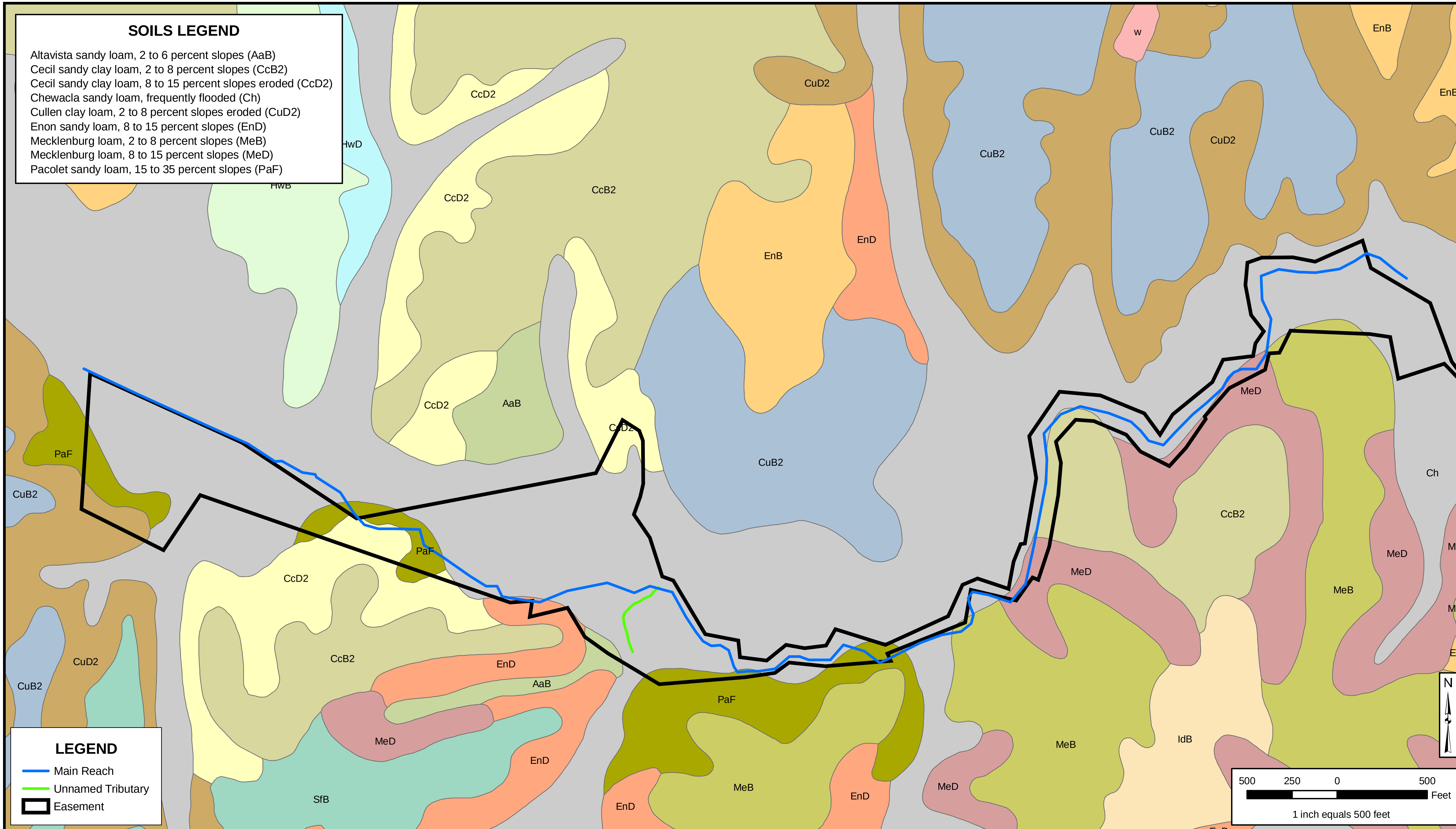
Dutch Buffalo Creek Stream Restoration Project
Project Site Vicinity Map
Cabarrus County, NC

Figure 1.1
May 2007
Project No: 3060002



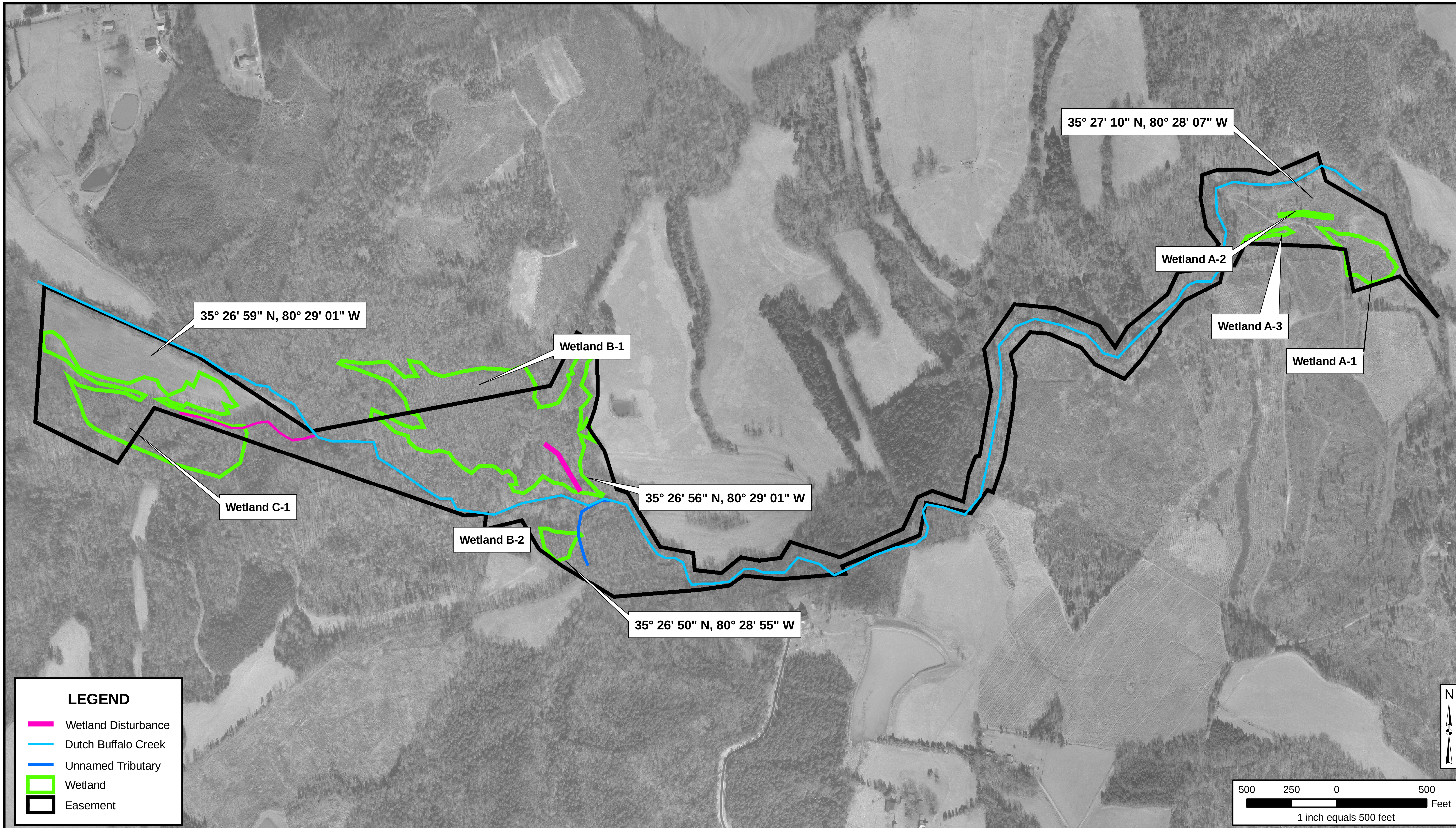
Dutch Buffalo Creek Stream Restoration Project
Project Site USGS Map, Mt. Pleasant Quadrangle
Cabarrus County, NC

Figure 2.1
May 2007
Project No: 3060002



Dutch Buffalo Creek Stream Restoration Project
Project Site NRCS Soils Map
Cabarrus County, NC

Figure 2.3
May 2007
Project No: 3060002

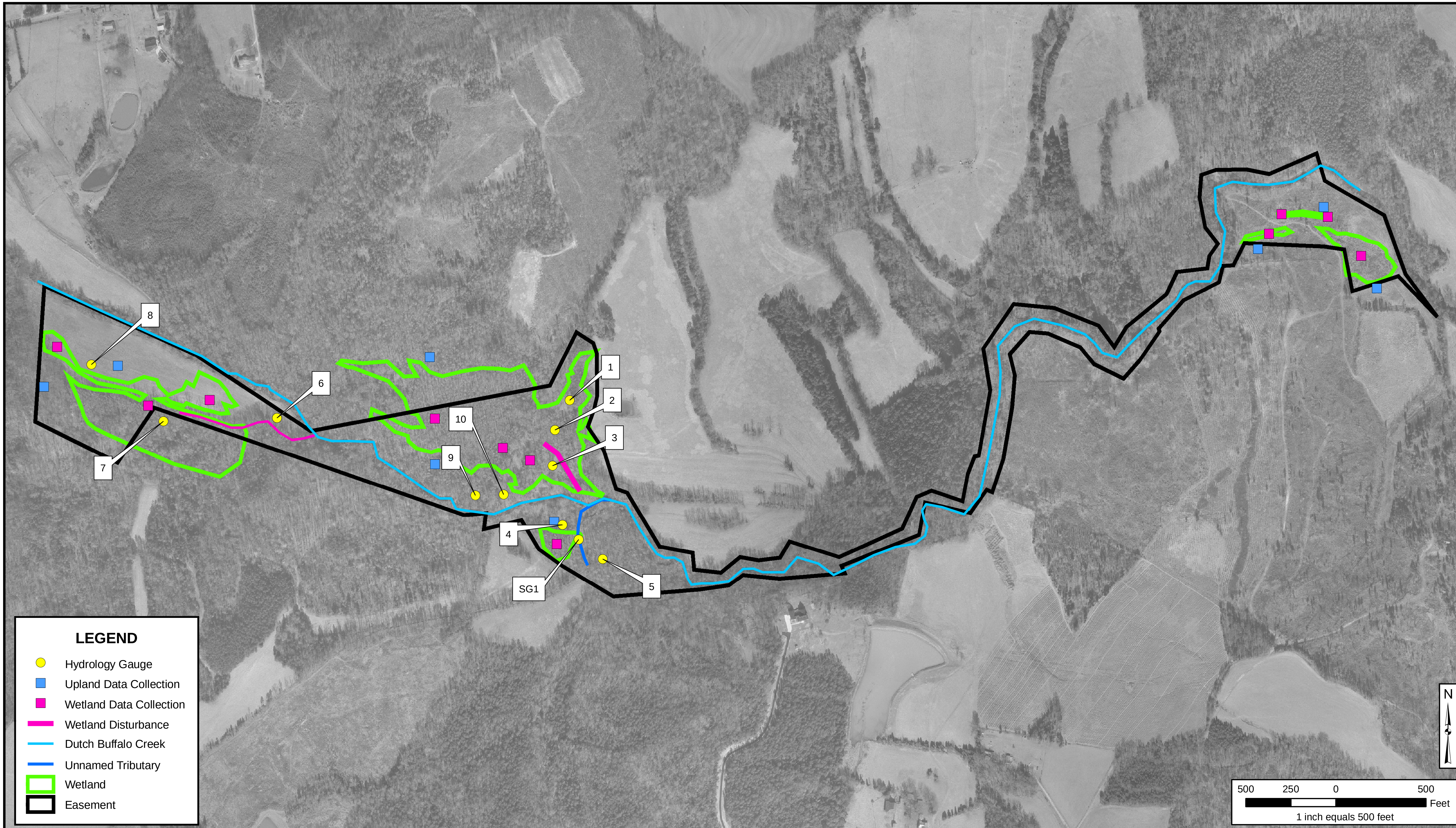


Ecosystem Enhancement Program

JORDAN JONES & GOULDING

Dutch Buffalo Creek Stream Restoration Project
Project Site Hydrological Features Map
Cabarrus County, NC

Figure 5.1a
September 2007
Project No: 3060002

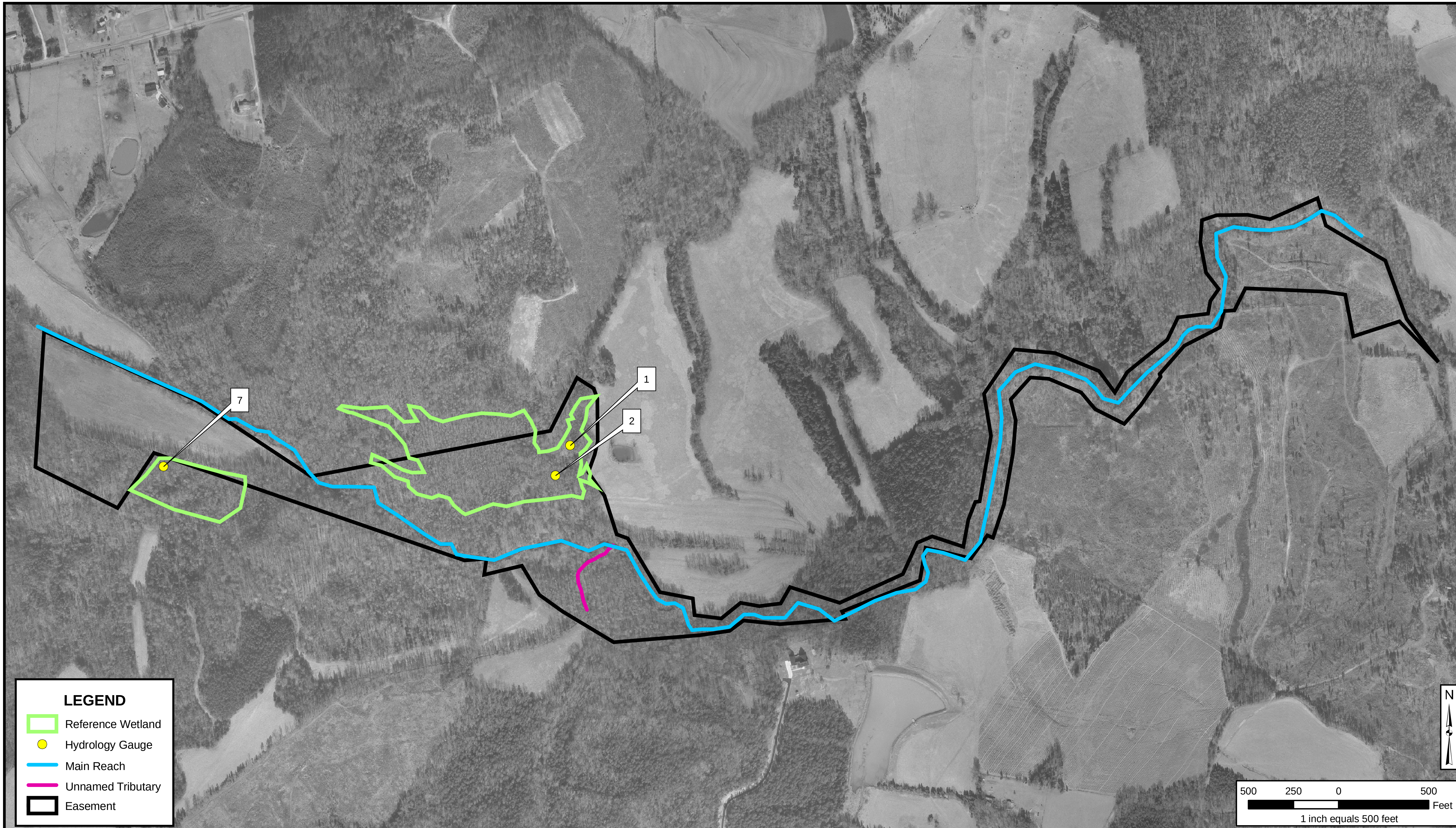


Ecosystem Enhancement Program

JORDAN JONES & GOULDING

Dutch Buffalo Creek Stream Restoration Project
Project Site Hydrological Studies Map
Cabarrus County, NC

Figure 5.1b
September 2007
Project No: 3060002



Ecosystem Enhancement Program

JORDAN JONES & GOULDING

Dutch Buffalo Creek Stream Restoration Project
Reference Wetlands Site Map
Cabarrus County, NC

Figure 6.1
May 2007
Project No: 3060002

SECTION 11
DESIGN SHEETS

MORPHOLOGICAL TABLE

	Parameter	Existing DBC Main Reach MIN	Existing DBC Main Reach MAX	Existing UT to DBC MIN	Existing UT to DBC MAX	Ref Reach Morgan Creek MIN	Ref Reach Morgan Creek MAX	Ref Reach Sal's Branch MIN	Ref Reach Sal's Branch MAX	Proposed DBC Main Reach MIN	Proposed DBC Main Reach MAX	Proposed UT MIN	Proposed UT MAX
General	Drainage Area (sq mi)	21.3		0.31		8.35		0.3		21.3		0.31	
	Stream Type (Rosgen)	C5e*		G5c*		C4		E4		C5e		C/E4	
	Valley Type	VIII		VIII		-		-		VIII		VIII	
Dimension	BKF Mean Velocity (Vbkf) (ft/s)	3.31	3.58	3.8		6.6		3.5		3.21		3.65	
	Bankfull Discharge (Qbkf)(cfs)	423***		39.04***		524		38		476***		32.83***	
	Bankfull XSEC Area, Abkf (sq ft)	146.68	158.41	10.17		75.1	79.8	10.95		148.29		9.00	
	Bankfull Width, Wbkf (ft)	32.02	49.31	8.68		33.2	33.5	8.3		39.70		9.00	
	Bankfull Mean Depth, dbkf (ft)	3.03	4.95	1.17		2.26	2.38	1.3		3.74		1.00	
	Width to Depth Ratio, W/D (ft/ft)	6.47	16.27	7.42		14.69	14.08	6.4		10.61		9.00	
	Width Floodprone Area, Wfpa (ft)	>150		9.8		77.5	86.8	130		150		150	
	Entrenchment Ratio, Wfpa/Wbkf) (ft/ft)	3.04	4.68	1.13		2.33	2.59	15.66		3.78		16.67	
	Max Depth @ bkf, Dmax (ft)	5.48	6.67	1.49		2.8	2.9	1.9		5.03		1.50	
	Max Depth Ratio, Dmax/dbkf	1.81	1.35	1.27		1.24	1.22	1.46		1.34		1.5	
	Max Depth @ tob, Dmaxtob (ft)	6.68	8.37	3.77		2.8	2.9	2.28		5.03		1.5	
	Bank Height Ratio, Dtob/Dmax (ft/ft)	1.22	1.25	2.53		1	1	1.2		1.00		1	
	Pool Max Depth, Dmaxpool (ft)	6.02	6.86	1.79		4.1		2.4		6.70		1.00	1.80
	Pool Max Depth Ratio, Dmaxpool/dbkf	1.99	1.39	1.53		1.81		1	1.8	1.79		1.00	1.8
	Pool Area, Apool (sqft)	158.5	189.5	10.26		88.9		26		153.20		11.30	
	Pool Area Ratio, Apool/Abkf	1.08	1.2	5.73		1.18		2.4		1.03		1.26	
	Pool Width, Wpool (ft)	32.89	40.76	10.16		25.9		14		51.50		11.70	
	Pool Width Ratio, Wpool/Wbkf	1.03	0.83	1.17		0.78		1.7		1.30		1.30	
	Pool Length, Lpool (ft)	52.47	194.86	5.89	37.56	-		7.8	35	52.47	194.86	21.1	54.1
	Pool Length Ratio, Lpool/Wbkf	1.64	3.95	0.68	4.33	-		0.9	4.2	1.64	3.95	2.34	6.01
	Pool-Pool Spacing, Lps (ft)	45.06	238.08	17.35	125.66	4.38	8.31	40.3	60	45.06	238.08	34.60	67.90
	Pool-Pool Spacing Ratio, Lps/Wbkf	1.41	4.83	2	14.48	0.13	0.25	4.9	7.2	1.41	4.83	3.84	7.54
Pattern	Meander Length, Lm (ft)	84.59	965.64	43	109	-		60	69	84.59	965.64	57.60	126.00
	Meander Length Ratio, Lm/Wbkf	2.64	19.58	4.98	21.9	-		7.2	8.3	2.64	19.58	6.40	14.00
	Radius of Curvature, Rc (ft)	39.25	153.4212	10.38	37.99	-		12	19	39.25	153.4212	22.50	27.00
	Rc Ratio, Rc/Wbkf	1.23	3.11	1.2	4.38	-		1.4	2.3	1.23	3.11	2.50	3.00
	Belt Width, Wblt (ft)	11.07	660.68	2.5	19.4	-		33	69	11.07	660.68	33.30	81.00
	Meander Width Ratio, Wblt/Wbkf (ft)	0.35	13.4	0.29	2.24	-		4	8.3	0.35	13.4	3.70	9.00
	Sinuosity, K	1.18^	1.4	1.24		-		1.8		1.18^	1.4	1.13	
Profile	Valley Slope, Sval (ft/ft)	0.0011		0.0063		-		0.012		0.0011		0.0062	
	Channel Slope, Schan (ft/ft)	0.0014		0.0078		0.007		0.005		0.0014		0.0055	
	Slope Riffle, Srif (ft/ft)	0.0016	0.0071	0.0031	0.0386	0.014	0.024	0.016	0.024	0.0016	0.0071	0.0140	0.0240
	Riffle Slope Ratio, Srif/Schan	1.14	5.05	0.39	4.95	2	3.43	3.2	4.8	1.14	5.05	2.55	4.36
	Riffle Length, Rlength (ft)	8.31	106.24	6.76	41.57	-		5.4	23	8.31	106.24	10	41.20
	Riffle Length Ratio, Rlength/Wbkf	0.26	2.15	0.78	4.79	-		0.7	2.8	0.26	2.15	1.11	4.58
	Slope Pool, Spool (ft/ft)	0.0004	0.0036	0	0.0051	0		0		0.0004	0.0036	0	0
	Pool Slope Ratio, Spool/Schan	0.29	2.59	0	0.65	0		0		0.29	2.59	0	0
	Slope Run, Srun (ft/ft)	0.0003	0.0022	0.001	0.0264	0.0026		-		0.0003	0.0022	-	
	Run Slope Ratio, Srun/Schan	0.22	1.55	0.13	3.38	0.37		-		0.22	1.55	-	
	Slope Glide, Sglide (ft/ft)	-		0.0026	0.0899	0.006		-		-		-	
	Glide Slope Ratio, Sglide/Schan	-		0.33	11.52	0.86		-		-		-	

Cells noted with a (*) have been classified using a typical cross-section within each reach. Cells noted with a (***) were calculated using Bentley Flowmaster, Cells noted with a (^) were calculated within enhancement reach limits

Cells noted with a (-), data were not provided. NCSU and NCDOT (http://www.ncdot.org/doh/preconstruct/highway/hydro/Stream/) used as verification for reference data collected at these streams

NO.	DATE	DESCRIPTION OF REVISION
C	11-01-07	REVISE PLAN ACCORDING TO FIELD VISIT
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
A	06-22-07	NCEEP COMMENTS

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REVIEW COORDINATOR LIN XU

SENIOR SCIENTIST DAN RICE

PROJECT ENGINEER MATTHEW CLABAUGH, PE

NOT RELEASED FOR CONSTRUCTION

DUTCH BUFFALO CREEK STREAM RESTORATION PROJECT

MORPHOLOGICAL TABLE

DESIGNED: MMC | CHECKED: DR | DATE: NOVEMBER, 2007 | SHEET 4 | REV C

DRAWN: MXD | JOB NO 03060-002 | SCALE:

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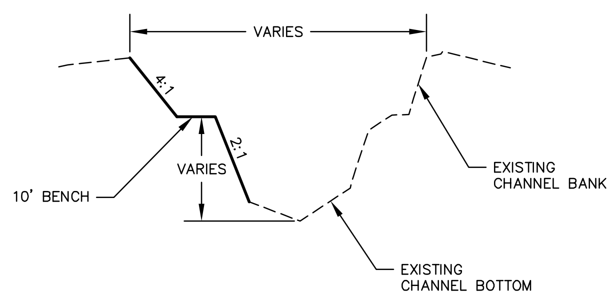
TYPICALS

NOT TO SCALE

DUTCH BUFFALO CREEK TYPICALS



LEFT BANK RIFFLE

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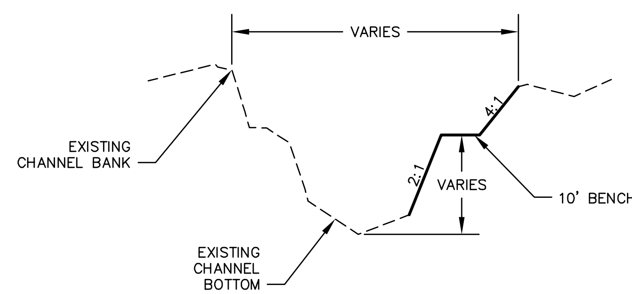

RIGHT BANK RIFFLE

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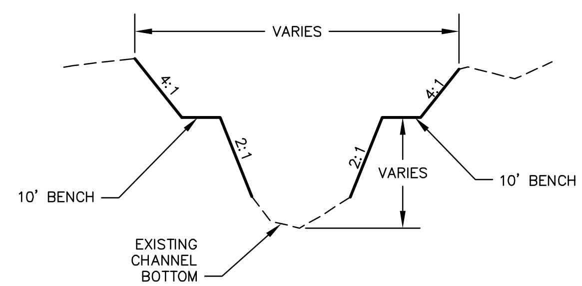

BOTH BANK RIFFLE

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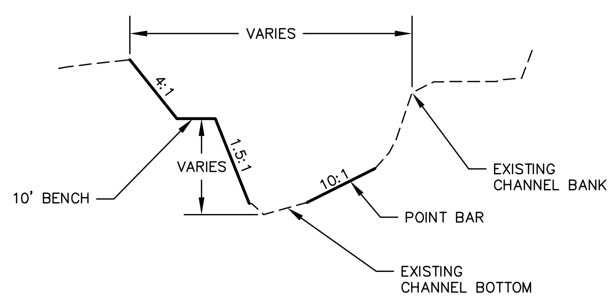

LEFT BANK POOL

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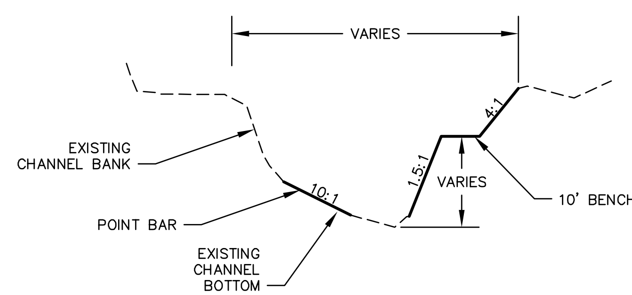
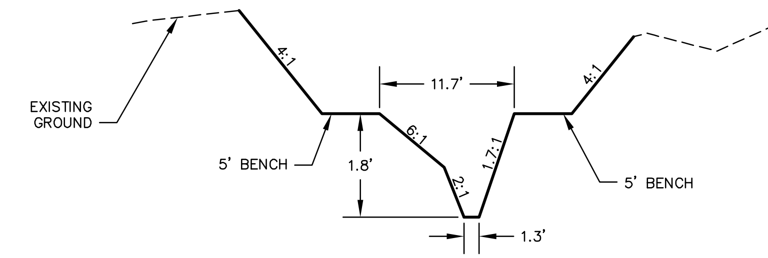


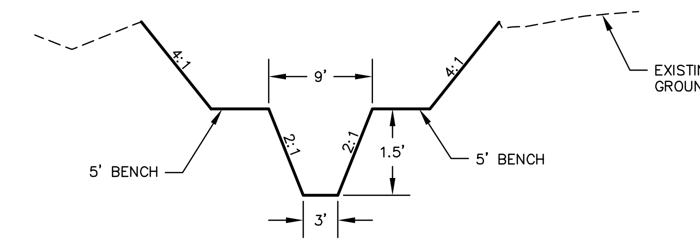
RIGHT BANK POOL

N.T.S.

UT TYPICALS



POOL



RIFFLE

NO.	DATE	DESCRIPTION OF REVISION
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
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TYPICALS

DESIGNED: MMC	CHECKED: DR	DATE: MAY, 2007	5	B
DRAWN: MXD	JOB NO. 03060-002	SCALE:	SHEET	REV

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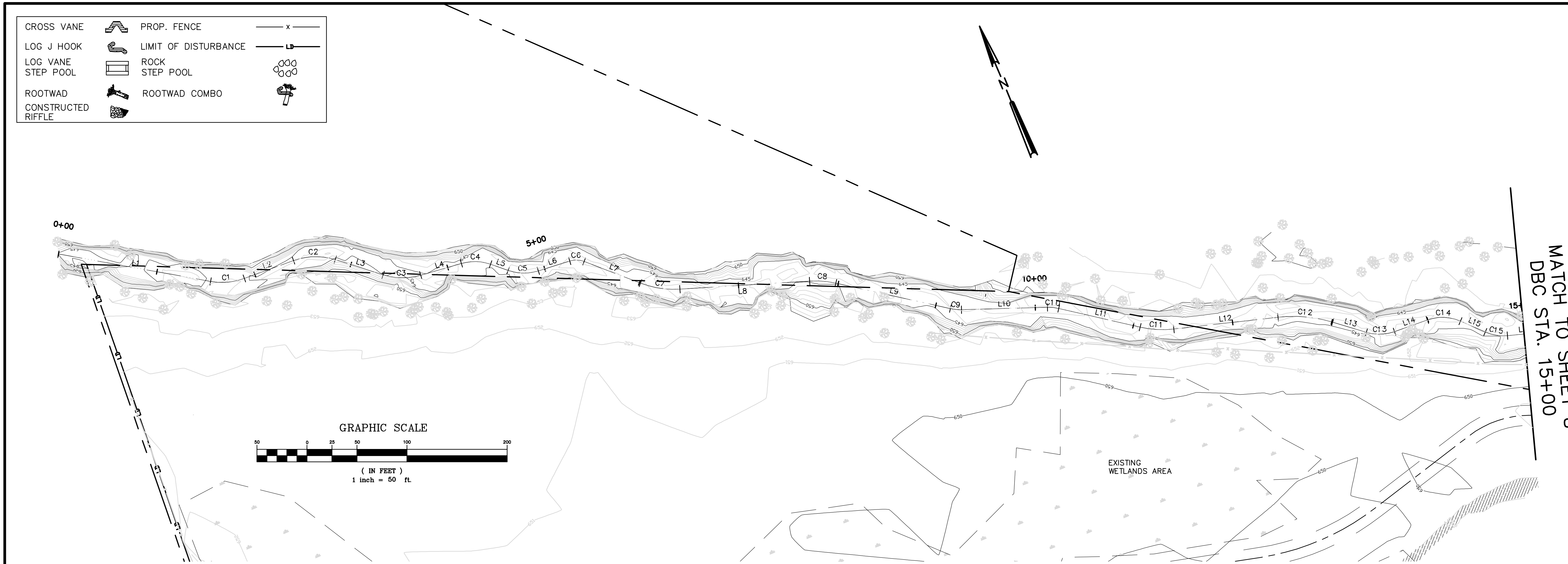

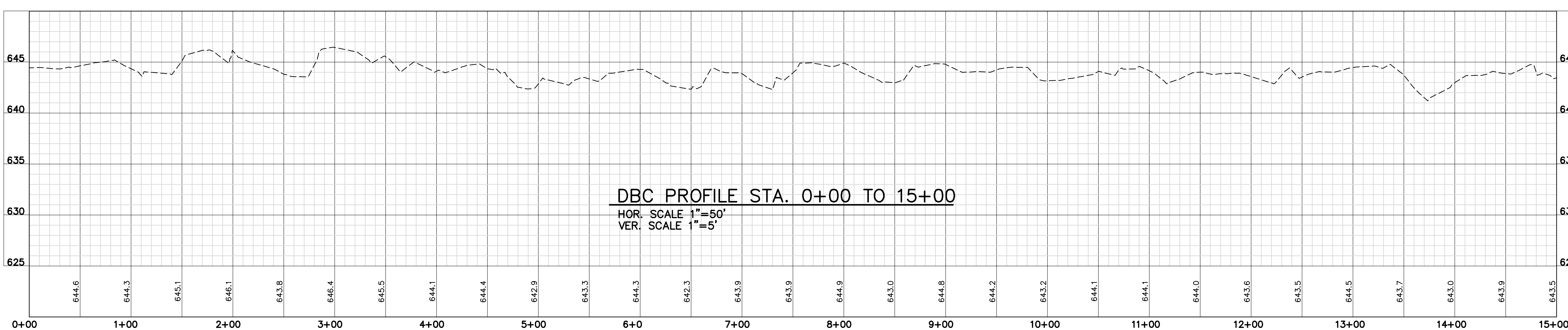

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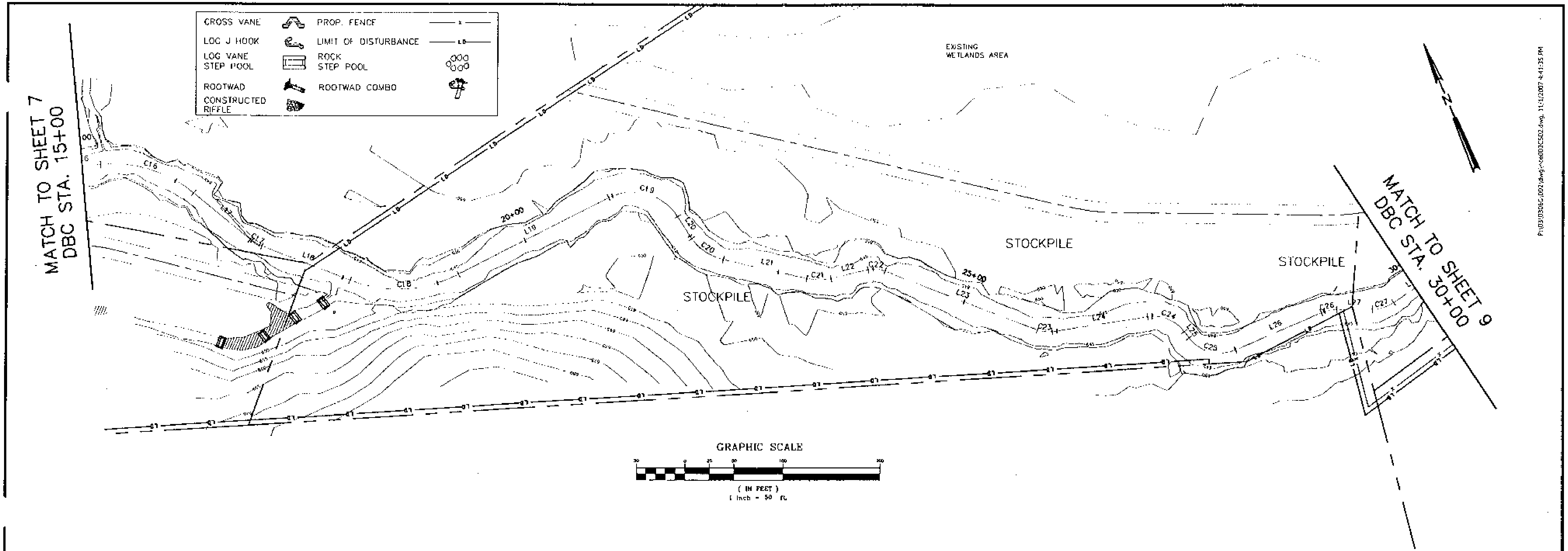
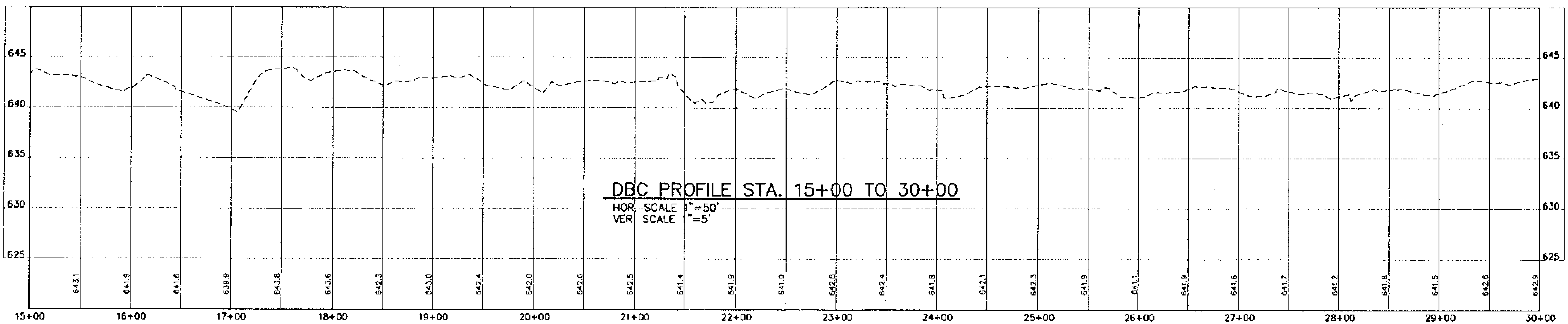
PLAN & PROFILE

DESIGNED: MMC	CHECKED: DR	DATE: MAY, 2007	7 SHEET	B REV
DRAWN: MXD	JOB NO. 03060-002	SCALE:		





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PLAN & PROFILE

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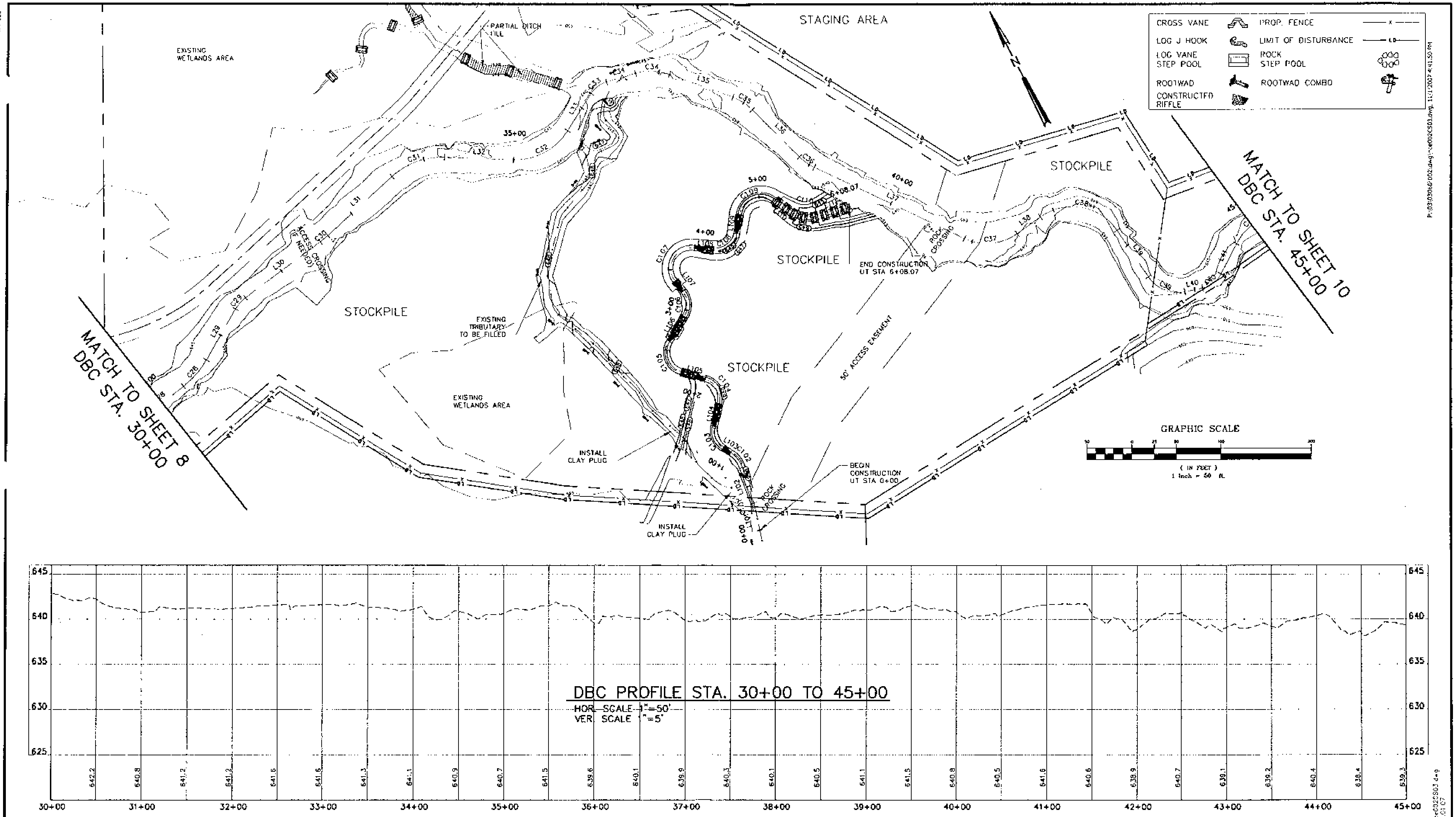

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STREAM RESTORATION PROJECT

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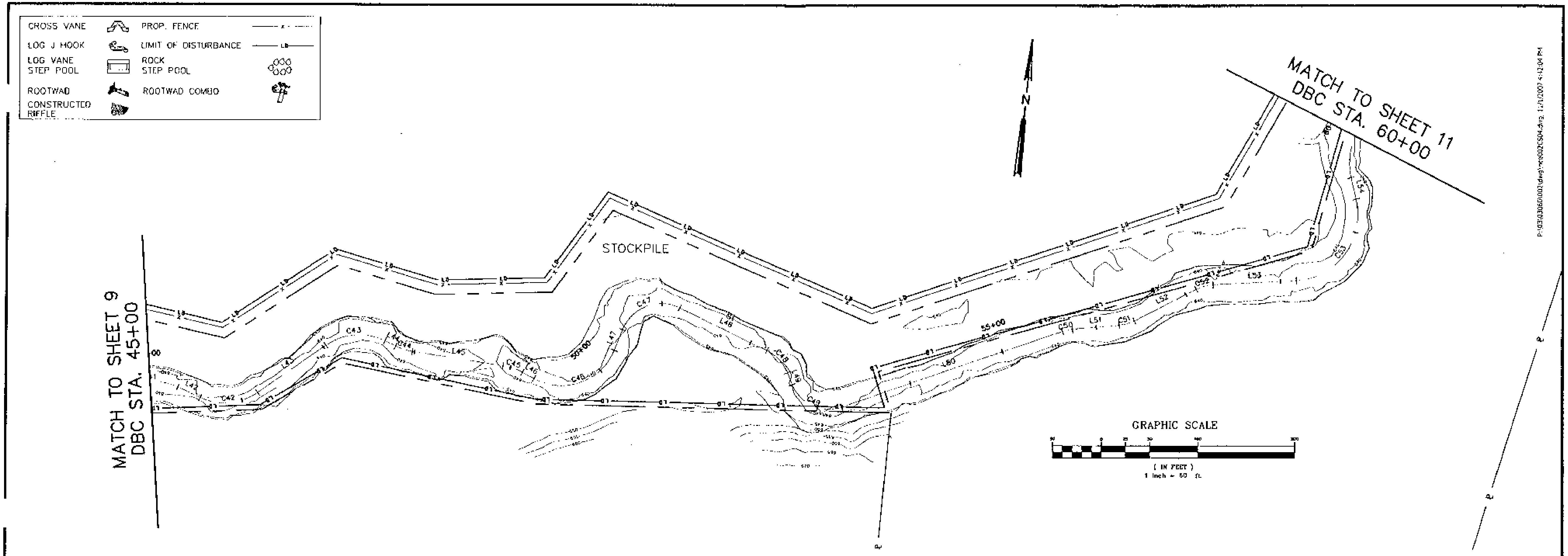

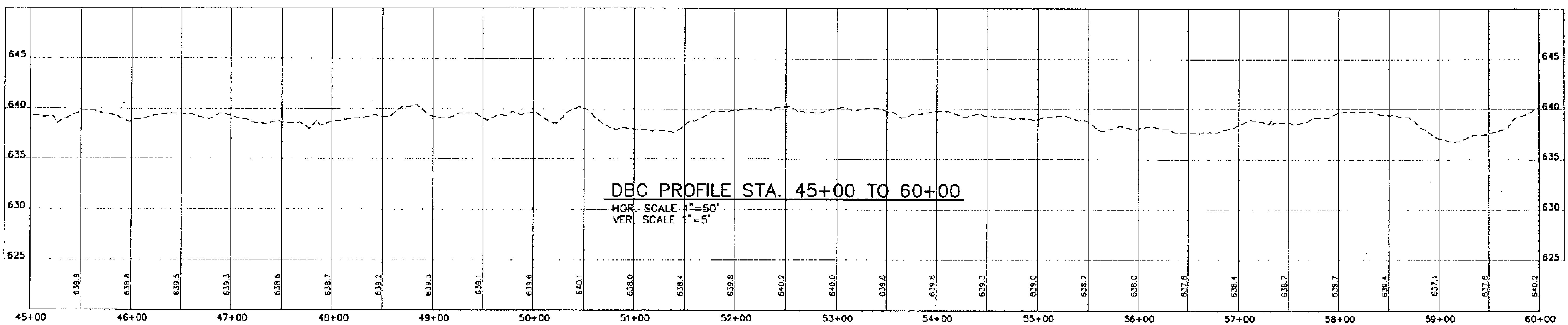

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PLAN & PROFILE

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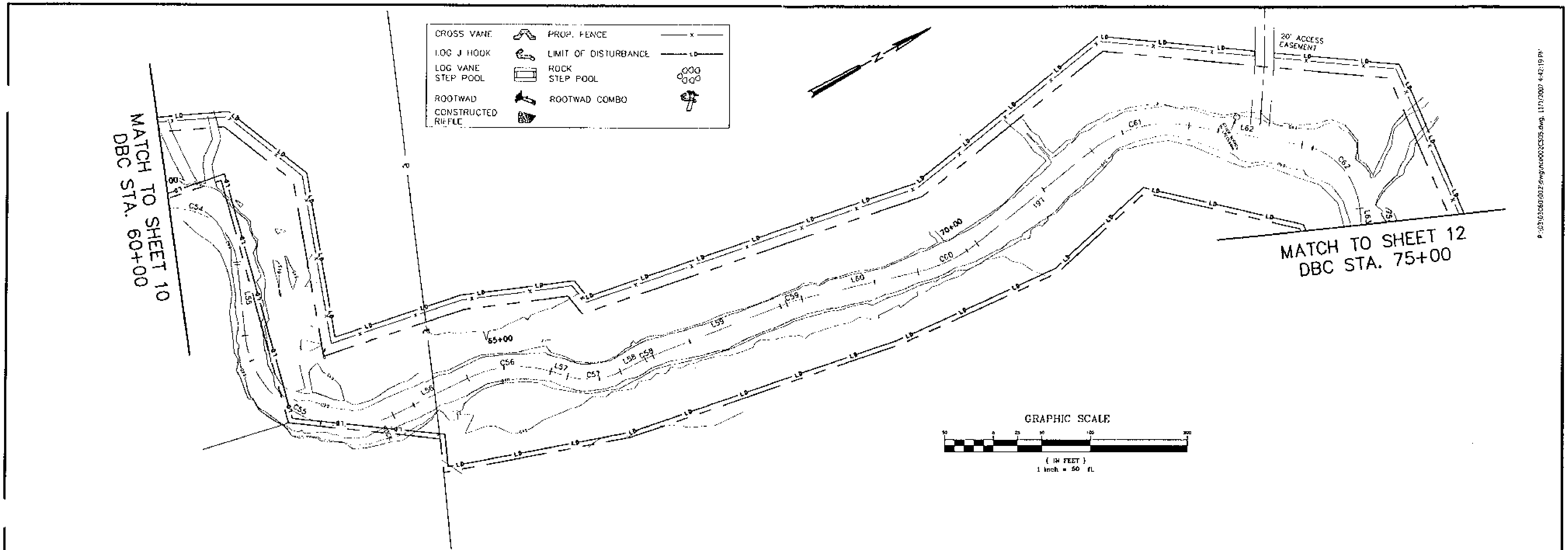

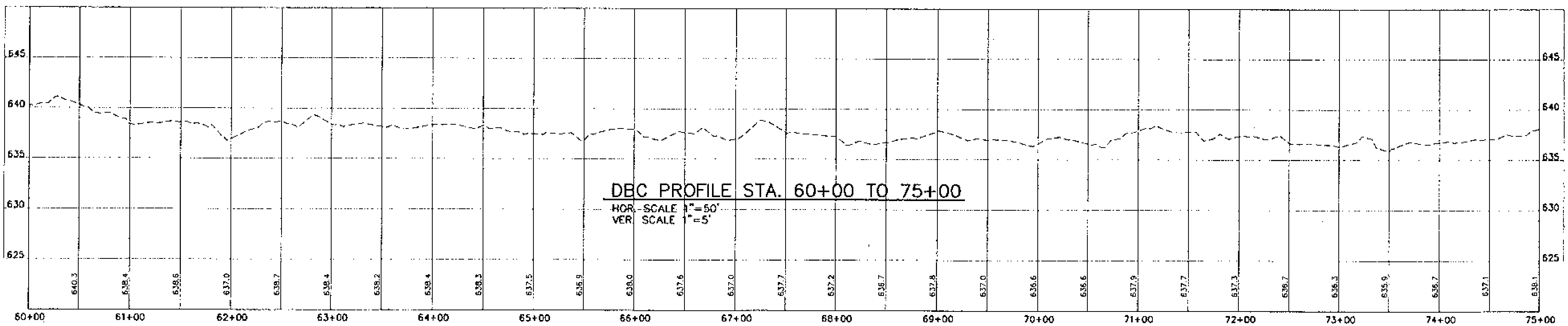

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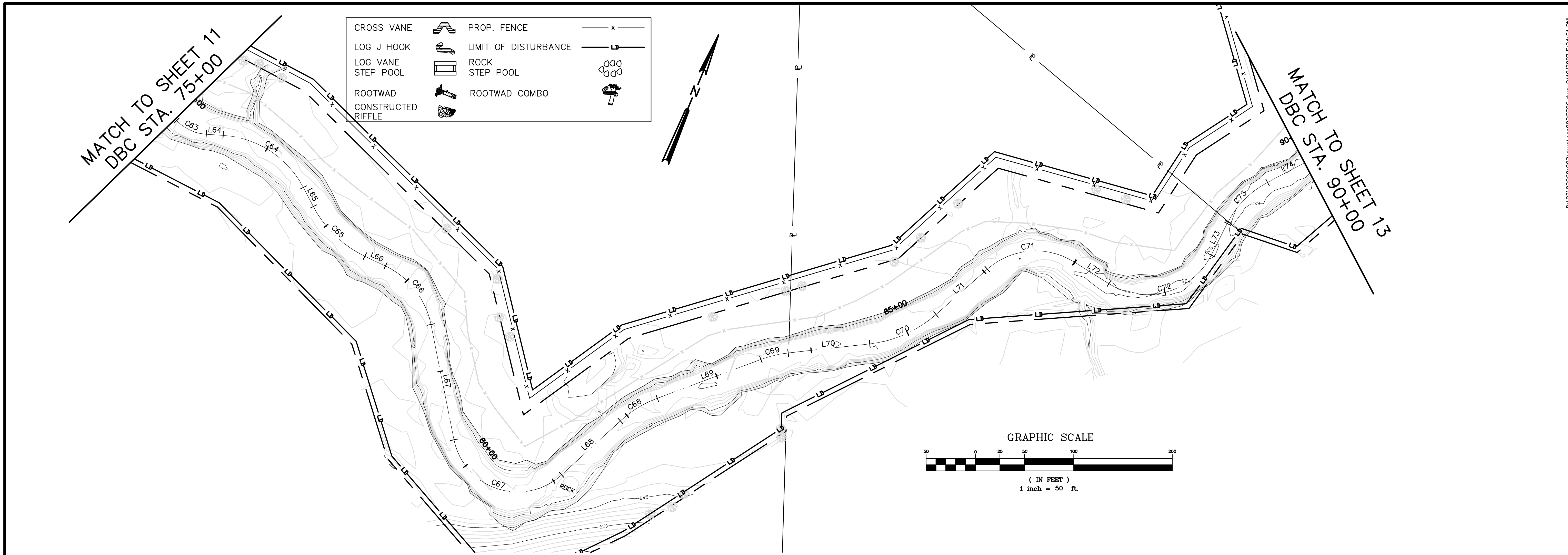

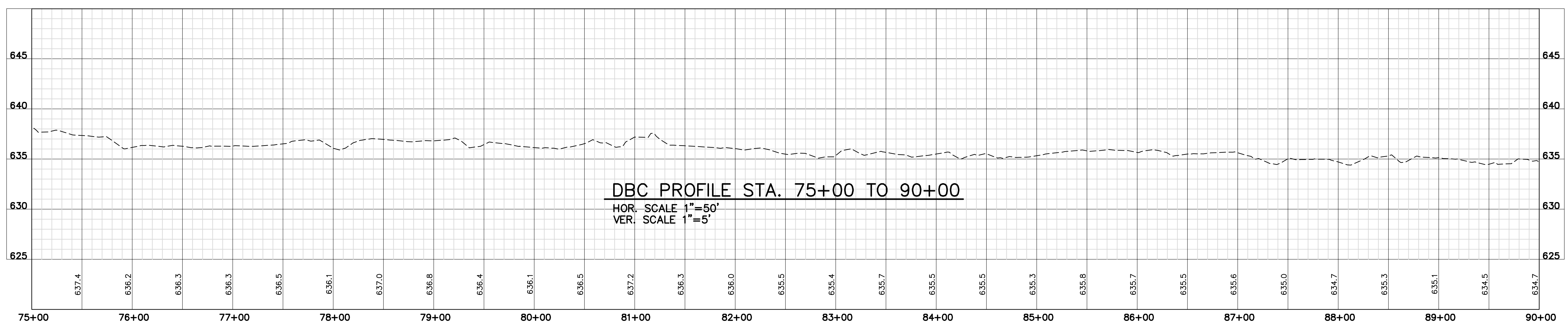

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PLAN & PROFILE

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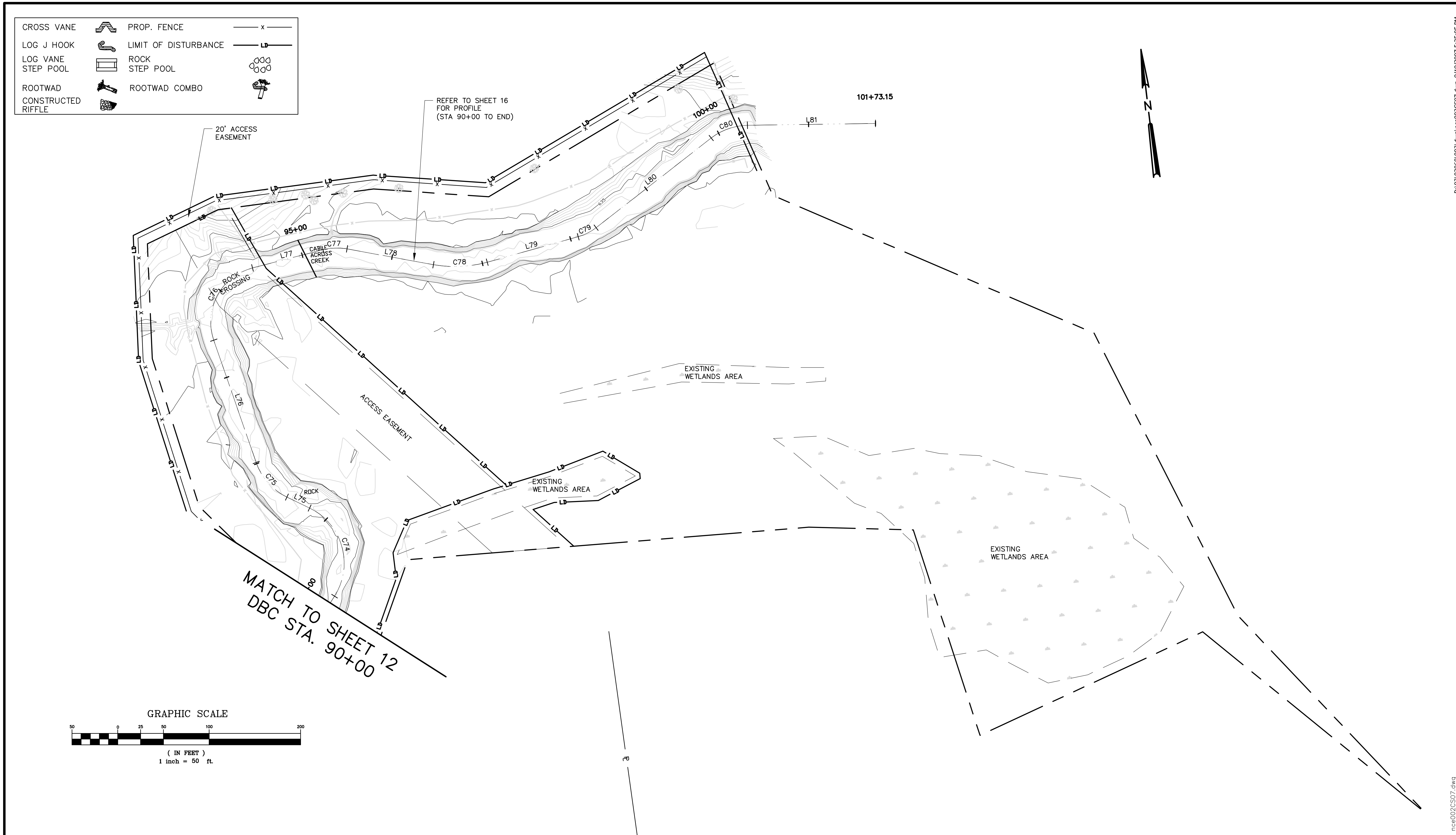

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DUTCH BUFFALO CREEK
STREAM RESTORATION PROJECT

PLAN & PROFILE

DESIGNED: MMC	CHECKED: DR	DATE: MAY, 2007	13 SHEET	B REV
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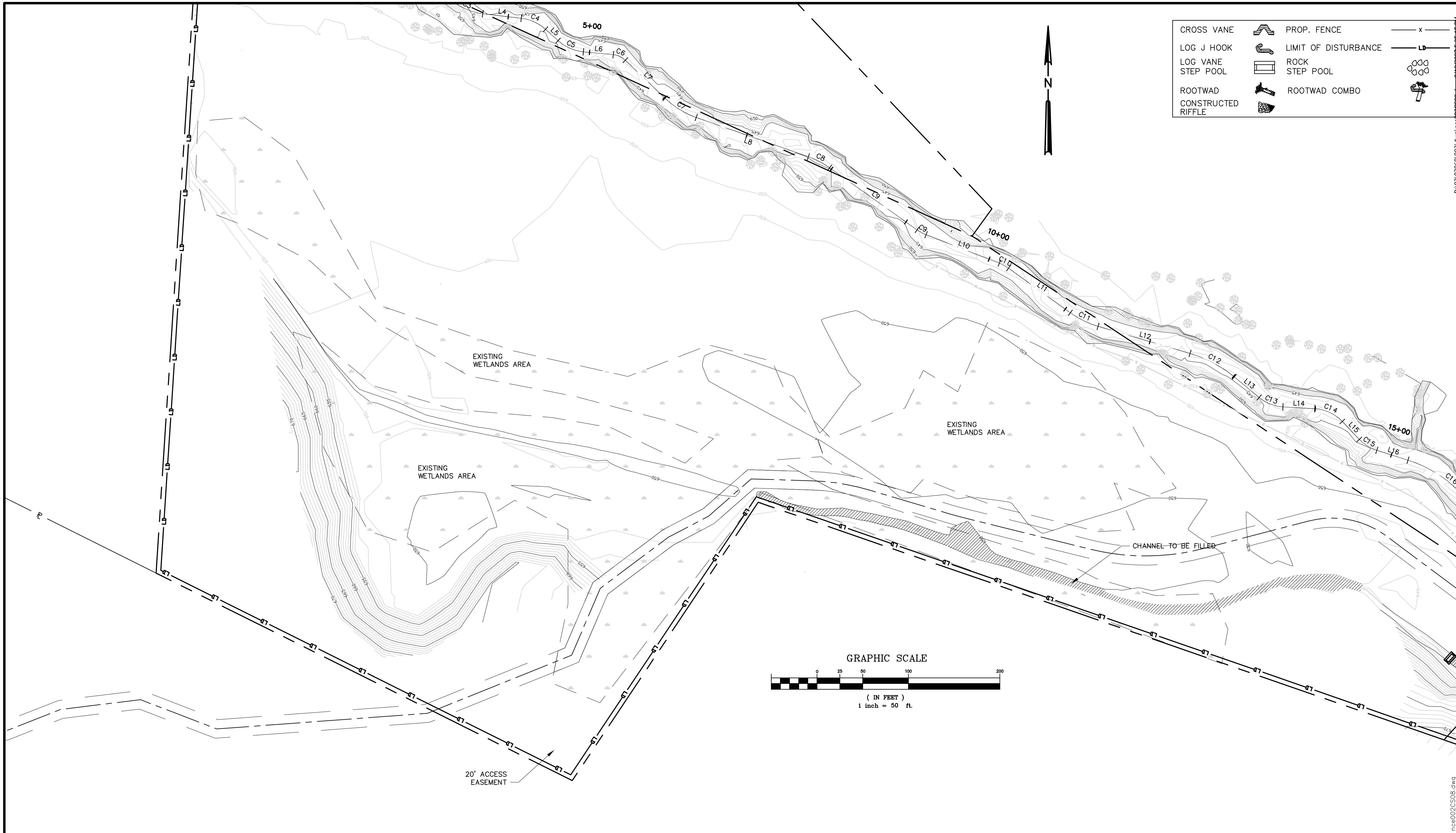

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DUTCH BUFFALO CREEK
STREAM RESTORATION PROJECT

WETLAND RESTORATION PLAN

DESIGNED: MMC	CHECKED: DR	DATE: MAY, 2007	14 SHEET	B REV
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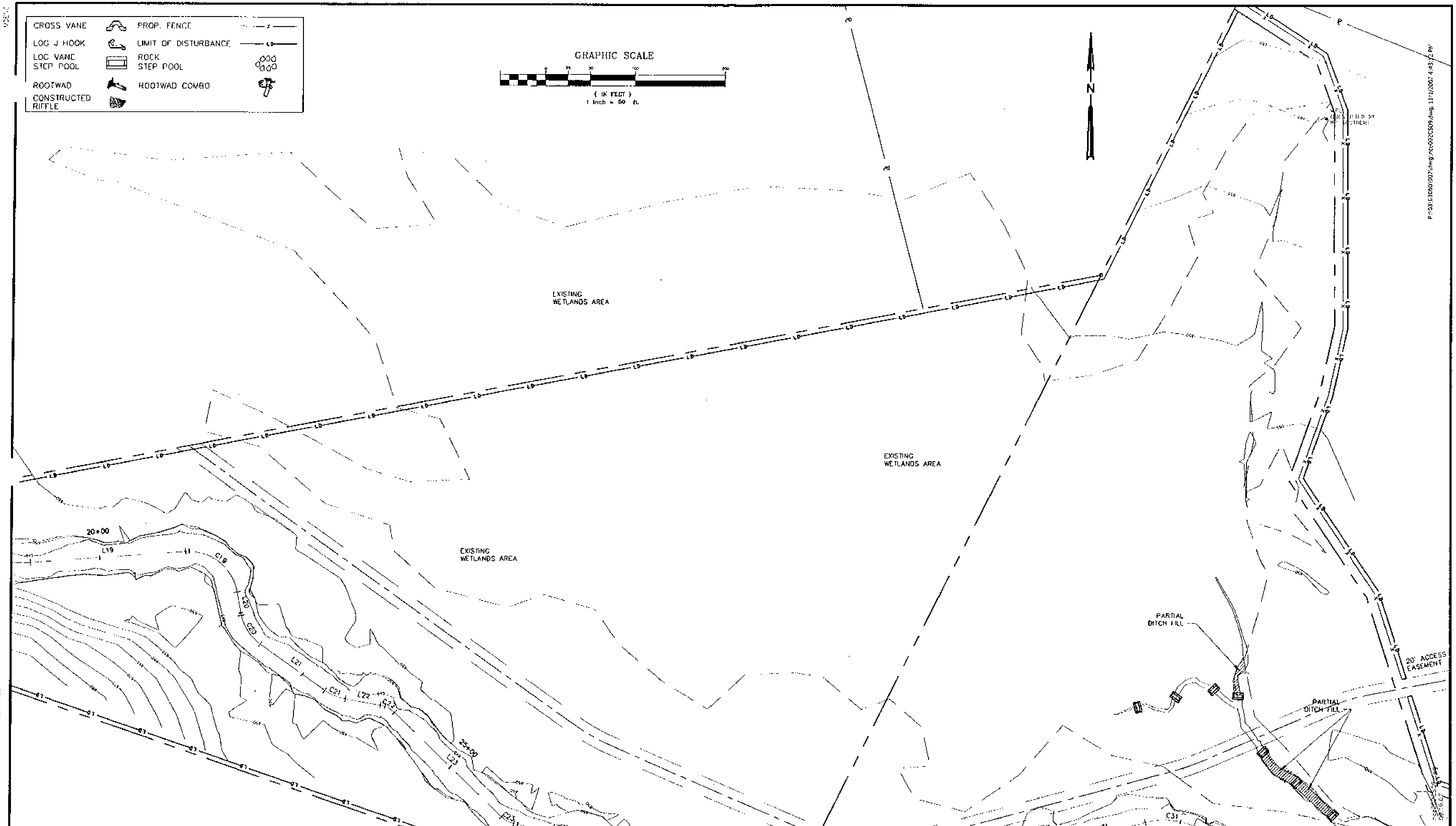

NO.	DATE	DESCRIPTION OF REVISION
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DUTCH BUFFALO CREEK
STREAM RESTORATION PROJECT

WETLAND RESTORATION PLAN

DESIGNED: MMC	CHECKED: DR	DATE: NOVEMBER, 2007	15	C
DRAWN: MXD	JOB NO. 03060-002	SCALE:	SHEET	REV

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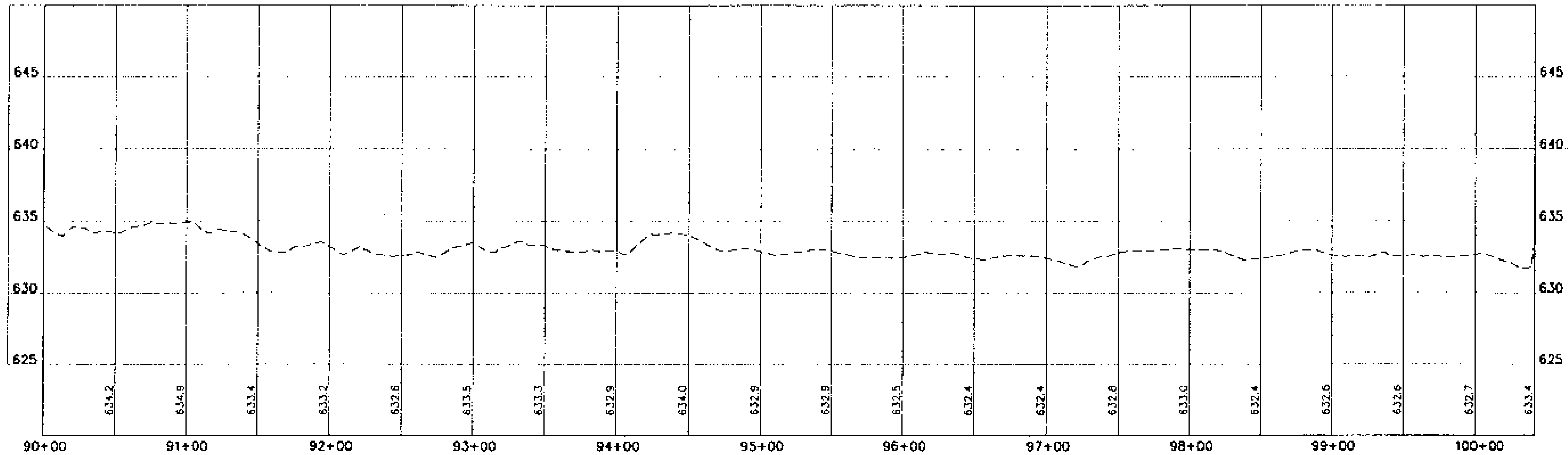

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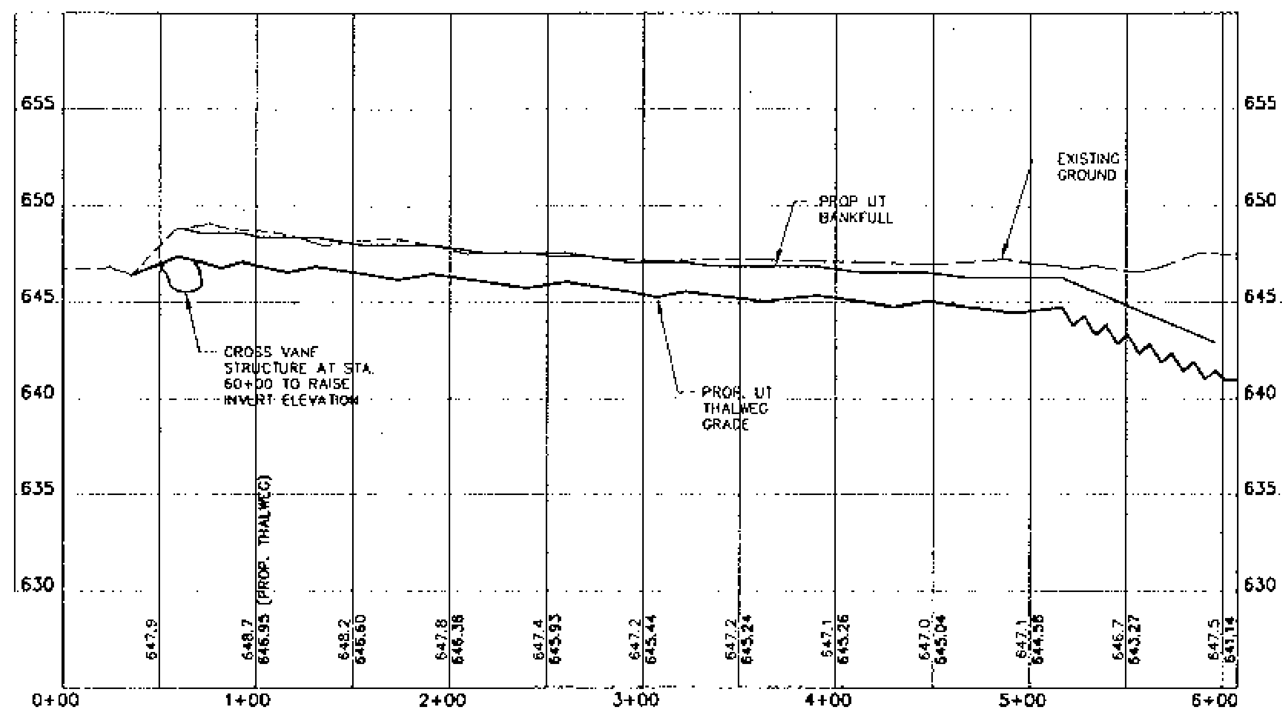
VER. SCALE 1"=5'



UT PROFILE

HOR. SCALE 1"=50'
VER. SCALE 1"=5'

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C	11-01-07	REVISE PLAN ACCORDING TO FIELD VISIT
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DUTCH BUFFALO CREEK STREAM RESTORATION PROJECT

PROFILE

DESIGNED: MMC	CHECKED: DR	DATE: NOVEMBER, 2007	16 SHEET	C REV
DRAWN: MXD	JOB NO 03060-002	SCALE:		

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MAIN CHANNEL – EXIST. CENTERLINE ALIGNMENT (TO BE RETAINED)

LINE TABLE

LINE	LENGTH	BEARING	START NORTHING	START EASTING	END NORTHING	END EASTING
L1	154.54	S56°56'28"E	622531.8403	1555600.7498	622447.5412	1555730.2675
L2	52.30	S87°08'03"E	622437.0996	1555762.4752	622434.4846	1555814.7144
L3	50.11	S49°36'38"E	622419.0736	1555853.5833	622386.6047	1555891.7484
L4	42.34	S83°15'17"E	622371.5624	1555926.2324	622366.5896	1555968.2760
L5	18.54	S47°51'42"E	622354.5152	1555994.8473	622342.0796	1556008.5866
L6	32.90	S84°33'12"E	622329.8897	1556036.2348	622326.7671	1556068.9841
L7	60.28	S46°09'33"E	622320.7343	1556082.1344	622278.9832	1556125.6099
L8	129.91	S70°41'19"E	622258.0712	1556159.6336	622215.1083	1556282.2379
L9	117.31	S54°36'27"E	622205.0265	1556305.5941	622135.0839	1556401.2255
L10	86.02	S68°43'48"E	622129.8334	1556410.9659	622098.6278	1556491.1262
L11	83.47	S54°11'20"E	622093.1858	1556501.1321	622044.3455	1556568.8229
L12	104.83	S73°36'57"E	622029.5011	1556599.1271	621999.9301	1556699.7042
L13	35.29	S50°22'50"E	621974.2129	1556748.0675	621951.7062	1556775.2546
L14	34.89	S86°40'43"E	621941.4451	1556801.3433	621939.4238	1556836.1718
L15	27.05	S43°30'12"E	621925.4773	1556866.2046	621905.8567	1556884.8747
L16	35.87	S72°29'22"E	621893.9219	1556903.9246	621883.1451	1556938.0622
L17	75.13	S28°45'14"E	621818.8697	1557016.3929	621753.0058	1557052.5329
L18	96.32	S45°58'22"E	621742.2976	1557060.7091	621675.3520	1557129.9671
L19	172.25	N85°51'01"E	621637.6050	1557235.7578	621650.0694	1557407.5582
L20	26.80	S10°22'33"E	621605.1192	1557465.6388	621578.7539	1557470.4662
L21	88.01	S54°21'32"E	621546.7726	1557491.9271	621495.4864	1557563.4543
L22	39.70	S79°57'34"E	621486.0263	1557585.9143	621479.1053	1557625.0035
L23	167.08	S46°01'07"E	621471.1517	1557640.6059	621355.1276	1557760.8305
L24	99.89	S75°57'25"E	621347.6111	1557774.3837	621323.3725	1557871.2887
L25	8.36	S14°25'38"E	621294.5341	1557900.3212	621286.4368	1557902.4044
L26	97.02	N89°24'20"E	621256.4050	1557941.5580	621257.4117	1558038.5728
L27	37.23	S67°43'17"E	621254.4279	1558054.1523	621240.3149	1558088.5998
L28	56.27	N78°47'05"E	621238.0928	1558111.5442	621249.0372	1558166.7393
L29	65.16	N56°33'51"E	621263.6770	1558202.3696	621299.5826	1558256.7695
L30	103.32	N80°39'18"E	621305.6716	1558272.3144	621322.4491	1558374.2663
L31	95.67	N74°26'16"E	621324.7880	1558384.8570	621350.4551	1558477.0202
L32	76.35	S60°38'40"E	621343.1155	1558537.7012	621305.6857	1558604.2492
L33	48.20	N59°12'16"E	621306.5423	1558672.3992	621331.2206	1558713.8046
L34	33.45	S79°25'41"E	621334.9415	1558734.6680	621328.8044	1558767.5502
L35	74.69	S43°06'41"E	621310.8280	1558800.3438	621256.3016	1558851.3889
L36	73.46	S18°10'59"E	621234.0198	1558864.5911	621164.2250	1558887.5158
L37	184.17	S37°34'56"E	621146.3545	1558896.9706	621000.4051	1559009.2946
L38	31.61	N81°26'51"E	620978.4242	1559063.8839	620983.1243	1559095.1377
L39	61.98	S07°06'27"E	620931.2155	1559163.5995	620869.7130	1559171.2683
L40	20.35	S74°28'55"E	620836.1204	1559200.2594	620830.6766	1559219.8654
L41	37.44	N54°42'48"E	620835.0948	1559245.2217	620856.7213	1559275.7809
L42	25.95	S71°21'13"E	620864.5957	1559329.6245	620856.2990	1559354.2119
L43	84.90	N48°46'02"E	620868.0273	1559412.9426	620923.9864	1559476.7904
L44	12.21	S70°01'19"E	620935.2536	1559536.8371	620931.0803	1559548.3167
L45	94.66	S87°15'16"E	620927.5387	1559565.9421	620923.0045	1559660.4888
L46	13.69	S67°13'40"E	620918.3965	1559680.8386	620913.0960	1559693.4653
L47	22.80	N15°29'07"E	620951.0894	1559771.8097	620973.0630	1559777.8975
L48	99.30	S70°04'52"E	621002.0099	1559833.9861	620968.1782	1559927.3495
L49	13.28	S27°39'19"E	620947.7092	1559950.7874	620935.9460	1559956.9515
L50	240.28	N64°49'50"E	620918.3100	1560009.3937	621020.4991	1560226.8565
L51	48.55	N78°46'48"E	621023.7599	1560236.7770	621033.2066	1560284.3961
L52	71.70	N56°51'43"E	621039.3784	1560299.5351	621078.5728	1560359.5720
L53	86.13	N81°01'26"E	621085.0400	1560376.3693	621098.4781	1560461.4439
L54	22.50	N19°46'47"W	621187.3674	1560514.0242	621208.5318	1560506.3991
L55	75.86	S67°45'05"E	621285.6664	1560586.8644	621256.9420	1560657.1008
L56	85.00	N02°20'16"E	621350.7266	1560803.1470	621435.6583	1560806.6143
L57	18.34	N45°41'02"E	621513.2495	1560841.1776	621526.0613	1560854.2890
L58	28.64	N01°43'30"E	621576.0951	1560876.2668	621604.7245	1560877.1790
L59	146.94	N07°41'22"E	621613.0207	1560877.8121	621758.6418	1560897.4736
L60	121.53	N15°50'30"E	621775.0645	1560900.8942	621891.9797	1560934.0697
L61	150.79	N08°25'35"W	621958.8042	1560937.8147	622107.5606	1560913.1176
L62	118.22	N38°39'02"E	622207.6809	1560939.2194	622300.0057	1561013.0545
L63	19.07	S66°48'48"E	622321.5159	1561098.8074	622314.0074	1561116.3375
L64	17.23	N71°01'44"E	622312.7905	1561149.4032	622318.3913	1561165.6958
L65	21.81	S50°15'47"E	622300.8986	1561261.1671	622286.9543	1561277.9411
L66	23.19	S87°05'58"E	622260.5352	1561345.6361	622259.3617	1561368.7933
L67	119.20	S33°55'56"E	622222.3591	1561434.2357	622123.4552	1561500.7773
L68	80.93	N24°49'16"E	622132.5922	1561615.4405	622206.0441	1561649.4129
L69	112.38	N46°51'36"E	622241.6827	1561675.1546	622318.5270	1561757.1577
L70	83.40	N61°02'53"E	622335.2411	1561780.1240	622375.6115	1561853.0986
L71	69.50	N25°55'06"E	622429.0396	1561903.7703	622491.5527	1561934.1499
L72	41.48	S80°31'40"E	622532.1990	1562012.8850	622525.3724	1562053.8008
L73	35.95	N04°07'30"E	622592.1262	1562138.6254	622627.9870	1562141.2116
L74	51.24	N39°35'19"E	622682.2813	1562162.9993	622721.7621	1562195.6669
L75	27.59	N57°08'34"W	622820.7560	1562180.3970	622835.7273	1562157.2170
L76	141.65	N12°05'50"W	622877.3374	1562128.4906	623015.8448	1562098.8043
L77	79.63	N82°34'30"E	623089.1171	1562150.5669	623099.4080	1562229.5339
L78	96.12	S72°36'27"E	623097.1306	1562255.6505	623068.4003	1562347.3715
L79	103.24	N81°22'39"E	623063.8916	1562406.1693	623079.3691	1562508.2377
L80	159.57	N59°07'59"E	623086.7987	1562528.9356	623168.6635	1562665.9017
L81	140.03	S83°47'29"E	623177.6245	1562706.9006	623162.4808	1562846.1055

CURVE TABLE

CURVE	ARC LENGTH	RADIUS	CHORD LENGTH	CHORD BEARING
C1	34.25	65.00	33.86	S72°07'16"E
C2	42.57	65.00	41.81	N68°22'21"W
C3	38.17	65.00	37.62	S66°25'57"E
C4	29.65	48.00	29.18	N65°33'30"W
C5	30.74	48.00	30.22	S66°17'27"E
C6	14.74	22.00	14.47	N65°21'23"W
C7	40.24	94.00	39.94	S58°25'28"E
C8	26.38	84.00	26.30	N67°38'53"W
C9	11.09	45.00	11.06	S01°40'08"E
C10	11.42	45.00	11.39	N61°27'34"W
C11	33.91	160.00	33.74	S63°54'08"E
C12	55.15	136.00	54.78	N61°59'54"W
C13	28.51	45.00	28.03	S68°31'46"E
C14	33.91	45.00	33.11	N65°05'28"W
C15	22.77	45.00	22.52	S57°59'47"E
C16	103.81	136.00	101.31	N50°37'18"W
C17	13.52	45.00	13.47	S37°21'48"E
C18	115.79	136.00	112.32	S70°21'47"E
C19	80.42	55.00	73.44	N52°15'46"W
C20	39.35	55.00	38.51	S33°51'48"E
C21	24.57	55.00	24.37	S67°09'33"E
C22	17.77	30.00	17.51	N62°59'21"W
C23	15.68	30.00	15.50	S60°59'16"E
C24	42.96	40.00	40.92	N45°11'32"W
C25	53.17	40.00	49.34	S52°30'38"E
C26	15.97	40.00	15.86	N79°09'28"W
C27	23.38	40.00	23.05	S84°28'06"E
C28	38.78	100.00	38.54	N67°40'28"E
C29	16.82	40.00	16.69	S68°36'35"W
C30	10.85	100.00	10.85	N77°32'47"E
C31	62.72	80.00	61.12	N83°05'12"W
C32	71.39	68.00	68.16	N89°16'48"E
C33	21.66	30.00	21.19	S79°53'17"W
C34	38.03	60.00	37.40	N61°15'11"W
C35	26.10	60.00	25.90	N30°38'50"W
C36	20.31	60.00	20.22	S27°52'58"E
C37	61.72	58.00	58.85	S68°04'07"E
C38	95.76	60.00	85.92	N57°49'48"W
C39	47.04	40.00	44.37	S40°47'41"E
C40	26.60	30.00	25.74	N80°06'56"E
C41	56.48	60.00	54.42	S81°40'47"W
C42	62.71	60.00	59.89	N78°42'24"E
C43	64.10	60.00	61.09	S79°22'21"W
C44	18.05	60.00	17.98	S78°38'18"E
C45	20.97	60.00	20.87	N77°14'28"W
C46	98.48	58.00	87.07	N64°07'44"E
C47	70.87	43.00	63.12	S62°42'07"W
C48	31.84	43.00	31.12	N48°57'06"W
C49	61.10	40.00	55.33	S71°24'45"E
C50	10.47	43.00	10.44	S71°48'18"W
C51	16.45	43.00	16.35	N67°49'14"E
C52	18.13	43.00	18.00	S68°56'34"W
C53	117.92	67.00	103.28	N30°36'19"E
C54	140.60	61.00	111.48	S46°13'04"W
C55	203.34	106.00	173.57	N57°17'35"E
C56	87.00	115.00	84.94	S24°00'39"W
C57	56.01	73.00	54.64	N23°42'16"E
C58	8.33	80.00	8.32	S04°42'26"W
C59	16.79	118.00	16.78	S11°45'56"W
C60	67.47	153.00	66.93	N03°12'27"E
C61	106.57	127.00	103.47	S14°36'43"W
C62	94.97	73.00	88.41	S75°55'07"W
C63	33.85	46.00	33.09	S87°53'32"E
C64	101.44	99.00	97.06	N79°37'02"W
C65	73.93	115.00	72.67	S68°40'52"E
C66	77.95	84.00	75.18	N60°30'56"W
C67	139.67	66.00	115.03	N85°26'40"E
C68	44.24	115.00	43.96	S35°50'26"W
C69	28.48	115.00	28.40	S53°57'15"W
C70	74.80	122.00	73.64	N43°29'00"E
C71	95.00	74.00	88.61	S62°41'43"W
C72	171.48	73.00	107.94	N51°47'55"E
C73	59.45	96.00	58.50	S21°51'54"W
C74	113.13	67.00	100.16	N08°46'08"W
C75	51.89	66.00	50.56	S34°37'12"E
C76	100.79	61.00	89.71	S35°14'20"W
C77	26.42	61.00	26.22	N85°00'58"W
C78	59.48	131.00	58.97	S85°36'54"E
C79	22.13	57.00	21.99	N70°15'19"E
C80	42.71	66.00	41.97	S77°40'15"W

PROP. TRIBUTARY – CENTERLINE ALIGNMENT

LINE TABLE

LINE	LENGTH	BEARING	START NORTHING	START EASTING	END NORTHING	END EASTING
L101	26.17	N14°47'05"E	620816.9136	1558660.9350	620842.2194	1558667.6138
L102	41.22	N09°03'25"E	620846.5212	1558668.5220	620887.2225	1558675.0100
L103	10.01	N31°13'13"W	620907.4950	1558671.0394	620916.0595	1558665.8484
L104	25.50	N40°07'50"E	620942.2259	1558667.8869	620961.7240	1558684.3254
L105	28.05	N45°28'28"W	620992.9458	1558682.8683	621012.6167	1558662.8690
L106	32.49	N57°25'45"E	621048.3970	1558666.6154	621065.8894	1558693.9983
L107	14.39	N10°06'17"W	621091.3437	1558705.1520	621105.5066	1558702.6280
L108	21.86	S55°12'16"E	621128.4294	1558738.3962	621115.9554	1558756.3468
L109	20.92	N36°06'54"E	621121.1706	1558787.3628	621138.0672	1558799.6907
L110	24.23	S28°09'34"E	621135.2476	1558840.2381	621113.8881	1558851.6715
L111	36.46	S79°51'12"E	621096.4653	1558875.6574	621090.0431	1558911.5424

CURVE TABLE

CURVE	ARC LENGTH	RADIUS	CHORD LENGTH	CHORD BEARING
C101	4.40	44.00	4.40	N11°55'15"E
C102	21.09	30.00	20.66	N11°04'54"W
C103	28.02	22.50	26.24	S04°27'18"W
C104	34.36	23.00	31.26	N02°40'19"W
C105	41.31	23.00	35.98	S05°58'39"W
C106	29.47	25.00	27.79	N23°39'44"E
C107	54.15	23.00	42.48	S57°20'44"W
C108	34.82	22.50	31.45	N80°27'19"E
C109	48.48	24.00	40.65	N86°01'20"W
C110	30.68	34.00	29.65	S54°00'23"E

STRUCTURE LOCATION TABLE

STREAM STRUCTURE LOCATIONS (UT #1)		
STR TYPE	STATION	SIDE OF STREAM(LOOKING D/S)
CROSS VANE	60	MID
CONST. RIFFLE	92.9	MID
CONST. RIFFLE	130.9	MID
CONST. RIFFLE	190.8	MID
CONST. RIFFLE	260.1	MID
CONST. RIFFLE	322.1	MID
CONST. RIFFLE	390.6	MID
CONST. RIFFLE	447.3	MID
LOG STEP POOL	516.7	MID
LOG STEP POOL	528.1	MID
LOG STEP POOL	539.5	MID
LOG STEP POOL	550.9	MID
LOG STEP POOL	562.3	MID
LOG STEP POOL	573.7	MID
LOG STEP POOL	585.1	MID
LOG STEP POOL	596.5	MID

NO.	DATE	DESCRIPTION OF REVISION
C	11-01-07	REVISE PLAN ACCORDING TO FIELD VISIT
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
A	06-22-07	NCEEP COMMENTS

JORDAN JONES & GOULDING

PLANS PREPARED FOR

Ecosystem Enhancement PROGRAM

PROJECT MANAGER ROBIN DOLIN

REVIEW COORDINATOR LIN XU

SENIOR SCIENTIST DAN RICE

PROJECT ENGINEER MATTHEW CLABAUGH, PE

NOT RELEASED FOR CONSTRUCTION

DUTCH BUFFALO CREEK STREAM RESTORATION PROJECT

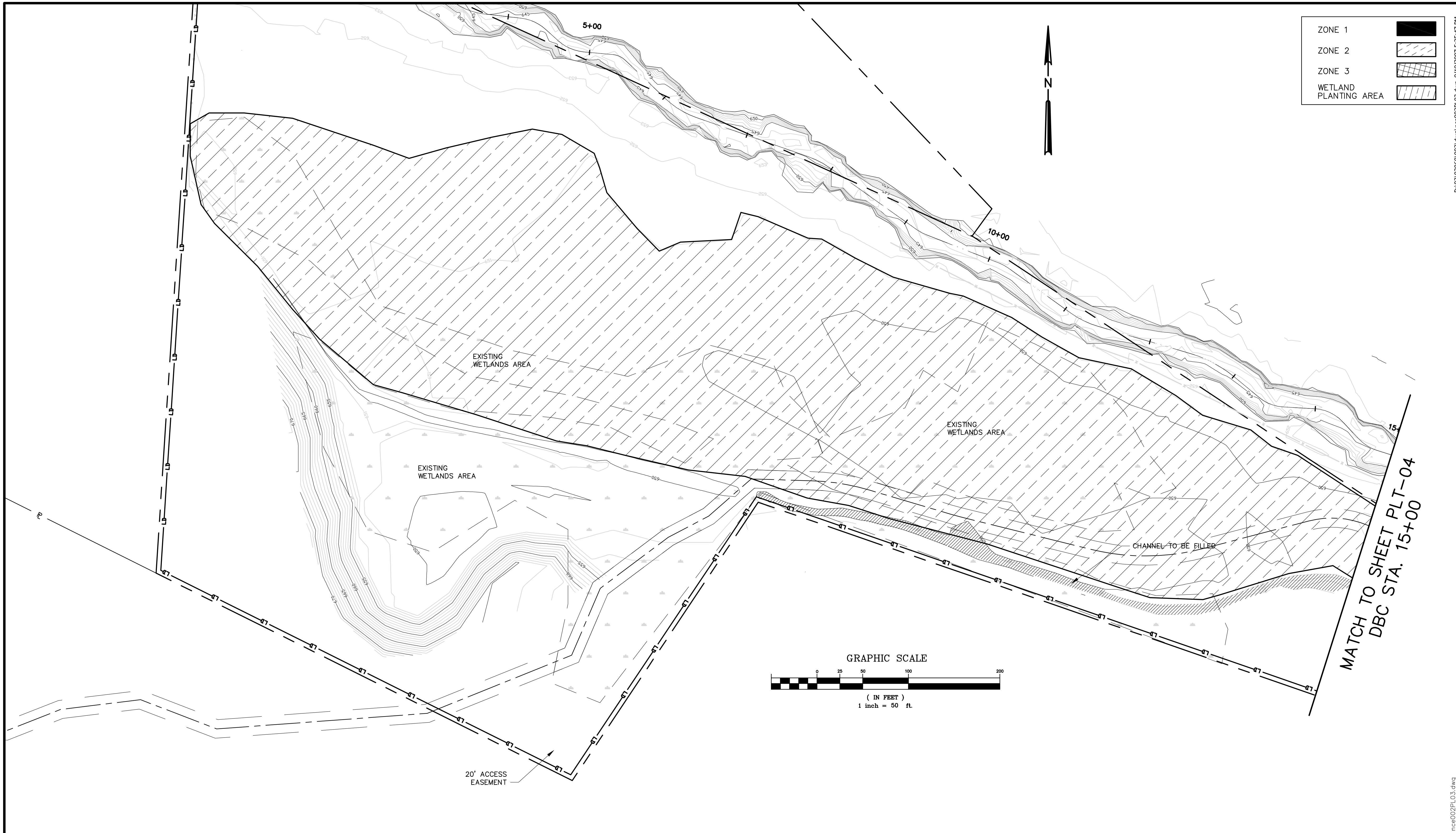
STREAM ALIGNMENT DATA

DESIGNED: MMC | CHECKED: DR | DATE: NOVEMBER, 2007

DRAWN: MXD | JOB NO. 03060-002 | SCALE:

SHEET 17 | REV C

THIS LINE IS ONE INCH LONG WHEN PLOTTED FULL SCALE



MDENG

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nce002PL03.dwg
05.07.07

NO.	DATE	DESCRIPTION OF REVISION
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
A	06-22-07	NCEEP COMMENTS

JORDAN
JONES &
GOULDING

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Ecosystem Enhancement PROGRAM

PROJECT MANAGER
ROBIN DOLIN

REVIEW COORDINATOR
LIN XU

SENIOR SCIENTIST
DAN RICE

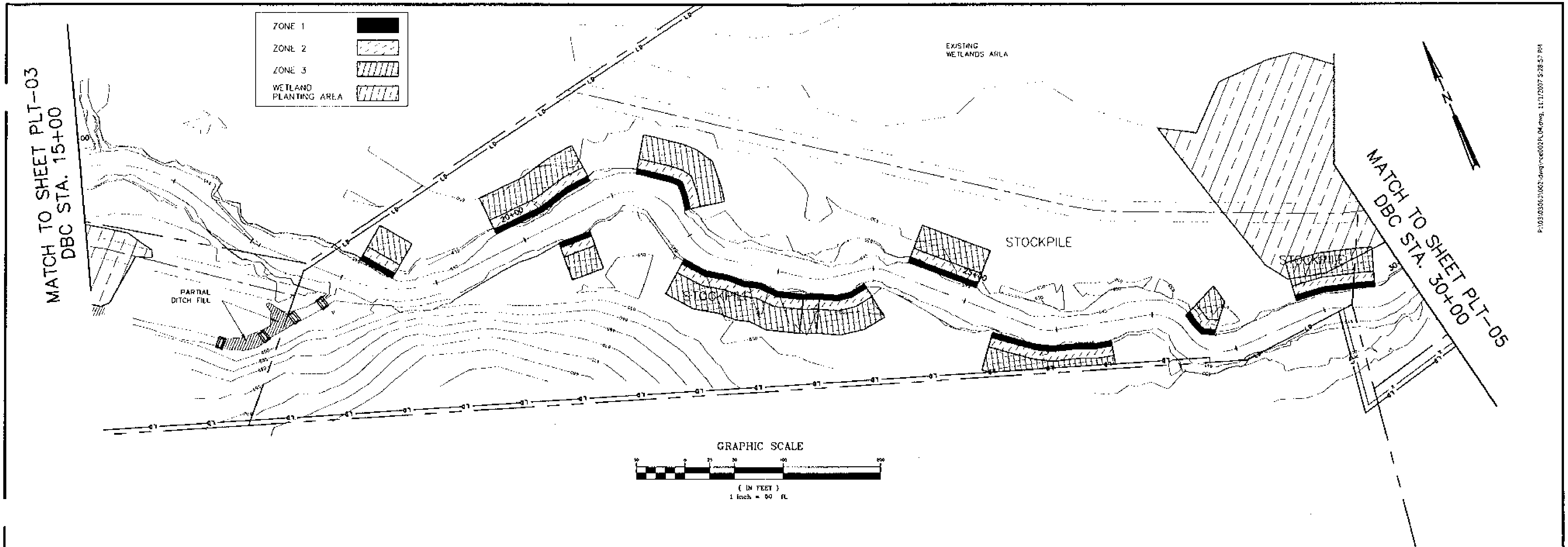
PROJECT ENGINEER
MATTHEW CLABAUGH, PE

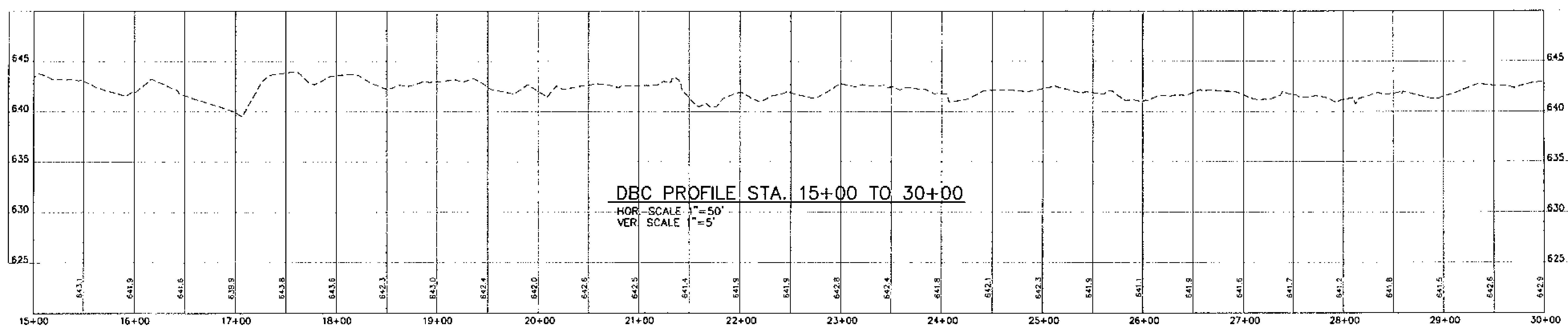
NOT RELEASED FOR CONSTRUCTION

DUTCH BUFFALO CREEK
STREAM RESTORATION PROJECT

PLANTING PLAN

DESIGNED: MMC	CHECKED: DR	DATE: MAY, 2007	PLT-03	B
DRAWN: MXD	JOB NO. 03060-002	SCALE:	SHEET	REV





NO.	DATE	DESCRIPTION OF REVISION
C	11-01-07	REVISE PLAN ACCORDING TO FIELD VISIT
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
A	06-22-07	NCEEP COMMENTS

JORDAN JONES & GOULDING

PLANS PREPARED FOR

Ecosystem Enhancement PROGRAM

PROJECT MANAGER ROBIN DOLIN

REVIEW COORDINATOR LIN XU

SENIOR SCIENTIST DAN RICE

PROJECT ENGINEER MATTHEW CLABAUGH, PE

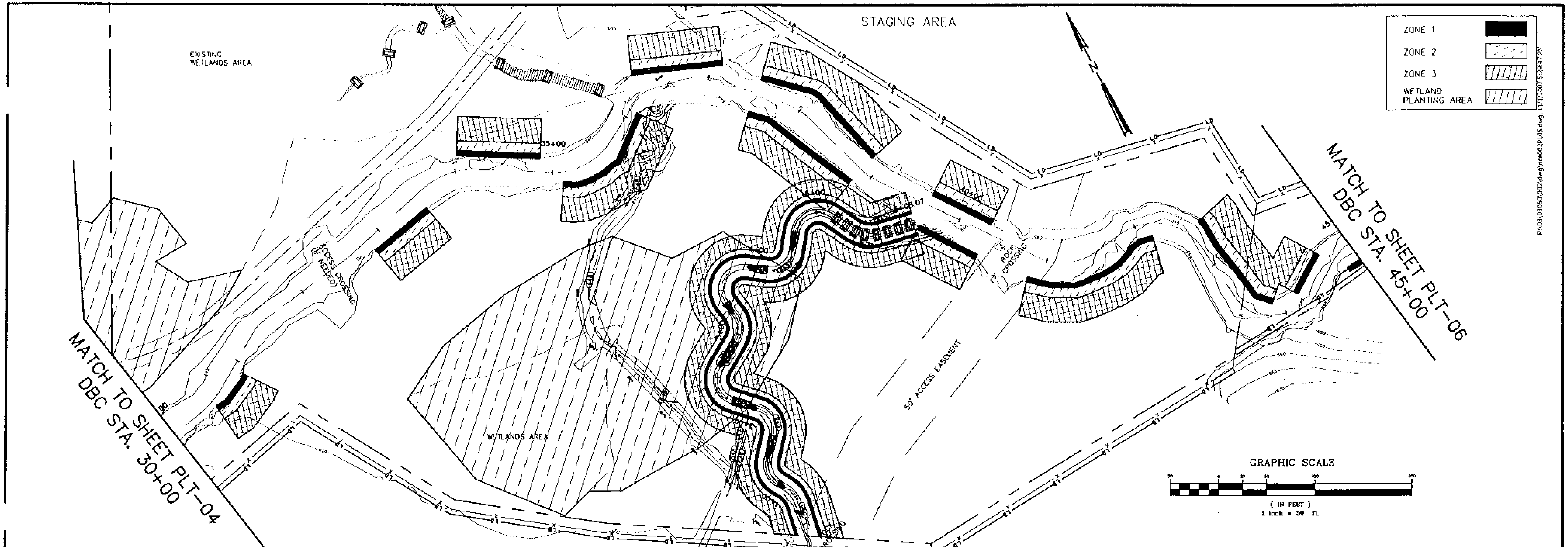
NOT RELEASED FOR CONSTRUCTION

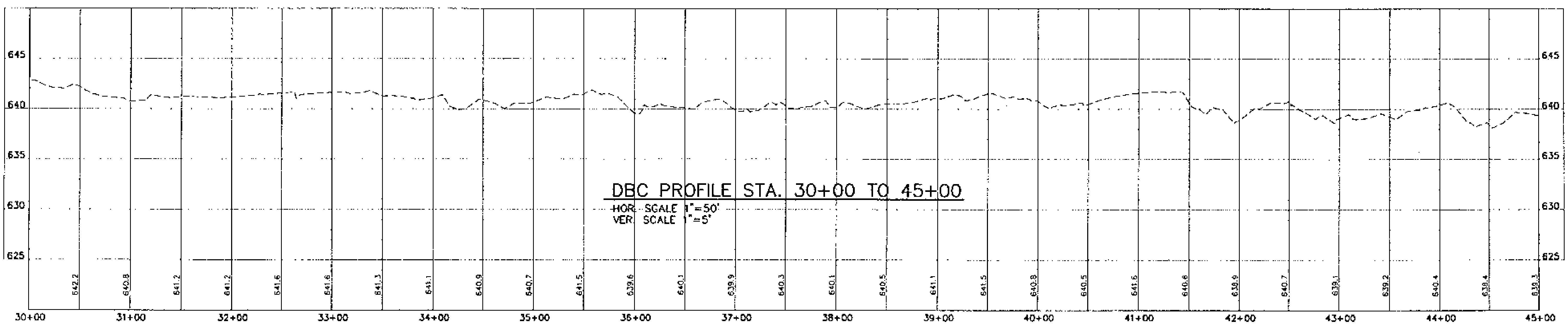
DUTCH BUFFALO CREEK
STREAM RESTORATION PROJECT

PLANTING PLAN

DESIGNED: MMC	CHECKED: DR	DATE: NOVEMBER, 2007	PLT-04 SHEET	C REV
DRAWN: MXD	JOB NO. 03060-002	SCALE:		

THIS LINE IS ONE INCH LONG WHEN PLOTTED FULL SCALE





NO.	DATE	DESCRIPTION OF REVISION
C	11-01-07	REVISE PLAN ACCORDING TO FIELD VISIT
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
A	06-22-07	NCEEP COMMENTS

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PROJECT MANAGER ROBIN DOLIN

REVIEW COORDINATOR LIN XU

SENIOR SCIENTIST DAN RICE

PROJECT ENGINEER MATTHEW CLABAUGH, PE

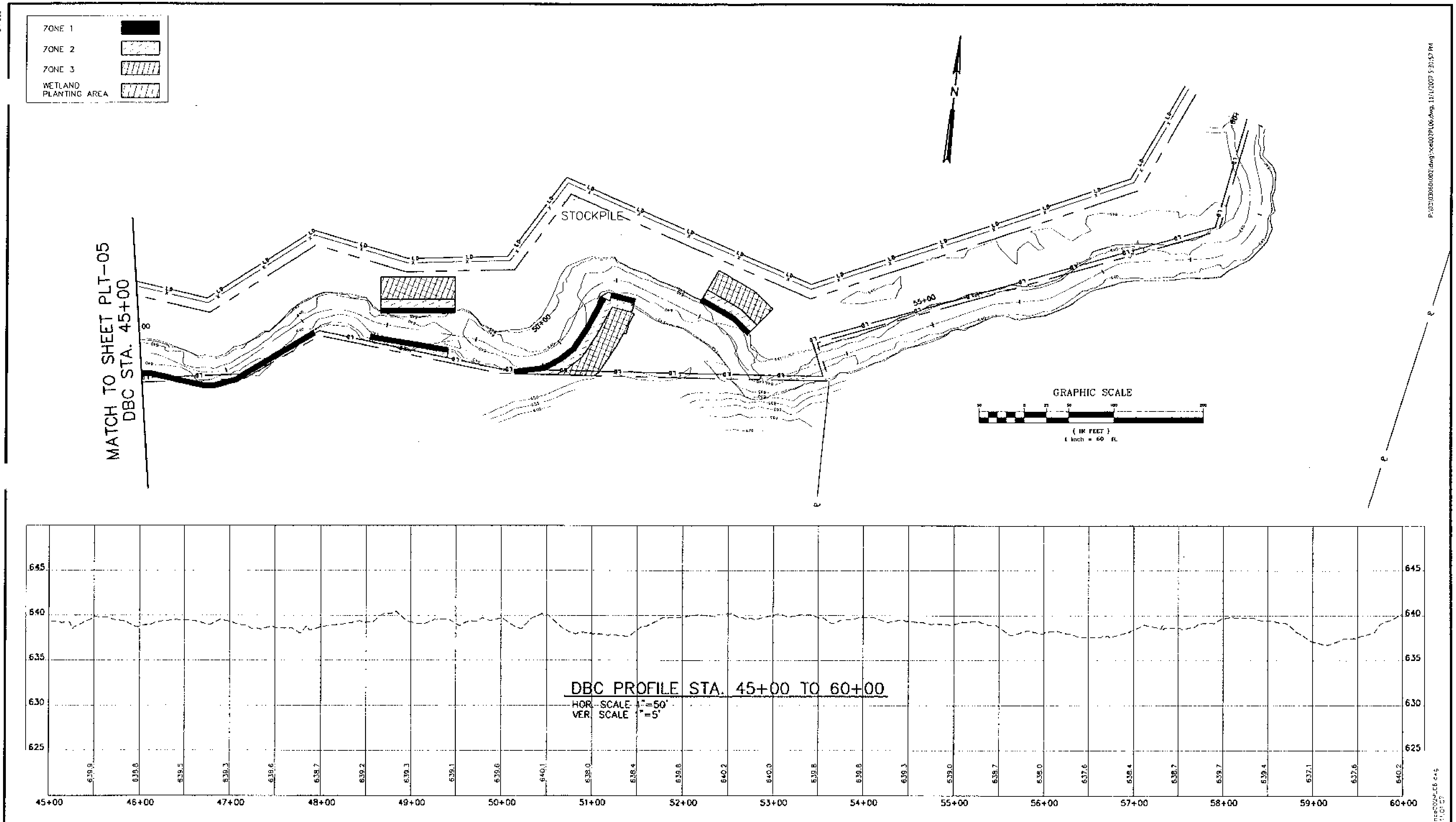
NOT RELEASED FOR CONSTRUCTION

DUTCH BUFFALO CREEK STREAM RESTORATION PROJECT

PLANTING PLAN

DESIGNED: MMC	CHECKED: DR	DATE: NOVEMBER, 2007	PLT-05	C
DRAWN: MXD	JOB NO 03060-002	SCALE:	SHEET	REV

THIS LINE IS ONE INCH LONG WHEN PLOTTED FULL SCALE



NO.	DATE	DESCRIPTION OF REVISION
C	11-01-07	REVISE PLAN ACCORDING TO FIELD VISIT
B	09-10-07	REVISE PLAN ACCORDING TO FIELD VISIT
A	06-22-07	NCEEP COMMENTS

JORDAN JONES & GOULDING

PLANS PREPARED FOR

Ecosystem Enhancement PROGRAM

PROJECT MANAGER ROBIN DOLIN

REVIEW COORDINATOR LIN XU

SENIOR SCIENTIST DAN RICE

PROJECT ENGINEER MATTHEW CLABAUGH, PE

NOT RELEASED FOR CONSTRUCTION

DUTCH BUFFALO CREEK STREAM RESTORATION PROJECT

PLANTING PLAN

DESIGNED: MMC	CHECKED: DR	DATE: NOVEMBER, 2007	PLT-06 SHEET	C REV
DRAWN: MXD	JOB NO. 03060-002	SCALE:		

SECTION 12
APPENDICES

Appendix 1 - Project Site Photos

Appendix 2 - Project Site USACE Routine Wetland Determination Data Forms

Appendix 3 - Project Site NCDWQ Stream Classification Forms

Appendix 4 – Reference Site Photos

Appendix 5 - Reference Site USACE Routine Wetland Determination Data Forms

Appendix 6 - Reference Site NCDWQ Stream Classification Forms

Appendix 7 – Hydrologic Gauge Data Summary; Groundwater and Rainfall Information

Appendix 8 – HEC-RAS Analysis

Appendix 9 – Supporting Documentation

APPENDIX 1
PROJECT SITE PHOTOS

1. Main Channel Bank Erosion
7.26.2006

2. Main Channel Vertical, Bare Bank
1.11.2007

3. Main Channel Looking Upstream at Crest Gauge
1.11.2007

4. Main Channel Looking Upstream
1.2.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding Incorporated

5. Storm Debris along Main Channel Floodplain
3.8.2007

6. Sediment Deposition on Main Channel Floodplain
3.8.2007

7. Storm Debris along Mr. Suther's Electric Fencing
3.8.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding Incorporated

8. Main Channel Typical Riffle Cross-Section
Looking Upstream 1.11.2007

9. Main Channel Typical Riffle Cross-Section
Looking Downstream 1.11.2007

10. Main Channel Typical Run Cross-Section
Looking Upstream 1.11.2007

11. Main Channel Typical Run Cross-Section
Looking Downstream 1.11.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding

12. Main Channel Typical Pool Cross-Section
Looking Upstream 1.11.2007

13. Main Channel Typical Pool Cross-Section
Looking Downstream 1.11.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding Incorporated

14. Wetland A-1 12.12.2006

15. Wetland A-2 12.12.2006

16. Wetland B-1 12.12.2006

17. Wetland B-1 12.12.2006

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding Incorporated

18. Wetland B-1 Disturbed Area
4.19.2007

19. Wetland B-1 Cattle Crossing
4.19.2007

20. Wetland C-1 Ditch Draining Wetland
4.19.2007

21. Wetland C-1 Switchgrass Field
4.19.2007

Prepared For: Ecosystem Enhancement Program	Dutch Buffalo Creek Restoration Plan	Date: June 2007
	Appendix 1. Project Site Photos	Jordan Jones & Goulding Incorporated

22. Unnamed Tributary and Main Channel Confluence
3.8.2007

23. Unnamed Tributary Bank Slump
1.2.2007

24. Unnamed Tributary
3.8.2007

25. Unnamed Tributary Bank Erosion
1.2.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding Incorporated

26. Unnamed Tributary Typical Riffle Cross-Section
Looking Upstream 1.11.2007

27. Unnamed Tributary Typical Riffle Cross-Section
Looking Downstream 1.11.2007

28. Unnamed Tributary Typical Pool Cross-Section
Looking Upstream 1.11.2007

29. Unnamed Tributary Typical Pool Cross-Section
Looking Downstream 1.11.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 1. Project Site Photos**	Jordan Jones & Goulding Incorporated

APPENDIX 2
PROJECT SITE USACE ROUTINE WETLAND DETERMINATION DATA FORMS

Data Form
Routine Wetland Determination

Job Number: **3060002**
City: **Concord**
Wetland Data Point: **A-1**

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 11, 2006**
County: **Cabarrus**
State: **NC**

[ ] Do normal circumstances exist on the site?
[X] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PSS1B**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Eleocharis obtusa*	Spikerush,Blunt		OBL
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Carex spp.*	Sedge species		FAC - OBL
X	*Typha latifolia*	Cattail,Broad-Leaf		OBL
X	*Scirpus cyperinus*	Wool-Grass		OBL
Shrub				
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Betula nigra*	Birch,River		FACW
X	*Salix nigra*	Willow,Black		OBL
X	*Cornus amomum*	Dogwood,Silky		FACW+
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Alnus serrulata*	Alder,Brook-Side		FACW+
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **91**
Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **6-8**
- Depth to Saturated Soils(in.): **>6**

Primary Wetland Hydrology Indicators
- [X] Inundated
- [X] Saturated in upper 12 inches
- [X] Water marks
- [ ] Drift lines
- [ ] Sediment deposits
- [ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [X] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks
crayfish burrows, multi-trunked tree species

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 5/2	10YR 4/4			Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: A-2

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 11, 2006**
County: **Cabarrus**
State: **NC**

[ ] Do normal circumstances exist on the site?
[X] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PSS1E**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Eleocharis obtusa*	Spikerush,Blunt		OBL
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Carex sp.*	sedge species		FAC - OBL
Shrub				
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Alnus serrulata*	Alder,Brook-Side		FACW+
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **83**

Cowardin Classification:

Remarks

Sapling and shrub plants are growing along the edge of inundated ditch

Hydrology

[ ] Recorded Data (describe in remarks)
  [ ] Stream, Lake, or Tide Gage
  [ ] Aerial Photograph
  [ ] Other (describe in remarks)

Field Observations:
  Depth of Surface Water(in.): **0**
  Depth to Free Water in Pit(in.): **0**
  Depth to Saturated Soils(in.): **0**

Primary Wetland Hydrology Indicators
[X] Inundated
[X] Saturated in upper 12 inches
[ ] Water marks
[ ] Drift lines
[ ] Sediment deposits
[ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
[ ] Oxidized root channels
[X] Water-stained leaves
[ ] Local soil survey data
[ ] FAC-Neutral test
[ ] Other (explain in remarks)

Remarks

Trapped Inundated Area within incised Ditch in proposed mitigation area.

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 3/2				Sandy Clay Loam

Hydric Soils Indicators
[ ] Histosol
[ ] Histic Epipedon
[ ] Sulfidic Odor
[ ] Probable Aquatic Moist Regime
[X] Reducing Conditions
[X] Gleyed or Low-Chroma Colors

[ ] Concretions
[ ] High Organic % in Surface Layer
[ ] Organic Streaking
[ ] Listed on Local Hydric Soils List
[ ] Listed on National Hydric Soils List
[ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Soils were collected at the edge of inundated area

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: A-3

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 11, 2006**
County: **Cabarrus**
State: **NC**

[ ] Do normal circumstances exist on the site?
[X] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PSS1B**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Eleocharis obtusa*	Spikerush,Blunt		OBL
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Carex spp.*	sedge species		FAC - OBL
X	*Scirpus cyperinus*	Wool-Grass		OBL
Shrub				
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Betula nigra*	Birch,River		FACW
X	*Salix nigra*	Willow,Black		OBL
X	*Cornus amomum*	Dogwood,Silky		FACW+
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Alnus serrulata*	Alder,Brook-Side		FACW+
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **90**
Cowardin Classification:
Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **NA**
- Depth to Saturated Soils(in.): **>12**

Primary Wetland Hydrology Indicators
- [ ] Inundated
- [X] Saturated in upper 12 inches
- [ ] Water marks
- [ ] Drift lines
- [ ] Sediment deposits
- [ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [X] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 5/2	10YR 4/4			Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:
Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present
Remarks

[X] This Data Point is a Wetland

Data Form
Routine Wetland Determination

Job Number: **3060002**
City: **Concord**
Wetland Data Point: **B-1**

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 11, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PFO1B/E**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Carex spp*	sedge species		FAC - OBL
X	*Boehmeria cylindrica*	False-Nettle,Small-Spike		FACW+
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Arundinaria gigantea*	Cane,Giant		FACW
Shrub				
X	*Cornus amomum*	Dogwood,Silky		FACW+
X	*Lindera benzoin*	Spicebush,Northern		FACW
Tree				
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Betula nigra*	Birch,River		FACW
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Quercus bicolor*	Oak,Swamp White		FACW+
X	*Quercus phellos*	Oak,Willow		FACW-
X	*Quercus michauxii*	Oak,Swamp Chestnut		FACW-
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **92**

Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **NA**
- Depth to Saturated Soils(in.): **6-8**

Primary Wetland Hydrology Indicators
- [X] Inundated
- [X] Saturated in upper 12 inches
- [X] Water marks
- [X] Drift lines
- [X] Sediment deposits
- [X] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [X] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 3/2				Sandy Clay Loam
0-12	A/B	10YR 5/2	10YR 4/4			Sandy Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: B-2

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: NCEEP
Investigator: BF

Date: **December 12, 2006**
County: Cabarrus
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: PFO1A
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Carex spp.*	sedge species		FAC - OBL
X	*Eleocharis obtusa*	Spikerush,Blunt		OBL
X	*Arundinaria gigantea*	Cane,Giant		FACW
Tree				
X	*Fraxinus pennsylvanica*	Ash,Green		FACW
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Acer negundo*	Box-Elder		FACW
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): 85

Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
[ ] Stream, Lake, or Tide Gage
[ ] Aerial Photograph
[ ] Other (describe in remarks)

Field Observations:
Depth of Surface Water(in.): **NA**
Depth to Free Water in Pit(in.): **NA**
Depth to Saturated Soils(in.): **<12**

Primary Wetland Hydrology Indicators
[ ] Inundated
[X] Saturated in upper 12 inches
[ ] Water marks
[X] Drift lines
[X] Sediment deposits
[X] Drainage patterns in wetlands

Secondary Hydrology Indicators
[ ] Oxidized root channels
[X] Water-stained leaves
[ ] Local soil survey data
[ ] FAC-Neutral test
[ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 6/2	10YR 4/6			Sandy Clay Loam

Hydric Soils Indicators
[ ] Histosol
[ ] Histic Epipedon
[ ] Sulfidic Odor
[ ] Probable Aquatic Moist Regime
[X] Reducing Conditions
[X] Gleyed or Low-Chroma Colors
[ ] Concretions
[ ] High Organic % in Surface Layer
[ ] Organic Streaking
[ ] Listed on Local Hydric Soils List
[ ] Listed on National Hydric Soils List
[ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: B-3

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PFO1A**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Eleocharis obtusa*	Spikerush,Blunt		OBL
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Arundinaria gigantea*	Cane,Giant		FACW
Tree				
X	*Fraxinus pennsylvanica*	Ash,Green		FACW
X	*Acer negundo*	Box-Elder		FACW
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **100**   Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **NA**
- Depth to Saturated Soils(in.): **<12**

Primary Wetland Hydrology Indicators
- [ ] Inundated
- [X] Saturated in upper 12 inches
- [X] Water marks
- [X] Drift lines
- [X] Sediment deposits
- [ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [X] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 6/2				Sandy Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: C-1

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PFO1B/E;PEM1B/E**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Carex spp.*	sedge species		FAC - OBL
X	*Panicum virgatum*	Switchgrass		FAC+
Shrub				
X	*Lindera benzoin*	Spicebush,Northern		FACW
X	*Cornus amomum*	Dogwood,Silky		FACW+
X	*Alnus serrulata*	Alder,Brook-Side		FACW+
Tree				
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Betula nigra*	Birch,River		FACW
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **90**
Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **NA**
- Depth to Saturated Soils(in.): **6-10**

Primary Wetland Hydrology Indicators
- [X] Inundated
- [X] Saturated in upper 12 inches
- [ ] Water marks
- [ ] Drift lines
- [ ] Sediment deposits
- [X] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [ ] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 6/2	10YR 4/6			Sandy Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % In Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:
Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Job Number: 3060002
City: Concord
Wetland Data Point: WL Area 1

Data Form
Routine Wetland Determination

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 11, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **Upland**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Shrub				
X	*Acer saccharum*	Maple,Sugar		FACU-
X	*Rubus argutus*	Blackberry,Serrate-Leaf		FACU+
X	*Liriodendron tulipifera*	Tree,Tulip		FAC
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Ulmus alata*	Elm,Winged		FACU+
X	*Pinus taeda*	Pine,Loblolly		FAC

% Species that are OBL, FACW, or FAC (except FAC-): **50**
Cowardin Classification:
Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **N/A**
- Depth to Free Water in Pit(in.): **>24**
- Depth to Saturated Soils(in.): **>24**

Primary Wetland Hydrology Indicators
[ ] Inundated
[ ] Saturated in upper 12 inches
[ ] Water marks
[ ] Drift lines
[ ] Sediment deposits
[ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
[ ] Oxidized root channels
[ ] Water-stained leaves
[ ] Local soil survey data
[ ] FAC-Neutral test
[ ] Other (explain in remarks)

Remarks
sufficient indicators were not observed

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 4/6				Sandy Clay

Hydric Soils Indicators
[ ] Histosol
[ ] Histic Epipedon
[ ] Sulfidic Odor
[ ] Probable Aquatic Moist Regime
[ ] Reducing Conditions
[ ] Gleyed or Low-Chroma Colors
[ ] Concretions
[ ] High Organic % in Surface Layer
[ ] Organic Streaking
[ ] Listed on Local Hydric Soils List
[ ] Listed on National Hydric Soils List
[ ] Other (explain in remarks)

Unit Name:
Drainage Class:
Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[ ] Hydrophytic Vegetation Present
[ ] Hydric Soils Present
[ ] Wetland Hydrology Present
[ ] This Data Point is a Wetland
Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: **Concord**
Wetland Data Point: **WL Area 2**

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**
[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**
Community ID: **Upland**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Shrub				
X	*Ilex opaca*	Holly,American		FAC-
Tree				
X	*Acer saccharum*	Maple,Sugar		FACU-
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Juniperus virginiana*	Cedar,Eastern Red		FACU-
X	*Juglans nigra*	Walnut,Black		FACU
X	*Fagus grandifolia*	Beech,American		FACU
X	*Liriodendron tulipifera*	Tree,Tulip		FAC
X	*Cornus florida*	Dogwood,Flowering		FACU

% Species that are OBL, FACW, or FAC (except FAC-): **25**
Cowardin Classification:
Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **>24**
- Depth to Saturated Soils(in.): **>24**

Primary Wetland Hydrology Indicators
[ ] Inundated
[ ] Saturated in upper 12 inches
[ ] Water marks
[ ] Drift lines
[ ] Sediment deposits
[ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
[ ] Oxidized root channels
[ ] Water-stained leaves
[ ] Local soil survey data
[ ] FAC-Neutral test
[ ] Other (explain in remarks)

Remarks
sufficient indicators were not observed

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 4/4				Sandy Clay Loam

Hydric Soils Indicators
[ ] Histosol
[ ] Histic Epipedon
[ ] Sulfidic Odor
[ ] Probable Aquatic Moist Regime
[ ] Reducing Conditions
[ ] Gleyed or Low-Chroma Colors

[ ] Concretions
[ ] High Organic % in Surface Layer
[ ] Organic Streaking
[ ] Listed on Local Hydric Soils List
[ ] Listed on National Hydric Soils List
[ ] Other (explain in remarks)

Unit Name:
Drainage Class:
Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[ ] Hydrophytic Vegetation Present
[ ] Hydric Soils Present
[ ] Wetland Hydrology Present

[ ] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: WL Area 3

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**
[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**
Community ID: **Upland**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Panicum virgatum*	Switchgrass		FAC+
Shrub				
X	*Ligustrum sinense*	Privet,Chinese		FAC
Tree				
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Juniperus virginiana*	Cedar,Eastern Red		FACU-
X	*Fagus grandifolia*	Beech,American		FACU

% Species that are OBL, FACW, or FAC (except FAC-): **60**
Cowardin Classification:
Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **>24**
- Depth to Saturated Soils(in.): **>24**

Primary Wetland Hydrology Indicators
[ ] Inundated
[ ] Saturated in upper 12 inches
[ ] Water marks
[ ] Drift lines
[ ] Sediment deposits
[ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
[ ] Oxidized root channels
[ ] Water-stained leaves
[ ] Local soil survey data
[ ] FAC-Neutral test
[ ] Other (explain in remarks)

Remarks
Sufficient indicators were not observed

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 4/4				Sandy Loam

Hydric Soils Indicators
[ ] Histosol
[ ] Histic Epipedon
[ ] Sulfidic Odor
[ ] Probable Aquatic Moist Regime
[ ] Reducing Conditions
[ ] Gleyed or Low-Chroma Colors
[ ] Concretions
[ ] High Organic % in Surface Layer
[ ] Organic Streaking
[ ] Listed on Local Hydric Soils List
[ ] Listed on National Hydric Soils List
[ ] Other (explain in remarks)

Unit Name:
Drainage Class:
Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[ ] Hydrophytic Vegetation Present
[ ] Hydric Soils Present
[ ] Wetland Hydrology Present
[ ] This Data Point is a Wetland

Remarks

APPENDIX 3
PROJECT SITE NCDWQ STREAM CLASSIFICATION FORMS

NCDWQ Stream Classification Form

Project Name: Dutch Buffalo Creek	River Basin: Yadkin-Pee Dee	County: Cabarrus	Evaluator: BF
DWQ Project Number:	Nearest Named Stream:	Latitude:	Signature:
Date: January 2007	USGS QUAD: Mt Pleasant	Longitude:	Location/Directions: East of Concord,NC

***PLEASE NOTE:** *If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used**

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	(2)	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	(1)	2	3
3) Are Natural Levees Present?	(0)	1	2	3
4) Is The Channel Sinuous?	0	(1)	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	(3)
6) Is The Channel Braided?	(0)	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	(3)
8) Is There A Bankfull Bench Present?	(0)	1	2	3
9) Is a Continuous Bed & Bank Present?	(0)	1	2	3
*(*NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0*)*				
10) Is a 2nd Order Or Greater Channel (As Indicated On Topo Map *And/Or* In Field) Present?	(*Yes*=3)		*No*=0	

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 13

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	(3)

PRIMARY HYDROLOGY INDICATOR POINTS: 3

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	(1)	0
2) Are Rooted Plants Present In Streambed?	3	2	(1)	0
3) Is Periphyton Present?	(0)	1	2	3
4) Are Bivalves Present?	0	(1)	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 3

Secondary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	(.5)	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	(1)	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	(1.5)

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 3

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last Year's) Leaflitter Present In Streambed?	(1.5)	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	(1)	1.5
3) Are Wrack Lines Present?	0	.5	(1)	1.5

4) Is Water In Channel *And* >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions *Or* In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?	*Yes=1.5*		*No=0*	

SECONDARY HYDROLOGY INDICATOR POINTS: 8

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed?	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(NOTE: If Total Absence Of All Plants In Streambed As Noted Above Skip This Step UNLESS SAV Present*).*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 3.5

TOTAL POINTS* (Primary + Secondary)** = 33.5 ***(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)

Notes:

APPENDIX 4
REFERENCE SITE PHOTOS

1. Morgan Creek Typical Riffle Cross-Section
2.7.2007

2. Morgan Creek Typical Pool Cross-Section
2.7.2007

3. Morgan Creek Looking Upstream from Bridge
2.7.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 4. Reference Site Photos**	Jordan Jones & Goulding Incorporated

4. Sal's Branch Typical Riffle Cross-Section
Looking Upstream 2.7.2007

5. Sal's Branch Typical Riffle Cross-Section
Looking Downstream 2.7.2007

6. Sal's Branch Typical Pool Cross-Section
2.7.2007

7. Sal's Branch Typical Run Cross-Section
2.7.2007

Prepared For:	Dutch Buffalo Creek Restoration Plan	Date: June 2007
Ecosystem Enhancement Program	**Appendix 4. Reference Site Photos**	Jordan Jones & Goulding

8. Dutch Buffalo Creek Reference Wetland B
4.19.2007

9. Dutch Buffalo Creek Reference Wetland B
4.19.2007

10. Dutch Buffalo Creek Reference Wetland B
4.19.2007

11. Dutch Buffalo Creek Reference Wetland C
4.19.2007

Prepared For:

Ecosystem Enhancement Program

Dutch Buffalo Creek
Restoration Plan

Date: June 2007

Appendix 4. Reference Site Photos

Jordan Jones & Goulding

APPENDIX 5
REFERENCE SITE USACE ROUTINE WETLAND DETERMINATION DATA FORMS

Data Form
Routine Wetland Determination

Job Number: **3060002**
City: **Concord**
Wetland Data Point: **B-1**

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 11, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PFO1B/E**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Carex spp*	sedge species		FAC - OBL
X	*Boehmeria cylindrica*	False-Nettle,Small-Spike		FACW+
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Arundinaria gigantea*	Cane,Giant		FACW
Shrub				
X	*Cornus amomum*	Dogwood,Silky		FACW+
X	*Lindera benzoin*	Spicebush,Northern		FACW
Tree				
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Betula nigra*	Birch,River		FACW
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Quercus bicolor*	Oak,Swamp White		FACW+
X	*Quercus phellos*	Oak,Willow		FACW-
X	*Quercus michauxii*	Oak,Swamp Chestnut		FACW-
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **92**

Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **NA**
- Depth to Saturated Soils(in.): **6-8**

Primary Wetland Hydrology Indicators
- [X] Inundated
- [X] Saturated in upper 12 inches
- [X] Water marks
- [X] Drift lines
- [X] Sediment deposits
- [X] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [X] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 3/2				Sandy Clay Loam
0-12	A/B	10YR 5/2	10YR 4/4			Sandy Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: **Concord**
Wetland Data Point: **WL Area 2**

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**
[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**
Community ID: **Upland**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Shrub				
X	*Ilex opaca*	Holly,American		FAC-
Tree				
X	*Acer saccharum*	Maple,Sugar		FACU-
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Juniperus virginiana*	Cedar,Eastern Red		FACU-
X	*Juglans nigra*	Walnut,Black		FACU
X	*Fagus grandifolia*	Beech,American		FACU
X	*Liriodendron tulipifera*	Tree,Tulip		FAC
X	*Cornus florida*	Dogwood,Flowering		FACU

% Species that are OBL, FACW, or FAC (except FAC-): **25**
Cowardin Classification:
Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **>24**
- Depth to Saturated Soils(in.): **>24**

Primary Wetland Hydrology Indicators
- [ ] Inundated
- [ ] Saturated in upper 12 inches
- [ ] Water marks
- [ ] Drift lines
- [ ] Sediment deposits
- [ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [ ] Oxidized root channels
- [ ] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks
sufficient indicators were not observed

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 4/4				Sandy Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [ ] Reducing Conditions
- [ ] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:
Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

- [ ] Hydrophytic Vegetation Present
- [ ] Hydric Soils Present
- [ ] Wetland Hydrology Present

[ ] This Data Point is a Wetland

Remarks

Job Number: 3060002
City: Concord
Wetland Data Point: C-1

Data Form
Routine Wetland Determination

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **PFO1B/E;PEM1B/E**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Juncus effusus*	Rush,Soft		FACW+
X	*Carex spp.*	sedge species		FAC - OBL
X	*Panicum virgatum*	Switchgrass		FAC+
Shrub				
X	*Lindera benzoin*	Spicebush,Northern		FACW
X	*Cornus amomum*	Dogwood,Silky		FACW+
X	*Alnus serrulata*	Alder,Brook-Side		FACW+
Tree				
X	*Platanus occidentalis*	Sycamore,American		FACW-
X	*Betula nigra*	Birch,River		FACW
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Ulmus americana*	Elm,American		FACW

% Species that are OBL, FACW, or FAC (except FAC-): **90**

Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **NA**
- Depth to Saturated Soils(in.): **6-10**

Primary Wetland Hydrology Indicators
- [X] Inundated
- [X] Saturated in upper 12 inches
- [ ] Water marks
- [ ] Drift lines
- [ ] Sediment deposits
- [X] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [X] Oxidized root channels
- [ ] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 6/2	10YR 4/6			Sandy Clay Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [X] Reducing Conditions
- [X] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % In Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

[X] Hydrophytic Vegetation Present
[X] Hydric Soils Present
[X] Wetland Hydrology Present

[X] This Data Point is a Wetland

Remarks

Data Form
Routine Wetland Determination

Job Number: 3060002
City: Concord
Wetland Data Point: WL Area 3

Project/Site: **Dutch Buffalo Creek Stream and Wetland Restoration**
Applicant/Owner: **NCEEP**
Investigator: **BF**

Date: **December 12, 2006**
County: **Cabarrus**
State: **NC**

[X] Do normal circumstances exist on the site?
[ ] Have vegetation, soils, or hydrology been disturbed?
[ ] Is the area a potential problem area?

Community ID: **Upland**
Station ID:
Plot ID:

Vegetation

Dominant	Species	Common Name	% Cover	Indicator
Herbaceous				
X	*Panicum virgatum*	Switchgrass		FAC+
Shrub				
X	*Ligustrum sinense*	Privet,Chinese		FAC
Tree				
X	*Liquidambar styraciflua*	Gum,Sweet		FAC+
X	*Juniperus virginiana*	Cedar,Eastern Red		FACU-
X	*Fagus grandifolia*	Beech,American		FACU

% Species that are OBL, FACW, or FAC (except FAC-): **60**

Cowardin Classification:

Remarks

Hydrology

[ ] Recorded Data (describe in remarks)
- [ ] Stream, Lake, or Tide Gage
- [ ] Aerial Photograph
- [ ] Other (describe in remarks)

Field Observations:
- Depth of Surface Water(in.): **NA**
- Depth to Free Water in Pit(in.): **>24**
- Depth to Saturated Soils(in.): **>24**

Primary Wetland Hydrology Indicators
- [ ] Inundated
- [ ] Saturated in upper 12 Inches
- [ ] Water marks
- [ ] Drift lines
- [ ] Sediment deposits
- [ ] Drainage patterns in wetlands

Secondary Hydrology Indicators
- [ ] Oxidized root channels
- [ ] Water-stained leaves
- [ ] Local soil survey data
- [ ] FAC-Neutral test
- [ ] Other (explain in remarks)

Remarks
Sufficient indicators were not observed

Soils

Depth (in.)	Hor.	Matrix Color	Mottle / 2nd Mottle Color	Abundance	Contrast	Texture, Structure, etc.
0-12	A/B	10YR 4/4				Sandy Loam

Hydric Soils Indicators
- [ ] Histosol
- [ ] Histic Epipedon
- [ ] Sulfidic Odor
- [ ] Probable Aquatic Moist Regime
- [ ] Reducing Conditions
- [ ] Gleyed or Low-Chroma Colors
- [ ] Concretions
- [ ] High Organic % in Surface Layer
- [ ] Organic Streaking
- [ ] Listed on Local Hydric Soils List
- [ ] Listed on National Hydric Soils List
- [ ] Other (explain in remarks)

Unit Name:
Drainage Class:

Taxonomy:
[ ] Field Observations match map

Remarks

Wetland Determination

- [ ] Hydrophytic Vegetation Present
- [ ] Hydric Soils Present
- [ ] Wetland Hydrology Present

[ ] This Data Point is a Wetland

Remarks

APPENDIX 6
REFERENCE SITE NCDWQ STREAM CLASSIFICATION FORMS

NCDWQ Stream Classification Form

Project Name: Dutch Buffalo Creek River Basin: Neuse County: Wake Evaluator: KY
DWQ Project Number: Nearest Named Stream: Sal's Branch Latitude: Signature:
Date: February 7, 2007 USGS QUAD: Longitude: Location/Directions: William B.Umstead Park-North Entrance

PLEASE NOTE:** *If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used*

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	**(3)**
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	**(3)**
3) Are Natural Levees Present?	**(0)**	1	2	3
4) Is The Channel Sinuous?	0	1	2	**(3)**
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	**(3)**
6) Is The Channel Braided?	**(0)**	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	**(3)**
8) Is There A Bankfull Bench Present?	0	1	2	**(3)**
9) Is a Continuous Bed & Bank Present?	0	1	2	**(3)**

*(*NOTE: If Bed & Bank Caused By Ditching And **WITHOUT** Sinuosity Then Score=0*)*

10) Is a 2nd Order Or Greater Channel (As Indicated On Topo Map ***And/Or*** In Field) Present? ***Yes***=3 ***No***=**(0)**

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 21

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	**(3)**

PRIMARY HYDROLOGY INDICATOR POINTS: 3

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	**(1)**	0
2) Are Rooted Plants Present In Streambed?	**(3)**	2	1	0
3) Is Periphyton Present?	0	1	2	**(3)**
4) Are Bivalves Present?	0	1	2	**(3)**

PRIMARY BIOLOGY INDICATOR POINTS: 10

Secondary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	**(0)**	.5	1	1.5
2) Is There A Grade Control Point In Channel?	**(0)**	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	**(1.5)**

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 1.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last Year's) Leaflitter Present In Streambed?	1.5	1	**(.5)**	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	**(1.5)**
3) Are Wrack Lines Present?	0	.5	1	**(1.5)**

4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5 (circled)
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5 (circled)
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		***Yes***=*1.5* (circled)		***No***=0

SECONDARY HYDROLOGY INDICATOR POINTS: 8

III. Biology	**Absent**	**Weak**	**Moderate**	**Strong**
1) Are Fish Present?	0	.5	1 (circled)	1.5
2) Are Amphibians Present?	0	.5 (circled)	1	1.5
3) Are AquaticTurtles Present?	0 (circled)	.5	1	1.5
4) Are Crayfish Present?	0	.5	1 (circled)	1.5
5) Are Macrobenthos Present?	0	.5	1 (circled)	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5 (circled)	1	1.5
7) Is Filamentous Algae Present?	0	.5 (circled)	1	1.5

8) Are Wetland Plants In Streambed?	**SAV**	**Mostly OBL**	**Mostly FACW**	**Mostly FAC**	**Mostly FACU**	**Mostly UPL**
(**NOTE:** If Total Absence Of All Plants In Streambed As Noted Above Skip This Step **UNLESS** SAV Present*).*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 4.5

TOTAL POINTS* (Primary + Secondary)** = 48 (If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)***

Notes:

NCDWQ Stream Classification Form

Project Name: Dutch Buffalo Creek River Basin: Cape Fear County: Orange Evaluator: KY
DWQ Project Number: Nearest Named Stream: Morgan Creek Latitude: Signature:
Date: February 7, 2007 USGS QUAD: Longitude: Location/Directions: USGS Gage Station Morgan Cr. Near White Cross

***PLEASE NOTE:** *If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used**

Primary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	**3**
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	**3**
3) Are Natural Levees Present?	**0**	1	2	3
4) Is The Channel Sinuous?	0	1	2	**3**
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	**3**
6) Is The Channel Braided?	**0**	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	**3**
8) Is There A Bankfull Bench Present?	0	1	2	**3**
9) Is a Continuous Bed & Bank Present?	0	1	2	**3**

*(*NOTE: If Bed & Bank Caused By Ditching And **WITHOUT** Sinuosity Then Score=0*)*

10) Is a 2nd Order Or Greater Channel (As Indicated On Topo Map ***And/Or*** In Field) Present? ***Yes***=3 ***No***=**0**

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 21

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	**3**

PRIMARY HYDROLOGY INDICATOR POINTS: ______

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	**1**	0
2) Are Rooted Plants Present In Streambed?	**3**	2	1	0
3) Is Periphyton Present?	0	1	**2**	3
4) Are Bivalves Present?	0	1	**2**	3

PRIMARY BIOLOGY INDICATOR POINTS: 8

Secondary Field Indicators: (Circle One Number Per Line)

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	**0**	.5	1	1.5
2) Is There A Grade Control Point In Channel?	**0**	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	**1.5**

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 1.5

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last Year's) Leaflitter Present In Streambed?	1.5	1	**.5**	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	**1.5**
3) Are Wrack Lines Present?	0	.5	1	**1.5**

4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5 (circled)
5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)?	0	.5	1	1.5 (circled)
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?	***Yes***=*1.5* (circled)		***No***=0	

SECONDARY HYDROLOGY INDICATOR POINTS: 8

III. Biology	**Absent**	**Weak**	**Moderate**	**Strong**
1) Are Fish Present?	0	.5	1 (circled)	1.5
2) Are Amphibians Present?	0	.5 (circled)	1	1.5
3) Are AquaticTurtles Present?	0 (circled)	.5	1	1.5
4) Are Crayfish Present?	0	.5	1 (circled)	1.5
5) Are Macrobenthos Present?	0	.5	1 (circled)	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5 (circled)	1	1.5
7) Is Filamentous Algae Present?	0	.5 (circled)	1	1.5

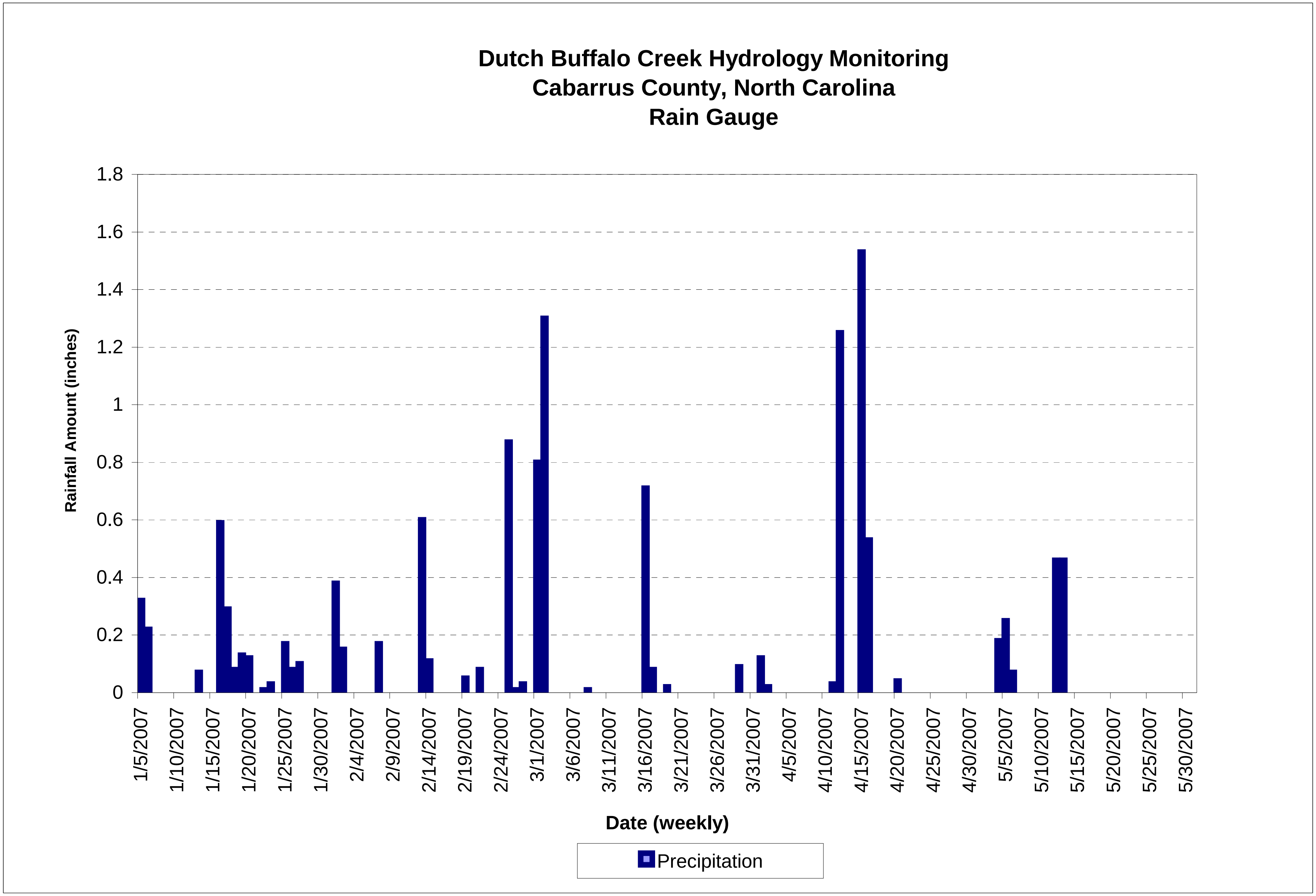
8) Are Wetland Plants In Streambed?	**SAV**	**Mostly OBL**	**Mostly FACW**	**Mostly FAC**	**Mostly FACU**	**Mostly UPL**
(**NOTE:** If Total Absence Of All Plants In Streambed As Noted Above Skip This Step **UNLESS** SAV Present*).*	2	1	.75	.5	0	0

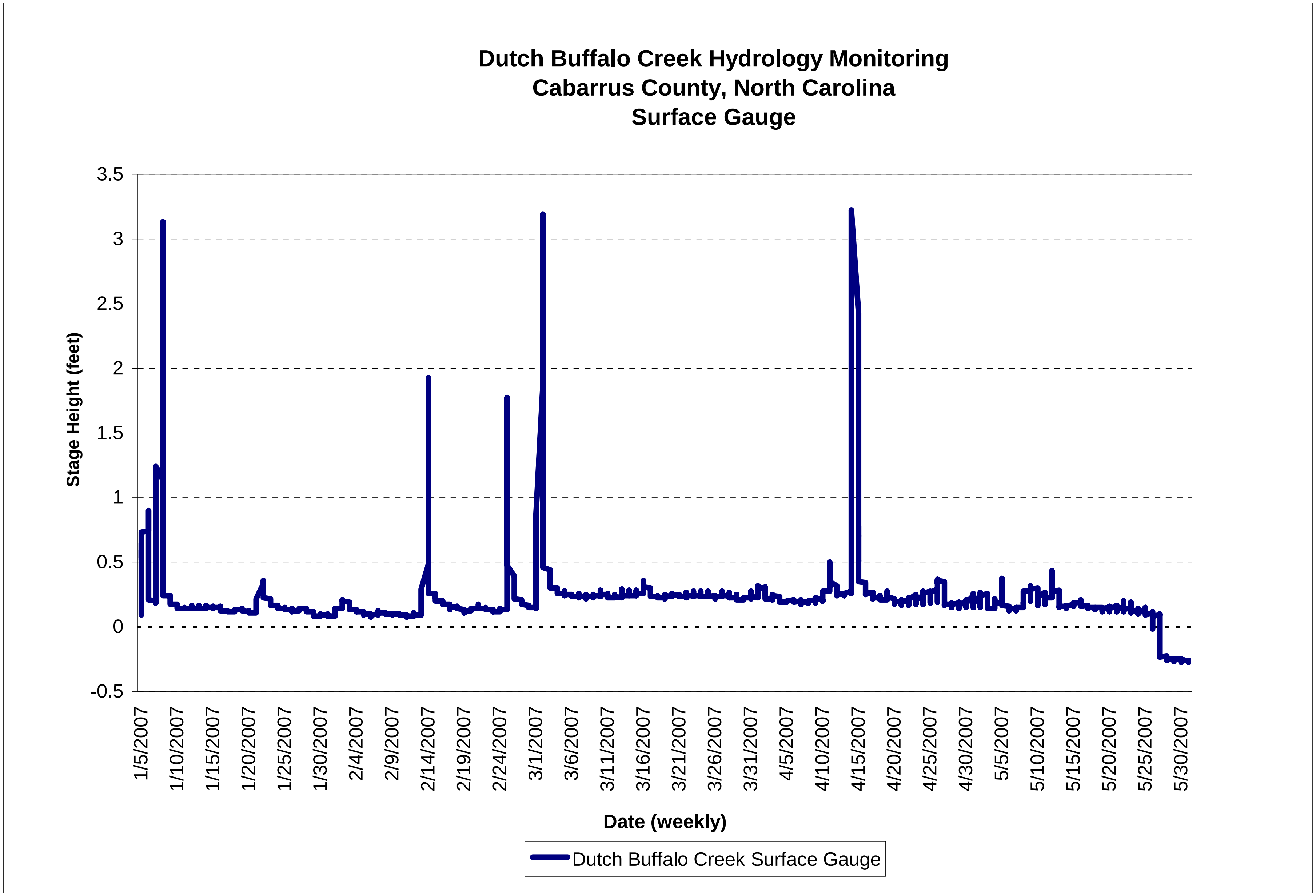
SECONDARY BIOLOGY INDICATOR POINTS: 4.5

TOTAL POINTS* (Primary + Secondary)** = 46 (If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)***

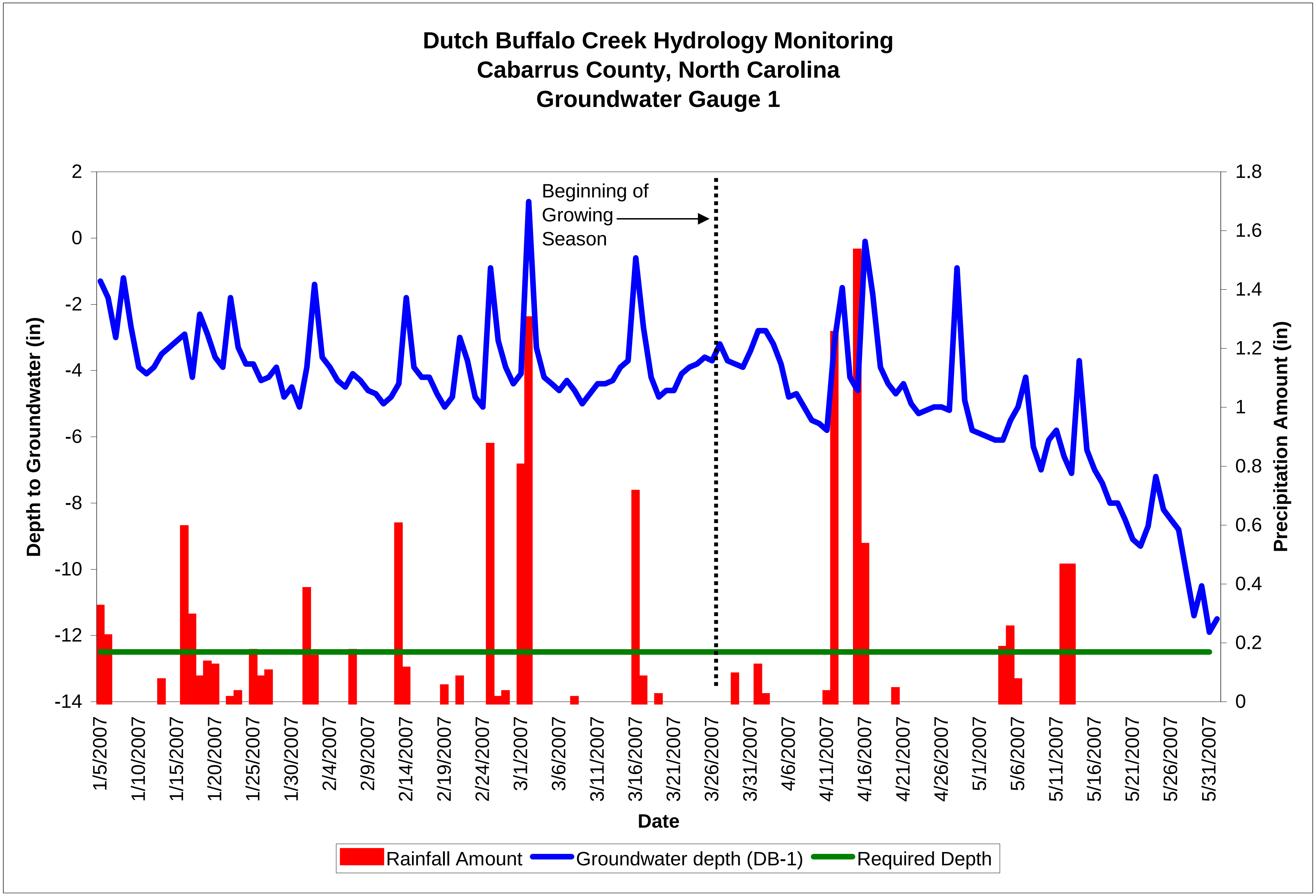
Notes:

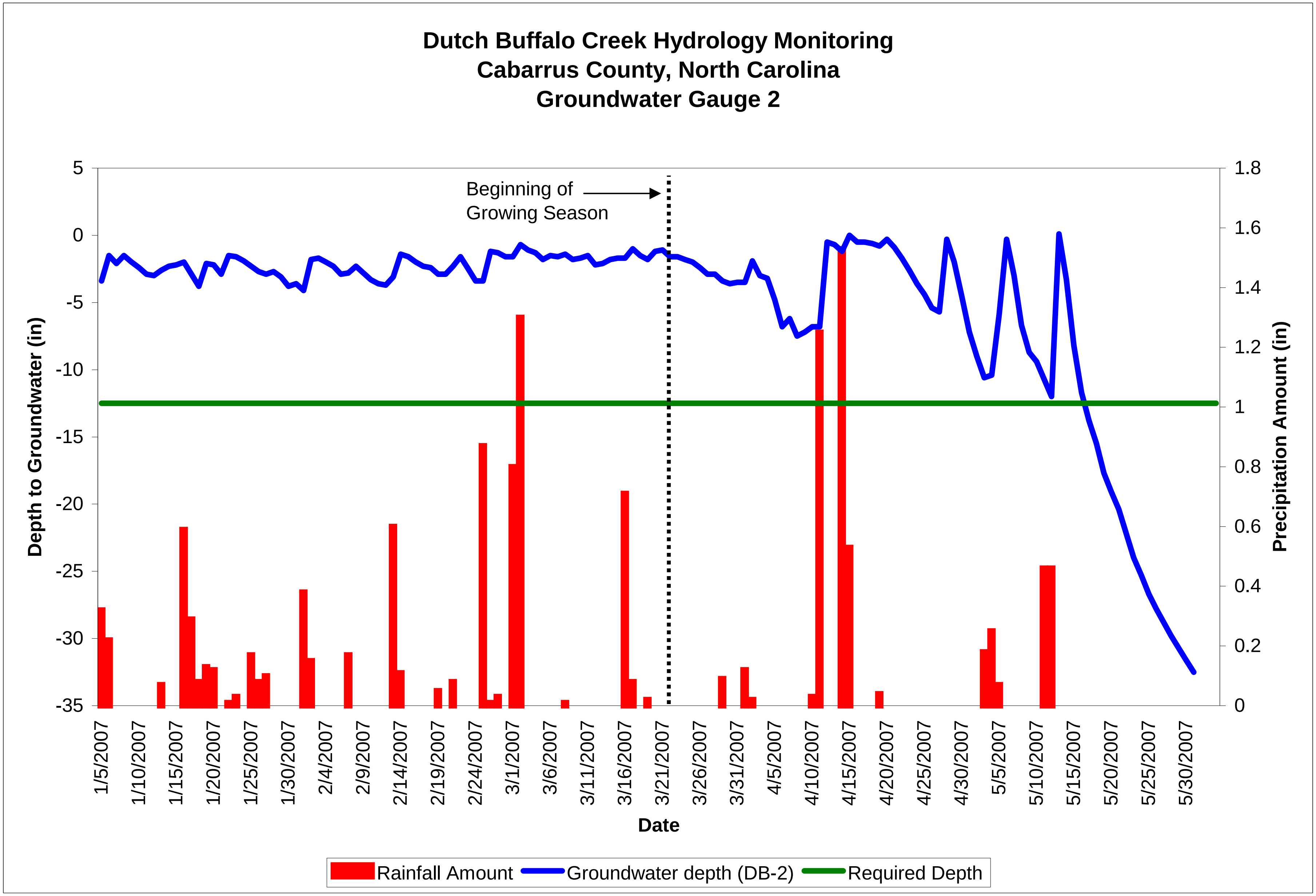
APPENDIX 7
HYDROLOGIC GAUGE DATA SUMMARY, GROUNDWATER AND RAINFALL INFORMATION

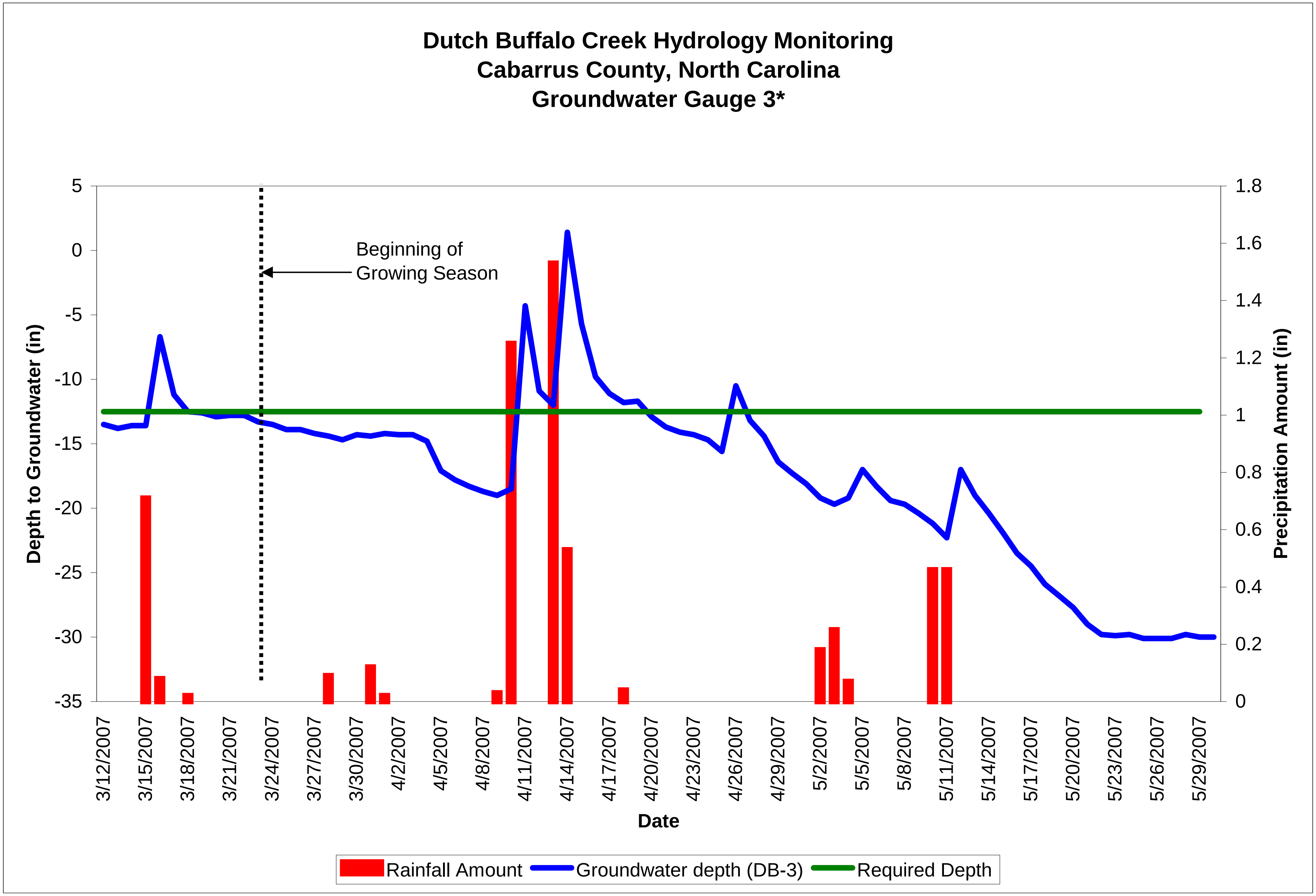

Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Rain Gauge
Rainfall Amount (inches)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Date (weekly)
Precipitation



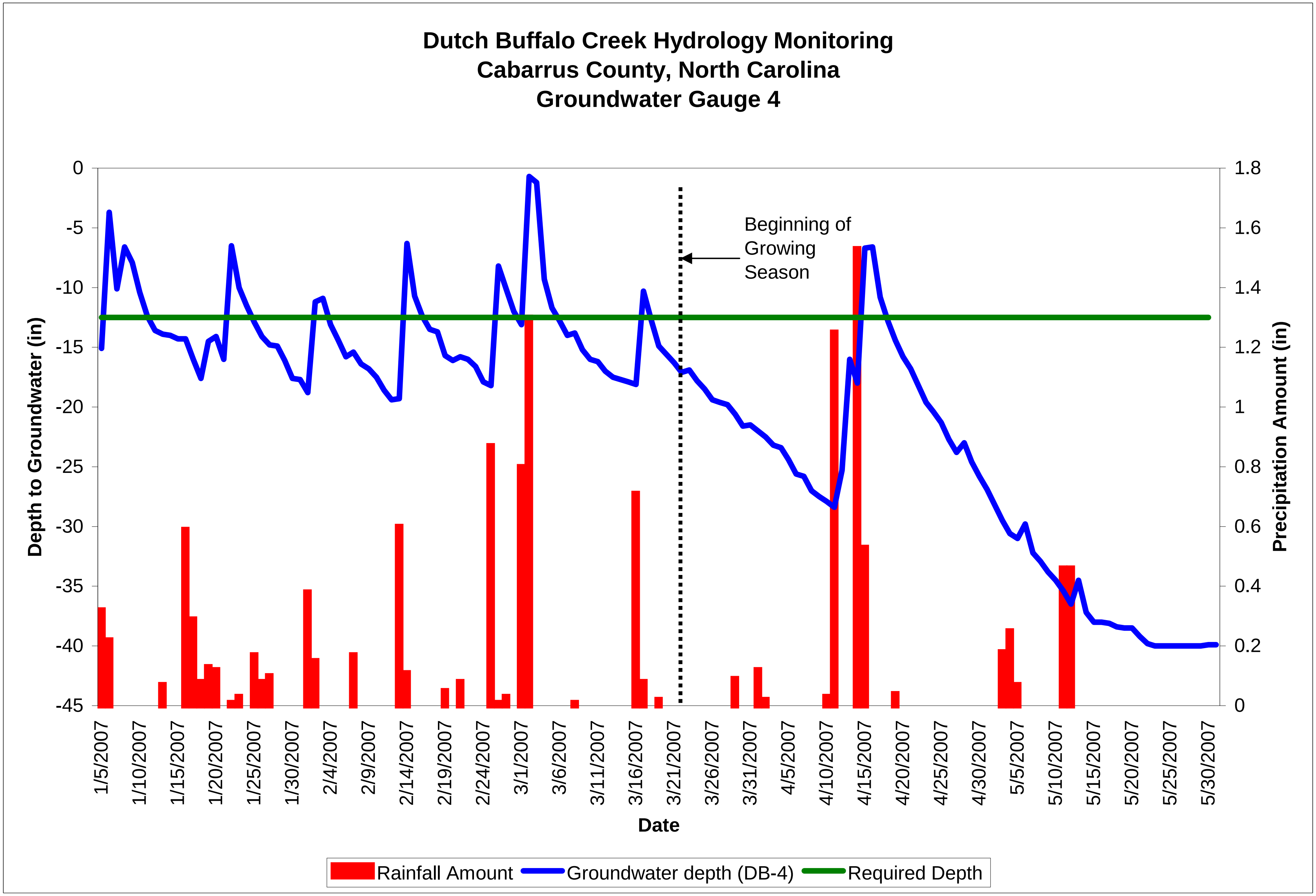
Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Surface Gauge
Stage Height (feet)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Date (weekly)
Dutch Buffalo Creek Surface Gauge


Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 1
Beginning of Growing Season
Depth to Groundwater (in)
Precipitation Amount (in)
Date
2
0
-2
-4
-6
-8
-10
-12
-14
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/6/2007
4/11/2007
4/16/2007
4/21/2007
4/26/2007
5/1/2007
5/6/2007
5/11/2007
5/16/2007
5/21/2007
5/26/2007
5/31/2007
Rainfall Amount
Groundwater depth (DB-1)
Required Depth

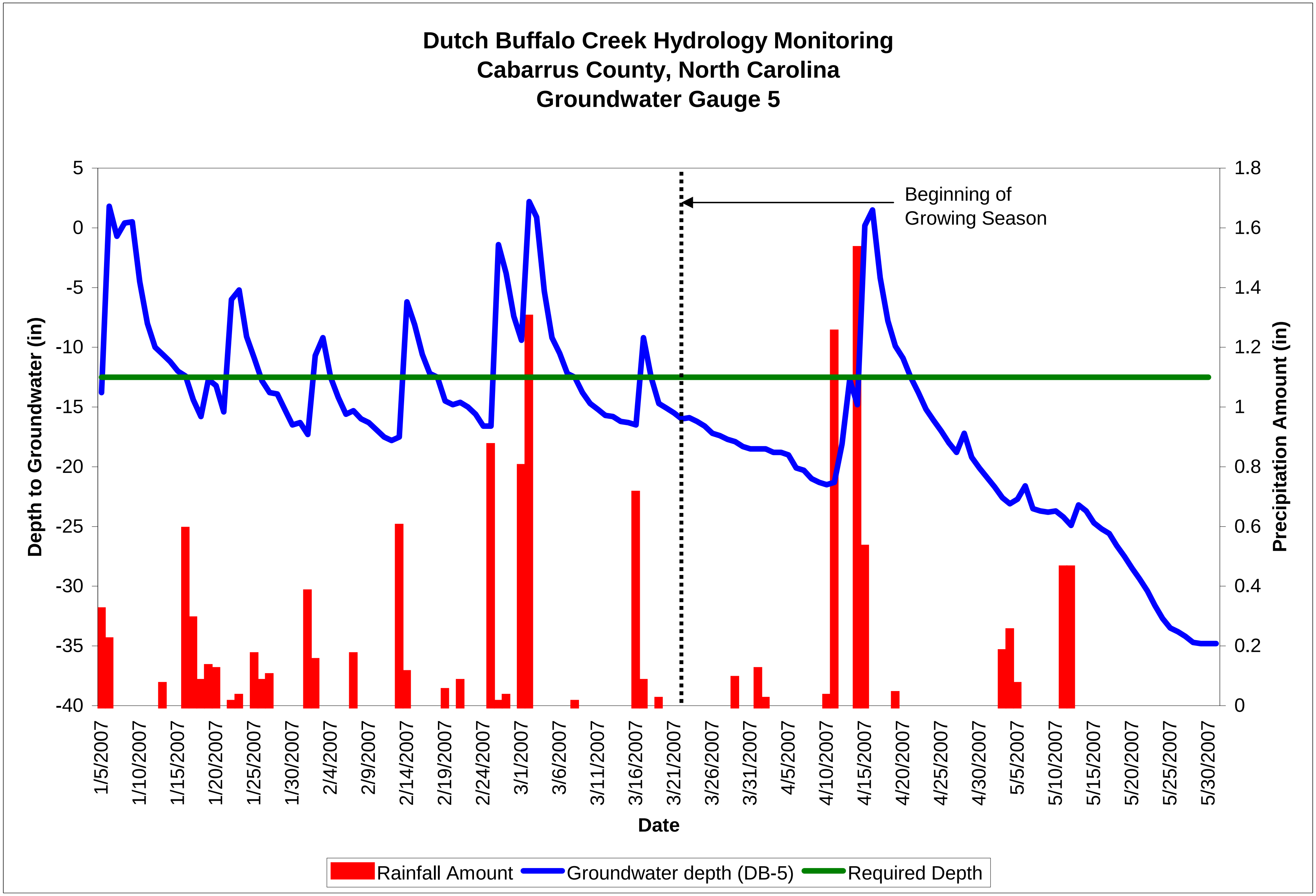

Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 2
Beginning of Growing Season
Depth to Groundwater (in)
Precipitation Amount (in)
Date
5
0
-5
-10
-15
-20
-25
-30
-35
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Rainfall Amount
Groundwater depth (DB-2)
Required Depth

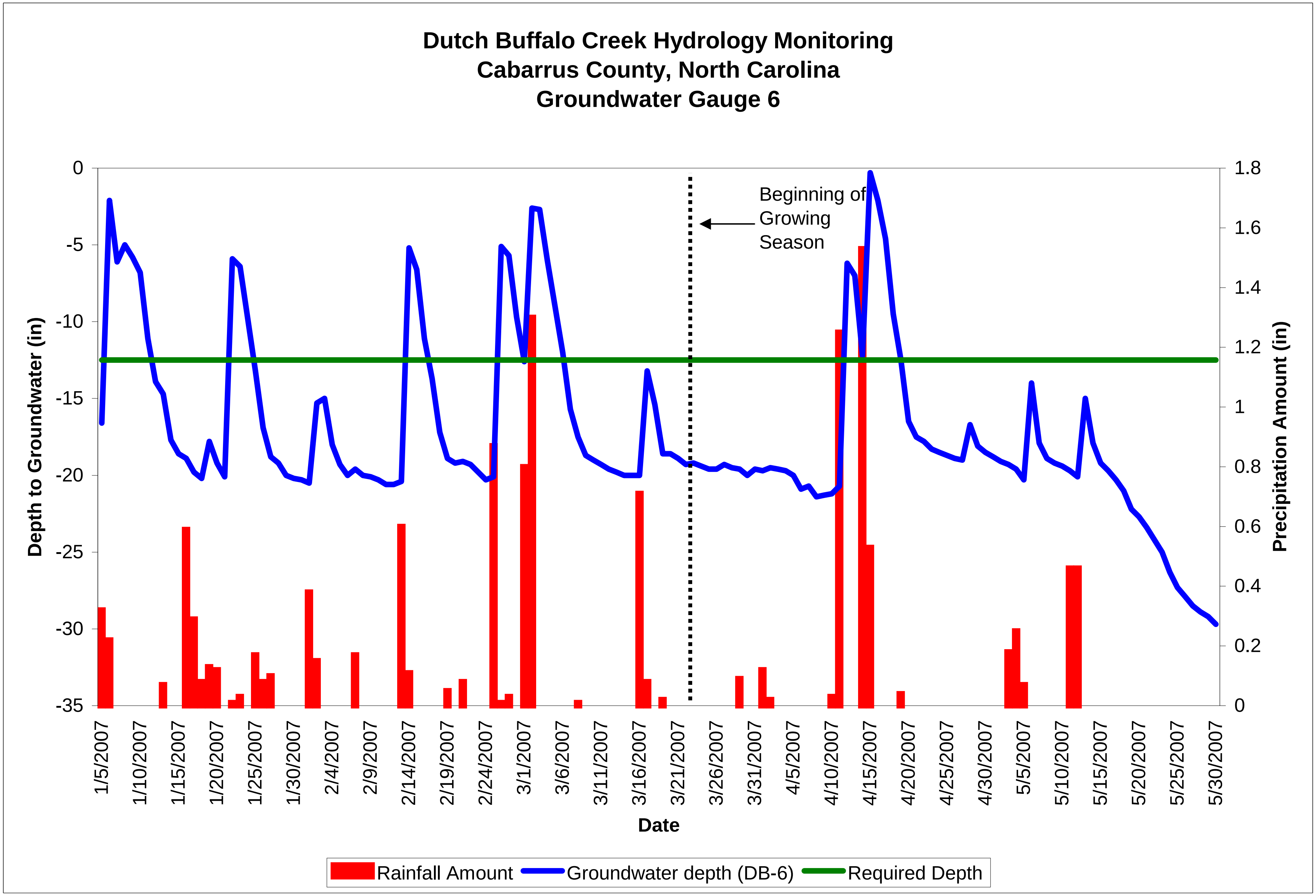


* Original gauge had to be replaced due to malfunction.

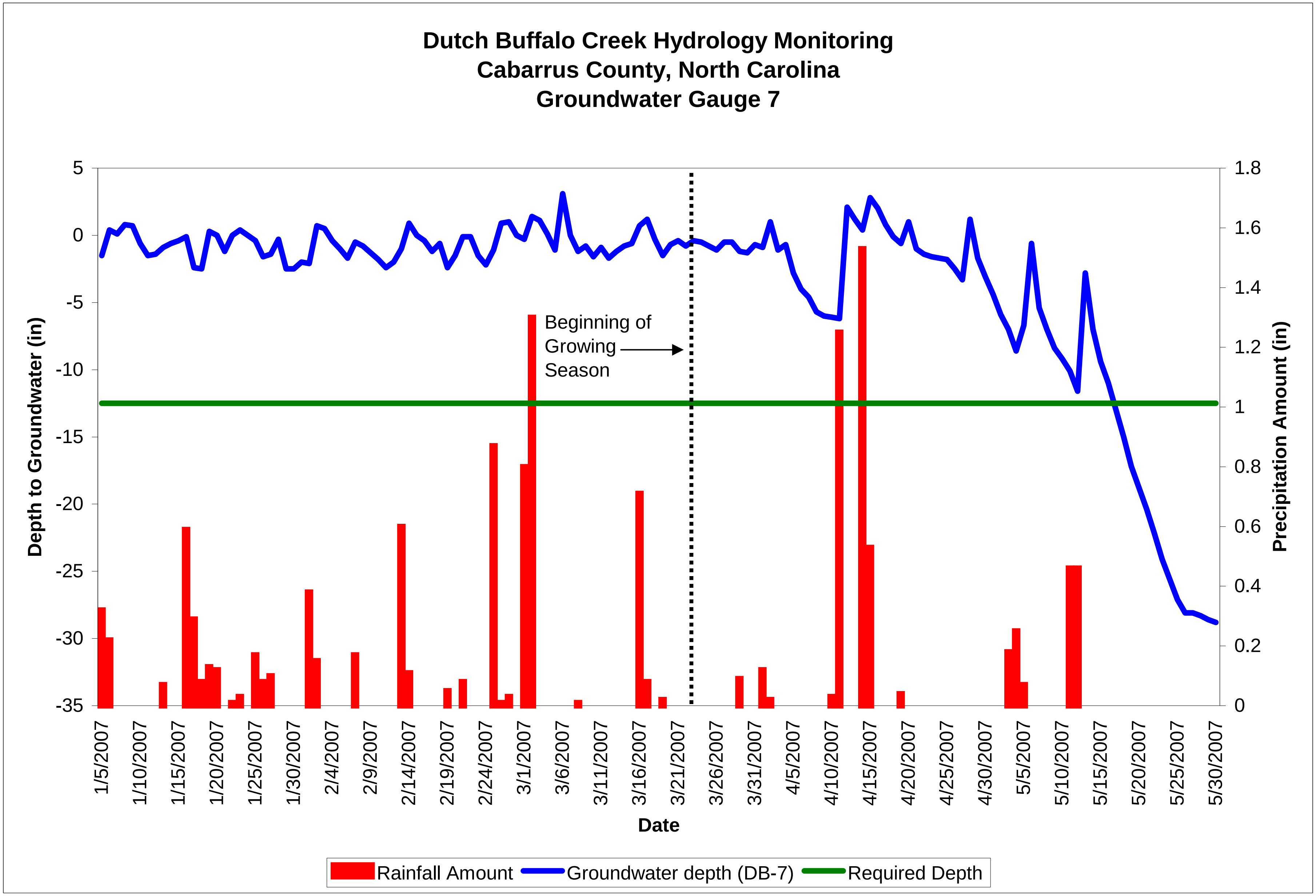


Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 4
Beginning of Growing Season
Depth to Groundwater (in)
Precipitation Amount (in)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Date
Rainfall Amount
Groundwater depth (DB-4)
Required Depth

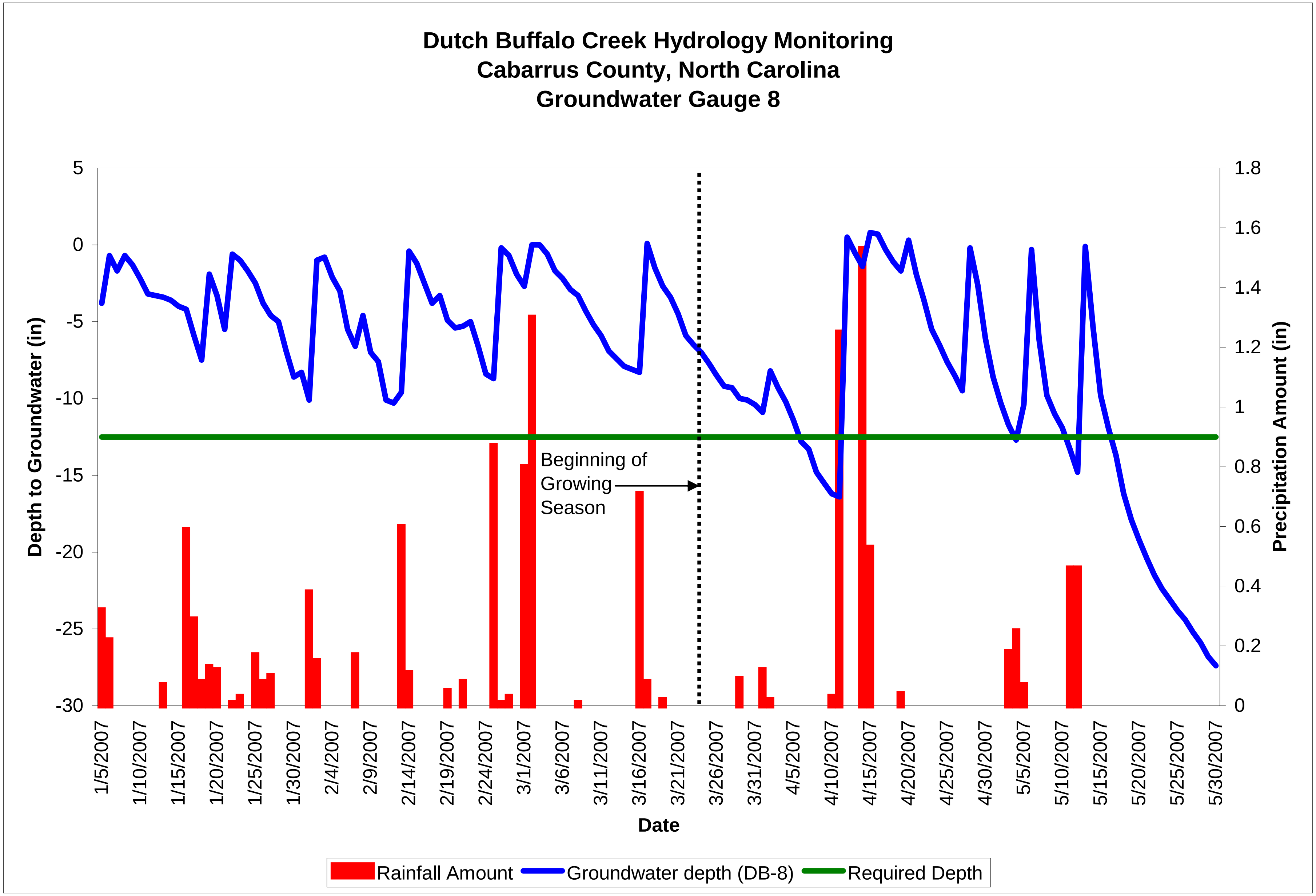

Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 5
Beginning of Growing Season
Depth to Groundwater (in)
Precipitation Amount (in)
Date
5
0
-5
-10
-15
-20
-25
-30
-35
-40
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Rainfall Amount
Groundwater depth (DB-5)
Required Depth

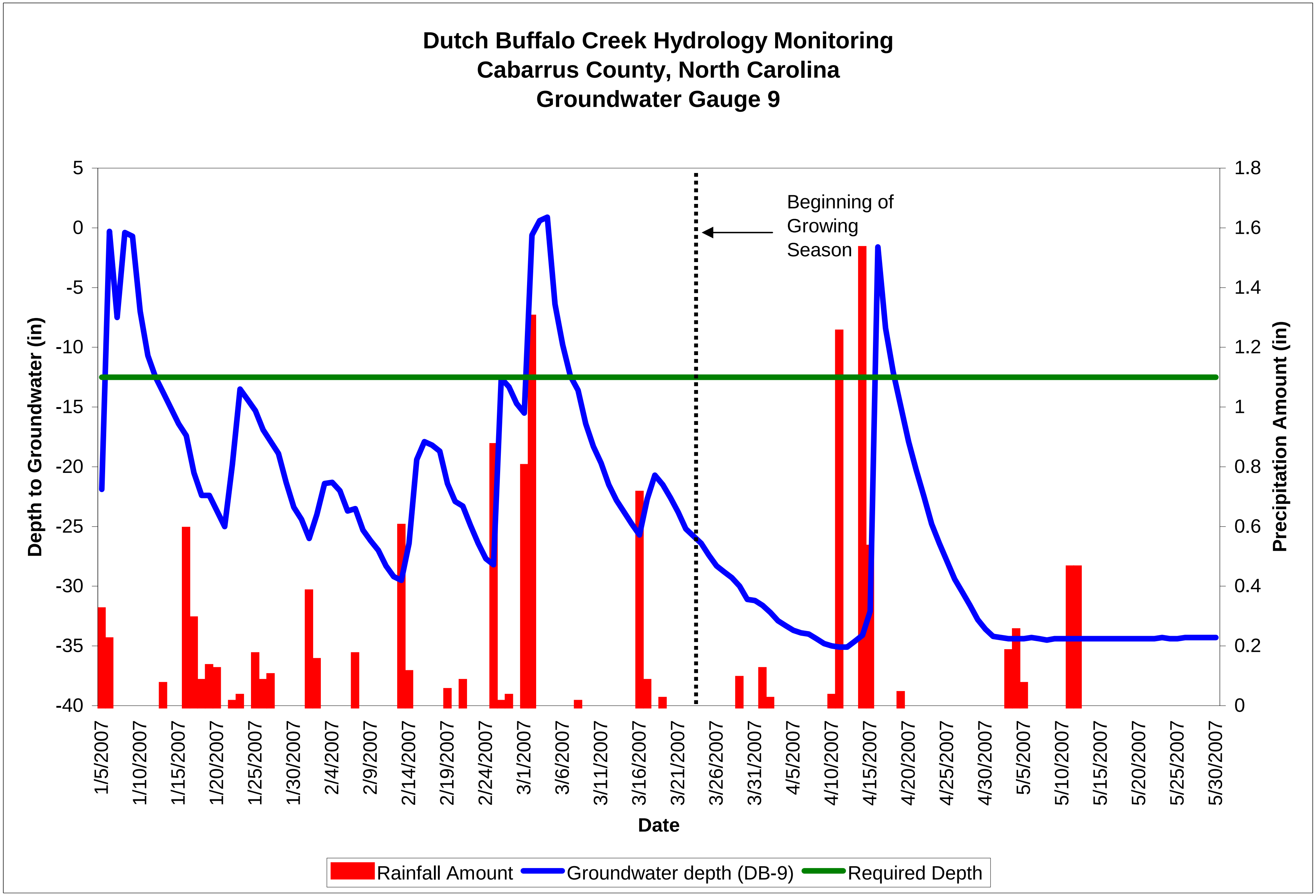


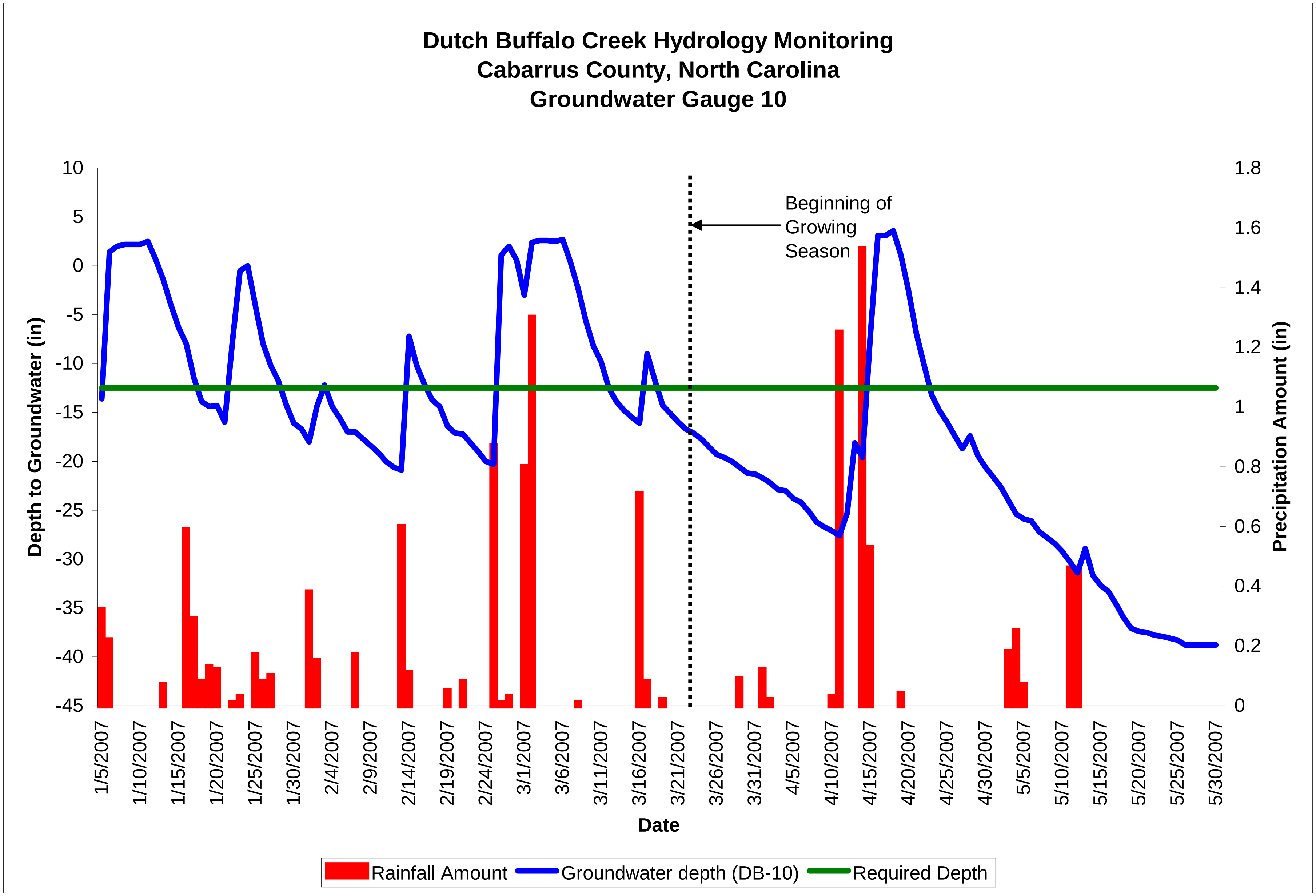
Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 6
Depth to Groundwater (in)
Precipitation Amount (in)
0
-5
-10
-15
-20
-25
-30
-35
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Beginning of
Growing
Season
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Date
Rainfall Amount
Groundwater depth (DB-6)
Required Depth



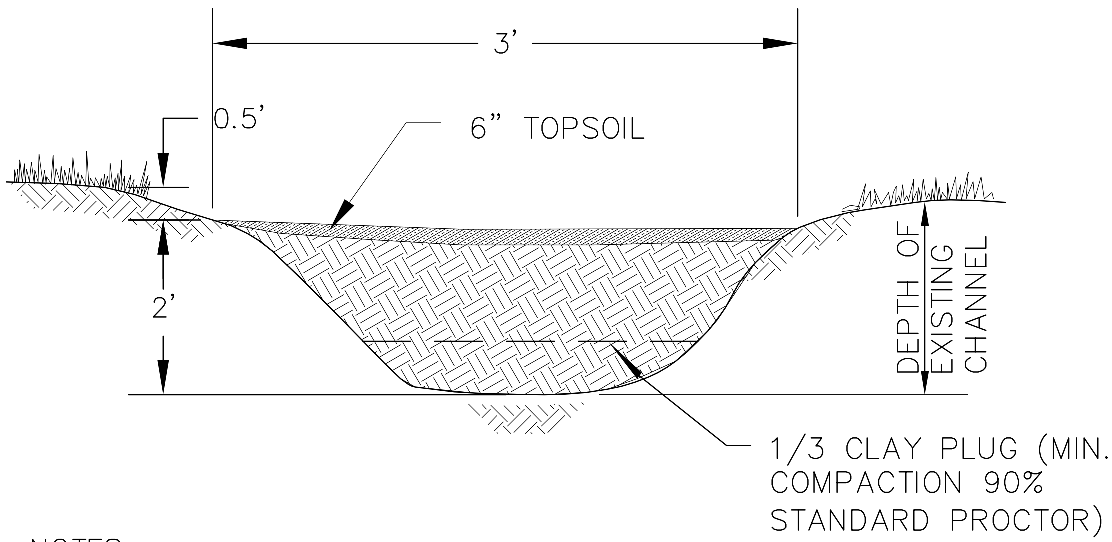
Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 7
Depth to Groundwater (in)
Precipitation Amount (in)
Date
Beginning of Growing Season
5
0
-5
-10
-15
-20
-25
-30
-35
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Rainfall Amount
Groundwater depth (DB-7)
Required Depth


Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 8
Depth to Groundwater (in)
Precipitation Amount (in)
Date
Beginning of Growing Season
5
0
-5
-10
-15
-20
-25
-30
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Rainfall Amount
Groundwater depth (DB-8)
Required Depth


Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 9
Beginning of Growing Season
Depth to Groundwater (in)
Precipitation Amount (in)
Date
5
0
-5
-10
-15
-20
-25
-30
-35
-40
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Rainfall Amount
Groundwater depth (DB-9)
Required Depth



Dutch Buffalo Creek Hydrology Monitoring
Cabarrus County, North Carolina
Groundwater Gauge 10
Depth to Groundwater (in)
Precipitation Amount (in)
Date
Beginning of Growing Season
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1/5/2007
1/10/2007
1/15/2007
1/20/2007
1/25/2007
1/30/2007
2/4/2007
2/9/2007
2/14/2007
2/19/2007
2/24/2007
3/1/2007
3/6/2007
3/11/2007
3/16/2007
3/21/2007
3/26/2007
3/31/2007
4/5/2007
4/10/2007
4/15/2007
4/20/2007
4/25/2007
4/30/2007
5/5/2007
5/10/2007
5/15/2007
5/20/2007
5/25/2007
5/30/2007
Rainfall Amount
Groundwater depth (DB-10)
Required Depth



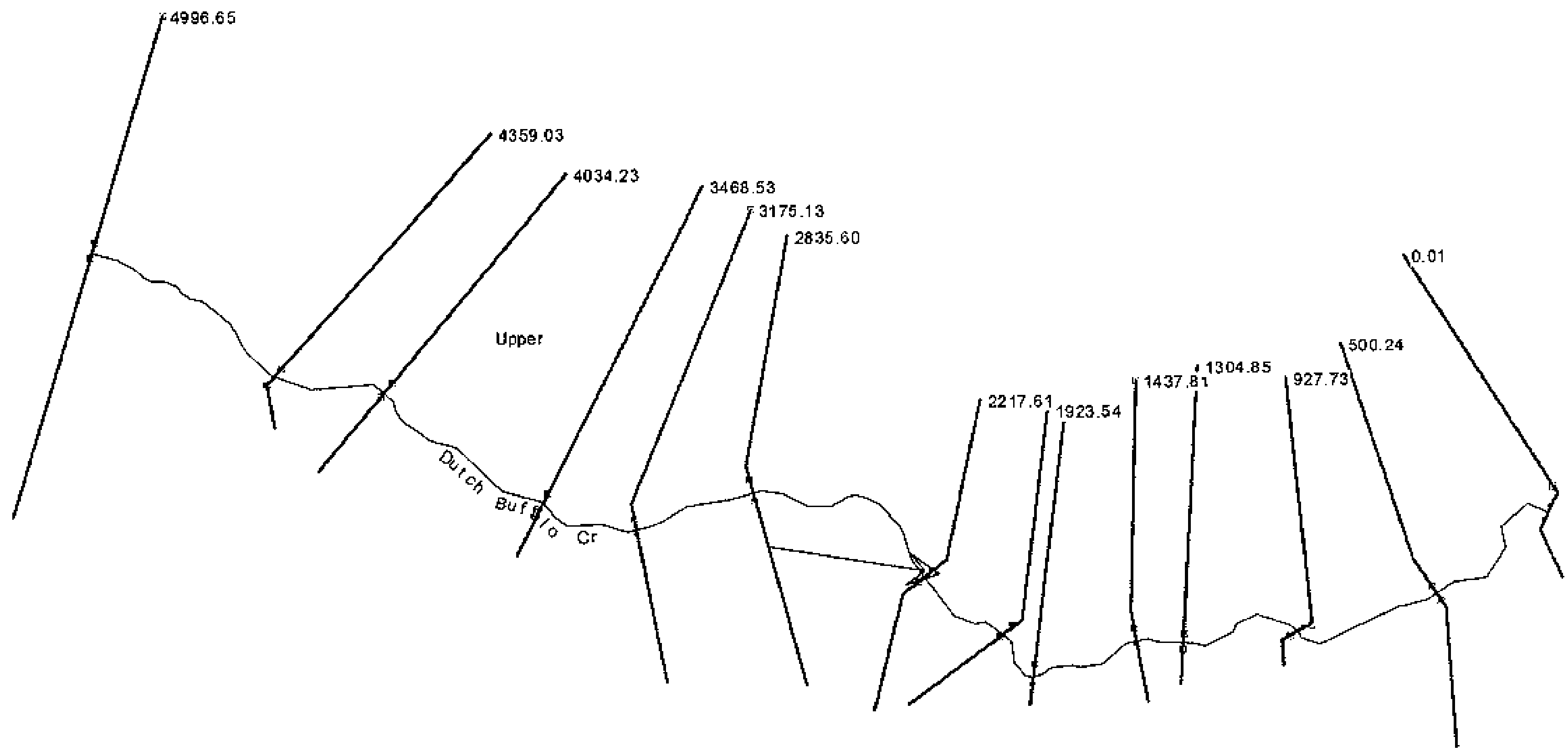
NOTES:

IN AREAS WITH PARTIAL FILL, LOG STEP POOL VANES WILL BE USED TO DETAIN FLOW IN REMAINING SHALLOW SWALE.

DITCH FILL

N.T.S.

APPENDIX 8
HEC-RAS ANALYSIS



DBC HEC-RAS Geometry and Cross-Section Stationing

HEC-RAS Plan: Exist River: Dutch Buffalo Cr Reach: Upper

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
Upper	4996.65	2 YEARS	1220.00	643.44	651.96	5.01	273.05	0.69
Upper	4996.65	5 YEARS	2022.00	643.44	652.88	3.58	909.33	0.33
Upper	4996.65	10 YEARS	2662.00	643.44	653.31	3.90	940.54	0.39
Upper	4996.65	25 YEARS	3597.00	643.44	654.01	4.05	990.31	0.40
Upper	4996.65	50 YEARS	4409.00	643.44	654.53	4.19	1028.43	0.42
Upper	4996.65	100 YEARS	5287.00	643.44	655.04	4.33	1062.62	0.44
Upper	4996.65	**1.5 YEARS**	565.00	643.44	649.78	3.94	33.99	0.45
Upper	4359.03	2 YEARS	1220.00	642.80	651.01	3.87	72.10	0.39
Upper	4359.03	5 YEARS	2022.00	642.80	652.06	4.22	728.08	0.44
Upper	4359.03	10 YEARS	2662.00	642.80	652.17	5.33	733.41	0.69
Upper	4359.03	25 YEARS	3597.00	642.80	652.85	5.79	763.18	0.79
Upper	4359.03	50 YEARS	4409.00	642.80	653.35	6.12	785.66	0.87
Upper	4359.03	100 YEARS	5287.00	642.80	653.85	6.41	806.63	0.93
Upper	4359.03	**1.5 YEARS**	565.00	642.80	649.17	2.60	46.61	0.19
Upper	4034.23	2 YEARS	1220.00	641.28	650.41	4.76	125.12	0.60
Upper	4034.23	5 YEARS	2022.00	641.28	650.79	7.30	126.65	1.38
Upper	4034.23	10 YEARS	2662.00	641.28	651.48	5.96	714.59	0.89
Upper	4034.23	25 YEARS	3597.00	641.28	652.18	6.29	778.70	0.96
Upper	4034.23	50 YEARS	4409.00	641.28	652.72	6.44	792.14	0.99
Upper	4034.23	100 YEARS	5287.00	641.28	653.24	6.61	805.02	1.02
Upper	4034.23	**1.5 YEARS**	565.00	641.28	648.89	2.94	37.87	0.24
Upper	3468.53	2 YEARS	1220.00	641.44	650.25	2.17	855.82	0.12
Upper	3468.53	5 YEARS	2022.00	641.44	650.46	3.31	865.92	0.28
Upper	3468.53	10 YEARS	2662.00	641.44	651.00	3.58	885.25	0.32
Upper	3468.53	25 YEARS	3597.00	641.44	651.68	3.92	915.91	0.37
Upper	3468.53	50 YEARS	4409.00	641.44	652.21	4.16	940.65	0.41
Upper	3468.53	100 YEARS	5287.00	641.44	652.73	4.38	952.07	0.44
Upper	3468.53	**1.5 YEARS**	565.00	641.44	648.41	2.76	58.85	0.22
Upper	3175.13	2 YEARS	1220.00	641.91	649.15	6.02	38.76	1.40
Upper	3175.13	5 YEARS	2022.00	641.91	650.21	3.05	758.45	0.35
Upper	3175.13	10 YEARS	2662.00	641.91	650.76	3.20	778.49	0.37
Upper	3175.13	25 YEARS	3597.00	641.91	651.44	3.41	794.20	0.40
Upper	3175.13	50 YEARS	4409.00	641.91	651.98	3.55	807.25	0.43
Upper	3175.13	100 YEARS	5287.00	641.91	652.50	3.72	822.12	0.46
Upper	3175.13	**1.5 YEARS**	565.00	641.91	647.90	3.57	32.95	0.51
Upper	2835.60	2 YEARS	1220.00	640.96	649.14	2.18	953.91	0.13
Upper	2835.60	5 YEARS	2022.00	640.96	649.98	2.58	1014.12	0.17
Upper	2835.60	10 YEARS	2662.00	640.96	650.52	2.82	1038.07	0.20
Upper	2835.60	25 YEARS	3597.00	640.96	651.19	3.13	1065.97	0.24
Upper	2835.60	50 YEARS	4409.00	640.96	651.72	3.40	1137.64	0.28
Upper	2835.60	100 YEARS	5287.00	640.96	652.22	3.64	1187.16	0.31
Upper	2835.60	**1.5 YEARS**	565.00	640.96	647.31	2.96	54.02	0.27
Upper	2217.61	2 YEARS	1220.00	640.19	648.57	3.62	559.35	0.36
Upper	2217.61	5 YEARS	2022.00	640.19	649.33	4.33	610.57	0.50
Upper	2217.61	10 YEARS	2662.00	640.19	649.83	4.71	644.70	0.57
Upper	2217.61	25 YEARS	3597.00	640.19	650.48	5.12	687.98	0.66
Upper	2217.61	50 YEARS	4409.00	640.19	650.98	5.40	721.96	0.71

HEC-RAS Plan: Exist River: Dutch Buffalo Cr Reach: Upper (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
Upper	2217.61	100 YEARS	5287.00	640.19	651.47	5.66	754.81	0.77
Upper	2217.61	**1.5 YEARS**	565.00	640.19	646.47	3.22	37.76	0.30
Upper	1923.54	2 YEARS	1220.00	639.26	648.10	4.05	667.89	0.45
Upper	1923.54	5 YEARS	2022.00	639.26	648.89	4.45	700.51	0.52
Upper	1923.54	10 YEARS	2662.00	639.26	649.42	4.60	722.79	0.55
Upper	1923.54	25 YEARS	3597.00	639.26	650.09	4.79	751.15	0.57
Upper	1923.54	50 YEARS	4409.00	639.26	650.61	4.92	773.27	0.59
Upper	1923.54	100 YEARS	5287.00	639.26	651.12	5.06	794.36	0.61
Upper	1923.54	**1.5 YEARS**	565.00	639.26	646.04	3.39	35.12	0.34
Upper	1758.49	2 YEARS	1220.00	640.03	647.86	3.93	445.60	0.43
Upper	1758.49	5 YEARS	2022.00	640.03	648.63	4.56	539.90	0.55
Upper	1758.49	10 YEARS	2662.00	640.03	649.18	4.75	559.87	0.58
Upper	1758.49	25 YEARS	3597.00	640.03	649.86	5.00	586.92	0.62
Upper	1758.49	50 YEARS	4409.00	640.03	650.39	5.17	610.00	0.65
Upper	1758.49	100 YEARS	5287.00	640.03	650.90	5.38	632.04	0.68
Upper	1758.49	**1.5 YEARS**	565.00	640.03	645.77	3.55	38.11	0.36
Upper	1437.81	2 YEARS	1220.00	637.88	647.14	4.73	139.21	0.61
Upper	1437.81	5 YEARS	2022.00	637.88	648.10	4.66	615.49	0.58
Upper	1437.81	10 YEARS	2662.00	637.88	648.70	4.76	687.76	0.59
Upper	1437.81	25 YEARS	3597.00	637.88	649.45	4.80	739.11	0.58
Upper	1437.81	50 YEARS	4409.00	637.88	650.00	4.93	811.60	0.60
Upper	1437.81	100 YEARS	5287.00	637.88	650.54	4.94	834.97	0.59
Upper	1437.81	**1.5 YEARS**	565.00	637.88	645.41	2.95	34.14	0.25
Upper	1304.85	2 YEARS	1220.00	638.83	646.92	4.42	120.26	0.52
Upper	1304.85	5 YEARS	2022.00	638.83	647.95	3.98	741.42	0.40
Upper	1304.85	10 YEARS	2662.00	638.83	648.57	3.97	766.91	0.39
Upper	1304.85	25 YEARS	3597.00	638.83	649.32	4.03	791.46	0.39
Upper	1304.85	50 YEARS	4409.00	638.83	649.88	4.12	810.06	0.40
Upper	1304.85	100 YEARS	5287.00	638.83	650.42	4.22	827.46	0.41
Upper	1304.85	**1.5 YEARS**	565.00	638.83	645.27	2.93	40.78	0.25
Upper	927.73	2 YEARS	1220.00	639.32	646.46	3.84	545.92	0.39
Upper	927.73	5 YEARS	2022.00	639.32	647.46	4.43	621.07	0.49
Upper	927.73	10 YEARS	2662.00	639.32	648.06	4.83	661.43	0.57
Upper	927.73	25 YEARS	3597.00	639.32	648.80	5.27	689.92	0.66
Upper	927.73	50 YEARS	4409.00	639.32	649.34	5.62	711.91	0.73
Upper	927.73	100 YEARS	5287.00	639.32	649.86	5.98	733.02	0.81
Upper	927.73	**1.5 YEARS**	565.00	639.32	644.80	3.24	43.22	0.31
Upper	500.24	2 YEARS	1220.00	637.11	646.00	3.38	574.18	0.32
Upper	500.24	5 YEARS	2022.00	637.11	647.01	3.84	646.83	0.39
Upper	500.24	10 YEARS	2662.00	637.11	647.59	4.22	694.51	0.46
Upper	500.24	25 YEARS	3597.00	637.11	648.30	4.69	760.79	0.54
Upper	500.24	50 YEARS	4409.00	637.11	648.83	5.03	797.53	0.61
Upper	500.24	100 YEARS	5287.00	637.11	649.33	5.36	831.02	0.68
Upper	500.24	**1.5 YEARS**	565.00	637.11	644.33	3.03	37.53	0.26
Upper	0.01	2 YEARS	1220.00	637.98	645.31	4.11	621.90	0.44
Upper	0.01	5 YEARS	2022.00	637.98	646.34	4.60	819.01	0.53

HEC-RAS Plan: Exist River: Dutch Buffalo Cr Reach: Upper (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
Upper	0.01	10 YEARS	2662.00	637.98	646.93	4.86	874.40	0.57
Upper	0.01	25 YEARS	3597.00	637.98	647.65	5.19	939.11	0.63
Upper	0.01	50 YEARS	4409.00	637.98	648.19	5.42	977.18	0.67
Upper	0.01	100 YEARS	5287.00	637.98	648.70	5.63	988.72	0.71
Upper	0.01	**1.5 YEARS**	565.00	637.98	643.70	3.38	51.91	0.33

HEC-RAS Plan: modified#2 River: Dutch Buffalo Cr Reach: Upper

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
Upper	4996.65	2 YEARS	1220.00	643.44	651.12	6.39	36.51	1.12
Upper	4996.65	5 YEARS	2022.00	643.44	652.25	7.59	288.49	1.55
Upper	4996.65	10 YEARS	2662.00	643.44	652.87	4.74	908.73	0.58
Upper	4996.65	25 YEARS	3597.00	643.44	653.58	4.74	959.50	0.56
Upper	4996.65	50 YEARS	4409.00	643.44	654.09	4.82	996.30	0.57
Upper	4996.65	100 YEARS	5287.00	643.44	654.60	4.92	1033.74	0.58
Upper	4996.65	**1.5 YEARS**	565.00	643.44	649.28	4.45	32.69	0.59
Upper	4359.03	2 YEARS	1220.00	642.80	650.21	3.31	90.70	0.30
Upper	4359.03	5 YEARS	2022.00	642.80	650.98	4.37	524.50	0.51
Upper	4359.03	10 YEARS	2662.00	642.80	651.55	4.86	646.35	0.61
Upper	4359.03	25 YEARS	3597.00	642.80	652.24	5.33	736.64	0.70
Upper	4359.03	50 YEARS	4409.00	642.80	652.77	5.62	759.67	0.76
Upper	4359.03	100 YEARS	5287.00	642.80	653.28	5.89	782.35	0.82
Upper	4359.03	**1.5 YEARS**	565.00	642.80	648.46	2.44	72.31	0.19
Upper	4034.23	2 YEARS	1220.00	641.28	649.88	3.11	85.83	0.27
Upper	4034.23	5 YEARS	2022.00	641.28	650.52	4.02	602.55	0.43
Upper	4034.23	10 YEARS	2662.00	641.28	651.07	4.44	667.35	0.51
Upper	4034.23	25 YEARS	3597.00	641.28	651.75	4.92	752.48	0.60
Upper	4034.23	50 YEARS	4409.00	641.28	652.27	5.19	780.96	0.65
Upper	4034.23	100 YEARS	5287.00	641.28	652.79	5.42	793.84	0.69
Upper	4034.23	**1.5 YEARS**	565.00	641.28	648.22	2.17	72.55	0.14
Upper	3468.53	2 YEARS	1220.00	641.44	649.20	3.53	104.73	0.35
Upper	3468.53	5 YEARS	2022.00	641.44	650.04	3.10	845.95	0.26
Upper	3468.53	10 YEARS	2662.00	641.44	650.59	3.35	870.99	0.29
Upper	3468.53	25 YEARS	3597.00	641.44	651.28	3.66	895.02	0.33
Upper	3468.53	50 YEARS	4409.00	641.44	651.80	3.91	925.53	0.37
Upper	3468.53	100 YEARS	5287.00	641.44	652.33	4.12	943.26	0.40
Upper	3468.53	**1.5 YEARS**	565.00	641.44	647.79	2.37	70.79	0.17
Upper	3175.13	2 YEARS	1220.00	641.91	648.81	3.48	667.64	0.44
Upper	3175.13	5 YEARS	2022.00	641.91	649.72	3.68	731.60	0.46
Upper	3175.13	10 YEARS	2662.00	641.91	650.29	3.83	762.61	0.49
Upper	3175.13	25 YEARS	3597.00	641.91	651.00	4.05	782.06	0.52
Upper	3175.13	50 YEARS	4409.00	641.91	651.53	4.24	796.46	0.55
Upper	3175.13	100 YEARS	5287.00	641.91	652.07	4.41	809.77	0.59
Upper	3175.13	**1.5 YEARS**	565.00	641.91	647.32	3.31	52.45	0.43
Upper	2835.60	2 YEARS	1220.00	640.96	648.48	2.69	546.10	0.21
Upper	2835.60	5 YEARS	2022.00	640.96	649.46	2.77	982.17	0.21
Upper	2835.60	10 YEARS	2662.00	640.96	650.04	2.97	1016.92	0.23
Upper	2835.60	25 YEARS	3597.00	640.96	650.75	3.23	1048.31	0.26
Upper	2835.60	50 YEARS	4409.00	640.96	651.28	3.42	1069.35	0.28
Upper	2835.60	100 YEARS	5287.00	640.96	651.81	3.67	1147.92	0.32
Upper	2835.60	**1.5 YEARS**	565.00	640.96	646.77	2.81	66.47	0.25
Upper	2217.61	2 YEARS	1220.00	640.19	647.78	3.37	340.45	0.32
Upper	2217.61	5 YEARS	2022.00	640.19	648.76	4.04	572.34	0.43
Upper	2217.61	10 YEARS	2662.00	640.19	649.32	4.41	609.72	0.49
Upper	2217.61	25 YEARS	3597.00	640.19	650.00	4.84	655.80	0.57
Upper	2217.61	50 YEARS	4409.00	640.19	650.53	5.13	691.21	0.63

HEC-RAS Plan: modified#2 River: Dutch Buffalo Cr Reach: Upper (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
Upper	2217.61	100 YEARS	5287.00	640.19	651.03	5.41	725.39	0.68
Upper	2217.61	**1.5 YEARS**	565.00	640.19	645.98	2.67	68.35	0.22
Upper	1923.54	2 YEARS	1220.00	639.26	647.46	3.19	90.83	0.28
Upper	1923.54	5 YEARS	2022.00	639.26	648.46	3.63	682.98	0.34
Upper	1923.54	10 YEARS	2662.00	639.26	649.03	3.89	706.20	0.38
Upper	1923.54	25 YEARS	3597.00	639.26	649.72	4.18	735.74	0.42
Upper	1923.54	50 YEARS	4409.00	639.26	650.26	4.38	758.39	0.45
Upper	1923.54	100 YEARS	5287.00	639.26	650.77	4.59	780.06	0.48
Upper	1923.54	**1.5 YEARS**	565.00	639.26	645.72	2.29	71.71	0.16
Upper	1758.49	2 YEARS	1220.00	640.03	647.07	4.36	64.28	0.54
Upper	1758.49	5 YEARS	2022.00	640.03	648.11	4.82	527.78	0.62
Upper	1758.49	10 YEARS	2662.00	640.03	648.74	4.87	550.55	0.61
Upper	1758.49	25 YEARS	3597.00	640.03	649.49	4.99	577.63	0.62
Upper	1758.49	50 YEARS	4409.00	640.03	650.05	5.09	600.57	0.63
Upper	1758.49	100 YEARS	5287.00	640.03	650.58	5.23	621.57	0.65
Upper	1758.49	**1.5 YEARS**	565.00	640.03	645.49	3.06	54.73	0.29
Upper	1437.81	2 YEARS	1220.00	637.88	646.88	2.64	389.79	0.19
Upper	1437.81	5 YEARS	2022.00	637.88	647.87	3.28	566.30	0.27
Upper	1437.81	10 YEARS	2662.00	637.88	648.47	3.62	669.10	0.32
Upper	1437.81	25 YEARS	3597.00	637.88	649.22	3.92	723.87	0.36
Upper	1437.81	50 YEARS	4409.00	637.88	649.77	4.16	789.59	0.40
Upper	1437.81	100 YEARS	5287.00	637.88	650.31	4.34	823.60	0.42
Upper	1437.81	**1.5 YEARS**	565.00	637.88	645.32	1.85	77.57	0.10
Upper	1304.85	2 YEARS	1220.00	638.83	646.78	2.89	490.30	0.23
Upper	1304.85	5 YEARS	2022.00	638.83	647.78	3.29	722.04	0.28
Upper	1304.85	10 YEARS	2662.00	638.83	648.39	3.43	760.99	0.29
Upper	1304.85	25 YEARS	3597.00	638.83	649.15	3.58	785.77	0.31
Upper	1304.85	50 YEARS	4409.00	638.83	649.71	3.72	804.50	0.32
Upper	1304.85	100 YEARS	5287.00	638.83	650.25	3.87	821.93	0.34
Upper	1304.85	**1.5 YEARS**	565.00	638.83	645.23	2.22	73.16	0.15
Upper	927.73	2 YEARS	1220.00	639.32	646.46	3.01	545.34	0.25
Upper	927.73	5 YEARS	2022.00	639.32	647.44	3.53	619.91	0.33
Upper	927.73	10 YEARS	2662.00	639.32	648.04	3.89	660.64	0.38
Upper	927.73	25 YEARS	3597.00	639.32	648.77	4.31	688.96	0.45
Upper	927.73	50 YEARS	4409.00	639.32	649.32	4.64	710.78	0.51
Upper	927.73	100 YEARS	5287.00	639.32	649.83	4.98	731.74	0.57
Upper	927.73	**1.5 YEARS**	565.00	639.32	644.84	2.69	69.15	0.23
Upper	500.24	2 YEARS	1220.00	637.11	646.00	3.38	574.18	0.32
Upper	500.24	5 YEARS	2022.00	637.11	647.01	3.84	646.83	0.39
Upper	500.24	10 YEARS	2662.00	637.11	647.59	4.22	694.51	0.46
Upper	500.24	25 YEARS	3597.00	637.11	648.30	4.69	760.84	0.54
Upper	500.24	50 YEARS	4409.00	637.11	648.83	5.03	797.57	0.61
Upper	500.24	100 YEARS	5287.00	637.11	649.33	5.36	831.02	0.68
Upper	500.24	**1.5 YEARS**	565.00	637.11	644.33	3.03	37.54	0.26
Upper	0.01	2 YEARS	1220.00	637.98	645.31	4.11	621.90	0.44
Upper	0.01	5 YEARS	2022.00	637.98	646.34	4.60	819.01	0.53

HEC-RAS Plan: modifted#2 River: Dutch Buffalo Cr Reach: Upper (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Top Width	Shear Chan
			(cfs)	(ft)	(ft)	(ft/s)	(ft)	(lb/sq ft)
Upper	0.01	10 YEARS	2662.00	637.98	646.93	4.86	874.40	0.57
Upper	0.01	25 YEARS	3597.00	637.98	647.65	5.19	939.11	0.63
Upper	0.01	50 YEARS	4409.00	637.98	648.19	5.42	977.18	0.67
Upper	0.01	100 YEARS	5287.00	637.98	648.70	5.63	988.72	0.71
Upper	0.01	**1.5 YEARS**	565.00	637.98	643.70	3.38	51.91	0.33

APPENDIX 9
SUPPORTING DOCUMENTATION

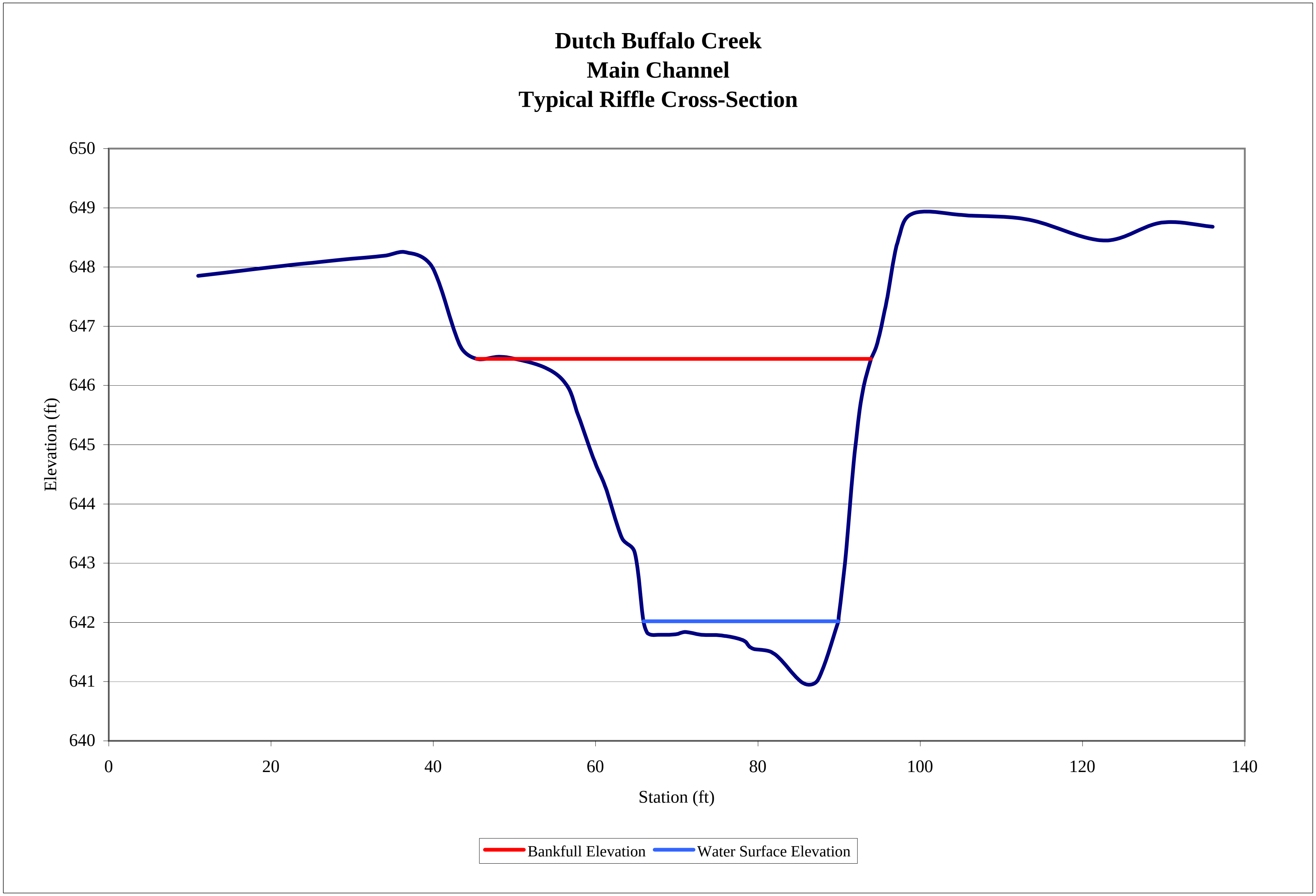
1. Typical Riffle and Pool Cross-Section and Pebble Count Plots for the Main Channel and Unnamed Tributary to Dutch Buffalo Creek.

2. Entrainment Plots for the Main Channel and Unnamed Tributary to Dutch Buffalo Creek.

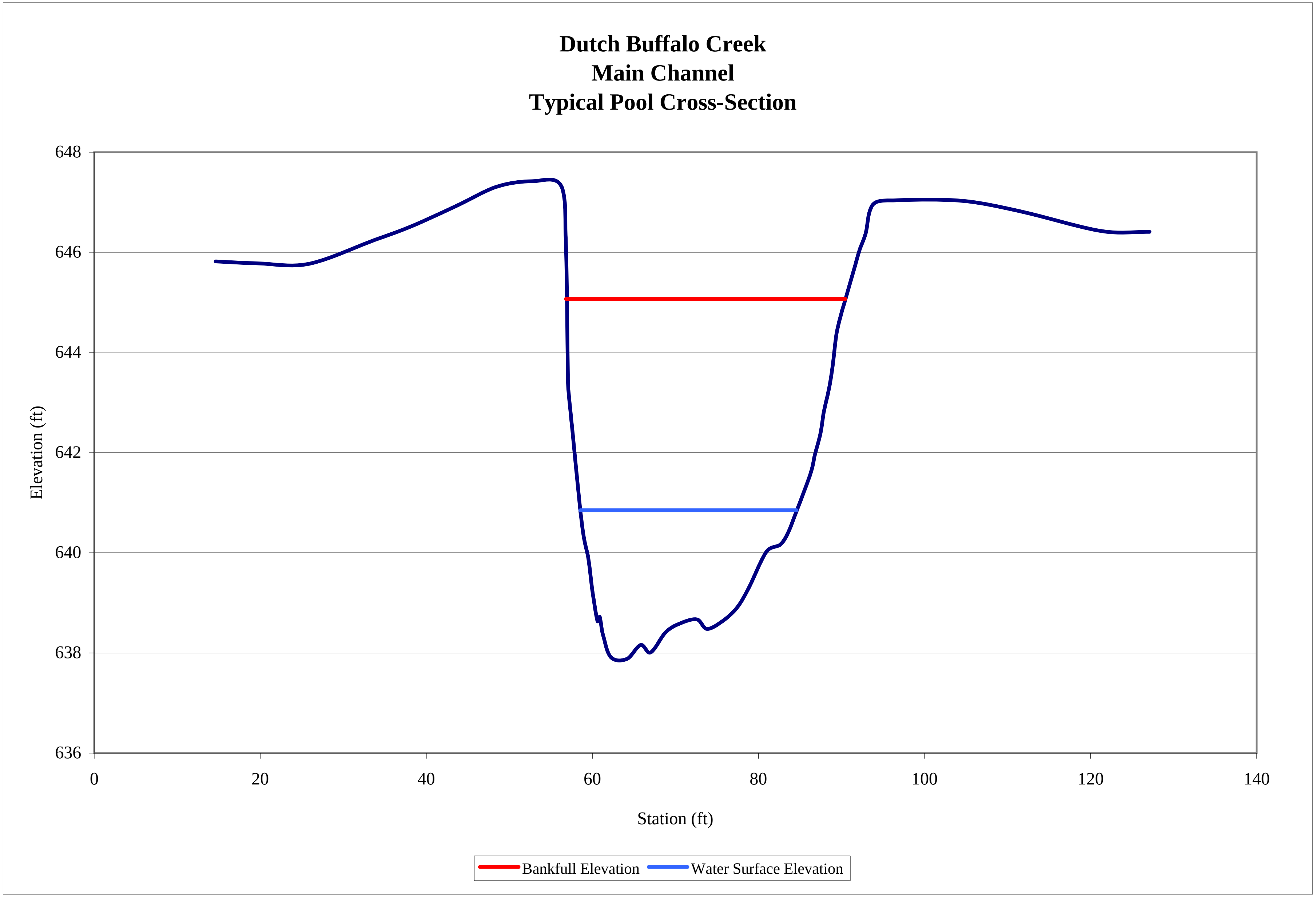
3. BAGS output Plots of Sediment Transport Rating Curves for the Main Channel and Unnamed Tributary to Dutch Buffalo Creek.

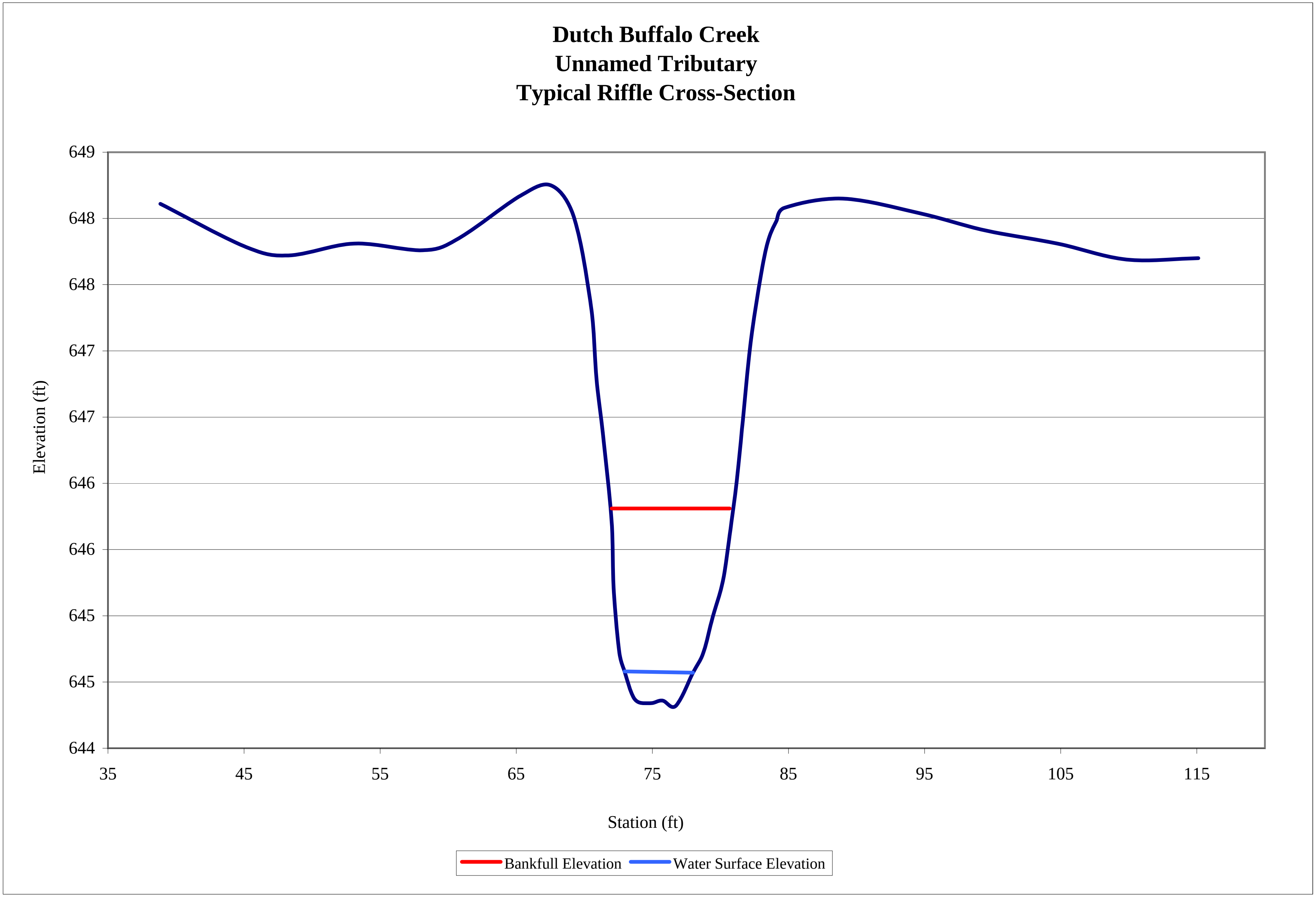
4. BEHI Raw Data Table for the Main Channel and Unnamed Tributary to Dutch Buffalo Creek.

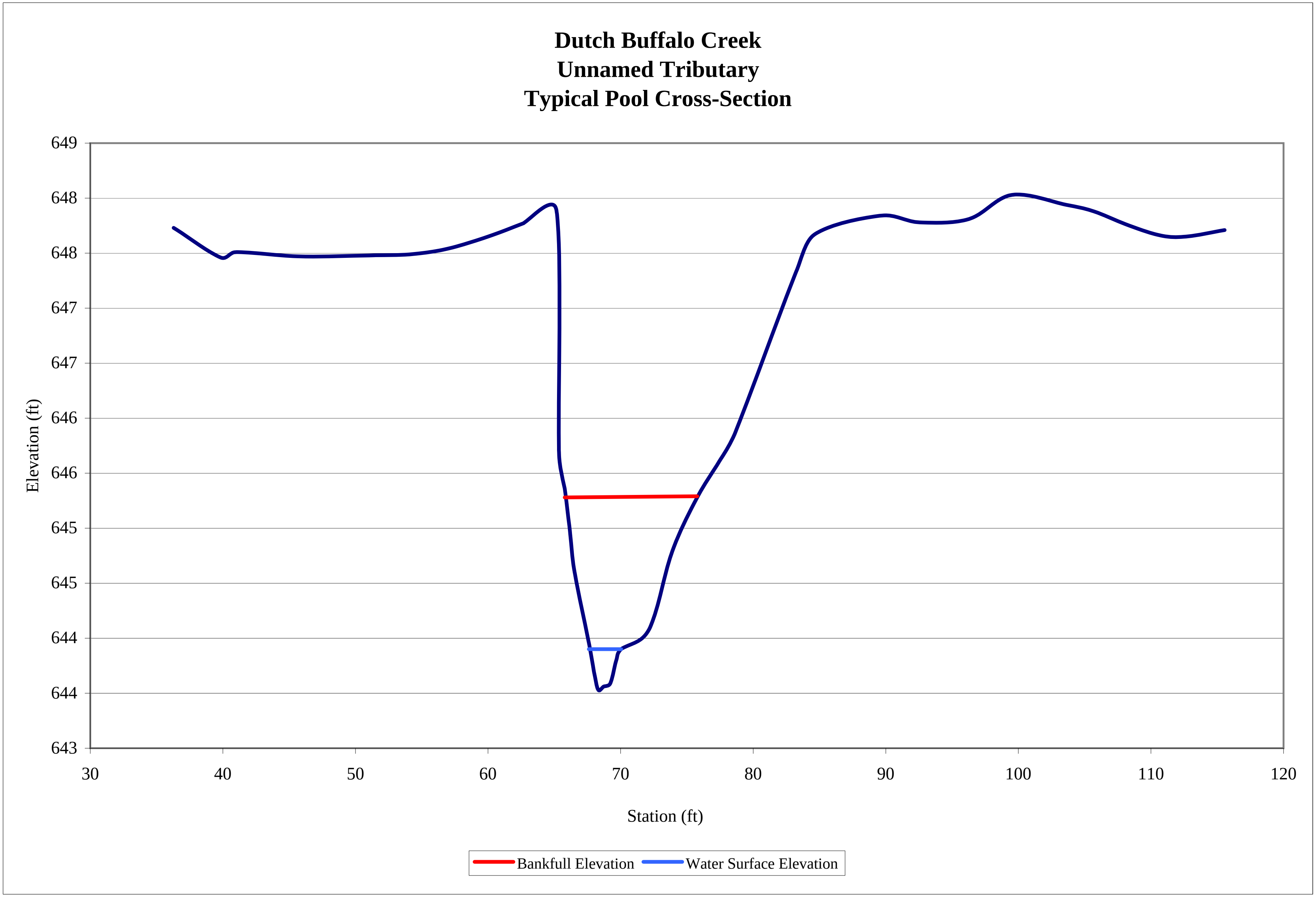
5. Water Budget Notes and Calculations.

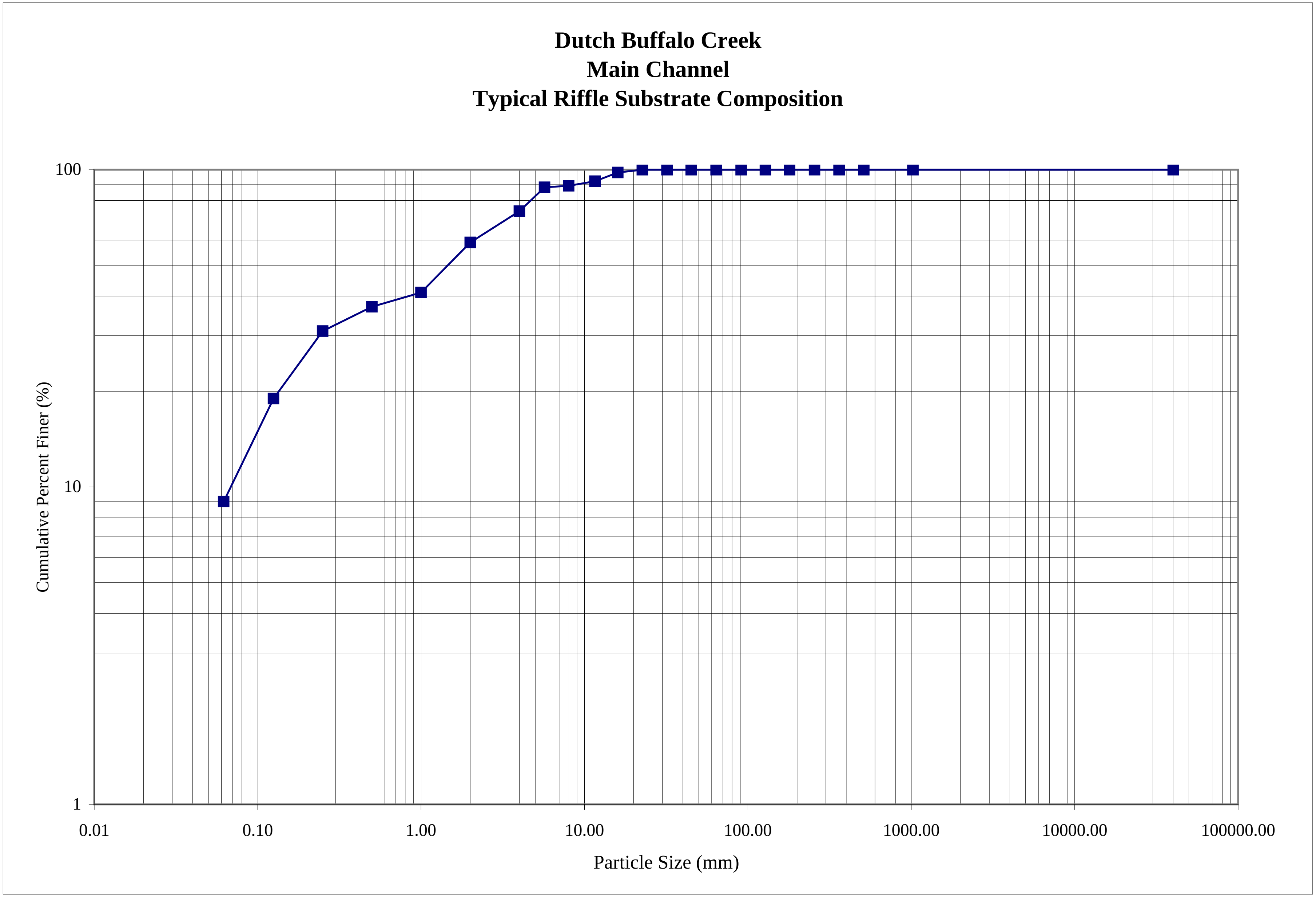


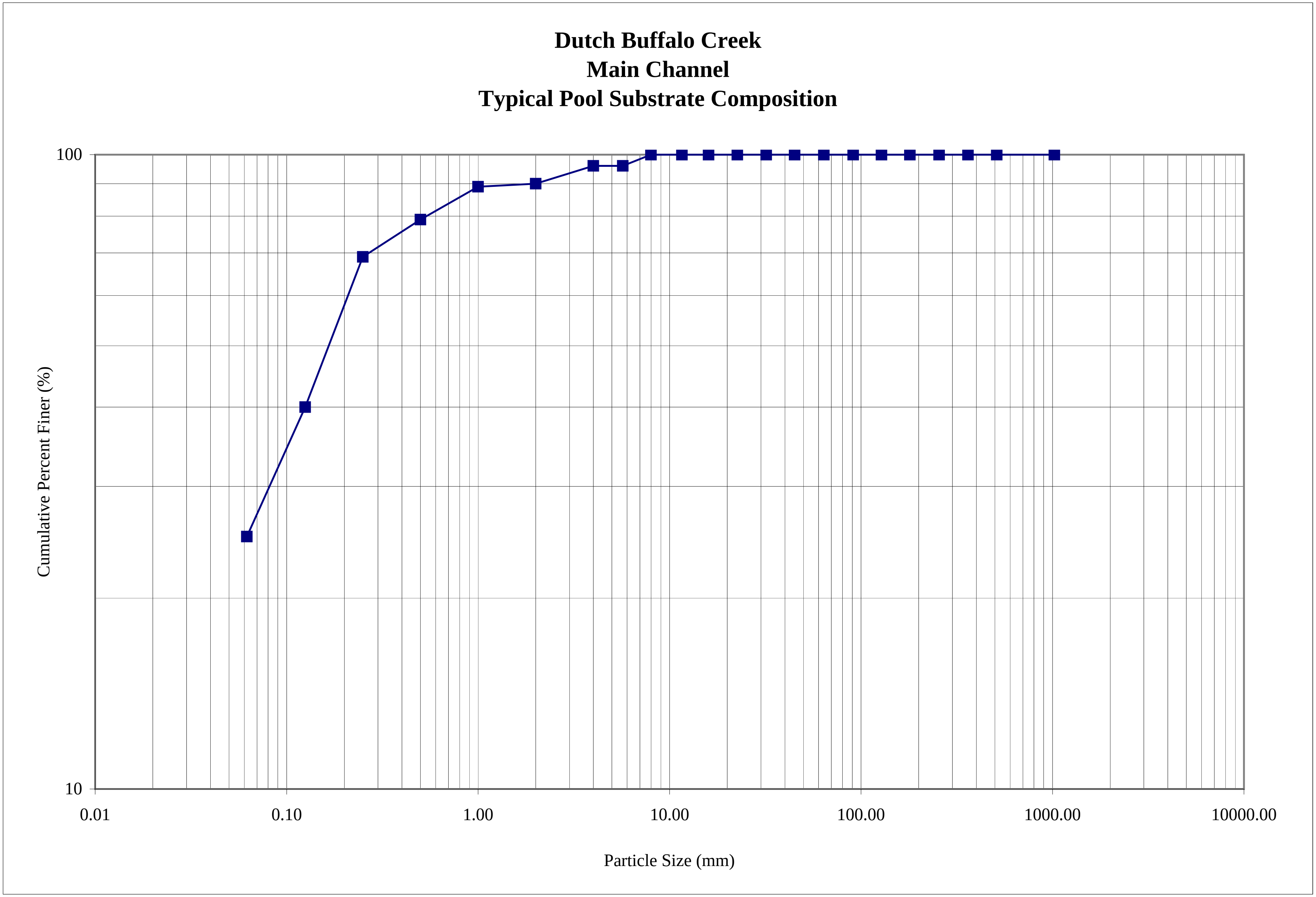
Dutch Buffalo Creek
Main Channel
Typical Riffle Cross-Section
650
649
648
647
646
645
644
643
642
641
640
Elevation (ft)
0
20
40
60
80
100
120
140
Station (ft)
Bankfull Elevation
Water Surface Elevation


Dutch Buffalo Creek
Main Channel
Typical Pool Cross-Section
648
646
644
642
640
638
636
Elevation (ft)
0
20
40
60
80
100
120
140
Station (ft)
Bankfull Elevation
Water Surface Elevation

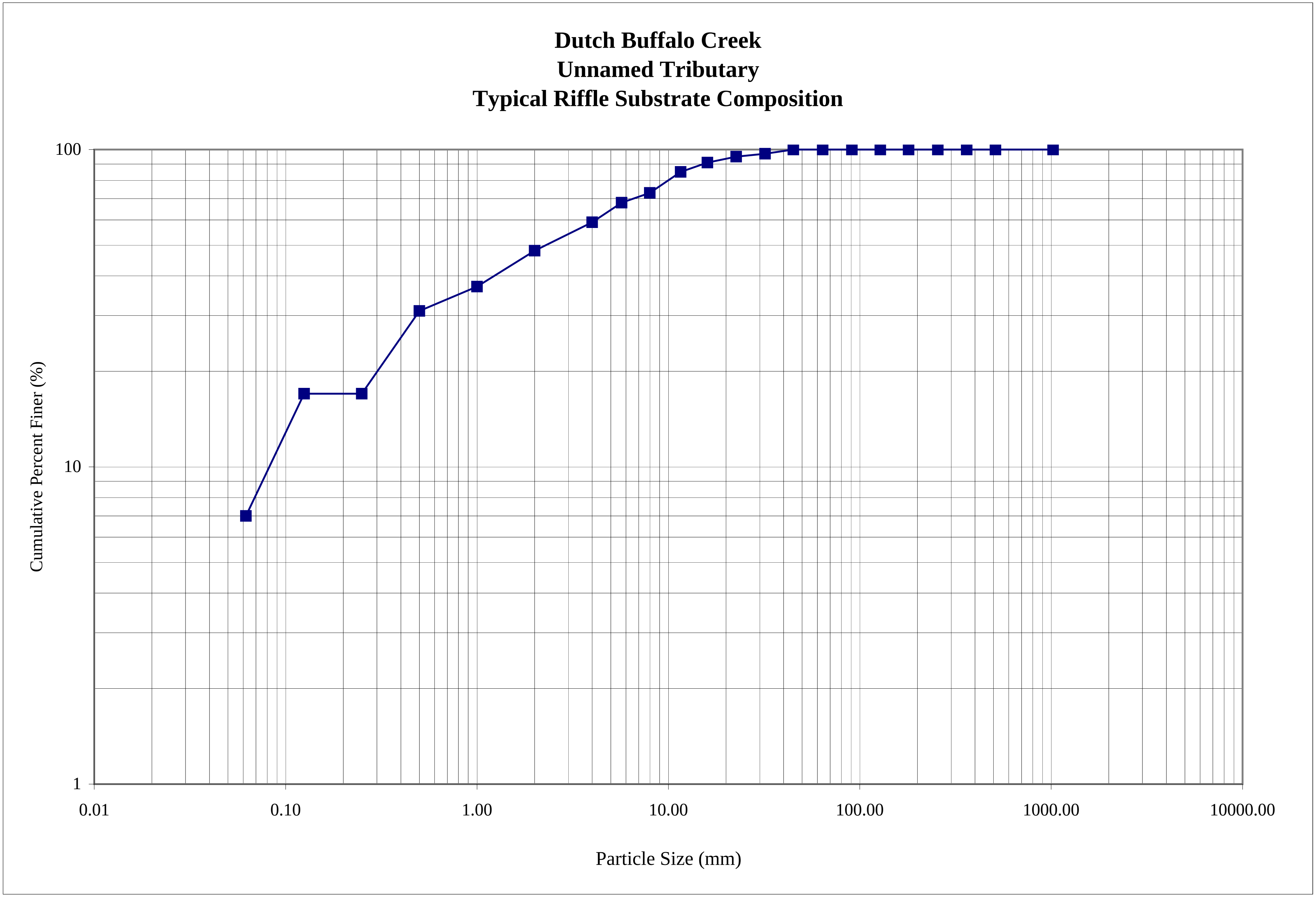

Dutch Buffalo Creek
Unnamed Tributary
Typical Riffle Cross-Section
Elevation (ft)
649
648
648
647
647
646
646
645
645
644
35
45
55
65
75
85
95
105
115
Station (ft)
Bankfull Elevation
Water Surface Elevation

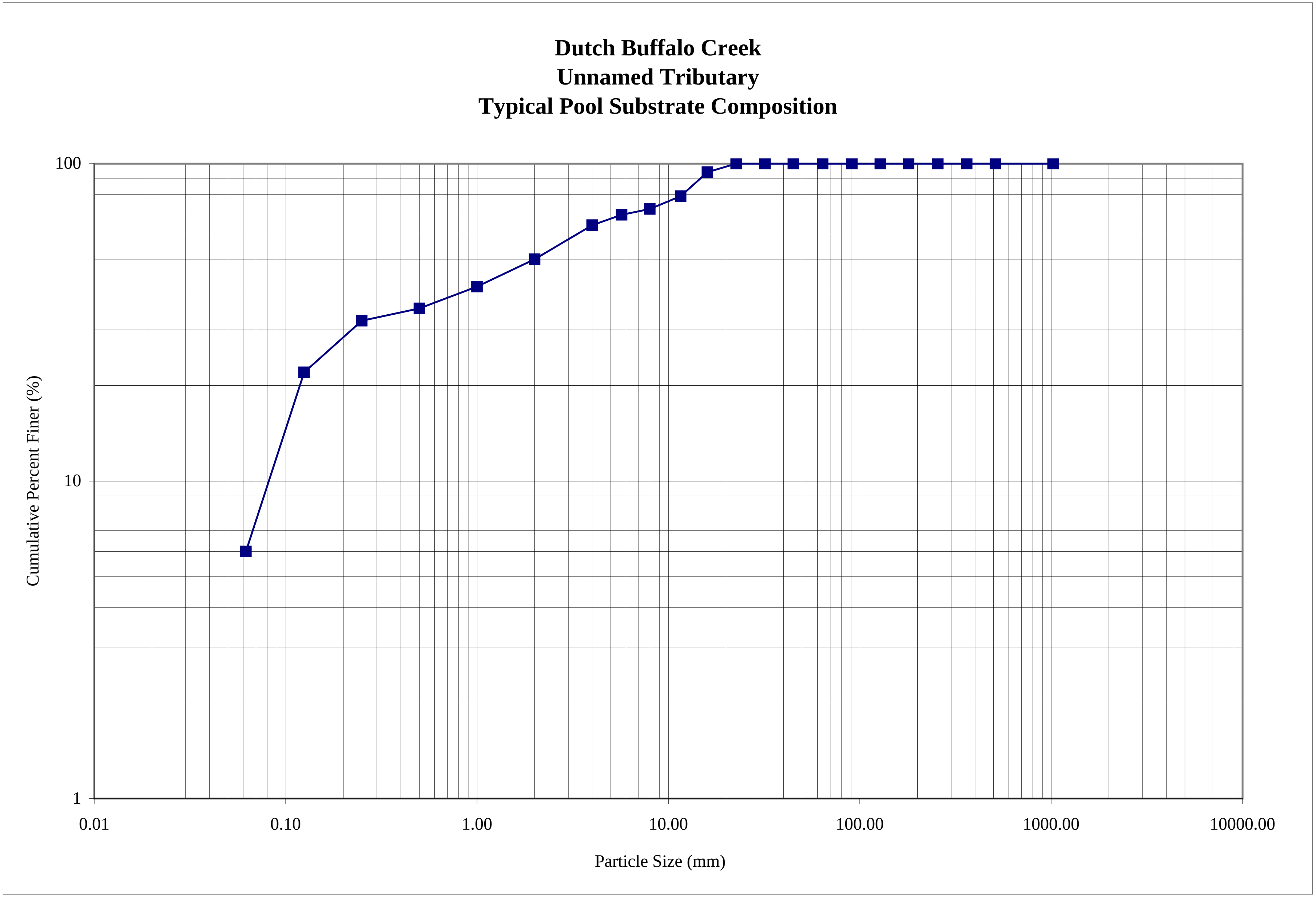

Dutch Buffalo Creek
Unnamed Tributary
Typical Pool Cross-Section
649
648
648
647
647
646
646
645
645
644
644
643
Elevation (ft)
30
40
50
60
70
80
90
100
110
120
Station (ft)
Bankfull Elevation
Water Surface Elevation


Dutch Buffalo Creek
Main Channel
Typical Riffle Substrate Composition
100
10
1
Cumulative Percent Finer (%)
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
100000.00
Particle Size (mm)

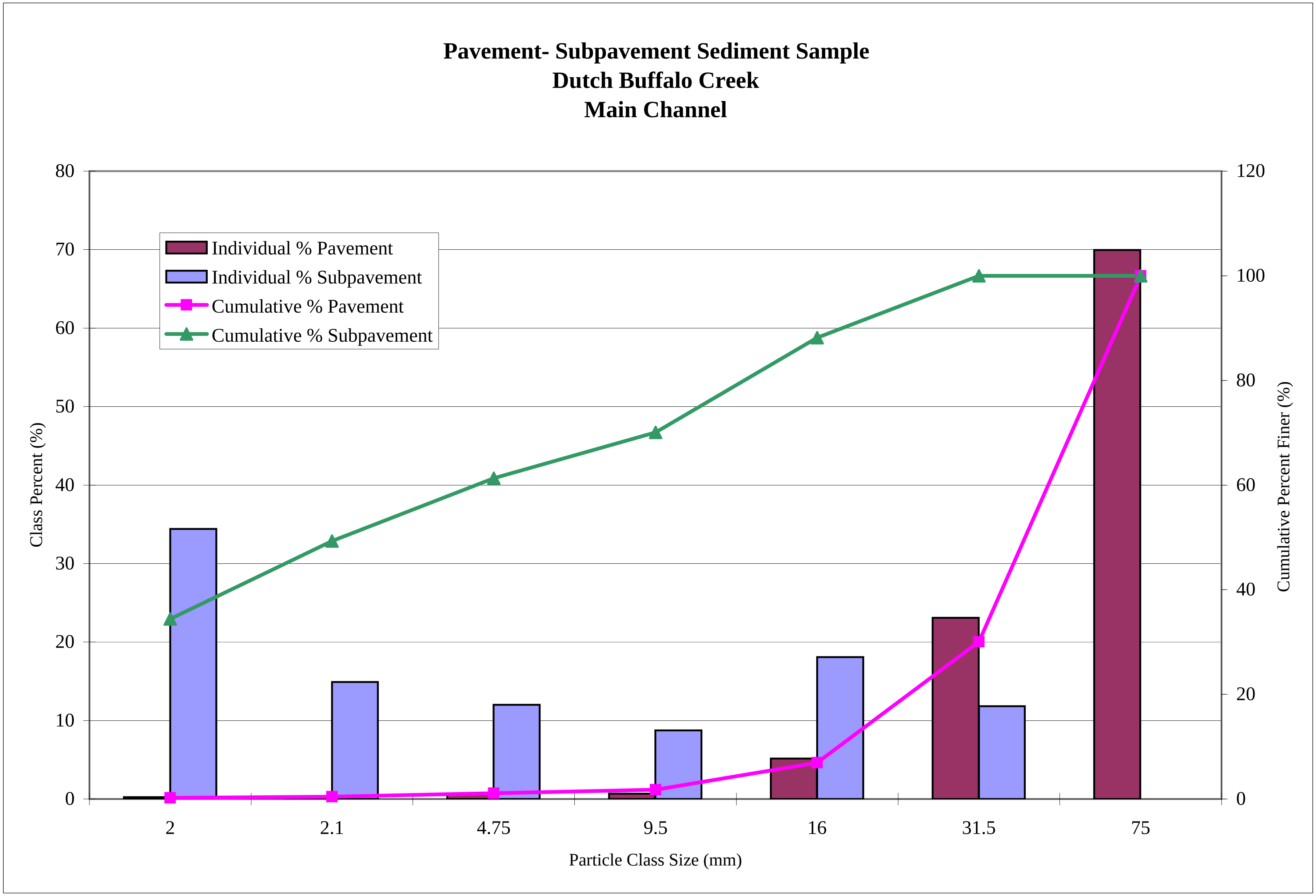


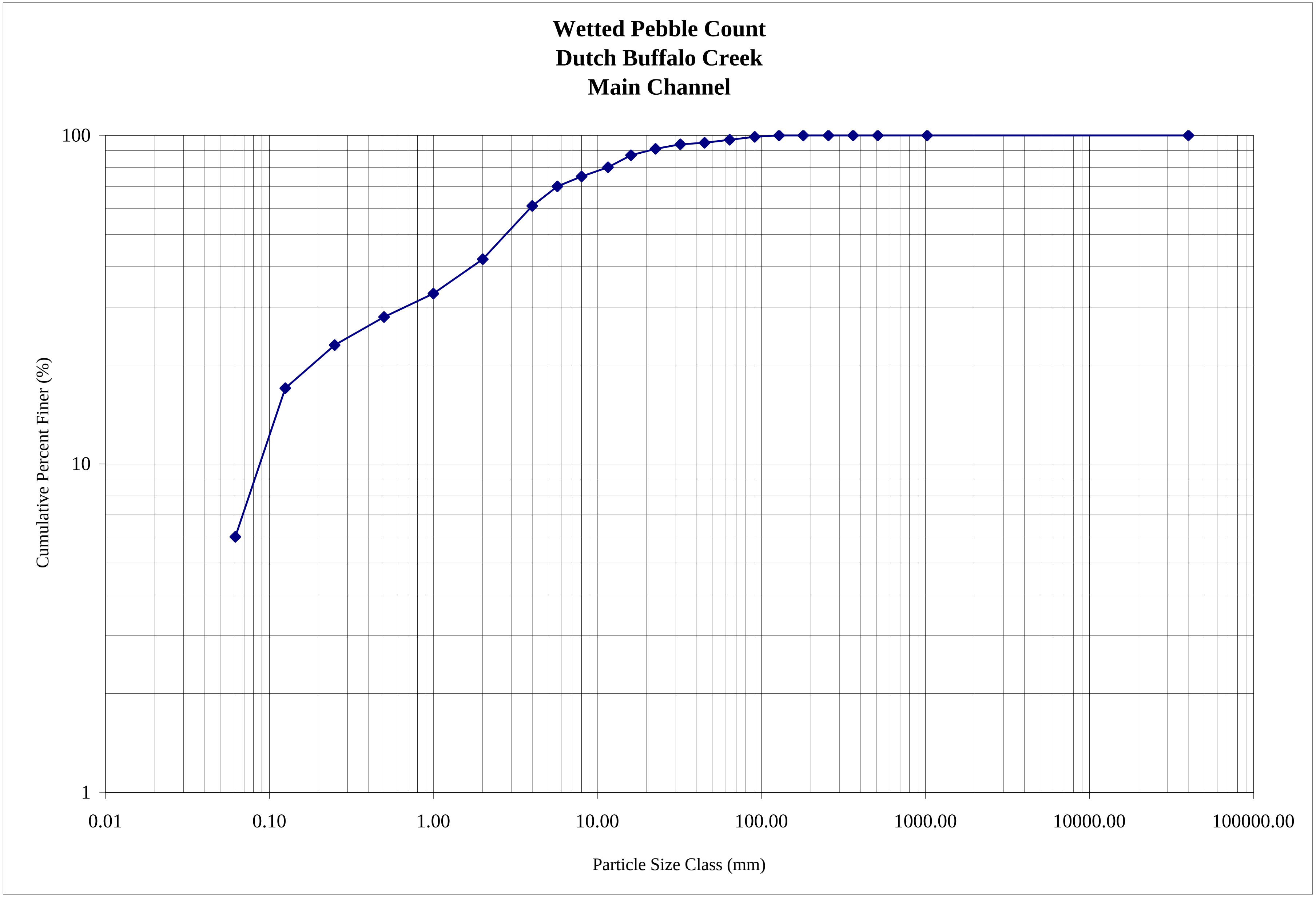
Dutch Buffalo Creek
Main Channel
Typical Pool Substrate Composition
100
10
Cumulative Percent Finer (%)
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
Particle Size (mm)

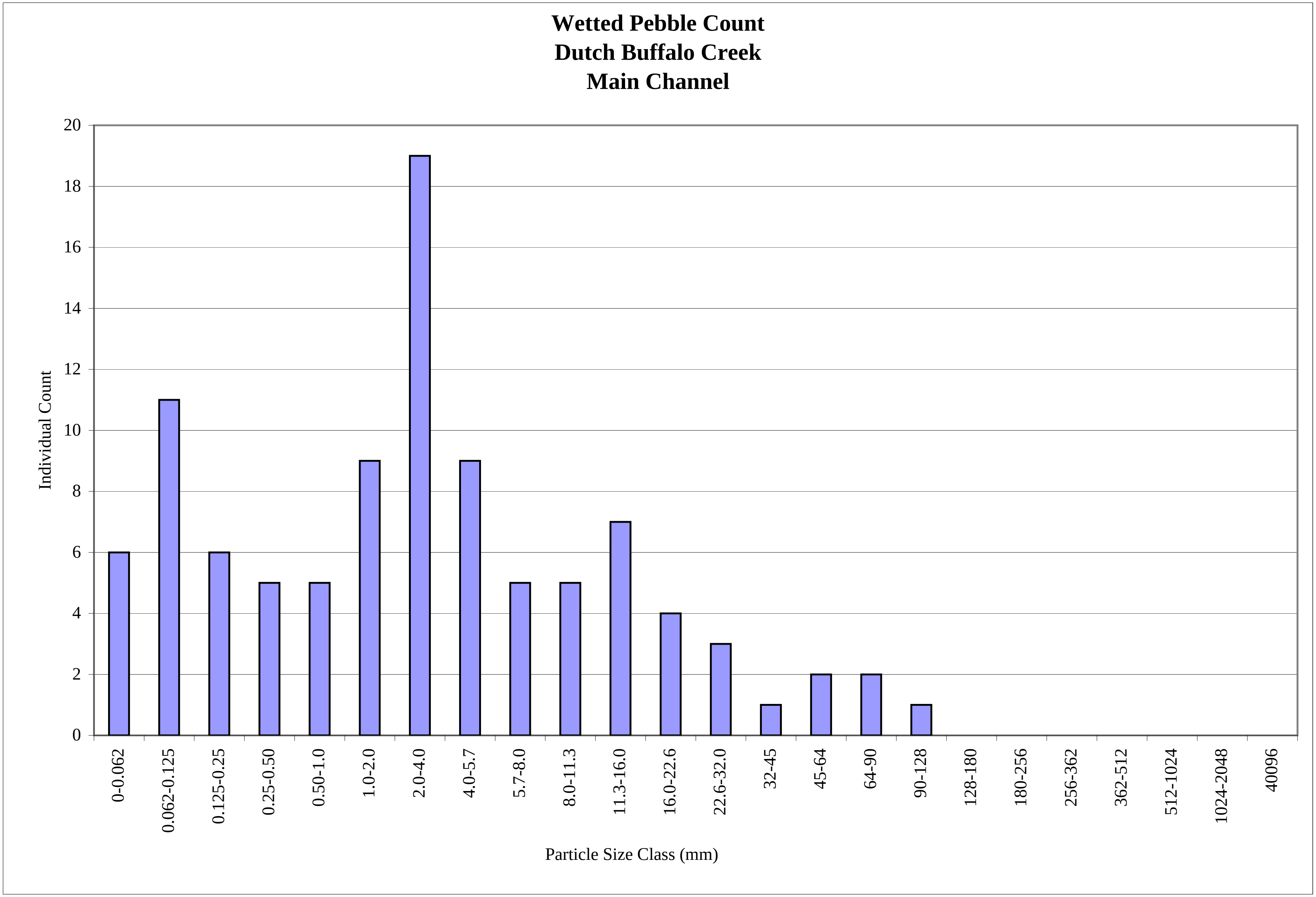

Dutch Buffalo Creek
Unnamed Tributary
Typical Riffle Substrate Composition
100
10
1
Cumulative Percent Finer (%)
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
Particle Size (mm)



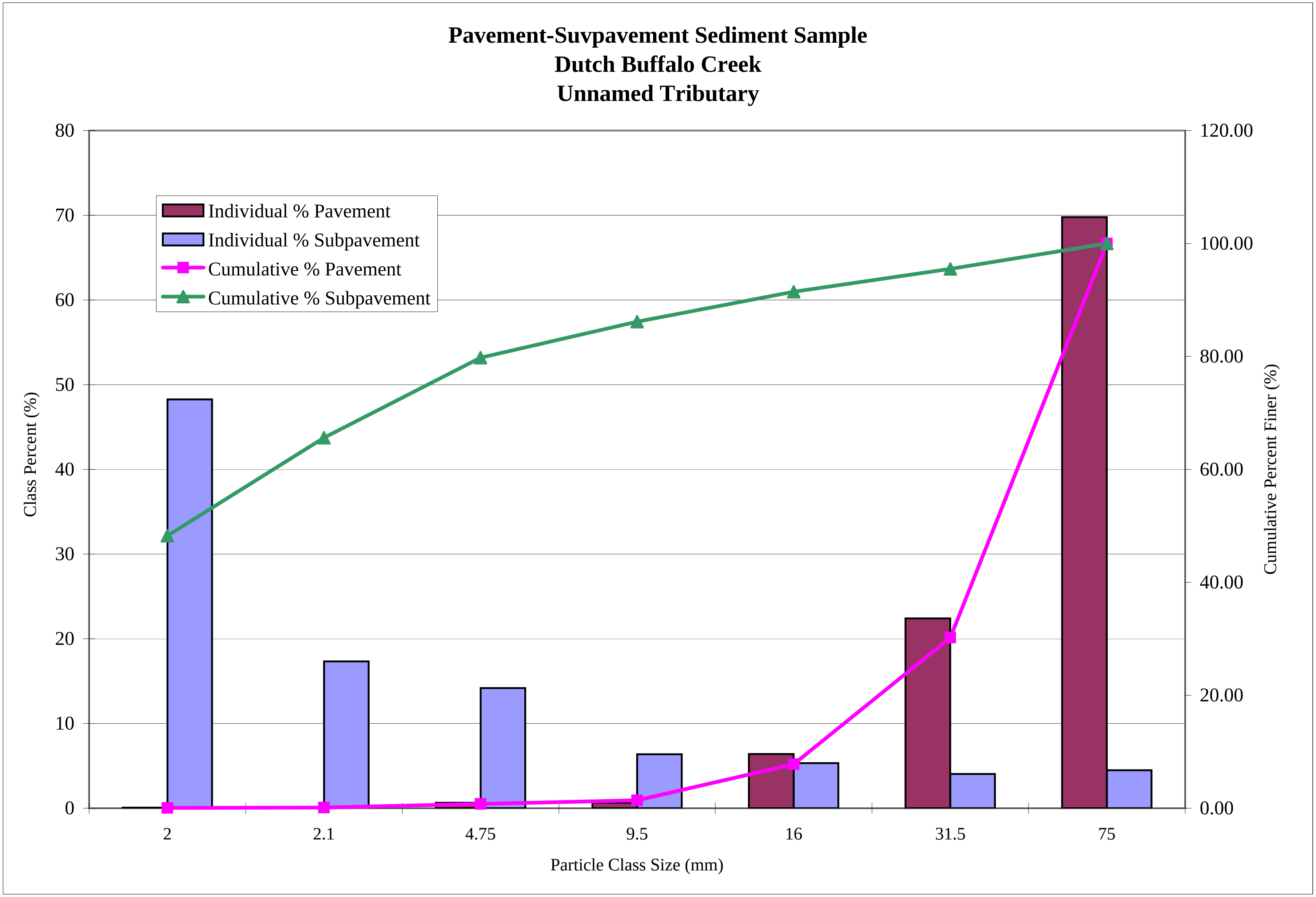
Dutch Buffalo Creek
Unnamed Tributary
Typical Pool Substrate Composition
100
10
1
Cumulative Percent Finer (%)
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
Particle Size (mm)

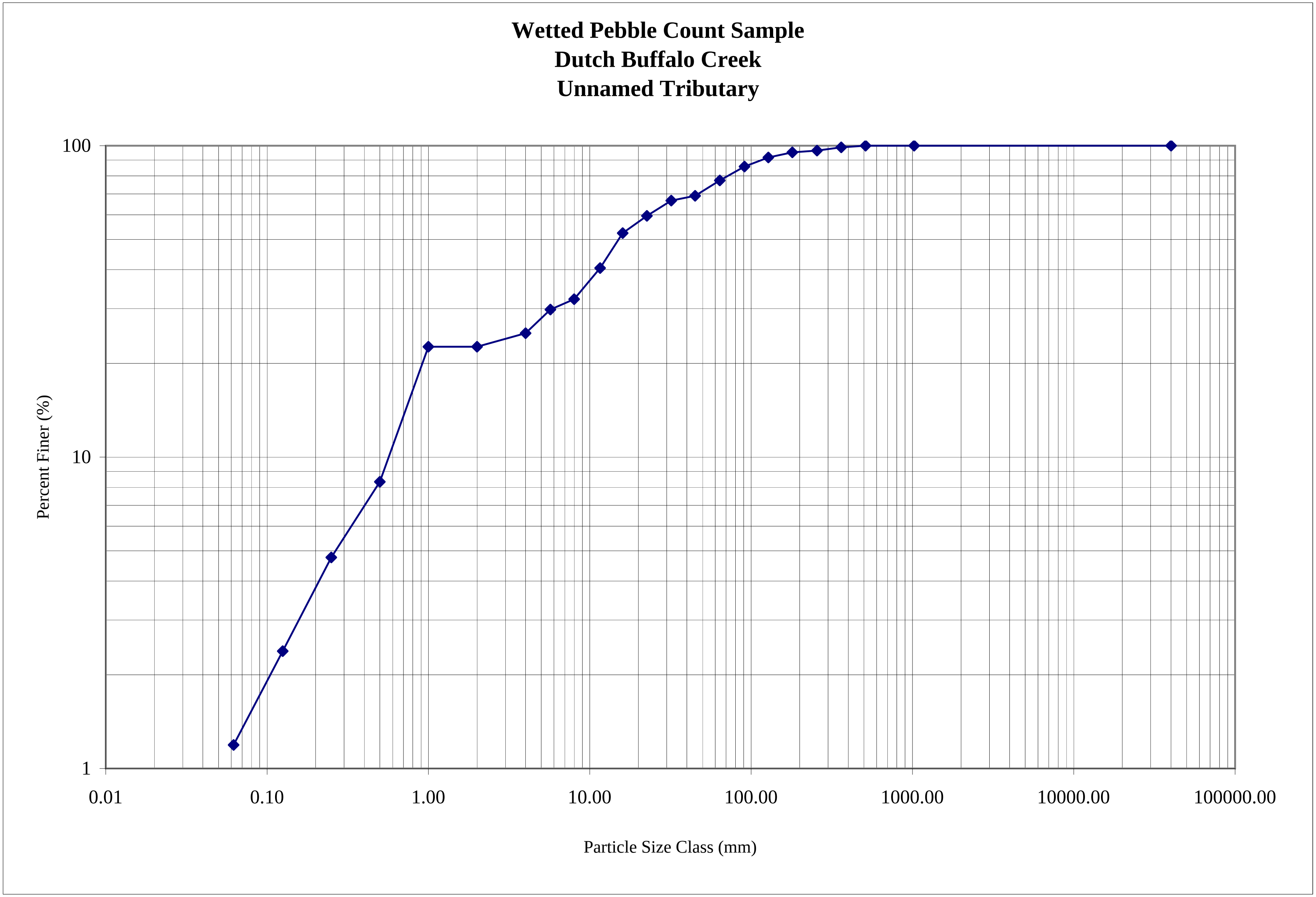

Pavement- Subpavement Sediment Sample
Dutch Buffalo Creek
Main Channel
Individual % Pavement
Individual % Subpavement
Cumulative % Pavement
Cumulative % Subpavement
Class Percent (%)
Cumulative Percent Finer (%)
Particle Class Size (mm)
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
120
2
2.1
4.75
9.5
16
31.5
75

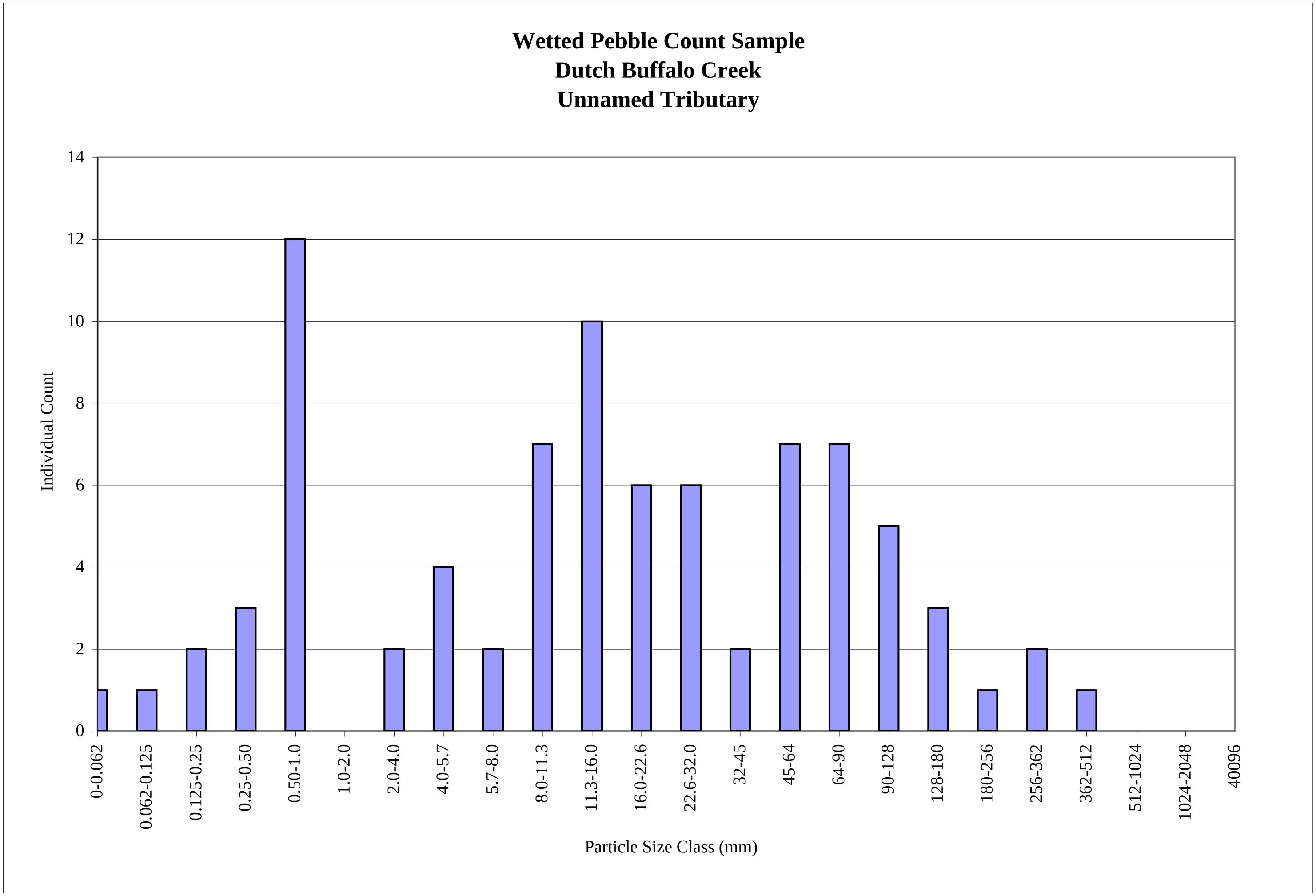

Wetted Pebble Count
Dutch Buffalo Creek
Main Channel
Cumulative Percent Finer (%)
100
10
1
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
100000.00
Particle Size Class (mm)



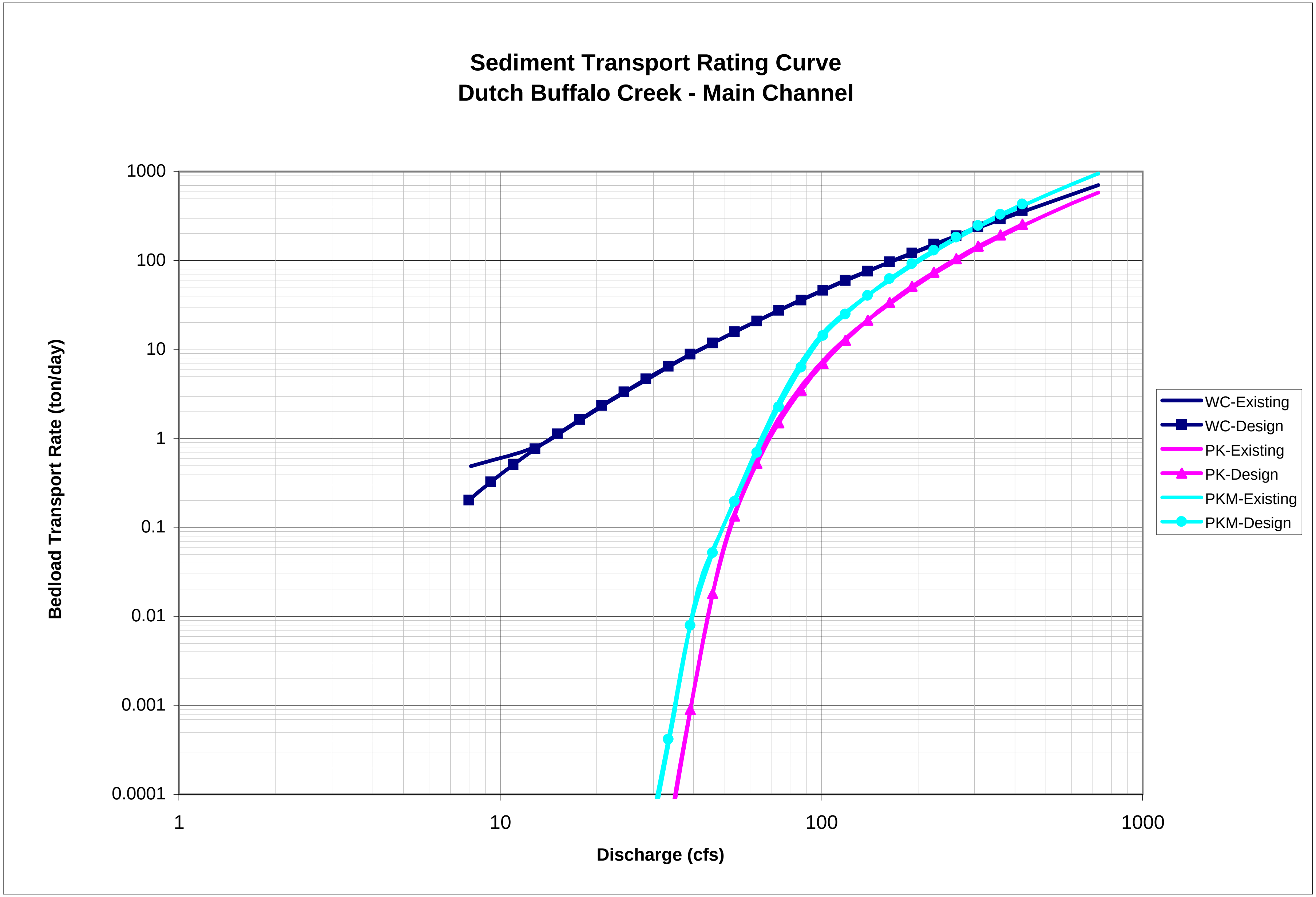
Wetted Pebble Count
Dutch Buffalo Creek
Main Channel
Individual Count
0
2
4
6
8
10
12
14
16
18
20
0-0.062
0.062-0.125
0.125-0.25
0.25-0.50
0.50-1.0
1.0-2.0
2.0-4.0
4.0-5.7
5.7-8.0
8.0-11.3
11.3-16.0
16.0-22.6
22.6-32.0
32-45
45-64
64-90
90-128
128-180
180-256
256-362
362-512
512-1024
1024-2048
40096
Particle Size Class (mm)

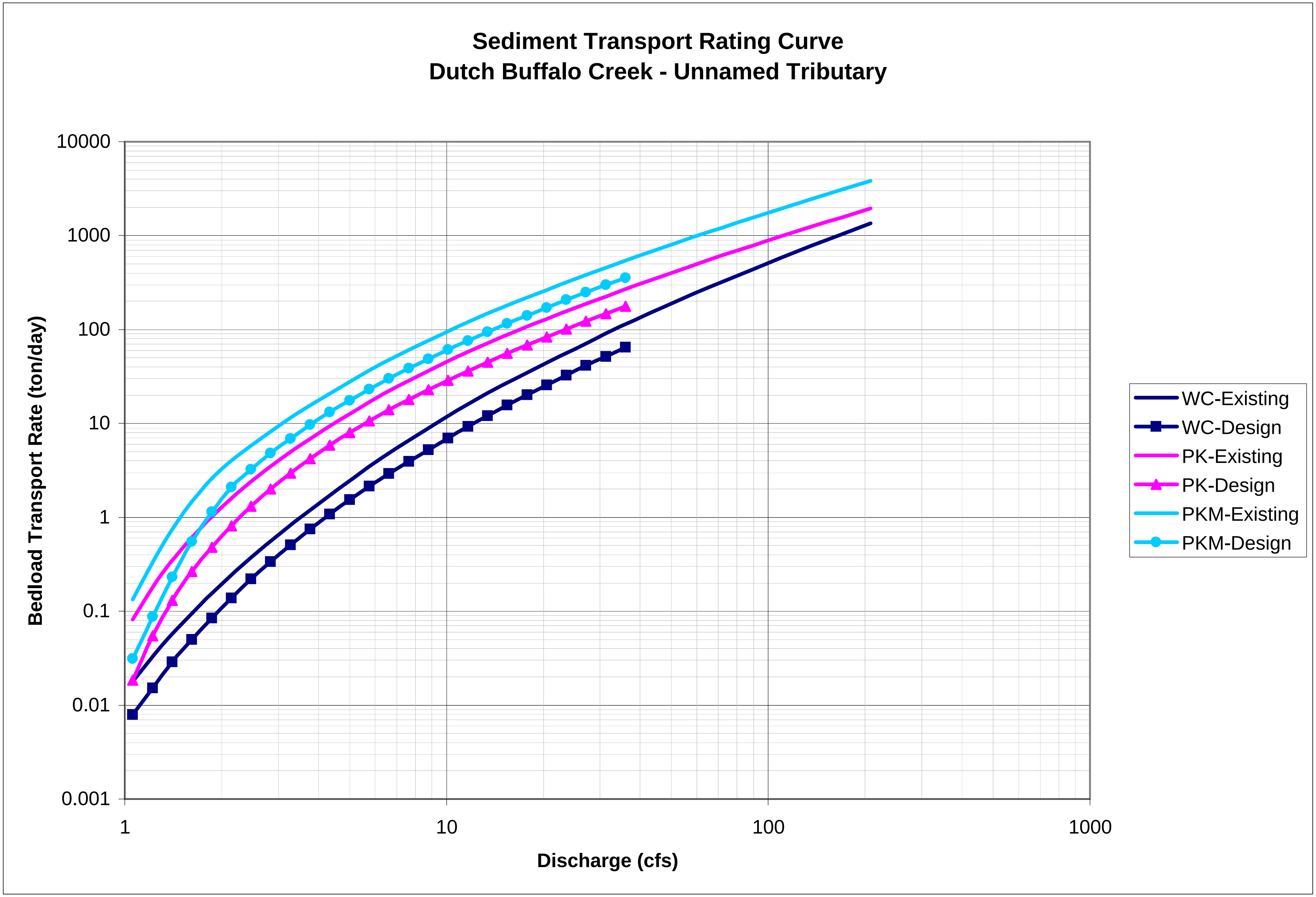

Pavement-Suvpavement Sediment Sample
Dutch Buffalo Creek
Unnamed Tributary
Individual % Pavement
Individual % Subpavement
Cumulative % Pavement
Cumulative % Subpavement
Class Percent (%)
Cumulative Percent Finer (%)
Particle Class Size (mm)
0
10
20
30
40
50
60
70
80
0.00
20.00
40.00
60.00
80.00
100.00
120.00
2
2.1
4.75
9.5
16
31.5
75


Wetted Pebble Count Sample
Dutch Buffalo Creek
Unnamed Tributary
100
10
1
Percent Finer (%)
0.01
0.10
1.00
10.00
100.00
1000.00
10000.00
100000.00
Particle Size Class (mm)



Wetted Pebble Count Sample
Dutch Buffalo Creek
Unnamed Tributary
Individual Count
0
2
4
6
8
10
12
14
0-0.062
0.062-0.125
0.125-0.25
0.25-0.50
0.50-1.0
1.0-2.0
2.0-4.0
4.0-5.7
5.7-8.0
8.0-11.3
11.3-16.0
16.0-22.6
22.6-32.0
32-45
45-64
64-90
90-128
128-180
180-256
256-362
362-512
512-1024
1024-2048
40096
Particle Size Class (mm)


Sediment Transport Rating Curve
Dutch Buffalo Creek - Main Channel
Bedload Transport Rate (ton/day)
1000
100
10
1
0.1
0.01
0.001
0.0001
1
10
100
1000
Discharge (cfs)
WC-Existing
WC-Design
PK-Existing
PK-Design
PKM-Existing
PKM-Design


Sediment Transport Rating Curve
Dutch Buffalo Creek - Unnamed Tributary
10000
1000
100
10
1
0.1
0.01
0.001
Bedload Transport Rate (ton/day)
1
10
100
1000
Discharge (cfs)
WC-Existing
WC-Design
PK-Existing
PK-Design
PKM-Existing
PKM-Design

Stream Name: Main Channel of Dutch Buffalo Creek
Date: 2/7/2007
Field Crew: K.Young, M. Clabaugh

LEFT BANK

Station (ft)	Section Length (ft)	Bank Height (ft)	BKF Height (ft)	Value	Index	Bank Erosion Potential	Root Depth (ft)	Value	Index	Bank Erosion Potential	Root Density (%)	Value	Index	Bank Erosion Potential	Bank Angle (°)	Index	Bank Erosion Potential	Surface Protection (%)	Index	Bank Erosion Potential	Notes	Bank Adjustments	Total Score	Bank Erosion	Rc	Wbkf	Rc/Wbkf Ratio	Near Bank Stress	Erosion Rate (ft/yr)	Total Stream Bank Erosion (ft^3/yr)
40	40	7.0	6	1.17	4.8	Moderate	1.5	0.21	6.8	High	15	3.21	10.0	Extreme	90	7.9	High	7	10.0	Extreme			39.50	High	75.2	37.4	2.0	high	0.50	140.00
145	105	6.5	6	1.08	4.0	Moderate	1.3	0.19	7.0	High	5	0.96	10.0	Extreme	55	3.3	Low	2	10.0	Extreme	Sand	10	44.30	Very High	105.2	37.4	2.8	low	0.18	122.85
230	85	7.0	6	1.17	4.8	Moderate	1.5	0.21	6.8	High	50	10.71	8.2	Very High	90	7.9	High	50	4.3	Moderate			32.00	High	105.2	37.4	2.8	low	0.18	107.10
252	22	6.5	6	1.08	4.0	Moderate	0.0	0.00	10.0	High	0	0.00	10.0	Extreme	70	5.0	Moderate	0	10.0	Extreme	Cattle crossing		39.00	High	93.1	37.4	2.5	low	0.18	25.74
276	24	7.0	6	1.17	4.8	Moderate	1.5	0.21	6.8	High	15	3.21	10.0	Extreme	82	6.1	High	7	10.0	Extreme			37.70	High	93.1	37.4	2.5	low	0.18	30.24
384	108	5.5	6	0.92	1.0	Very Low	1.0	0.18	7.1	High	22	4.00	10.0	Extreme	45	3.0	Low	28	6.1	High	Sandy point bar	10	37.20	High	93.1	37.4	2.5	low	0.18	106.92
520	136	6.5	6	1.08	4.0	Moderate	1.5	0.23	6.9	High	25	5.77	8.7	Very High	90	7.9	High	20	7.0	High			34.50	High	74.2	37.4	2.0	high	0.50	442.00
590	70	6.5	6	1.08	4.0	Moderate	1.0	0.15	7.2	High	5	0.77	10.0	Extreme	75	4.8	Moderate	5	10.0	Extreme			36.00	High	39.3	37.4	1.0	extreme	1.50	682.50
675	85	8.0	6	1.33	5.6	Moderate	1.0	0.13	8.2	Very High	30	3.75	10.0	Extreme	95	8.3	Very High	30	5.9	Moderate	Sandy point bar	10	48.00	Extreme	42.9	37.4	1.1	extreme	10.00	6800.00
700	25	8.0	6	1.33	5.6	Moderate	1.0	0.13	8.2	Very High	10	1.25	10.0	Extreme	45	3.0	Low	90	1.5	Very Low	Bedrock		28.30	Moderate	213.9	37.4	5.7	very low	0.05	10.00
760	60	8.0	6	1.33	5.6	Moderate	1.0	0.13	8.2	Very High	15	1.88	10.0	Extreme	85	6.3	High	15	7.9	High			38.00	High	106.9	37.4	2.9	low	0.18	86.40
860	100	8.0	6	1.33	5.6	Moderate	1.0	0.13	8.2	Very High	40	5.00	10.0	Extreme	90	7.9	High	45	5.0	Moderate			36.70	High	101.2	37.4	2.7	low	0.18	144.00
1160	300	7.0	6	1.17	4.3	Moderate	2.0	0.29	6.0	High	30	8.57	8.5	Very High	80	5.9	Moderate	30	5.9	Moderate			30.60	High	61.1	37.4	1.6	very high	0.50	1050.00

Total (ft^3/yr)	9747.75	*Left Bank*
Total (tons/yr)	649.85	

RIGHT BANK

Station (ft)	Section Length (ft)	Bank Height (ft)	BKF Height (ft)	Value	Index	Bank Erosion Potential	Root Depth (ft)	Value	Index	Bank Erosion Potential	Root Density (%)	Value	Index	Bank Erosion Potential	Bank Angle (°)	Index	Bank Erosion Potential	Surface Protection (%)	Index	Bank Erosion Potential	Notes	Bank Adjustments	Total Score	Bank Erosion	Rc	Wbkf	Rc/Wbkf Ratio	Near Bank Stress	Erosion Rate (ft/yr)	Total Stream Bank Erosion (ft^3/yr)
105	105	7.8	6	1.30	5.7	Moderate	1.5	0.19	7.0	High	17	3.27	10.0	Extreme	105	8.7	Very High	40	5.1	Moderate			36.50	High	79.0	37.4	2.1	Moderate	0.30	245.70
265	160	7.0	6	1.17	4.8	Moderate	1.5	0.21	6.8	High	60	12.86	8.1	Very High	70	5.0	Moderate	60	3.5	Low			28.20	Moderate	105.2	37.4	2.8	Low	0.09	100.80
295	30	5.5	6	0.92	1.0	Very Low	0.0	0.00	0.1	Extreme	0	0.00	10.0	Extreme	60	3.9	Low	0	10.0	Extreme	Cattle Crossing		24.95	Moderate	93.1	37.4	2.5	Low	0.09	14.85
395	100	7.0	6	1.17	4.8	Moderate	1.0	0.14	8.1	Very High	45	6.43	10.0	Extreme	90	7.9	High	42	4.8	Moderate			35.60	High	93.1	37.4	2.5	Low	0.18	126.00
495	100	5.5	6	0.92	1.0	Very Low	1.0	0.18	7.1	High	20	3.64	10.0	Extreme	40	3.0	Low	20	7.4	High	Sand	10	38.50	High	74.2	37.4	2.0	High	0.50	275.00
595	100	8.0	6	1.33	5.9	Moderate	1.0	0.13	8.2	Very High	1.5	0.19	10.0	Extreme	90	7.9	High	2.5	10.0	Extreme			42.00	Very High	39.3	37.4	1.0	Extreme	1.50	1200.00
680	85	8.0	6	1.33	5.9	Moderate	1.5	0.19	7.1	High	28	5.25	10.0	Extreme	82.5	6.1	High	28	5.9	High			35.00	High	42.9	37.4	1.1	Extreme	1.50	1020.00
760	80	8.0	6	1.33	5.6	Moderate	1.5	0.19	7.2	High	15	2.81	10.0	Extreme	85	6.3	High	10	9.0	Very High			38.10	High	106.9	37.4	2.9	Low	0.18	115.20
860	100	8.0	6	1.33	6.6	Moderate	1.5	0.19	7.2	High	80	15.00	7.9	Moderate	90	7.9	High	60	3.5	Low	Grass		33.10	High	101.2	37.4	2.7	Low	0.18	144.00
960	100	8.0	6	1.33	7.6	Moderate	1.5	0.19	7.2	High	70	13.13	8.2	Very High	90	7.9	High	40	5.1	Moderate			36.00	High	66.5	37.4	1.8	Very high	0.50	400.00
1110	150	7.0	6	1.17	3.8	Low	0.0	0.00	0.1	Extreme	0	0.00	10.0	Extreme	68	4.9	Moderate	0	10.0	Extreme	Cattle Crossing		28.75	Moderate	61.1	37.4	1.6	Very high	0.28	294.00
1210	100	9.0	6	1.50	6.3	High	2.5	0.28	6.1	High	30	8.33	10.0	Extreme	100	8.5	Very High	10	10.0	Extreme	Scouring Under Roots		40.90	Very High	52.6	37.4	1.4	Extreme	1.50	1350.00

Total (ft^3/yr)	5285.55	*Right Bank*
Total (tons/yr)	352.37	
Total (ft^3/yr)	15033.30	**Both Banks**
Total (tons/yr)	1002.22	

Stream Name: Unnamed Tributary of Dutch Buffalo Creek
Date: 2/7/2007
Field Crew: K.Young, M. Clabaugh

LEFT BANK

Station (ft)	Section Length (ft)	Bank Height (ft)	BKF Height (ft)	Value	Index	Bank Erosion Potential	Root Depth (ft)	Value	Index	Bank Erosion Potential	Root Density (%)	Value	Index	Bank Erosion Potential	Bank Angle (°)	Index	Bank Erosion Potential	Surface Protection (%)	Index	Bank Erosion Potential	Total Score	Bank Erosion	Rc	Wbkf	Rc/Wbkf Ratio	Near Bank Stress	Erosion Rate (ft/yr)	Total Stream
50	50	4.00	1.50	2.67	6.2	High	1.0	0.25	7.0	High	10	2.50	10.0	Extreme	90	7.9	High	15	7.9	High	39.00	High	30.4	8.68	3.50	Very Low	0.11	22.00
170	120	4.00	1.50	2.67	6.2	High	1.5	0.38	5.8	Moderate	60	22.50	7.3	High	82	6.1	High	60	3.5	Low	28.90	Moderate	22.0	8.68	2.53	Low	0.09	43.20
220	50	4.00	1.50	2.67	6.2	High	2.0	0.50	4.3	Moderate	35	17.50	7.8	High	60	3.9	Low	45	5.0	Moderate	27.20	Moderate	19.6	8.68	2.26	Low	0.09	18.00
260	40	4.00	1.50	2.67	6.2	High	1.5	0.38	5.8	Moderate	10	3.75	10.0	Extreme	90	7.9	High	10	9.0	Very High	38.90	High	21.2	8.68	2.44	Low	0.18	28.80
320	60	4.00	1.50	2.67	6.2	High	1.5	0.38	5.8	Moderte	30	11.25	8.5	Very High	80	5.9	Moderate	30	5.9	Moderate	32.30	High	18.9	8.68	2.18	Moderate	0.29	69.60
380	60	4.50	1.50	3.00	7.9	High	1.0	0.22	6.9	High	5	1.11	10.0	Extreme	85	6.3	High	8	10.0	Extreme	41.10	Very High	13.0	8.68	1.50	Very High	0.80	216.00
400	20	4.50	1.50	3.00	7.9	High	0.0	0.00	10.0	Extreme	0	0.00	10.0	Extreme	40	3.0	Low	0	11.0	Extreme	41.90	Very High	10.4	8.68	1.20	Extreme	1.30	117.00
480	80	4.50	1.50	3.00	7.9	High	1.0	0.22	6.9	High	<2	0.00	10.0	Extreme	85	6.3	High	<1	12.0	Extreme	43.10	Very High	13.1	8.68	1.51	Very High	0.80	288.00

(ft^3/yr)	802.60	*Left BankTotal*
(tons/yr)	53.51	

RIGHT BANK

Station (ft)	Section Length (ft)	Bank Height (ft)	BKF Height (ft)	Value	Index	Bank Erosion Potential	Root Depth (ft)	Value	Index	Bank Erosion Potential	Root Density (%)	Value	Index	Bank Erosion Potential	Bank Angle (°)	Index	Bank Erosion Potential	Surface Protection (%)	Index	Bank Erosion Potential	Total Score	Bank Erosion	Rc	Wbkf	Rc/Wbkf Ratio	Near Bank Stress	Erosion Rate (ft/yr)	Total Stream
50	50	4.00	1.50	2.67	6.2	High	2.0	0.50	4.3	Moderate	90	45.00	5.0	Moderate	45	3.0	Low	90	1.5	Very Low	20.00	Moderate	30.4	8.68	3.50	Very Low	0.04	8.00
125	75	4.00	1.50	2.67	6.2	High	2.5	0.63	3.7	Low	55	34.38	5.9	Moderate	70	5.0	Moderate	65	3.0	Low	23.80	Moderate	22.0	8.68	2.53	Low	0.09	27.00
170	45	3.50	1.50	2.33	6.2	High	0.1	0.02	10.0	Extreme	8	0.18	10.0	Extreme	45	3.0	Low	15	7.9	High	37.10	High	22.0	8.68	2.53	Low	0.18	28.35
220	50	4.00	1.50	2.67	6.2	High	2.5	0.63	3.7	Low	35	21.88	7.2	High	80	5.9	Moderate	40	5.1	Moderate	28.10	Moderate	19.6	8.68	2.26	Low	0.09	18.00
290	70	5.00	1.50	3.33	8.1	Very High	1.5	0.30	5.7	Moderate	18	5.40	10.0	Extreme	83	6.1	High	22	7.5	High	37.40	High	21.2	8.68	2.44	Low	0.18	63.00
380	90	5.50	1.50	3.67	8.2	Very High	0.5	0.09	10.0	Extreme	10	0.91	10.0	Extreme	88	7.0	High	12	8.8	Very High	44.00	Very High	13.0	8.68	1.50	Very High	0.80	396.00
480	100	5.00	1.50	3.33	8.1	Very High	1.0	0.20	7.4	High	25	5.00	10.0	Extreme	90	7.9	High	30	5.9	Moderate	39.30	High	13.1	8.68	1.51	Very High	0.80	400.00

(ft^3/yr)	940.35	*Right BankTotal*
(tons/yr)	62.69	
(ft^3/yr)	1742.95	*Both Banks Total*
(tons/yr)	116.20	

Water Budget Notes and Calculations

Climatic Period	Precip. (in) [1]	Surface Inflow (in)	Over TOB influx (in)	GW [3] Net (in)	PET [2] (in)	Surface Outflow (in)	Infiltration (in)	Change in Storage (in)
January - April Average	15.2	28.4	36.0	0	12.1	63.4	4.1	0.01
January - April 2007	13.8	9.8	72.0	0	12.8	78.7	4.1	0.01

Notes:

1 Average precipitation data used for the Dutch Buffalo Creek study period is based off of the total average precipitation data recorded for Concord, NC for the months of January through April.

2 Potential evapotranspiration (PET) data used for the Dutch Buffalo Creek water budget was calculated from temperature data recorded at the Piedmont Research Station located in Salisbury, NC. Data was provided by the State Climate Office of North Carolina. PET was calculated using the Thornthwaite Method, which is primarily based on temperature. Temperature was assumed not to vary significantly between Salisbury and Concord. Average PET was calculated for the months of January through April between 1982 and 2006.

3 The net groundwater inflow and outflow was assumed to be zero in order to provide a conservative estimate of water available for the wetland restoration.

4 DBC precipitation data for the month of April reflects precipitation data collected at the Concord Airport. Precipitation data for Dutch Buffalo Creek for the month of April had not been collected at the time of this report

Calculations:

Inputs

Surface Inflow = ((Precipitation – PET) X Total Drainage Area)) – ((Precipitation – PET) X Total Wetland Area)) / Total Wetland Area

Over Top of Bank (OTB) Influx = Average Wetland Depth X Wetland Area X Number of OTB Events

Outputs

Surface Outflow = Inputs – (PET + Infiltration + Depressional Volume)

Infiltration = vertical permeability of sandy loam 2.4X10-5in/min X 120 days

Net

Change in Storage = (Inputs – Outputs) + ((Depressional Volume) / Wetland Area)