# <u>DETAILED RESTORATION PLAN</u>
# GATLIN SWAMP WETLAND RESTORATION SITE
## MARTIN COUNTY, NORTH CAROLINA

**(RFP #16-D05024)**
**FULL DELIVERY PROJECT**
**TO PROVIDE NON RIVERINE WETLAND RESTORATION**
**IN THE ROANOKE RIVER BASIN**
**CATALOGING UNIT 03010107**

**Prepared for:**

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## EXECUTIVE SUMMARY

Restoration Systems, L.L.C. (Restoration Systems) is currently developing wetland restoration sites in the Coastal Plain region of the Roanoke River basin. As part of this effort, Restoration Systems has completed detailed restoration plans involving approximately 150 acres of interstream flat, nonriverine wetlands at the Gatlin Swamp Wetland Restoration Site (Site) located approximately 1.5 miles southwest of Oak City, in Martin County.

The Site is located within sub-basin 03-02-09 of the Roanoke River Basin. This area is part of USGS Hydrologic Unit 03010107 of the South Atlantic/Gulf Region (14 digit hydrologic unit 03010107120020). Site features drain to Etheridge Swamp and Conoho Creek, which is a major tributary to the Roanoke River.

The Site has been cleared, ditched, and drained with wetlands effectively eliminated. The drainage ditch system was installed to facilitate agricultural production and to convey drainage from the precipitation flat into Etheridge Swamp. Additional impacts to former wetland surfaces include leveling and compaction designed to further facilitate agricultural production.

This document details wetland restoration procedures at the Site. A 150-acre conservation easement has been conveyed to the State that will incorporate all planned restoration activities. The Site encompasses approximately 125 acres of drained, hydric soil that may be suitable for wetland restoration. An additional 25 acres of non-hydric soil are interspersed throughout the Site and will provide an important mosaic of upland habitat within the interstream flat.

Wetland restoration activities have been designed to restore wetland features and functions similar to those exhibited by reference wetlands in the region. Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology include depression construction, impervious ditch plug construction, ditch backfilling, and harrowing/scarification of wetland soil surfaces. Subsequently, tree and shrub planting will occur throughout the Site to facilitate establishment of diagnostic natural communities, including Mesic Pine Flatwoods and Wet Pine Flatwoods. Ecotonal changes between community types will be encouraged to provide diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife.

After implementation, the Site is expected to support 125 acres of restored nonriverine forested wetlands and 25 acres of nonriverine upland pine flats. Monitoring of Site restoration efforts will be performed until success criteria are fulfilled. Monitoring is proposed for wetland components of hydrology and vegetation.

# Table of Contents

## List of Figures



## List of Tables

# DETAILED RESTORATION PLAN
# GATLIN SWAMP WETLAND RESTORATION SITE
# MARTIN COUNTY, NORTH CAROLINA

## 1.0 INTRODUCTION

Restoration Systems, L.L.C. (Restoration Systems) is currently evaluating wetland restoration potential involving interstream flat, nonriverine wetlands at the Gatlin Swamp Wetland Restoration Site (Site) located approximately 1.5 miles southwest of Oak City, in Martin County (Figure 1, Appendix A).

The location of the Site within the Roanoke River Basin Cataloging Unit (CU) 03010107 is depicted in Figure 2 (Appendix A). The boundary between the 8-digit CUs 03010107 and 03020103 is currently shown to divide the Site (USGS 1974); however, the majority of the Site flows into an unnamed tributary to Etheridge Swamp which is depicted as a stream on the United States Geological Survey (USGS) Oak City, North Carolina, 7.5-minute topographic quadrangle (Figure 3, Appendix A). Therefore, water storage and wildlife habitat functions resulting from restoration will accrue in CU 03010107. The Site encompasses approximately 150 acres of land that is currently utilized for row crop production.

The Site is situated in an expansive interstream flat characterized primarily by timber production and agriculture (Figure 4, Appendix A). Site drainage flows to an unnamed tributary to Etheridge Swamp. Drainage to the unnamed tributary occurs directly through perimeter ditches along the northern edge of the Site, or through a complex network of roadside and/or timber stand ditches. The unnamed tributary drains for approximately 2 miles prior to converging with Etheridge Swamp, a third-order stream draining to the larger Conoho Creek.

The entire Site has been cleared of native forest vegetation, ditched for agricultural purposes, and planted in agricultural row crops (Figure 5, Appendix A). Based on preliminary estimates, it appears that approximately 125 acres of hydric soil have been cleared and drained in support of row crop production at the Site. Restoration activities outlined in this detailed plan are expected to restore jurisdictional wetland to 125 acres of drained hydric soil.

Due to its position in the landscape, the Site provides important headwater storage benefits to Etheridge Swamp and other downstream aquatic systems. The dominant presence of hydric soils, an extensive ditch network, and a vegetation structure/composition modified from relatively undisturbed conditions highlight the potential for an exceptional wetland restoration opportunity at the Site

### 1.1 Project Goals

The purpose of this study is to establish a detailed restoration plan for wetland restoration alternatives. The following objectives are proposed to provide mitigation credit requested under the North Carolina Ecosystem Enhancement Program (EEP) solicitation (Request For Proposal [RFP] #16-D05024 dated October 22, 2004):

- Provide 125 acres of nonriverine Wetland Mitigation Units, as calculated in accordance with the requirements stipulated in RFP #16-D05024.
- Restore approximately 125 acres of wetland through filling agricultural ditches, removal of spoil castings, eliminating row crop production activities, and/or planting with native forest vegetation.
- Protect the Site in perpetuity with a conservation easement which is held by the State of North Carolina.

The primary goals of this nonriverine wetland restoration project focus on improving water quality, enhancing flood attenuation, and restoring wildlife habitat and will be accomplished by:

1. Removing non-point sources of pollution associated with agricultural row crop production including a) cessation of broadcasting fertilization, pesticides, and agricultural materials into and adjacent to Site drainage ditches and b) providing a vegetative buffer adjacent to headwater streams and wetlands to treat agricultural runoff which may be laden with sediment and/or agricultural pollutants.
2. Restoration of wetland hydroperiods that satisfy wetland jurisdictional requirements and approximate the Site's natural range of variation.
3. Promoting floodwater attenuation through removal of inter-field ditches and enhancing groundwater storage capacity.
4. Restoration and re-establishment of natural community structure, habitat diversity, and functional continuity.
5. Protection of the Site's full potential of wetland functions and values in perpetuity.

This document represents a detailed restoration plan summarizing activities proposed within the Site. The plan includes 1) descriptions of existing conditions, 2) groundwater model applications, 3) reference studies, 4) restoration plans, and 4) Site monitoring and success criteria. Upon approval of this plan by regulatory agencies activities will be implemented as outlined. Proposed restoration activities may be modified during the construction stage due to constraints such as access issues, sediment-erosion control measures, drainage needs, or other design considerations.

## 2.0 METHODS

Natural resource information was obtained from available sources. USGS 7.5-minute topographic quadrangle (Oak City, North Carolina), United States Fish and Wildlife Service (FWS) National Wetlands Inventory (NWI) mapping, Natural Resource Conservation Service (NRCS) soils mapping for Martin County (NRCS 1989), and recent Martin County aerial photography were utilized to evaluate existing landscape, wetland, and soil information prior to on-Site inspection.

Current (1998) aerial photography was utilized to determine primary hydrologic features and to map relevant environmental features (Figure 4, Appendix A). Subsequently, fields, reference wetland surfaces, agricultural field ditch cross-sections, and profiles were measured to quantify elevational gradients affecting hydrologic parameters and to predict wetland restoration potential.

North Carolina Natural Heritage Program (NCNHP) data bases were evaluated for the presence of protected species and designated natural areas which may serve as reference (relatively undisturbed) wetlands for restoration design. A listing of federally-protected species whose ranges extend into Martin County was also obtained from the FWS (February 2003). State Historic Preservation Office (SHPO) records were evaluated for the presence of significant cultural resources in the Site vicinity. Results of these database reviews have been presented to the State of North Carolina in a Catagoracle Exclusion (CE) document. The CE document did not identify issues that may hinder Site development for wetland restoration.

Regional conservation areas within the nearby, Roanoke River Wetlands (Game Land No. 27) were also evaluated for reference use (NCWRC 2004). Identified sites were sampled and evaluated to provide information on target (post-restoration) wetland condition. Characteristic and target natural community patterns were classified according to Schafale and Weakley's, *Classification of the Natural Communities of North Carolina* (1990).

Detailed field investigations were performed in July and August 2004, and consisted of hydrological measurements, soil surveys, and mapping of on-Site resources. Project scientists evaluated hydrology, vegetation, and soil parameters to map hydric soils, open waters, conduct detailed soils measurements, and collect data for groundwater models. Existing plant communities were also delineated, mapped, and described by structure and composition.

NRCS soil mapping was modified to identify hydric soil boundaries and to predict (target) biological diversity prior to human disturbances. Detailed soil mapping was conducted by NRCS representative Stanley Letchworth of the Tarboro Farm Service Center on April 16, 2004. Soil mapping was validated by licensed soil scientists to verify existing units and to map inclusions and taxadjunct areas. A taxadjunct area contains soils which cannot be classified in a series recognized in the classification system. Such soils are named for a series they resemble and are designated as taxadjuncts to that series.

Groundwater conditions were modeled using the Boussinesq Equation and DRAINMOD computer model. The Boussinesq Equation represents a two-dimensional general flow equation for unconfined aquifers. The equation has been applied in the past to predict the decline in elevation of the water table near a pumping well as time progresses. The equation is based primarily on hydraulic conductivity, drainable porosity, and the saturated thickness of the aquifer. DRAINMOD is a computer model for simulating drainage rates for relatively shallow soils with high water tables. The model was utilized to predict historic hydroperiods, the extent of wetland degradation due to ditching, and the potential for wetland restoration through effective removal of the drainage network.

Field survey information was platted and compiled within Geographic Information System (GIS) base mapping and analyzed to evaluate the Site under existing conditions. Based on field investigations and data analyses, a wetland restoration plan has been developed for review and approval prior to on-Site implementation.

## 3.0 EXISTING CONDITIONS

### 3.1 Physiography, Topography, and Land Use

The Site is located in the Coastal Plain physiographic province of North Carolina primarily within USGS CU 03010107, Subbasin 03-02-09 of the Roanoke River Basin (14 digit hydrologic unit 03010107120020). Regional physiography is characterized as gently undulating with wide floodplains and broad, flat interstream divides (Griffith et al. 2002). Elevations within the Site are nearly level averaging approximately 26 feet National Geodetic Vertical Datum (USGS Oak City, North Carolina 7.5-minute topographic quadrangle).

The Site includes approximately 150 acres of land located in an expansive, nonriverine interstream flat. The entire 150-acre tract is utilized for agricultural row crop production (Figure 5, Appendix A). The Site is bound by an agricultural road to the south, timber tracts approximately 20 years in age to the west, and private land to the north and east. An extensive ditch system has been excavated to drain the Site for agricultural land uses. Inter-field ditches have been excavated to a depth of approximately 2 to 4 feet and are oriented primarily in a north to south direction. Inter-field ditches drain towards perimeter ditches which remove hydrology from the Site.

Site drainage flows to an unnamed tributary to Etheridge Swamp. Drainage to the unnamed tributary occurs directly through perimeter ditches along the northern edge of the Site, or through a complex network of roadside and/or timber stand ditches. Although on-Site ditches and the unnamed tributary to Etheridge Swamp are depicted on USGS 7.5-minute topographic mapping as blue-line streams, field investigations - including North Carolina Division of Water Quality (DWQ) stream data forms (Appendix B) - indicate that the tributary initiates downstream from the Site boundaries (Figure 3, Appendix A). Site drainage flows for approximately 2 miles prior to converging with Etheridge Swamp, a third-order stream draining to the larger Conoho Creek.

Due to its position in the landscape, the Site provides important headwater storage benefits to Etheridge Swamp and other downstream aquatic systems. The dominant presence of hydric soils, an extensive ditch network, and a vegetation structure/composition modified from relatively undisturbed conditions highlight the potential for an exceptional wetland restoration opportunity at the Site.

### 3.2 Water Quality

The Site is located within sub-basin 03-02-09 of the Roanoke River Basin (DWQ 2001a). This area is part of USGS Hydrologic Unit 03010107 of the South Atlantic/Gulf Region [Figure 2, Appendix A]). Site features drain to Etheridge Swamp and Conoho Creek, which is a major tributary to the Roanoke River. The portion of Conoho Creek that receives Site drainage has been assigned Stream Index Number 23-49 by DWQ. In the vicinity of the Site, Conoho Creek has not been rated (**NR**) by DWQ (DWQ 2001b). These streams have not been rated due to their low flow and swampy nature which results in skewed water quality readings. DWQ is in the process of collecting reference data for low flow, swampy streams to develop use support ratings in the vicinity of the Site.

### 3.3 Soils

Site soils have been mapped by the NRCS (NRCS 1989) (Figure 6, Appendix A). Detailed soil mapping was conducted by NRCS representative Stanley Letchworth of the Tarboro Farm Service Center on April 16, 2004. Detailed soil mapping was conducted in support of the Wetland Reserve Program and is depicted in Figure 7 (Appendix A). Further ground truthing of soil map units was conducted in January 2005 by a licensed soil scientist to refine soil map units and to locate inclusions.

Based on NRCS mapping, the Site is underlain by Rains fine sandy loam (*Typic Paleaquults*) and Lynchburg fine sandy loam (*Aeric Paleaquults*). Soils identified within the Site are described in Table 1.

**Table 1. NRCS Soils Mapped within the Site**

| Soil Series | Hydric Status | Family | Description |
|---|---|---|---|
| Rains | Class A | *Typic Paleaquults* | This series consists of poorly drained, moderately permeable soils of broad flats or shallow depressions on smooth uplands. Slopes are generally less than 2 percent. Depth to seasonal high water table is about 1.0 foot during wet months. |
| Lynchburg | Class B | *Aeric Paleaquults* | This series consists of somewhat poorly drained, moderately permeable soils of broad smooth areas or shallow depressions on uplands. Slopes are generally less than 2 percent. Depth to seasonal high water table is between 0.5 and 1.5 feet during wet months. |

The Rains series is considered hydric (Class A) in Martin County and the Lynchburg series is non-hydric with the potential for hydric inclusions (Class B) in Martin County (NRCS 1997).

Detailed soil mapping for the Site has been prepared based on landscape position and hydric verses non-hydric characteristics. Hydric soils are defined as "soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper soil layer" (SCS 1987). As depicted in Figure 7 (Appendix A), two revised soil map units were identified: 1) Rains Soils and 2) Lynchburg Soils.

Rains Soils

Hydric soils of the Rains series encompass approximately 125 acres (83 percent) of the on-Site interstream flat. Rains soils are characterized by light yellowish-brown surface consisting of fine sandy loam. This surface horizon (layer) is underlain by a brownish-yellow sandy clay loam with mottles in shades of red, brown, and gray (Figure 8, Appendix A). In general, Rains soils have been disturbed by ditching, deforestation, and plowing associated with agricultural row crop production. Based on preliminary studies, on-Site hydric soils appear to be drained by agricultural ditching; however, exhibit signs of groundwater saturation prior to ditching activities. These soils are located in broad, expansive precipitation flats that are poorly drained, with a seasonal high water table at about 1.0 foot during wet months.

Currently, on-Site hydric soils do not support hydrophytic vegetation and/or wetland hydrology. These areas are targeted for wetland restoration since the areas appear to have historically supported jurisdictional wetlands. Restoration of wetland hydrology and replanting with native hydric vegetation will be performed in these areas. See Section 3.6 for more information on jurisdictional wetlands and Section 6.0 for detailed wetland restoration information.

Lynchburg Soils

Non-hydric Lynchburg soils mapped at the Site occur as isolated pockets or inclusions within the predominantly Rains soil flat and encompass approximately 25 acres (17 percent) of the Site (Figure 7, Appendix A). Lynchburg soils are characterized by dark grayish-brown sandy loam underlain by yellowish-brown fine sandy loam. These soils are located in broad, expansive precipitation flats that are poorly drained, with a seasonal high water table at about 0.5 to 1.5 feet during wet months.

### 3.3.1 Surface and Subsurface Soil Compaction/Leveling

Soil surfaces have been leveled, graded, and compacted as a result of agricultural practices. In crop land supporting clayey subsurface horizons (ex: Rains series), approximately 9 inches of the soil surface (A horizon) represents relatively high permeability, loamy soils that have been annually plowed. Immediately below the plow layer, a compacted clay layer or "pan" (upper portion of the B horizon) exhibits low permeabilities. Precipitation infiltrates to the top of this clay pan and may migrate laterally through the permeable surface horizon. As a result, perched water in active crop land tends to flow laterally away from the fields and towards ditches. This preferential migration laterally through the surface soil horizon may assist in providing adequate drainage for farming shallow rooted crops in hydric soil areas.

Surface (A horizon) and subsurface (B horizon) microtopography represents an important component of nonriverine wetlands as water storage functions and micro-habitat complexity are provided by hummocks and swales across the wetland landscape. If ditches are back-filled but the clay pan is not modified, perched water may continue preferential migration laterally through the surface soil layer, promoting flood conditions in downslope areas and dryer conditions in upper landscape positions.

## 3.4 Plant Communities

The Site is entirely composed of agricultural land utilized for row crop production. Crops harvested from the Site appear to include corn, soybeans, and peanuts. During initial field investigations, corn was planted at the Site and fields consisted of a near monoculture of the crop. A few opportunistic herbaceous species were interspersed within the corn including sicklepod (*Cassia obtusifolia*), nightshade (*Solanum carolinense*), dog fennel (*Eupatorium capillifolium*), and blackberry (*Rubus* sp.).

Agricultural field margins and ditch margins, which remain free from planting, were also characterized by disturbance adapted shrub and herbaceous species. Agricultural field margins were characterized by more mesic species due to the drainage effect from perimeter ditches including woody species such as persimmon (*Diospyros virginiana*), southern red oak (*Quercus falcata*), winged sumac (*Rhus copallinum*), sweetgum (*Liquidambar styraciflua*), loblolly pine (*Pinus taeda*), Japanese clover (*Lespedeza striata*), pokeweed (*Phytolacca americana*), and sweet pepperbush (*Clethra alnifolia*). Ditches appear to have not been maintained over the past two years and are currently colonized by fast growing vegetation including winged sumac, rushes (*Juncus* spp.), sedges (*Carex* spp.), sweet pepperbush, muscadine (*Vitis rotundifolia*), blackberry, poison ivy (*Toxicodendron radicans*), and sweetgum.

Reforestation of Mesic Pine Flatwoods to Wet Pine Flatwoods species may be achievable within the entire 150 acre Site. An ecological approach to restoration is expected within the Site; therefore, a varied forest structure should target habitat diversity.

### 3.5 Hydrology

The hydrophysiographic region consists of relatively flat, Coastal Plain environments characterized by moderate rainfall, averaging approximately 48 inches of precipitation per year (NRCS 1989). The Site is situated along the apex of a Coastal Plain interstream divide and includes groundwater slopes at the upper headwaters of an unnamed tributary to Etheridge Swamp. Therefore, historic wetlands were most likely influenced primarily by precipitation and lateral migration of groundwater flows toward the upper reaches of the tributary to Etheridge Swamp.

Topographically, the Site is generally expressed as a broad flat grading towards the tributary to Etheridge Swamp. Adjacent, broad interstream divides cover approximately 0.5 square miles of land with groundwater discharging from these interstream divides migrating towards the Site. Near surface groundwater is intercepted by a network of drainage ditches designed to facilitate alternative land uses such as agriculture and timber management in the watershed.

Under historic conditions, interior wetlands most likely served as an above headwater storage and groundwater discharge area for Etheridge Swamp. Currently, groundwater migration has been accelerated in crop lands by the leveled soil surface, increased permeability within the plow layer, and potential removal of subsurface impediments to flow (rooting functions and B horizon surface complexity). The induced groundwater migration is intercepted by a network of inter-field ditches which effectively drain farmed portions of the Site. Approximately 27,185 linear feet of ditch have been excavated, which range in depth from approximately 2 to 3 feet through the agricultural fields to 4 feet in perimeter ditches at the Site outfall.

### 3.6 Jurisdictional Wetlands

Jurisdictional wetland limits are defined using criteria set forth in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987). As stipulated in this manual, the presence of three clearly defined parameters (hydrophytic vegetation, hydric soils, and evidence of wetland hydrology) are required for a wetland jurisdictional determination.

Hydric soil limits were mapped in the field during April 2004 and January 2005 by a licensed soil scientist. Based on groundwater modeling it appears that jurisdictional wetland hydrology within the entire 150-acre tract has been effectively removed by agricultural field ditches (Section 4.2.2 Groundwater Model – Existing Conditions).

Historically, on-Site jurisdictional wetlands may have been seasonally flooded by precipitation and lateral groundwater migration, as evidenced by mottling and organic streaking in soils from ground-water table fluctuations. Jurisdictional wetlands are located in poorly drained, depressional pockets, which capture precipitation due to low permeability of the soil body. These areas are underlain by clayey soils which are gray in color with frequent mottling. On-Site soils appear to have been significantly disturbed by agricultural practices including plowing, draining, and application of pesticides, fertilizers, and lime.

Historically, on-Site wetlands may have supported a community grading between Mesic Pine Flatwoods in drier portions of the Site to Wet Pine Flatwoods in wetter portions of the Site (Schafale and Weakley 1990). The canopy was likely to have been closed, dependent upon the fire regime and was characterized by various pine species: longleaf pine (*Pinus palustris*), loblolly pine (*Pinus taeda*), and pond pine (*Pinus serotina*). The understory may have been relatively sparse in frequently burned sites, but once the fire regime was altered invading hardwoods may have become relatively dense.

Disturbance to on-Site jurisdictional wetlands may have collectively reduced the functionality of these systems. On-Site impacts may have reduced hydrologic functions, biogeochemical functions, and plant and animal habitat interactions.

### 3.7 Threatened and Endangered Species

Based on the February 24, 2003 FWS list, the only federally-protected species which may occur in Martin County is the bald eagle. Typical nesting habitat for bald eagles includes tall, live or dead trees in conspicuous areas located near open water (Hamel 1992). No open water occurs within 20 miles of the Site. In addition, no critical habitat has been designated for this species. Based on an initial field review for species habitat and the FWS list for Martin County, federally-protected species do not present an environmental concern that may affect future activities proposed for this project.

**<u>State Species</u>**

Plant and animal species which are on the North Carolina State list as Endangered, Threatened, Special Concern, Candidate, Significantly Rare, or Proposed (Amoroso 2002, LeGrand and Hall 2001) receive limited protection under the North Carolina Endangered Species Act (G.S. 113-331 et seq.) and the North Carolina Plant Protection Act of 1979 (G.S.

106-202 et seq.). Based on NCNHP records, one state listed species is documented within 2.0 miles of the Site. Eastern Henslow's sparrow (Ammodramus henslowii), a state listed Significantly Rare (SR) species, is documented to occur approximately 1.9 miles southwest of the Site.

## 4.0 GROUNDWATER MODELING

Groundwater modeling was performed to characterize water table elevations under historic (reference), existing, and post-restoration conditions. Specifically, the study compared the output of two models (the Boussinesq Equation and DRAINMOD) to estimate the linear distance from the edge of agricultural field ditches where the potential exists for drainage impacts to occur within jurisdictional wetlands.

### 4.1 Groundwater Model Descriptions

The Boussinesq Equation represents a two-dimensional general flow equation for unconfined aquifers. The equation has been applied in the past to predict the decline in elevation of the water table near a pumping well as time progresses. The equation is based primarily on hydraulic conductivity, drainable porosity, and the saturated thickness of the aquifer. One form of the equation is as follows:

$$X = (K\ h_0\ t/f)^{½} / F(D,H)$$

Where:

K = hydraulic conductivity (in/hr)
$h_0$ = depth to aquiclude (in)
t = duration (hours)
f = drainable porosity (dimensionless ratio)
F(D,H) = profiles (graphs) relating ditch depth, water table depth, and depth to the aquiclude ($h_0$)
X = wetland impact distance (in)

DRAINMOD was originally developed to simulate the performance of agricultural drainage and water table control systems on sites with shallow water table conditions. DRAINMOD predicts water balances in the soil-water regime at the midpoint between two drains of equal elevation. The model is capable of calculating hourly values for water table depth, surface runoff, subsurface drainage, infiltration, and actual evapotranspiration over long periods referenced to measured climatological data. The reliability of DRAINMOD has been tested for a wide range of soil, crop, and climatological conditions. Results of tests in North Carolina (Skaggs 1982), Ohio (Skaggs et al. 1981), Louisiana (Gayle et al. 1985; Fouss et al. 1987), Florida (Rogers 1985), Michigan (Belcher and Merva 1987), and Belgium (Susanto et al. 1987) indicate that the model can be used to reliably predict water table elevations and drain flow rates. DRAINMOD has also been used to evaluate wetland hydrology by Skaggs et al. (1993). Methods for evaluating water balance equations and equation variables are discussed in detail in Skaggs (1980).

DRAINMOD was modified for application in wetland studies by adding a counter that accumulates the number of events wherein the water table rises above a specified depth and remains above that threshold depth for a given duration during the growing season. Important inputs into the DRAINMOD model include rainfall data, soil and surface storage parameters, evapotranspiration rates, ditch depth and spacing, and hydraulic conductivity values.

### 4.1.2 Model Application – Boussinesq Equation

In this study, the Boussinesq Equation was applied to agricultural field ditches to predict where the linear distance of a drawdown in the groundwater exceeds 1 foot for 5 percent and 12.5 percent of the growing season. These percentages were selected based upon guidance from the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987). The equation is solved for the wetland impact distance with data for the following variables: 1) equivalent hydraulic conductivity, 2) drainable porosity, 3) an estimated depth to the impermeable layer or aquiclude, 4) the time duration of the drawdown, 5) target water table depth (1 foot below the soil surface), and 6) minimum ditch depth.

Hydraulic conductivity (K) values were estimated using published conductivity data for the Rains series in the Coastal Plain of North Carolina (Skaggs et al. 2002). The soil layer depths were obtained from descriptions in the Martin County soil survey then verified in the field. Drainable porosity was determined using published data (Skaggs et al. 1986). The drainable porosities were cross-referenced with water depth to drained-volume relationship provided by MUUF for depths between 0 and 1 foot for the Rains series. The depth to the aquiclude was obtained from published values for the Rains series (Skaggs et al. 1986).

The time variable, t, is based on 5 and 12.5 percent of the Martin County growing season, 12 and 30 days, respectively. For the purpose of this study, the growing season is defined as the period between March 16 and November 14 (NRCS 1989). Values for the function F(D,H), defined as a function of ditch depth, water table depth, and depth to the aquiclude, were taken from plotted numerical solutions to the Boussinesq Equation (Figure 2j, Skaggs 1976), where D=d/h0 and H=h/h0. The variable d is defined as the ditch elevation above the aquiclude. The variable h0 is the distance from the soil surface to the aquiclude. The variable h is equal to the height after drawdown for the water above the aquiclude at distance X from the ditch. For the purposes of this analysis, h was defined as the distance between the aquiclude and a point 1 foot below the surface. Minimum ditch depths were determined during cross-sectional analysis of agricultural field ditches.

### 4.1.3 Model Application – DRAINMOD

DRAINMOD was used to model the zone of wetland loss resulting from Site agricultural field ditches. This zone was estimated by determining the threshold drain spacing of parallel ditches that would result in the area between ditches meeting wetland hydrology criteria in just over one-half of the years simulated. Ditches spaced closer than this threshold distance would result in the entire area between the ditches experiencing a loss of wetland hydrology. Ditches spaced further apart than the threshold distance would result in a strip between the ditches which would still meet the wetland hydrology criteria. One-half of this threshold spacing provides an estimate of the drainage effect on each side of a single agricultural field ditch.

Wetland hydrology is defined for DRAINMOD as groundwater within 12 inches of the ground surface for 12 and 30 consecutive days (5 and 12.5 percent, respectively) during the growing season in Martin County. Wetland hydrology is achieved in the model if target hydroperiods are met for more than one-half of the years modeled (i.e. 19 out of 38 years).

Additional inputs for soil parameters and relationships derived from soil and water characteristic data such as the water table depth/volume drained/upflux relationship, Green-ampt parameters, and the water content/matrix suction relationship were obtained from published values (Skaggs et al. 1986) for the Rains series. Hydraulic conductivities and ditch depths were calculated as described above. Surface depressional storage was estimated from published ranges (Skaggs et al. 1994 and Skaggs 1980) after visiting the Site. Drainage coefficients for the ditches were calculated based on formulas provided with DRAINMOD.

Weather data for a 38-year period was obtained for Greenville, North Carolina in Pitt County. Potential evapotranspiration rates were calculated based on Thornthwaite's method and adjusted using monthly factors derived from more reliable average values for crop evapotranspiration for the Coastal Plain known from Pitt County. The DRAINMOD simulation was conducted for the time period from 1956 through 1993.

## 4.2 Groundwater Model Results

### 4.2.1 Reference Wetland Model

For development of reference wetland standards, modeling was performed to predict historic wetland hydroperiods (as a percentage of the growing season) in various undrained conditions. The reference model was developed by effectively eliminating the influence of ditching and forecasting the average hydroperiod over the number of years modeled. Two iterations were performed to evaluate changes in wetland hydroperiod between: 1) old field (post farmland) stages of wetland development and 2) forested stages of wetland development.

Old field stages of wetland development were simulated by modifying soil drainage characteristics such as rooting functions in proximity to the B (clay) horizon, A horizon (plow layer) hydraulic conductivity, and water storage capacity within the plow layer. The old field model provides a hypothetical approximation of the potential hydroperiod exhibited immediately after the drainage ditches are plugged and backfilled.

Forested stages were modeled to predict wetland hydroperiods that may occur within reference (relatively undisturbed) wetlands in the region. The reference forest model may provide a projection of wetland hydroperiods and associated functions that may be achieved over the long-term (10+ years) as a result of wetland restoration activities and steady state forest conditions. The steady state model application assumes an increase in rooting functions, organic matter content, and water storage capacity relative to post-farmland periods.

The reference model predicts that, in Rains soils, old field stages of wetland development exhibit an average wetland hydroperiod encompassing 14 percent of the growing season over the years modeled (Table 2). This average hydroperiod translates to free water within 1 foot of the soil surface for a 33 day period extending from March 16 to April 18. During the 38-year modeling period, reference wetland hydroperiods exhibited a range extending from less than 2 percent (1 out of 38 years) to more than 26 percent (2 out of 38 years) of the growing season, dependent upon rainfall patterns.

**Table 2. DRAINMOD Results Reference Wetland Hydroperiod
Rains Soils
Gatlin Swamp Wetland Restoration Site**

| **Percent of Growing Season** | | **Number of Years Wetland Hydrology is Achieved** (38-year model period) | |
|---|---|---|---|
| % Season | Days | **Old Field Stage** (immediately after backfilling and plugging ditches, relatively low surface water storage) | **Forested Stage** (10+ years after restoration, relatively high surface water storage) |
| 2 | 5 | 37 / 38 | 37 / 38 |
| 4 | 10 | 36 / 38 | 36 / 38 |
| 6 | 15 | 36 / 38 | 36 / 38 |
| 8 | 19 | 33 / 38 | 34 / 38 |
| 10 | 24 | 30 / 38 | 33 / 38 |
| 12 | 29 | 25 / 38 | 32 / 38 |
| **14** | **34** | **17 / 38** | 29 / 38 |
| 16 | 39 | 15 / 38 | 25 / 38 |
| **18** | **44** | 11 / 38 | **21 / 38** |
| **20** | **49** | 5 / 38 | **15 / 38** |
| 22 | 53 | 4 / 38 | 14 / 38 |
| 24 | 58 | 2 / 38 | 8 / 38 |
| 26 | 63 | 2 / 38 | 7 / 38 |
| 28 | 68 | 0 / 38 | 6 / 38 |
| 30 | 73 | 0 / 38 | 5 / 38 |

As surface topography, rooting, roughness, and storage variables increase during successional phases, the model predicts that hydroperiods will increase to steady state forest conditions averaging a 19 percent wetland hydroperiod over the 38 years modeled (Table 2). The average hydroperiod translates to free water within 1 foot of the soil surface for a 46 day period extending from March 16 to May 1. Again, the hydroperiod ranges from less than 12 percent (6 years) to more than 30 percent (5 years) during the 38-year period dependent upon rainfall patterns. Therefore, the reference model suggests that groundwater fluctuations must be tracked within a reference wetland site to accurately assess a target hydroperiod for any given year.

As described above, the average wetland hydroperiod in Rains soil is forecast by the reference model to exhibit a gradual increase from less than 12 percent of the growing season immediately after drainage structures are removed to as much as 30 percent under steady state forest conditions. A gradual increase in hydroperiods may suggest that water storage capacity (rooting functions, organic materials/debris accumulation, microtopography, etc.) exhibits a significant effect on maintenance of wetland hydrology in precipitation driven wetlands. In old field stages of succession, accelerated runoff may occur within the former plow layer. For purposes of this preliminary model, runoff is assumed to occur at accelerated rates which reduce the influence of evapotranspiration on wetland hydrodynamics. This accelerated drainage would be expected to decrease as successional vegetation colonizes the Site.

Because wetland hydroperiods during old field stages of wetland development are projected to extend for less than 12.5 percent of the growing season, wetland monitoring plans that extend for a five year period after restoration should utilize a minimum 5 percent wetland hydrology criteria to substantiate restoration success. Alternatively, hydroperiods within the restored wetland area may be tracked relative to groundwater gauges placed in the adjacent reference wetland. Utilizing reference groundwater gauges to establish success criteria may stipulate that restored hydroperiods exceed 74 percent of the hydroperiod exhibited by reference groundwater gauges. The 74 percent threshold is established by dividing model predictions for old field stages of wetland development (14 percent projected hydroperiod) by model predictions for reference, steady state wetlands (19 percent projected hydroperiod).

Methods may be employed to increase complexity in the soil surface (A horizon plow layer) during restoration activities. These modifications, including woody debris deposition and soil scarification, may increase water storage capacity across the surface of relatively impermeable clay layers (B horizon surface). If water storage is not adequately established during early stages of wetland development, marginal or non-wetland conditions may occur in elevated areas of the Site. Invariably, rooting influences on water storage capacity will require an extended period of forest development to establish (assumed at greater than 10 years).

### 4.2.2 Existing Site Conditions

Groundwater models were utilized to forecast the maximum zone of ditch influence on jurisdictional wetland hydroperiods. The maximum zone of influence may be used to predict the area of wetland hydrological restoration that may result due to effective ditch removal. Ditch depths and spacing were varied in the model until wetland hydroperiods were reduced relative to the jurisdictional wetland hydroperiods outlined by the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987).

Both the Boussinesq Equation and DRAINMOD have an ability to support different ditch morphology and features, suggesting that use of these methods in evaluation of drainage impacts from agricultural field ditches is applicable with proper data inputs. Performing a comparison of output from both models is recommended because output can be considered to predict the lower limits (Boussinesq Equation) and upper limits (DRAINMOD) of drainage influence that is likely to occur in real world conditions. Groundwater model results are presented in Table 3.

The Boussinesq Equation and DRAINMOD model predict a range of influence on the jurisdictional wetland hydroperiod (12.5 percent of growing season) of 106 to 326 feet for a 3-foot ditch, respectively (Table 3). The Boussinesq Equation value is expected to be at the low end of the drainage impact and the DRAINMOD model value is expected to be at the high end of the drainage impact. Therefore, an average value of 216 feet of drainage impact for a 3-foot ditch has been used for this study. Figure 9 provides a depiction of modeled wetland hydroperiods based on ditch depths and spacing under existing conditions. As the Site succeeds towards steady state forest conditions, the zone of potential wetland is expected to be reduced due to projected, lower infiltration and runoff rates.

**Table 3. Groundwater Model Results**
**Zone of Wetland Loss**
**Rains Soil Series**

| | **Boussinesq Equation** | | **DRAINMOD Model** | | **Drainage Impact Used for this Study** | |
|---|---|---|---|---|---|---|
| Ditch Depth (ft) | Wetland Hydroperiod (% of Growing Season) | | | | | |
| | 5% | 12.5% | 5% | 12.5% | 5% | 12.5% |
| | Zone of Influence (feet)* | | | | | |
| 2 | 61 | 97 | 44 | 263 | 53 | 180 |
| 3 | 67 | 106 | 59 | 326 | 63 | 216 |
| 4 | 76 | 120 | 67 | 359 | 72 | 240 |

* Zone of influence equal to ½ of the modeled ditch spacing

Groundwater model simulations for existing conditions indicate that portions of the Site are forecast to meet hydrology criteria (5 percent of the growing season) at distances of 53 feet to 72 feet from the existing drainage ditches (Table 3 and Figure 10). Under existing conditions approximately 60 acres of agricultural field is projected to support average hydroperiods ranging from 5 to 8 percent of the growing season. Rains soils are considered effectively drained throughout the Site for hydrologic criteria of 12.5 percent of the growing season due to the groundwater drawdown from the agricultural field drainage ditch network (Table 3 and Figure 9).

## 5.0 REFERENCE STUDIES

Reference wetland systems were utilized as the primary method for development of this wetland restoration plan. Due to time constraints, the reference sites have been divided between hydrologic reference and vegetative reference. Hydrologic reference areas are located immediately adjacent to the Site in un-ditched portions of the Rains flat (Figures 1 and 6, Appendix A). Hydrologic reference areas will be utilized to develop post-project hydrologic parameters for success criteria. The primary reference vegetative community, as depicted in Figure 1 (Appendix A), is located approximately 9 miles east of the Site on the fringe of the Roanoke River floodplain. Reference vegetative community areas will be utilized to supplement Schafale and Weakley's, *Classification of the Natural Communities of North Carolina* (1990) vegetative community descriptions for Mesic Pine Flatwoods and Wet Pine Flatwoods.

### 5.1 Reference Forest Ecosystems

According to Mitigation Site Classification (MiST) guidelines (EPA 1990), Reference Forest Ecosystems (RFEs) must be established for restoration sites. RFEs are forested areas on which to model restoration efforts of the restoration site in relation to soils, hydrology, and vegetation. RFEs should be ecologically stable climax communities and should represent believed historical (pre-disturbance) conditions of the restoration site. Quantitative data describing plant community composition and structure are collected at the RFEs and subsequently applied as reference data for design of the restoration site.

Reference vegetative communities for this project are located adjacent to the Roanoke River approximately 9 miles northeast of the Site (Figure 1, Appendix A). Although the Site planting scheme includes Mesic Pine Flatwoods and Wet Pine Flatwoods, these areas are largely cleared for agriculture or are planted in loblolly pine for timber harvest. Therefore, NCNHP Significant Natural Areas listed as Mesic Mixed Hardwood Forest were targeted for measurement of vegetative communities and are expected to supplement community descriptions for Pine Flatwoods. Field data (Table 4) indicates importance values of dominant tree species calculated based on relative density, dominance, and frequency of tree species composition (Smith 1980).

Three 0.1-acre plots were established in reference vegetative community areas that will be utilized to supplement community descriptions for Pine Flatwoods. Forest vegetation was dominated by hop hornbeam (*Ostrya virginiana*) and swamp chestnut oak (*Quercus michauxii*). Portions of the canopy were also dominated by sweetgum (*Liquidambar sytraciflua*) and tulip tree (*Liriodendron tulipifera*).

Understory species in the dense sapling and shrub layers of wet portions of the RFE include strawberry bush (*Euonymus americanus*), pawpaw (*Asimina triloba*), black gum (*Nyssa sylvatica*), and spicebush (*Lindera benzoin*). The understory in non-wet portions of the RFE were vegetated with American holly (*Ilex opaca*), ironwood (*Carpinus caroliniana*), bitternut hickory (*Cary cordiformis*), and umbrella tree (*Magnolia tripetala*).

Table 4. Reference Forest Ecosystem

## 5.2 Soil Surface Characterization

Wetland surface microtopography was evaluated in reference wetlands by estimating changes in relief across local reaches of the landscape. In Rains soils, depressional storage associated with microtopography appears to play an important role in wetland hydrology and function. Surface topography varies from approximately 0.5 to 1.0 foot across the soil surface. Within the interior reference hydrology area, depressional areas are generally spaced at distances ranging from 30 to 100 feet between hummocks and flats. The depressions ranged from 20 to 70 feet in width and averaged approximately 0.5 foot in maximum depth. The depressional areas also support an increased accumulation of organic matter, with sphagnum mosses and characteristic Wet Pine Flatwoods species dominating the inundated areas.

## 6.0 RESTORATION PLAN

Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology include: 1) ditch cleaning prior to backfill, 2) depression construction, 3) impervious ditch plug construction, 4) ditch backfilling, 5) floodplain soil scarification, and 6) plant community restoration (Figure 10, Appendix A). Restoration plans depicted in Figure 10 are expected to restore 125 acres of nonriverine, interstream flat wetland.

### 6.1 Ditch Cleaning Prior to Backfill

Ditches identified for backfilling in Figure 10 (Appendix A) will be cleaned, as needed, to remove unconsolidated sediments within the lower portion of the cross-section. Accumulated sediment within the ditches represents relatively high permeability material that may act as a conduit for continued drainage after restoration. The unconsolidated sediments will be lifted from the channel to expose the underlying, relatively impermeable clay substrate along the ditch invert. The sediment will be temporarily placed on adjacent surfaces during depression construction and ditch backfilling. Subsequently, the unconsolidated sediment will be incorporated into top soils graded during soil preparation for planting.

### 6.2 Depression Construction

Based on volume calculations for ditch-backfill material, approximately 24,375 cubic yards of material must be borrowed from the Site. Borrow material will be generated through excavation of groundwater storage depressions throughout the Site landscape. The primary purpose of these depressions is to provide suitable, low permeability material for ditch plugs and backfilling, to increase water storage potential within the wetland restoration area, and to increase potential for biological diversity within the complex. A conceptual model of the constructed depression, after restoration is complete, is depicted in Figure 11 (Appendix A).

The depression will be constructed by excavating and stockpiling top soils overlying the B horizon (clay layer) surface. Subsequently, clay from the B horizon will be excavated as individual pockets approximately 2 to 3 feet in width and 2 to 3 feet in depth, such that the landscape is “pockmarked” with small, groundwater storage depressions. Clays excavated from the depressions will be utilized as backfill material on adjacent ditch sections. Top soils and sediment removed from ditch cleaning efforts will be utilized to backfill the depression to within 0.3 foot of the surface.

The location, depth, and configuration of each depression will be modified during construction to maximize landscape diversity, provide varying depths throughout the Site, and to balance cut and fill needs for ditch backfilling and plug construction.

## 6.3 Ditch Plugs

Ditch plugs will be installed along on-Site ditches at locations conceptually depicted in Figure 10 (Appendix A). In addition, all Site outfall locations will be effectively plugged to prevent migration of surface water to and from the Site. The plugs will represent low density material designed to withstand erosive forces associated with concentrated surface water or groundwater flows. If earthen material is used, each plug will consist of earthen material backfilled in 2-foot lifts of vegetation free material and compacted into the bottom of the ditch. Earthen plugs may be reinforced by incorporation of filter cloth into the plug to minimize preferential flow of groundwater through fill material. Earthen material may be obtained from upland borrow pits or through excavation of groundwater storage depressions within the Site.

## 6.4 Ditch Backfilling

Ditches will be backfilled using on-Site, earthen material from excavated depressions as depicted in Figure 10 (Appendix A). Based on cut-fill estimates for this project, approximately 24,375 cubic yards of ditch backfill material will be required to effectively fill all on-Site ditches. Material excavated from the groundwater storage depressions will be stockpiled adjacent to the ditches to be backfilled. Ditch backfill locations will be filled, compacted, and graded to the approximate elevation of the adjacent wetland surface. Certain, non-critical ditch sections may remain open to provide habitat and hydrologic storage. Open ditch sections will be isolated between effectively backfilled reaches to reduce potential for long-term, preferential groundwater migration.

## 6.5 Floodplain Soil Scarification

Microtopography and differential drainage rates within localized areas represent important components of interstream flat functions. Reference hydrology areas north of the Site exhibit complex surface microtopography. Small concavities, swales, exposed root systems, seasonal pools, oxbows, and hummocks associated with vegetative growth and hydrological patterns are scattered throughout these systems. Efforts to advance the development of characteristic surface microtopography will be implemented.

In areas where soil surfaces have been compacted, ripping or scarification will be performed. After construction, the soil surface is expected to exhibit complex microtopography ranging to 1 foot in vertical asymmetry across local reaches of the landscape. Subsequently, community restoration will be initiated on complex surfaces.

## 6.6 Plant Community Restoration

Restoration of interstream flat forest allows for development and expansion of characteristic species across the landscape. Ecotonal changes between community types contribute to diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife.

Reference Forest Ecosystem (RFE) data, on-Site observations, and community descriptions from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990) were used to develop the primary plant community associations that will be promoted during community restoration activities. Based on Schafale and Weakley (1990) community descriptions, the Site ranges from Mesic Pine Flatwoods in drier portions of the Site to Wet Pine Flatwoods in wetter portions of the Site. These areas occur on flat or rolling Coastal Plain sediments with a significant seasonal high water table. Pine Flatwood communities typically occur on wet sandy soils and contain a sparse shrub layer (in frequently burned sites). Vegetative species present within the reference vegetation areas are characteristic of Mesic Hardwood Forest as described by Schafale and Weakley (1990), and will be utilized to supplement species descriptions listed by Schafale and Weakley (1990) for Pine Flatwood communities.

### 6.6.1 Planting Plan

On-Site observations and community descriptions from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990) were used to develop the primary plant community association to be promoted during restoration efforts. The entire 150-acre Site will be planted with species characteristic of a Pine Flatwoods community. Planting elements are listed below.

<u>Pine Flatwoods</u>

1. Loblolly Pine (*Pinus taeda*)
2. Pond Pine (*Pinus serotina*)
3. Swamp Chestnut Oak (*Quercus michauxii*)
4. Cherrybark Oak (*Quercus pagodaefolia*)
5. Southern Red Oak (*Quercus falcata*)
6. Water Oak (*Quercus nigra)*
7. Willow Oak (*Quercus phellos)*
8. Sweetbay (*Magnolia virginiana*)
9. River Birch (*Betula nigra*)

Site re-vegetation efforts are expected to include 1) acquisition of available plant species and 2) planting selected species. Species selected for planting will be dependent upon availability of local seedling sources. Advance notification to nurseries has occurred to determine availability of various non-commercial elements.

Bare-root seedlings of tree and shrub species may be planted within the Site at a density up to 1000 stems per acre (6.6-foot centers). Planting should be performed between December 1 and March 15 to allow plants to stabilize during the dormant period and set root during the spring season. Bare-root seedlings should be hand planted to minimize Site soil disturbance, thereby minimizing potential for sedimentation/siltation into Site streams and receiving streams. A total of 150,003 diagnostic tree and shrub seedlings may be planted in support of Site wetland restoration (Table 5). The entire 150-acre restoration area is expected to be re-vegetated during implementation of this plan.

### 6.6.2 Nuisance Species Management

No nuisance species were observed in the on-Site agricultural fields; therefore, no nuisance species controls are proposed at this time. Potential for other nuisance species including non-native floral species may be monitored over the course of the 5-year monitoring period. Appropriate actions may be taken to ameliorate negative impacts regarding vegetation development and/or water management on an as-needed basis.

**Table 5. Planting Plan**

| **Vegetation Association (Planting Area)** | **Pine Flatwoods** | |
|---|---|---|
| **Area (acres)** | **150** | |
| **SPECIES** | **Total Number Planted[1]** | **Percentage of Total[2]** |
| Loblolly Pine (*Pinus taeda*) | 16,667 | 11.1 |
| Pond Pine (*Pinus serotina*) | 16,667 | 11.1 |
| Swamp Chestnut Oak (*Quercus michauxii*) | 16,667 | 11.1 |
| Cherrybark Oak (*Quercus pagodaefolia*) | 16,667 | 11.1 |
| Southern Red Oak (*Quercus falcata*) | 16,667 | 11.1 |
| Water Oak (*Quercus nigra*) | 16,667 | 11.1 |
| Willow Oak (*Quercus phellos*) | 16,667 | 11.1 |
| Sweetbay (*Magnolia virginiana*) | 16,667 | 11.1 |
| River Birch (*Betula nigra*) | 16,667 | 11.1 |
| **TOTAL** | **150,003** | **100** |

1: Planting densities comprise 1000 trees and/or shrubs per acre within the planting area.

2: Some non-commercial elements may not be locally available at the time of planting. The stem count for unavailable species should be distributed among other target elements based on the percent (%) distribution. One year of advance notice to forest nurseries will promote availability of some non-commercial elements. However, reproductive failure in the nursery may occur.

## 7.0 MONITORING PLAN

Monitoring of Site restoration efforts will be performed until success criteria are fulfilled. Monitoring is proposed for wetland components of hydrology and vegetation. A general Site monitoring plan is depicted in Figure 12 (Appendix A).

### 7.1 Hydrology Monitoring

After hydrological modifications are performed, continuous monitored, groundwater monitoring gauges will be installed at the Site in accordance with specifications in *Installing Monitoring Wells/Piezometers in Wetlands* (WRP 1993). Approximately seven groundwater monitoring gauges (two gauges within reference and five gauges on-Site) will be installed at the Site as conceptually depicted in Figure 12 (Appendix A). Monitoring gauges will be set to a minimum depth of 12 inches below the soil surface. Hydrological sampling will continue throughout the growing season at intervals necessary to satisfy the hydrology success criteria (EPA 1990).

### 7.2 Hydrology Success Criteria

Target hydrological characteristics include a minimum regulatory wetland hydrology criteria based upon reference groundwater modeling. Evaluation of success criteria will also be supplemented by sampling and data comparison between restoration areas and the reference wetland site.

The reference groundwater model forecasts that the wetland hydroperiod in restoration areas will range between approximately 2 and 26 percent of the growing season in early successional phases (Section 4.2.1 and Table 2). Because wetland hydroperiods during old field stages of wetland development are projected to extend for less than 12.5 percent of the growing season, wetland monitoring plans that extend for a five year period after restoration should utilize a minimum 5 percent wetland hydrology criterion to substantiate restoration success.

The average wetland hydroperiod is forecast to exhibit a gradual increase of the growing season immediately after farm land is abandoned and drainage ditches are removed to as much as 30 percent under steady state forest conditions. A gradual increase in hydroperiods may suggest that water storage capacity (rooting functions, organic materials/debris accumulation, microtopography, etc.) exhibits a significant effect on maintenance of wetland hydrology in precipitation driven wetlands. In old field stages of succession, accelerated runoff may occur within the former plow layer, relict field crowns, and any relict linear depressions or conduits associated with backfilled ditches. For purposes of this model, runoff is assumed to occur at accelerated rates which reduce the influence of evapotranspiration on wetland hydrodynamics. Consequently, accelerated drainage would be expected to decrease, and wetland hydroperiods increase, as successional vegetation colonizes the Site.

Based on the groundwater model, hydrology success criteria for the five-year monitoring period will include a minimum regulatory criterion, comprising saturation (free water) within one foot of the soil surface for 5 percent of the growing season.

Reference Wetland Sites

Two monitoring wells will be placed in reference wetlands located in the northern and eastern periphery of the Site. Wetland hydroperiods measured by groundwater gauges located within the reference areas will be compared to the hydroperiods exhibited by groundwater gauges in the restoration area to further evaluate restoration success. Success criteria outlined by the groundwater model indicates that the wetland restoration area should maintain saturation within one foot of the soil surface for at least 74 percent of the hydroperiod exhibited by the reference wetland (14 percent [old field hydroperiod] / 19 percent [forest hydroperiod]) in any given year.

## 7.3 Vegetation Monitoring

Restoration monitoring procedures for vegetation are designed in accordance with EPA guidelines enumerated in *Mitigation Site Type Classification* (MiST) (EPA 1990) and United States Army Corps of Engineers (ACE) *Compensatory Hardwood Mitigation Guidelines* (Environmental Laboratory 1993). A general discussion of the restoration monitoring program is provided. A photographic record of plant growth should be included in each annual monitoring report.

After planting has been completed in winter or early spring, an initial evaluation will be performed to verify planting methods and to determine initial species composition and density. Supplemental planting and additional Site modifications will be implemented, if necessary.

During the first year, vegetation will receive visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed between September 1 and October 30, after each growing season, until the vegetation success criteria are achieved.

During quantitative vegetation sampling in early fall of the first year, up to five sample plots will be randomly placed within the Site. Sample-plot distributions are expected to resemble locations depicted in Figure 12 (Appendix A); however, best professional judgment may be necessary to establish vegetative monitoring plots upon completion of construction activities. In each sample plot, vegetation parameters to be monitored include species composition and species density. Visual observations of the percent cover of shrub and herbaceous species will also be recorded.

## 7.4 Vegetation Success Criteria

Success criteria have been established to verify that the vegetation component supports community elements necessary for floodplain forest development. Success criteria are dependent upon the density and growth of characteristic forest species. Additional success criteria are dependent upon density and growth of "Characteristic Tree Species." Characteristic Tree Species include planted species and species identified through inventory of an approved reference (relatively undisturbed) forest community used to orient the planting plan. All canopy tree species planted and identified in the reference forest will be utilized to define “Characteristic Tree Species” as termed in the success criteria.

An average density of 320 stems per acre of Characteristic Tree Species must be surviving in the first three monitoring years. Subsequently, 290 Characteristic Tree Species per acre must be surviving in year 4 and 260 Characteristic Tree Species per acre in year 5. Planted species must represent a minimum of 30 percent of the required stems per acre total (96 stems/acre). Planted Characteristic Tree Species may serve as a seed source for species maintenance during mid-successional phases of forest development. Each naturally recruited Characteristic Tree Species may represent up to 10 percent of the required stems per acre total. In essence, seven naturally recruited Characteristic Tree Species may represent a maximum of 70 percent of the required stems per acre total. Additional stems of naturally recruited species above the 10 percent and 70 percent thresholds are discarded from the statistical analysis.

If vegetation success criteria are not achieved based on average density calculations from combined plots over the entire restoration area, supplemental planting may be performed with tree species approved by regulatory agencies. Supplemental planting will be performed as needed until achievement of vegetation success criteria.

No quantitative sampling requirements are proposed for herb assemblages as part of the vegetation success criteria. Development of floodplain forests over several decades will dictate the success in migration and establishment of desired understory and groundcover populations. Visual estimates of the percent cover of herbaceous species and photographic evidence will be reported for information purposes.

### 7.5 Report Submittal

An "as-built" plan drawing of the area, including initial species compositions by community type, and sample plot and well locations, will be provided after completion of planting. A discussion of the planting design, including the type of species planted, the species densities, and number of stems planted will be included. The report will be provided within 90 days of completion of all work.

Subsequently, reports will be submitted yearly to appropriate permitting agencies following each assessment. Reports will document the sample plot locations, along with photographs which illustrate Site conditions.

Groundwater monitoring gauge data will be presented. The duration of wetland hydrology during the growing season will also be calculated.

The survival and density of planted tree stock and natural recruitment will be reported and evaluated relative to the success criteria.

### 7.6 Contingency

In the event that vegetation or hydrology success criteria are not fulfilled, a mechanism for contingency will be implemented. For vegetation contingency, replanting and extended monitoring periods will be implemented if community restoration does not fulfill minimum species density and distribution requirements.

Hydrological contingency will require consultation with hydrologists and regulatory agencies if wetland hydrology restoration is not achieved during the monitoring period. Recommendations for contingency to establish wetland hydrology will be implemented and monitored until the hydrology success criteria are achieved.

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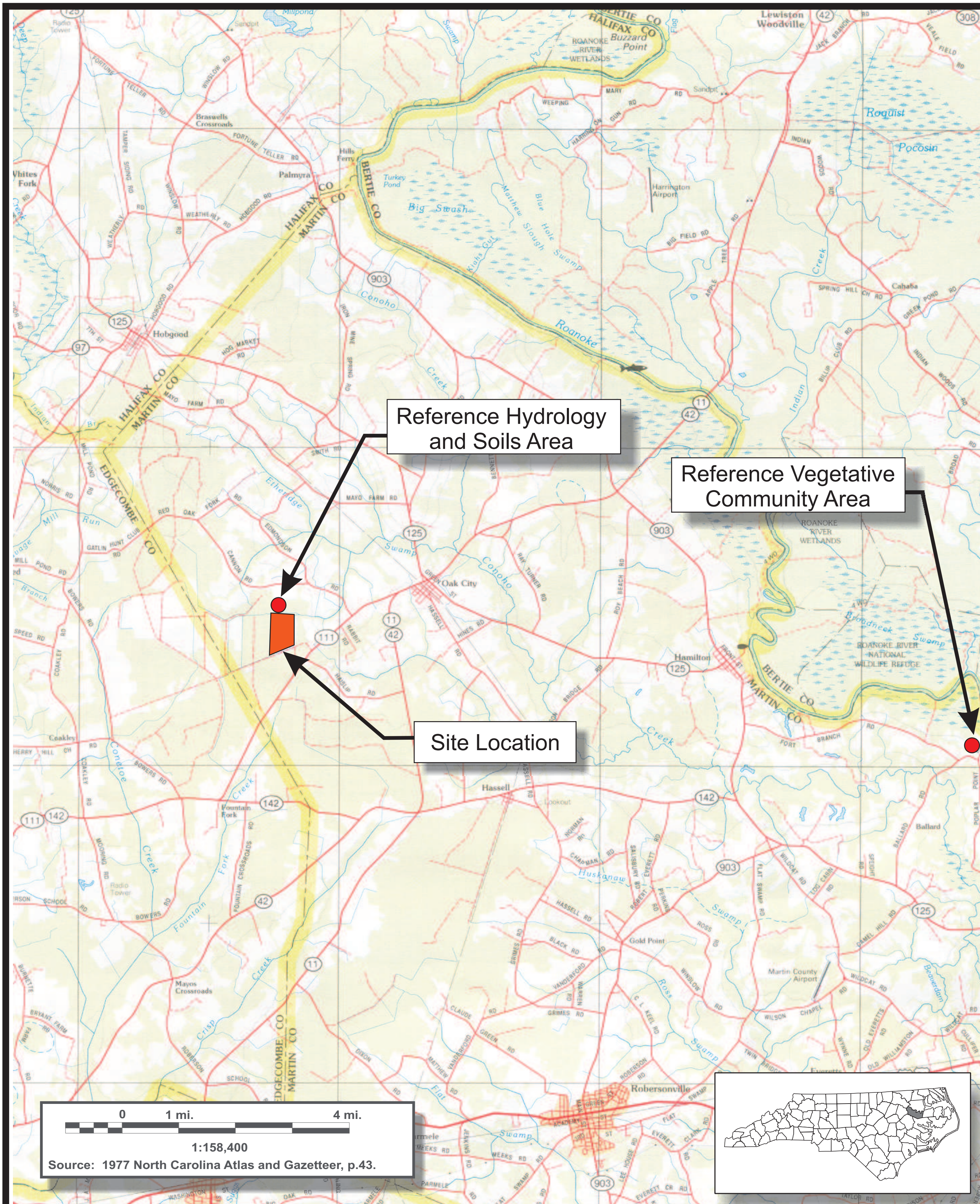
# APPENDIX A: FIGURES




Axiom Environmental
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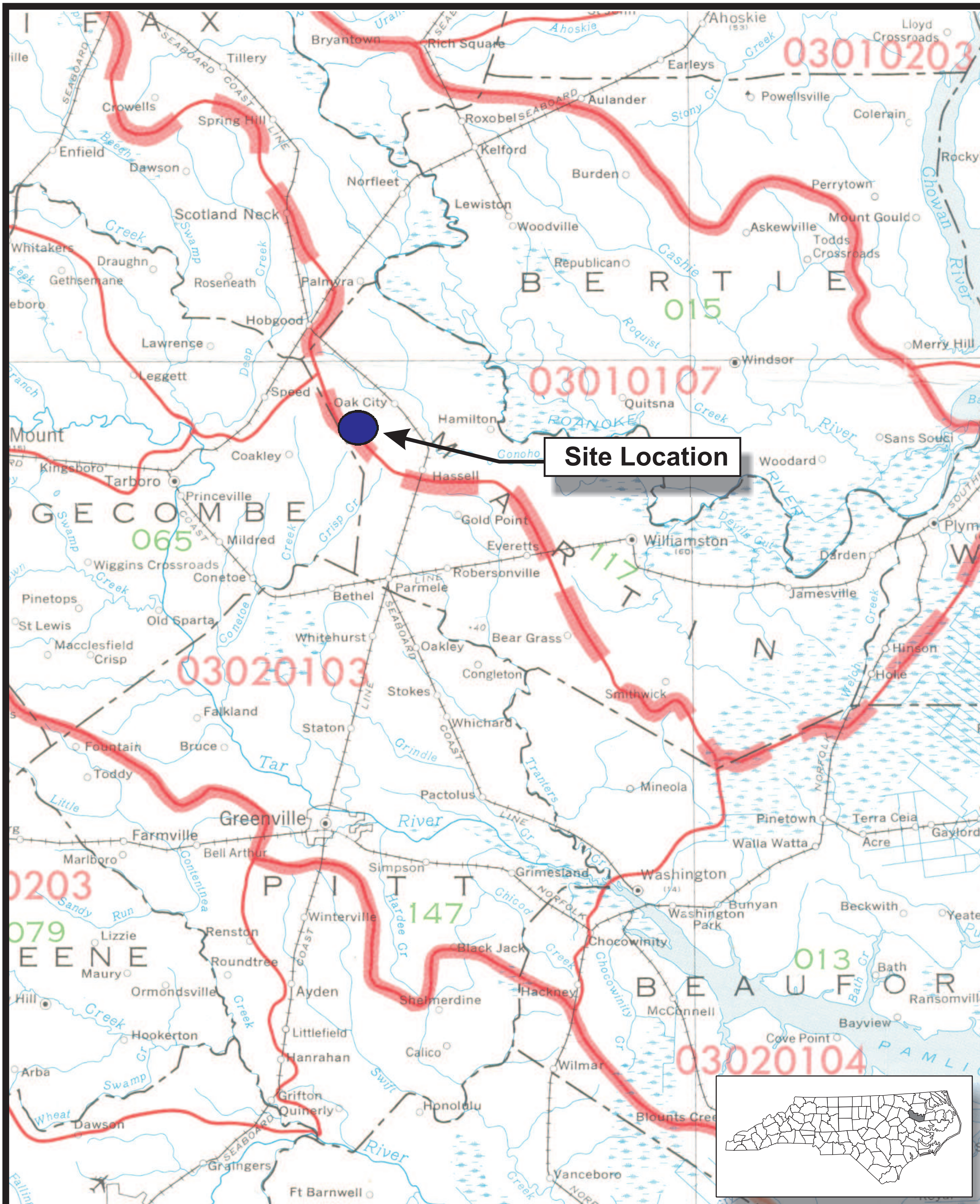
Willow Springs, NC 27592
(919) 215-1693
(919) 341-3839 fax

SITE LOCATION
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: | WGL |
| Ckd by: | WGL |
| Date: | Sept 2005 |
| Project: | 05-009 |

FIGURE
1





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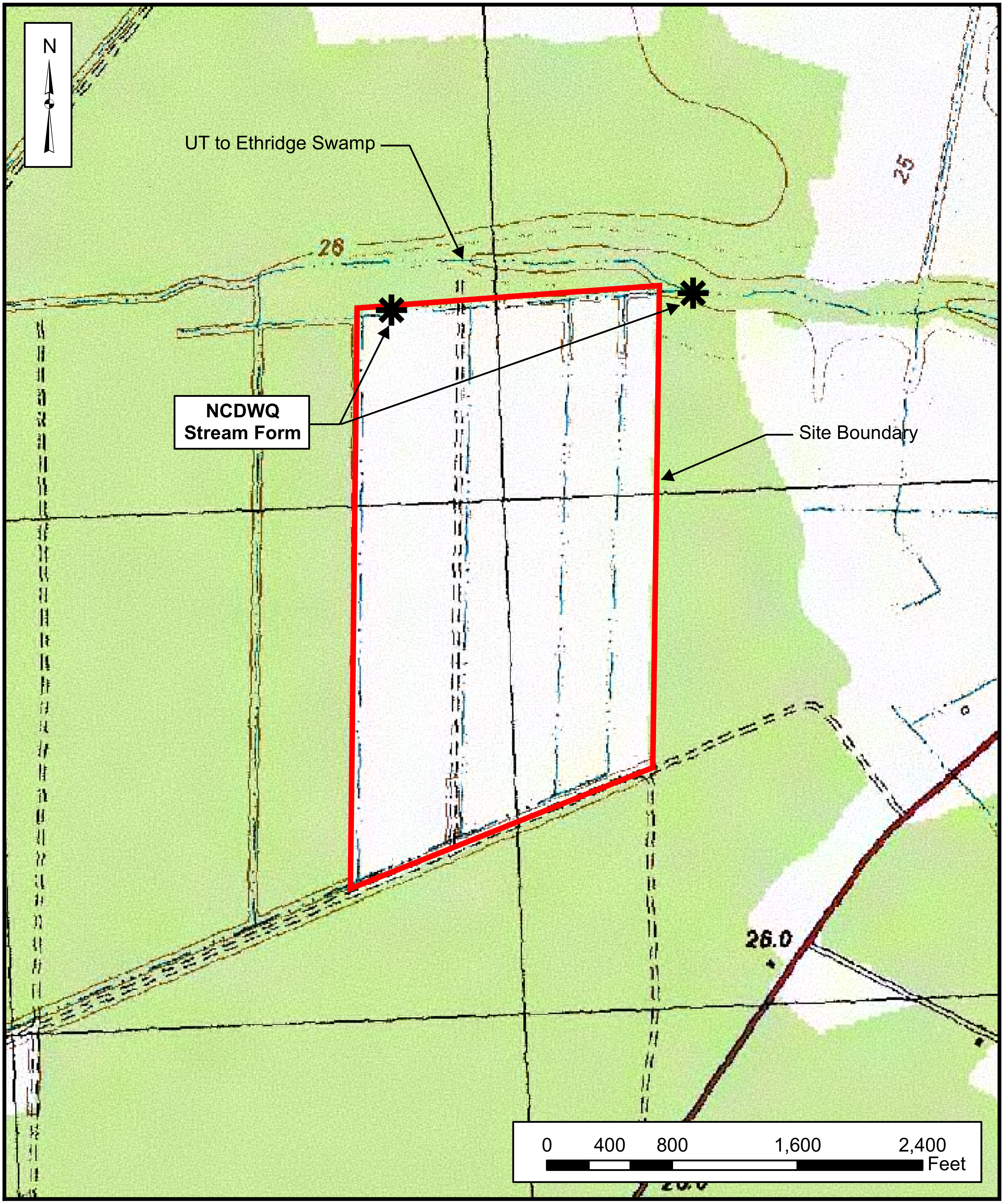
USGS HYDROLOGIC UNIT MAP
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: | WGL |
| Ckd by: | WGL |
| Date: | Sept 2005 |
| Project: | 05-009 |

FIGURE

2

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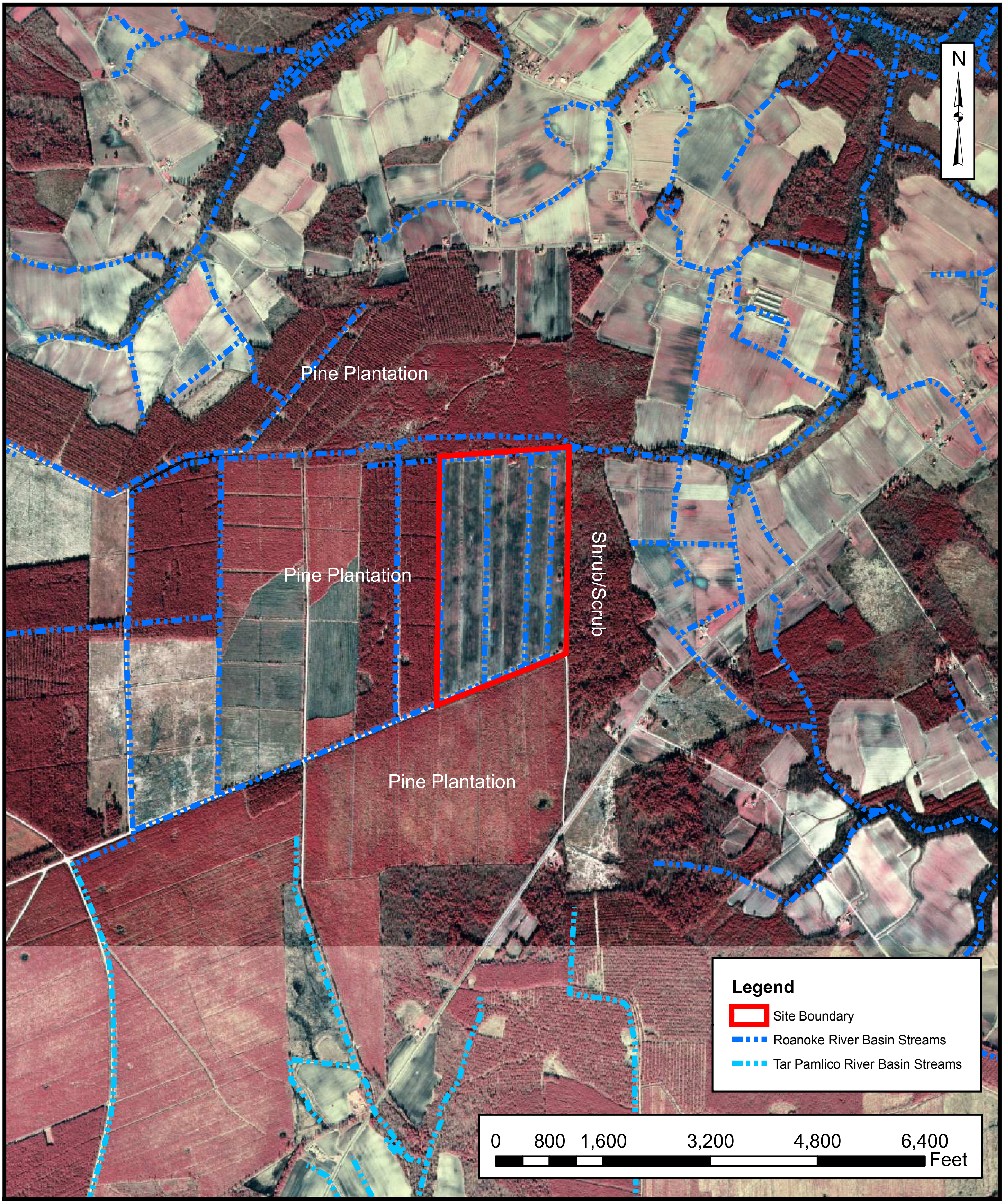
(919) 215-1693
(919) 341-3839 fax

TOPOGRAPHY
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by. WGL | FIGURE 3 |
| Date: Sept 2005 | |
| Project: 05-009 | |

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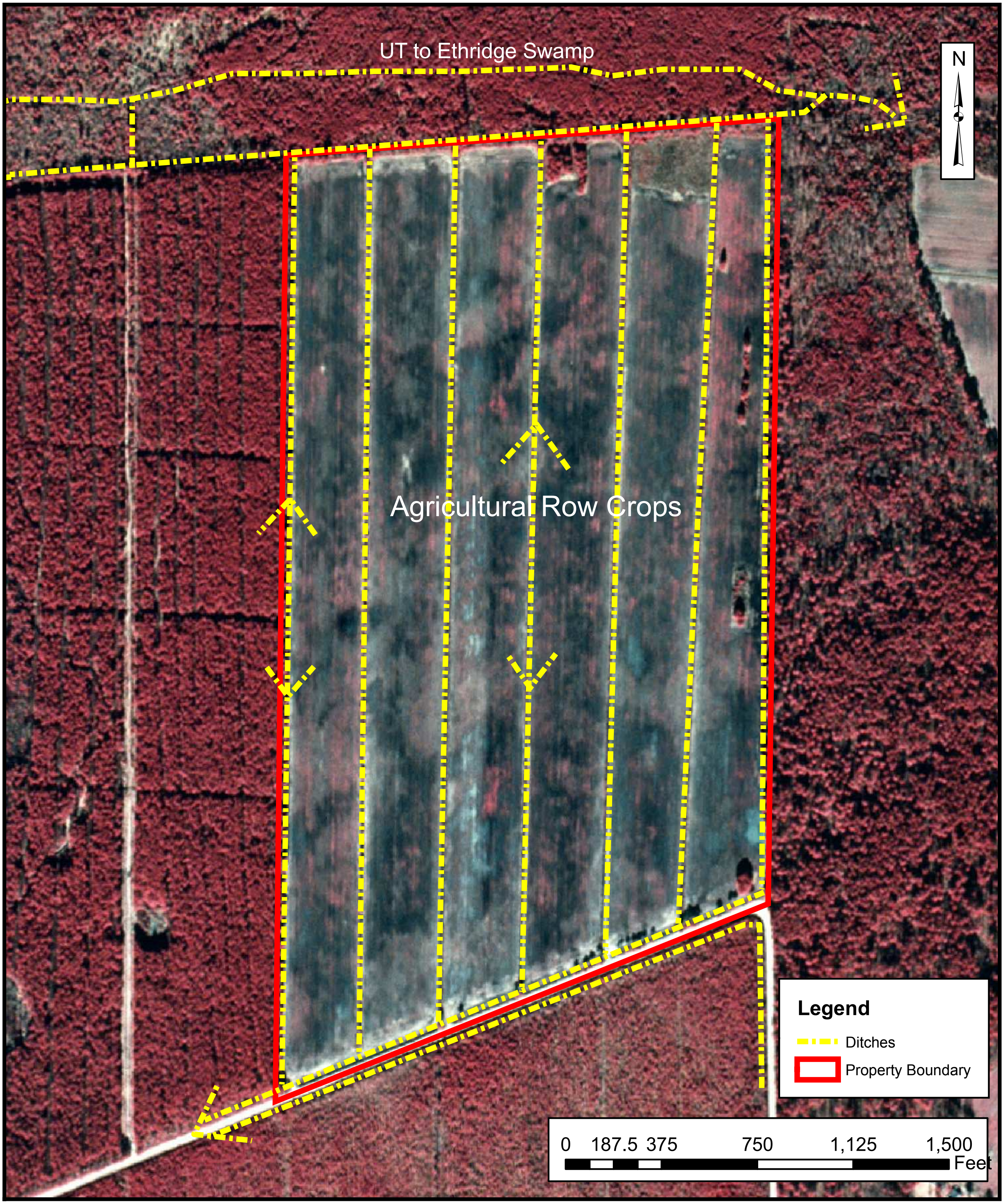
DRAINAGE AREA LAND USE
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

Dwn. by: WGL

Date: Sept 2005

Project: 05-009

FIGURE 4

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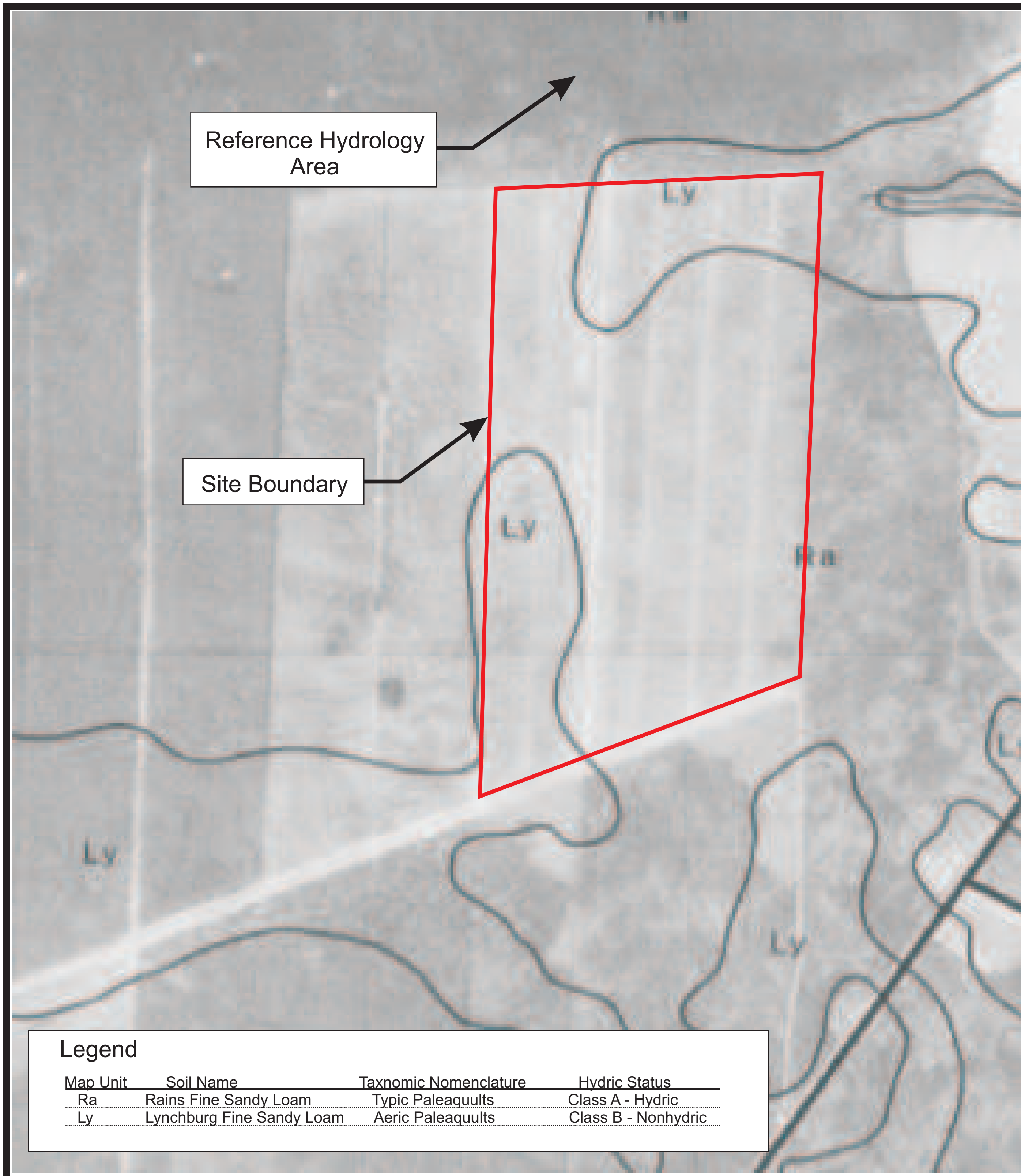
ON-SITE LAND USE
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by. WGL | FIGURE 5 |
| Date: Sept 2005 | |
| Project: 05-009 | |




## Legend

| Map Unit | Soil Name | Taxnomic Nomenclature | Hydric Status |
|---|---|---|---|
| Ra | Rains Fine Sandy Loam | Typic Paleaquults | Class A - Hydric |
| Ly | Lynchburg Fine Sandy Loam | Aeric Paleaquults | Class B - Nonhydric |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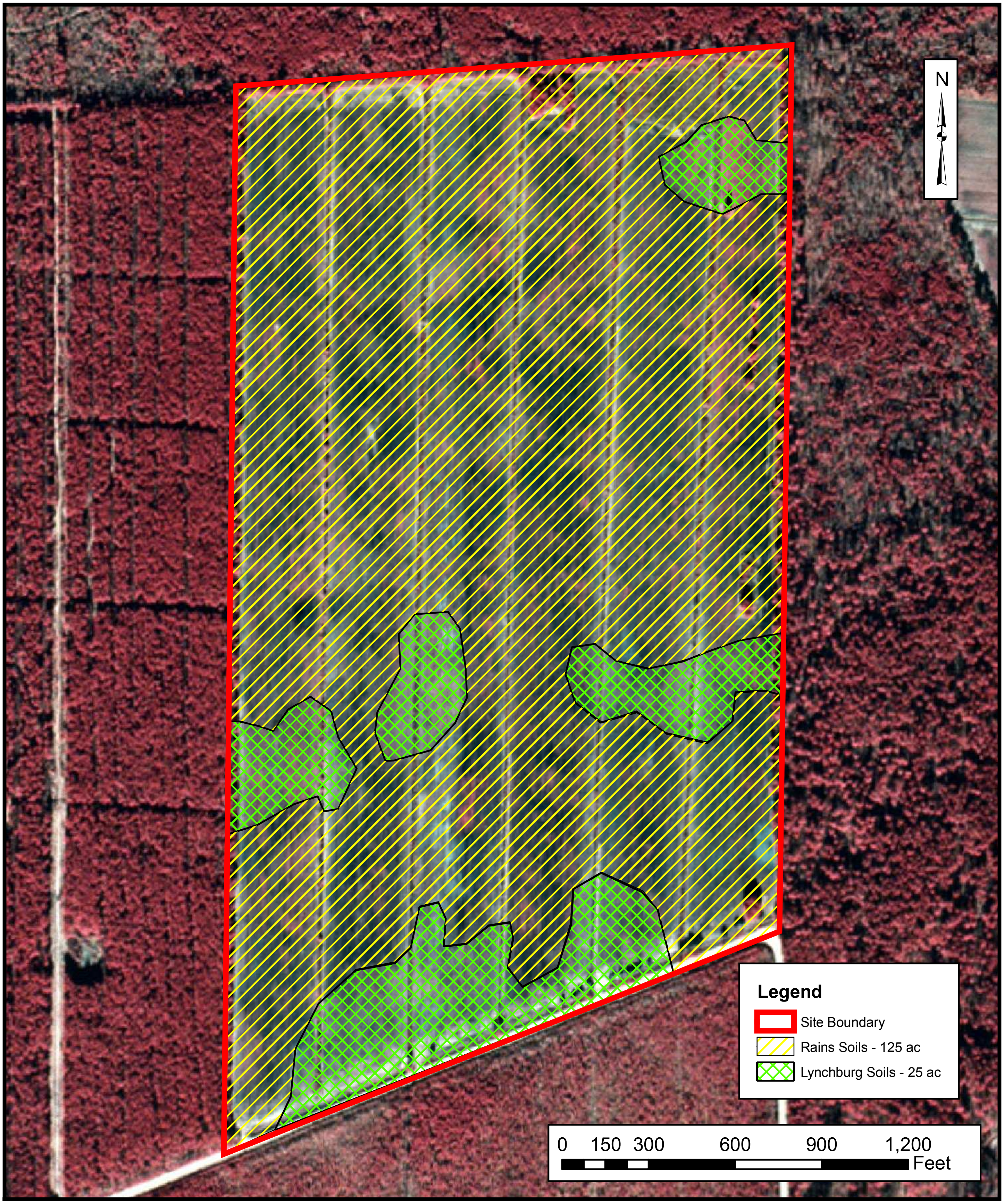
NRCS SOIL MAP
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: | WGL |
| Ckd by: | WGL |
| Date: | Sept 2005 |
| Project: | 05-009 |

FIGURE 6

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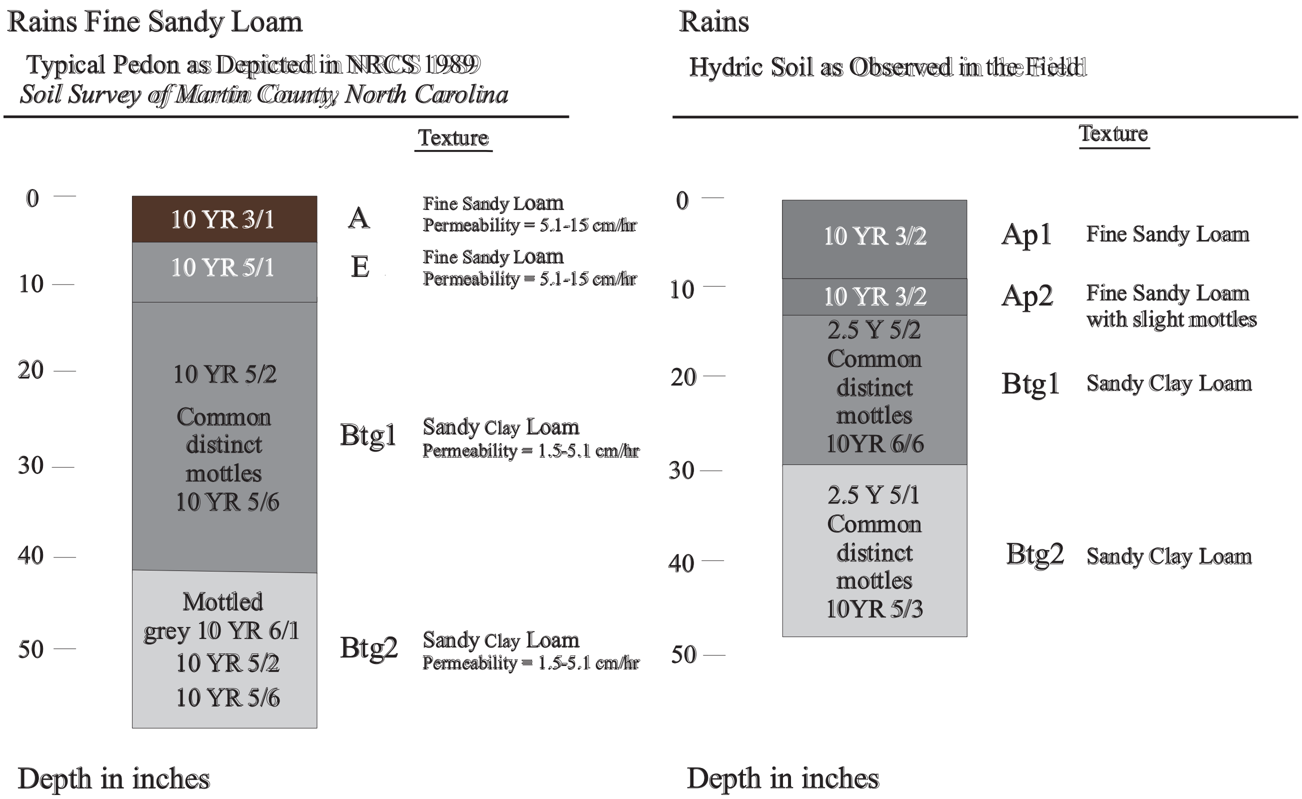
DETAILED SOIL MAPPING
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: WGL | FIGURE 7 |
| Date: Sept 2005 | |
| Project: 05-009 | |

# SOIL PROFILES

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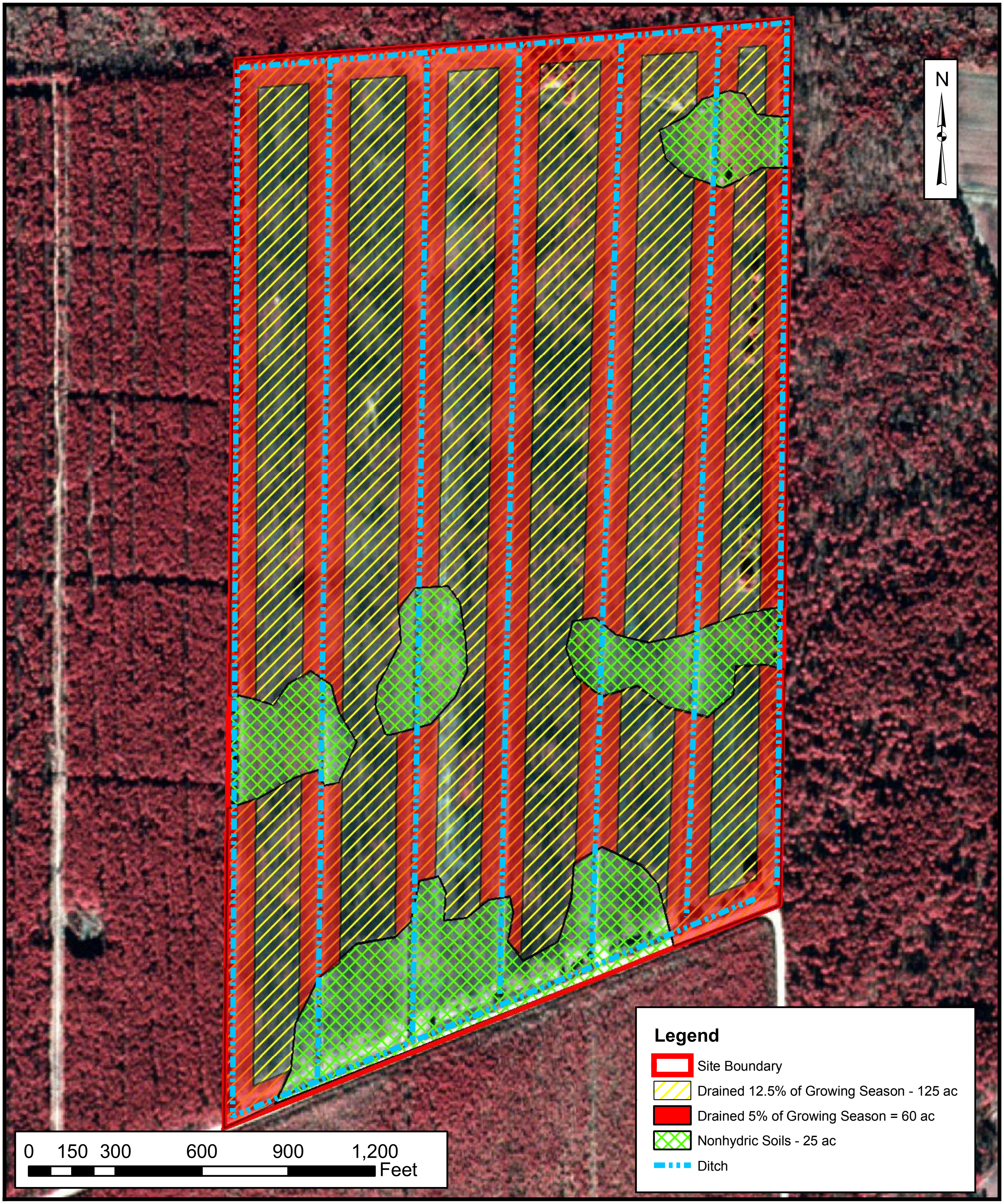
SOIL PROFILES
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: | WGL |
| Ckd by: | WGL |
| Date: | Sept 2005 |
| Project: | 05-009 |

FIGURE
8

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DRAINMOD - EXISTING CONDITIONS
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: WGL | FIGURE 9 |
| Date: Sept 2005 | |
| Project: 05-009 | |


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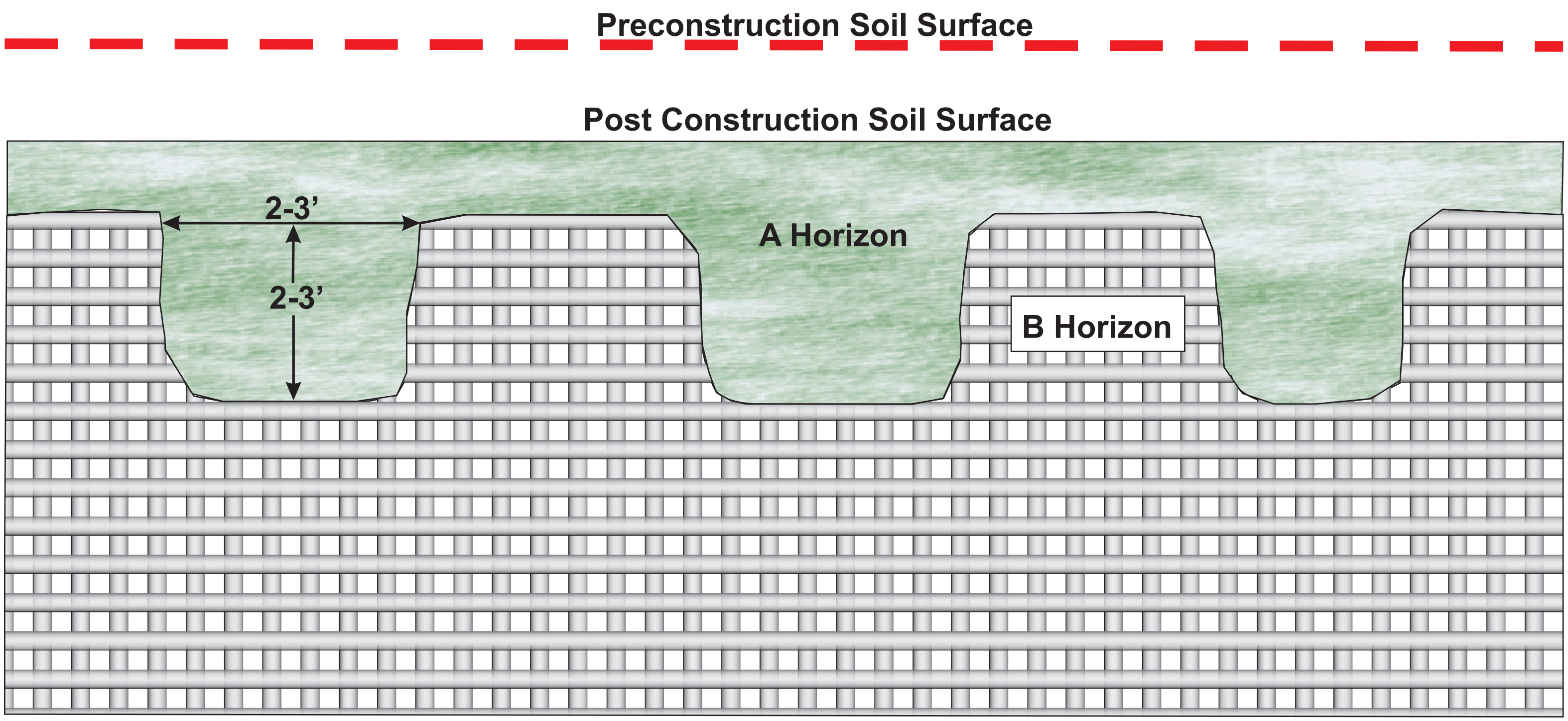
WETLAND RESTORATION PLAN
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| Dwn. by. | FIGURE |
|---|---|
| WGL | 10 |
| Date: Sept 2005 | |
| Project: 05-009 | |

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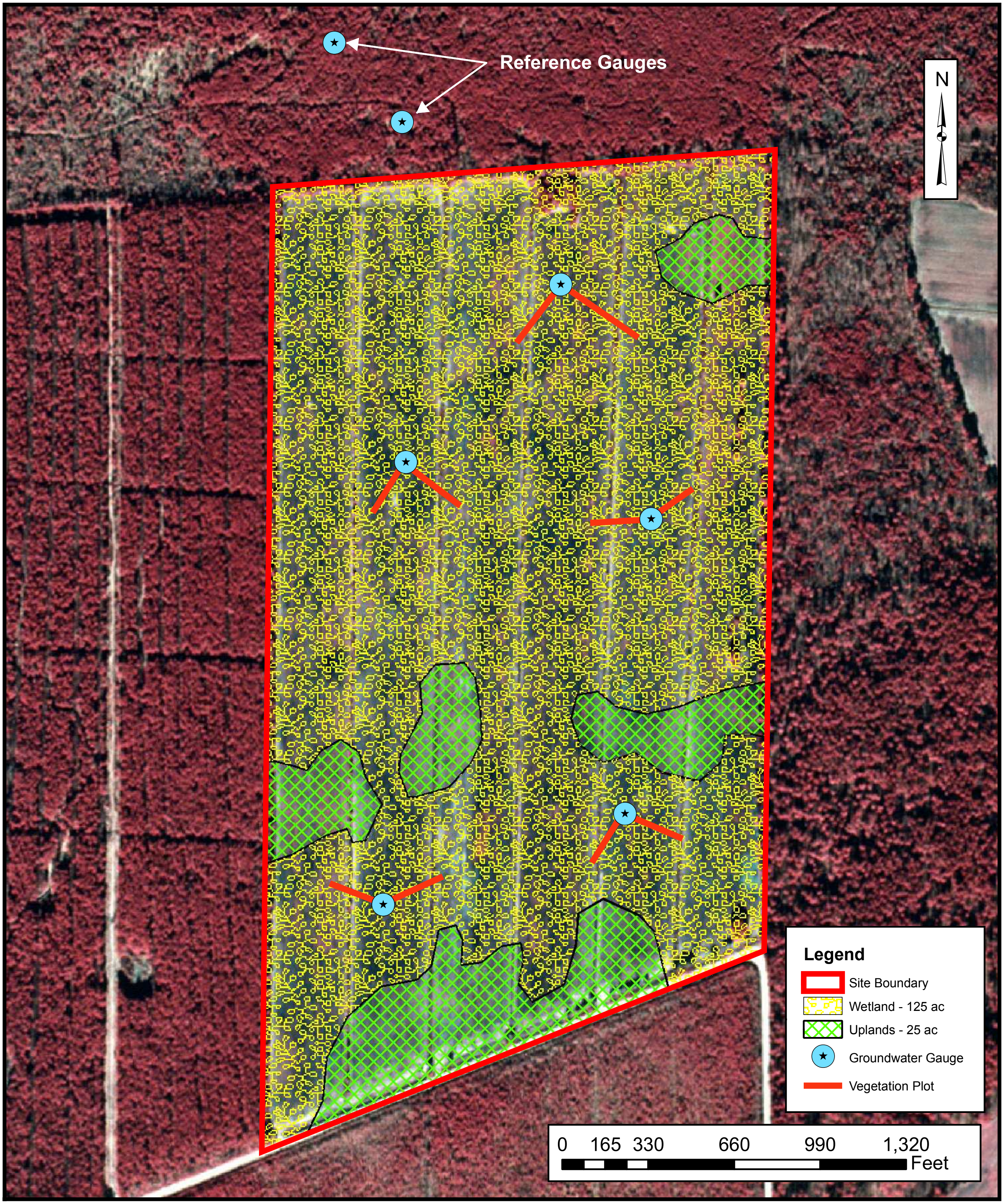
DEPRESSION CONSTRUCTION
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: | WGL |
| Ckd by: | WGL |
| Date: | Sept 2005 |
| Project: | 05-009 |

FIGURE
11

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Axiom Environmental

MONITORING PLAN
GATLIN SWAMP WETLAND RESTORATION SITE
Martin County, North Carolina

| | |
|---|---|
| Dwn. by: WGL | FIGURE 12 |
| Date: Sept 2005 | |
| Project: 05-009 | |

# APPENDIX B: NORTH CAROLINA DIVISION OF WATER QUALITY STREAM FORMS

Form 1 - Upstream

# NCDWQ Stream Classification Form

Project Name: Gatlin Swamp River Basin: Roanoke County: Martin Evaluator: Grant Lewis

DWQ Project Number: Nearest Named Stream: Esteridge swamp Latitude: Signature: W Grant Lr

Date: 7/21/05 USGS QUAD: Oak City Longitude: Location/Directions:

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

## Primary Field Indicators: *(Circle One Number Per Line)*

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

***PRIMARY GEOMORPHOLOGY INDICATOR POINTS:*** 1

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

***PRIMARY HYDROLOGY INDICATOR POINTS:*** 2

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

***PRIMARY BIOLOGY INDICATOR POINTS:*** 3

## Secondary Field Indicators: *(Circle One Number Per Line)*

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

***SECONDARY GEOMORPHOLOGY INDICATOR POINTS:*** 0

| II. Hydrology | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1) Is This Year's (Or Last's) Leaflitter Present In Streambed? | 1.5 | 1 | .5 | 0 |
| 2) Is Sediment On Plants (Or Debris) Present? | 0 | .5 | 1 | 1.5 |
| 3) Are Wrack Lines Present? | 0 | .5 | 1 | 1.5 |
| 4) Is Water In Channel *And* >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)* | 0 | .5 | 1 | 1.5 |
| 5) Is There Water In Channel During Dry Conditions *Or* In Growing Season)? | 0 | .5 | 1 | 1.5 |
| 6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)? | | ***Yes***=1.5 | ***No***=0 | |

***SECONDARY HYDROLOGY INDICATOR POINTS:*** 2

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

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

***SECONDARY BIOLOGY INDICATOR POINTS:*** 0.5

***TOTAL POINTS*** ***(Primary + Secondary)***= 14 ***(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)***

Form 2 - Downstream of Site

# NCDWQ Stream Classification Form

Project Name: Gatlin Swamp River Basin: Roanoke County: Martin Evaluator: Grant Lewis

DWQ Project Number: Nearest Named Stream: Etheridge Swamp Latitude: Signature: W Grant Lewis

Date: 7/21/05 USGS QUAD: Oak City Longitude: Location/Directions:

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

## Primary Field Indicators: *(Circle One Number Per Line)*

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

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

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

***PRIMARY GEOMORPHOLOGY INDICATOR POINTS:*** 4

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

***PRIMARY HYDROLOGY INDICATOR POINTS:*** 2

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

***PRIMARY BIOLOGY INDICATOR POINTS:*** 4

## Secondary Field Indicators: *(Circle One Number Per Line)*

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

***SECONDARY GEOMORPHOLOGY INDICATOR POINTS:*** 0.5

| II. Hydrology | Absent | Weak | Moderate | Strong |
|---|---|---|---|---|
| 1) Is This Year's (Or Last's) Leaflitter Present In Streambed? | 1.5 | 1 | .5 | 0 |
| 2) Is Sediment On Plants (Or Debris) Present? | 0 | .5 | 1 | 1.5 |
| 3) Are Wrack Lines Present? | 0 | .5 | 1 | 1.5 |
| 4) Is Water In Channel ***And*** >48 Hrs. Since Last ***Known*** Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)* | 0 | .5 | 1 | 1.5 |
| 5) Is There Water In Channel During Dry Conditions ***Or*** In Growing Season)? | 0 | .5 | 1 | 1.5 |

6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)? ***Yes***=1.5 ***No***=0

***SECONDARY HYDROLOGY INDICATOR POINTS:*** 3

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

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

***SECONDARY BIOLOGY INDICATOR POINTS:*** 1

***TOTAL POINTS*** ***(Primary + Secondary)***= 9 ***(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)***

# APPENDIX C: GROUNDWATER MODEL DATA (ON-SITE AND REFERENCE)