Jacksonville Country Club

Stream Restoration Project
Jacksonville, Onslow County, NC

Final Restoration Plan Report

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Ecosystem Enhancement PROGRAM

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TABLE OF CONTENTS

	EXECUTIVE SUMMARY	i
1.0	PROJECT SITE IDENTIFICATION AND LOCATION	1
	1.1 Directions to Project Site	1
	1.2 USGS Hydrologic Unit Code and NCDWQ River Basin	1
	1.3 Project Vicinity Map	1
2.0	WATERSHED CHARACTERIZATION	1
	Introduction	1
	2.1 Drainage Area	2
	2.2 Surface Water Classification/Water Quality	2
	2.3 Physiography, Geology and Soils	2
	2.4 Historical Land Use and Development Trends	3
	2.5 Growth Potential	4
	2.6 Endangered/Threatened Species	5
	2.7 Cultural Resources	5
	2.8 Potential Constraints	5
3.0	PROJECT SITE STREAMS (existing conditions)	5
	3.1 Introduction	5
	3.2 Channel Classification and Morphology	6
	3.3 Vegetation	7
4.0	REFERENCE STREAM	7
	4.1 Reference Stream Investigation	7
	4.2 Watershed Characterization	7
	4.3 Channel Morphology	8
	4.4 Vegetation	8
5.0	PROJECT SITE RESTORATION PLAN	8
	5.1 Introduction to Stream System Restoration Design Approach	8
	5.2 Analog Methodology	8
	5.3 Empirical Methodology	9
	5.4 Analytical Methodology	10
	5.5 Project Analysis and Design Restoration Approach	10
	5.6 Stream Dimensional Design	11
	5.7 Stream Pattern Design	12
	5.8 Stream Profile Design	12

5.9 Sediment Transport and Shear Stress 12
5.10 In-Stream Structures 13
5.11 Vegetation Community Restoration 13
5.12 Soils Restoration 14
5.13 Stormwater Best Management Practices 14

6.0 TYPICALS 16

7.0. PERFORMANCE CRITERIA 21
7.1 Streams 21
7.2 Stormwater Management Devices 21
7.3 Vegetation 21
7.4 Schedule/Reporting 21

8.0 REFERENCES 22

9.0 TABLES 23
Table 1. Project Restoration Structure and Objectives 24
Table 2. Drainage Area 24
Table 3. Land Use of Watershed 25
Table 4. Morphological Table 26
Table 5. BEHI/NBS and Sediment Export Estimate for Project Stream 38
Table 6. BEHI/NBS and Sediment Export Estimate for Reference Stream 38
Table 7. Designed Vegetative Communities 39

10. FIGURES
Figure 1. Project Site Vicinity Map
Figure 2. Project Site Watershed Map
Figure 3. Project Site NRCS Soil Survey Map
Figure 4. Project Site Hydrological Features Map with Gauge Locations
Figure 5. Reference Site Vicinity Map
Figure 6. Reference Site Watershed Map
Figure 7. Reference Site NRCS Soil Survey Map

11. DESIGNED SHEETS
Sheet 1. Existing Conditions
Sheet 2. Designed Site Conditions
Sheet 3. Designed Vegetative Communities Map

12. APPENDICES

Appendix 1. Project Site Photos

Appendix 2. USACE Stream Quality Assessment Worksheets

Appendix 3. Reference Site Photos

Appendix 4. Approved Concept Plan

EXECUTIVE SUMMARY

The Jacksonville Country Club project is being undertaken to restore, enhance, and/or protect functional aspects of streams on the Jacksonville Country Club property located in Jacksonville, Onslow County, NC. The project is funded by the North Carolina Ecosystem Enhancement Program (EEP). Located within a 253 acre developing watershed, the stream network within the project area consists of a main channel with three tributaries of varying sizes. Portions of all of the channels have been impacted through the development within the watershed. Channels have been straightened and runoff has increased. The channels are characterized by sparse woody vegetation and by steep eroding banks. Five existing channels have been designated for either restoration, enhancement or buffering with a total length of 3,613 linear feet. Channels A, B, C and E are considered perennial and have a combined existing length of 2,976 linear feet. Channel D is intermittent with an existing length of 637 feet. Channel A, B and C will have priority 2 restoration (2,724 feet), while Channel D and E (1,110 feet) will have enhancement or stabilization. The designed stream will have a total length of 4,302 linear feet, 3,611feet of restoration/enhancement for Channels A, B, C and E and 691 feet of enhancement/buffering on Channel D. This will be accomplished by changing dimension, pattern and profile of the existing stream. Where possible, there will be fifty-foot buffers placed on each side of the channel. Vegetation zones and types will vary depending on specific site location and golf course activities. The provision of a wider flood plain, the retrofitting of an existing stormwater wetland and the addition of a stormwater BMP (best management practice) will help maintain the integrity of the designed project. In addition, the project will replace habitat to a system relatively void in plant community diversity.

The overall goal of the Jacksonville Country project is to facilitate the development of a natural system which will exhibit desired functions appropriate to the geomorphic setting of the site. Specific goals include: 1) water quality improvement; and 2) natural community improvement. To achieve this goal, the following objectives are being pursued:

- Form and/or reform stream dimension, pattern, and profile for a stable system
- Generate aquatic and terrestrial habitat elements
- Implement pollutant removal features

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Directions to Project Site

The Country Club is located northwest of the intersection of Country Club Rd and Country Club Drive in Jacksonville, Onslow County, North Carolina (Site Vicinity Map, Figure. 1). The site and contributing watersheds are located in the Southern outer coastal plain hydrophysiographic region of North Carolina.

The site is located at on the southeastern portion of the United States Geological Survey (USGS) *Jacksonville North* 7.5 Minute Topographic Quadrangle and southwestern portion of *Kellum* Quadrangle (Map 3-2 USGS 7.5 Minute Topographic Quadrangle). The latitude and longitude of the center point of the restored stream is Latitude: 34°46', Longitude -77°22'. It is in the White Oak River basin, within the USGS 8-digit hydrologic unit 03030001.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin

The project is on an unnamed tributary of Northeast Creek. The Northeast Creek reach just downstream of the project area has been designated Stream Index 19-16-(0.5) by the North Carolina Division of Water Quality (NCDWQ). This reach has also been designated as Nutrient Sensitive Water (SC NSW) by NCDWQ. The reach is in subbasin 03-05-02. The following lists baseline watershed planning information for Northeast Creek, since the stream onsite is an unnamed tributary to Northeast Creek.

River Basin	White Oak
NCDWQ Stream Index #	19-16-(0.5)
NCDWQ Stream Class Rating	SC NSW
NCDWQ Subbasin #	03-05-02
USGS 8-Digit Cataloging Unit	03030001
USGS 14-Digit Hydrologic Unit	03030001020010

1.3 Project Vicinity Map

(Figure 1 in the Figures Section 10.0)

2.0 WATERSHED CHARACTERISTICS

Introduction

A wide variety of data sources were investigated and many different GIS data layers were obtained for use on the project. The first layers utilized were the USGS 7.5 Minute Topographic Maps, LIDAR elevational data and the USGS 14-digit Hydrologic Units. Watershed boundaries were delineated using LIDAR data and an automated watershed delineation tool. Subwatersheds were also delineated to separate drainage areas.

After determination of the boundaries, the watershed characteristics were reviewed using Onslow County digital aerial imagery, 2004 true-color aerial imagery, 1993 Grayscale USGS Digital Orthophoto Quarter Quadrangles (DOQQ), 1999 Color Infrared USGS DOQQ, 1996 Land Use / Land Cover (LULC), North Carolina Gap Analysis (GAP), digital Onslow County Soil Survey, USGS Digital Line Graph (DLG) hydrography, Onslow County parcels, and the Onslow County roads layer. These datasets were then used in several different aspects of the project including siting of monitoring equipment, identification of important watershed features, preparation of plans for field surveying, development of input data for hydrologic and hydraulic modeling, and development of a new high resolution Land Use / Land Cover map.

2.1 Drainage Area

Historically, aerials show that the watershed boundary for the project site has changed over time. Water flow has been redirected as the watershed has developed to allow for the road, residential and commercial construction. With this, there has been an increase in the percent impervious and stormwater runoff. The current size of the watershed is 253 acres (Project Site Watershed Map, Figure 2). The stream network within the project area consists of a main channel with four tributaries. Portions of all of the channels have been impacted through the development within the watershed. Channels have been straightened and runoff/flows have increased. The channels are characterized by sparse woody vegetation and by steep eroding banks.

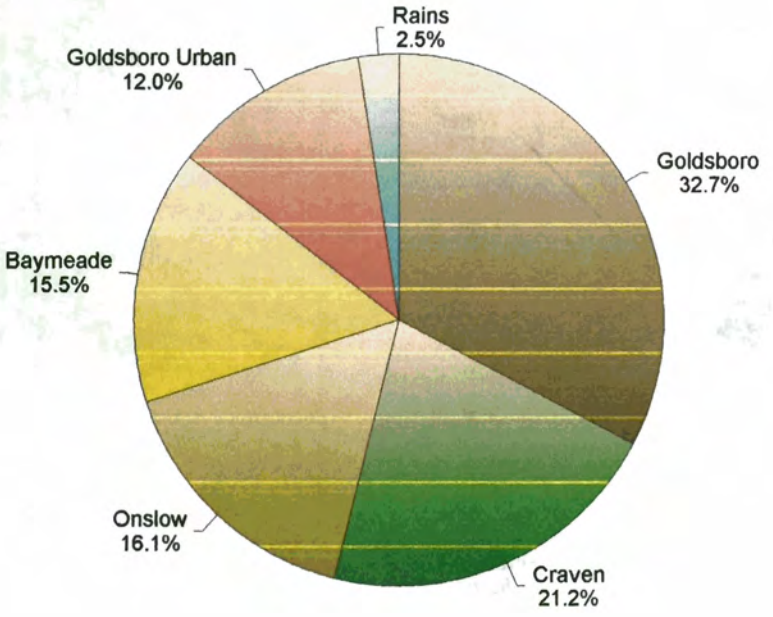
2.2 Surface Water Classification/Water Quality

The project is on an unnamed tributary of Northeast Creek. The Northeast Creek reach just downstream of the project area has been designated Stream Index 19-16-(0.5) by the North Carolina Division of Water Quality (NCDWQ). This reach has also been designated a Nutrient Sensitive Water (SC NSW) by NCDWQ.

2.3 Physiography, Geology and Soils

Soil types (mapping units) from the USDA-NRCS Onslow County Soil Survey GIS layer were used to develop coverage of the watershed soils (Project Site Soil Survey, Figure 3). There are six soil types represented in the watershed. The most prevalent soil types are: Goldsboro (32.7%), Craven (21.2%), Onslow (16.1%) and Baymeade (15.5%). All of these four soil types have a fine sandy texture and are usually well-drained and located on uplands. Chart 2-1 indicates the distribution of soil types within the watershed.

Chart 2-1 Soil Types (Onslow County Soil Survey)

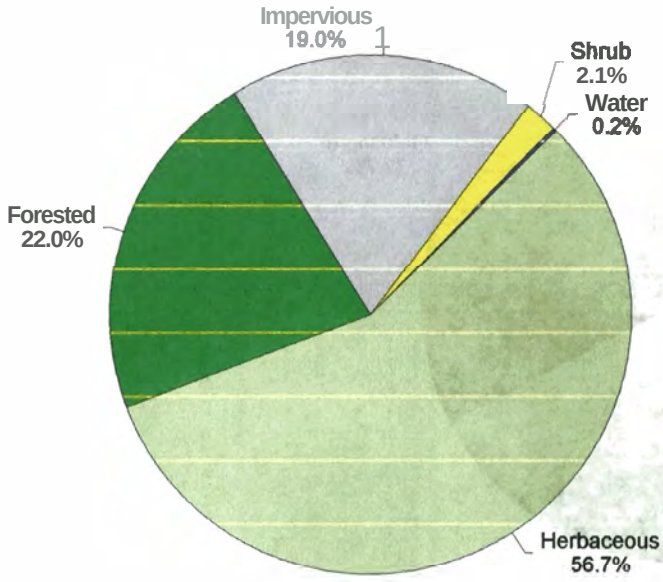


The soil types within are project area are mainly comprised of three types – Craven, along the stream channel and Baymeade and Onslow throughout the rest of the project. For Craven (CrC), the typical pedon is fine sandy loam. Having been formed in fine textured marine sediments, the series consist of moderately well drained soils on uplands. The erosion factors are K of 0.37 and T of 5 for this series. The typical pedon of Baymeade (BaB and BmB) is fine sand and is also well-drained. Having been formed on moderately coarse textured sediments, the erosion factors for K and T are 0.10 and 5, respectively. For Onslow the typical pedon is Onslow loamy fine sand. The series consists of moderately well drained and somewhat poorly drained soils on uplands. The erosion factors for K is 0.17 and for T is 4. Both Craven and Baymeade are considered hydric B as they are mapped as having inclusions of hydric soils or have wet spots. Baymeade has inclusions of Muckalee and Leon, while Craven has inclusions of Muckalee.

2.4 Historical Land Use and Development Trends

Land Use/Land Cover (LULC) for the watershed was created from 2004 true aerial color imagery. The primary land cover in the watershed is herbaceous (Chart 2-2). This is mainly due to the golf course, which occupies the majority of the watershed. A forested area is located between the golf course and the community college. Scattered trees and small forested areas are also found throughout the golf course. Most of the impervious area is found in the headwater area of the main channel and the headwaters of one of the side tributaries. A large shrub area identified on the aerial imagery has since been developed into single-family homes.

Chart 2-2 Land Use / Land Cover



2.5 Growth Potential

Fifty percent of the watershed is owned by the Jacksonville Country Club. The golf course takes up the majority of the property and it is unlikely land use will change in the future. Except for the road frontage, there is very limited space for future buildings on the country club parcel. The Country Club is considering selling a portion of the road frontage land for private development. In the near future, the road in front of the site is scheduled to be widened to up to five lanes of traffic. A culvert under the road which directs water to the site has been replaced to account for the road work. Coastal Carolina Community College owns over 22% of the land in the watershed, approximately 55 acres. About half of the community college campus is in the watershed. It contains buildings and parking lots laid out in an approximately 25 acre area. Large grassy areas remain where future buildings could be constructed. The other 30 acres owned by the community college within the watershed are undeveloped and for the most part forested. One other undeveloped, forested area, approximately 10 acres in size, is found in southern portion of the watershed. Almost half of this area is platted for single-family homes. Commercial development will most likely occur on about 3 of the 10 acres.

Population projections from Onslow County based on the US Census data are shown below. This data was obtained from the North Carolina Office of State Budget & Management.

Onslow County Population Projections (Census Data)

Year	Population	Change
2000	150,355	-
2010	164,883	9.7%
2020	173,617	5.3%

2.6 Endangered/Threatened Species

According to the 2000 Natural Heritage Element Occurrence GIS file from the North Carolina Center for Geographic Information and Analysis (CGIA), no threatened or endangered species are located in the project area. It is unlikely a threatened or endangered species exists in the project area as most of the native vegetation has been replaced with grass. Significant natural heritage areas are also not present in the project area. The tidal forest of Northeast Creek, just downstream of the project area, is considered a significant natural heritage area. Further analysis was not undertaken.

2.7 Cultural Resources

Verbal communication with NC State Historic Preservation Office (SHPO) and Country Club personnel, in regards to previous on-site work, it was determined that there are no known cultural resources problems within the project area. A review of the NC Listing of National Register of Historic Places in NC for Onslow County also did not list any site within the vicinity of the Jacksonville Country Club. There are four gravesites of a Confederate soldier and family members near the Country Club clubhouse, but not near the project area. The issue of no cultural resources problem is being formally verified with a letter to SHPO.

2.8 Potential Constraints

The only real recognizable constraint with the project is with the utilities/irrigation system. Small water lines for irrigation purposes cross the stream channel at several places and will have to be moved and relocated during construction. There are no problems with property ownership, site access or FEMA/hydrologic trespass.

A temporary issue with traffic flow to the club house will occur during the placement of the additional flood plain culverts on the main channel, but those issues have been addressed to the Country Club board members.

3.0 PROJECT SITE STREAMS (existing conditions)

3.1 Introduction

The project site consists of the main channel, A, and its three tributaries, B, C and D. There is an upper section of C that is referred to as E, but this is for identification purposes only. Total existing stream length is 3,613 linear feet. The main channel appears as a blue-line stream on the United States Geological Survey (USGS) Jacksonville North 7.5 Minute Topographic Quadrangle.

All waterways in this plan are referred to as channels. All stream channels are perennial, except for Channel D. The stream and its three side tributaries are excellent candidates for stream restoration. Most are incised with vertical banks in many locations. There is little to no woody riparian vegetation along the banks of any of the channels. Due to excessive erosion, concrete rip rap and debris has been used to help stabilize the site. Waterways have been

restricted with road crossings with undersized culverts. As a result, relatively small storm events can create substantial flooding at the entranceway. Increased development in the watershed has resulted in increased runoff being directed to the site.

To better analyze the stream conditions and the impact from the watershed, six rain gauges, five water level recorders and one weather station have been installed (Project Site Hydrological Features Map with Gauge Locations, Figure 4). The gauges are downloaded on a monthly basis. The data is used to determine flow rates and in stream water levels for use and design and future monitoring.

Site soil analysis was performed by taking cores to verify the existing soils to mostly sandy loam or loamy sand. Findings from the Habitat Assessment data sheets and the Urban Low Order Riparian Assessment verify that the channels are eroding with little cover or habitat intact.

3.2 Stream Classification and Morphology

Cross sections were measured approximately every 160' along the channels. The standard morphological measurements were taken to determine the Rosgen classification for each channel (Section 9, Table 4a-e). All points were flagged, field measured and surveyed for verification. Bankfull measurements were field determined and verified with calculations. Discharge was verified with the use of the instream water level recorders. Soil cores were taken at every cross section. The findings were that the banks are typically sandy loam or loamy sand. Channel bottom range from sand to silt/clay to broken concrete. The broken concrete is from concrete blocks being broken into smaller pieces and used to retard erosion and head cutting. Channel A, the main channel has an existing length of 1,947 feet. Channel A had entrenchment ratios ranging from 4.7 to 14.74. The width/depth ratio ranged from 3.95 to 10.76 feet. Sinuosity was 1.19 and the channel slope was 0.7%. Rosgen classification was determined to be G5. Channel B has an existing unculverted length of 277 linear feet. The upper portion of the stream is culverted and will be daylighted as a part of this project. It is greatly impacted from added runoff from the Country Club Road with severely eroding banks at the culvert termination point. The entrenchment ratio ranged from 13.55 to 23.17. Width/depth ranges were 2.84 to 3.18 feet. The channel sinuosity is 1.15 and the channel slope is 1.7%. Rosgen classification was determined to be G5 For this project assessment and design, Channel C was broken into 3 sections, the 2 lower sections which have a culvert in between the open water sections is referred to as Channel C and an upper channel, which was designated as Channel E. Channel C has an existing length of 379 feet, which does not include the portion that will remain in the culvert. The entrenchment ratio ranged from 9.58 to 12.50. The ranges for the width/depth ratio were from 5.22 to 11.40 feet. The sinuosity was 1.01 and the channel slope was 1.5%. The channel was classified as G5. Channel D is a small channel which drains into Channel A near the end of the project. Through the use of the NC Division of Water Quality classification forms, this segment is considered intermittent. Reinforced in areas with concrete blocks and brick to slow erosion, the channel pattern is relatively straight. The entrenchment ratio range is from 8.25 to 33.8. The width/ depth ratio is from 2.09 to 15.14 feet. Channel sinuosity and slope is 1.16 and 2.8% respectively. Channel D was classified as G5. Channel E has an existing length of 373 feet. The calculated entrenchment

ratio ranged from 6.3 to 10.4. The width depth ratio ranged from 3.87 to 8.07 feet. Channel sinuosity was 1.0 and channel slope was 2.17%. The stream was classified as C.

3.3 Vegetation

Vegetation was sampled throughout the site. Being situated on a golf course, the woody vegetation is sparse and consists of a small patches of loblolly pine (*Pinus taeda*) and scattered large trees of sweet gum (*Liquidambar styraciflua*), turkey oak (*Quercus laevis*), white oak (*Quercus alba*), Southern magnolia (*Magnolia grandiflora*) and loblolly pine (*Pinus taeda*), The majority of the shrub layer consists of planted azaleas. Streams banks are herbaceous, a maintained fairway. The largest intact vegetative layer is along the left bank of the main channel near the end of the project. Although the right bank has been cleared of the under story and some of the trees, it is still designated as a natural area.

4.0 REFERENCE STREAMS

4.1 Reference Stream Investigation

To utilize reference streams for geometric design of the Jacksonville Country Club project, or any other restoration project, several conditions must be met:

- The project watershed must match the hydrologic character of the reference watershed to a significant degree (including boundary conditions).
- The reference watershed and site must be stable and have been so for a significant time period.
- The project watershed must be stable, have been so for a significant time period, and will continue to be so for the design life of the project.
- The project site parameters must match the reference site parameters to a significant degree (bank vegetation, channel slopes, bank slopes, water table depth, bed material, etc).

4.2 Watershed Characterization

Using the above criteria as parameters, six potential reference sites/watersheds were identified for field investigation. Additional criteria in the selection process were watershed size and soil types. The site selected had a watershed size of 226 acres, compared to 253 acres for the project watershed. The mapped soils types within the reference reach watershed are mostly Goldsboro, Rains and Marvyn. These soils are sandy in texture and similar to the ones found within the project site. The reference site is within the Jacksonville city limits, in an area just undergoing increased development. The site location is found by traveling north on Highway 17 through Jacksonville. Turn left on Gum Branch Road and then right at the next light on Nottingham Road. The site is approximately 0.5 miles on the northern end of the Sherwood Estates. The selected watershed was well buffered with a relatively pristine headwater system. The latitude and longitude of the center point of the reference site is Latitude: 34°07', Longitude -77°24' (Reference Site Vicinity Map, Figure 5, Reference Site Watershed Map, Figure 6 and Reference Site Soil Survey Map, Figure 7).

4.3 Channel Morphology

Typical measurements were taken to obtain the reference stream morphology (Table 4-f). The entrenchment ratios ranged from 1.8 to 11.6. The width depth ratios were from 4.8 to 7.2 feet. Channel sinuosity was calculated to be 1.6. The channel was determined to have a Rosgen classification of E5. The longitudinal slope of the stream is 0.5. Stream bankfull depth varies from approximately 0.6 feet to 1.4 feet deep and width ranges between 4.3 feet and 6.79 feet. Channel dimension varies from 3.2 feet to 7.7 square feet. The stream substrate is fine sand.

4.4 Vegetation

The reference site was fairly heavily vegetated with trees and branches over hanging the stream with significant woody debris in the stream. The canopy provided about 85% covered. Sample vegetation included alder, (*Ulnus americana*), tulip poplar (*Liriodendron tuliperfers*), loblolly pine (*Pinus taeda),* sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum)* as canopy species. The under story consisted of ironwood (*Carpinus Carolina),* ti-ti (*Cyrilla racemosa)* with various ferns and grape (*Vitus. sp.)* and green briar (*Smilax sp.)* as groundcover. Using Schafale and Weakley's Classification of the Natural Communities of North Carolina, the reference site was categorized as a coastal plain stream swamp (blackwater subtype).

5.0 PROJECT SITE RESTORATION PLAN

5.1 Introduction to Stream System Restoration Design Approach

In the United States, most ecosystem restoration efforts focusing on streams and wetlands have been unsuccessful. Many reasons have been given for these failures, with the lack of detailed hydrologic and hydraulic investigation, modeling, and design being generally the most common cause. To be successful, ecosystem restoration efforts (as with any planning and design effort) require various methodologies to be employed dependent upon the individual type and character of the specific project.

Stream design methodologies can generally be separated into three categories: 1) Analog; 2) Empirical; 3) Analytical. Each of these methodologies has strengths and weaknesses. As such, various aspects of each methodology may be employed in any given project.

5.2 Analog Methodology

The Analog methodology is typified by the reference reach method popularized by Dave Rosgen of Wildland Hydrology and is the most simplistic of the three methodologies. The Analog methodology is based on the logical and statistical inference that if two systems are known to be alike in some respects, then they must be alike in other respects. In this methodology, sets of geometric and hydraulic parameters are measured relative to flow rate return intervals. This information is then applied to the design of the system being restored.

For a project to be successful using this methodology, several considerations must be met: 1) the project watershed matches the hydrologic character of the reference watershed(s) to a significant degree; 2) the site and reach parameters must match the reference site(s) to a significant degree (bank vegetation, channel slopes, bank slopes, water table depth, bed material, etc); 3) The reference watershed(s) and site(s) must be stable and have been so for a significant time period; 4) The project watershed must be stable, have been so for a significant time period, and continue to be so for the design life of the project. If these conditions are not met, this methodology is not applicable for project design.

As such, this methodology is generally not applicable to projects in urbanizing watersheds, watersheds which may experience development or redevelopment during the project's design life, watersheds where agricultural practices are changing or may change during the project's design life, watersheds where reservoirs may be constructed or removed, and various instances of watershed change. This method is generally suitable for sites at which the hydrologic response of the contributing watershed is significantly stable and will remain such for the intended lifetime of the project.

5.3 Empirical Methodology

As the name of this methodology suggests, the Empirical methodology is based on the application of statistically derived parameters from large datasets and intensive system studies. This methodology is somewhat similar to the analog method in that both methodologies are based on sets of measured data. The main difference is that the Empirical methodology utilizes much larger, refined, and more focused datasets than does the Analog methodology. A secondary difference is that the Empirical methodology often utilizes mean annual flow rate as the primary design parameter whereas the Analog methodology generally employs the bankfull flow rate as the primary design parameter, with the consideration that the bankfull flow is the channel forming discharge. The Empirical methodology is typified by the regime reach method.

As with the Analog methodology, for a project to be successful using the Empirical methodology, several considerations must be met: 1) specific project watershed response parameters of the project watershed must match specific watershed response parameters of the dataset watersheds to a significant degree; 2) specific project site and reach parameters must match specific parameters of the dataset sites and reaches to a significant degree (bank vegetation, channel slopes, bank slopes, water table depth, bed material, etc); 3) during the data collection period, the dataset watersheds, sites, and reaches must be equivalently stable or varying as the project watershed, site, and reach and continue to be so for the design life of the project (equal to, or less than, the data collection period if varying). If these conditions are not met, this methodology is not applicable for project design.

With the proper dataset and considerable understanding of this dataset, watershed hydrology, and fluvial geomorphology, it is potentially possible to apply the Empirical methodology to projects in urbanizing watersheds, watersheds which may experience development or redevelopment during the project's design life, watersheds where agricultural practices are changing or may change during the project's design life, and watersheds where reservoirs may be constructed or removed, and various instances of watershed change. This however, is

generally well beyond the limits of available datasets as well as the statistical validity of such extrapolations. Again as with the Analog methodology, this method is generally suitable for sites at which the hydrologic response of the contributing watershed is significantly stable and will remain such for the intended lifetime of the project.

5.4 Analytical Methodology

The Analytical methodology is based on the application of physically based mathematical models of natural phenomena to the project site and watershed. This methodology is quite different from the Analog and Empirical methodologies as no dependence is placed on datasets external from the project. Temporally and spatially distributed phenomena may also be addressed with this methodology, as opposed to Analog and Empirical methodologies. The Analytical methodology is typified by the system simulation method and is the primary methodology employed by the US Army Corps of Engineers and the US Geological Survey.

To successfully employ the Analytical methodology, two considerations must be met: 1) the designer must be able to adequately mathematically describe the relevant primary natural phenomena within the system; 2) adequate environmental parameters must be available to drive the mathematical model of the system. If these conditions are not met, this methodology is not applicable for project design.

The Analytical methodology is the most flexible and robust of the three methodologies presented and the only one that can be used to design and analyze the system for specific project functions such as pollutant removal, flood attenuation, and habitat development. This methodology can be applied to projects in urbanizing watersheds, watersheds which may experience development or redevelopment during the project's design life, watersheds where agricultural practices are changing or may change during the project's design life, watersheds where reservoirs may be constructed or removed, and other various instances of watershed change as well as significantly stable watersheds.

5.5 Project Analysis and Design Restoration Approach

For the stream design, focus is placed on applying the analytical methodology of stream design in combination with the analog (reference) methodology. The analytical methodology is based on the application of physically-based mathematical models of natural phenomena to the project site and wetland. It is not dependent on data sets external to the project. The methodology is the primary one utilized by the US Army Corps of Engineers.

When developing the analysis and design approach, the system location, project goals, and available project timeline were particularly taken into consideration. A hybrid analysis and design approach was developed for the project that utilized aspects of the Analog (reference reach) and Empirical (regime reach) methodologies with the Analytical (system simulation) approach at the core. The developed approach involves combining various stream restoration and hydraulic design techniques. The approach also included integration of advanced watershed hydrologic and stream hydraulic modeling, utilizing SWMM (Storm Water Management Model simulation system of the US Environmental Protection Agency), WEPP

(Water Erosion Prediction Project simulation system of the US Natural Resources Conservation Service), GSTARS (Generalized Sediment Transport for Alluvial Rivers simulation system of the US Bureau of Reclamation), and CCHE1D (Center for Computational Hydroscience and Engineering 1 Dimensional simulation system of the University of Mississippi). A few of the main sources detailing these methods are referenced at the end of this section. Although fairly involved and detailed as well as modified to account for site parameters as the project progressed, the general analysis and design approach employed is as follows:

1) Estimate watershed and stream response utilizing relatively simple models and methods
2) Develop preliminary channel planform and cross-sections
3) Utilize continuous simulation models to analyze watershed response
4) Employ channel hydraulics and sediment transport simulation models for reach analysis
5) Develop preliminary channel profile and refined channel planform and cross-sections
6) Iterate parameters and analysis to design final system

The design stream channels will be priority 2 restoration on Channel A, B and C and enhancement/stabilization on Channel D and E.

5.6 Stream Dimensional Design

The reference analysis found average bankfull widths of 5.7 feet. Most side slopes are supported by dense vegetation on the channel banks including overhanging trees. Tree roots were prominent in the channel banks. Due to the sandy, non-cohesive soils in the area, steep bank angles would not be stable without dense vegetative root mass. This vegetative support will take years to develop and the proposed stream will have to be constructed to remain stable independent of such vegetation. As a result, the restored stream will be designed to remain stable based on its geometry and a limited amount of vegetative cover and protection. The result is a stream with a larger cross-sectional area and sideslopes with a flatter, more stable, repose angle

Cross sectional areas are larger than the reference due to sandy material and the absence of vegetation. The size of the project dictates that flow rates and sediment loads will change along the length of the stream. Therefore, the stream parameters will vary from upstream to downstream. Channel dimensions will provide adequate sediment transport. The channel capacity design (geometry and slope) allows overbank flow into the riparian areas. The balance between adequate sediment transport to prevent excessive deposition and nonexcessive sideslope repose to prevent bank failure are key aspects of the design.

Initial cross-sections were developed employing full channel flow rate estimates. Expected flow rate was estimated utilizing US Natural Resources Conservation Service (NRCS) Curve Number (CN) methodology, US Geological Survey (USGS) National Flood Frequency (NFF) regional regression equations, and a combination of NC State University (NCSU) Stream Restoration Institute (SRI) regional regression equations.

Using preliminary flow estimates, initial cross-section dimensions were chosen for further analysis with the final pattern and profile designs. The base width of the design channels will range from 1 foot to 6 feet. Side slopes for all channels will be 3:1 (H:V). The bankfull depths will range from 1 foot to 2.5 feet. Channel top widths will range from 8.5 feet to 21.5 feet. This will create an average width to depth ratios of 8.5 ft/ft to 8.6 ft/ft, which will change as woody vegetation grows and alters cross-sections.

5.7 Stream Pattern Design

The pattern of the analyzed reference reach exhibited meanders – sinuosity was 1.6. It was determined, however, that those reaches are significantly supported by root mass and dense streamside vegetation. The new stream must be stable for a relatively long time independent of such vegetative support. Therefore, various empirically derived mathematical relationships were used to generate estimates for the design pattern information. The planform design was then developed relative to this range of pattern values, site landform, and quantitative simulation analysis. The pattern design resulted in a restored/enhanced total channel length of 4,302 feet: 2,244 feet for Channel A; 468 feet for Channel B; 480 feet for Channel C, 691 feet for Channel D; and 419 feet for Channel E (Tables 4-g-l).

5.8 Stream Profile Design

The flood plain slope is the major parameter driving and constraining channel slope. Site features influencing the profile design are primarily existing elevations and slopes, with connecting stream channels also a significant consideration. Overly deep channels will excessively drain the surrounding area, will not exhibit sufficient out of channel flow, will develop periodic stagnant conditions, and may be overly stressed along the banks. Overly shallow channels may become easily blocked and reroute, resulting in a highly unstable channel that could cause undesirable site conditions..

As the restored stream will need to be stable under a variety of conditions, analysis was completed to determine a range of stable slope possibilities. The restored stream reach slopes average 0.039 ft/ft. Morphological tables for each of the three streams comparing the existing, reference, and design stream is included at the end of this section.

5.9 Sediment Transport and Shear Stress

Stream analysis has been undertaken using multiple hydraulic analysis applications: CCHE1D, GSTARS, and WinXSpro. CCHE1D is a watershed-based channel network simulation system. The system simulates fractional sediment transport, bed aggradation and degradation, bed material composition (hydraulic sorting and armoring), bank erosion, and the resulting channel morphologic changes under unsteady flow conditions. GSTARS is a numerical model for simulating the flow of water and sediment transport in alluvial channels. GSTARS computes hydraulic forces in a manner similar to the US Army Corps of Engineers (USACE) HEC-RAS (Hydrologic Engineering Center River Analysis System) hydraulic model, but also has the capability to complete a full sediment transport analysis based on incoming sediment loads, shear stress, bed scour, and bank movement. WinXSPro, a software application of the US

Forest Service (USFS), for analysis of stream channel cross-sections. Functions are included for geometric, hydraulic, and sediment transport analysis. Analyses have been undertaken to assess the stability and response of design channel dimensions and pattern. Specific statistical return period events (1.5 yr, 2 yr, 5 yr, and 25 yr) and continuous "long term" temporal spans have been employed for these analyses.

Sediment transport in sand bed streams occurs frequently, often mobilizing much (or all) of the bed at flows significantly less than bankfull. Stability is a balance between incoming sediment load and deposition and localized erosion and scour. In a sand dominated system, the potential for deposition and aggradation must be equally weighed with the potential for erosion and degradation. Therefore, approaches to determine channel stability must utilize the above procedures, but also incorporate additional detailed methods to assess this balance.

Shear stress analysis has been undertaken for the design channels. It is expected and desired that shear stress exceed that indicated for a "stable" channel bed as regular bed fluidization is expected and desired. Channel sediment transport has been undertaken with shear stress analysis. Stable velocity limits for sandy material typically ranges between 2 ft/s and 2.5 ft/s. The critical shear stress for sandy material is typically 0.01 lb/sf. It is expected that these thresholds will be exceeded in the proposed channels well below bankfull stage. Banks will be protected against erosion during these flow events, while the beds will mobilize.

5.10 In-Stream Structures

In-stream structures will be used along each of the stream channels to provide bed grade control, prevent excessive erosion, and aid development of bedform features. Woody debris, such as fallen trees and limbs, were determined to be present in the reference stream, as was expected. Accumulation of woody debris will be facilitated by instream structures and bank vegetation. Roots from streamside trees traversed the reference stream bed. Large roots traversing the reference stream bed function in a similar manner as log weirs will in the proposed stream channels. Log weirs will be incorporated in the design for streambed stability and directing channel flow. Root wads will be installed in meander bends, which will function in a manner similar to trees along the reference stream banks. Construction detail drawings for typical in-stream structures are included in Section 6 (Typical Drawings) of this document. Location of the structures can be viewed on the Designed Channel Alignment and Structures, Figure 2a – 2e, where 2-a shows the entire project, 2-b shows Channel E, 2-c shows Channel A, reach AB and Channel B, 2-d shows Channel C and 2-e shows Channel A, reach BC and Channel D.

5.11 Vegetation Community Restoration

The project area will be planted entirely with native, noninvasive vegetation. Planting densities throughout the project area will be 350 stems per acre. Containerized plants of varying sizes (1 or 2 gallon pots) will be used throughout the project area. The project area is divided into four planting zones: buffer along the upper, smaller channels, buffer along the lower, larger channels, the riparian area/flood plain and the graded rough (Designed Vegetative Communities Map, Design Sheet 3). Plants selection was based on the reference area

vegetation, the soil types and expected associated vegetation types and the use of the areas by the Country Club. Where possible, a fifty foot buffer is maintained on each side of the stream bank. Plantings within the buffer will range from a zone with tree, shrub and herbaceous layers to a zone with small growing shrubs along the slopes and upper limits of the project boundary. A graded (graduated) rough grass buffer will be incorporated within the design in the play-over areas. Here the woody plantings, mainly shrubs with low vertical height will be limited to the slopes with the graded rough zoned for the remainder of the buffer width. The rough will decrease in height as it approached the fairway, to a minimum of 6 inches. The target communities are Mesic Mixed Hardwood forest, a Coastal Fringe Evergreen forest and a Coastal Plain Small Stream Swamp (blackwater subtype). The upper part of Channel B, in the area of the daylighted channel will have the largest area for a widened flood plain then anywhere else within the project boundary. Here the widened flood plain area will be approximately 0.5 acres along the 165 foot reach.

5.12 Soils Restoration

Soil preparation activities on the site will include minimal grading work. The entire site will be tilled or scarified to a depth of at 6" to 18". Grading activities will be managed to maintain an appropriate A horizon (topsoil) in the areas. If grading is likely to require excavation below existing A horizons or reduce the depth significantly, topsoil will be stripped and stockpiled for later replacement. Soil amendments will be kept to a minimum, but may include broadcast fertilizer application, some targeted fertilizer application, and possibly some organic matter addition.

Proper construction management will be critical to soils preparation and to avoid adverse impacts at the site. Traffic of heavy construction equipment must be limited to avoid compaction. Management must also ensure that tillage practices are completed correctly and to the specified extent. The manager must ensure that erosion control practices are followed to prevent the loss of topsoil from the site. Soil testing for bulk density, chemistry, or other parameters may be needed during the construction process to ensure that soil conditions will be appropriate for the restoration.

5.13 Stormwater Best Management Practices

In addition to the stream component, there will be two stormwater best management practices (BMP's) installed. One is a retrofit to an existing, failing stormwater wetland that was installed during the construction of the new clubhouse and parking lots. It is located within the project boundary on Channel A. It will serve to reduce direct input and overland flows into the stream. The second BMP will be installed at the upper reach of Channel D. It will be placed in an area where overland flows concentrate to increase channel erosion. Currently, the site is being treated with the use of brick and concrete rubble.

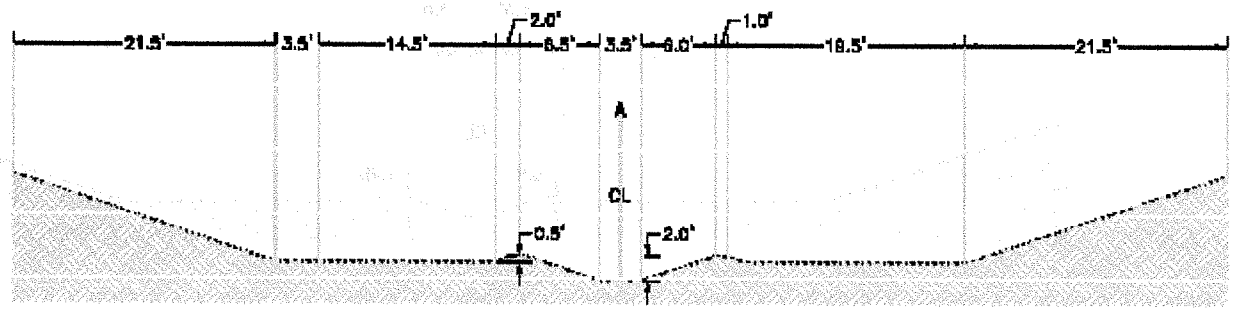
Only native, non-invasive plants will be selected for use in the BMP's. Vegetation selection will be made from species that can tolerate a wide hydrologic range from periods of very wet to very dry. Due to the location and setting on the golf course, aesthetics will also be a deciding factor. Examples of plants to be installed are:

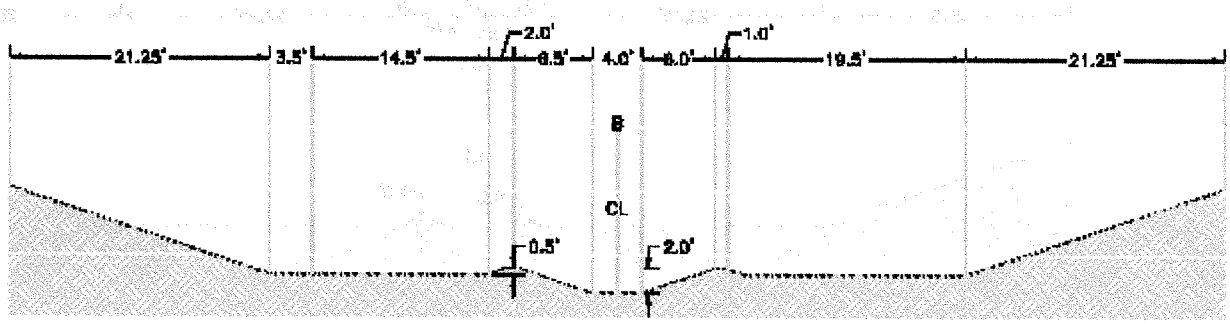
Trees	*Carya glabra*	Pignut hickory
	Osmanthus americana	Wild Olive
	Juniperus virginiana	Eastern Red Cedar
Shrubs	*Ilex vomitoria*	Yaupon Holly
	Ilex glabra	Inkberry
	Morella cerifera	Wax Myrtle
	Hamamelis virginiana	Witchhazel
	Campsis radicans	Trumpet Creeper
Wetland Seed Mix	*Asclepia tuberosa*	Butterfly Milkweed
	Aster spectabilis	Showy Aster
	Echinacea purpurea	Purple Coneflower
	Muhlenbergia capillari	Pink Hair Grass
	Kosteletskya virginica	Seashore Mallow
	Rudbeckia hirta	Blackeyed Susan
	Salvia azurea	Blue Sage
	Sorghastrum nutlans	Indian grass
	Verbena Canadensis	Clump Verbena

At the point where Channel A flows under the entrance road, additional flood plain culverts will be added. Culverts throughout the project area are undersized. The inadequate size has produced excessive scour downstream and flooding upstream, of these culverts. Currently, three culverts are located at the stream crossing. These culverts, in particularly, are not of an adequate capacity to handle the flows. Culverts will be both added and replaced to address these issues.

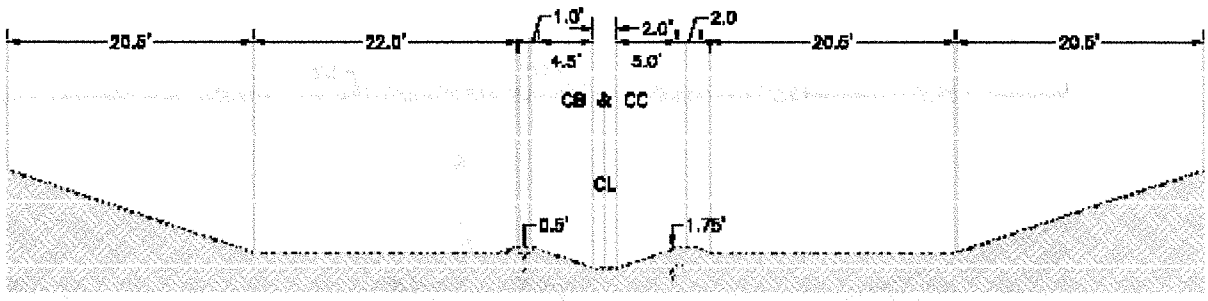
6.0 TYPICAL DRAWINGS

Channel A (sections AB and AC)

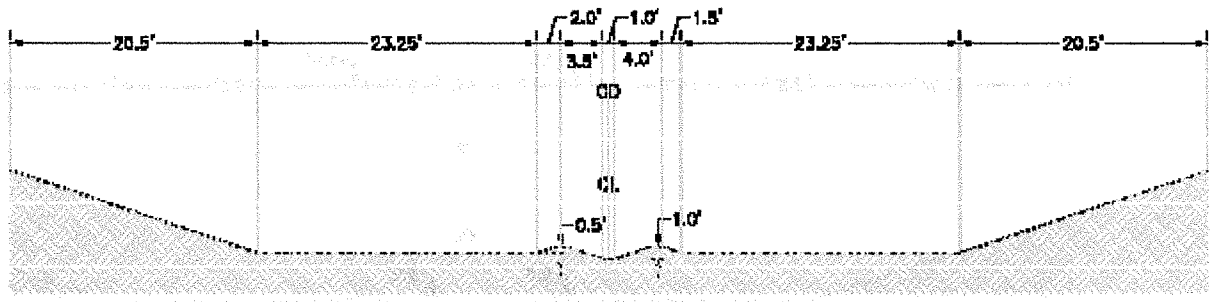




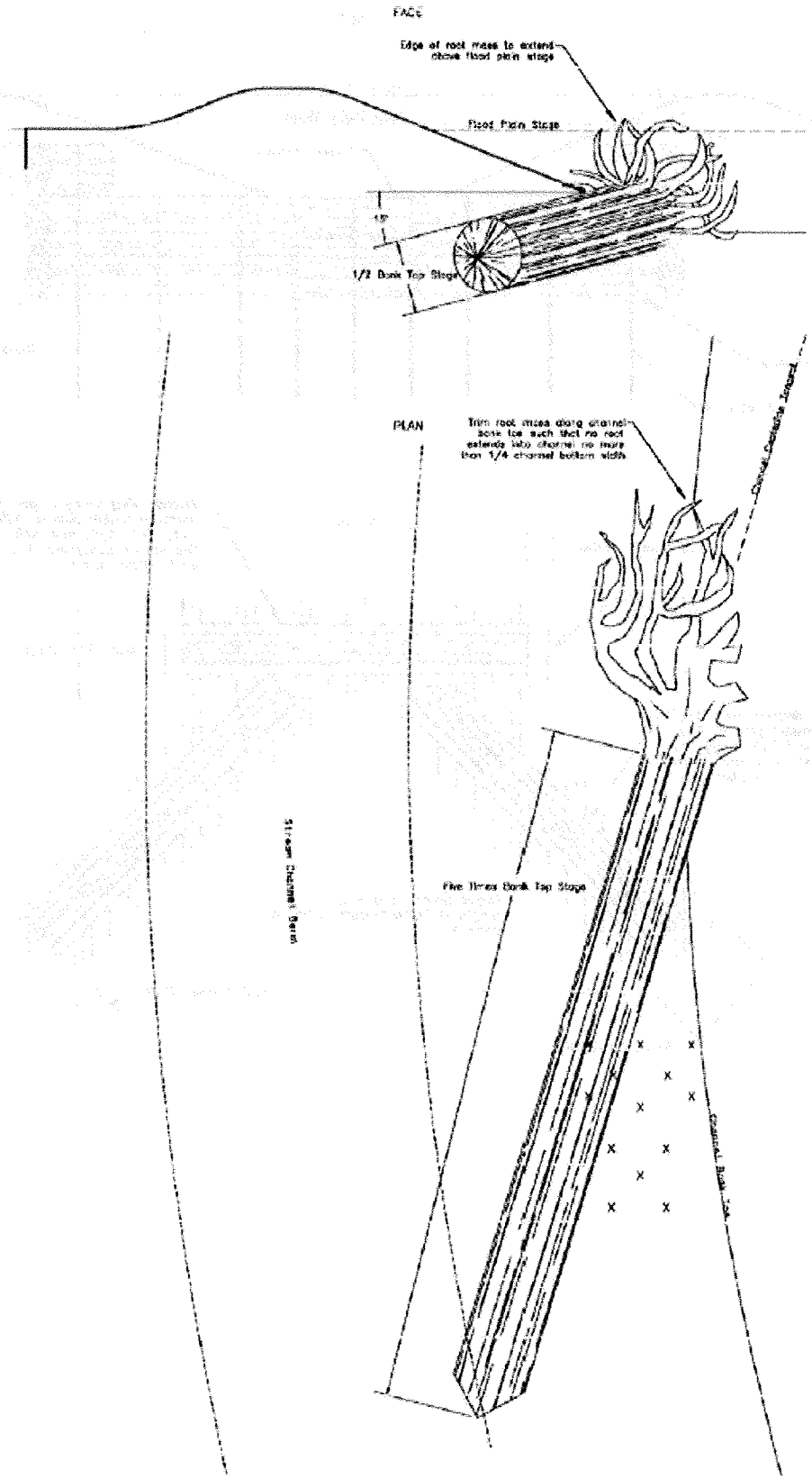
Channels Band C



Channel D

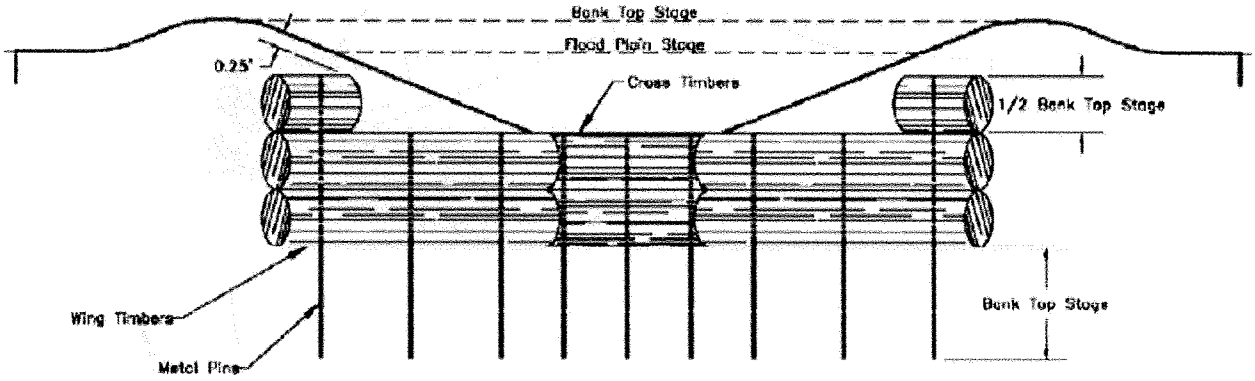


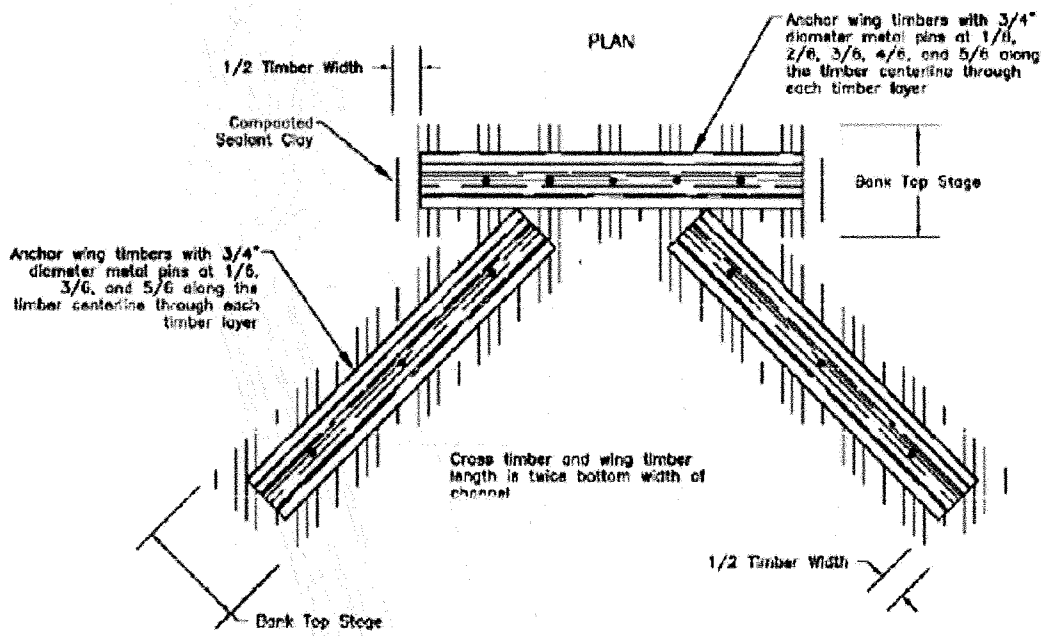
ROOT WAD STRUCTURE (FACE AND PLAN)
(N.T.S.)



LOG WEIR STRUCTURE (FACE AND PLAN)
(N.T.S.)

FACE





7.0 PERFORMANCE CRITERIA

7.1 Streams

Channel cross-sections, profile, pattern, and materials will be assessed. One cross-section will be established approximately every 500 feet along each new channel. The designed stream lengths total 4,302 feet and 9 permanent cross sections will be established. At each cross section the width/depth ratio, entrenchment ratio, and low bank height ratio will be measured and compared with the designed stream geomorphology (the as-builts) for dimension and profile. Photo reference points will be established at each cross section. Longitudinal profiles will be checked for sinuosity, meander width ratio, radius of curvature and compared with the post construction as-builts. Grab samples will be collected to determine the established d50 and d85.

7.2 Vegetation

Success will be considered from the establishment of the wetland seed mix along the stream banks and an 80% survival rate of planted vegetation in the vegetated zones at the end of the first year. Vegetation will be assessed in sixteen permanent plots, either 10 M X 10M or 20M X 5 M in size, will be placed along the channel segments, 8 on Channel A and 2 each on Channel B, C, D and E. Within each plot, data will be collected pertaining to species composition, presence of volunteer or invasive species, height and percent survival.

7.3 Stormwater Management Devices / Best Management Practices

The stormwater wetlands will be assessed for vegetation growth and stability. The purpose of the stormwater wetlands is to provide water storage and consequent slow release of flows. There is no intent of measuring water quality improvements at this time.

7.4 Schedule/Reporting

The site will be monitored once a month for the first three months and quarterly thereafter during the first post-construction year. Each visit will consist of a visual inspection for general site conditions, presence of eroding banks, condition of the installed structures and general stream stability. Data from the rain gauges, water level recorders and the weather station will be downloaded and compiled. Vegetation will be assessed for survival and growth. Near the end of the first year of project implementation the stream will be surveyed for existing conditions and general evaluations will be made.

Permanent photo stations will be established at key points for compiling a record of project success over the monitoring period. A monitoring report will be submitted to the Ecosystem Enhancement Program at the end of the first post-construction year. Any recommendations for remedial actions will be made at this time. The restoration project will be monitored for an additional four years by an independent contractor.

8.0 REFERENCES

- Barnhill, W.L., Soil Conservation Service, 1992 Soil Survey of Onslow County, North Carolina United States Department of Agriculture
- Copeland, Ronald R, Dinah N McComas, Colin R Thorne, Philip J Soar, Meg M Jonas, and Jon B Fripp, 2001 Hydraulic Design of Stream Restoration Projects (ERDC/CHL TR-01-28) US Army Corps of Engineers, Coastal and Hydraulics Laboratory, Vicksburg, MS
- Federal Interagency Stream Restoration Working Group, 1998 Stream Corridor Restoration: Principles, Processes, and Practices National Technical Information Service, US Department of Commerce, Springfield, VA
- Millar, R G and B J MacVicar, 1998 An analytical method for natural channel design In: Proceedings of the ASCE Wetlands Engineering and River Restoration Conference, Denver, CO
- Miller, D E and P B Skidmore, 2001 Natural Channel Design: How Does Rosgen Classification-Based Design Compare with Other Methods? In: Proceedings of ASCE Wetlands/River Restoration Conference, Reno, NV
- Pope, Benjamin F, Gary D Tasker, and Jeanne C Robbins, 2001 Estimating the Magnitude and Frequency of Floods in Rural Basins of North Carolina - Revised (WRIR 01-4207) US Geological Survey, Raleigh, NC
- Rosgen, D L, 1996 Applied River Morphology Wildland Hydrology Books, Pagosa Springs, CO
- Schafale, Michael P. and Alan S. Weakley, 1990 Classification of the Natural Communities of North Carolina NC Natural Heritage Program, Raleigh, NC
- Skidmore, P B, F D Shields, M W Doyle, and D E Miller, 2001 A Categorization of Approaches to Natural Channel Design In: Proceedings of ASCE Wetlands/River Restoration Conference, Reno, NV
- Thorne, Colin R and Philip J Soar, 2001 Channel Restoration Design for Meandering Rivers (ERDC/CHL CR-01-1) US Army Corps of Engineers, Coastal and Hydraulics Laboratory, Vicksburg, MS

9.0 TABLES

Table 1 Project Restoration Structure and Objectives

Project Restoration Structure and Objectives Project Number JCC/WOK/05 (Jacksonville Country Club)						
Restoration Segment/ Reach ID	Station Range (existing)	Restoration Type	Priority Approach	Existing Linear Footage	Designed Linear Footage	Comment
Channel A/ Reach AB	00+00-8+45	Restoration	P2	732	845	
Channel A/ Reach BC	8.45-22+44	Restoration	P2	1215	1399	
Channel B	00+00-4+68	Restoration	P2	277	468	
Channel C	00+00-6+03	Restoration	P2	379	480	
Channel D	00+00-6+91	Enhancement 1/ Stabilization	P2?SS	637	691	May just reshape channel slopes and plant buffer and place grade controls
Channel E	00+00-4+19	Enhancement 1/ Stabilization	P2/SS	373	419	May just reshape channel slopes and plant buffer and place grade controls

Table 2 Drainage areas

Drainage Areas Project Number JCC/WOK/05 (Jacksonville Country Club)	
Channel/Segment	Drainage Area (acres)
Channel A Reach AB	99
Channel A Reach BC (to project end)	253
Channel B tributary	55
Channel C tributary	79
Channel D tributary	7
Channel E tributary	12
Total at project end	253

Table 3 Land Use of Watershed

Land Use of Watershed (253 acres) Project Number JCC/WOK/05 (Jacksonville Country Club)		
Land Use	Acreage	Percentage
Herbaceous	143.45	56.7%
Forested	55.66	22.0%
Impervious	48.07	19.0%
Shrub	5.31	2.1%
Water	0.51	0.2%

Table 4a – Morphological Table Channel A existing

Parameter	Minimum	Maximum	Average
Drainage Area, DA (sq mi)			3.95
Stream Length			1947
Stream Type (Rosgen)			G5*
Bankfull Cross-sectional Area, Abkf (sq ft)	6.16	14.60	9.66
Bankfull Width, Wbkf (ft)	5.76	9.04	7.29
Bankfull Depth, Dbkf (ft)	0.76	1.78	1.32
Width to Depth Ratio, W/D (ft/ft)	3.95	10.76	6.05
Width Floodprone Area, Wfpa (ft)	11.16	64.97	27.17
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	4.70	14.74	10.68
Max Depth @ bkf, Dmax (ft)	1.20	2.90	2.10
Max Depth Ratio, Dmax/Dbkf	1.42	1.83	1.59
Max Depth @ tob, Dmaxtob (ft)	3.20	5.60	4.18
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.25	2.67	2.11
Meander Length, Lm (ft)	23.02	125.96	44.26
Meander Length Ratio, Lm/Wbkf (ft/ft)	1.98	14.01	5.51
Radius of Curvature, Rc (ft)	15.46	51.08	25.74
Rc ratio, Rc/Wbkf (ft/ft)	1.41	5.68	3.17
Belt Width, Wblt (ft)	9.08	63	23.17
Meander Width Ratio, Wblt/Wbkf (ft/ft)	1.29	24	2.82
Sinuosity, K			1.19
Valley Slope, Sval (ft/ft)			1%
Channel Slope, Schan (ft/ft)			0.7%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4b – Morphological Table Channel B existing

Parameter	Minimum	Maximum	Average
Drainage Area, DA (sq mi)			0.086
Stream Length (ft)			277
Stream Type (Rosgen)			G5*
Bankfull Cross-sectional Area, Abkf (sq ft)	3.88	4.95	4.42
Bankfull Width, Wbkf (ft)	3.32	3.97	3.65
Bankfull Depth, Dbkf (ft)	1.17	1.25	1.21
Width to Depth Ratio, W/D (ft/ft)	2.84	3.18	3.01
Width Floodprone Area, Wfpa (ft)	45.00	92.00	68.50
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	13.55	23.17	18.36
Max Depth @ bkf, Dmax (ft)	1.80	2.11	1.96
Max Depth Ratio, Dmax/Dbkf	1.54	1.69	1.62
Max Depth @ tob, Dmaxtob (ft)	2.99	3.67	3.33
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.66	1.74	1.70
Meander Length, Lm (ft)	14.02	17.20	15.61
Meander Length Ratio, Lm/Wbkf (ft/ft)	4.22	4.33	4.28
Radius of Curvature, Rc (ft)	12.68	18.36	15.52
Rc ratio, Rc/Wbkf (ft/ft)	3.82	4.62	4.22
Belt Width, Wblt (ft)	6.25	8.38	7.32
Meander Width Ratio, Wblt/Wbkf (ft/ft)	1.88	2.11	2.00
Sinuosity, K			1.15
Valley Slope, Sval (ft/ft)			5%
Channel Slope, Schan (ft/ft)			1.7%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4c – Morphological Table Channel C existing

Parameter	Minimum	Maximum	Average
Drainage Area, DA (sq mi)			0.012
Stream Length (ft)			379
Stream Type (Rosgen)			G5*
Bankfull Cross-sectional Area, Abkf (sq ft)	6.26	7.70	6.98
Bankfull Width, Wbkf (ft)	5.71	9.37	7.45
Bankfull Depth, Dbkf (ft)	0.82	1.10	0.96
Width to Depth Ratio, W/D (ft/ft)	5.22	11.40	8.06
Width Floodprone Area, Wfpa (ft)	71.40	89.73	77.70
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	9.58	12.50	10.66
Max Depth @ bkf, Dmax (ft)	1.53	2.01	1.73
Max Depth Ratio, Dmax/Dbkf	1.40	2.45	1.85
Max Depth @ tob, Dmaxtob (ft)	2.35	2.87	2.66
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.37	1.74	1.55
Meander Length, Lm (ft)	23.70	74.04	50.73
Meander Length Ratio, Lm/Wbkf (ft/ft)	3.26	12.98	7.35
Radius of Curvature, Rc (ft)	14.66	50.25	32.17
Rc ratio, Rc/Wbkf (ft/ft)	2.02	8.81	4.73
Belt Width, Wblt (ft)	10.29	18.86	15.34
Meander Width Ratio, Wblt/Wbkf (ft/ft)	1.42	2.96	2.13
Sinuosity, K			1.08
Valley Slope, Sval (ft/ft)			2%
Channel Slope, Schan (ft/ft)			1.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

able 4d – Morphological Table Channel D existing

Parameter	Minimum	Maximum	Average
Drainage Area, DA (sq mi)			0.011
Stream Length			637
Stream Type (Rosgen)			G5*
Bankfull Cross-sectional Area, Abkf (sq ft)	2.32	30.14	11.06
Bankfull Width, Wbkf (ft)	3.55	14.55	7.09
Bankfull Depth, Dbkf (ft)	0.53	2.07	1.46
Width to Depth Ratio, W/D (ft/ft)	2.09	15.14	5.51
Width Floodprone Area, Wfpa (ft)	23.90	121.00	72.91
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	8.25	33.80	19.59
Max Depth @ bkf, Dmax (ft)	1.09	3.97	2.32
Max Depth Ratio, Dmax/Dbkf	1.24	2.17	1.63
Max Depth @ tob, Dmaxtob (ft)	1.42	5.11	3.02
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.11	1.46	1.30
Meander Length, Lm (ft)	34.93	50.12	42.72
Meander Length Ratio, Lm/Wbkf (ft/ft)	2.40	5.92	4.08
Radius of Curvature, Rc (ft)	24.49	146.23	69.36
Rc ratio, Rc/Wbkf (ft/ft)	2.93	10.05	5.45
Belt Width, Wblt (ft)	14.99	23.65	19.61
Meander Width Ratio, Wblt/Wbkf (ft/ft)	1.18	3.25	1.94
Sinuosity, K			1.16
Valley Slope, Sval (ft/ft)			3%
Channel Slope, Schan (ft/ft)			2.8%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4e – Morphological Table Channel E existing

Parameter	Minimum	Maximum	Average
Drainage Area, DA (sq mi)			0.019
Stream Length			373
Stream Type (Rosgen)			C5*
Bankfull Cross-sectional Area, Abkf (sq ft)	14.59	23.61	19.1
Bankfull Width, Wbkf (ft)	12.51	13.33	12.92
Bankfull Depth, Dbkf (ft)	1.55	3.44	2.495
Width to Depth Ratio, W/D (ft/ft)	8.07	3.87	5.97
Width Floodprone Area, Wfpa (ft)	84	130	107
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	6.3	10.4	8.35
Max Depth @ bkf, Dmax (ft)	1.55	3.44	2.49
Max Depth Ratio, Dmax/Dbkf	1	1	1
Max Depth @ tob, Dmaxtob (ft)	1.55	3.44	2.495
Bank Height Ratio, Dtob/Dmax (ft/ft)	1	1	1
Meander Length, Lm (ft)	74	101	87.5
Meander Length Ratio, Lm/Wbkf (ft/ft)	5.92	7.58	6.75
Radius of Curvature, Rc (ft)	n/a	n/a	n/a
Rc ratio, Rc/Wbkf (ft/ft)	n/a	n/a	n/a
Belt Width, Wblt (ft)	n/a	n/a	n/a
Meander Width Ratio, Wblt/Wbkf (ft/ft)	n/a	n/a	n/a
Sinuosity, K	1	1	1
Valley Slope, Sval (ft/ft)	2.03	2.03	2.03
Channel Slope, Schan (ft/ft)	2.17	2.17	2.17
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4f – Morphological Table reference site

Parameter	Minimum	Maximum	Average
Drainage Area, DA (sq mi)			0.35
Stream Length			143
Stream Type (Rosgen)			E5
Bankfull Cross-sectional Area, Abkf (sq ft)	3.2	7.7	5.4
Bankfull Width, Wbkf (ft)	4.3	6.7	5.7
Bankfull Depth, Dbkf (ft)	0.6	1.4	1.0
Width to Depth Ratio, W/D (ft/ft)	7.2	4.8	5.7
Width Floodprone Area, Wfpa (ft)	10.7	53.0+	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	1.8	11.6	6.7
Max Depth @ bkf, Dmax (ft)	0.8	2.1	1.4
Max Depth Ratio, Dmax/Dbkf	1.3	1.5	1.4
Max Depth @ tob, Dmaxtob (ft)	1.1	2.7	1.6
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.4	1.3	1.4
Meander Length, Lm (ft)			45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)			7.14
Radius of Curvature, Rc (ft)			9.2
Rc ratio, Rc/Wbkf (ft/ft)			1.6
Belt Width, Wblt (ft)			15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)			2.3
Sinuosity, K			1.6
Valley Slope, Sval (ft/ft)			
Channel Slope, Schan (ft/ft)			0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

Table 4g – Morphological Table Channel A Reach AB

Morphological Table Project Number JCC/WOK/05 (Jacksonville Country Club)			
Item	**Existing**	**Designed**	**Reference**
Drainage Area, DA (sq mi)	0.15	0.15	0.35
Stream Length (ft)	732	845	143
Stream Type (Rosgen)	G5*	C5	E5
Bankfull Cross-sectional Area, Abkf (sq ft)	9.66	19.0	5.4
Bankfull Width, Wbkf (ft)	7.29	15	5.7
Bankfull Depth, Dbkf (ft)	1.32	2	1.0
Width to Depth Ratio, W/D (ft/ft)	6.05	7.5	5.7
Width Floodprone Area, Wfpa (ft)	27.17	71.5	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	10.68	4.8	6.7
Max Depth @ bkf, Dmax (ft)	2.10	2	1.4
Max Depth Ratio, Dmax/Dbkf	1.59	1	1.4
Max Depth @ tob, Dmaxtob (ft)	4.18	2	1.63
Bank Height Ratio, Dtob/Dmax (ft/ft)	2.11	1	1.4
Meander Length, Lm (ft)	44.26	112	45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)	5.51	5.3	7.14
Radius of Curvature, Rc (ft)	25.74	45	9.2
Rc ratio, Rc/Wbkf (ft/ft)	3.17	3	1.6
Belt Width, Wblt (ft)	23.17	27	15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)	2.82	1.8	2.3
Sinuosity, K	1.1	1.1	1.6
Valley Slope, Sval (ft/ft)	1%	0.8%	
Channel Slope, Schan (ft/ft)	0.7%	0.7%	0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4h – Morphological Table Channel A Reach BC

Morphological Table Project Number JCC/WOK/05 (Jacksonville Country Club)			
Item	**Existing**	**Designed**	**Reference**
Drainage Area, DA (sq mi)	0.395	0.395	0.35
Stream Length (ft)	1215	1399	143
Stream Type (Rosgen)	G5*	C5	E5
Bankfull Cross-sectional Area, Abkf (sq ft)	9.66	33.75	5.4
Bankfull Width, Wbkf (ft)	7.29	21	5.7
Bankfull Depth, Dbkf (ft)	1.32	2.5	1.0
Width to Depth Ratio, W/D (ft/ft)	6.05	10	5.7
Width Floodprone Area, Wfpa (ft)	27.17	80	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	10.68	3.8	6.7
Max Depth @ bkf, Dmax (ft)	2.10	2.5	1.4
Max Depth Ratio, Dmax/Dbkf	1.59	1	1.4
Max Depth @ tob, Dmaxtob (ft)	4.18	2.5	1.63
Bank Height Ratio, Dtob/Dmax (ft/ft)	2.11	1	1.4
Meander Length, Lm (ft)	44.26	112	45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)	5.51	5.3	7.14
Radius of Curvature, Rc (ft)	25.74	45	9.2
Rc ratio, Rc/Wbkf (ft/ft)	3.17	3	1.6
Belt Width, Wblt (ft)	23.17	27	15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)	2.82	1.8	2.3
Sinuosity, K	1.8	1.9	1.6
Valley Slope, Sval (ft/ft)	1%	0.8%	
Channel Slope, Schan (ft/ft)	0.7%	0.7%	0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4i – Morphological Table Channel B

Morphological Table Project Number JCC/WOK/05 (Jacksonville Country Club)			
Item	**Existing**	**Designed**	**Reference**
Drainage Area, DA (sq mi)	0.086	0.086	0.35
Stream Length (ft)	277	468	143
Stream Type (Rosgen)	G5*	C5b	E5
Bankfull Cross-sectional Area, Abkf (sq ft)	4.42	12.7	5.4
Bankfull Width, Wbkf (ft)	3.65	12.5	5.7
Bankfull Depth, Dbkf (ft)	1.21	1.75	1.0
Width to Depth Ratio, W/D (ft/ft)	3.01	7.14	5.7
Width Floodprone Area, Wfpa (ft)	68.50	72	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	18.36	5.76	6.7
Max Depth @ bkf, Dmax (ft)	1.96	1.75	1.4
Max Depth Ratio, Dmax/Dbkf	1.62	1	1.4
Max Depth @ tob, Dmaxtob (ft)	3.33	1.75	1.63
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.70	1	1.4
Meander Length, Lm (ft)	15.61	115	45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)	4.28	9.2	7.14
Radius of Curvature, Rc (ft)	15.52	53	9.2
Rc ratio, Rc/Wbkf (ft/ft)	4.22	4.24	1.6
Belt Width, Wblt (ft)	7.32	38	15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)	2.00	3.04	2.3
Sinuosity, K	1.15	1.2	1.6
Valley Slope, Sval (ft/ft)	5%	2.0%	
Channel Slope, Schan (ft/ft)	1.7%	1.8%	0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4j – Morphological Table Channel C

Morphological Table Project Number JCC/WOK/05 (Jacksonville Country Club)			
Item	**Existing**	**Designed**	**Reference**
Drainage Area, DA (sq mi)	0.012	0.012	0.35
Stream Length (ft)	379	480	143
Stream Type (Rosgen)	C5*	C5b	E5
Bankfull Cross-sectional Area, Abkf (sq ft)	6.98	12.7	5.4
Bankfull Width, Wbkf (ft)	7.45	12.5	5.7
Bankfull Depth, Dbkf (ft)	0.96	1.75	1.0
Width to Depth Ratio, W/D (ft/ft)	8.06	7.14	5.7
Width Floodprone Area, Wfpa (ft)	77.70	72	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	10.66	5.76	6.7
Max Depth @ bkf, Dmax (ft)	1.73	1.75	1.4
Max Depth Ratio, Dmax/Dbkf	1.85	1	1.4
Max Depth @ tob, Dmaxtob (ft)	2.66	1.75	1.63
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.55	1	1.4
Meander Length, Lm (ft)	50.73	83	45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)	7.35	6.6	7.14
Radius of Curvature, Rc (ft)	32.17	46	9.2
Rc ratio, Rc/Wbkf (ft/ft)	4.73	3.68	1.6
Belt Width, Wblt (ft)	15.34	12.5	15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)	2.13	1	2.3
Sinuosity, K	1.08	1.2	1.6
Valley Slope, Sval (ft/ft)	2%	1.2%	
Channel Slope, Schan (ft/ft)	1.5%	1.0%	0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4k – Morphological Table Channel D

Morphological Table Project Number JCC/WOK/05 (Jacksonville Country Club)			
Item	**Existing**	**Designed**	**Reference**
Drainage Area, DA (sq mi)	0.011	0.011	0.35
Stream Length (ft)	637 ft.	691	143
Stream Type (Rosgen)	G5	C5b	E5
Bankfull Cross-sectional Area, Abkf (sq ft)	11.06	4.0	5.4
Bankfull Width, Wbkf (ft)	7.09	7.0	5.7
Bankfull Depth, Dbkf (ft)	1.46	1.0	1.0
Width to Depth Ratio, W/D (ft/ft)	5.51	7.0	5.7
Width Floodprone Area, Wfpa (ft)	72.91	67.5	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	19.59	9.6	6.7
Max Depth @ bkf, Dmax (ft)	2.32	1.0	1.4
Max Depth Ratio, Dmax/Dbkf	1.63	1.0	1.4
Max Depth @ tob, Dmaxtob (ft)	3.02	1.0	1.63
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.30	1.0	1.4
Meander Length, Lm (ft)	42.72	118	45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)	4.08	16.9	7.14
Radius of Curvature, Rc (ft)	69.36	45	9.2
Rc ratio, Rc/Wbkf (ft/ft)	5.45	6.4	1.6
Belt Width, Wblt (ft)	19.61	33	15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)	1.94	4.7	2.3
Sinuosity, K	1.2	1.3	1.6
Valley Slope, Sval (ft/ft)	3%	3.4%	
Channel Slope, Schan (ft/ft)	2.8%	2.6%	0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 4l – Morphological Table Channel E

Morphological Table Project Number JCC/WOK/05 (Jacksonville Country Club)			
Item	**Existing**	**Designed**	**Reference**
Drainage Area, DA (sq mi)	0.019	.019	0.35
Stream Length (ft)	373	419	143
Stream Type (Rosgen)	G5*	C5b	E5
Bankfull Cross-sectional Area, Abkf (sq ft)	19.1	4.0	5.4
Bankfull Width, Wbkf (ft)	12.92	7.0	5.7
Bankfull Depth, Dbkf (ft)	2.495	1.0	1.0
Width to Depth Ratio, W/D (ft/ft)	5.97	7.0	5.7
Width Floodprone Area, Wfpa (ft)	107	67.5	35.1
Entrenchment Ratio, Wfpa/Wbkf (ft/ft)	8.35	9.6	6.7
Max Depth @ bkf, Dmax (ft)	2.49	1.0	1.4
Max Depth Ratio, Dmax/Dbkf	1	1.0	1.4
Max Depth @ tob, Dmaxtob (ft)	2.495	1.0	1.63
Bank Height Ratio, Dtob/Dmax (ft/ft)	1	1.0	1.4
Meander Length, Lm (ft)	87.5	120	45.4
Meander Length Ratio, Lm/Wbkf (ft/ft)	6.75	17.14	7.14
Radius of Curvature, Rc (ft)	n/a	31	9.2
Rc ratio, Rc/Wbkf (ft/ft)	n/a	4.43	1.6
Belt Width, Wblt (ft)	n/a	26	15.5
Meander Width Ratio, Wblt/Wbkf (ft/ft)	n/a	3.71	2.3
Sinuosity, K	1	1.09	1.6
Valley Slope, Sval (ft/ft)	2.03	2.74%	n/a
Channel Slope, Schan (ft/ft)	2.17	2.52%	0.5%
D16 (mm)			
D35 (mm)			
D50 (mm)			
D84 (mm)			
D95 (mm)			

* Calculated numbers for the existing stream types do not match any of the Rosgen morphological classification. Classification based on calculations and field observations.

Table 5 BEHI/NBS and Sediment Transport for Project Site Streams

BEHI and Sediment Export Estimates for Project Site Streams Project Number JCC/WOK/05 (Jacksonville Country Club)															
Time Point	Segment	Acreage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Ton/yr
Pre con	A (Reach AB)	99			na	40.7									na
	A (Reach BC)	253					na	29.6							na
	B	55					na	36.2							na
	C	79					na	38.1							na
	D	8					na	32.6							na
	E	12													

Table 6 BEHI/NBS and Sediment Transport for Reference Streams

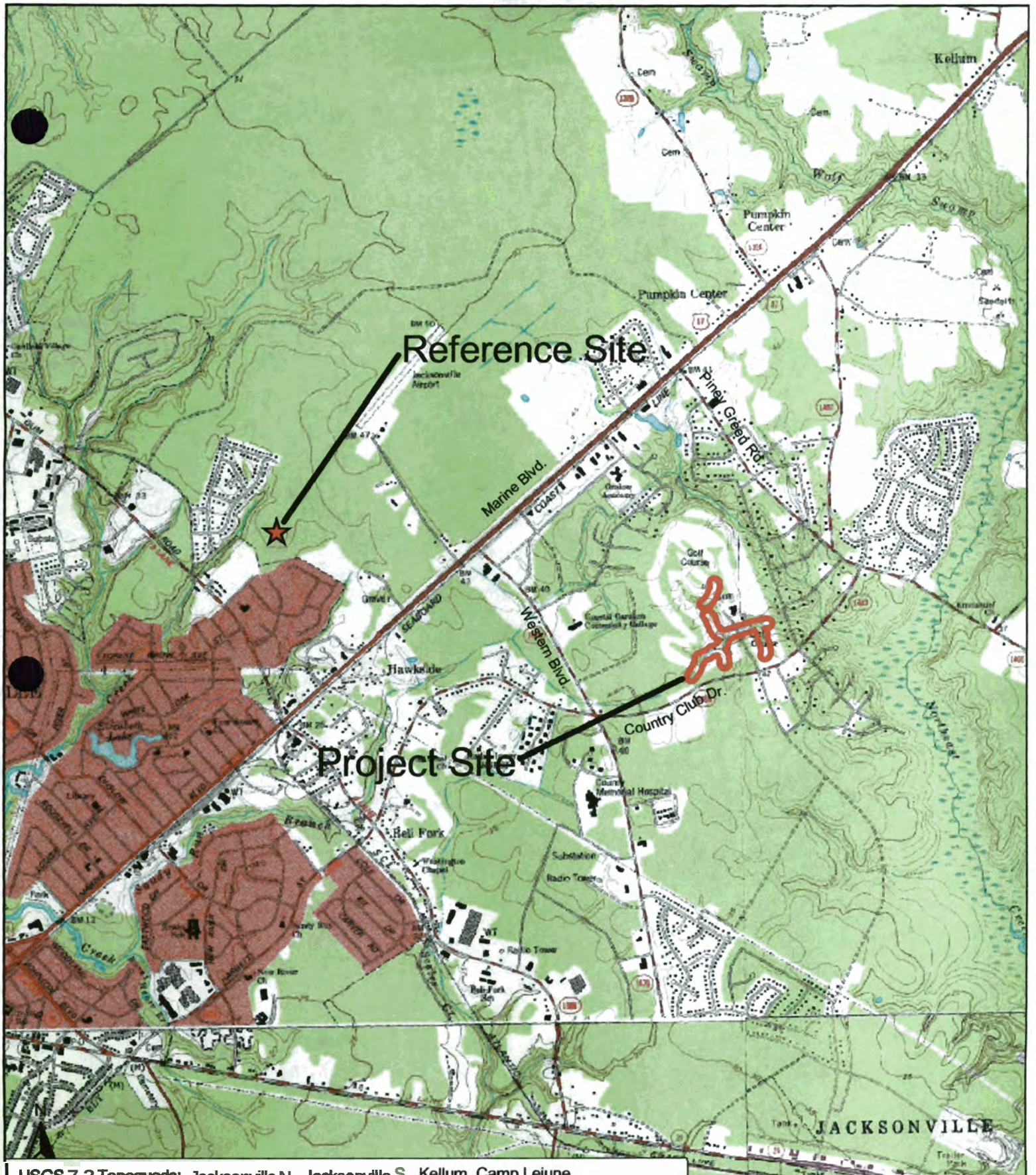
BEHI and Sediment Export Estimates for Reference Streams Project Number JCC/WOK/05 (Jacksonville Country Club)															
Time Point	Segment	Acreage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
			ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	Ton/yr
Apr '06		226							na	29.1					na

Table 7 Designed Vegetative Community (by zone)

Type	Zone	Scientific Name	Common Name
Potted	Buffer (smaller channels)		
Trees		*Fagus grandifolia*	Beech
		Quercus alba	White oak
		Quercus rubra	Red oak
		Cornus florida	Dogwood
		Ostrya virginiana	American Hophornbeam
		Ilex opaca	American holly
Shrubs		*Kalmia latiflora*	Lamb-Kill
		Carpinus caroliniana	Ironwood
		Callicarpa americana	American Beautyberry
		Clethra alnifolia	Summer Sweet Clethra
		Rhododendron atlanticum	Dwarf Azalea
		Vaccinium corymbosum	Highbush Blueberry
		Euonymus americanus	Strawberry Bush
		Ilex glabra	Inkberry
Wetland Seed Mix		*Aristida stricta*	Wiregrass
		Asclepia tuberosa	Butterfly Milkweed
		Aster spectabilis	Showy Aster
		Echinacea purpurea	Purple Coneflower
		Muhlenbergia capillari	Pink Hair Grass
		Kosteletskya virginica	Seashore Mallow
		Rudbeckia hirta	Blackeyed Susan
		Salvia azurea	Blue Sage
		Sorghastrum nutlans	Indian grass
		Verbena Canadensis	Clump Verbena
Potted	Buffer (large channels)		
Trees		*Quercus virginiana*	Live Oak
		Carya glabra	Pignut hickory
		Quercus nigra	Water Oak
		Osmanthus americana	Wild Olive
		Juniperus virginiana	Eastern Red Cedar
		Sassafras albidum	Sassafras
Shrubs		*Ilex vomitoria*	Youpon Holly
		Ilex glabra	Inkberry
		Morella cerifera	Wax Myrtle
		Hamamelis virginiana	Witchhazel
		Campsis radicans	Trumpet Creeper

Wetland Seed Mix		*Asclepia tuberosa*	Butterfly Milkweed
		Aster spectabilis	Showy Aster
		Echinacea purpurea	Purple Coneflower
		Muhlenbergia capillari	Pink Hair Grass
		Kosteletskya virginica	Seashore Mallow
		Rudbeckia hirta	Blackeyed Susan
		Salvia azurea	Blue Sage
		Sorghastrum nutlans	Indian grass
		Verbena Canadensis	Clump Verbena
Potted	Riparian area/flood plain		
Trees		*Quercus laurifolia*	Darlington Oak
		Betula nigra	River Birch
		Cyrilla racemiflora	Titi
Shrubs		*Leucothoe racemosa*	Sweet Bells
		Magnolia virginiana	Sweetbay
		Itea virginica	Swwetspire
		Morella cerifera	Wax Myrtle
		Lyonia lucida	Fetterbush
		Vaccinium elliottli	Highbush Blueberry
Wetland Seed Mix		*Eupatorium maculatum*	Joe Pye Weed
		Impatiens capensis	Touch-Me-Not
		Monarda didyma	Scarlet Bee-Balm
		Mondarda puncta	Coastal Bee-Balm
		Echinacea purpurea	Purple Coneflower
		Rudbeckia hirta	Blackeyed Susan
		Hibiscus moscheutos	Rose Mallow
		Phlox divaricata	Blue Phlox
		Schizachyrium Scoparium	Little Bluestem

10.0 FIGURES



USGS 7.3 Topoquads: Jacksonville N., Jacksonville S., Kellum, Camp Lejune

ure 1. Site Vicinity Map
cksonville *Country* Club Ecosystem Enhancement Project
Jacksonville, Onslow *County*, NC
BLWI PN: 040075 - EEP PN: JCC/WOK/05

Scale: 1" = 0.50 miles
April 24,2006

0 0.5 Miles

BLUE Land Infrastructure Infras

Ecosystem Enhancement

Figure 2. Project Site Watershed Map
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

300 0 300 600 900 1200 Feet

Scale: 1" = 500
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement Program

Figure 3. Project Site NRCS Soil Survey Map
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

250 0 250 500 750 1000 Feet

Scale: 1" = 500
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement

Figure 4. Project Site Hydrological Features Map with Gauge Locations
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

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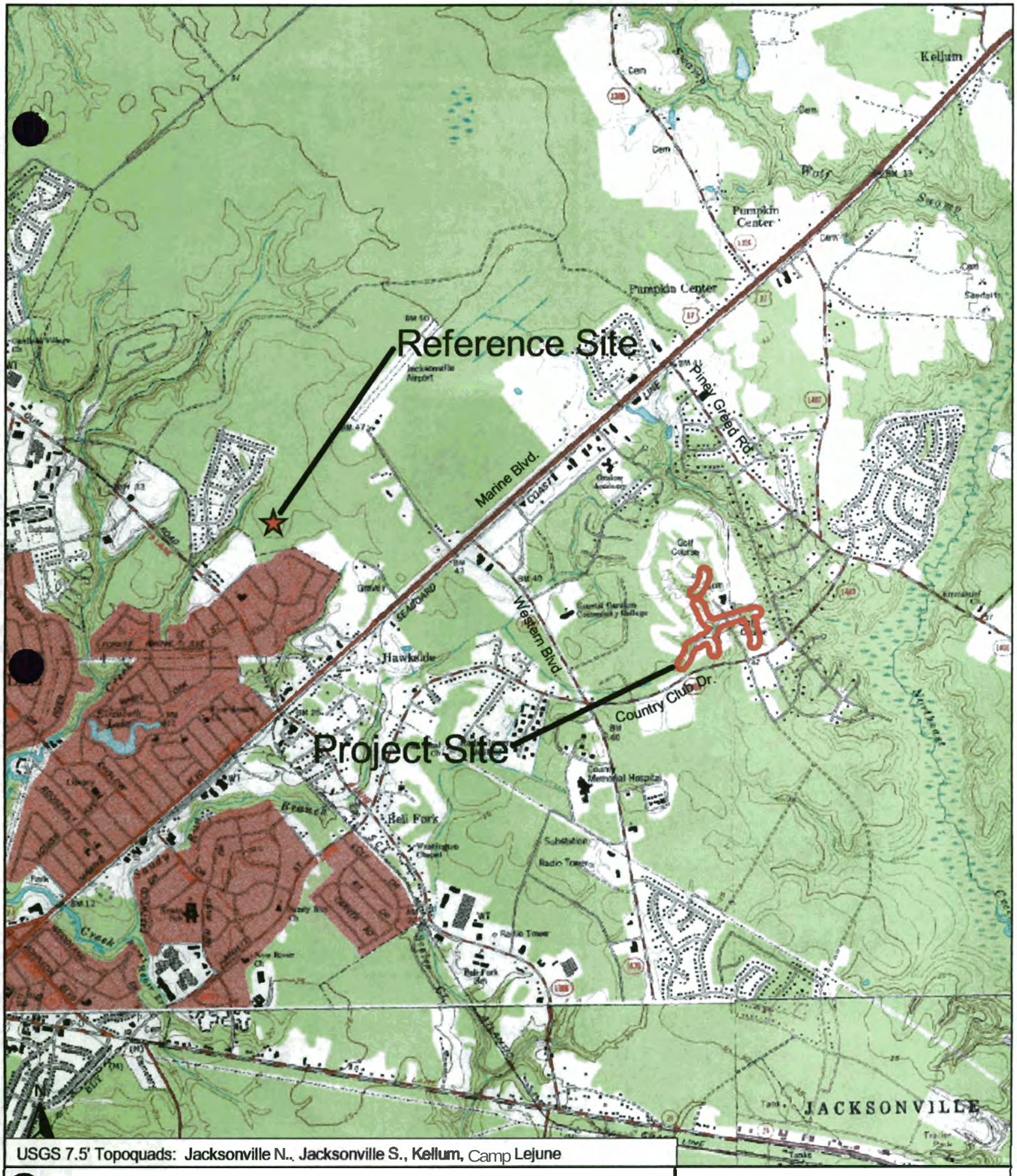
Scale: 1" = 600
April 24, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement



USGS 7.5' Topoquads: Jacksonville N., Jacksonville S., Kellum, Camp Lejune

ure 5. Reference Site **Vicinity** Map
cksonville Country Club **Ecosystem** Enhancement **Project**
Jacksonville, Onslow County, NC
BLWI PN: 040075 - EEP PN: JCC/WOK/05

Scale: 1" = 0.50 miles
April 24,2006

0.5 0 0. 0.5 **Miles**

BLUE Land Infrastructure Infras

Ecosystem Enhancement

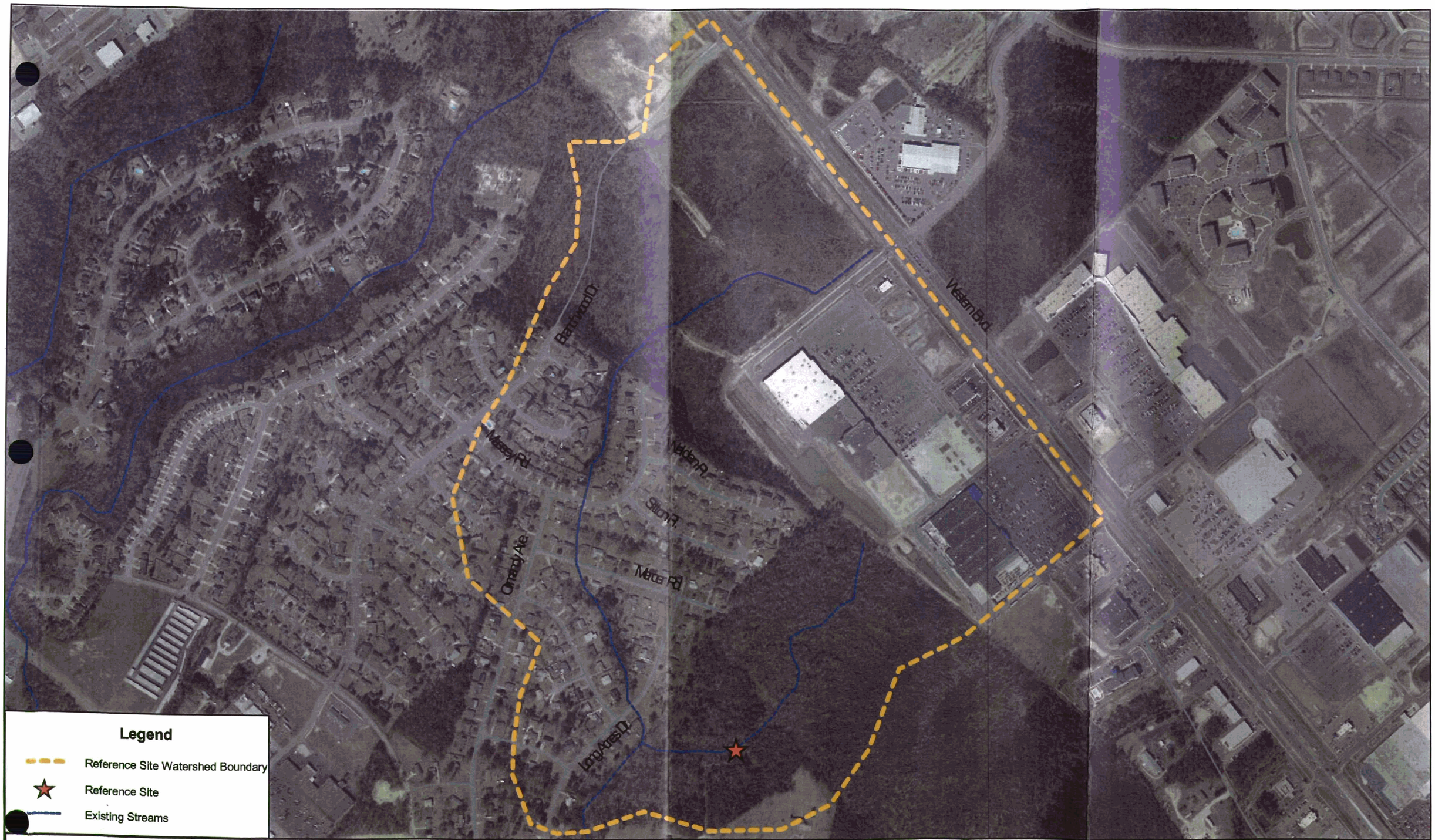


Figure 6. Reference Site Watershed Map
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

250 0 250 500 750 1000 Feet

Scale: 1" = 500
April 24, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement

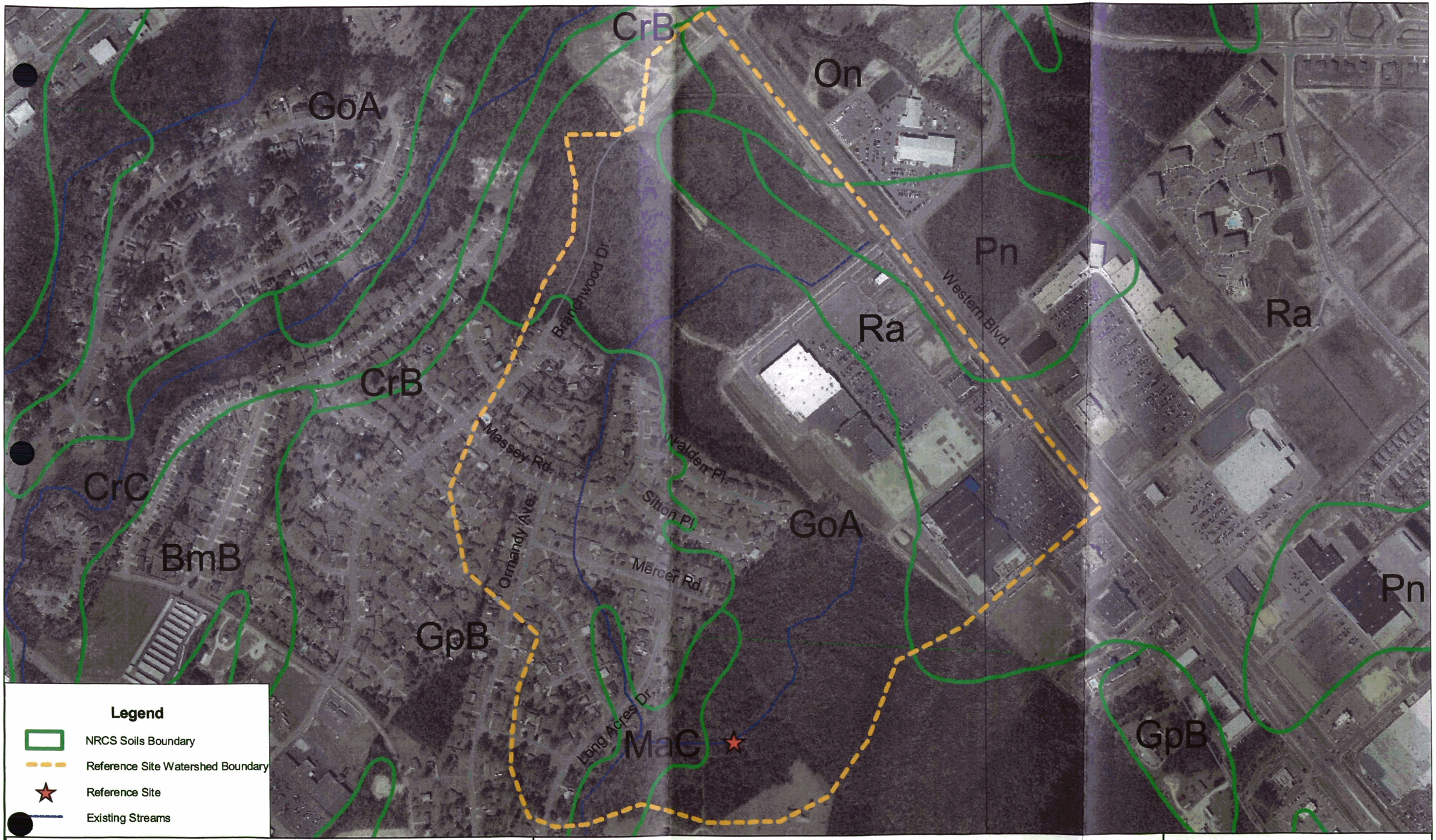
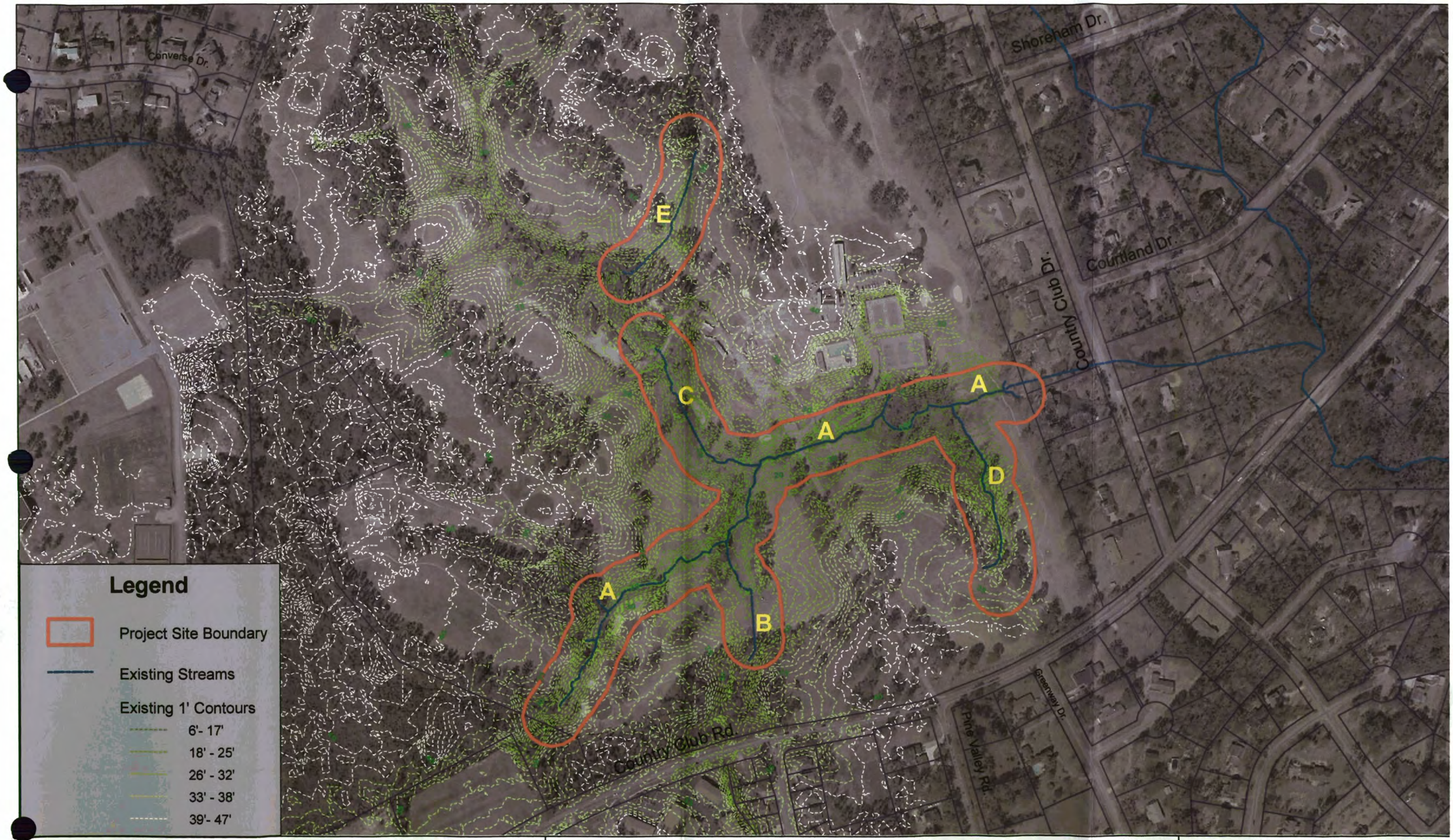


Figure 7. Reference Site NRCS Soil Survey Map
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

11.0 DESIGNED SHEETS



Design Sheet 1. Existing Site Conditions
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

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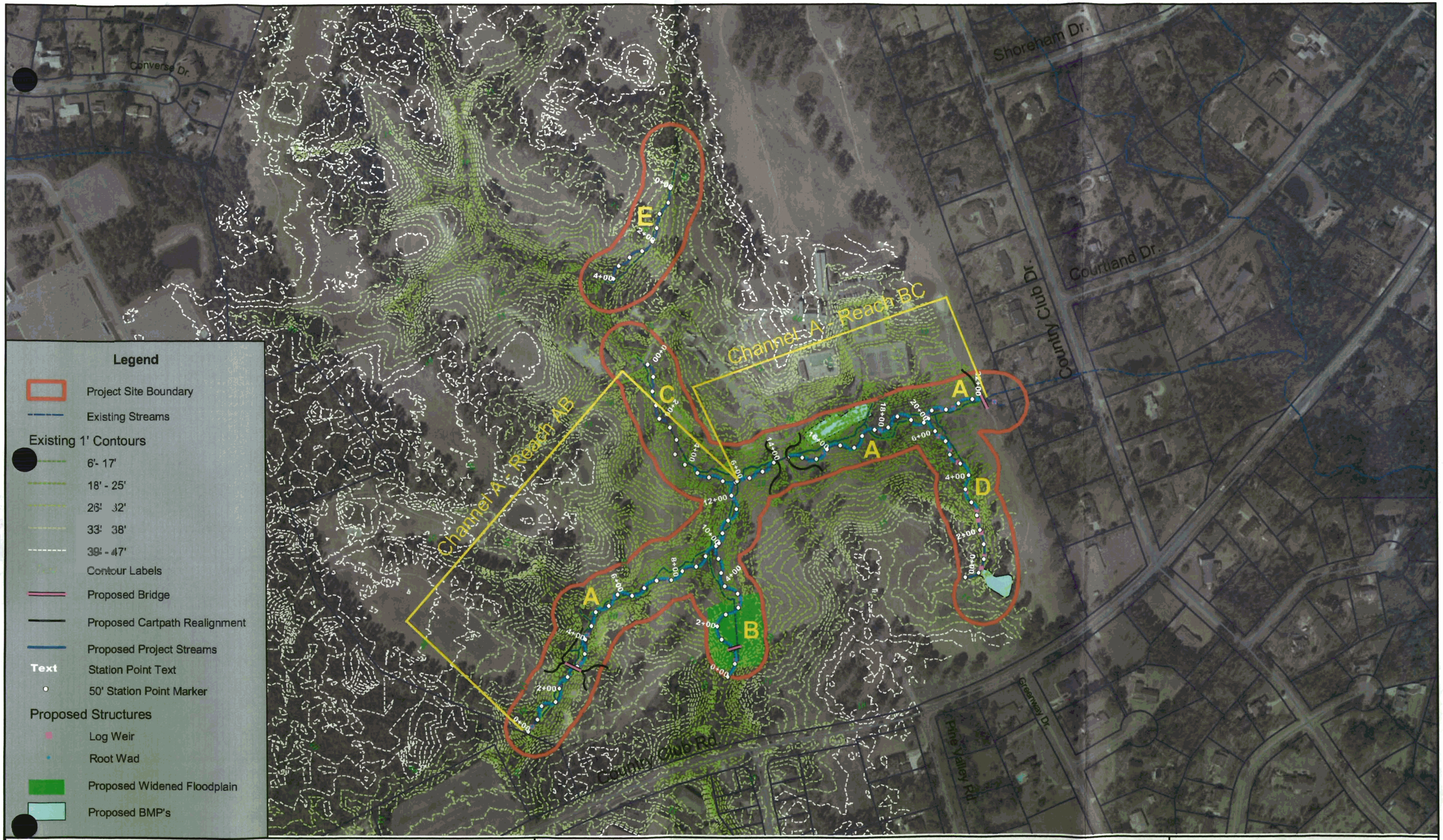
Scale: 1" = 300
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement



Design Sheet 2a. Designed Channel Alignment and Structures
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

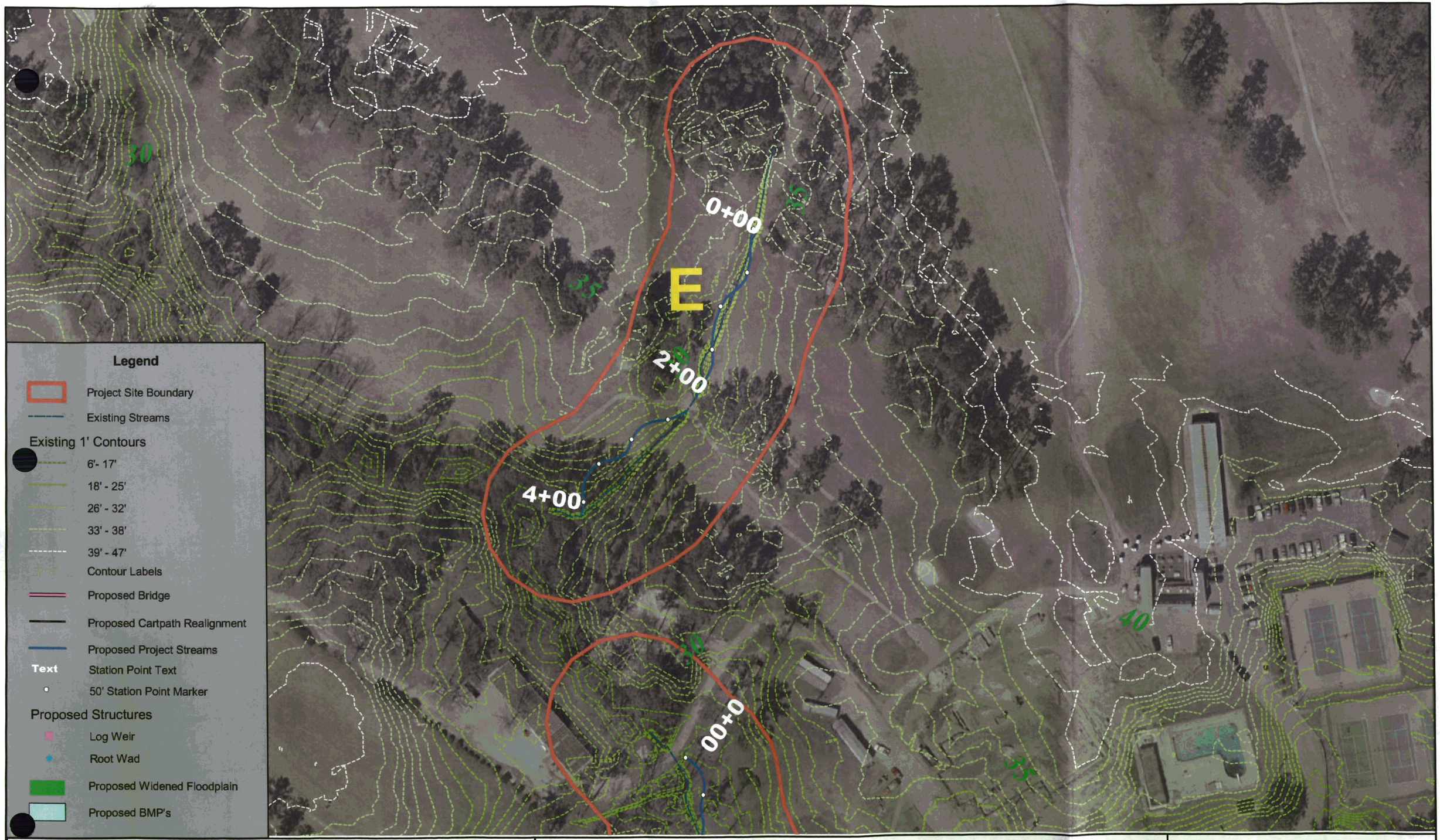
300 0 300 600 Feet

Scale: 1" = 300
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement



Design Sheet 2b. Designed Channel Alignment and Structures
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

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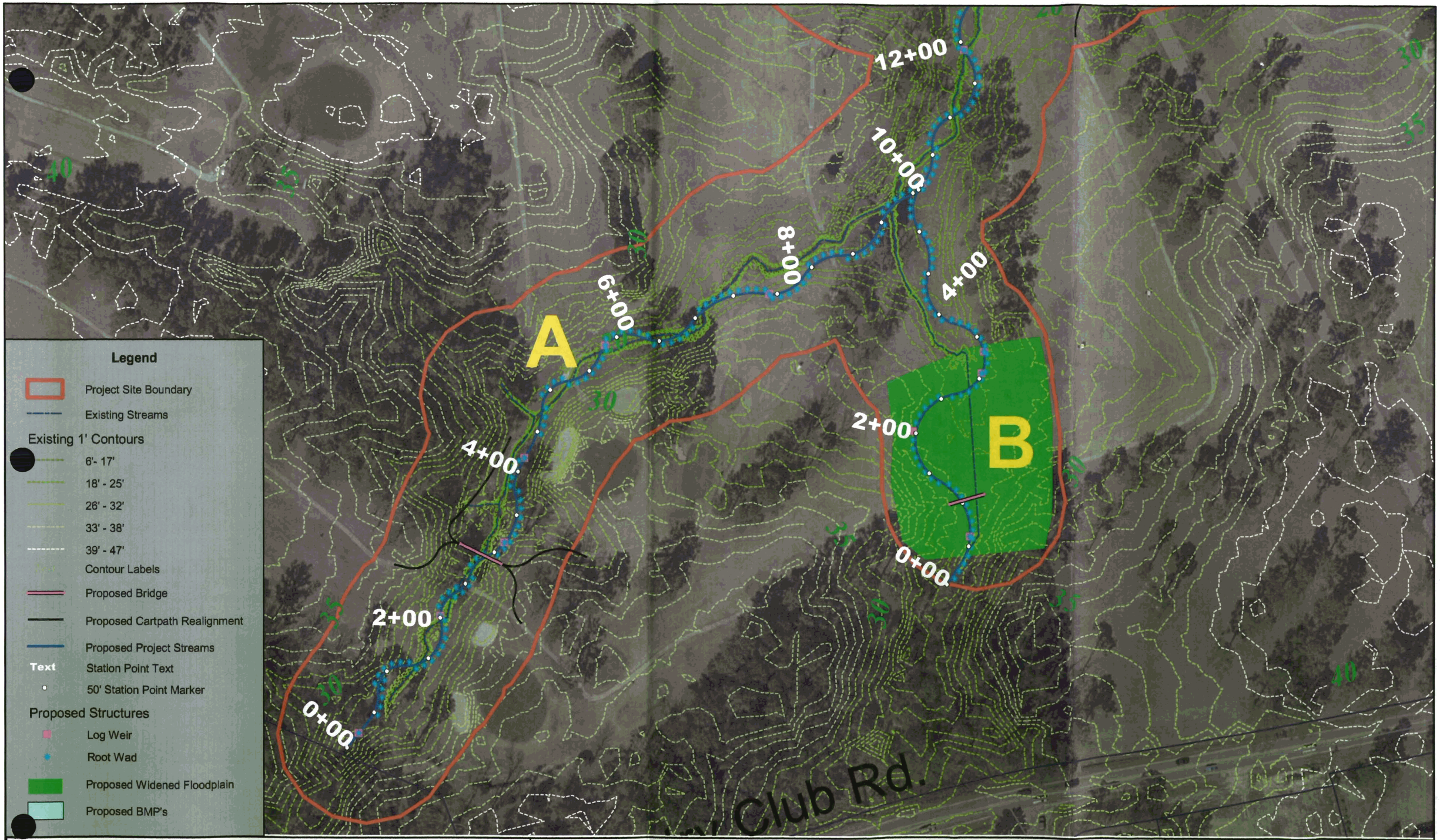
Scale: 1" = 100
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement Program



Design Sheet 2c. Designed Channel Alignment and Structures
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

50 0 50 100 150 200 250 300 Feet

Scale: 1" = 100
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement

Design Sheet 2d. Designed Channel Alignment and Structures
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

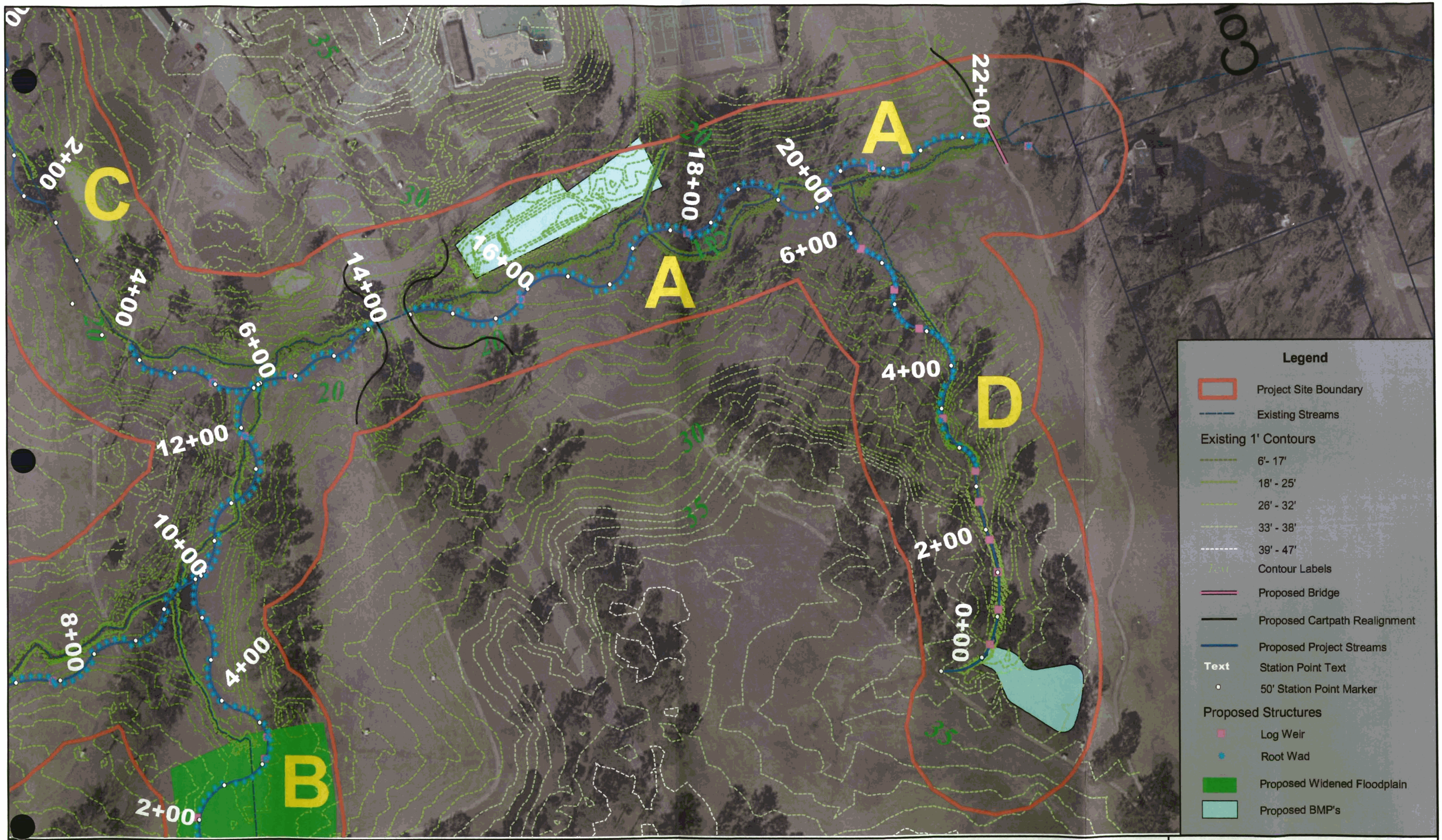
50 0 50 100 150 200 250 300 Feet

Scale: 1" = 100
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement



Design Sheet 2e. Designed Channel Alignment and Structures
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

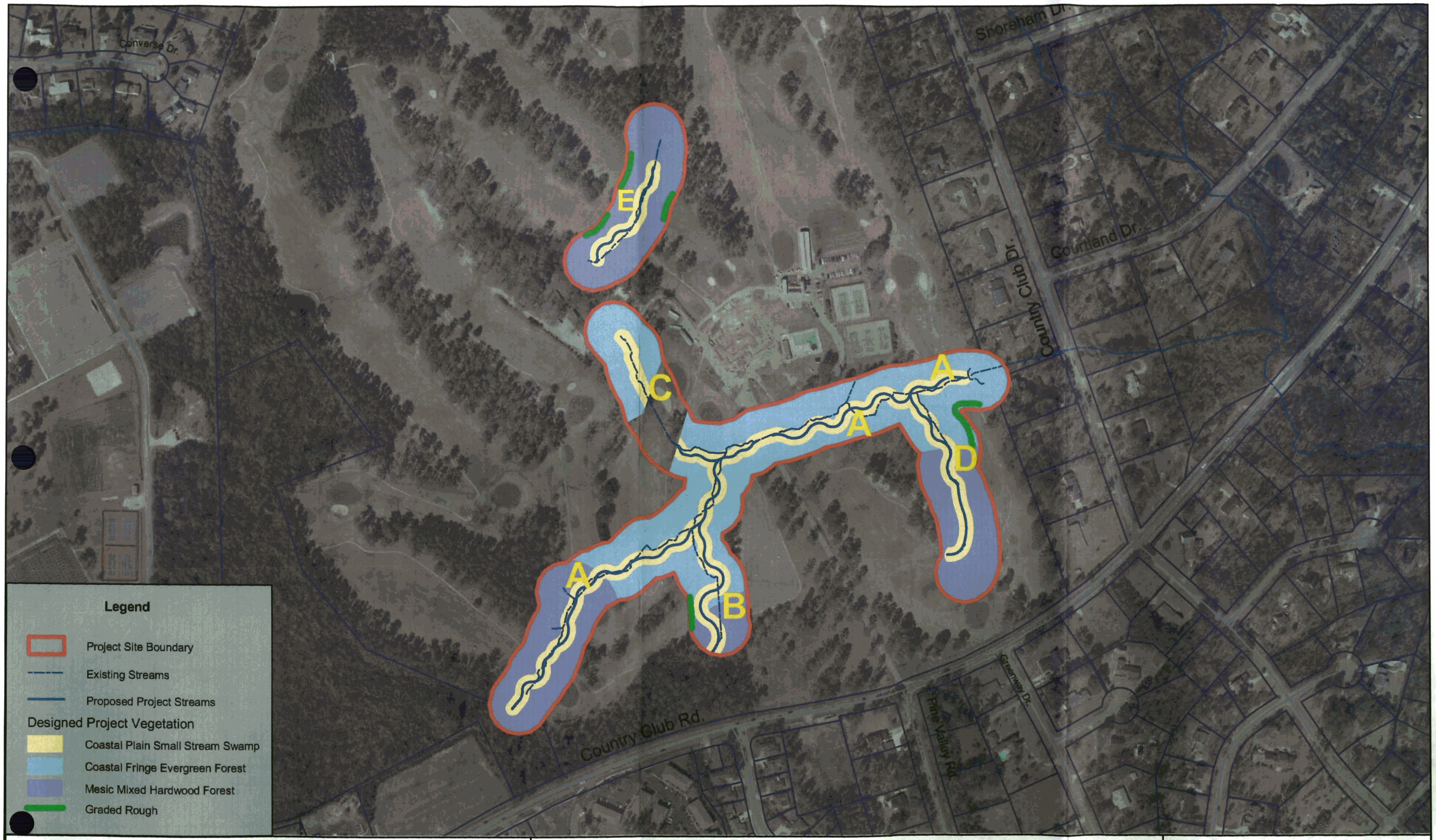
50 0 50 100 150 200 250 300 Feet

Scale: 1" = 100
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement Program



Design Sheet 3. Designed Vegetative Communities Map
Jacksonville Country Club Ecosystem Enhancement Project
Jacksonville, Onslow County, NC

N

Source: Onslow County, NC Aerial Photography from March 2001

300 0 300 600 Feet

Scale: 1" = 300
June 14, 2006

BLWI Project Number: 040075
EEP Project Number: JCC/WOK/05

BLUE Land Water Infrastructure

Ecosystem Enhancement

12.0 APPENDICES

Appendix 1

Project Site Photos

Channel A upper segment

Channel A at Channel B confluence

Channel A entrance road crossing/culverts

Channel A near end of project

Channel B

Channel C

Channel D

Channel E

Stonnwater retrofit

Channel A (note foot bridges)

Channel A after rain event (note foot bridges)

Appendix 2

USACE Stream Quality Assessment Worksheets

USACE AID#_____ DWQ #_____ Site # 1 (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: EEP
2. Evaluator's name: Lory L. Hubb.
3. Date of evaluation: 24 May 06
4. Time of evaluation: 12:04
5. Name of stream: UT to NE Creek
6. River basin: White Oak
7. Approximate drainage area: 253 Ac
8. Stream order: 2
9. Length of reach evaluated: 1947'
10. County: Onslow
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): Jacksonville C C

Latitude (ex. 34.872312): 34.46.295 Longitude (ex. -77.556611): -77.22.537

Method location determined (circle): (GPS) Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other_____

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location):
Jacksonville Country Club

14. Proposed channel work (if any): dimension, pattern and profile

15. Recent weather conditions: clear - sunny 70-85°

16. Site conditions at time of visit: sunny 85°

17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ✓ Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)

18. Is there a pond or lake located upstream of the evaluation point? YES (NO) If yes, estimate the water surface area:_____

19. Does channel appear on USGS quad map? (YES) NO

20. Does channel appear on USDA Soil Survey? (YES) NO

21. Estimated watershed land use: 19% Residential ___% Commercial ___% Industrial 57 % ~~Agricultural~~ Golf Course 22% Forested ___% Cleared / Logged 2 % Other (_____)

22. Bankfull width: 50"

23. Bank height (from bed to top of bank): 64"

24. Channel slope down center of stream: ✓ Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)

25. Channel sinuosity: ___Straight ✓ Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 18 **Comments:**_____

Evaluator's Signature Lory L Hubb **Date** 24 May 06

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	5
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	0
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	0
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	0
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	0
STABILITY	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	1
	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	0
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	0
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	2
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	2
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	1
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	1
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	2
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	2
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	0
Total Points Possible			100	100	100	18
TOTAL SCORE (also enter on first page)						

* These characteristics are not assessed in coastal streams.

USACE AID#_____ DWQ #_____ Site # B (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: EEP
2. Evaluator's name: Larry L. Hubbs
3. Date of evaluation: 24 May 06
4. Time of evaluation: 11:59
5. Name of stream: UT to NE Creek
6. River basin: White Oak
7. Approximate drainage area: 55 ac
8. Stream order: 1
9. Length of reach evaluated: 272'
10. County: Onslow
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): Jacksonville Cc

Latitude (ex. 34.872312): 34.46.275 Longitude (ex. -77.556611): -77.22.543

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other_____

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location): Jacksonville Country Club

14. Proposed channel work (if any): dimension, pattern, profile, daylighting

15. Recent weather conditions: clear sunny 70's 80's

16. Site conditions at time of visit: sunny 80's

17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ✓ Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)

18. Is there a pond or lake located upstream of the evaluation point? YES (NO) If yes, estimate the water surface area:_____

19. Does channel appear on USGS quad map? (YES) NO

20. Does channel appear on USDA Soil Survey? (YES) NO

21. Estimated watershed land use: 19 % Residential ___% Commercial ___% Industrial 57 % ~~Agricultural~~ golf course 22 % Forested ___% Cleared / Logged 2 % Other (_____)

22. Bankfull width: 42"

23. Bank height (from bed to top of bank): 45"

24. Channel slope down center of stream: ✓ Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)

25. Channel sinuosity: ___Straight ✓ Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 12 **Comments:**_____

Evaluator's Signature Larry L. Hubbs **Date** 24 May 06

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	5
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	1
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	0
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	0
STABILITY	11	**Size & diversity of channel bed substrate** (fine, homogeneous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	0
	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	0
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	0
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	1
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	0
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	1
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	1
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	1
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	0
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				12

* These characteristics are not assessed in coastal streams.

USACE AID#_____ DWQ #_____ Site #_C_ (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: EEP
2. Evaluator's name: Lecy L. Hobbs
3. Date of evaluation: 24 May 06
4. Time of evaluation: 11:49
5. Name of stream: UT to NE ch
6. River basin: White Oak
7. Approximate drainage area: 79 ac
8. Stream order: 1
9. Length of reach evaluated: 379'
10. County: Onslow
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): Jacksonville, CC

Latitude (ex. 34.872312): 34.46.741 Longitude (ex. -77.556611): -77.22.549

Method location determined (circle): (GPS) Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other_____

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location):
Jacksonville Country Club

14. Proposed channel work (if any): diamond - y: Acc profile

15. Recent weather conditions: clear, sunny 70-85°

16. Site conditions at time of visit: sunny 85°

17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ✓ Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)

18. Is there a pond or lake located upstream of the evaluation point? YES (NO) If yes, estimate the water surface area:_____

19. Does channel appear on USGS quad map? (YES) NO

20. Does channel appear on USDA Soil Survey? (YES) NO

21. Estimated watershed land use: 19% Residential ___% Commercial ___% Industrial 57% ~~Agricultural~~ Golf Course
22% Forested ___% Cleared / Logged 2% Other (_____)

22. Bankfull width: 31"

23. Bank height (from bed to top of bank): 31"

24. Channel slope down center of stream: ✓ Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)

25. Channel sinuosity: ___Straight ___Occasional bends ✓ Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 16 **Comments:**_____

Evaluator's Signature_____ **Date**_____

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STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	4
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	0
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	2
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	1
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	1
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	2
STABILITY	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	1
	11	**Size & diversity of channel bed substrate** (fine, homogenous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	1
	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	0
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	1
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture, livestock, or timber production** (substantial impact = 0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	1
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	0
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	1
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	1
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	1
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	0
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				16

* These characteristics are not assessed in coastal streams.

USACE AID#_____ DWQ #_____ Site # D (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: EEP
2. Evaluator's name: Larry L. Hubbs
3. Date of evaluation: 24 May 06
4. Time of evaluation: 12:15
5. Name of stream: UT to NE Creek
6. River basin: White Oak
7. Approximate drainage area: < 1 sq
8. Stream order: 1 - intermittent
9. Length of reach evaluated: 637'
10. County: Onslow
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): Jacksonville CC

Latitude (ex. 34.872312): 34.46.329 Longitude (ex. -77.556611): -77.22.509

Method location determined (circle): (GPS) Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location):
Jacksonville Country Club

14. Proposed channel work (if any): dimension, pattern, profile
15. Recent weather conditions: clear, sunny 70-85
16. Site conditions at time of visit: sunny 85

17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ✓ Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)

18. Is there a pond or lake located upstream of the evaluation point? YES (NO) If yes, estimate the water surface area:

19. Does channel appear on USGS quad map? YES (NO) 20. Does channel appear on USDA Soil Survey? YES (NO)

21. Estimated watershed land use: 19% Residential ___% Commercial ___% Industrial 57% ~~Agricultural~~ golf course
22% Forested ___% Cleared / Logged 2% Other (_____)

22. Bankfull width: 47" 23. Bank height (from bed to top of bank): 54"

24. Channel slope down center of stream: ✓ Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)

25. Channel sinuosity: ✓ Straight ___Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 14 **Comments:**

Evaluator's Signature Larry L Hubbs **Date** 24 May 06

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE			SCORE
			Coastal	Piedmont	Mountain	
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 – 5	0 – 4	0 – 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 – 6	0 – 5	0 – 5	0
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 – 6	0 – 4	0 – 5	2
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 – 5	0 – 4	0 – 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 – 3	0 – 4	0 – 4	0
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 – 4	0 – 4	0 – 2	0
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 – 5	0 – 4	0 – 2	0
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 – 6	0 – 4	0 – 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 – 5	0 – 4	0 – 3	1
STABILITY	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 – 5	0 – 4	0 – 4	0
	11	**Size & diversity of channel bed substrate** (fine, homogeneous = 0; large, diverse sizes = max points)	NA*	0 – 4	0 – 5	1
	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 – 5	0 – 4	0 – 5	0
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 – 5	0 – 5	0 – 5	0
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 – 3	0 – 4	0 – 5	1
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 – 5	0 – 4	0 – 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 – 3	0 – 5	0 – 6	1
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 – 6	0 – 6	0 – 6	1
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 – 5	0 – 5	0 – 5	2
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 – 4	0 – 4	1
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 5	0 – 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	1
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 – 4	0 – 4	0 – 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 – 6	0 – 5	0 – 5	2
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				19

* These characteristics are not assessed in coastal streams.

USACE AID#_____ DWQ #_____ Site # E (indicate on attached map)

STREAM QUALITY ASSESSMENT WORKSHEET

Provide the following information for the stream reach under assessment:

1. Applicant's name: EEP
2. Evaluator's name: Larry L. Hobbs
3. Date of evaluation: 24 May 06
4. Time of evaluation: 11:30
5. Name of stream: UT to NE CK
6. River basin: White Oak
7. Approximate drainage area: 12 ac
8. Stream order: 1
9. Length of reach evaluated: 373'
10. County: Onslow
11. Site coordinates (if known): prefer in decimal degrees.
12. Subdivision name (if any): Jacksonville CC

Latitude (ex. 34.872312): 34.46.461 Longitude (ex. -77.556611): -77.22.598

Method location determined (circle): GPS Topo Sheet Ortho (Aerial) Photo/GIS Other GIS Other

13. Location of reach under evaluation (note nearby roads and landmarks and attach map identifying stream(s) location):
Jacksonville Country Club

14. Proposed channel work (if any): pattern, pro file
15. Recent weather conditions: clear, sunny 70-85°
16. Site conditions at time of visit: sunny - 85°
17. Identify any special waterway classifications known: ___Section 10 ___Tidal Waters ___Essential Fisheries Habitat ___Trout Waters ___Outstanding Resource Waters ___Nutrient Sensitive Waters ___Water Supply Watershed ___(I-IV)
18. Is there a pond or lake located upstream of the evaluation point? YES (NO) If yes, estimate the water surface area:
19. Does channel appear on USGS quad map? (YES) NO
20. Does channel appear on USDA Soil Survey? (YES) NO
21. Estimated watershed land use: 19% Residential ___% Commercial ___% Industrial 57% ~~Agricultural~~ golf course 22% Forested ___% Cleared / Logged 2% Other (_____)
22. Bankfull width: 17"
23. Bank height (from bed to top of bank): 45"
24. Channel slope down center of stream: ✓ Flat (0 to 2%) ___Gentle (2 to 4%) ___Moderate (4 to 10%) ___Steep (>10%)
25. Channel sinuosity: ___Straight ✓ Occasional bends ___Frequent meander ___Very sinuous ___Braided channel

Instructions for completion of worksheet (located on page 2): Begin by determining the most appropriate ecoregion based on location, terrain, vegetation, stream classification, etc. Every characteristic must be scored using the same ecoregion. Assign points to each characteristic within the range shown for the ecoregion. Page 3 provides a brief description of how to review the characteristics identified in the worksheet. Scores should reflect an overall assessment of the stream reach under evaluation. If a characteristic cannot be evaluated due to site or weather conditions, enter 0 in the scoring box and provide an explanation in the comment section. Where there are obvious changes in the character of a stream under review (e.g., the stream flows from a pasture into a forest), the stream may be divided into smaller reaches that display more continuity, and a separate form used to evaluate each reach. The total score assigned to a stream reach must range between 0 and 100, with a score of 100 representing a stream of the highest quality.

Total Score (from reverse): 14 **Comments:**

Evaluator's Signature_____ **Date**_____

This channel evaluation form is intended to be used only as a guide to assist landowners and environmental professionals in gathering the data required by the United States Army Corps of Engineers to make a preliminary assessment of stream quality. The total score resulting from the completion of this form is subject to USACE approval and does not imply a particular mitigation ratio or requirement. Form subject to change – version 06/03. To Comment, please call 919-876-8441 x 26.

STREAM QUALITY ASSESSMENT WORKSHEET

	#	CHARACTERISTICS	ECOREGION POINT RANGE Coastal	Piedmont	Mountain	SCORE
PHYSICAL	1	**Presence of flow / persistent pools in stream** (no flow or saturation = 0; strong flow = max points)	0 - 5	0 - 4	0 - 5	3
	2	**Evidence of past human alteration** (extensive alteration = 0; no alteration = max points)	0 - 6	0 - 5	0 - 5	1
	3	**Riparian zone** (no buffer = 0; contiguous, wide buffer = max points)	0 - 6	0 - 4	0 - 5	0
	4	**Evidence of nutrient or chemical discharges** (extensive discharges = 0; no discharges = max points)	0 - 5	0 - 4	0 - 4	0
	5	**Groundwater discharge** (no discharge = 0; springs, seeps, wetlands, etc. = max points)	0 - 3	0 - 4	0 - 4	0
	6	**Presence of adjacent floodplain** (no floodplain = 0; extensive floodplain = max points)	0 - 4	0 - 4	0 - 2	0
	7	**Entrenchment / floodplain access** (deeply entrenched = 0; frequent flooding = max points)	0 - 5	0 - 4	0 - 2	1
	8	**Presence of adjacent wetlands** (no wetlands = 0; large adjacent wetlands = max points)	0 - 6	0 - 4	0 - 2	0
	9	**Channel sinuosity** (extensive channelization = 0; natural meander = max points)	0 - 5	0 - 4	0 - 3	1
STABILITY	10	**Sediment input** (extensive deposition= 0; little or no sediment = max points)	0 - 5	0 - 4	0 - 4	3
	11	**Size & diversity of channel bed substrate** (fine, homogeneous = 0; large, diverse sizes = max points)	NA*	0 - 4	0 - 5	1
	12	**Evidence of channel incision or widening** (deeply incised = 0; stable bed & banks = max points)	0 - 5	0 - 4	0 - 5	1
	13	**Presence of major bank failures** (severe erosion = 0; no erosion, stable banks = max points)	0 - 5	0 - 5	0 - 5	2
	14	**Root depth and density on banks** (no visible roots = 0; dense roots throughout = max points)	0 - 3	0 - 4	0 - 5	1
	15	**Impact by agriculture, livestock, or timber production** (substantial impact =0; no evidence = max points)	0 - 5	0 - 4	0 - 5	0
HABITAT	16	**Presence of riffle-pool/ripple-pool complexes** (no riffles/ripples or pools = 0; well-developed = max points)	0 - 3	0 - 5	0 - 6	0
	17	**Habitat complexity** (little or no habitat = 0; frequent, varied habitats = max points)	0 - 6	0 - 6	0 - 6	0
	18	**Canopy coverage over streambed** (no shading vegetation = 0; continuous canopy = max points)	0 - 5	0 - 5	0 - 5	0
	19	**Substrate embeddedness** (deeply embedded = 0; loose structure = max)	NA*	0 - 4	0 - 4	1
BIOLOGY	20	**Presence of stream invertebrates** (see page 4) (no evidence = 0; common, numerous types = max points)	0 - 4	0 - 5	0 - 5	0
	21	**Presence of amphibians** (no evidence = 0; common, numerous types = max points)	0 - 4	0 - 4	0 - 4	1
	22	**Presence of fish** (no evidence = 0; common, numerous types = max points)	0 - 4	0 - 4	0 - 4	0
	23	**Evidence of wildlife use** (no evidence = 0; abundant evidence = max points)	0 - 6	0 - 5	0 - 5	0
		Total Points Possible	100	100	100	
		TOTAL SCORE (also enter on first page)				14

* These characteristics are not assessed in coastal streams.

Appendix 3

Reference Site Photos

Reference site at beginning of reach

Reference site at end of reach

Appendix 4

Approved Concept Plan

Jacksonville Country Club

Ecosystem Enhancement Project

City of Jacksonville, County of Onslow
North Carolina

Concept Plan

2005.04.27
Revised 2005.10.19

EEP = crossing EEP will pay for
stays = crossing to remain

100 0 100 200 Feet

Graded Rough

Primarily Grade Controls and Buffering with possible Minor Realignment, Work will not Extend into the Existing Fairways

C2

Proposed Staging Area

Buffering Along Entire Reach

Realignment and Buffering Along Entire Reach to Remain outside of Fairways

Retrofitted Stormwater BMP

Graded Rough

Cartway Realignment

A

Beginning of Stream Work

C1

Minor Stream Realignment

Cartway Realignment

Grade Controls and Buffering from here to Channel Head

D

Additional Culvert Installation

New Wooden Bridge

EEP

Realignment and Buffering Along Entire Reach

A

Realignment and Buffering Along Entire Reach

Stormwater BMP

Channel Daylighting

B

Stormwater BMP

EEP

Cartway Realignment

New Wooden Bridge

New Wooden Bridge

EEP

Cartway Realignment

Proposed Staging Area

Proposed Access Road

Ecosystem Enhancement PROGRAM

BLUE Land Water Infrastructure