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Benson Grove Church Wetland Mitigation Plan
Johnston County, North Carolina

Consulting Project No. 98-RK-01/98-RK-07
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North Carolina Department of Transportation
Project Development and Environmental Analysis Branch

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WETLAND MITIGATION PLAN
BENSON GROVE CHURCH WETLAND MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA

EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) is constructing the Northern Wake Expressway (Raleigh Outer Loop) in Wake County, North Carolina (TIP No. R-2000) on new location. As part of this project, project segments 8.U401712 (R-2000EA) and 8.U401712 (R-2000EB) have been constructed or are in the process of being constructed. Pending segments include Project 8.U401712 (R-2000F), 8.U401711 (R-2000AA), 8.U401708 (R-2000AB) and U401712 (R-2000G). The intent of this wetland mitigation project is to provide compensatory wetland mitigation for impacts associated with Project 8.U401712 (R-2000F) and 8.U401712 (R-2000G) along a corridor approximately 8.9 miles (mi) [14.4 kilometers (km)] in length. The project exhibits potential to impact up to 19.98 acres (ac) [8.1 hectares (ha)] of wetlands.

NCDOT evaluated on-site wetland mitigation options and determined that suitable on-site mitigation opportunities were not available. Subsequently, NCDOT initiated a regional search for suitable mitigation sites within the Upper Neuse River Basin in 1998. This search resulted in the identification of a 81.91 ac (33.16 ha) site located in the Black Creek sub-basin (Hydrological Unit 030404) near Benson in Johnston County. This parcel is known as the Benson Grove Church Wetland Mitigation Site, hereafter known as the "Site". Based on the results of feasibility studies and a jurisdictional determination by the U.S. Army Corps of Engineers, NCDOT purchased the Site in 2000.

The Site is situated adjacent to Black Creek and has physiographic features consisting primarily of a riverine floodplain in transition with a lower floodplain terrace. Other features include seepage slopes and upland ridges. The Site has been in cultivation since the late 1940's. The Site includes a crescent-shaped ditch excavated to drain the property for agricultural purposes in the 1970's. Additionally, cultivation was further facilitated by diverting flow from an unnamed upstream tributary away from the Site with a low berm. Vegetation communities presently consist of successional meadow and shrub communities characteristic of fallow farm fields.

Alterations to the Site have induced significant degradation to the previously existing wetland system, including reductions in water table elevations, surface water storage, flood retention capacity, nutrient cycling functions, and wetland community structure. Approximately 35.52 ac (14.38 ha) of historic wetlands have been modified by the drainage and diversionary activities associated with the agricultural activities.

The Site has been managed primarily as pasture land in recent years and is presently fallow, facilitating natural re-vegetation. Incremental increase in beaver activity and downed trees from Hurricane Fran (1996) and Hurricane Floyd (1999) have increased the incident and duration of flooding on the property and this appears to be reducing impacts to the wetland system. However, significant areas remain under the drainage influence of historic ditching and stream diversion measures.

The purpose of this document is to: 1) describe the antecedent and existing conditions at the Site; 2) present a mitigation plan for restoring and preserving palustrine (river-influenced) wetlands; and 3) present a plan for monitoring and measuring success of restoration efforts. Wetland and stream mitigation activities have been designed to restore the historic wetland features and functions that existed on the Site prior to the drainage and diversion activities. Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology are diversionary berm removal, filling and plugging of the existing ditch and ditch backfilling. Subsequently, tree planting will occur throughout the Site to facilitate establishment of a bottomland hardwood forest community.

Upon implementation, restoration activities are expected to restore 35.52 ac (14.38 ha) of bottomland hardwood forest wetlands and preserve an additional 46.39 ac (18.78 ha) of bottomland hardwood forest wetlands. Modifications to existing drainage features is expected to restore Site hydrology to meet wetland criteria. Credits from the Site are expected to provide more than sufficient credits to offset the 19.98 ac (8.088 ha) of wetland impacts associated with the construction of project segments 8.U401712 (R-2000F) and 8.U401712 (R-2000G) of the Northern Wake Expressway (Raleigh Outer Loop) in Wake County, North Carolina (TIP No. R-2000).

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1.0 INTRODUCTION

The North Carolina Department of Transportation (NCDOT) is constructing the Northern Wake Expressway (Raleigh Outer Loop) in Wake County, North Carolina (TIP No. R-2000) on new location. As part of this project, project segments 8.U401712 (R-2000EA) and 8.U401712 (R-2000EB) have been constructed or are in process of being constructed. Pending segments include Projects 8.U401712 (R-2000F), 8.U401711 (R-2000AA), 8.U401708 (R-2000AB) and U401712 (R-2000G). The intent of this wetland mitigation project is to provide compensatory wetland mitigation for impacts associated with Project 8.U401712 (R-2000F) and 8.U401712 (R-2000G) along a corridor approximately 8.9 miles (mi) [14.34 kilometers (km)] in length. The project exhibits potential to impact up to 19.98 acres (ac) [8.09 hectares (ha)] of wetlands.

NCDOT evaluated on-site wetland mitigation options and determined that suitable on-site mitigation opportunities were not available. Subsequently, NCDOT initiated a regional search for suitable mitigation sites within the Upper Neuse River Basin in 1998. This search resulted in the identification of a 81.91 ac (33.16 ha) site located in the Black Creek sub-basin (Hydrological Unit 030404) near Benson in Johnston County. This parcel is known as the Benson Grove Church Wetland Mitigation Site, hereafter known as the "Site". Based on the results of feasibility studies and a jurisdictional determination by the U.S. Army Corps of Engineers, NCDOT purchased the Site in 2000.

This document represents detailed mitigation procedures to facilitate the implementation of restoration and preservation activities on the Site. The purpose of this document is to: 1) describe the historical, antecedent and existing conditions at the Site; 2) present a mitigation plan for restoring and preserving palustrine (river-influenced) wetlands; and 3) present a plan for monitoring and measuring success of restoration efforts.

1.1 METHODS

Aerial photography was prepared by GeoData Corporation in 1999 for mitigation planning purposes. Topographic mapping to one-foot contour intervals was generated from the photography. In 2000, additional land surveys were performed to plat property boundaries, provide the ditch location and cross-sections in obscured areas, and to determine groundwater gauge locations and elevations.

Field reconnaissance was performed to validate published resource inventories and to identify areas of particular environmental concern. Resources utilized in support of the field effort include U.S. Geological Survey (USGS) topographic mapping, U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) mapping (Benson, NC USGS 7 1/2 minute quadrangle), and Natural Resource Conservation Service (NRCS) soils information for Johnston County (USDA 1986).

North Carolina Natural Heritage Program (NCNHP) data bases and US Fish and Wildlife (USFWS) were consulted for the presence of protected species whose ranges extend into Johnston County and designated Rare and/or Unique Natural Area near the Site. State

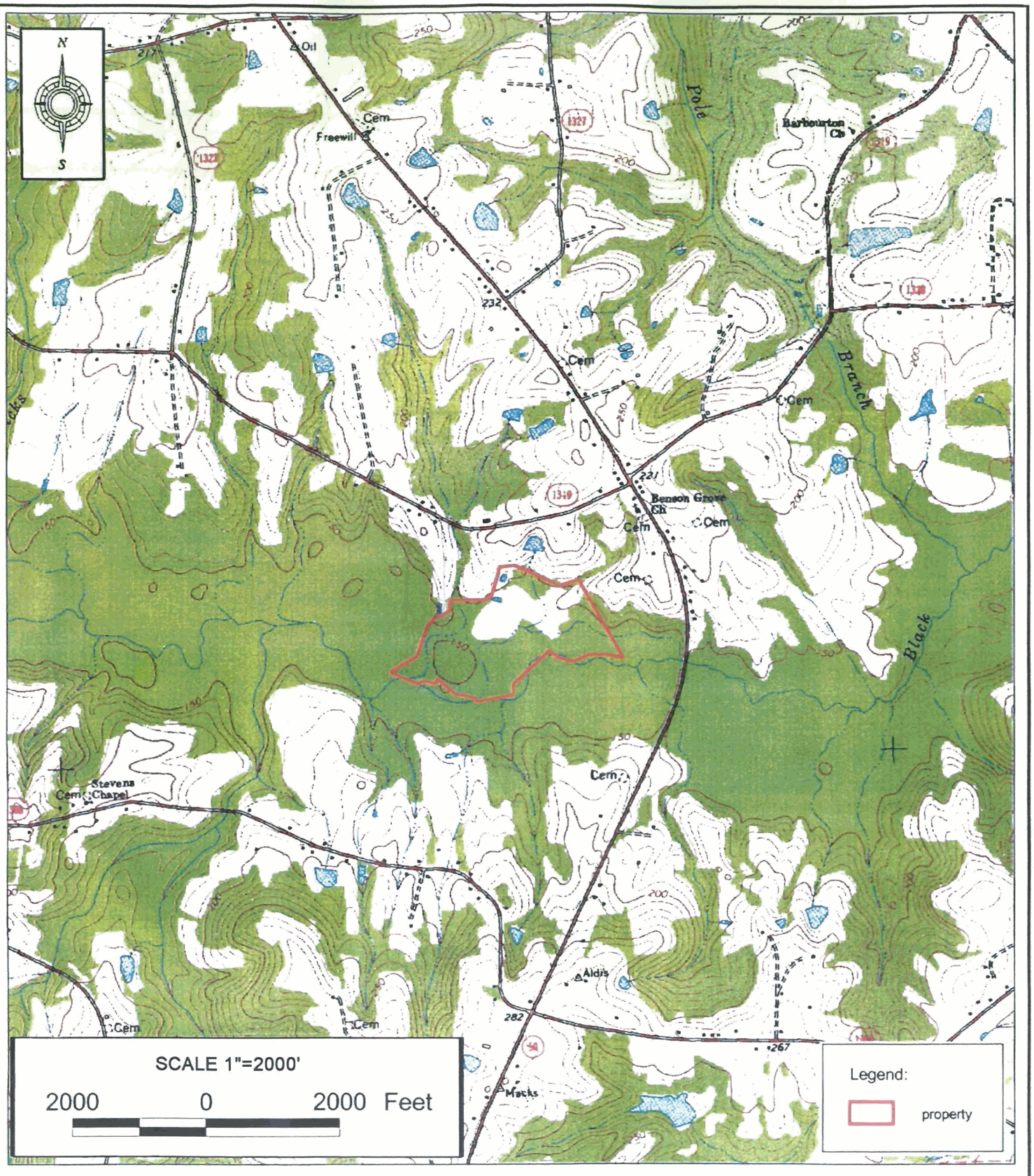
Historic Preservation Office (SHPO) records were evaluated for the presence of significant cultural resources in the vicinity.

Field investigations were initiated in 1999 and include hydrological evaluations, an independent detailed review of NRCS soil mapping, and evaluation of on-site resources. Existing plant communities, surface water flow, and soil disturbances were delineated, mapped, and described by structure and composition. The US Army Corps of Engineers conducted a review and made a formal jurisdictional determination regarding the Site on November 10, 1999.

Fourteen continuous groundwater monitoring gauges were installed to provide groundwater data and wetland hydroperiod information relative to the natural influence of Black Creek and the existing drainage features. Data on Site groundwater hydrology has been obtained from two growing seasons (1999 and 2000).

Field survey and study information was compiled to evaluate the Site under existing conditions. Interviews were conducted with the son of the previous owner to determine the major agricultural activities that disrupted Site hydrology and their timing. Where gaps in information on the previous Site conditions exist, the investigators were able to accurately speculate utilizing observations from aerial photographs, Site contours, and gauge data.

Land use and how this relates to the hydraulic conditions of the Site will be described throughout this document. Conditions will be referred to as 1) existing conditions; 2) antecedent conditions; and 3) historic conditions. Existing conditions describe the present conditions. Antecedent conditions include the period beginning in the 1930's and the subsequent conversion of the Site to crop land and historic conditions describe the time period prior to entry of mechanized equipment in the 1930's.



No	REVISIONS	DATE

USGS 7.5 Minute Quad:
Benson, NC

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA

SITE LOCATION MAP

Dwn By:	Date	Figure
Ckd By:	Scale:	1

2.0 SITE DESCRIPTION

2.1 SITE CONDITION

2.1.1 Existing Conditions

The Site is located in the upper part of the southern Coastal Plain Physiographic Province. The landscape is characterized by broad, gently rolling inter-stream divides, intermixed with steeper slopes bordering well-defined drainage ways, with wide floodplains. The Site is situated in the Black Creek floodplain within the greater Neuse River Basin (Hydrological Unit 030404).

The Site comprises approximately 81.91 ac (33.16 ha) and is located just west of NC 50 on SR 1319 (Zacks Mill Rd) in Johnston County (**Figure 1** – Site Location Map). The property is irregularly-shaped and lies lengthwise along an east-west axis. Black Creek forms the boundary along the southern edge of the property, and upland slopes border the northern boundary (**Figure 2** - Site Map).

The Site consists predominantly of a riverine floodplain terrace. This landscape unit extends as a broad band lengthwise through the Site, from the gradual slope to Black Creek, with continuous connectivity to Black Creek. Elevations on the property vary from 143.2 feet (ft) [43.65 meters (m)] (above sea level) at the lower southeastern corner, to 149.1 ft (45.45 m) at the northwestern corner. The property gradually grades down from west to east. On the lowest-lying portion of this terrace (the uncultivated segments), the normal water elevations of Black Creek keep these saturated almost continuously.

Bordering the western property line is an unnamed tributary. This tributary has been diverted with a ditch and berm to connect to Black Creek upstream of the Site. This tributary has a drainage basin of 380.7 ac (154.1 ha).

Groundwater slopes, bordering the northern edge of the Site, include gradually sloped banks adjacent to the floodplain terrace. This area is separate from the drainage basin of the unnamed tributary bordering the western edge of the property. Additional flow is directed through the Site from this watershed area 158.1 ac (64.0 ha) in size. Numerous seeps exhibit a near continuous, surficial expression of groundwater along the incline of the slope uphill of the property.

The two dominate hydrodynamic influences at the Site are overbank flooding of Black Creek and flow from the unnamed tributary bordering the western property line.

The US Army Corps of Engineers conducted a review of the Site and made a formal jurisdictional determination on November 10, 1999. The jurisdictional boundary is marked and identified on **Figure 2** – Site Map. Part of this jurisdictional determination included a review of information provided by the Natural Resources Conservation Service (NRCS) regarding "Prior Converted" agricultural areas. "Prior Converted" determinations are made based on the agricultural development and agricultural use history as it pertains to a Site, and not necessarily on the three-parameter approach as it may exist at any given time.

2.1.2 Antecedent Conditions

According to James Stuart, son of the former property owner, W. C. Stuart, the Site was completely wooded when they took possession of the property in 1947. The Site was gradually cleared for agriculture over the next decade. Mr. Stuart reported that during the 60's and 70's, Black Creek was "real clear" of snags and blockages to drainage. The local farming community removed fallen trees quickly and beaver activity was minimal. This situation changed gradually over the 80's when flooding became more frequent and of longer duration. Mr. Stuart attributed this to increased beaver activity and the gradual decrease in agricultural activities.

Because of the increase in flooding from the river, the Stuarts, along with other property owners in the area, timbered virtually all of the Black Creek floodplain in the early 1990's. Interviews with representatives of Georgia-Pacific who handled the sale of the Stuart's timber verify Mr. Stuart's account. Joe Evans, a Forester with Georgia Pacific, mentioned during an interview in May, 2001, that beaver activity increased to such a level in the early 1990's that the Stuart's and other property owners in the area were in danger of losing timber investments due to increased flooding incidents.

Mr. Stuart indicated the crescent-shaped ditch was excavated with a tracked hoe in the early 1970's. Spoil from the excavation was placed on the east side of the channel and allowed to dewater. Approximately a year later, the spoil was leveled over the adjacent uplands with a bulldozer. Mr. Stuart said the ditch is crescent-shaped, as opposed to being straight, because it connected all the "low areas" along its length. The ditch is approximately 1,704 ft (519 m) in length.

The lower pond was excavated in the late 70's and early 80's with a dragline. The spoil material was leveled significantly with the dragline initially, and spread with a bulldozer a year or two later. Mr. Stuart said the spoil was only spread a short distance around the pond by using the dozer primarily in "back blade" mode. He did not recall any significant leveling of the spoil into the adjacent fields. The pond was excavated to provide a water source for cattle.

Mr. Stuart mentioned seeps on the adjacent uplands. He said these seeps are perennial and have observable flow. Prior to the ditch excavation, Mr. Stuart believes the seeps kept large portions of the subject property saturated almost continuously. Additionally, the upper end of the crescent-shaped ditch terminates at a perennial spring created by the outlet from the tile drainage system under the adjacent tobacco field.

Mr. Stuart commented that the Site has always been wetter than the surrounding farmland. The property was last cultivated with row crops (corn) in 1994. Since then, the property has been a pasture. Mr. Stuart said the hurricanes of the 90's (Fran and Floyd) increased the number of downed trees in the creek. Because of this, and the relatively constant increase in beaver activity, the incidents and duration of flooding have increased even more in recent years. Photographs received from the Smithfield Office of the Agricultural Stabilization and Conservation Service (ASC) are shown in **Figure 3**.

2.1.3 Historic Conditions

Under historic conditions, it is postulated the Site was wooded and was part of the larger Coastal Plain Bottomland Hardwood Forest - Blackwater Subtype that occupied the broad floodplain of Black Creek. With the entry of mechanized equipment into agriculture in the 1930's, regional land clearing likely increased stream sediment loads and farming activities altered Coastal Plain Bottomland Hardwood Forest - Blackwater Subtype ecological settings into Coastal Plain Bottomland Hardwood Forest - Brownwater Subtype (Schafale and Weakley).

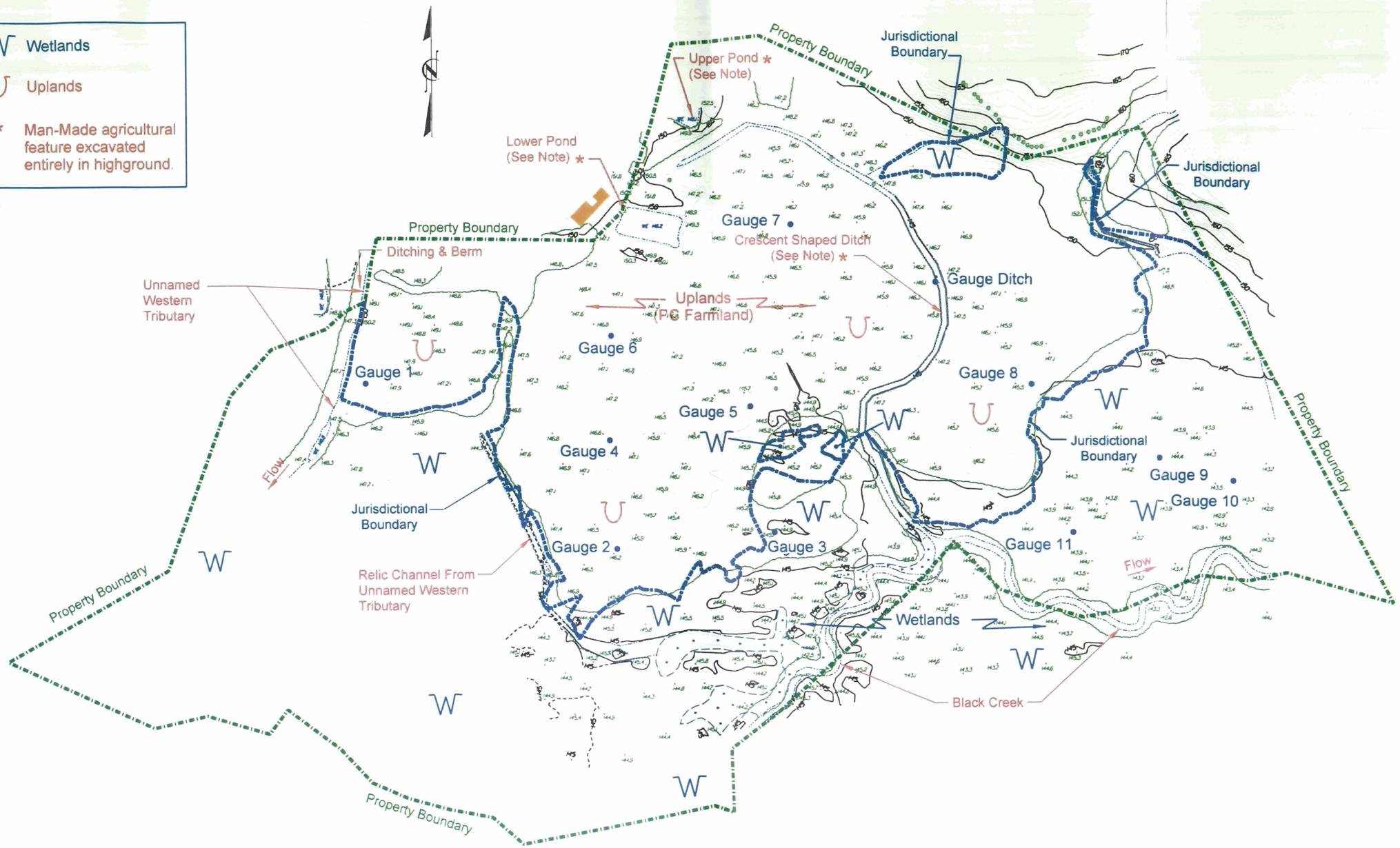
2.1.4 Site Condition Summary

Alterations to the landscape by previous activities include excavation of the crescent-shaped ditch and the diversion of the unnamed tributary bordering the western property line. This ditch begins as a linear-shaped wet depression on the northwest side, and makes a long arch over to the center of the property, where it curves and runs south, eventually connecting to Black Creek. Along this course, water depths progressively increase (**See Figure 2** – Site Map).

The crescent-shaped ditch is designed to direct waters from flooding events back to Black Creek as quickly as possible. This is effective at draining surface waters from the Site, but its effectiveness is dependent on the duration of the flooding of Black Creek. As will be seen later in this report with the presentation of the gauge data, the crescent-shaped ditch is effective in removing floodwaters, runoff and seepage, sufficient enough to allow cultivation of the Site.

From a review of aerial photography and from Site inspections, it appears the unnamed western-most tributary had a natural channel that previously extended across the southwest corner of the Site. Evidence indicates possibly some of the earliest activities related to preparing the property for agricultural purposes involved diverting and filling portions of this channel. This is further evidenced by the ditch and berm that extend along the property line that divert the stream channel to Black Creek. Additional evidence of this diversion includes the relic channel along the southern portion of the Site. The flow and flooding associated with this unnamed tributary likely had a negative influence on attempts to clear and cultivate the Site. Once the flow was diverted, the flow and flooding ceased (or was greatly reduced) and the relic channel served as an additional Site drainage feature (**See Figure 2** – Site Map).

The incremental increase in beaver activity and downed trees from Hurricane Fran (1996) and Hurricane Floyd (1999) appear to have increased the incident and duration of flooding on the Site. This appears to be reducing impacts to the wetland system over time. However, significant areas remain under the drainage influence of the crescent-shaped ditch and the diversionary berm associated with the unnamed tributary to the west.



No.	REVISIONS	DATE

Figure 2

Date:

Scale:

Dwn By:

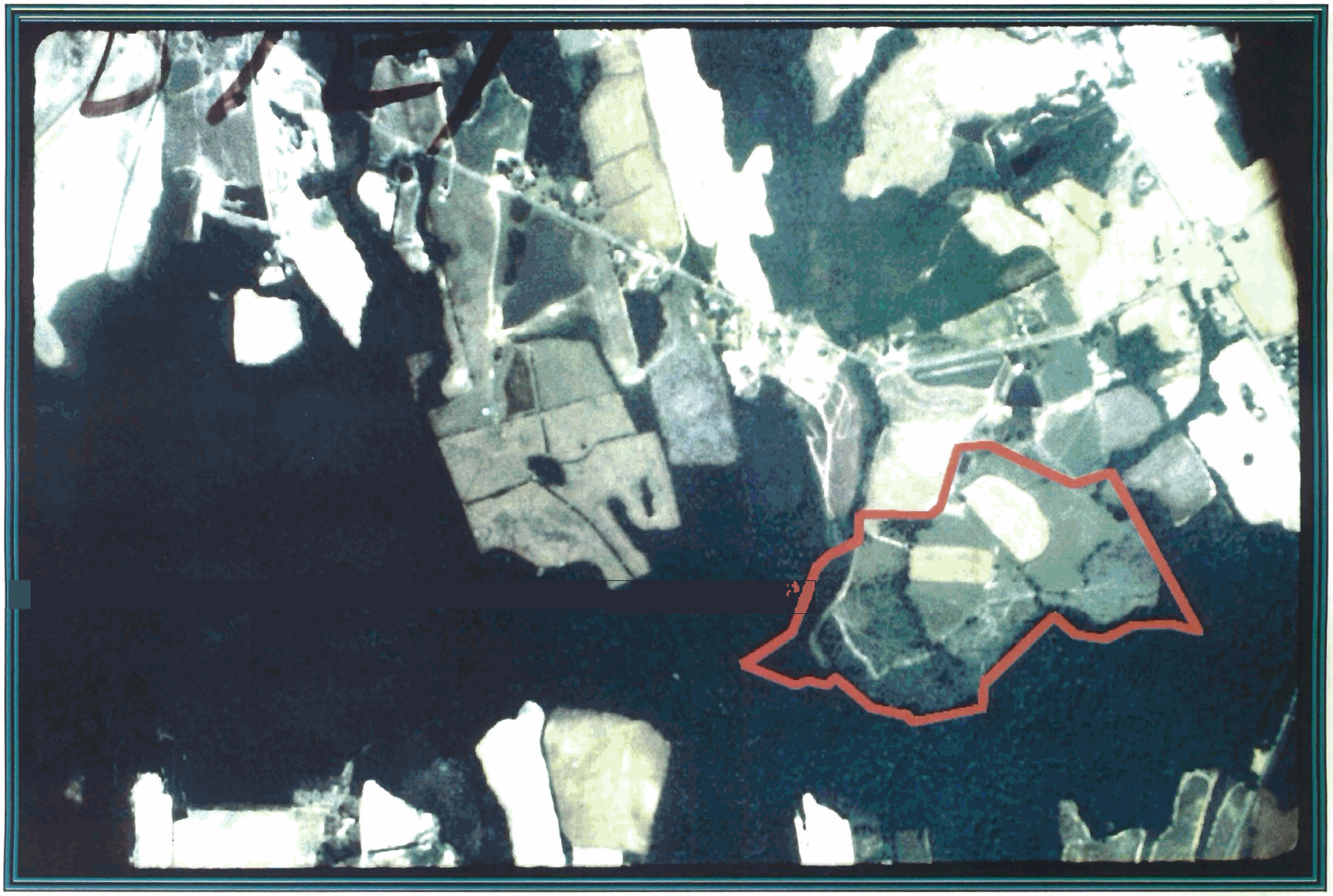
Ckd By:

Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA

SITE MAP

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

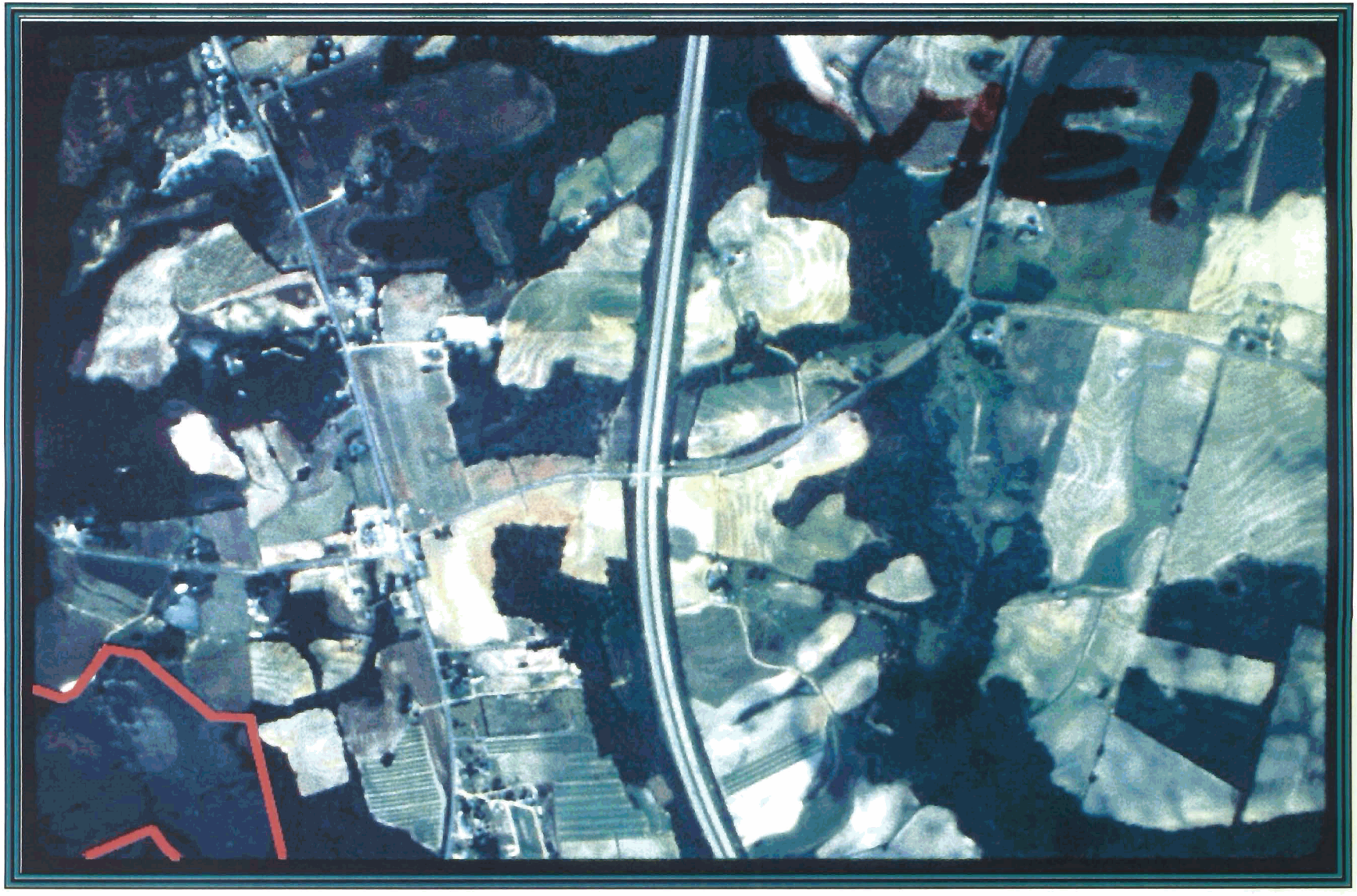


Benson Grove Wetland Mitigation Site
ASCS Photography 1994

FIGURE 3a

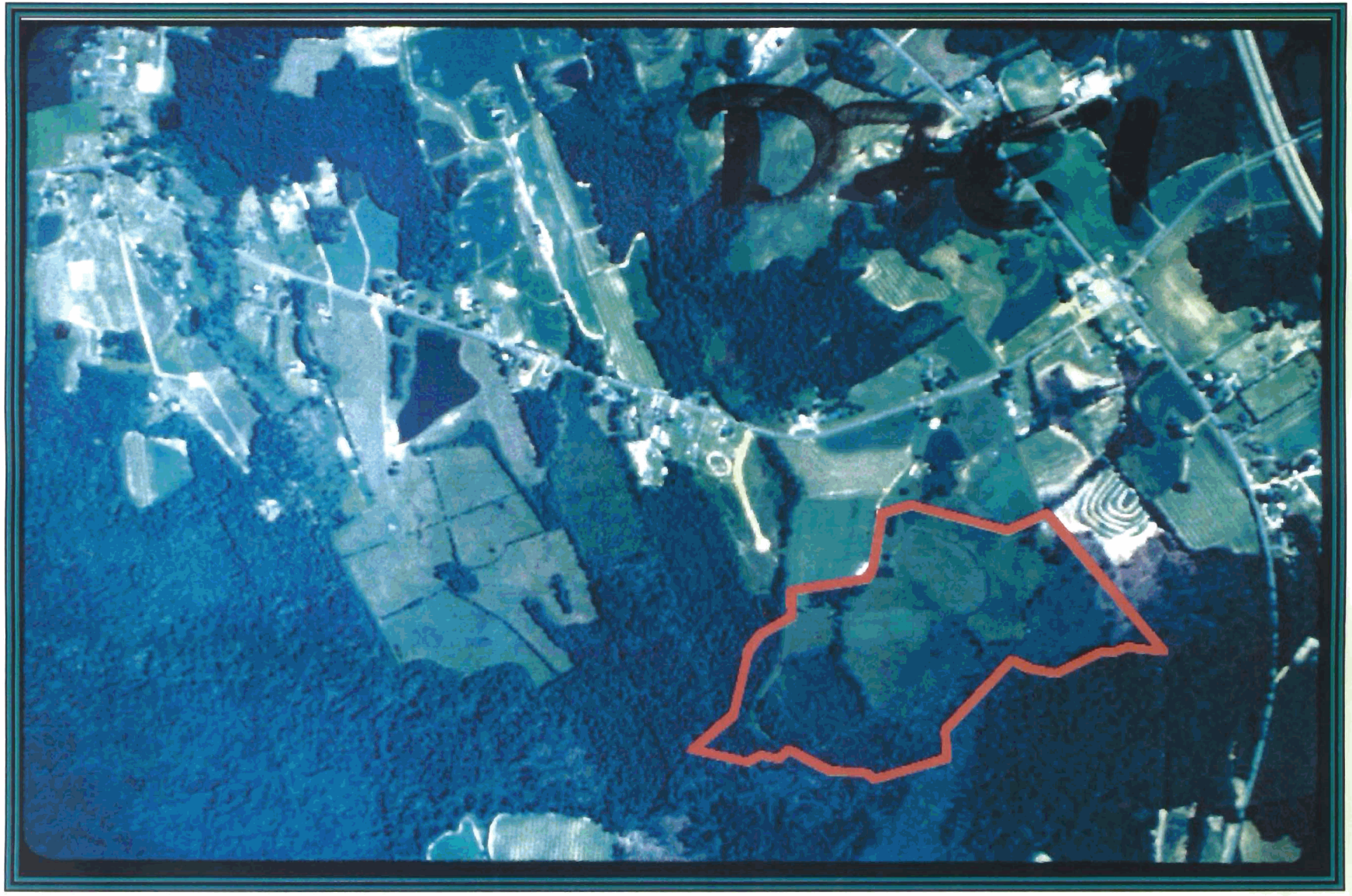
Benson Grove Wetland Mitigation Site
ASCS Photograph (Early)1995

FIGURE 3b



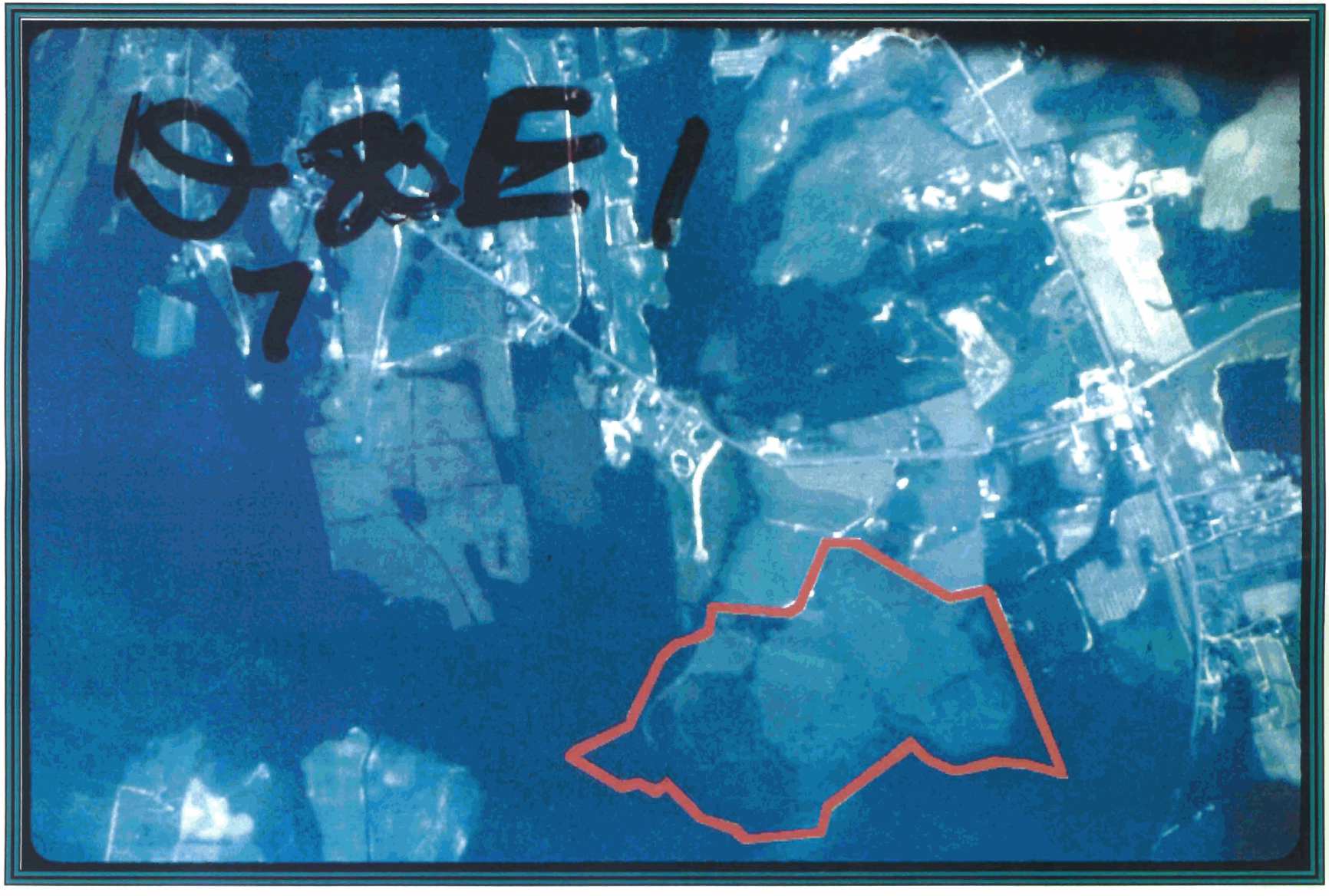
Benson Grove Wetland Mitigation Site
ASCS Photograph (Late)1995

FIGURE 3c



Benson Grove Wetland Mitigation Site
ASCS Photograph 1996

FIGURE 3d

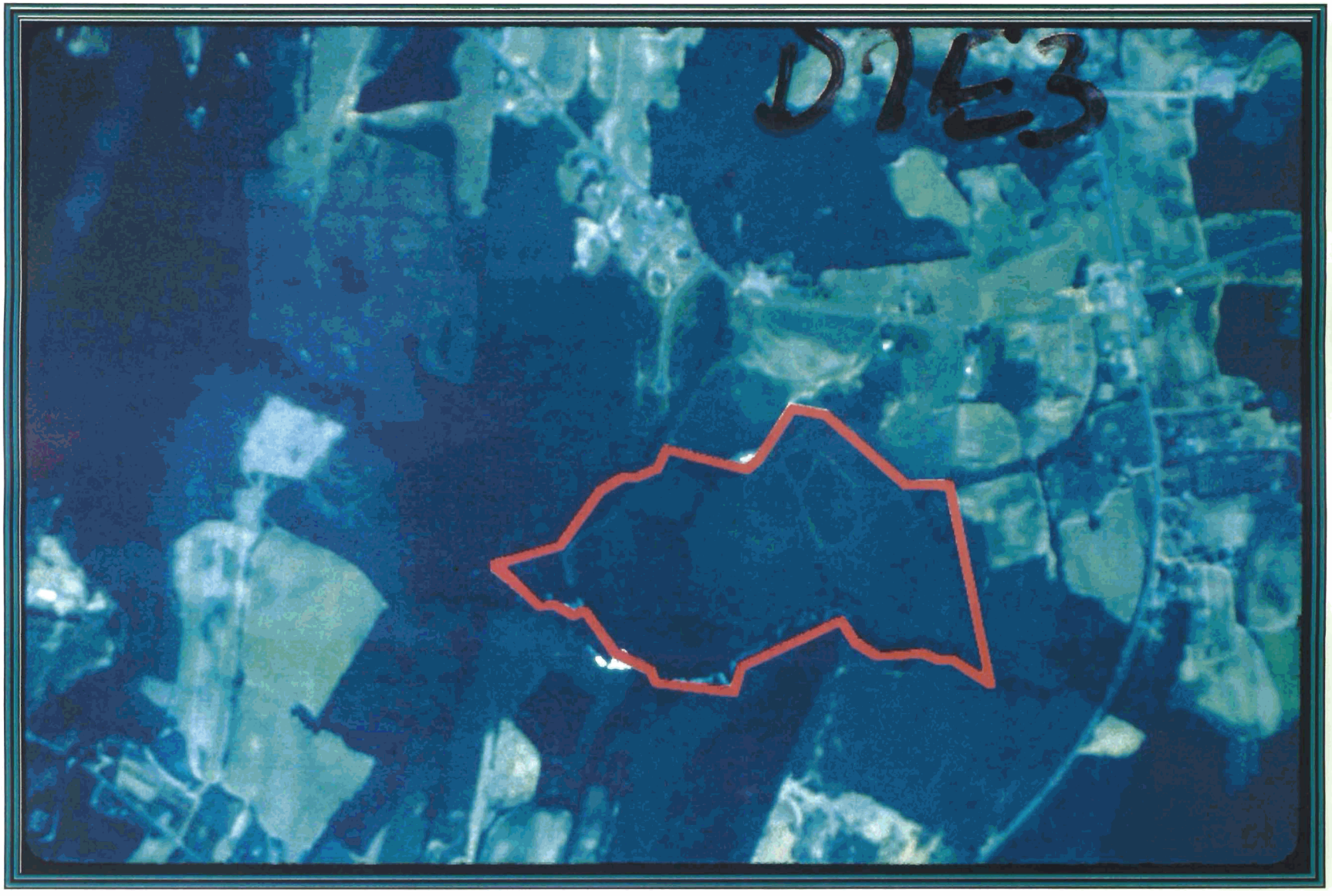


Benson Grove Wetland Mitigation Site
ASCS Photograph 1997

FIGURE 3e

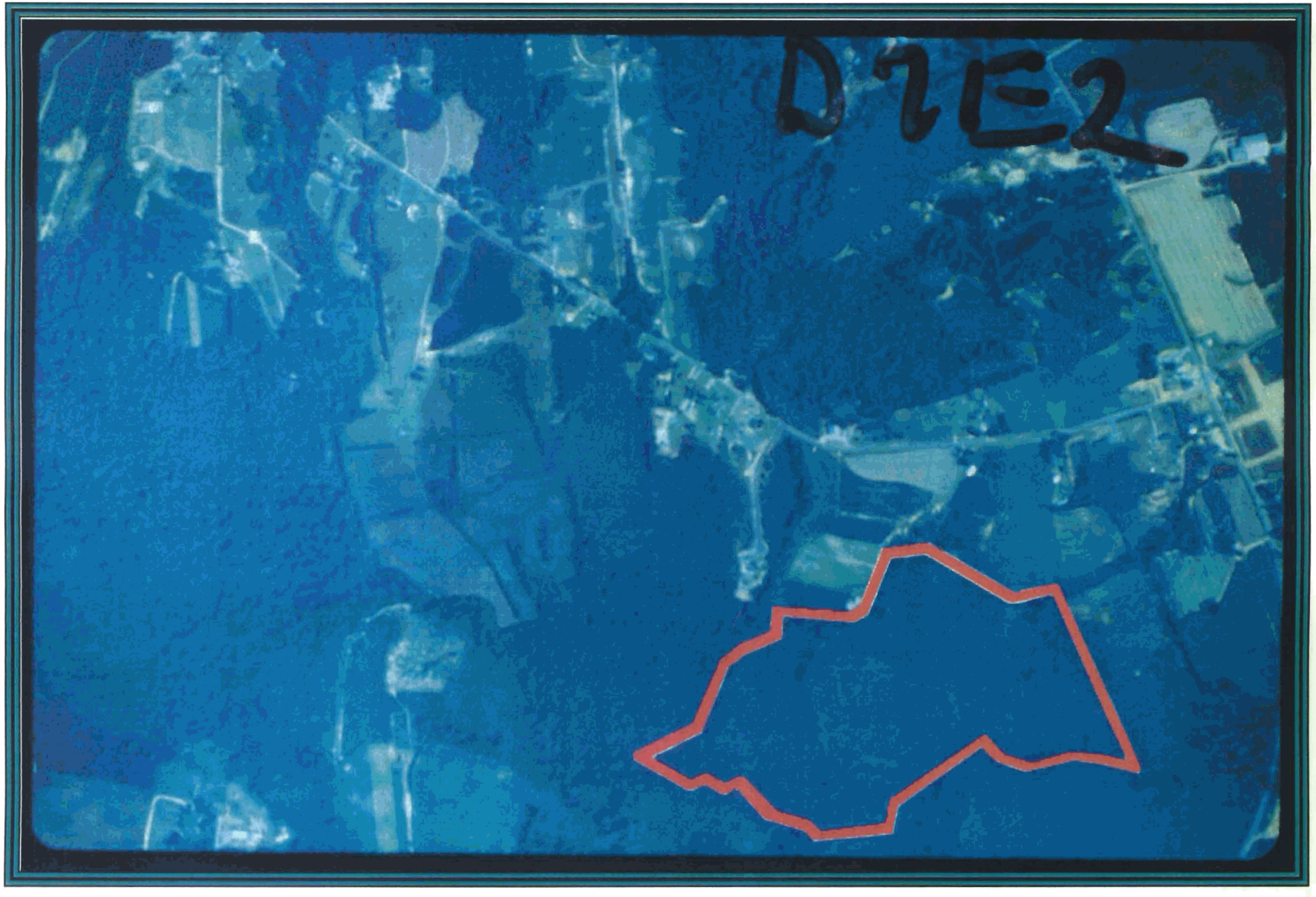
Benson Grove Wetland Mitigation Site
ASCS Photograph 1998

FIGURE 3f



Benson Grove Wetland Mitigation Site
ASCS Photograph 1999

FIGURE 3g



Benson Grove Wetand Mitigation Site
ASCS Photograph 2000

FIGURE 3h

2.2 SOILS

Soils have been mapped in Johnston County by NRCS (USDA, 1994). Soils were verified in June 2001 by a Licensed Soil Scientist (LSS) associated with Cpec Environmental, Inc. Soil mapping units were refined and inclusions and tax-adjunct (dissimilar soils, but not dissimilar enough to assign the area to a different series) areas were identified. Systematic transects were established and sampled to ensure proper coverage.

The following soil series were identified onsite: Tomotley, Tomotley/Wehadkee Complex, Tomotley series tax-adjunct, Gilead and Augusta. Soil series profile characteristics from the Johnston County Soil Survey are summarized in **Table 1**. Refined soil mapping is shown in **Figure 4**. A copy of the detailed soils report is included in **Appendix B**.

2.2.1 Hydric Soils

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 part" (USDA 1987). Soil mapping identifies three hydric soils types in the mitigation area, Tomotley (Typic Endoaquults), Tomotley/Wehadkee (Typic Fluvaquents) complex and Tomotley series tax-adjunct.

The Tomotley/Wehadkee complex occupies the greatest area of the Site, approximately 45.9 ac (18.6 ha) or 55.8%, and is located in the lowest areas of the floodplain. Tomotley/Wehadkee complex soils typically support bottomland hardwood species, unless the hydroperiod nearer the stream is prolonged, where they support trees species adapted to extended hydroperiods such as bald cypress (*Taxodium distichum*), swamp tupelo (*Nyssa biflora*) or green ash (*Fraxinus pensylvannica*). Tomotley soils [approximately 34.1 ac (13.8 ha), or 41.2% of the Site] are poorly drained and located on the first stream terrace, at a slightly higher elevation than the Tomotley/Wehadkee complex, and generally support bottomland hardwood species. The Tomotley series tax-adjunct occupies 1.6 ac (0.63 ha), or 1.9% of the Site.

2.2.2 Non-Hydric Soils

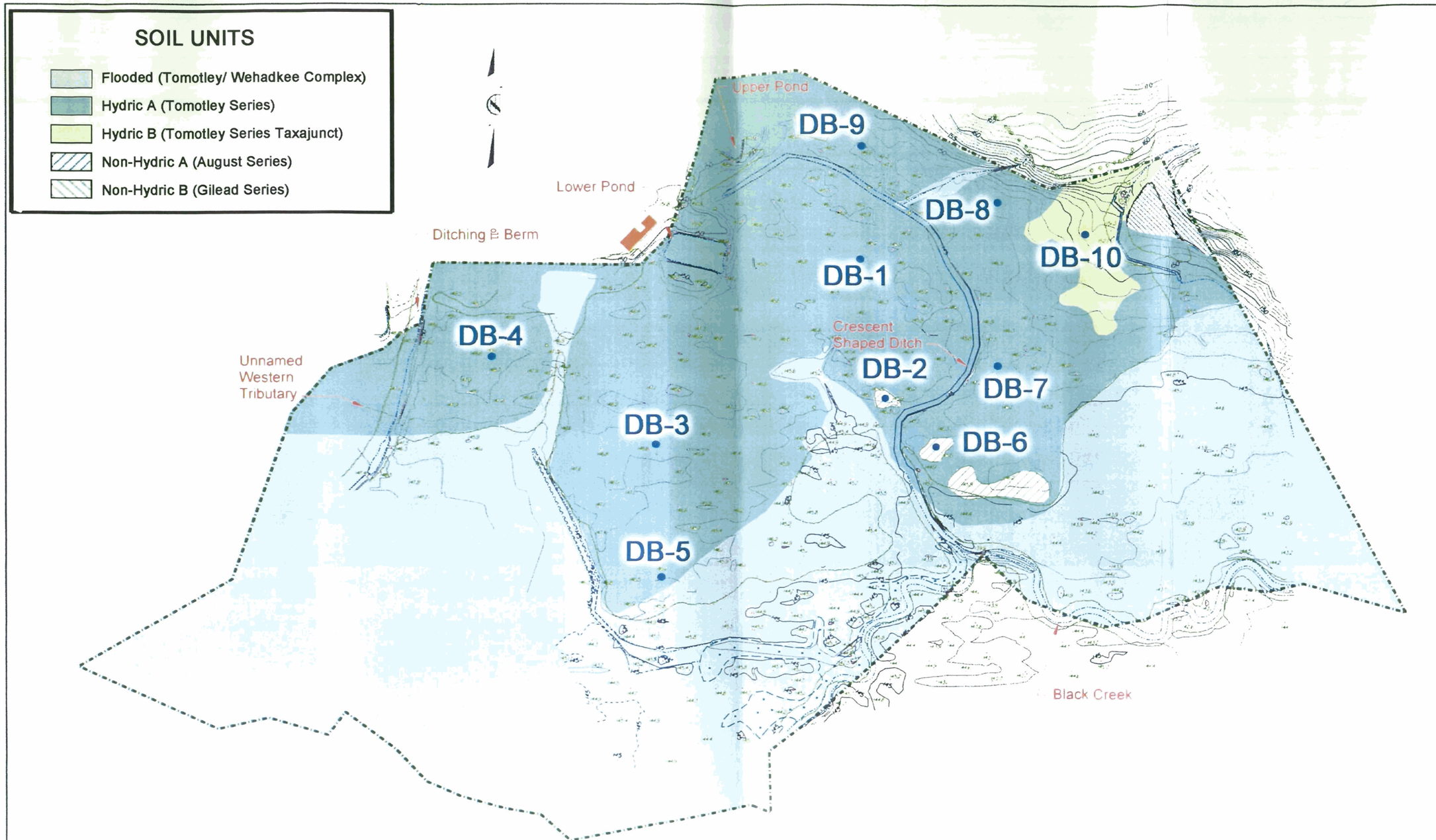
Gilead and Augusta soils are the non-hydric soils present onsite. Gilead occupies the greater area of the Site, approximately 0.56 ac (0.23 ha) or 0.7% of the Site. Gilead soils typically occupy sideslope topographic positions in the coastal plain. Common canopy woody species include loblolly pine (*Pinus taeda*), longleaf pine (*Pinus palustris*), white oak (*Quercus alba*), southern red oak (*Quercus falcata*) and sweetgum (*Liquidambar styraciflua*).

Augusta occupies approximately 0.18 ac (0.07 ha) or 0.2% of the Site. Augusta is a somewhat poorly drained soil occupying stream terraces. Common canopy species include loblolly pine (*Pinus taeda*), sweetgum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*) and yellow-poplar (*Lirodendron tulipifera*).

TABLE 1
BENSON GROVE WETLAND MITIGATION SITE
SOILS AND SOIL CHARACTERISTICS

Tomotley	Wehadkee	Gilead	Augusta
Ap---0-10"; grayish brown (10YR5/2) loamy coarse sand	A—0-7" dark brown (10YR 4/3) loam	Ap—0-5"; pale brown (10YR 6/3) sandy loam	Ap—0-7"; grayish brown (10YR 5/2) sandy loam
Btg1--8-20"; gray (10YR 6/1) Sandy clay loam, common distinct 10YR6/6 mottles	Bg1—7-18"; light brownish gray (2.5Y 6/2) loam, many distinct (10YR 5/4) mottles	Bt1—5-9"; strong brown (7.5YR 5.8) sandy clay loam	BE—7-11"; pale brown (10YR 6/3) sandy loam w/ 10YR 5/6 and 7/2 mottles
Btg2—20-40"; gray (10YR 6/1) sandy clay loam	Bg2—18-32"; gray (10YR 6/1) clay loam, many distinct (10YR 5/6) mottles	Bt2—9-15"; yellowish brown (10YR 5/8) sandy clay loam	Bt—11-25"; light yellowish brown (2/5Y 6/4) sandy clay loam w/ 10YR 7/2 and 7.5YR 5/6 mottles
Cg—40-60"; gray (N6/0) sand	Bg3—32-49"; gray (10YR 6/1) clay loam, many (7.5YR 4/4) mottles	Bt3—15-20"; yellowish brown (10YR 5/8) clay loam w/ 10Yr 7/2 & 2.5YR 5/8 mottles	Btg—25-32"; light gray (10YR 7/2) sandy clay loam w/ 10YR 5/6 mottles
	Cg—49-63"; mottled gray (10YR 6/1) and strong brown (7.5YR 5/6) clay loam	Bt4—20-29"; reddish yellow (7.5YR 6/8) clay w/ 2.5YR 5/8 & 10YR 7.2 mottles	BCg—32-43"; light gray (10YR 7/2) sandy loam w/ (10YR 5/6) mottles
		Btg—29-38"; light gray 10YR 7/2 clay loam w/ 7.5YR 5/8 mottles	Cg—43-60"; white (10YR 8/1) coarse sand w/ 10YR 6/6 mottles
		Cg—38-75"; light gray (10YR 7/2) sandy clay loam w/ 2.5YR 5/8 mottles	

SOURCE: Soil Survey of Johnston County, USDA, Soil Conservation Service, 1994



No	REVISIONS	DATE

Figure 4

Date

Scale

Dwn By

Ckd By

Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
REFINED SOIL MAPPING

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

2.3 PLANT COMMUNITIES

Distribution and composition of plant communities reflect landscape-level variations in topography, soils, hydrology, and past land use practices. The major plant communities identified in the study area include: palustrine emergent wetland, wet meadow, forested wetland/fence line, "wet" old successional field, logged successional field/wetland, palustrine emergent/scrub-shrub wetland, and successional fallow field. (**See Figure 5** – Major Plant Communities).

Plant communities were delineated by observing primarily dominant plant species/groups and changes in community types. No formal plant sampling, such as transects or plots, was done. Dominant plants and many of the other species were noted for each community. See the attached plan for community locations (**See Figure 5** – Major Plant Communities).

2.3.1 Plant Community 1: 1A. Palustrine Emergent Wetland & 1B. Wet Meadow

Herbaceous (non-woody) plants dominate Plant Community 1. Section 1A, a palustrine emergent wetland contains soft rush (*Juncus effusus*), Aster (*Aster simplex*), broom-sedge (*Andropogon virginicus*), groundsel trees (*Baccharis halimifolia*), red maple (*Acer rubrum*), willow oak (*Quercus phellos*), smartweeds (*Polygonum* spp.), and wool grass (*Scirpus cyperinus*). Section 1B, the field adjacent to the wetland is influenced by occasional flooding and/or saturation, but does not display all three criteria of wetlands (hydrophytic vegetation, wetland hydrology and hydric soils). Grasses such as broom-sedge (*Andropogon virginicus*) and panic grasses (*Panicum* spp.) dominate this wet meadow. Other herbaceous plants in the meadow include soft rush (*Juncus effusus*) and flowering herbs primarily from the aster family (Compositae). Small sections of the meadow also contain some invasive species such as Japanese honeysuckle (*Lonicera japonica*) and blackberries (*Rubus* spp.). In addition, some small groundsel trees (*Baccharis halimifolia* or *glomeruliflora*) and sweet gum (*Liquidambar styraciflua*) seedlings grow throughout the meadow.

2.3.2 Plant Community 2: Forested Wetland/Fence line

Community 2, a linear forested area, follows a shallow channel/stream and an old fence line. Small trees (~3 to 6 inches DBH, diameter at breast height) dominate the relatively open forest canopy, with a few larger trees (~12 to 24+ inches DBH) growing primarily along the fence line. Tree species include sweet gum, red maple (*Acer rubrum*), willow oak (*Quercus phellos*), other oaks (*Quercus* spp.) and American holly (*Ilex opaca*). Red maple is the dominant tree in the channel. The understory/shrub layer includes groundsel tree, sweet gum saplings, red maple saplings, American holly and some *Rubus* spp. The herb layer, primarily in the channel, includes smartweeds (*Polygonum* spp.), greenbrier (*Smilax* spp.), giant cane (*Arundinaria gigantea*), soft rush, wool grass (*Scirpus cyperinus*), *Aster* spp., sensitive fern (*Onoclea sensibilis*) and sedges (*Carex* spp.).

2.3.3 Plant Community 3: "Wet" Old Successional Field

Community 3 comprises a primarily herbaceous field with many saplings (in transition to forest). Although not included in the formal wetland delineation (outside of defined project area), this community is probably a wetland with some upland hummocks mixed throughout. Herbaceous plants in the field include soft rush, wool grass, panic grasses, greenbrier and

giant plume grass (*Erianthus giganteus*). Groundsel tree dominates the shrub layer, while sweet gum and loblolly pine (*Pinus taeda*) dominate the saplings.

2.3.4 Plant Community 4: Logged, Successional Field/Wetland, 4A. Palustrine Emergent/Scrub-Shrub Wetland & 4B. Successional Field

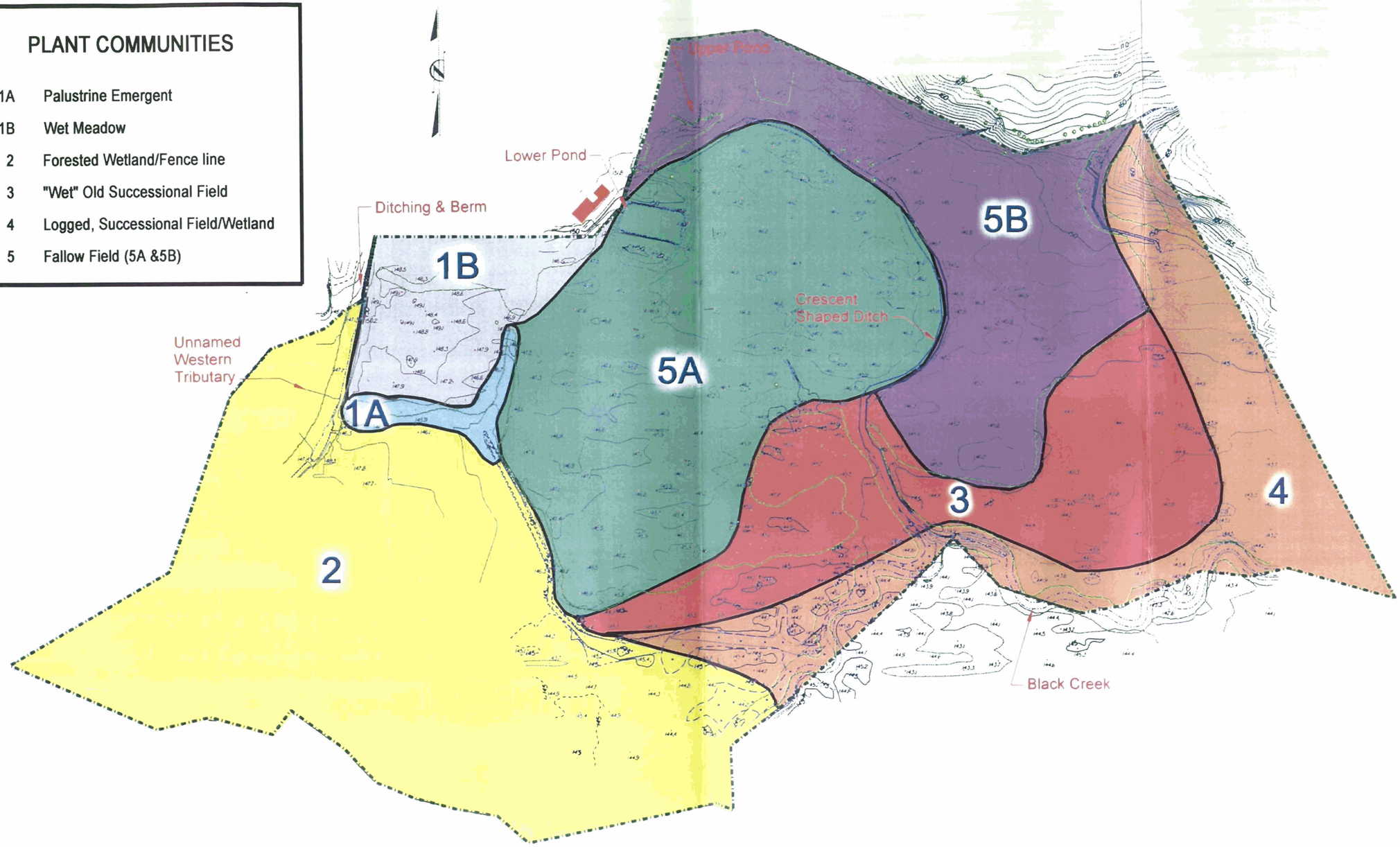
The tree stumps from previous logging efforts still dot this area. There is not a distinct boundary between the wetland and the field, but the wetland contains predominately hydrophytic vegetation as described on the wetland data sheet. Herbaceous plants in the field include panic grasses, soft rush, asters and broom-sedge. Shrubs and saplings include sweet gum and *Rubus* sp. Sweet gum and red maple strongly dominate the small stands of trees that grow in the area.

2.3.5 Plant Community 5: Fallow Field

This herbaceous community, split by a ditch (5A & 5B), was maintained by mowing through the summer of 2000. The area was used as pasture up to 1998. Panic grasses dominate Field 5A. This field also contains broom-sedge, soft rush, asters and other grasses and weedy herbs. Field 5B contains most of the same species, but it is dominated by broom-sedge in one section and dog fennel (*Eupatorium capillifolium*) in the other. Field 5B also includes horse-nettle (*Solanum carolinense*) and other grasses. This entire community is beginning to develop a shrub layer as the first step in a successional progression.

PLANT COMMUNITIES

1A	Palustrine Emergent
1B	Wet Meadow
2	Forested Wetland/Fence line
3	"Wet" Old Successional Field
4	Logged, Successional Field/Wetland
5	Fallow Field (5A &5B)



No	REVISIONS	DATE

Figure 5

Date

Scale

Dwn By:

Ckd By

Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA

MAJOR PLANT COMMUNITIES

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

2.4 HYDROLOGY

2.4.1 Watersheds (Surface Water Hydrology)

The Site has been subdivided into three sub-watersheds for surface water studies and planning purposes: 1) the primary watershed associated with the Black Creek drainage basin; 2) the secondary watershed associated with the unnamed tributary to the west and 3) the secondary watershed associated with the elevations immediately uphill, adjacent to the Site.

2.4.2 Primary Watershed

The primary watershed associated with Black Creek drains west central Johnston County and the extreme southeastern corner of Wake County. The watershed area of Black Creek upstream of the Site is 40,948 ac (16,577 ha). The basin includes suburban segments of the Town of Fuquay Varina and the Town of Angier. The basin also includes portions of Highway 55, 42 and 210, which are secondary road corridors. Land use includes silviculture, agriculture and dairy/poultry production, primarily. Secondary uses include residential, commercial, and recreational development associated with rural and surburban areas.

Elevations within the Black Creek basin rise to approximately 400 ft (125 m) above National Geodetic Vertical Datum (NGVD). Elevation along Black Creek, at the Site, is approximately 145 ft (45.31 m) above NGVD.

2.4.3 Secondary Watersheds

The two secondary watersheds that contribute water to the Site include the unnamed tributary to the west and the watershed immediately north and northeast of the Site. The watershed of the unnamed tributary to the west encompasses approximately 380.7 ac (154.1 ha). The drainage basin immeadiately north and northeast of the Site is approximately 158.1 ac (64.0 ha) in size.

Waters from the unnamed tributary to the west enter the property by overtopping a low berm constructed to divert the waters to Black Creek. Base surface water flows do not enter the Site from this source under present conditions. It is speculated the excess water that flows and sometimes stands in this location, adjacent to and upstream of the Site, finds its way into the groundwater and contributes to the elevated water tables measured on the west side of the Site.

The waters from the drainage basin immediately to the north and east of the Site flow through a series of channels, ponds and groundwater seeps prior to reaching the property. Water sources include the outlet of a tile drainage system from an adjacent tobacco field. Both of these secondary watersheds support primarily crop land, secondary roads, scattered residential use, and woodland.

2.4.4 Groundwater

Topographically, the Site is generally expressed as a relatively flat valley floor bounded by Black Creek to the south and a low gradient slope to the north. Within the valley floor, groundwater flow is most likely dominated by vertical movement during normal climatic

conditions. Lateral migration may occur episodically during wet periods, mimicking surface water flow patterns. The gravitational forces of the down valley gradient (west to east) and higher elevations to low channel gradient (perpendicular to the Black Creek stream channel) produces a movement that likely moves at an angle relative to the general down valley direction.

Fourteen groundwater gauges were installed in 1998 and 1999 to track groundwater fluctuations relative to surface elevations. Data from these gauges is available for the 1999 and 2000 growing seasons. Information provided by this data indicates the existing crescent-shaped ditch of the Site diverts flow from the internal segments of the Site into Black Creek. This drainage feature greatly assists the discharge of excess water from flooding and shallow groundwater flow. On the west side of the Site, the unnamed tributary periodically overflows the low berm allowing additional waters to flow through the Site.

Cpec Environmental, as part of their soil investigation at the Site in August, 2001, conducted in-situ saturated hydraulic conductivity measurements. These locations correspond to the deep boring locations 1, 2, 3, 4, and 7. Cpec previously identified distinct upper and lower zones in the soil having different morphological characteristics and partitioned the zones in order to obtain distinct hydraulic measurements for each. A copy of the detailed soils report is included in **Appendix B**.

Using a rising-head slug test, field measurements were solved for saturated hydraulic conductivity using the Hvorslev method. From 16 recorded slug tests, estimated saturated hydraulic conductivity ranged from 0.38 in/hr. (0.77 ft/d) to 0.71 in/hr. (1.42 ft/d) in the upper C-horizon, with a mean value of 0.49 in/hr. (0.97 ft/d). In the lower C-horizon, estimated saturated hydraulic conductivity ranged from 1.23 in/hr. (2.46 ft/d) to 3.01 in/hr. (6.03 ft/d) with a mean value of 1.83 in/hr. (3.66 ft/d). These relatively moderate to high conductivities indicate why the hydrological influences within the Site (the crescent-shaped ditch) and adjacent to the Site (the western-most tributary) are so influential in determining water table elevations.

2.5 JURISDICTIONAL WETLANDS

Wetlands were identified and mapped and the US Army Corps of Engineers performed a jurisdictional determination on November 10, 1999. The jurisdictional determination was made utilizing the three-parameter approach outlined in the USCOE 1987 Wetlands Delineation Manual (USCOE, 1987). Portions of the Site were further evaluated utilizing the August 24, 1993 agreement between the Natural Resources Conservation Service and the U.S. Army Corps of Engineers (USCOE) regarding "Prior Converted" farmland. Of the 81.92 ac (33.16 ha) Site, approximately 45.33 ac (18.35 ha) of jurisdictional wetlands were identified. The remaining 36.59 ac (14.81 ha) were determined to be non-jurisdictional or prior converted wetlands. **Figure 2** – Site Map depicts the boundary location of existing jurisdictional wetland systems. The jurisdictional boundary was surveyed by GPS.

Of the non-jurisdictional areas, approximately 35.52 ac (14.38 ha) were determined to be hydric soils prior converted by agricultural activities or otherwise did not support the three-parameters of jurisdictional wetlands.

2.6 CULTURAL RESOURCES

The term 'cultural resources' refers to prehistoric or historic archaeological sites, structures, or artifact deposits over 50 years old. 'Significant' cultural resources are those that are eligible or potentially eligible for inclusion in the *National Register of Historic Places.* Evaluations of Site significance are made with reference to the eligibility criteria of the National Register (36 CFR 60) and in consultation with the North Carolina State Historic Preservation Officer (SHPO).

Documented correspondence with the SHPO determined no eligible historical architecture or significant cultural resources have been documented within the boundaries of the Site.

2.7 HAZARDOUS MATERIALS

Environmental Screening was conducted during multiple field visits in order to evaluate the presence of potentially harmful environmental hazards. Environmental concerns under review include past or present storage of hazardous or regulated materials and/or waste, illicit dumping of solids or hazardous waste, and degradation of surface waters which may have a negative impact on the environment. Visual screening for objects such as storage tanks, debris, hazardous material, and evidence of waste burial was conducted through field reconnaissance within study area. Cursory field observations and interviews with Mr. Stuart indicate that chemical mixing occurred occasionally at the barn that borders the property on the western boundary. Other than this, field observations and interviews did not indicate evidence of a potential contamination hazard.

In addition to cursory field surveys, an Environmental Data Resources, Inc. (EDR) report was obtained (**Appendix A**). No mapped sites were identified by the EDR record search within the study area or within the American Society for Testing and Materials (ASTM E 1527-97) search radius. The databases reviewed are included below:

NPL	National Priority List
Delisted NPL	NPL Deletions
RCRIS-TSD	Resource Conservation and Recovery Information System
SHWS	State Hazardous Waste
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CERC-NFRAP	Comprehensive Environmental Response, Compensation, and Liability Information System
CORRACTS	Corrective Action Report
SWF/LF	Solid Waste Facilities
LUST	Incidents Management Databases
UST	Petroleum Underground Storage Tank Database
RAATS	RCRA Administrative Action Tracking System
RCRIS-SQG	Resource Conservation and Recovery Information System
RCRIS-LQG	Resource Conservation and Recovery Information System
HMIRS	Hazardous Materials Information Reporting System
PADS	PCB Activity Database System
ERNS	Emergency Response Notification System
FINDS	Facility Index System/Facility Identification Initiative Program Summary Report
TRIS	Toxic Chemical Release Inventory System
NPL Lien	NPL liens
NC HSDC	Hazardous Substance Disposal Site
IMD	Incident Management Database
TSCA	Toxic Substance Control Act

MLTS	Material Licensing Tracking System
ROD	ROD
CONSENT	Superfund (CERCLA) Consent Decrees
CoalGas	Former Manufactured gas (Coal Gas) Sites

Unmapped (Orphan) sites were not considered as part of the foregoing analyses

2.8 PROTECTED SPECIES

Species with the Federal classification of Endandered (E) or Threatened (T) are protected under the Endangered Species Act (ESA) of 1973, as amended. Currently, the FWS lists four species in Johnston County as E or T (list updated March 22, 2001). These species are as follows: red-cockaded woodpecker (*Picoides borealis*), dwarf wedge mussel (*Alasmidonta heterodon*), Tar spinymussel (*Elliptio steinstansana*), and Michaux's sumac (*Rhus michauxii*). In addition there are nine species designated as Federal species of concern (FSC).

Coordination occurred with the US Fish and Wildlife Service (FWS) and the North Carolina Natural Heritage Program (NHP) early in the study process. Findings of this coordination indicate no Federally Endangered or Threatened species, or High Quality Natural Areas are documented within the boundaries of the Site. However, it was also recommended that Mr. John Alderman of the North Carolina Wildlife Resources (NCWRC) be contacted regarding possible protected mussel species and a FSC, the Tar River crayfish (*Procambarus medialis*), occuring in or in close proximity to Black Creek. A response from Mr. Alderman is still pending on this issue. Field surveys for occurences or habitat for the remainder of the Federally listed species were negative.

3.0 WETLAND RESTORATION STUDIES

3.1 HYDROLOGY / CLIMATE

3.1.1 Introduction / Method

Wetland hydrology is defined as inundation or saturation (within 12" of the surface) by surface or groundwater for at least a consecutive 12.5% of the growing season in most years. Areas inundated or saturated for less than 5% of the growing season in most years are always classified as non-wetlands. Areas inundated or saturated between 5% and 12.5% of the growing season in most years can be classified as wetlands depending upon factors such as the presence of wetland vegetation and hydric soils. The growing season for the project Site in Johnston County is defined as the period between 21 March and 4 November (228 days, USDA 1994).

Fourteen groundwater gauges (WL-40s) manufactured by Remote Data Systems (RDS) have been installed since late 1998 to track groundwater fluctuations relative to surface elevations. **Figure 2** – Site Map illustrates the locations of the monitoring gauges. The automatic monitoring gauges record daily readings of groundwater depth. In addition, one surface water gauge was installed to measure surface water fluctuations. The results are presented in **Tables 3 and 6**.

Some of the gauges malfunctioned in the process of acquiring data, and this resulted in loss of data. These gauges were located generally in the lower portions of the property, adjacent to Black Creek. It is believed the failures were related to prolonged submersion. The gauges

occasionally record positive readings, however, the groundwater gauges do not accurately measure surface water; they only indicate when the water is above the surface. Daily rainfall data was acquired from the National Climatic Data Service on the Smithfield, NC weather station. **Tables 2 and 5** show the precipitation data for the study period.

During both the 1999 and 2000 growing seasons periods of abnormally high rainfall were recorded. In 1999 an abnormally high rainfall amount was recorded for the month of September. The abnormally high rainfall was punctuated by the effects of Hurricane Floyd on September 16, 1999, when 9.5 inches was recorded. The total rainfall for September, 1999 was 20.62 inches, more than 4.5 times normal. From September 6, the effect of rainfall was to either flood and/or saturate the Site for the remainder of the 1999 growing season.

During the 2000 growing season, June, August and September exhibited higher than normal rainfall. Each of these months recorded rainfall amounts that are more than those expected once every five years. Additionally, July, 2000, though approximately an average rainfall month, sustained and elevated the water table, making for a continuously wet four-month period. Persistant rainfall amounts after June 19 flooded and/or saturated the Site for the duration of the 2000 growing season.

The periods of abnormally high rainfall have been discounted for the purposes of this report. For the 1999 growing season, gauge response was examined between March 21 and September 6 and for the 2000 growing season gauge response was examined between March 21 and June 19. It was observed, however, that the early part of the growing season provides sufficient gauge data to perform analysis of the Site hydrology.

During the 1999 growing season, through September 6, 5 of the gauges exhibited soil saturation within 12 inches of the surface for greater than 12.5% of the growing season. None of the gauges demonstrated soil saturation within 12 inches of the surface between 5% and 12% of the growing season and three of the gauges demonstrated soil saturation within 12 inches of the surface for less than 5% of the growing season. **Table 3** contains the number of days and percent of the growing season for each gauge.

Four gauges did not record any usable data. Because these gauges are located in low topographic positions, and surface water was frequently observed at these points, inundation may have caused the malfunction of the gauges. The three gauges demonstrating soil saturation within 12 inches of the surface for less than 5% of the growing season each appear to be within the influence of the crescent-shaped ditch or another drainage feature (such as the relic creek bed adjacent to the location of gauge 2).

Data collected from the groundwater monitoring gauges and the surface gauge indicate approximately three quarters of the area planned for restoration exhibited wetland hydrology or marginal wetland hydrology during the 1999 growing season. **Tables 4a-4l** show daily water levels and precipitation for each individual gauge. **Figure 6** is a contour map showing equipotential lines of continuous days meeting the wetland criteria during the 1999 growing season, through September 6. The influence of the crescent-shaped ditch, and the drainage it provides, is evident from the graphical presentation in this figure.

Similar trends for the 2000 growing season are shown in **Table 6.** Through June 19, six gauges exhibited saturation within 12 inches of the surface for more than 12.5% of the growing season. No gauges recorded saturation between 5 and 12% of the growing season

and two recorded saturation within 12 inches of the surface for less than 12.5% of the growing season. Two gauges malfunctioned at the end of the growing season, but had sufficient data for the observation period.

Data collected from the groundwater monitoring gauges and the surface gauge indicate approximately two thirds of the area planned for restoration exhibited wetland hydrology or marginal wetland hydrology during the 2000 growing season. **Tables 7a-7l** show daily water levels and precipitation for each individual gauge. **Figure 7** is a contour map showing equipotential lines of continuous days meeting the wetland criteria during the 2000 growing season, up to June 19. Similarly, the influence of the crescent-shaped ditch, and the drainage it provides, is evident from the graphical presentation in **Figure 7**.

3.1.2 Climate Data

Except for January, monthly rainfall amounts in 1999 were below average for the months leading up to September. **Table 2** shows monthly recorded precipitation data, average rainfall, 2 years in 10 minimum and maximum for January to December, 1999. In September, rainfall associated with Hurricane Floyd caused the precipitation to be substantially above average. Rainfall remained above average for September and October, returning to below average for November and December.

Table 5 illustrates monthly rainfall, average rainfall, and 2 years in 10 minimum and maximums for January to December 2000. Monthly rainfall was below average in February, March, April, and May. June, August, and September had greater than average rainfall. July had approximately average rainfall. October did not have any precipitation, and November was also below average.

3.1.3 Conclusion

Groundwater monitoring data collected for the years 1999 and 2000 show significant areas of the Site meet or exceed the criteria for jurisdictional wetland hydrology for more than 5% of the growing season. The drainage influence of the crescent-shaped ditch, however, is evident from the data, particularly when this data is related to the other gauges in the graphical presentations in **Figure 6** and **Figure 7**.

Consideration was given to hydrological modeling of antecedent, existing and proposed groundwater conditions of the Site utilizing conceptual computer models such as DRAINMOD, MODFLOW or HECRAS. In deferance to the actual measurements that already demonstrate significant active wetland hydrology at the Site, the time and expense of formulating, developing, calibrating and verifying such conceptual models was determined to be unnecessary.

TABLE 2
PRECIPITATION FOR SMITHFIELD, NC
JANUARY TO DECEMBER, 1999

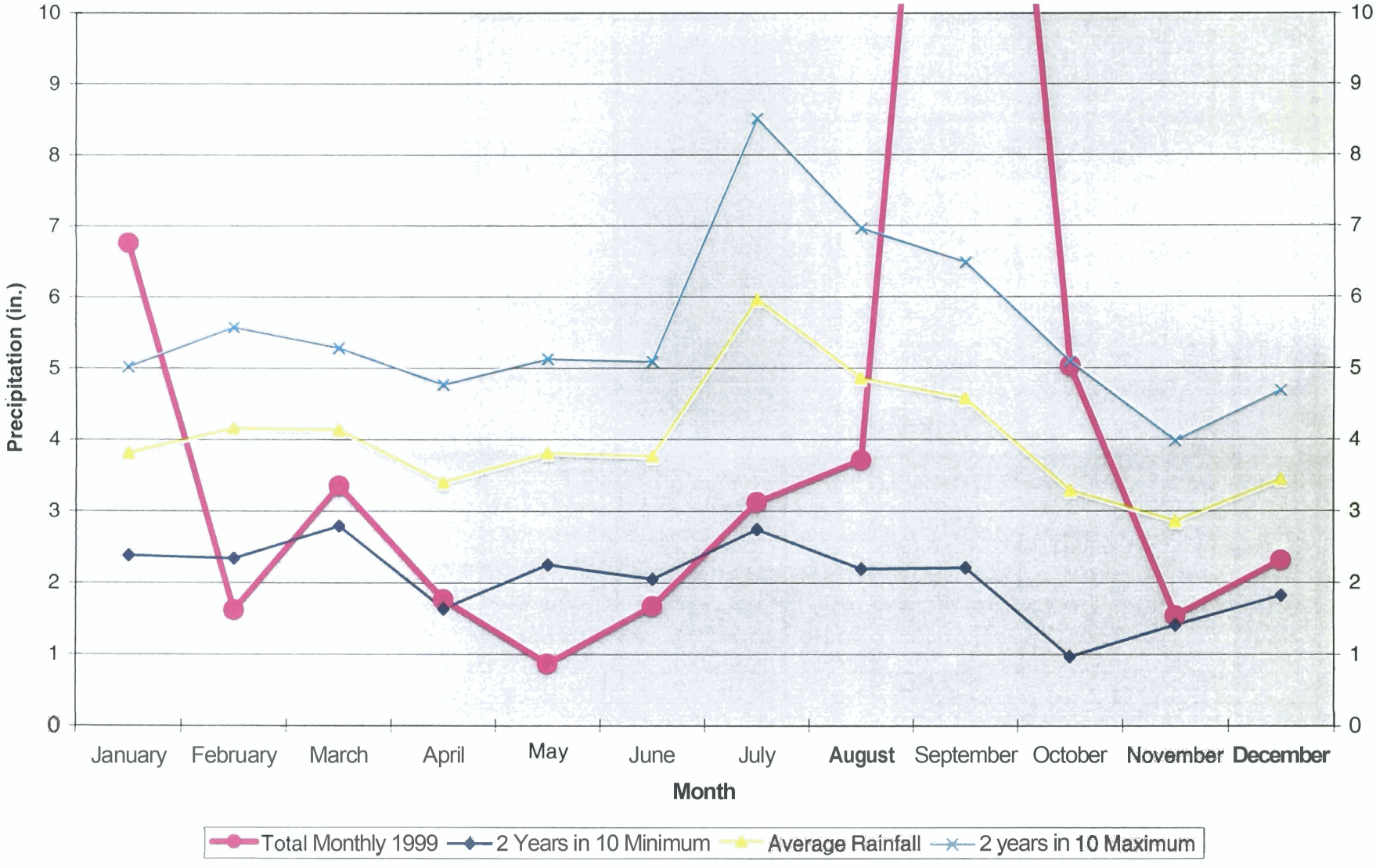


TABLE 3
BENSON GROVE WETLAND MITIGATION SITE
HYDROLOGICAL MONITORING RESULTS, 1999

MONITORING GAUGE	GENERAL LOCATION	SUCCESS DATES	NUMBER OF DAYS	ACTUAL %	<5%	5 TO 12.5%	>12.5%	COMMENT
1	(PC) JD Up	May 6 to Sept. 6	123	53.95			X	
2	(PC) JD Up	June 14 to June 23	9	3.95	X			Partial Data (Begins 6/5)
3	JD Wetland							No Data
4	(PC) JD Up	June 12 to Sept. 6	86	37.72			X	Partial Data (Begins 6/9)
5	(PC) JD Up							No Data
6	(PC) JD Up	Mar. 21 to June 12	83	36.4			X	
7	(PC) JD Up	July 12 to July 14	2	0.88	X			
8	(PC) JD Up	Mar. 21 to May 23	63	27.63			X	
9	JD Wetland							No Data
10	JD Wetland	Mar. 21 to Sept. 6	169	74.12			X	Partial Data (Begins 6/4)
11	JD Wetland							Corrupt Data - Possible Battery Failure
DITCH	(PC) JD Up	Mar. 21 to Mar. 30	9	3.95	X			

TABLE 4a
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #1

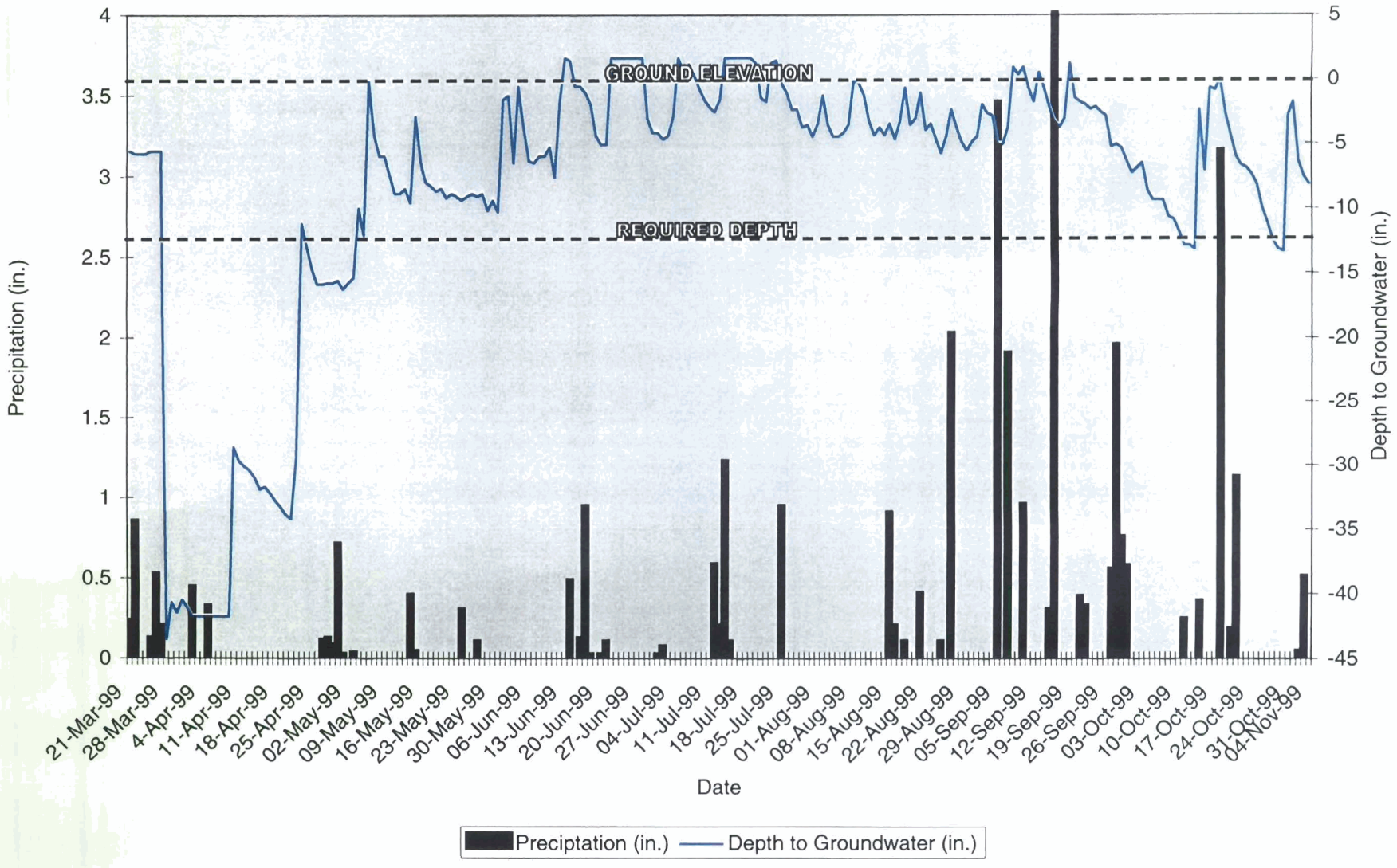


TABLE 4b
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWIING SEASON
GAUGE #2

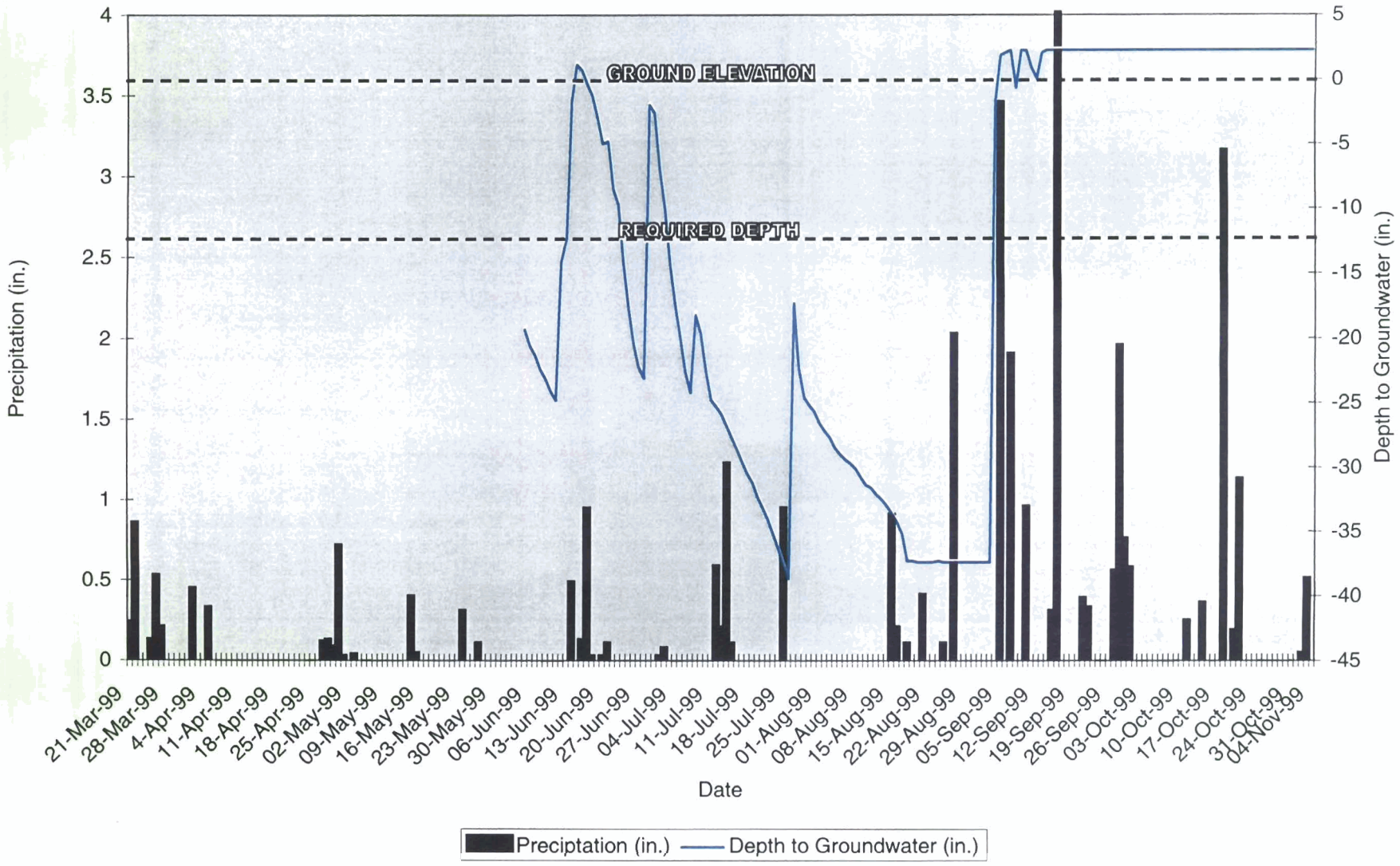


TABLE 4c
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #4

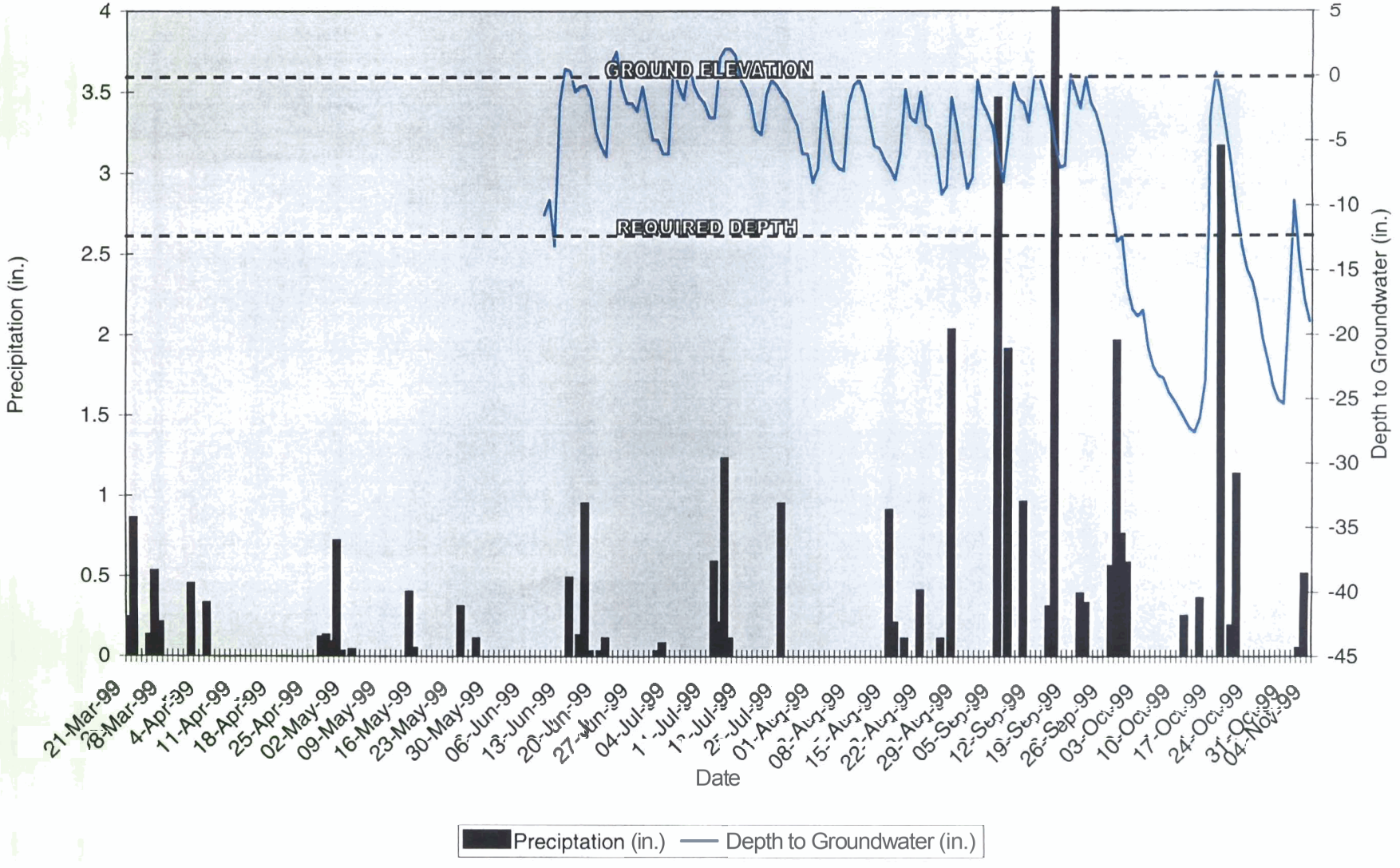


TABLE 4d
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #6

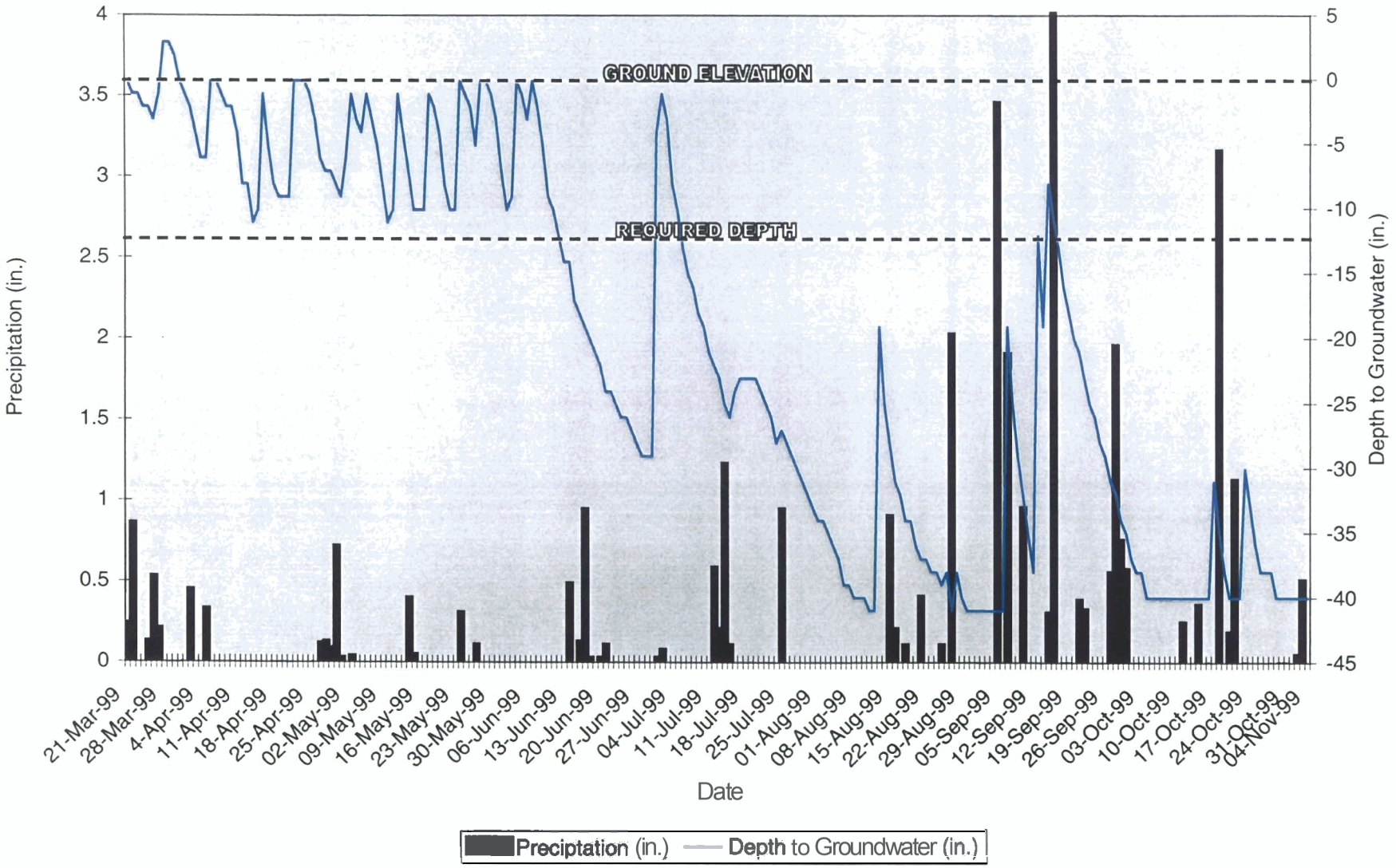


TABLE 4e
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #7

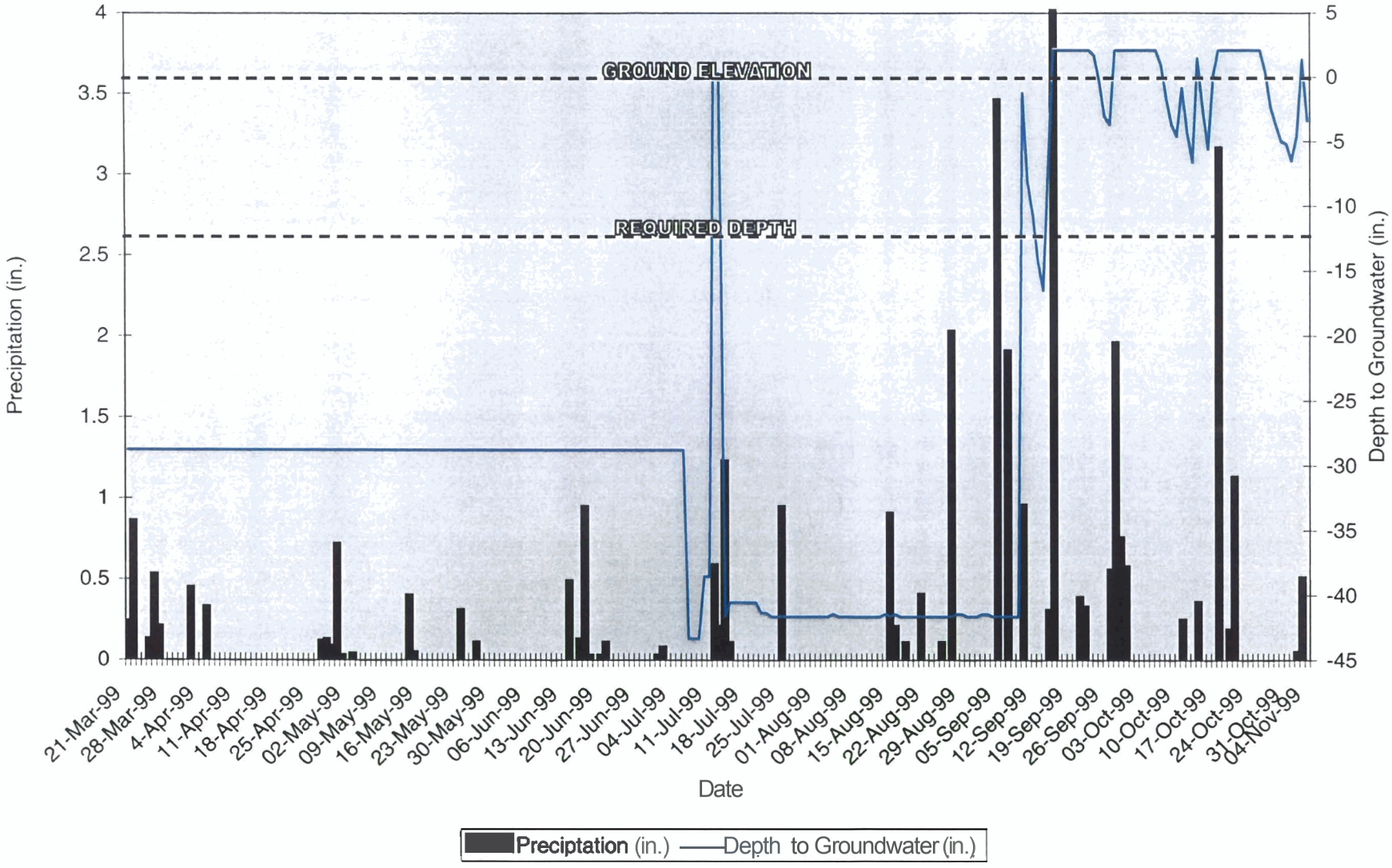


TABLE 4f
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #8

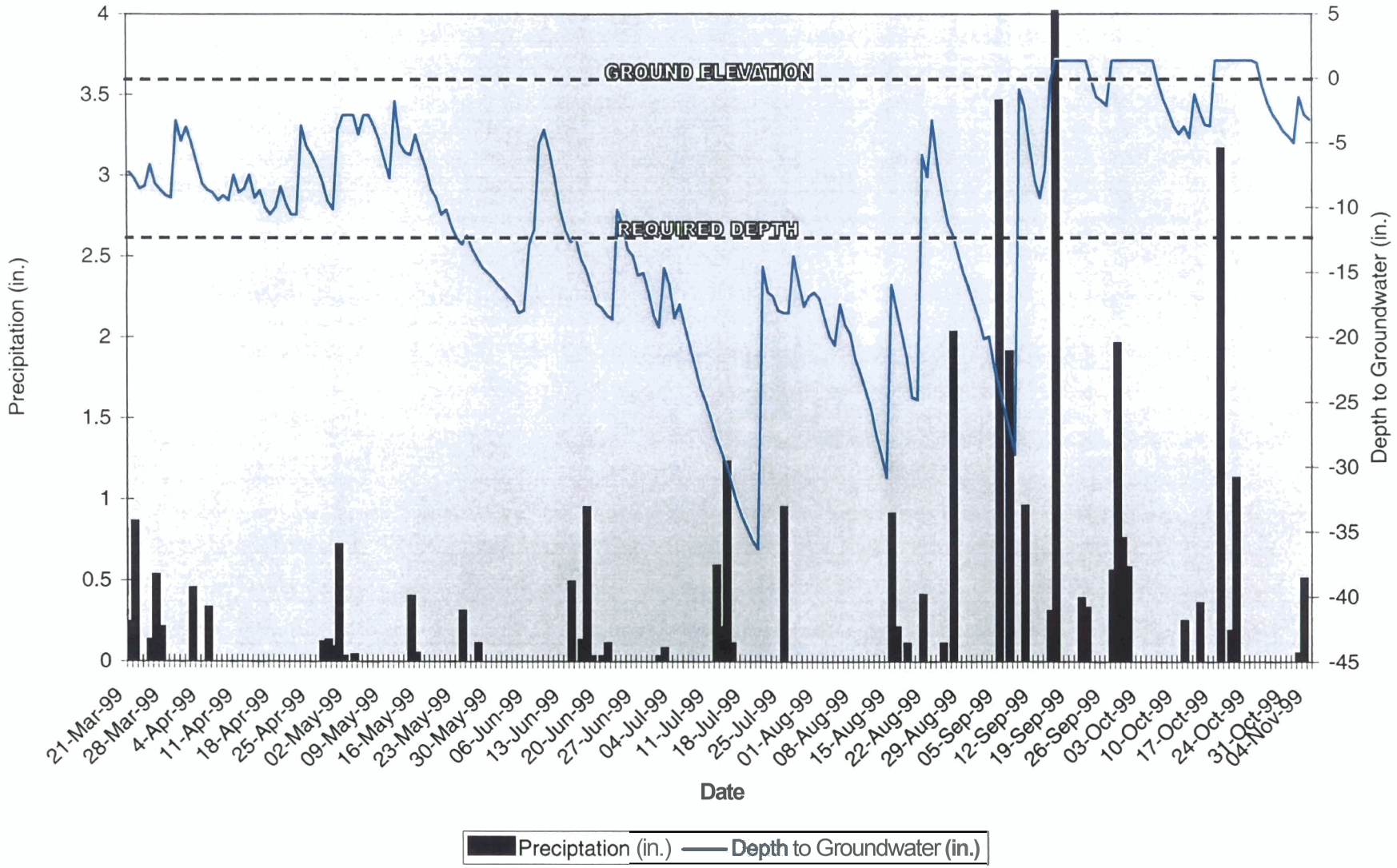


TABLE 4g
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #10

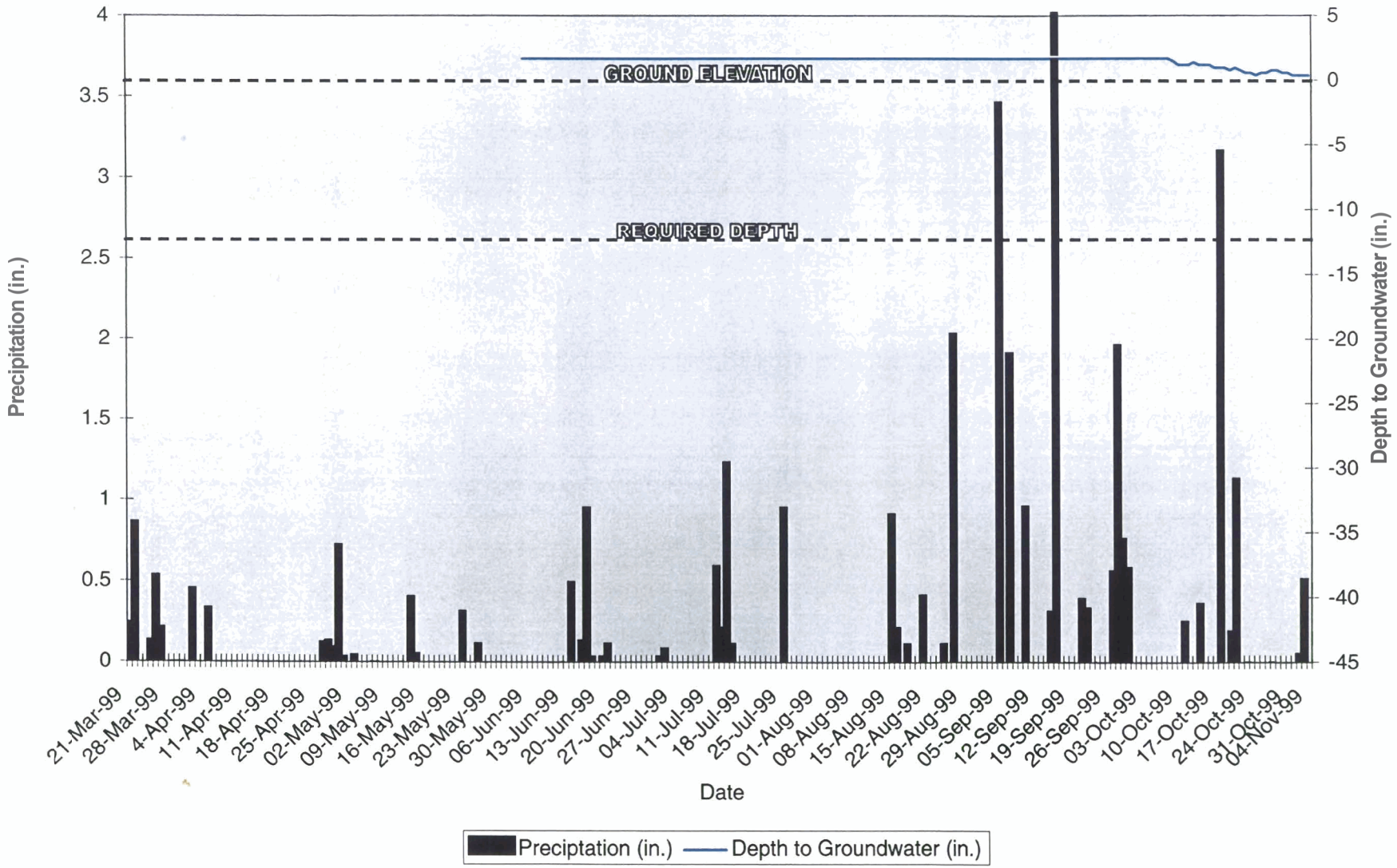


TABLE 4h
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
GAUGE #11

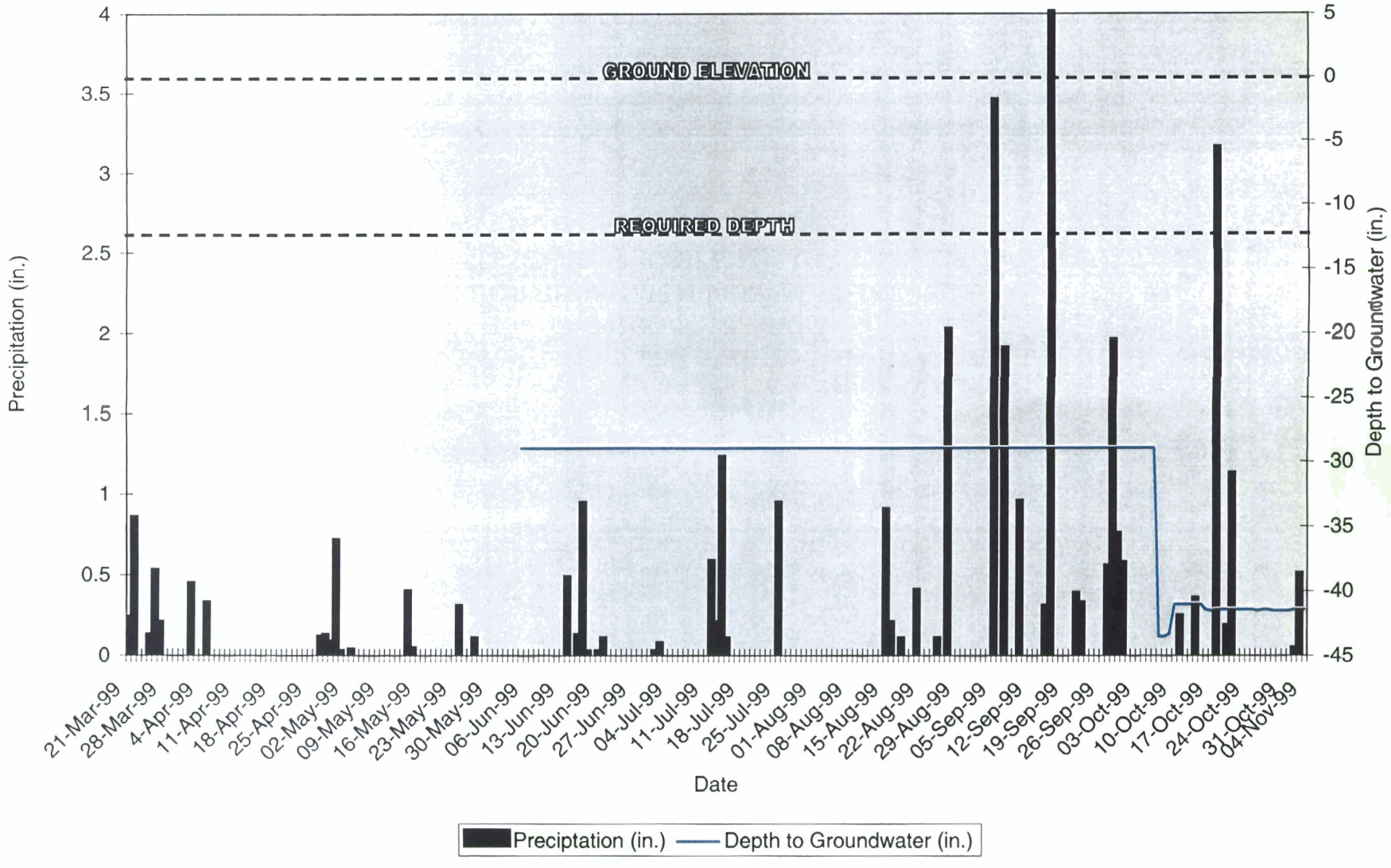
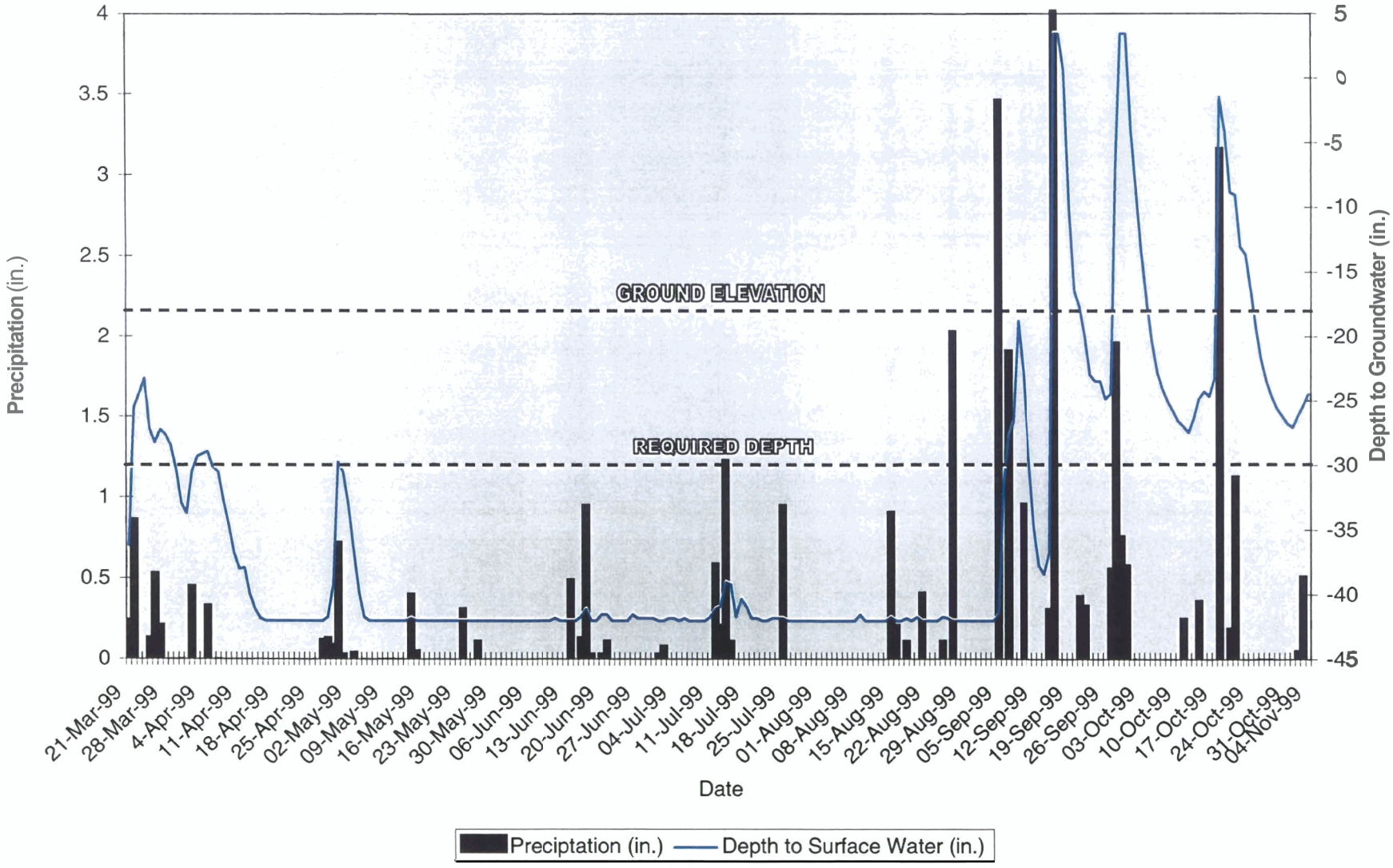
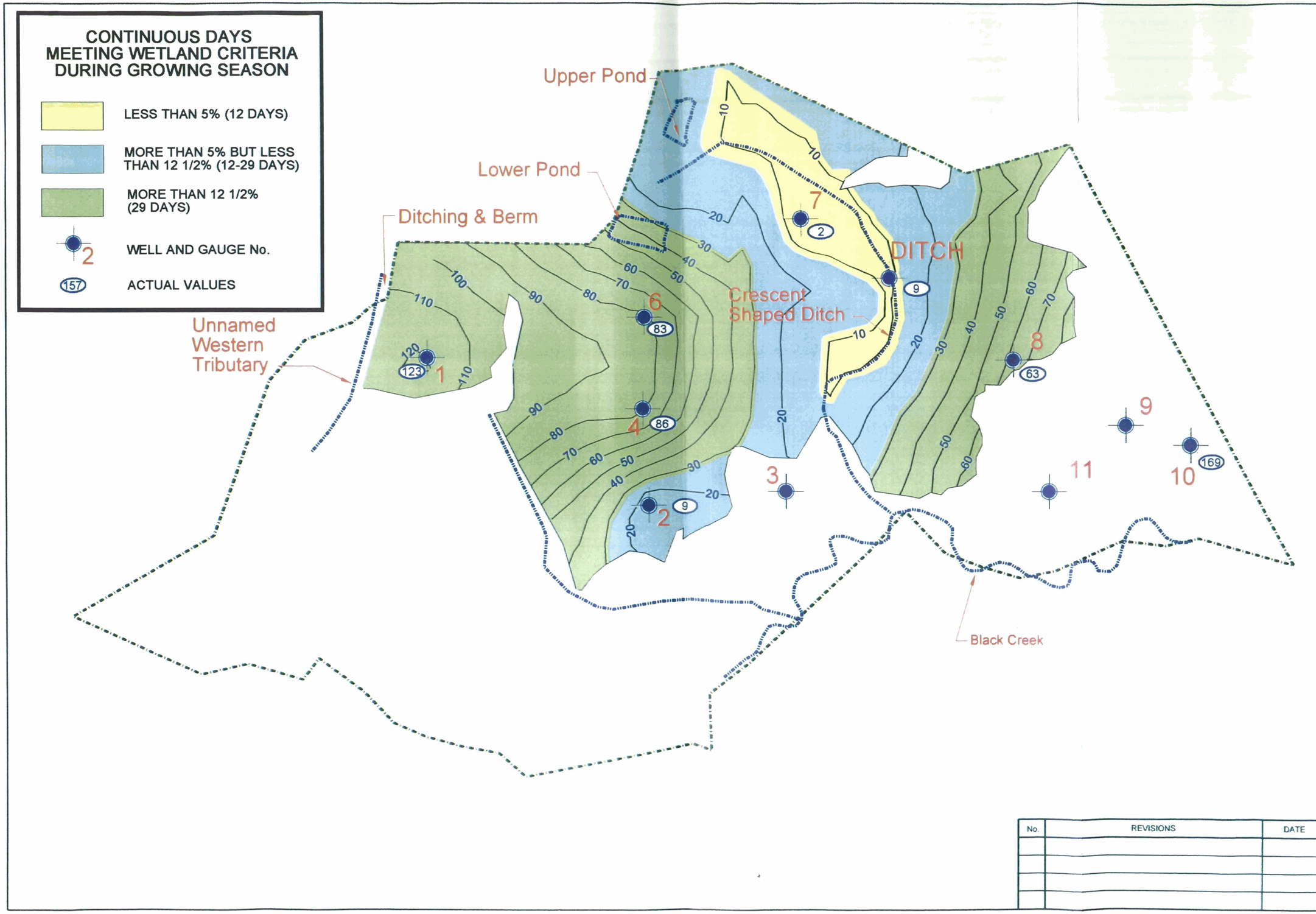


TABLE 4i
BENSON GROVE WETLAND MITIGATION SITE
1999 GROWING SEASON
DITCH GAUGE





No.	REVISIONS	DATE

Figure 6

Date:

Scale:

Dwn By:

Ckd By:

Project: BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
YEAR 1999 GAUGE DATA

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

TABLE 5
PRECIPITATION FOR SMITHFIELD, NC
JANUARY TO DECEMBER 2000

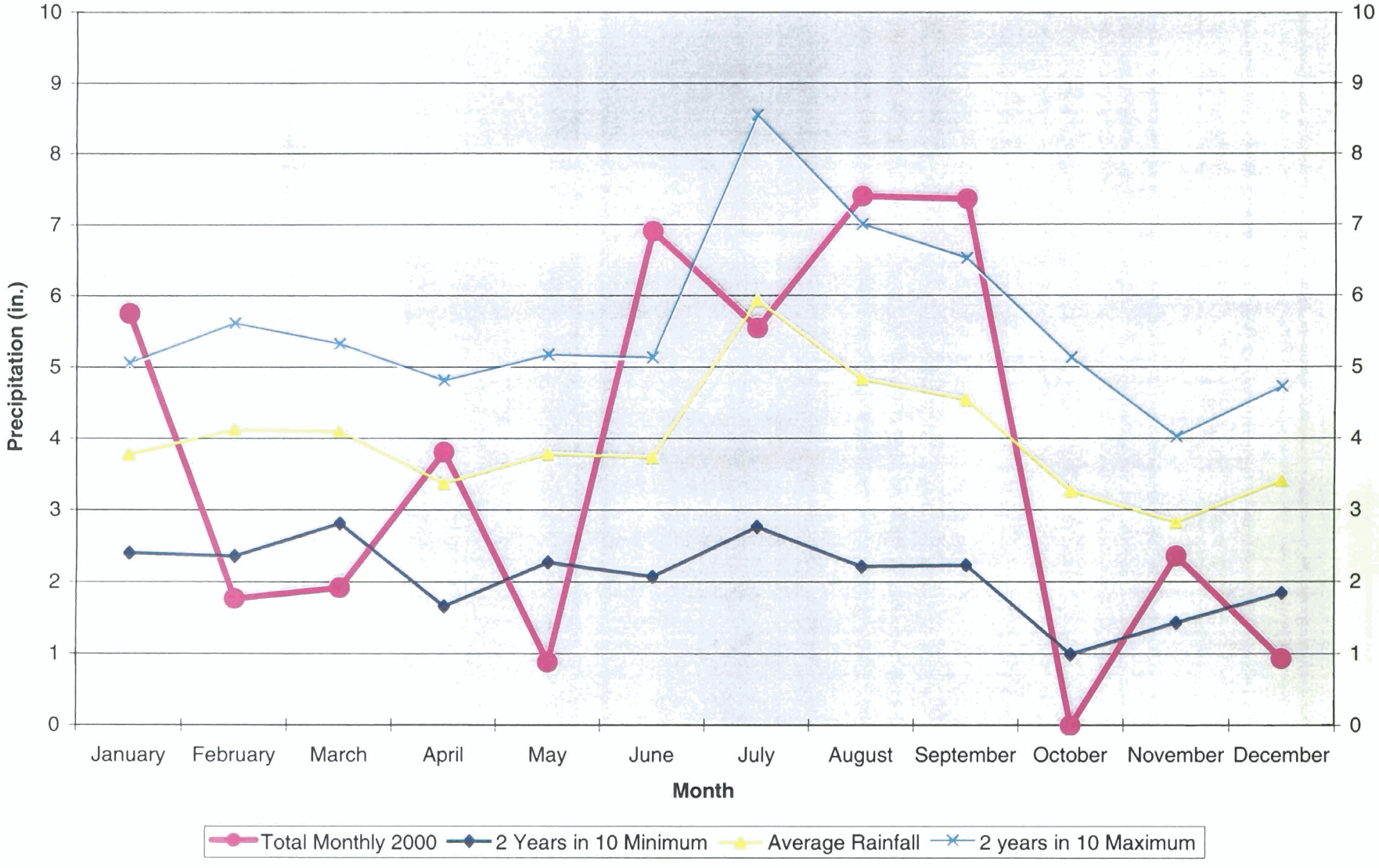


TABLE 6
BENSON GROVE WETLAND MITIGATION SITE
HYDROLOGICAL MONITORING RESULTS, 2000

MONITORING GAUGE	GENERAL LOCATION	SUCCESS DATES	NUMBER OF DAYS	ACTUAL %	<5%	5 TO 12.5%	>12.5%	COMMENT
1	(PC) JD Up	Mar. 21 to May 11	50	21.93			X	
2	(PC) JD Up	Mar. 21 to May 8	47	20.61				
3	JD Wetland							No Data
4	(PC) JD Up	Mar. 21 to May 8	47	20.61			X	
5	(PC) JD Up							No Data
6	(PC) JD Up	Mar. 21 to May 17	56	24.56			X	Partial Data (Ends 10/27)
7	(PC) JD Up	Mar. 21 to Mar. 30	8	3.51	X			
8	(PC) JD Up	Mar. 21 to May 8	47	20.61			X	
9	JD Wetland							No Data
10	JD Wetland	Mar. 21 to May 15	54	23.68			X	
11	JD Wetland	Mar. 21 to May 17	56	24.56			X	Partial Data (Ends 10/27)
DITCH	(PC) JD Up	April 15 to April 22	6	2.63	X			

TABLE 7a
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #1

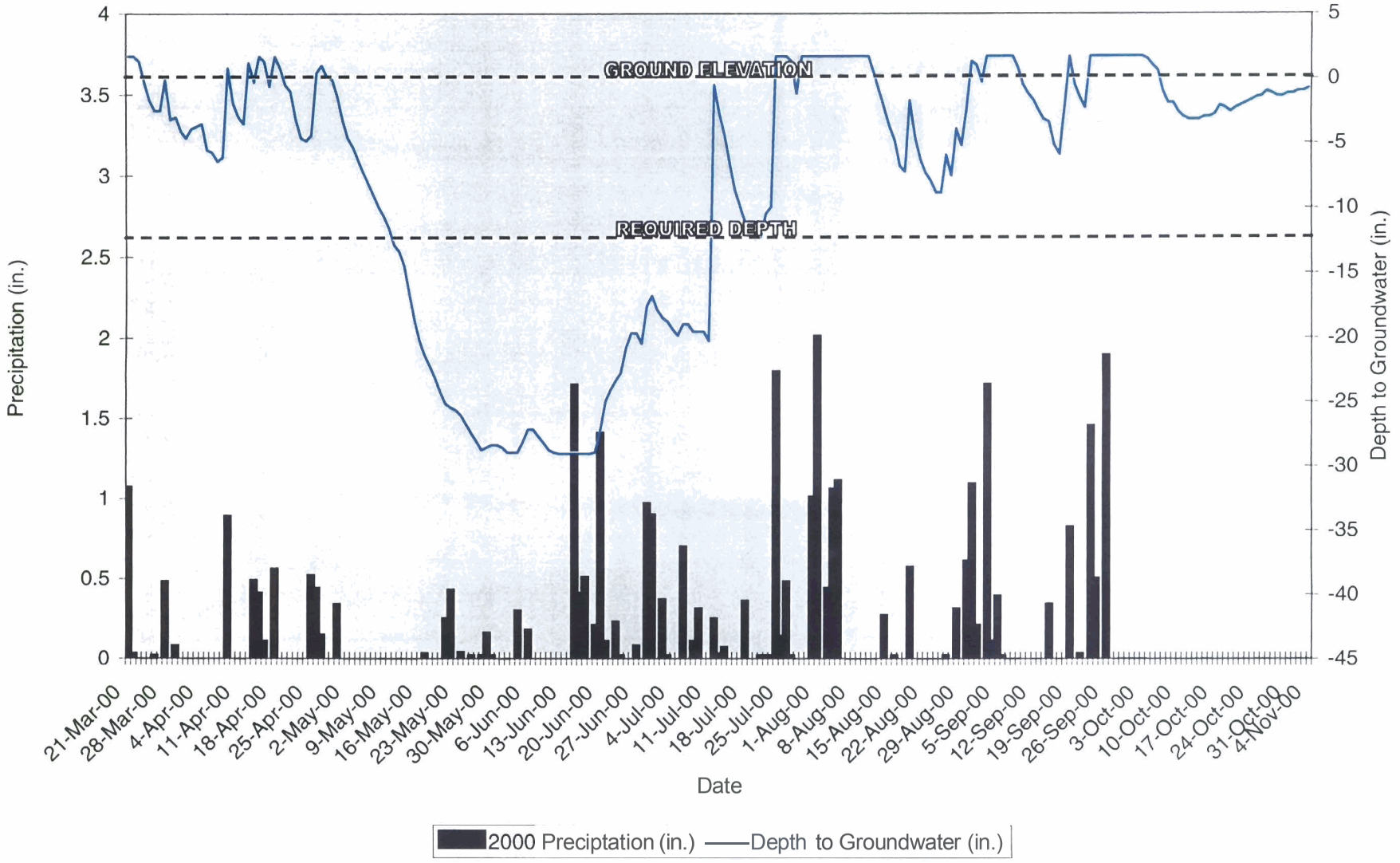


TABLE 7b
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #2

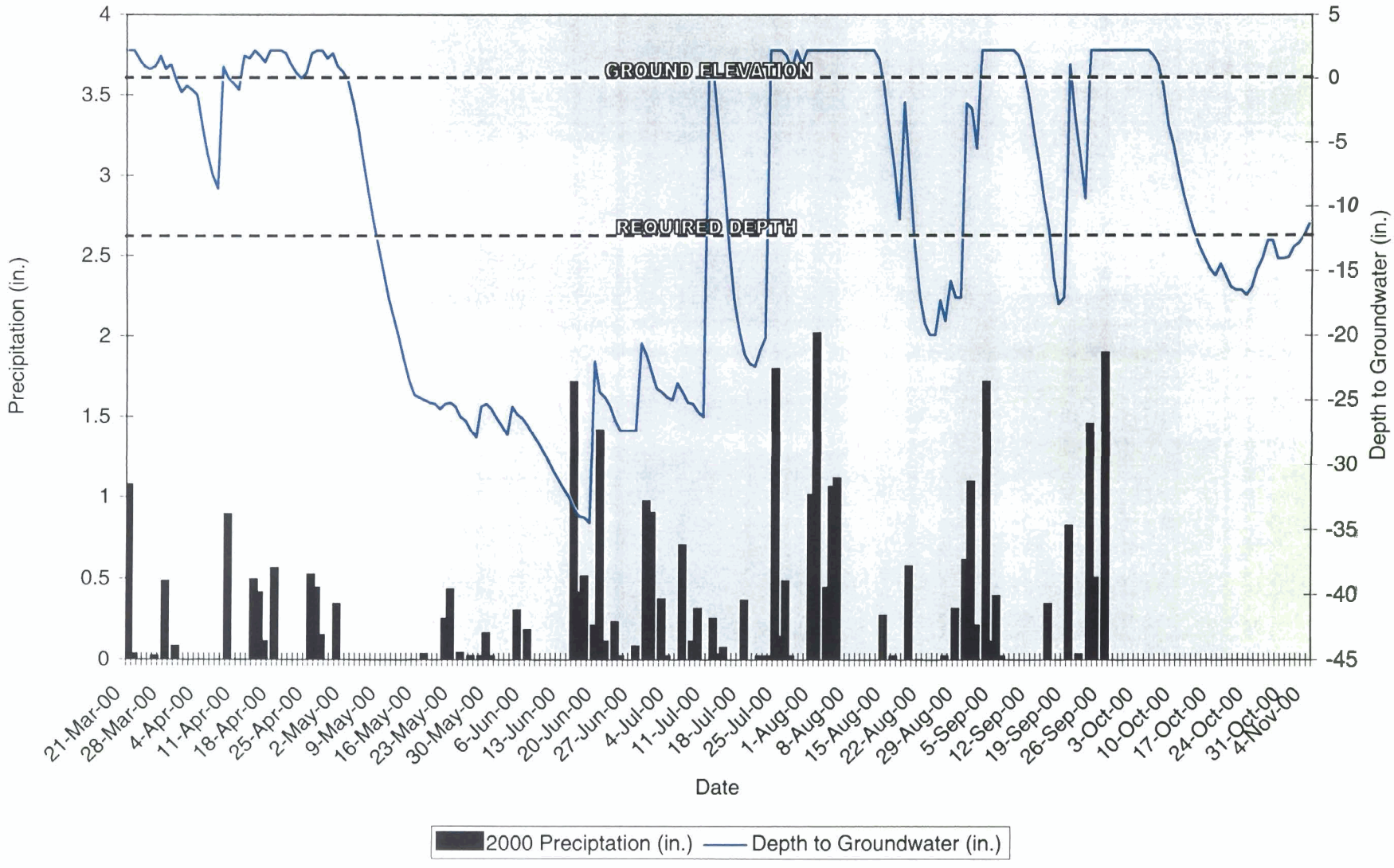


TABLE 7c
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #4

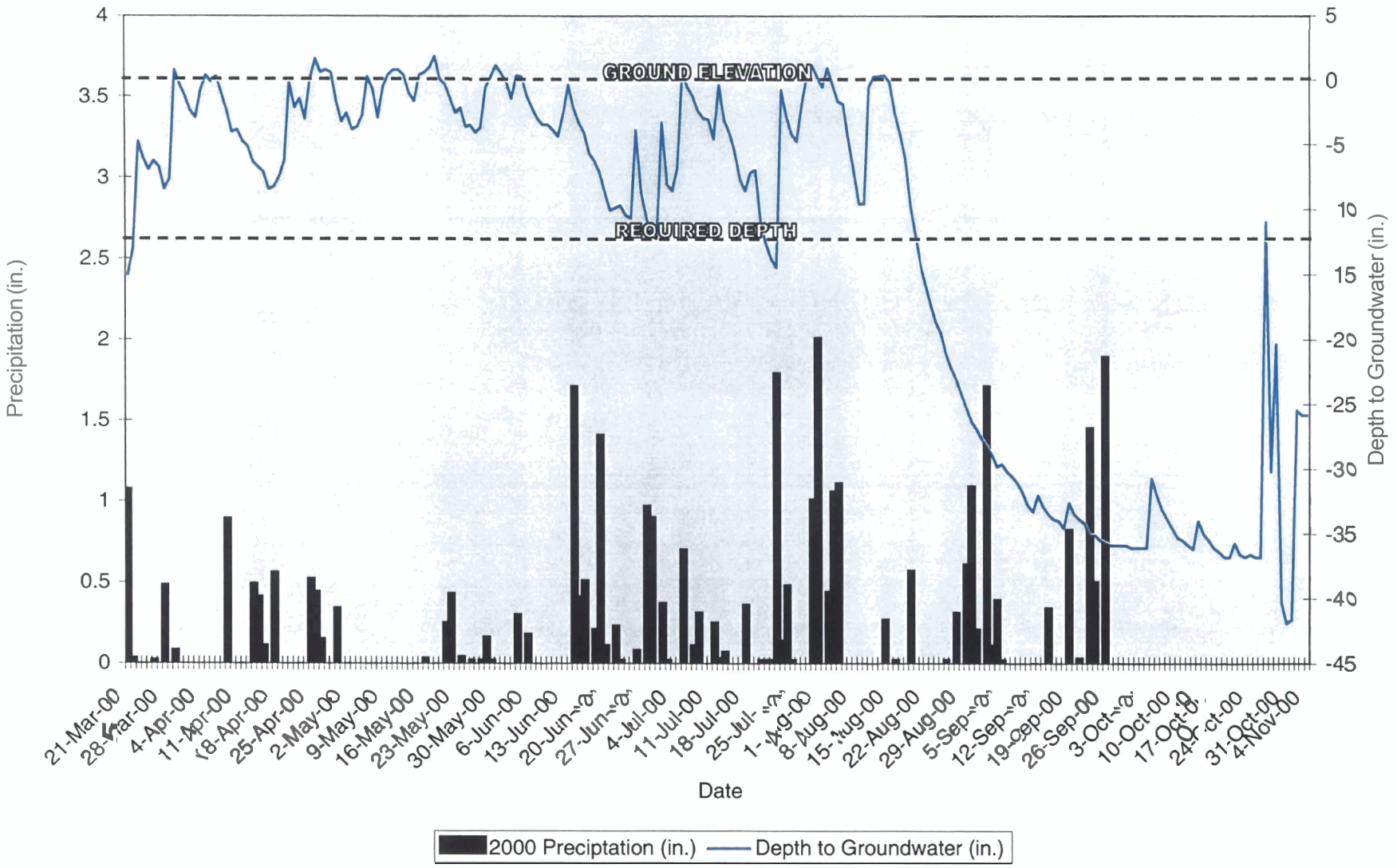


TABLE 7d
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #6

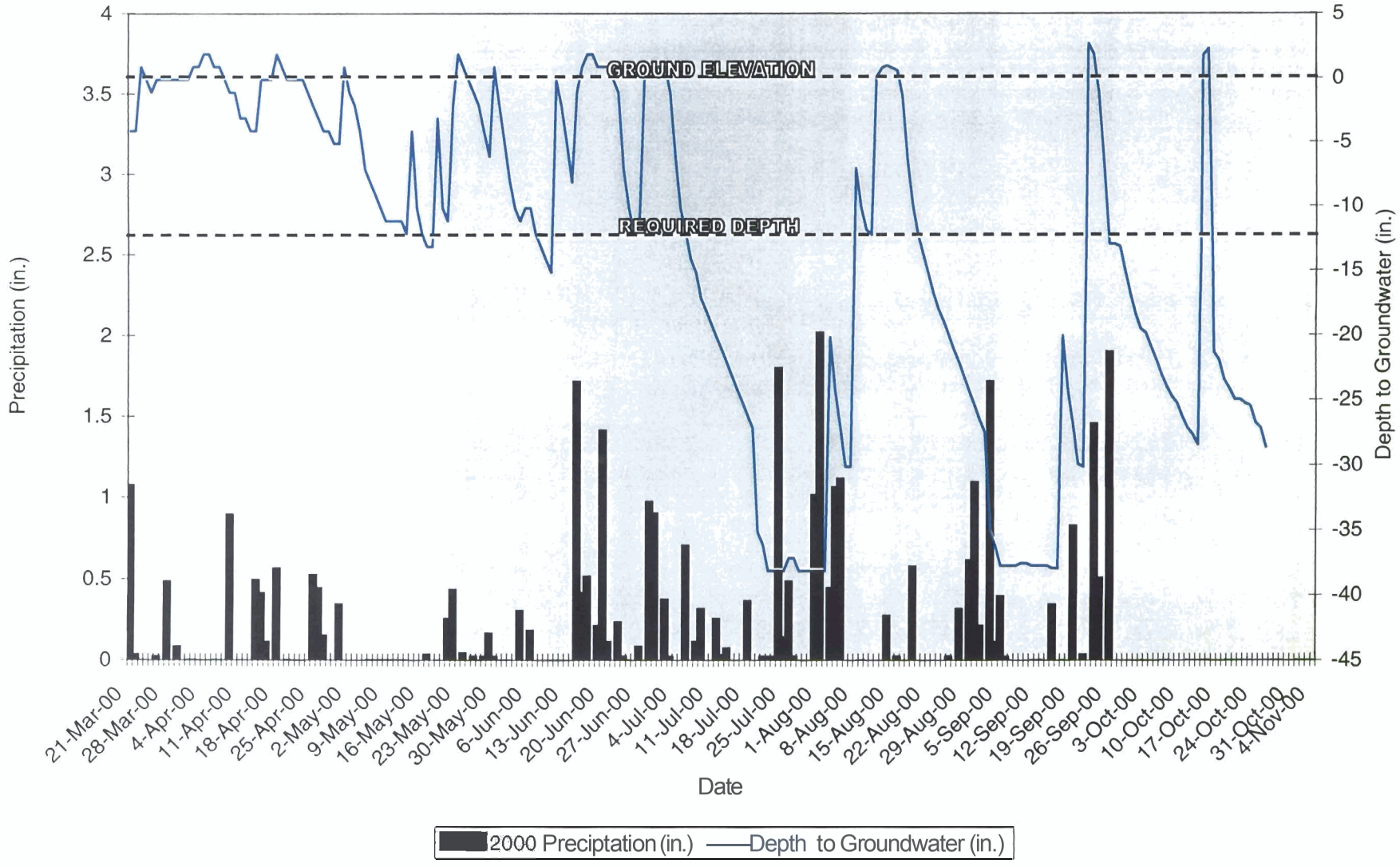


TABLE 7e
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #7

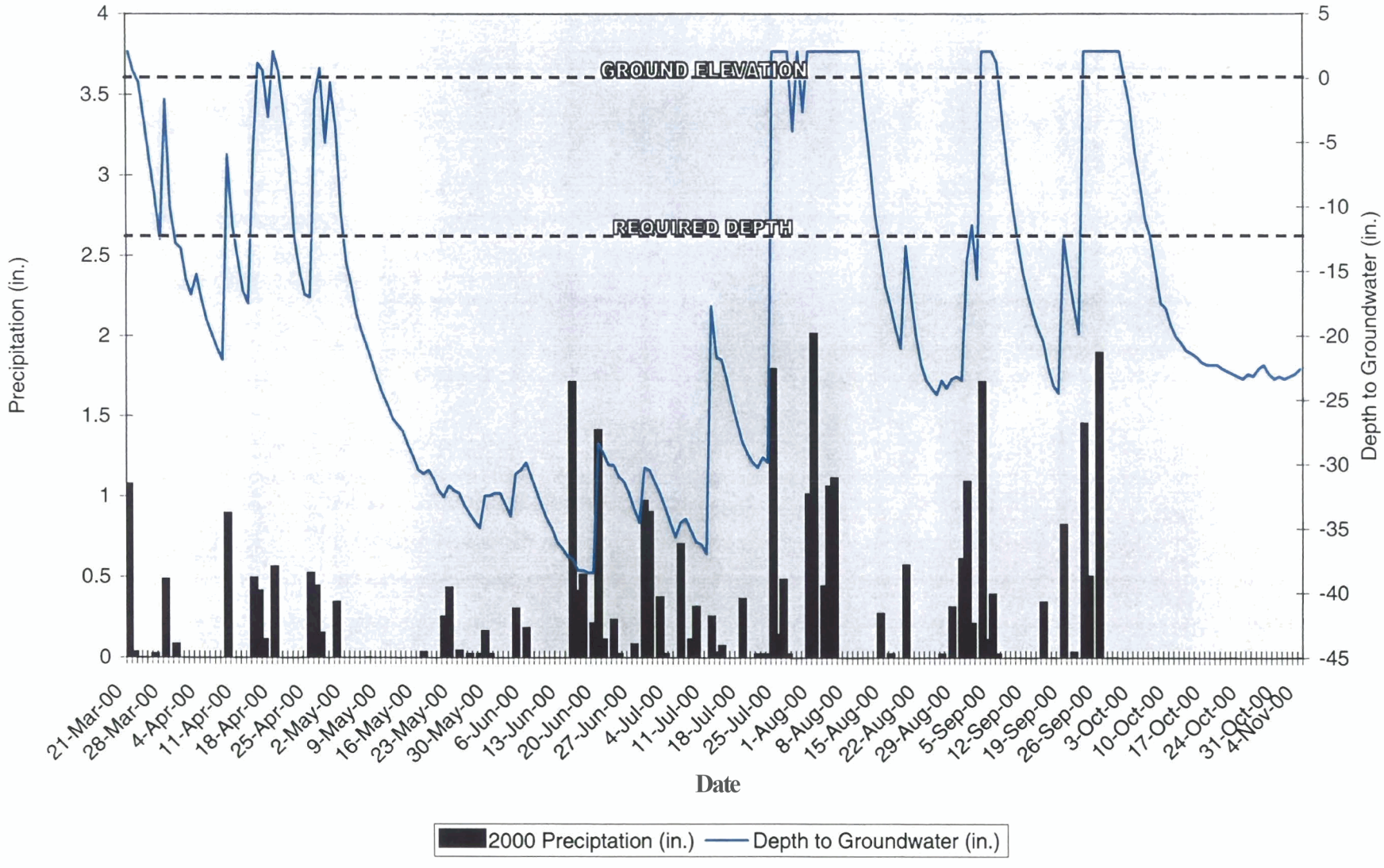


TABLE 7f
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #8

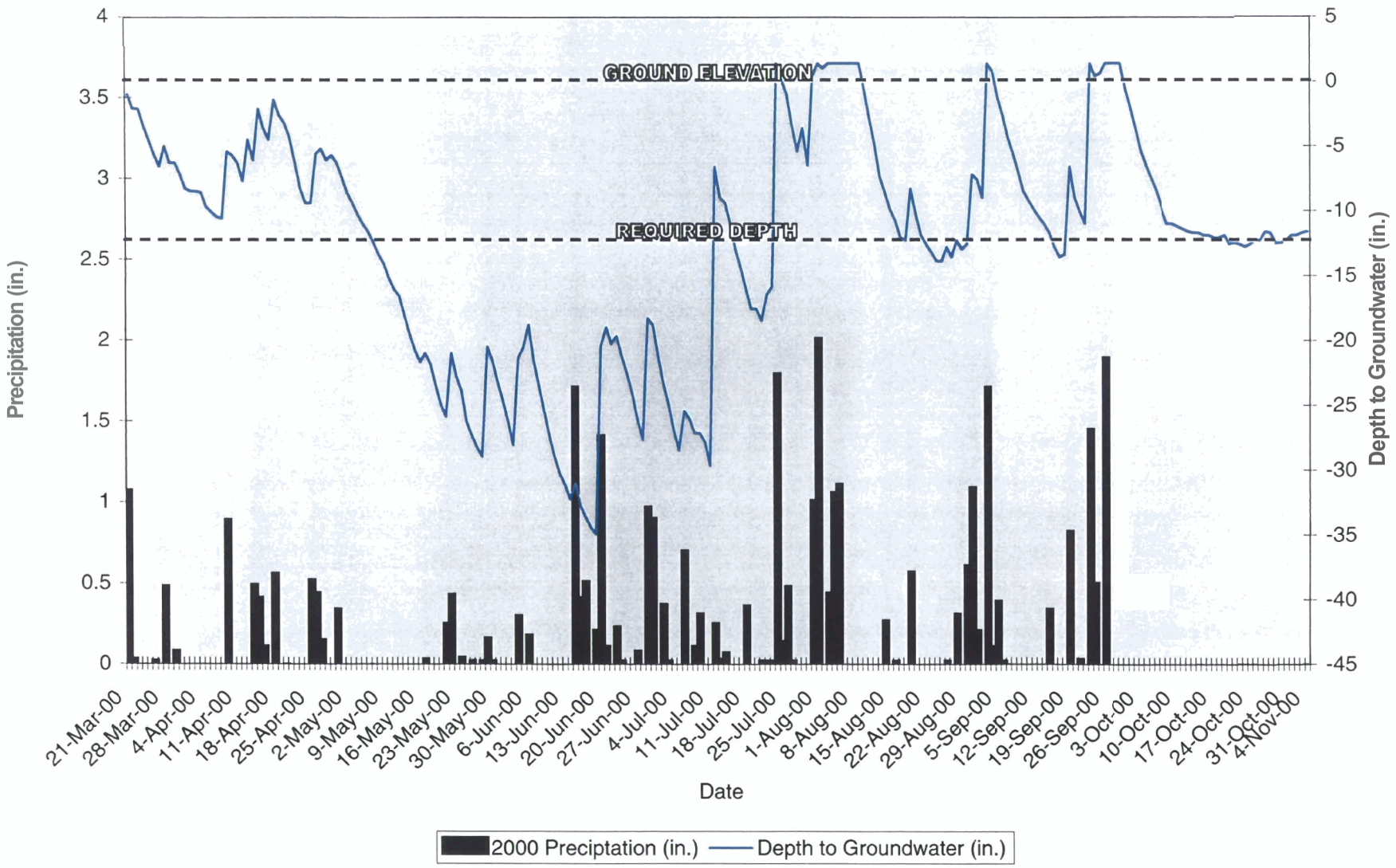


TABLE 7g
BENSON GROVE WETLAND MITIGTION SITE
2000 GROWING SEASON
GAUGE #10

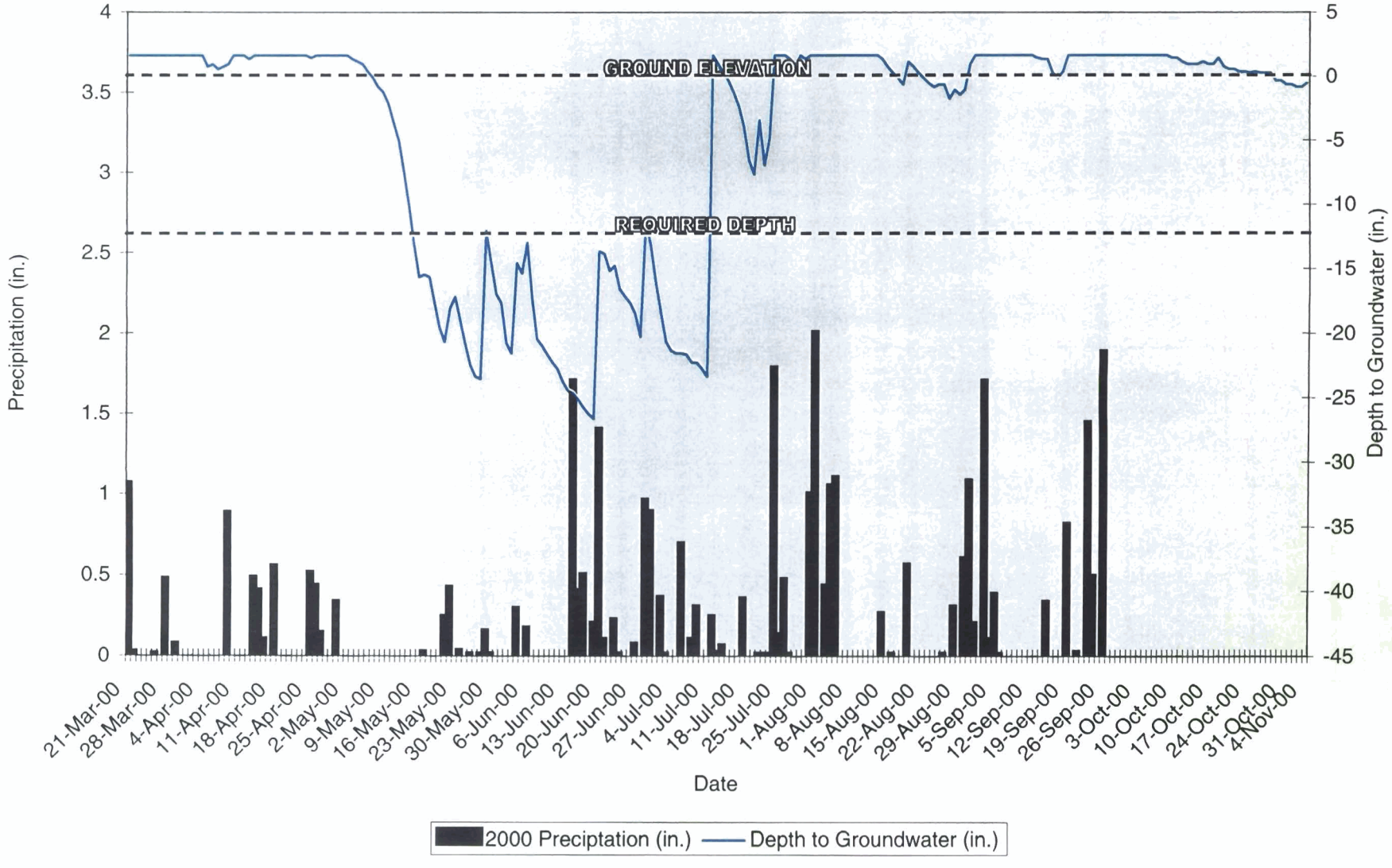


TABLE 7h
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
GAUGE #11

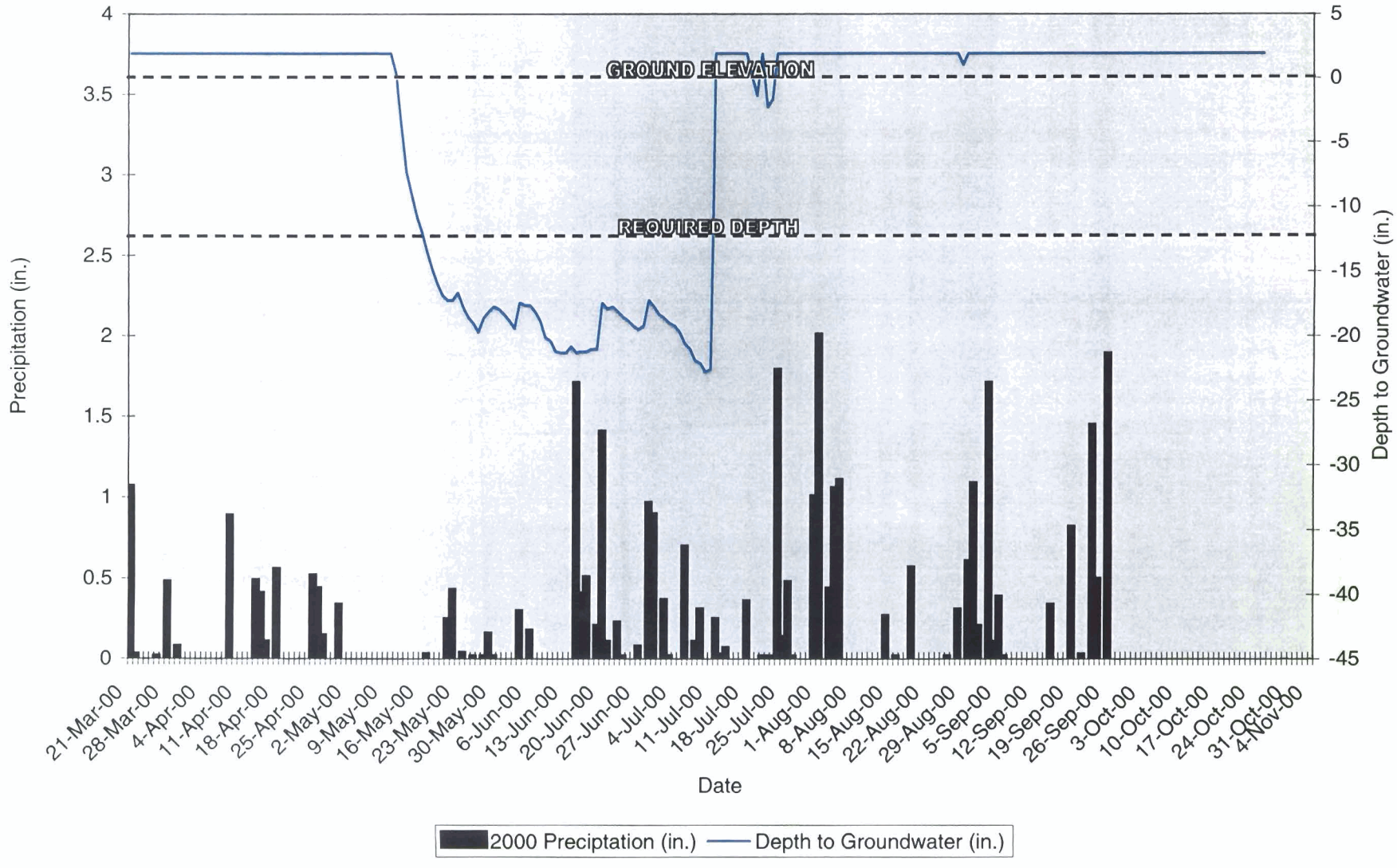
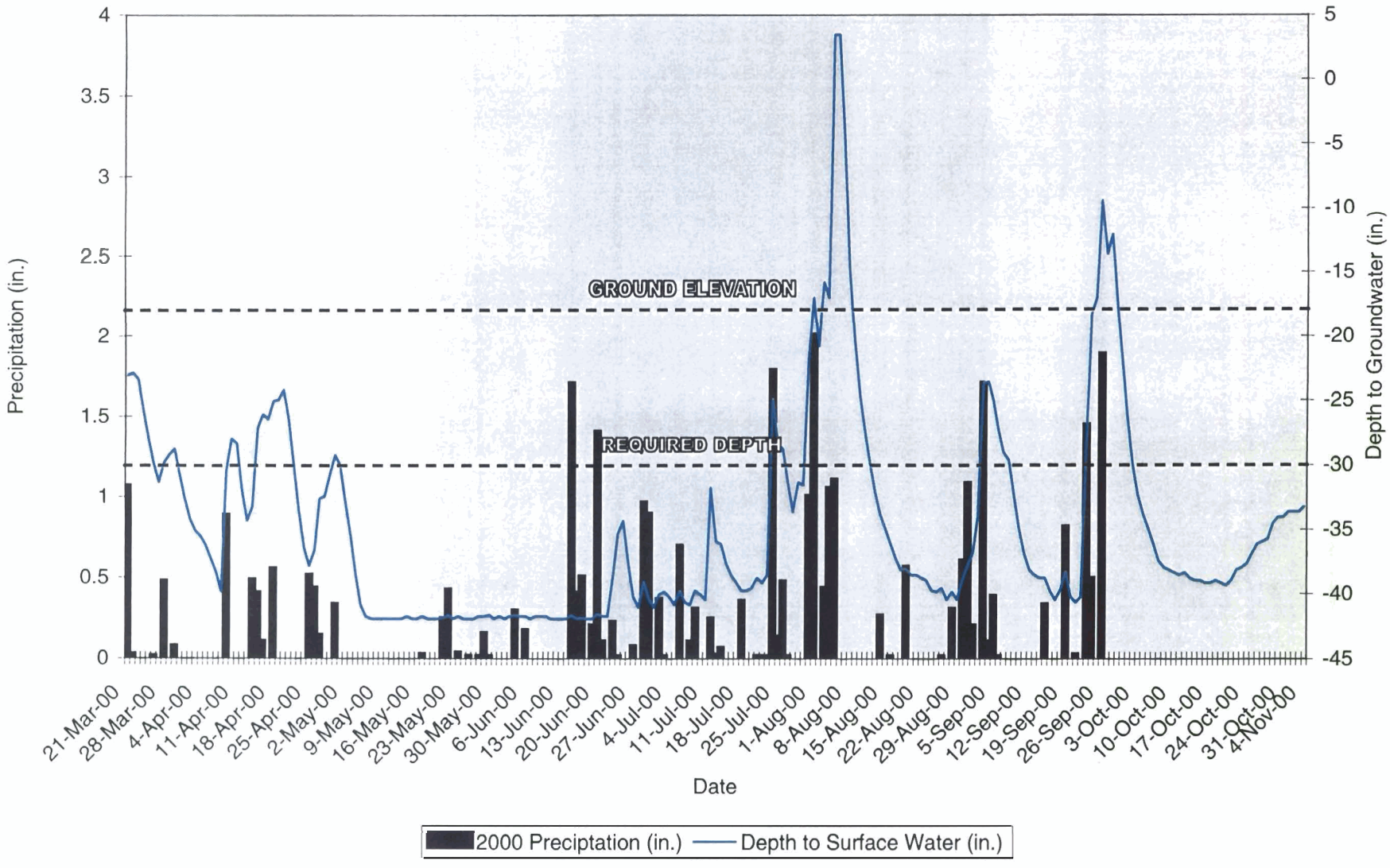
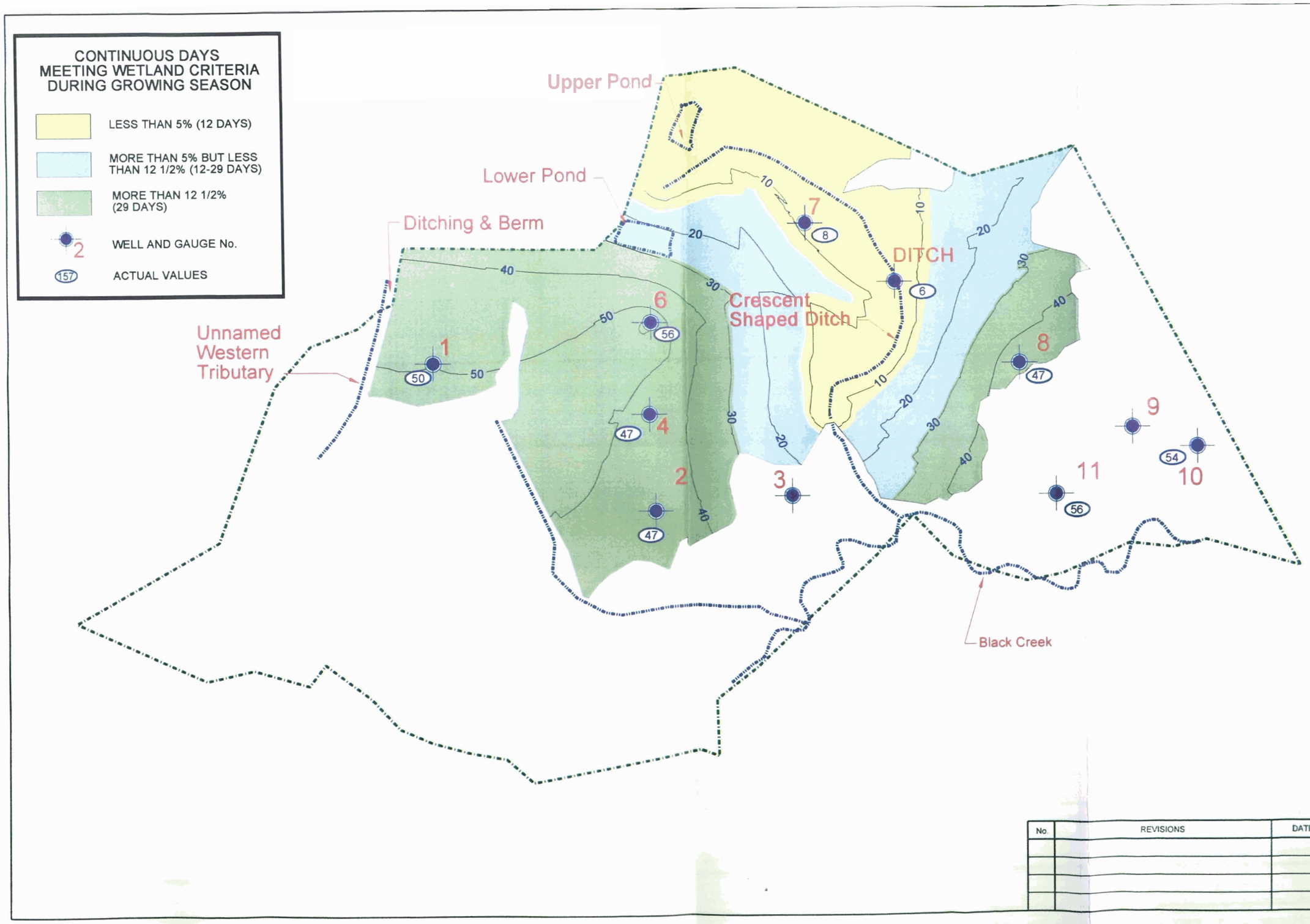


TABLE 7i
BENSON GROVE WETLAND MITIGATION SITE
2000 GROWING SEASON
DITCH GAUGE





No.	REVISIONS	DATE

Figure 7

Date

Scale

Drwn By

Ckd By

Project

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
YEAR 2000 GAUGE DATA

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

3.2 VEGETATION

An on-site reference wetland system was identified in the vicinity of Gauges 9, 10 and 11 (See **Figure 2** – Site Map). A review of the gauge data in this location indicates the reference area meets the wetland hydrological parameter for more than 12.5% of the growing season in most years. This area has been disturbed by logging activities in the early 1990's and is vegetated primarily with successional vegetation dominated by sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*). The species indicated in the planting plan have been modified to reflect a mature community utilizing descriptions by Schafale and Weakley (1990) and as per information provided by Georgia Pacific from their records regarding the species harvested from the Site.

3.3 SOILS

Of the non-jurisdictional areas on the Site, approximately 35.52 ac (14.38 ha) were determined to be hydric soils prior converted by agricultural activities. Primarily, the restoration area is composed of Tomotley soils, hydric soils which are poorly drained. Tomotley soils are located on the first stream terrace, at a slightly higher elevation than the Tomotley/Wehadkee complex, another hydric soil that is poorly drained. The reference wetland system is located in the Tomotley/Wehadkee soils complex.

The portions of the restoration area designated as Tomotley/Wehadkee soils, generally support representative examples of the Coastal Plain Small Stream Swamp Forest (Brownwater subtype) described by Schafale and Weakley (1990). The Tomotley soils, at their slightly higher elevation, support the Coastal Plain Bottomland Hardwood Forest (Brownwater subtype). In general, because the plant species currently dominating the reference wetland are unacceptable as plantings to the regulatory agencies, the wetland systems proposed in the wetland restoration will follow the guidance provided by Schafale and Weakley (1990) for both soil types.

3.2 WETLAND RESTORATION

3.2.1 Hydrology Restoration

Site alterations designed to restore characteristic wetland soil features and groundwater wetland hydrology will be accomplished primarily through ditch plugs, ditch backfilling, and berm removal. Construction plans include alterations to the crescent-shaped ditch and berm to restore Site contours and hydrology. The crescent-shaped ditch will undergo a construction transformation into a gradual depression in its same location. Ditch sections identified for plugging and backfilling in **Figure 8a, 8b and 8c** will be cleaned, as needed, to remove unconsolidated sediments within the bottom of the ditch. Areas will then be cut and filled as shown on the cross-sections. The berm on the western boundary as shown in **Figure 8d**, will be removed, allowing overflow waters from the unnamed western tributary to flow through the Site, saturating the surrounding soils.

3.2.1.1 Crescent-Shaped Ditch

The crescent-shaped ditch drains floodwaters, rainfall and seepage from the northern portion of the Site to Black River. The ditch is proposed to be filled and transformed into a slight dome over the area where the ditch previously existed.

Sediment accumulations in ditches have been associated with unnaturally high lateral permeability rates. It is postulated sediment accumulation within the crescent-shaped ditch is highly permeable relative to surrounding soils and could create a conduit whereby adjacent areas continue to drain. Because of this, accumulated sediments will be excavated from the ditch by tracked hoe and placed directly into a dump truck. These sediments will be transported offsite to a highground location for disposal.

Clearing out the potentially highly permeable sediment exposes the underlying, relatively impermeable natural substrate. Back-fill material will consist of available native earthen material, partially from previously-excavated sediment located along the edge of the ditch and from clean fill material transported in from offsite. The area of the ditch channel will be overfilled and graded to be slightly domed. The purpose is to divert surface water away from the location of the previous ditch channel to preclude entry into what may be a channel of preferential flow. Sections A and B of the ditch, show how the dome will be shaped and the proposed fill lines.

The dome configuration will reduce both the horizontal and vertical soil water gradient of the Site, with the previous drainage influence of the ditch eliminated. Surface waters will be forced to sheet flow on either side of the previous location of the crescent-shaped ditch. This will greatly increase retention times, whereby allowing infiltration to occur and greatly increasing soil saturation.

At the southern end of the crescent shaped ditch, installation of two ditch plugs, as shown in **Figure 8c**, will limit ground water movement that may prefer the former ditch channel as a route of concentrated flow. The plugs will consist of low permeable earthen material that will be installed sufficiently wide and deep to form an imbedded overlap in the ditch bed and banks. Compaction and smearing of the topsoil layer should be avoided in the location of the former ditch as this will hamper deep rooting of the plantings. The ditch plugs, however, will be compacted to limit and potentially stop water permeability. The ditch plugs perform as very low dams to soil water.

3.2.1.2 Berm

The berm on the western boundary will be removed, allowing overflow waters from the unnamed western tributary to flow through the Site. **Figure 8d** shows a cross section of the berm sitting on pre-existing contours at approximately 147 feet above MSL. The berm currently stands approximately 2 feet high. Beginning at the watermost end, using a tracked backhoe, the berm will be removed and excavated sediments will be place directly into dump trucks. Materials will be transported and disposed of at a highground location. The tracked hoe will remove sediments as it moves towards the highground, returning ground elevations to the pre-existing contours of the adjacent wetlands.

3.2.2 Wetland Community Restoration

The Benson Grove Wetland Mitigation Site is located on the Black Creek floodplain between Benson and Garner. Although the watershed originates in the Piedmont, it differs from Piedmont stream morphology, which typically forms alluvial land deposits adjacent to the active channel. Slope gradient slightly increases as distance from the creek increases. Low elevations next to Black Creek provide creek overflow areas on approximately one-third of the Site. The remainder of the Site is also covered by a hydric soil and floods occasionally, however less frequently than areas by the channel.

Farming, the primary land use of the Site, has proven difficult due to limitations caused by soil moisture. In the mid 1970's, the crescent-shaped ditch was dredged in the center of the property. Similarly, the western-most tributary was altered on the west side of the property to control soil moisture and to divert surface waters. The purpose of these activities was to increase farmable areas. These alterations to the natural land contours play a significant part in the uncharacteristic aspects of the Site. Nonetheless, the morphological modifications are minimal. There are minor alluvial land deposits, however no natural levee forest, cypress-gum swamp, or bottomland hardwood system exists by the channel. Rather, the land gradually slopes upward away from the channel. This performs as a small stream swamp.

This wetland mitigation Site will involve the establishment of a Coastal Plain Small Stream Swamp Forest (Brownwater subtype) natural community in the area closest to Black Creek, and this will grade into a Coastal Plain Bottomland Hardwood Forest (Brownwater subtype) natural community progressing inland perpendicular to the main stream. Eventually this wetland system will transition in to a Mesic, Mixed Hardwood Forest located on the non-hydric soils along the upland slope. Transitional species will be planted between zones to allow for an ecotone effect. Because of the susceptibility of communities in this geomorphic position to long-term flooding, the natural communities are populated with species adapted to survival under these conditions.

The characteristics of these communities are well documented on pages 46 through 49, 155 through 157, and 163 through 165 of Shafale and Weakley. Additional guidance used in preparing the planting plan includes the Johnson County Soil Survey (NRCS, 1994) and the Department of Environment and Natural Resources, Division of Water Quality, Wetland Restoration Program Guidelines for Riparian Buffer Restoration (2001).

An examination of the Coastal Plain Small Stream Swamp Forest (Brownwater subtype) (**Table 8**) and Coastal Plain Bottomland Forest (Brownwater subtype) (**Table 9**) indicate vegetative characteristics vary slightly depending upon frequency of flooding. The Mesic Mixed Hardwood Forest (Coastal Plain subtype) (**Table 10**) is characterized by the presence of less flood tolerant species. The soils at this Site were mapped by Cpec Environmental's licensed soil scientist, Mr. Tommy Hinson, as Wehadkee/Tomotley Complex, adjacent to Black Creek. These grade into Tomotley across the floodplain and small pockets of Augusta (non-hydric) lie within the floodplain. Some inconsistencies with the community descriptions outlined in Shafale and Weakley are noted under the "Zone" descriptions.

The presence of Wehadkee soils (Typic Fluvaquent) are indicative of Coastal Plain Small Stream Swamps (Brownwater subtype). This nearly level, poorly drained soil is on floodplains, generally along streams. Seasonal high water table is at the surface or within a depth of 1 foot. It can be frequently flooded for brief periods. Most areas of Wehadkee soil is used as

woodland. The flooding and the wetness are the main limitations and results in high mortality rate of pine. The soil is well suited for the production of hardwood. Common canopy species are sweetgum, yellow-poplar, loblolly pine, water oak, ash, and American sycamore.

Tomotley soils (Typic Endoaquults) form complexes with the Wehadkee soils, both experiencing seasonal flooding adjacent to Black Creek. Tomotley is a poorly drained soil on stream terraces on the coastal plain. Seasonal water table is at the surface or within a depth of 1-foot in winter and spring. Tomotley soil is typically used as woodland with wetness being the main limitation. Common canopy species are loblolly pine, sweetgum, yellow-poplar, water oak, and pond pine. Common understory species are ironwood, switchcane, holly, myrtle, blueberry, and bay.

Augusta soil is a somewhat poorly drained soil found on stream terraces. Wetness is the main limitation. Common canopy species are loblolly pine, sweetgum, American sycamore, white oak, water oak, cherrybark oak, yellow-poplar, and willow oak. Common understory species are hornbeam and American holly.

Gilead soil is a moderately well drained soil in the uplands on the coastal plain. This soil is well suited to woodlands and is generally in higher areas. Common canopy species are loblolly pine, longleaf pine, white oak, red oak, sweetgum, and hickory. The main understory species are dogwood, sourwood, holly, and sassafras.

The intent of this restoration plan is to guide vegetative succession to a mature (trees) stand representative of these communities. Success will be gauged by survival rates of the tree plantings over the next five years. With this in mind, the broad diversity of herbaceous and shrub species in the early successional stages of the project will be dependent on the seed stock transported to the Site by wind and flood water. Canopy and understory species, listed above in the soil descriptions, are expected to colonize naturally.

This strategy of natural colonization will insure even distribution of the more successionally transient species, while at the same time, allowing the project focus to be on the ultimate goal of a successful, stable, and natural, mature vegetative community. In addition, wildlife benefits are of particular interest within the proposed community and species providing good habitat and food resources have been chosen accordingly.

A detailed description of the proposed planting zones is listed below and can be viewed in **Figure 9**.

3.2.2.1 Zone A - Coastal Plain Small Stream Swamp Forest (Brownwater subtype)

The Coastal Plain Small Stream Swamp community restoration will border the area adjacent to Black Creek and extend northward away from the creek. This area experiences seasonal flood conditions caused by the shallow entrenchment and slow-moving waters of Black Creek. Field observations show that the natural community does not accurately mimic the description of a Coastal Plain Small Stream Swamp in Shafele and Weakley. Actual conditions reflect a larger than normal stream size, which in this case is a creek, that is adjacent to a floodplain without well-developed alluvial landforms. In both cases, the boundary is arbitrary and is difficult to place. Differing somewhat from actual conditions, typical brownwater subtypes originate in the Piedmont, carry a heavy sediment load, and form alluvial landforms or levee systems as the sediments settle out of floodwaters. Due to the headwaters originating at the

edge of the piedmont physiographic region, in the vicinity of Fuquay-Varina, this Site seems to show some mixing of blackwater and brownwater characteristics. However, the vegetation at Benson Grove shows closer resemblance to the brownwater subtype.

Zone A planting plan is designed to promote a natural vegetative community that is tolerant of regular flooding by Black Creek. Species include bare root stock of trees (depending on availability) that grow in seasonally submerged soils. These plants are rated as Obligate (OBL) species in the southeastern portion, Region 2, of the United States. See **Table 8** for a list of the proposed plantings, wetland ratings, and benefits for Zone A.

3.2.2.2 Zone B - Coastal Plain Bottomland Hardwood Forest (Brownwater subtype)

Zone B is located along a terrace in relatively high parts of the flood plain away from the active channel. The planting plan is designed to form a stable climax forest, having an uneven-aged canopy with primarily gap phase regeneration. Bottomland hardwood forests often encounter unusually deep and prolonged flooding that may cause widespread mortality, especially in pines. Current field analysis indicates that the Site was logged and cleared in the early 1990's, resulting in a dominance of disturbed species such as red maple and sweetgum. Moving inland along a gradient perpendicular to the creek, soil moisture decreases and grades from the Coastal Plain Small Stream Swamp community to a Coastal Plain Bottomland Hardwood Forest community.

Zone B is composed mostly of hydric Tomotley soils. Pockets of the non-hydric Augusta and Gilead soils are scattered throughout. The following vegetation will be planted throughout all of Zone B although the pockets of non-hydric soils may slightly alter the continuity of Zone B. The suggested plants are rated as Obligate (OBL), Facultative Wet (FACW) and Facultative (FAC) species in the southeastern portion, Region 2, of the United States. See **Table 9** for a list of the proposed plantings, wetland ratings, and benefits for Zone B.

3.2.2.3 Zone C - Mesic Mixed Hardwood Forest (Coastal Plain subtype)

Zone C is a small portion along the edge of the slope northward of Black Creek. It is designed to promote a natural vegetative community that may experience seldom flooding and regular dry periods. As the slope gradually increases along the northern boundary of the Site, changes in the soil moisture regime are evident. The transition from Coastal Plain Bottomland Hardwood Forest to Mesic Mixed Hardwood Forest (Coastal Plain subtype) is characterized by the presence of moist upland soils, such as Augusta and Gilead, and upland species less tolerant of flood conditions. These plants are rated as Facultative Upland (FACU) species in the southeastern portion, Region 2, of the United States. See **Table 10** for a list of the proposed plantings, wetland ratings, and benefits for Zone C.

3.2.2.4 Planting Criteria

According to the Guidelines for Riparian Buffer Restoration, plant density varies depending upon the size, age, and growth rate of the plant. Considering budget limitations, bare root stock is often used in mitigation planting plans. Over a five-year period, success will be gauged by survival rates of the plantings.

Target species quantities will be adapted from vegetation at local reference sites as well as the Department of Environment and Natural Resources, Division of Water Quality, Wetland Restoration Program Guidelines for Riparian Buffer Restoration (2001). Preferred plantings are one year old bare root stock planted on 8 X 8 centers. This will provide a planting density of 680 plants per acre. In addition to the expected planting success, it is anticipated that many of the species identified as occuring in the various ecological zones will naturally colonize the Site.

3.2.2.5 Wildlife Benefits

Current transitional vegetation on the Site such as blackberry, grasses and sedges provide food for many species including the cottontail rabbit, bobwite quail, prairie warbler, yellow-breasted chat and whitetail deer. The production of seeds from these plants furnishes food for rodents like the hispid cotton rat and meadow vole. As mentioned previously, current vegetation on the Site provides excellent seed sources and is expected to colonize much of the Site naturally. Transitioning from early successional farm fields to a mature hardwood stand will provide a variety of vegetative communities advantageous to a wide diversity of wildlife. RK&K will focus its planting efforts on the mature hardwood vegetative community such as mast producing species and thereby attract numerous wildlife species.

A variety of mast producing species have been included in the planting plan in Zones A through C. Among these, green ash, cherrybark oak, swamp chestnut oak and the flowering dogwood provide important habitat for a variety of wildlife including wild turkey, ruffed grouse, wood ducks, Carolina chickadee, tufted titmouse, downy woodpecker, wood thrush, scarlet tanager, white-tail deer, raccoon, and gray squirrels. Stands of these trees also provide food for rodents and thus benefit predators such as the red-shoulder hawk, barred owl and black racer snake. In addition, some salamanders may only breed in pools of mature hardwood forests.

The proposed planting plan has been developed with the intent of developing a successful, stable and mature vegetative community that provides habitat and food resources for a diversity of wildlife species common to the coastal plain of North Carolina.

TABLE 8a
BENSON GROVE WETLAND MITIGATION SITE
PROPOSED ECOSYSTEM CHARACTERISTICS
COASTAL PLAIN SMALL STREAM SWAMP (BROWNWATER SUBTYPE)

Common Name	Scientific Name	Wetland Classification
Canopy		
Sycamore	*Platanus occidentallis*	FACW-
River Birch	*Betula nigra*	FACW
Baldcypress	*Taxodium distichum*	OBL
Water Tupelo	*Nyssa aquatica*	OBL
Sugarberry	*Celtis laevigata*	FACW
Green Ash	*Fraxinus pennsylvanica*	FACW
Shumard Oak	*Quercus shumardii*	FACW
Swamp Laurel Oak	*Quercus laurifolia*	FACW
Water Oak	*Quercus nigra*	FAC
Willow Oak	*Quercus phellos*	FACW-
Swamp Chestnut Oak	*Quercus michauxii*	FACW-
Cherrybark Oak	*Quercus pagoda*	FAC+
Sweetgum	*Liquidambar sytraciflua*	FAC+
Black Willow	*Salix nigra*	OBL
Swamp Cottonwood	*Populus heterophylla*	OBL
Understory		
Carolina Ash	*Fraxinus caroliniana*	OBL
Red Maple	*Acer rubrum*	FAC
Ironwood	*Carpinus caroliniana*	FAC
American Holly	*Ilex opaca*	FAC-

SOURCE: ***Classification of the Natural Communities of North Carolina, Third Approximation*** **, Shafale and Weakley, NC Division of Environment, Health and Natural Resources, 1990**

TABLE 8b
BENSON GROVE WETLAND MITIGATION SITE
PROPOSED ECOSYSTEM CHARACTERISTICS
COASTAL PLAIN BOTTOMLAND FOREST (BROWNWATER SUBTYPE)

Common Name	Scientific Name	Wetland Classification
Canopy		
Water Hickory	*Carya aquatica*	OBL
Bitternut Hickory	*Carya cordiformis*	FAC
Shagbark Hickory	*Carya ovata*	FACU
Hackberry	*Celtis laevigata*	FACW
Green Ash	*Fraxinus pennsylvanica*	FACW
Sweetgum	*Liquidambar styraciflua*	FAC
Black Walnut	*Juglans nigra*	FACU
American Elm	*Ulmus americana*	FACW
Sugarberry	*Celtis laevigata*	FACW
Swamp Chestnut Oak	*Quercus michauxii*	FACW-
Cherrybark Oak	*Quercus pagoda*	FAC+
Shumard Oak	*Quercus shumardii*	FACW
Swamp Laurel Oak	*Quercus laurifolia*	FACW
Water Oak	*Quercus nigra*	FAC
Willow Oak	*Quercus phellos*	FACW-
Understory		
Pawpaw	*Asimina triloba*	FAC
Ironwood	*Carpinus caroliniana*	FAC
American Holly	*Ilex opaca*	FAC-
Deciduous Holly	*Ilex decidua*	FACW-
Vines		
Poison Ivy	*Toxicodendron radicans*	FAC
Grapevine	*Vitis rotundifolia*	FAC
Greenbrier	*Smilax spp.*	FAC
Alabama Supple-jack	*Berchemia scandens*	FACW
Herbs		
Giant Cane	*Arundinaria gigantea*	FACW-
Sedge	*Carex spp.*	(depends on species)
Indian Sea Oats	*Chasmanthium latifolium*	FAC-
Slender Spikegrass	*Cahasmanthurm laxum*	FACW-
Violet	*Viola spp.*	(depends on species)
False Nettle	*Boehmeria cylindrica*	FACW-

SOURCE: ***Classification of the Natural Communities of North Carolina, Third Approximation*** **, Shafale and Weakley, NC Division of Environment, Health and Natural Resources, 1990**

TABLE 9a
BENSON GROVE WETLAND MITIGATION SITE
PROPOSED PLANTINGS*
ZONE A

Common Name	Scientific Name	Region 2	Benefits
Baldcypress	*Taxodium distichum*	OBL	Replace natural stand
Swamp Cottonwood	*Populus heteropylla*	OBL	Grows rapidly, prevents erosion and flood damage
Water Tupelo	*Nyssa aquatica*	OBL	Provides shelter and wildlife food
Black Willow	*Salix nigra*	OBL	Prevents erosion and flood damage
Buttonbush	*Cephalanthus occidentalis*	OBL	Provides shelter and wildlife food

*NOTE: Actual species comprising the plantings are subject to availability.

TABLE 9b
BENSON GROVE WETLAND MITIGATION SITE
PROPOSED PLANTINGS*
ZONE B

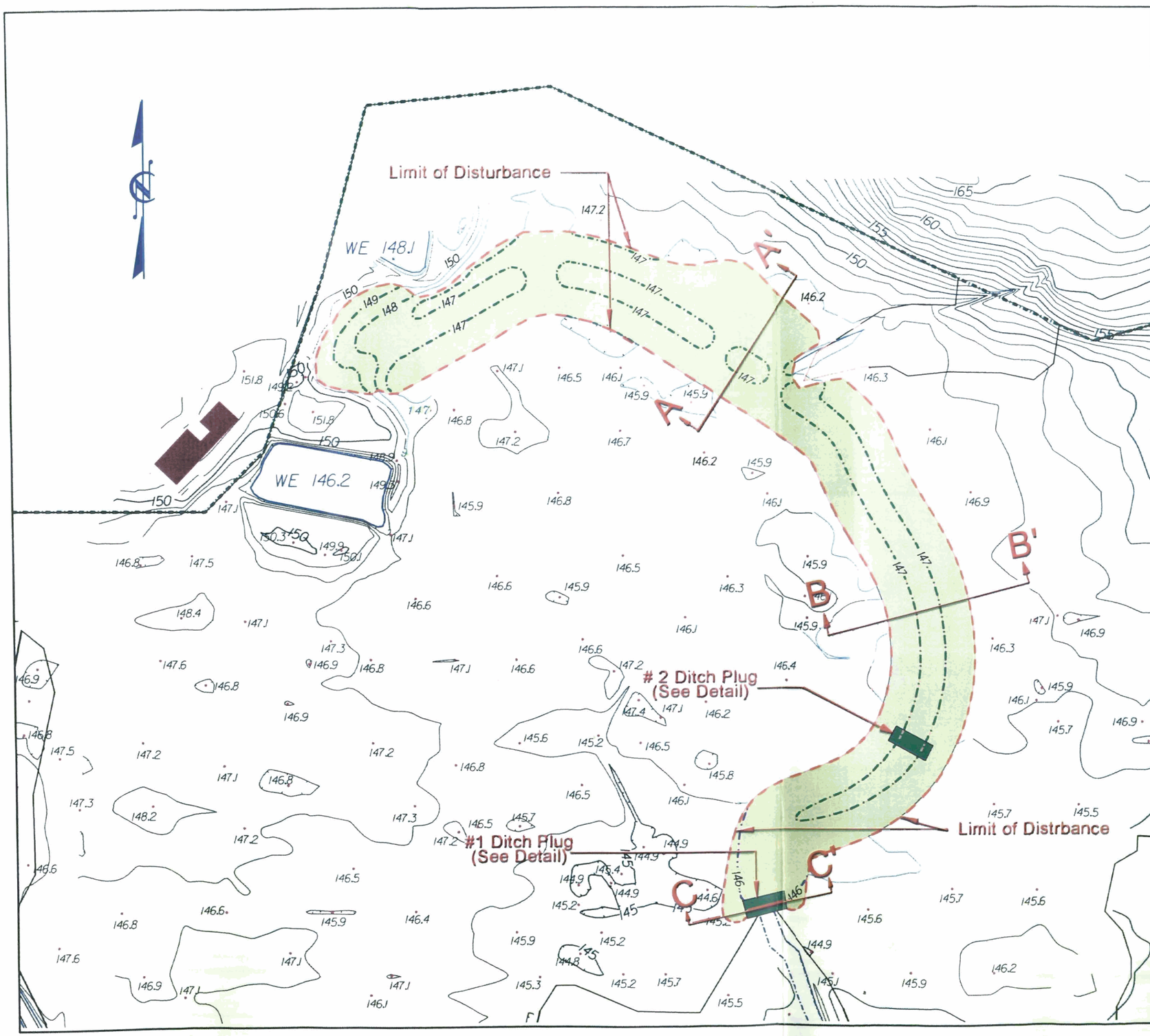
Common Name	Scientific Name	Region 2	Benefits
Water Hickory	*Carya aquatica*	OBL	Provides shelter and wildlife food
Swamp Chestnut Oak	*Quercus michauxii*	FACW	Provides shelter and wildlife food
Willow Oak	*Quercus phellos*	FACW	Provides shelter and wildlife food
Water Oak	*Quercus nigra*	FAC	Provides shelter and wildlife food
Overcup Oak	*Quercus lyrata*	OBL	Provides shelter and wildlife food
Cherrybark Oak	*Quercus pagoda*	FAC+	Provides shelter and wildlife food
Tulip Poplar	*Liriodendron tulipifera*	FAC	Provides shelter and wildlife food
Green Ash	*Fraxinus pennsylvanica*	FACW	Provides shelter and wildlife food
Sugarberry (Hackberry)	*Celtis laevigata*	FACW	Provides shelter and wildlife food
Common Pawpaw	*Asimina triloba*	FAC	Provides shelter and wildlife food
Deciduous Holly (Winterberry, Possumhaw)	*Ilex decidua*	FACW	Provides shelter and wildlife food
Ironwood	*Carpinus caroliniana*	FAC	Provides shelter and wildlife food

*NOTE: Actual species comprising the plantings are subject to availability.

TABLE 9c
BENSON GROVE WETLAND MITIGATION SITE
PROPOSED PLANTINGS*
ZONE C

Common Name	Scientific Name	Region 2	Benefits
American Beech	*Fagus grandifolia*	FACU	Provides shelter and wildlife food
Shagbark Hickory	*Carya ovata*	FACU	Provides shelter and wildlife food
Flowering Dogwood	*Cornus florida*	FACU	Provides shelter and wildlife food
Black Cherry	*Prunus serotina*	FACU	Provides shelter and wildlife food

*NOTE: Actual species comprising the plantings are subject to availability.

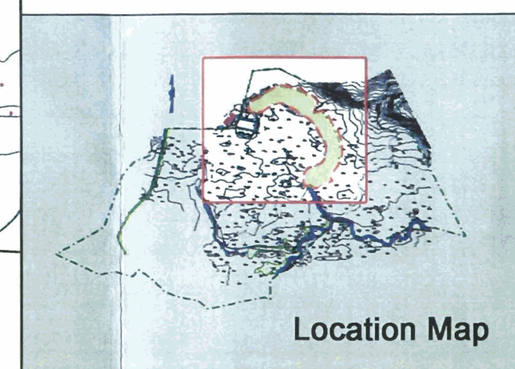


Legend

- Lowest Extent of Disturbance
- Finished Contours
- Limit of Disturbance
- 146.1 Existing Elevations
- Existing Contours
- A A' Cross-Sections

0 100' 200'

1" = 100' Scale



No.	REVISIONS	DATE

Figure 8a

Date

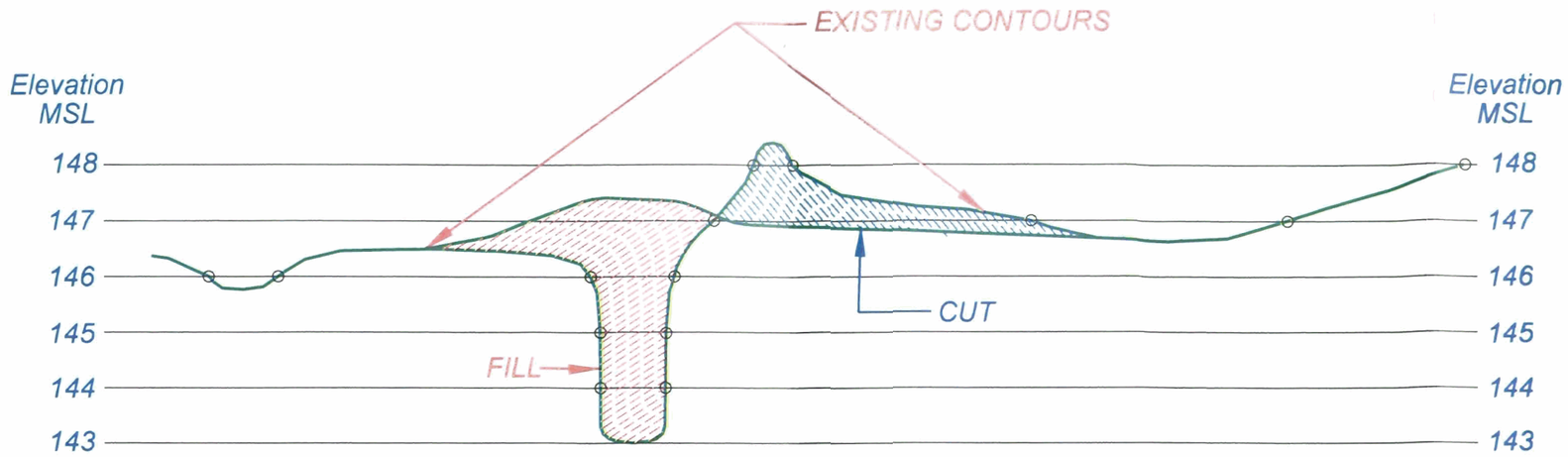
Scale:

Dwn By:

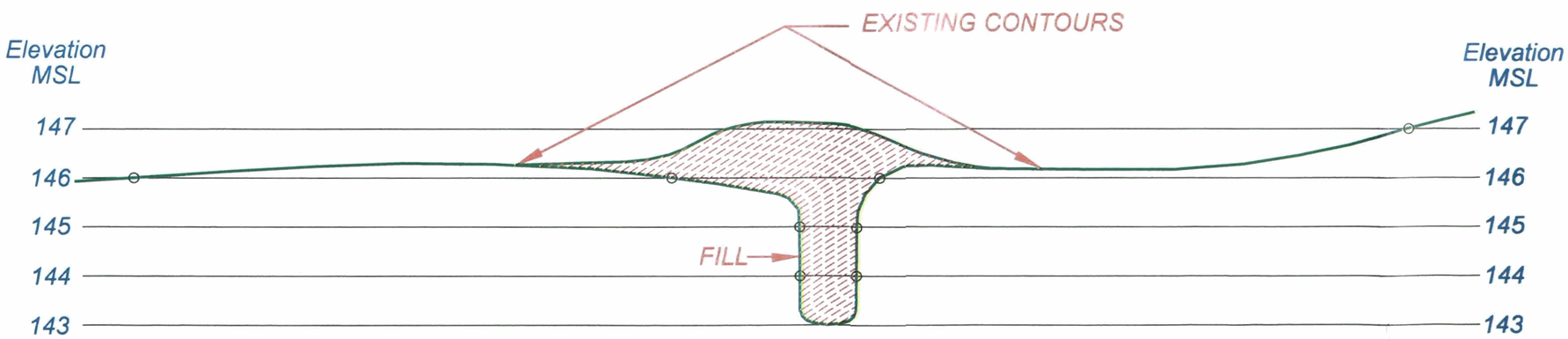
Ckd By:

Project: BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
RESTORATION PLAN
DITCH RESTORATION

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611



SECTION ALONG PROFILE A-A'
LOOKING NORTH



SECTION ALONG PROFILE B-B'
LOOKING NORTH

10X VERTICAL
EXAGGERATION

No.	REVISIONS	DATE

Figure: 8b

Date:

Scale:

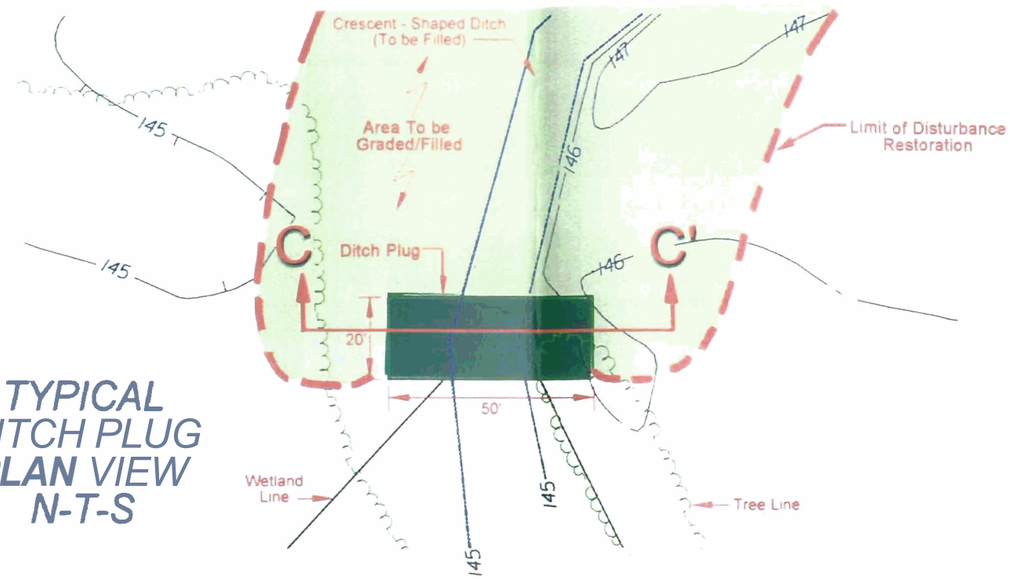
Dwn By:

Ckd By:

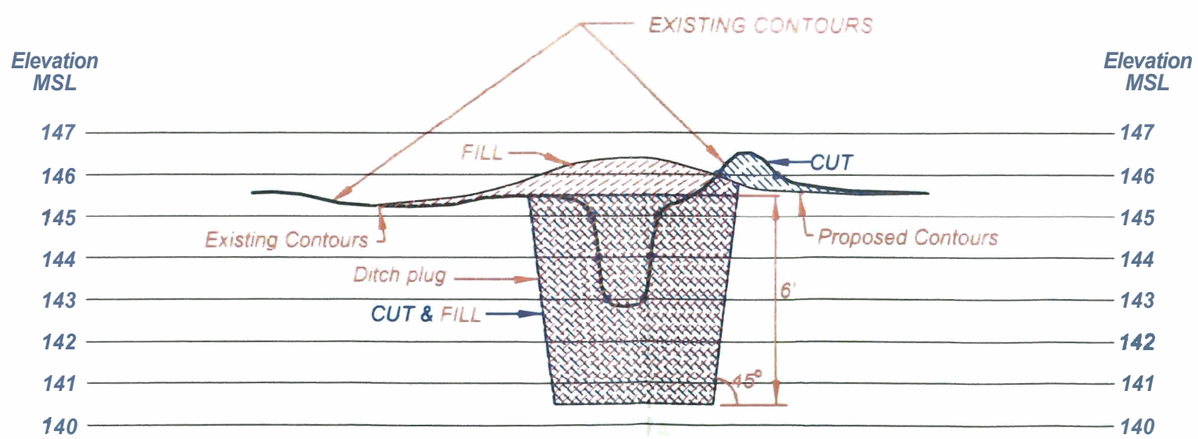
Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
RESTORATION PLAN
PROFILE SECTIONS A-A' & B-B'

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611



TYPICAL
DITCH PLUG
PLAN VIEW
N-T-S



SECTION ALONG **PROFILE C-C'**
LOOKING NORTH

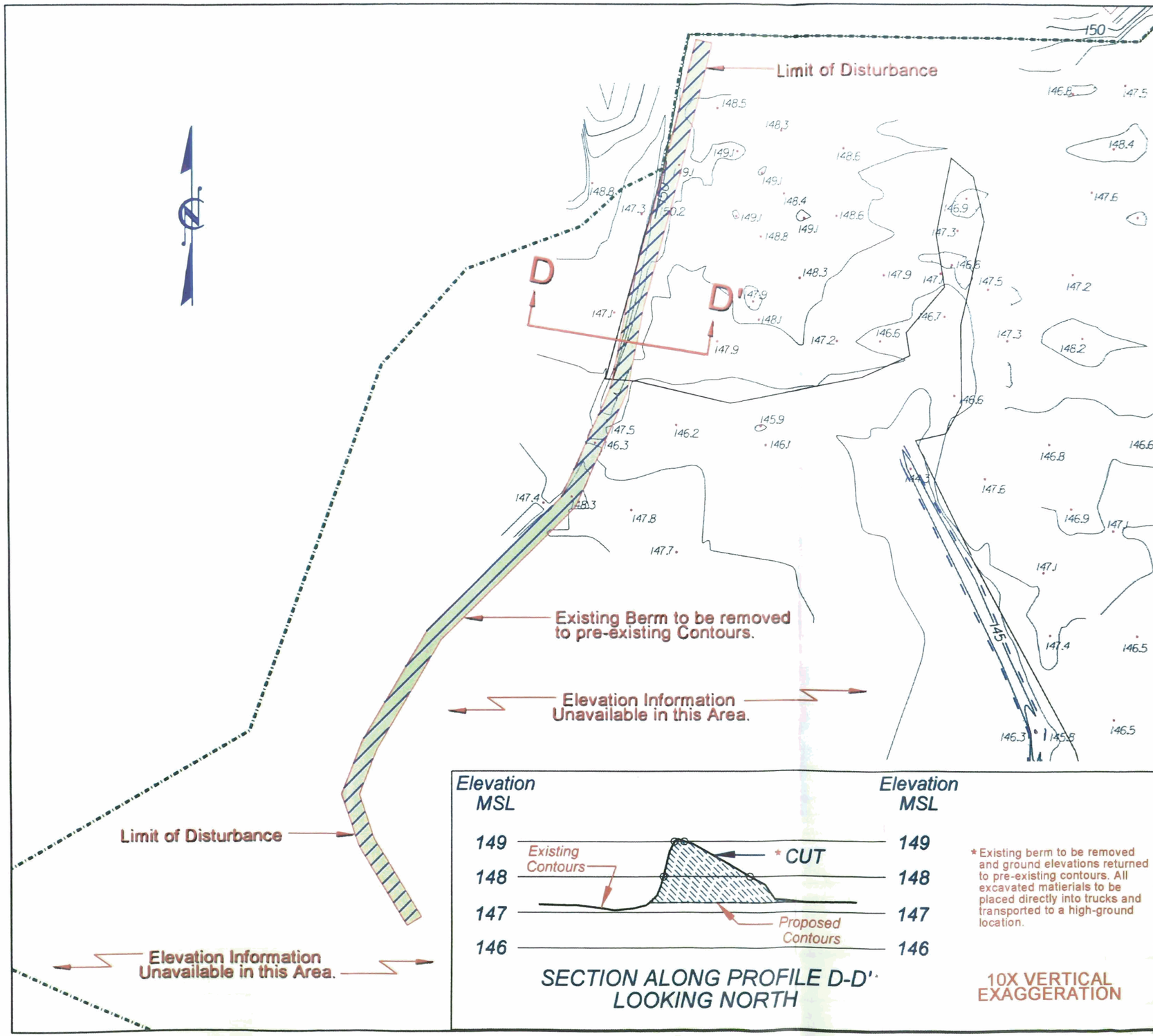
10X VERTICAL
EXAGGERATION

No.	REVISIONS	DATE

Project: BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
RESTORATION PLAN
DITCH PLUG

Dwn By: | Date | Figure 8C
Ckd By | Scale

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

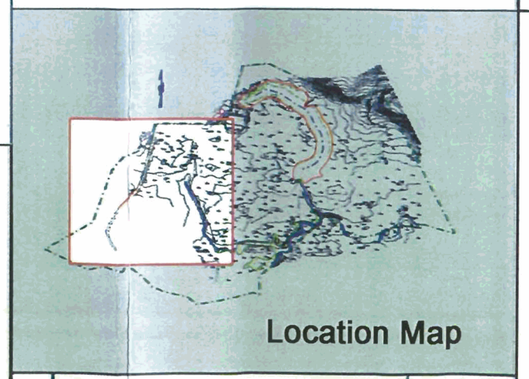


Legend

- 145 — Lowest Extent of Disturbance
- 146 — Finished Contours
- Limit of Disturbance
- 146.1 — Existing Elevations
- Existing Contours
- A A' — Cross-Sections

0 100' 200'

1" = 100' Scale



No.	REVISIONS	DATE

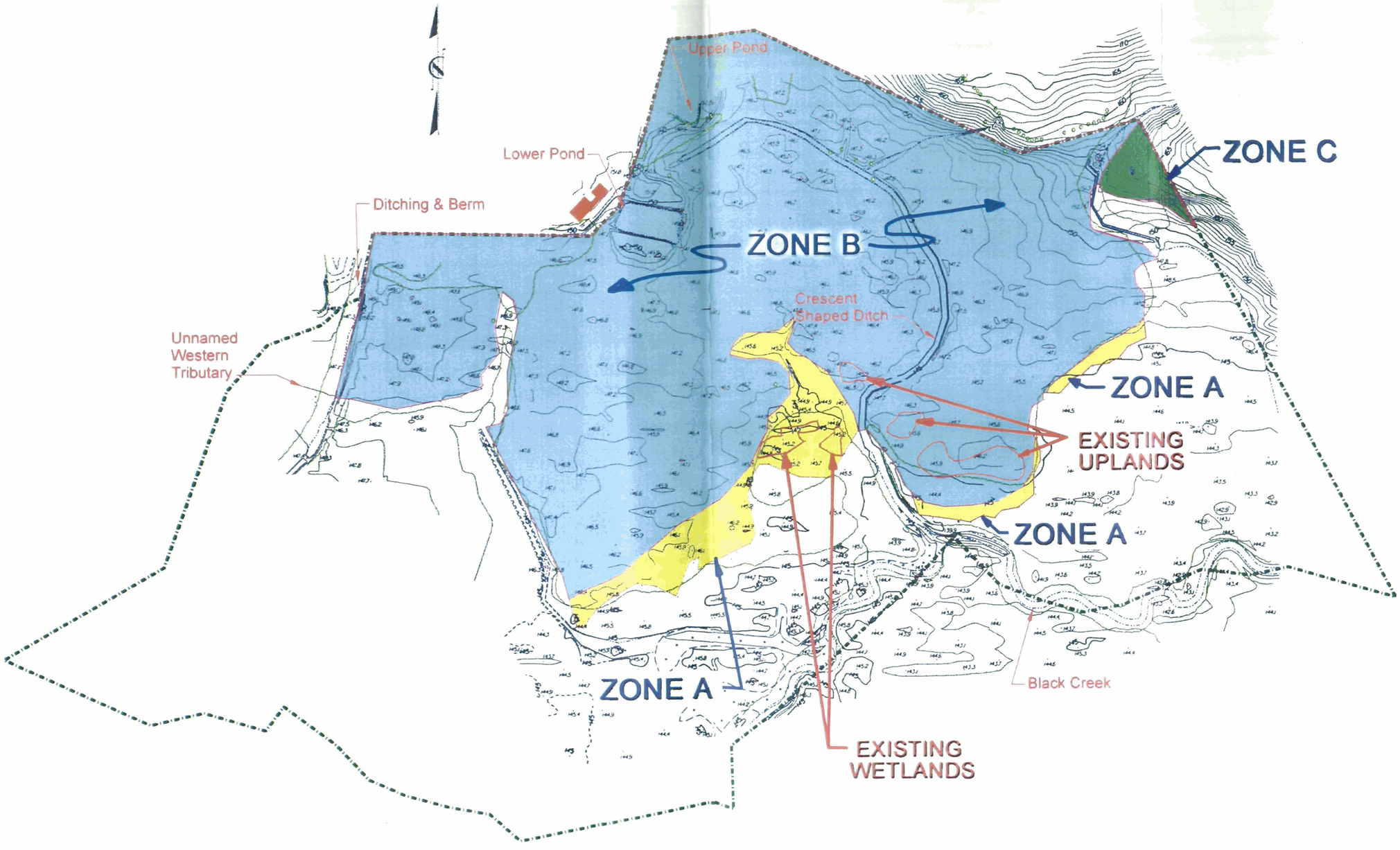
Figure 8d

Dwn By | Date

Ckd By | Scale

Project: BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
RESTORATION PLAN
BERM REMOVAL

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611



No	REVISIONS	DATE

Figure 9a

Date

Scale

Dwn By

Ckd By

Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA

PLANTING PLAN

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

Coastal Plain Small Stream Swamp (Brownwater Subtype)	Coastal Plain Bottomland Hardwood (Brownwater Subtype)	Mesic Mixed Hardwood Forest (Coastal Plain Subtype)
ZONE A	ZONE B	ZONE C

Bald Cypress Swamp Cottonwood Water Tupelo Black Willow Buttonbush	Wate[illegible] Swam[illegible] Wil[illegible] Green Ash Sugarberry Pawpaw Deciduous Holly Ironwood Red Mulberry	American Beech Shagbark Hickory Flowering Dogwood Black Cherry
Wehadkee/Tomotley	Tomotley	Gilead
Poorly Drained	Poorly Drained	Moderately Well Drained

No	REVISIONS	DATE

Figure 9b

Date:

Scale:

Dwn By:

Ckd By:

Project:

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
PLANTING PLAN
TARGET LANDSCAPE ECOSYSTEMS

NC DEP TMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NOR CAROLINA 27611

4.0 MONITORING PLAN

The Monitoring Plan consists of a comparison between reference and restoration areas along with evaluation of jurisdictional wetland criteria. Wetland monitoring will entail analysis of two primary parameters: vegetation and hydrology. Monitoring of restoration and enhancement efforts will be performed for 5 years or until success criteria are fulfilled.

4.1 HYDROLOGY MONITORING

After hydrological modifications are performed, monitoring gauges will be re-installed in accordance with specifications in U.S. Army Corps of Engineers', Installing Monitoring Wells/Piezometers in Wetlands (WRP Technical Note HY-IA-3.1, August 1993). Monitoring guages will be set to a depth of 42 inches (in) [105 centimeters (cm)] below the soil surface. All screened portions of the guage will be buried in a sand screen, filter fabric, and/or a bentonite cap to prevent siltation.

Fourteen continuous monitoring guages will be installed in restoration areas to provide representative coverage of the Site. These locations will approximate the previous gauge installation locations. Three gauges to measure surface waters will also be installed. The elevation of each guage will be surveyed. The reference gauge data will be used to evaluate Site modifications to insure wetland hydrological parameters are met. This data will supplement regulatory evaluation of success criteria and also provide information that will allow interpretation of mitigation success in years not supporting, 'normal rainfall conditions'. Hydrological sampling will be performed on a daily basis throughout the year. Well gauge data will be downloaded from the data logger on an average 6 week interval.

4.1.1 Hydrology Success Criteria

Target hydrological characteristics include a minimum regulatory criteria or comparisons to reference wells in drought years.

4.1.1.1 Regulatory Criteria

Target hydrological characteristics during years with average rainfall include saturation or inundation (free water) within one foot of the soil surface for at least 12.5% of the growing season. This hydroperiod translates to saturation for a minimum, 29-day consecutive period during the growing season, extending from March 21 through November 4.

4.1.1.2 Reference Criteria

Alternatively, hydrology success criteria may be established through comparison of well data between the wetland restoration area and the reference wetland (i.e. depth to groundwater). Specifically, a surveyed cross section will be established at each reference well depicting variation in elevation across the land surface. The cross section at each well location will extend 100 feet, with measurements taken at 10 foot increments. The average hydroperiod along the cross sections will be calculated assuming a level groundwater table. Subsequently, the reference hydroperiod will be compared to restoration areas in each successive year. The hydroperiod must exceed 75 percent of the hydroperiod exhibited by the reference guages, located within the same physiographic landscape area.

4.1.2 PLANTING MONITORING

Restoration monitoring procedures for vegetation are designed in accordance with EPA guidelines enumerated in Mitigation Site Type (MIST) documentation (EPA 1990) and COE Compensatory Hardwood Mitigation Guidelines (DOA 1993). Quantitative vegetation sampling will take place in early autumn of the first year following planting. Only fully planted wetland restoration areas will be vegetatively monitored. Permanent 50 X 50 ft plots will be established randomly within each restored ecosystem type, in the proximity to monitoring gauges. Four plots will be established and correlated with hydrological monitoring locations to provide point-related data on hydrological and vegetation parameters.

4.1.2.1 Planting Success Criteria

Success criteria include the verification, per the vegetation data form, that each plot supports a species composition sufficient for a jurisdictional determination. Characteristic species will include planted elements and may include naturally recruited species indentified in reference wetlands.

4.2 REPORT SUBMITTAL

An "as built" drawing of the area, including initial species compositions by community type, and sample plot and gauge locations, will be provided after completion of planting. A discussion of the planting design, including what species were planted, the species densities and numbers planted will also 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.

Surficial gauge data will be also be presented. The duration of wetland hydrology during the growing season will also be calculated within each community restoration map unit. The survival and density of planted tree stock and natural recruitment will be reported and evaluated relative to the success criteria.

4.3 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.

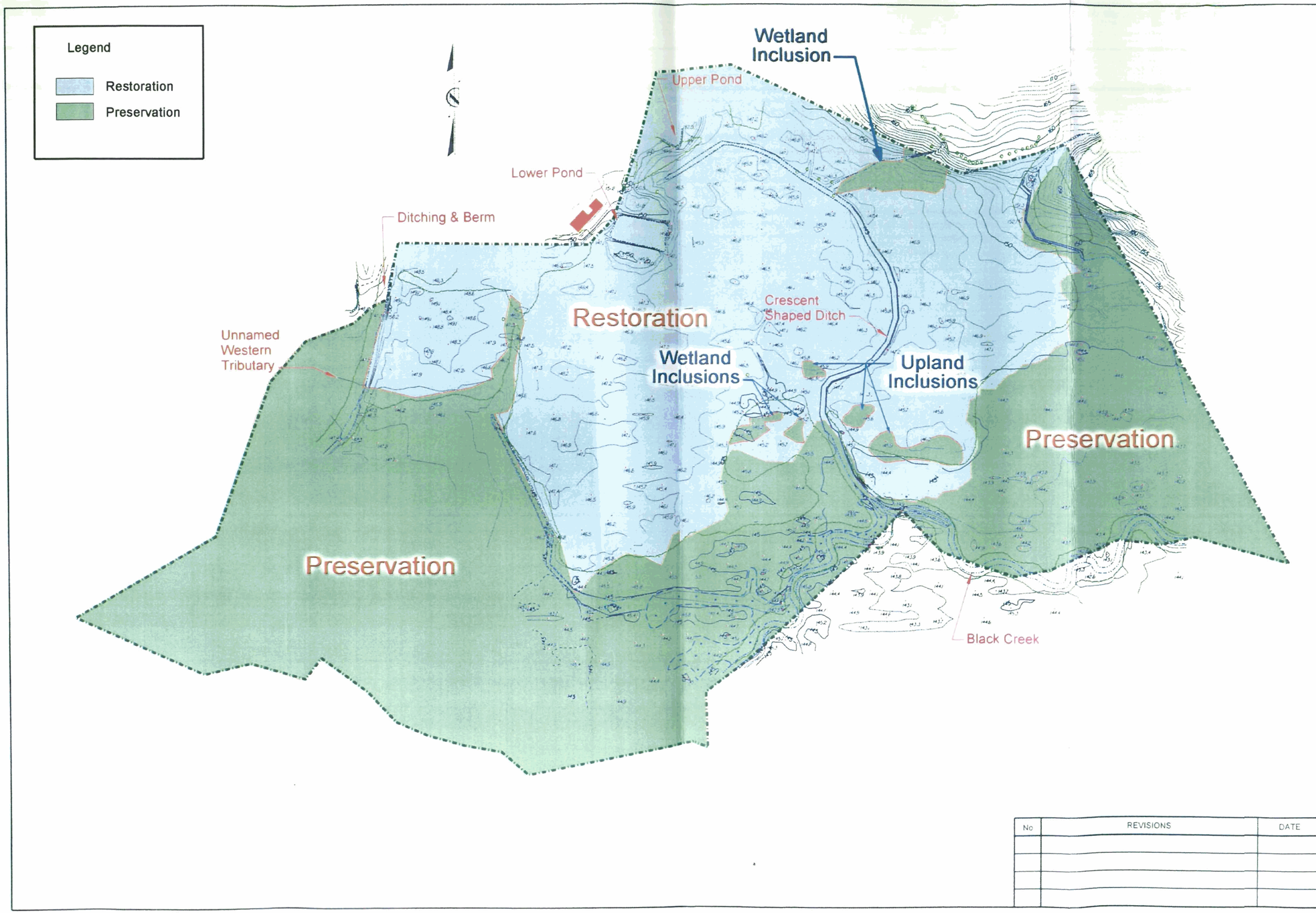
Hydrological contingency will require consultation with hydrologists and regulatory agencies if wetland hydrology restoration is not achieved during the monitoring period. Recommendations for contingency to establish wetland hydrology will be implemented and monitored until the Hydrology Success Criteria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

4.4 DISPENSATION OF PROPERTY

The property is currently optioned by NCDOT. NCDOT will maintain responsibility for all on-Site mitigation activities for five years or until mitigation activities are deemed successful. Covenants and/or restrictions on the deed will be included that will ensure adequate management and protection of the Site in perpetuity.

5.0 WETLAND MITIGATION POTENTIAL

Upon implementation, restoration activities are expected to restore 35.52 ac (14.38 ha) of bottomland hardwood forest wetlands and preserve an additional 46.39 ac (18.78 ha) of bottomland hardwood forest wetlands (See **Figure 10a**). Modifications to existing drainage features is expected to restore Site hydrology to meet the continuous day wetland criteria for most years as illustrated in **Figure 10b**. The credits from this Site are expected to provide more than sufficient credits to offset the 19.98 ac (8.088 ha) of wetland impacts associated with the construction of project segments 8.U401712 (R-2000F) and 8.U401712 (R-2000G) of the Northern Wake Expressway (Raleigh Outer Loop) in Wake County, North Carolina (TIP No. R-2000).



No	REVISIONS	DATE

Figure 10a

Date

Scale

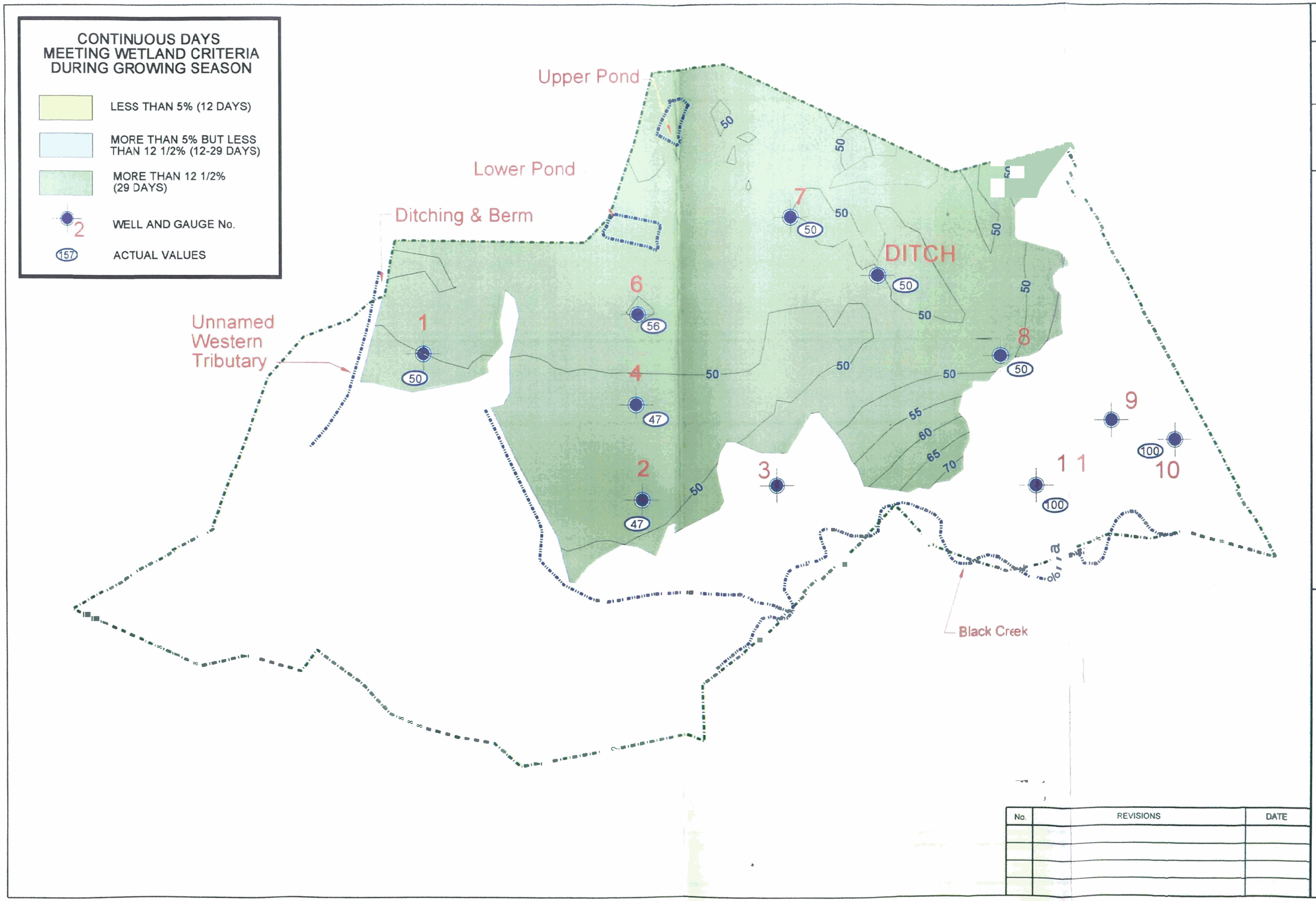
Dwn By

Ckd By

Project

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
COMPLETED RESTORATION PRESERVATION
RESTORATION AREAS

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611



No.	REVISIONS	DATE

Figure 10b

Date

Scale

Dwn By

Ckd By

Project

BENSON GROVE MITIGATION SITE
JOHNSTON COUNTY, NORTH CAROLINA
COMPLETED RESTORATION
PROPOSED HYDROLOGY

NC DEPARTMENT OF TRANSPORTATION
P.O. BOX 25201
RALEIGH, NORTH CAROLINA 27611

6.0 REFERENCES

Cowardin, L.M., V. Carter, F. C. Golet, and Edward T. Laroe. 1979. Classification of Wetland and Deepwater Habitats of the United States. Fish and Wildlife Service, U.S. Department of Interior.

Department of the Army (DOA). 1987. Corps of Engineers Wetland Delineation Manual.
Tech. Rpt. Y-87-1, Waterways Experiment Station, COE, Vicksburg, Mississippi.

Schafale, M. P., A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation, NC Natural Heritage Program, Division of Parks and Recreation, NC DEM, Raleigh NC.

Radford, A.E., H.E. Ahles, and C.R. Bell. 1968. Manual of the Vascular Flora of the
Carolinas. University of North Carolina Press, Chapel Hill, NC. 1 1 83 pp.

U.S. Department of Agriculture (USDA). 1996. Soil Survey of Johnston County, North
Carolina, USDA Natural Resource Conservation Service.

The EDR-Radius Map
with GeoCheck®

Benson Grove Wetland Mitigation Site
SR 1319
Benson, NC 27504

Inquiry Number: 571114.3s

December 05, 2000

Environmental Data Resources, Inc.

The Source For Environmental Risk Management Data

3530 Post Road
Southport, Connecticut 06490

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

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Orphan Summary	6
Government Records Searched/Data Currency Tracking	GR-1

GEOCHECK ADDENDUM

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Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

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EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR). The report meets the government records search requirements of ASTM Standard Practice for Environmental Site Assessments, E 1527-00. Search distances are per ASTM standard or custom distances requested by the user.

TARGET PROPERTY INFORMATION

ADDRESS

SR 1319
BENSON, NC 27504

COORDINATES

Latitude (North):	35.464700 - 35˚ 27' 52.9"
Longitude (West):	78.560000 - 78˚ 33' 36.0"
Universal Tranverse Mercator:	Zone 17
UTM X (Meters):	721415.2
UTM Y (Meters):	3927116.0

USGS TOPOGRAPHIC MAP ASSOCIATED WITH TARGET PROPERTY

Target Property:	2435078-D5 BENSON, NC
Source:	USGS 7.5 min quad index

TARGET PROPERTY SEARCH RESULTS

The target property was not listed in any of the databases searched by EDR.

DATABASES WITH NO MAPPED SITES

No mapped sites were found in EDR's search of available ("reasonably ascertainable ") government records either on the target property or within the ASTM E 1527-00 search radius around the target property for the following databases:

FEDERAL ASTM STANDARD

NPL..... National Priority List
CERCLIS..... Comprehensive Environmental Response, Compensation, and Liability Information System
CERC-NFRAP..... Comprehensive Environmental Response, Compensation, and Liability Information System
CORRACTS..... Corrective Action Report
RCRIS-TSD..... Resource Conservation and Recovery Information System
RCRIS-LQG..... Resource Conservation and Recovery Information System
RCRIS-SQG..... Resource Conservation and Recovery Information System
ERNS..... Emergency Response Notification System

STATE ASTM STANDARD

SHWS..... State Haz. Waste
SWF/LF..... Solid Waste Facilities
LUST..... Incidents Management Database
UST..... Petroleum Underground Storage Tank Database

EXECUTIVE SUMMARY

FEDERAL ASTM SUPPLEMENTAL

CONSENT..... CONSENT
ROD..... ROD
Delisted NPL..... NPL Deletions
FINDS..... Facility Index System/Facility Identification Initiative Program Summary Report
HMIRS..... Hazardous Materials Information Reporting System
MLTS..... Material Licensing Tracking System
MINES..... Mines Master Index File
NPL Lien..... NPL Liens
PADS..... PCB Activity Database System
RAATS..... RCRA Administrative Action Tracking System
TRIS..... Toxic Chemical Release Inventory System
TSCA..... Toxic Substances Control Act

STATE OR LOCAL ASTM SUPPLEMENTAL

NC HSDS..... Hazardous Substance Disposal Site
IMD..... Incident Management Database

EDR PROPRIETARY DATABASES

Coal Gas..... Former Manufactured gas (Coal Gas) Sites.

SURROUNDING SITES: SEARCH RESULTS

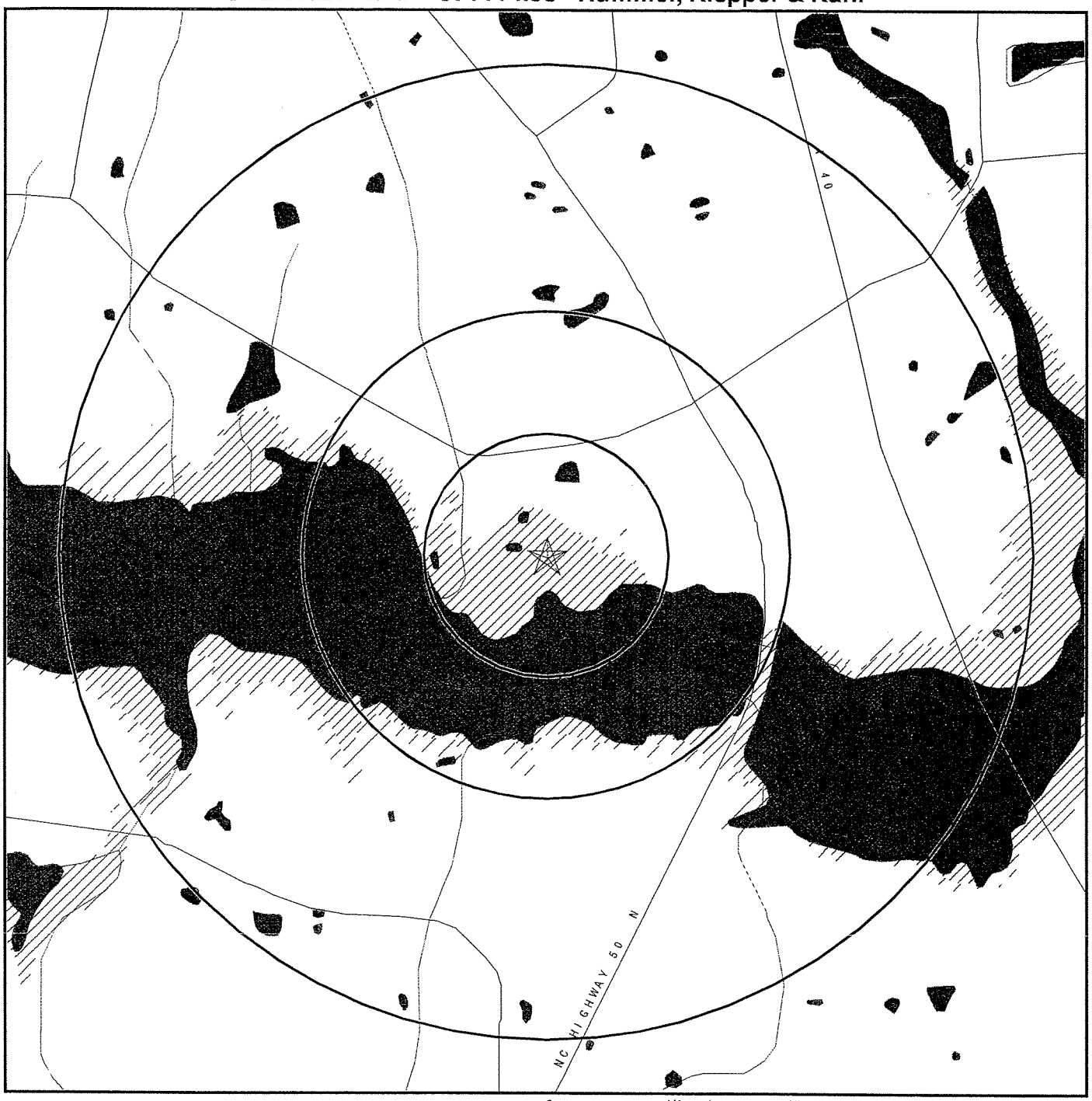
Surrounding sites were not identified.

EXECUTIVE SUMMARY

Due to poor or inadequate address information, the following sites were not mapped:

Site Name	Database(s)
T-MART #3	LUST
JERRY POLLARD STORE	LUST
J H CARROLL'S GENERAL STORE	LUST
C.C. BAREFOOT	UST
GODWINS SUPPLY	UST
COUNTRY STORE	UST
E Z SHOP #25	UST
PARRISH OIL COMPANY	UST
NORTH CAROLINA NATURAL GAS CO	UST
TART BROTHERS	UST
PIPKINS USED TIRES	UST
CUB-MART #1	UST
BLACKMANS GAS & GROCERY	UST
THE CORNER STORE	UST
KNOWLES SERVICE STATION	UST
RUDOLPH W JONES	UST
GLENN'S QUIK MART	UST
PLEASANTS GROCERY	UST
BENSON QUARRY	UST
BENSON EXCHANGE	UST
T-MART #3	UST
ROBIN HOOD OIL CO INC	UST
JOHNNY C. JOHNSON. INC.	UST
BENSON CIVIC CENTER	UST
BENSON ELEMENTARY SCHOOL	UST
BEASLEY'S STORE	UST
BENSON TOWN OF	PADS
BENSON WWTP, TOWN OF	FINDS
MARTIN MARIETTA AGGREGATES - BENSON	FINDS
CAROLINA EASTERN/BENSON	FINDS
BENSON TOWN OF	FINDS

OVERVIEW MAP - 571114.3s - Rummel, Klepper & Kahl

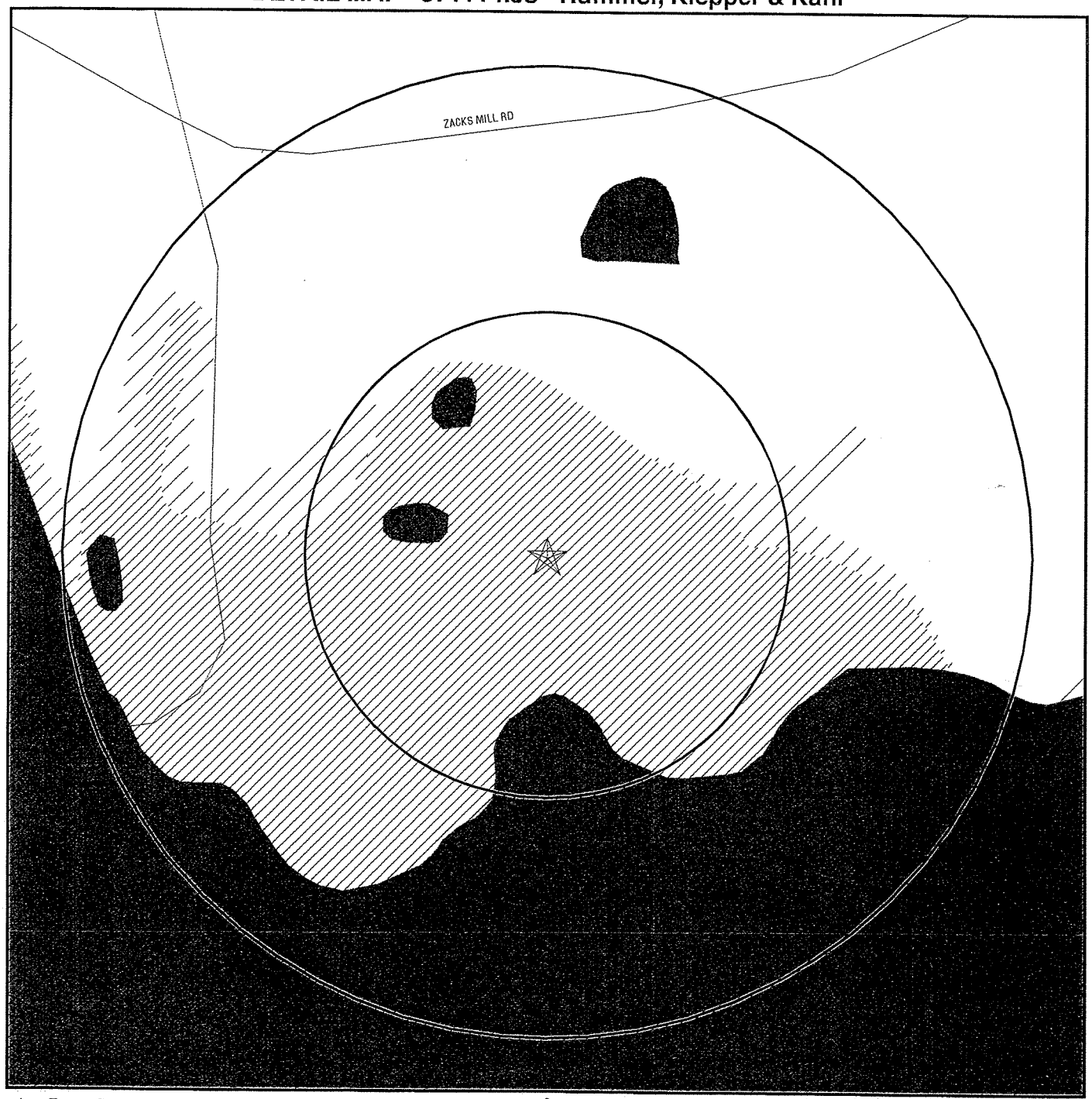


0 1/4 1/2 1 Miles

- ★ Target Property
- ▲ Sites at elevations higher than or equal to the target property
- ◆ Sites at elevations lower than the target property
- Coal Gasification Sites (if requested)
- National Priority List Sites
- Landfill Sites
- Power transmission lines
- Oil & Gas pipelines
- 100-year flood zone
- 500-year flood zone
- Wetlands per National Wetlands Inventory
- Hazardous Substance Disposal Sites

TARGET PROPERTY:	Benson Grove Wetland Mitigation Site	CUSTOMER:	Rummel, Klepper & Kahl
ADDRESS:	SR 1319	CONTACT:	Marc Seelinger
CITY/STATE/ZIP:	Benson NC 27504	INQUIRY #:	571114.3s
LAT/LONG:	35.4647 / 78.5600	DATE:	December 05, 2000 5:54 pm

DETAIL MAP - 571114.3s - Rummel, Klepper & Kahl



- ★ Target Property
- ▲ Sites at elevations higher than or equal to the target property
- ◆ Sites at elevations lower than the target property
- Coal Gasification Sites (if requested)
- Sensitive Receptors
- National Priority List Sites
- Landfill Sites

0 1/16 1/8 1/4 Miles

- Power transmission lines
- Oil & Gas pipelines
- 100-year flood zone
- 500-year flood zone
- Wetlands per National Wetlands Inventory
- Hazardous Substance Disposal Sites

N

TARGET PROPERTY:	Benson Grove Wetland Mitigation Site	CUSTOMER:	Rummel, Klepper & Kahl
ADDRESS:	SR 1319	CONTACT:	Marc Seelinger
CITY/STATE/ZIP:	Benson NC 27504	INQUIRY #:	571114.3s
LAT/LONG:	35.4647 / 78.5600	DATE:	December 05, 2000 5:54 pm

MAP FINDINGS SUMMARY

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
FEDERAL ASTM STANDARD								
NPL		1.000	0	0	0	0	NR	0
CERCLIS		0.500	0	0	0	NR	NR	0
CERC-NFRAP		0.250	0	0	NR	NR	NR	0
CORRACTS		1.000	0	0	0	0	NR	0
RCRIS-TSD		0.500	0	0	0	NR	NR	0
RCRIS Lg. Quan. Gen.		0.250	0	0	NR	NR	NR	0
RCRIS Sm. Quan. Gen.		0.250	0	0	NR	NR	NR	0
ERNS		TP	NR	NR	NR	NR	NR	0
STATE ASTM STANDARD								
State Haz. Waste		1.000	0	0	0	0	NR	0
State Landfill		0.500	0	0	0	NR	NR	0
LUST		0.500	0	0	0	NR	NR	0
UST		0.250	0	0	NR	NR	NR	0
FEDERAL ASTM SUPPLEMENTAL								
CONSENT		1.000	0	0	0	0	NR	0
ROD		1.000	0	0	0	0	NR	0
Delisted NPL		1.000	0	0	0	0	NR	0
FINDS		TP	NR	NR	NR	NR	NR	0
HMIRS		TP	NR	NR	NR	NR	NR	0
MLTS		TP	NR	NR	NR	NR	NR	0
MINES		0.250	0	0	NR	NR	NR	0
NPL Liens		TP	NR	NR	NR	NR	NR	0
PADS		TP	NR	NR	NR	NR	NR	0
RAATS		TP	NR	NR	NR	NR	NR	0
TRIS		TP	NR	NR	NR	NR	NR	0
TSCA		TP	NR	NR	NR	NR	NR	0
STATE OR LOCAL ASTM SUPPLEMENTAL								
NC HSDS		1.000	0	0	0	0	NR	0
IMD		TP	NR	NR	NR	NR	NR	0
EDR PROPRIETARY DATABASES								
Coal Gas		1.000	0	0	0	0	NR	0

AQUIFLOW - see EDR Physical Setting Source Addendum

TP = Target Property

NR = Not Requested at this Search Distance

* Sites may be listed in more than one database

Map ID Direction Distance Distance (ft.) Elevation	Site	Database(s)	EDR ID Number EPA ID Number

MAP FINDINGS

Coal Gas Site Search: No site was found in a search of Real Property Scan's ENVIROHAZ database.

NO SITES FOUND

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)	Facility ID
BENSON	U001436347	C.C. BAREFOOT	HIGHWAY #50 EAST	27504	UST	0-013541
BENSON	U001439352	GODWINS SUPPLY	RT 1 50 HWY NORTH	27504	UST	0-030278
BENSON	1002963890	BENSON WWTP, TOWN OF	SR 1171, SOUTH OF I-95	27504	FINDS	
BENSON	U003146164	COUNTRY STORE	ROUTE 2 / R.R. 1116	27504	UST	0-025189
BENSON	U001436304	E Z SHOP #25	ROUTE 2 (MEADOW)	27504	UST	0-013423
BENSON	U003562608	PARRISH OIL COMPANY	HIGHWAY 301 SOUTH	27504	UST	0-014930
BENSON	U003562564	NORTH CAROLINA NATURAL GAS CO	HIGHWAY 301 SOUTH	27504	UST	0-014101
BENSON	U003144624	TART BROTHERS	HWY 301 N.	27504	UST	0-014810
BENSON	U001437167	PIPKINS USED TIRES	HWY 301	27504	UST	0-017211
BENSON	S103717505	T-MART #3	HWY 301 S. / W. HILL ST.	27504	LUST	19314
BENSON	U003144998	CUB-MART #1	HWY 50 E	27504	UST	0-017203
BENSON	U003135490	BLACKMANS GAS & GROCERY	HIGHWAY 50 E	27504	UST	0-013339
BENSON	U003007965	THE CORNER STORE	HWY 50 & HWY 301	27504	UST	0-017199
BENSON	U001437908	KNOWLES SERVICE STATION	HWY 50	27504	UST	0-021339
BENSON	U001436409	RUDOLPH W JONES	HWY 50 10 N. BENSON	27504	UST	0-013687
BENSON	U001436329	GLENN'S QUIK MART	HWY 50 & 210	27504	UST	0-013456
BENSON	U001436328	PLEASANTS GROCERY	HWY 50	27504	UST	0-013455
BENSON	S102611404	JERRY POLLARD STORE	HIGHWAY 50	27504	LUST	17580
BENSON	U001438384	BENSON QUARRY	PO BOX 365	27504	UST	0-023306
BENSON	S104547222	J H CARROLL'S GENERAL STORE	675 CHURCH ROAD SR-1520	27504	LUST	21710
BENSON	U001439842	BENSON EXCHANGE	E. HILL ST.	27504	UST	0-032789
BENSON	1002963860	MARTIN MARIETTA AGGREGATES - BENSON	US HWY 301 & SR 1330	27504	FINDS	
BENSON	1002811776	CAROLINA EASTERN/BENSON	8858 NC HWY 96 S	27504	FINDS	
BENSON	U003160489	T-MART #3	US HWY 301 N	27504	UST	0-027581
BENSON	U001434324	ROBIN HOOD OIL CO INC	701 HWY	27504	UST	0-001857
BENSON	U001436483	JOHNNY C. JOHNSON. INC.	INTERSECTION OF SR 1319 & 1330	27504	UST	0-013905
BENSON	U001439034	BENSON CIVIC CENTER	NORTH JOHNSON STREET	27504	UST	0-027903
BENSON	U001436382	BENSON ELEMENTARY SCHOOL	314 LEE STREET	27504	UST	0-013643
BENSON	1002963284	BENSON TOWN OF	N MARKET ST	27504	FINDS	
BENSON	1001965081	BENSON TOWN OF	N MARKET ST	27504	PADS	
FOUR OAKS	U001436379	BEASLEY'S STORE	RT 3 BENSON	27504	UST	0-013637

Date of Government Version: 06/21/00
Date Made Active at EDR: 07/31/00
Database Release Frequency: Semi-Annually

Date of Data Arrival at EDR: 07/10/00
Elapsed ASTM days: 21
Date of Last EDR Contact: 11/09/00

ERNS: Emergency Response Notification System
Source: EPA/NTIS
Telephone: 202-260-2342
Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 08/08/00
Date Made Active at EDR: 09/06/00
Database Release Frequency: Quarterly

Date of Data Arrival at EDR: 08/11/00
Elapsed ASTM days: 26
Date of Last EDR Contact: 10/31/00

FEDERAL ASTM SUPPLEMENTAL RECORDS

BRS: Biennial Reporting System
Source: EPA/NTIS
Telephone: 800-424-9346
The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/31/97
Database Release Frequency: Biennially

Date of Last EDR Contact: 09/18/00
Date of Next Scheduled EDR Contact: 12/18/00

CONSENT: Superfund (CERCLA) Consent Decrees
Source: EPA Regional Offices
Telephone: Varies
Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: N/A
Database Release Frequency: Varies

Date of Last EDR Contact: N/A
Date of Next Scheduled EDR Contact: N/A

ROD: Records Of Decision
Source: NTIS
Telephone: 703-416-0223
Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 01/31/99
Database Release Frequency: Annually

Date of Last EDR Contact: 10/12/00
Date of Next Scheduled EDR Contact: 01/08/01

DELISTED NPL: NPL Deletions
Source: EPA
Telephone: N/A
The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 06/13/00
Database Release Frequency: Semi-Annually

Date of Last EDR Contact: 11/06/00
Date of Next Scheduled EDR Contact: 02/05/01

FINDS: Facility Index System/Facility Identification Initiative Program Summary Report
Source: EPA
Telephone: N/A
Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 07/07/00
Database Release Frequency: Quarterly
Date of Last EDR Contact: 10/10/00
Date of Next Scheduled EDR Contact: 01/08/01

HMIRS: Hazardous Materials Information Reporting System
Source: U.S. Department of Transportation
Telephone: 202-366-4526
Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 06/30/99
Database Release Frequency: Annually
Date of Last EDR Contact: 10/24/00
Date of Next Scheduled EDR Contact: 01/22/01

MLTS: Material Licensing Tracking System
Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/23/00
Database Release Frequency: Quarterly
Date of Last EDR Contact: 10/10/00
Date of Next Scheduled EDR Contact: 01/08/01

MINES: Mines Master Index File
Source: Department of Labor, Mine Safety and Health Administration
Telephone: 303-231-5959

Date of Government Version: 08/01/98
Database Release Frequency: Semi-Annually
Date of Last EDR Contact: 10/02/00
Date of Next Scheduled EDR Contact: 01/01/01

NPL LIENS: Federal Superfund Liens
Source: EPA
Telephone: 205-564-4267
Federal Superfund Liens. Under the authority granted the USEPA by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner receives notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/91
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 08/21/00
Date of Next Scheduled EDR Contact: 11/20/00

PADS: PCB Activity Database System
Source: EPA
Telephone: 202-260-3936
PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 01/01/00
Database Release Frequency: Annually
Date of Last EDR Contact: 08/15/00
Date of Next Scheduled EDR Contact: 11/13/00

RAATS: RCRA Administrative Action Tracking System
Source: EPA
Telephone: 202-564-4104
RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/95
Database Release Frequency: No Update Planned
Date of Last EDR Contact: 09/12/00
Date of Next Scheduled EDR Contact: 12/11/00

TRIS: Toxic Chemical Release Inventory System
Source: EPA
Telephone: 202-260-1531
Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/97
Database Release Frequency: Annually
Date of Last EDR Contact: 09/25/00
Date of Next Scheduled EDR Contact: 12/25/00

TSCA: Toxic Substances Control Act
Source: EPA
Telephone: 202-260-1444
Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/98
Database Release Frequency: Every 4 Years
Date of Last EDR Contact: 09/12/00
Date of Next Scheduled EDR Contact: 12/11/00

STATE OF NORTH CAROLINA ASTM STANDARD RECORDS

SHWS: Inactive Hazardous Sites Inventory
Source: Department of Environment, Health and Natural Resources
Telephone: 919-733-2801
State Hazardous Waste Sites. State hazardous waste site records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. Available information varies by state.

Date of Government Version: 03/15/00
Date Made Active at EDR: 06/23/00
Database Release Frequency: Annually
Date of Data Arrival at EDR: 05/12/00
Elapsed ASTM days: 42
Date of Last EDR Contact: 10/17/00

LF: List of Solid Waste Facilities
Source: Department of Environment, Health and Natural Resources
Telephone: 919-733-0692
Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 07/01/00
Date Made Active at EDR: 09/01/00
Database Release Frequency: Semi-Annually
Date of Data Arrival at EDR: 08/01/00
Elapsed ASTM days: 31
Date of Last EDR Contact: 10/31/00

LUST: Incidents Management Database
Source: Department of Environment, Health and Natural Resources
Telephone: 919-733-1315
Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 07/27/00
Date Made Active at EDR: 09/01/00
Database Release Frequency: Quarterly
Date of Data Arrival at EDR: 07/31/00
Elapsed ASTM days: 32
Date of Last EDR Contact: 10/30/00

UST: Petroleum Underground Storage Tank Database
Source: Department of Environment, Health and Natural Resources
Telephone: 919-733-1308
Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

Date of Government Version: 11/16/99
Date Made Active at EDR: 12/27/99
Database Release Frequency: Quarterly

Date of Data Arrival at EDR: 12/13/99
Elapsed ASTM days: 14
Date of Last EDR Contact: 09/15/00

STATE OF NORTH CAROLINA ASTM SUPPLEMENTAL RECORDS

HSDS: Hazardous Substance Disposal Site
Source: North Carolina Center for Geographic Information and Analysis
Telephone: 919-733-2090
Locations of uncontrolled and unregulated hazardous waste sites. The file includes sites on the National Priority List as well as those on the state priority list.

Date of Government Version: 06/21/95
Database Release Frequency: Biennially

Date of Last EDR Contact: 09/08/00
Date of Next Scheduled EDR Contact: 12/04/00

IMD: Incident Management Database
Source: Department of Health and Natural Resources
Telephone: 919-733-1315

Date of Government Version: 07/27/00
Database Release Frequency: Quarterly

Date of Last EDR Contact: 10/30/00
Date of Next Scheduled EDR Contact: 01/29/01

EDR PROPRIETARY DATABASES

Former Manufactured Gas (Coal Gas) Sites: The existence and location of Coal Gas sites is provided exclusively to EDR by Real Property Scan, Inc. ©Copyright 1993 Real Property Scan, Inc. For a technical description of the types of hazards which may be found at such sites, contact your EDR customer service representative.

Disclaimer Provided by Real Property Scan, Inc.

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HISTORICAL AND OTHER DATABASE(S)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

Oil/Gas Pipelines/Electrical Transmission Lines: This data was obtained by EDR from the USGS in 1994. It is referred to by USGS as GeoData Digital Line Graphs from 1:100,000-Scale Maps. It was extracted from the transportation category including some oil, but primarily gas pipelines and electrical transmission lines.

Sensitive Receptors: There are individuals deemed sensitive receptors due to their fragile immune systems and special sensitivity to environmental discharges. These sensitive receptors typically include the elderly, the sick, and children. While the location of all sensitive receptors cannot be determined, EDR indicates those buildings and facilities - schools, daycares, hospitals, medical centers, and nursing homes - where individuals who are sensitive receptors are likely to be located.

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 1999 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 1999 from the U.S. Fish and Wildlife Service.

GEOCHECK®- PHYSICAL SETTING SOURCE ADDENDUM

TARGET PROPERTY ADDRESS

BENSON GROVE WETLAND MITIGATION SITE
SR 1319
BENSON, NC 27504

TARGET PROPERTY COORDINATES

Latitude (North):	35.464699 - 35˚ 27' 52.9"
Longitude (West):	78.559998 - 78˚ 33' 36.0"
Universal Tranverse Mercator:	Zone 17
UTM X (Meters):	721415.2
UTM Y (Meters):	3927116.0

EDR's GeoCheck Physical Setting Source Addendum has been developed to assist the environmental professional with the collection of physical setting source information in accordance with ASTM 1527-00, Section 7.2.3. Section 7.2.3 requires that a current USGS 7.5 Minute Topographic Map (or equivalent, such as the USGS Digital Elevation Model) be reviewed. It also requires that one or more additional physical setting sources be sought when (1) conditions have been identified in which hazardous substances or petroleum products are likely to migrate to or from the property, and (2) more information than is provided in the current USGS 7.5 Minute Topographic Map (or equivalent) is generally obtained, pursuant to local good commercial or customary practice, to assess the impact of migration of recognized environmental conditions in connection with the property. Such additional physical setting sources generally include information about the topographic, hydrologic, hydrogeologic, and geologic characteristics of a site, and wells in the area.

Assessment of the impact of contaminant migration generally has two principle investigative components:

1. Groundwater flow direction, and
2. Groundwater flow velocity.

Groundwater flow direction may be impacted by surface topography, hydrology, hydrogeology, characteristics of the soil, and nearby wells. Groundwater flow velocity is generally impacted by the nature of the geologic strata. EDR's GeoCheck Physical Setting Source Addendum is provided to assist the environmental professional in forming an opinion about the impact of potential contaminant migration.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW DIRECTION INFORMATION

Groundwater flow direction for a particular site is best determined by a qualified environmental professional using site-specific well data. If such data is not reasonably ascertainable, it may be necessary to rely on other sources of information, such as surface topographic information, hydrologic information, hydrogeologic data collected on nearby properties, and regional groundwater flow information (from deep aquifers).

TOPOGRAPHIC INFORMATION

Surface topography may be indicative of the direction of surficial groundwater flow. This information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

USGS TOPOGRAPHIC MAP ASSOCIATED WITH THIS SITE

Target Property: 2435078-D5 BENSON, NC
Source: USGS 7.5 min quad index

GENERAL TOPOGRAPHIC GRADIENT AT TARGET PROPERTY

Target Property: General South

Source: General Topographic Gradient has been determined from the USGS 1 Degree Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified.

HYDROLOGIC INFORMATION

Surface water can act as a hydrologic barrier to groundwater flow. Such hydrologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

Refer to the Physical Setting Source Map following this summary for hydrologic information (major waterways and bodies of water).

FEMA FLOOD ZONE

Target Property County	FEMA Q3 Flood Data Electronic Coverage
JOHNSTON, NC	YES - refer to the Overview Map and Detail Map

Flood Plain Panel at Target Property:	3701380095B / CBPP
Additional Panels in search area:	3701380120B / CBPP

NATIONAL WETLAND INVENTORY

NWI Quad at Target Property	NWI Electronic Coverage
BENSON	YES - refer to the Overview Map and Detail Map

HYDROGEOLOGIC INFORMATION

Hydrogeologic information obtained by installation of wells on a specific site can often be an indicator of groundwater flow direction in the immediate area. Such hydrogeologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

AQUIFLOW®

Search Radius: 2.000 Miles.

EDR has developed the AQUIFLOW Information System to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted by environmental professionals to regulatory authorities at select sites and has extracted the date of the report, groundwater flow direction as determined hydrogeologically, and the depth to water table.

MAP ID	LOCATION FROM TP	GENERAL DIRECTION GROUNDWATER FLOW
Not Reported		

GROUNDWATER FLOW VELOCITY INFORMATION

Groundwater flow velocity information for a particular site is best determined by a qualified environmental professional using site specific geologic and soil strata data. If such data are not reasonably ascertainable, it may be necessary to rely on other sources of information, including geologic age identification, rock stratigraphic unit and soil characteristics data collected on nearby properties and regional soil information. In general, contaminant plumes move more quickly through sandy-gravelly types of soils than silty-clayey types of soils.

GEOLOGIC INFORMATION IN GENERAL AREA OF TARGET PROPERTY

Geologic information can be used by the environmental professional in forming an opinion about the relative speed at which contaminant migration may be occurring.

GEOLOGIC AGE IDENTIFICATION

Geologic Code:	Ce
Era:	Paleozoic
System:	Cambrian
Series:	Cambrian

ROCK STRATIGRAPHIC UNIT

Category: Eugeosynclinal Deposits

Geologic Age and Rock Stratigraphic Unit Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - a digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

DOMINANT SOIL COMPOSITION IN GENERAL AREA OF TARGET PROPERTY

The U.S. Department of Agriculture's (USDA) Soil Conservation Service (SCS) leads the National Cooperative Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps. The following information is based on Soil Conservation Service STATSGO data.

Soil Component Name:	CANDOR
Soil Surface Texture:	sand
Hydrologic Group:	Class A - High infiltration rates. Soils are deep, well drained to excessively drained sands and gravels.
Soil Drainage Class:	Somewhat excessive. Soils have high hydraulic conductivity and low water holding capacity. Depth to water table is more than 6 feet.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

Hydric Status: Soil does not meet the requirements for a hydric soil.

Corrosion Potential - Uncoated Steel: LOW

Depth to Bedrock Min: > 60 inches

Depth to Bedrock Max: > 60 inches

Soil Layer Information						
	Boundary			Classification		
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil	Permeability Rate (in/hr)
1	0 inches	21 inches	sand	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	COURSE-GRAINED SOILS, Sands, Sands with fines, Silty Sand.	Max: 20.00 Min: 6.00
2	21 inches	34 inches	loamy sand	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	COURSE-GRAINED SOILS, Sands, Sands with fines, Silty Sand.	Max: 20.00 Min: 6.00
3	34 inches	56 inches	sand	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	COURSE-GRAINED SOILS, Sands, Sands with fines, Silty Sand.	Max: 20.00 Min: 6.00
4	56 inches	72 inches	sandy loam	Granular materials (35 pct. or less passing No. 200), Silty, or Clayey Gravel and Sand.	COURSE-GRAINED SOILS, Sands, Sands with fines, Clayey sand.	Max: 2.00 Min: 0.60
5	72 inches	80 inches	variable	Not reported	Not reported	Max: 0.00 Min: 0.00

OTHER SOIL TYPES IN AREA

Based on Soil Conservation Service STATSGO data, the following additional subordinant soil types may appear within the general area of target property.

Soil Surface Textures: loamy sand
loam
sandy loam

Surficial Soil Types: loamy sand
loam
sandy loam

Shallow Soil Types: sand

sandy loam
sandy clay
sandy clay loam

Deeper Soil Types: sand
stratified
sandy clay loam

ADDITIONAL ENVIRONMENTAL RECORD SOURCES

According to ASTM E 1527-00, Section 7.2.2, "one or more additional state or local sources of environmental records may be checked, in the discretion of the environmental professional, to enhance and supplement federal and state sources... Factors to consider in determining which local or additional state records, if any, should be checked include (1) whether they are reasonably ascertainable, (2) whether they are sufficiently useful, accurate, and complete in light of the objective of the records review (see 7.1.1), and (3) whether they are obtained, pursuant to local, good commercial or customary practice." One of the record sources listed in Section 7.2.2 is water well information. Water well information can be used to assist the environmental professional in assessing sources that may impact groundwater flow direction, and in forming an opinion about the impact of contaminant migration on nearby drinking water wells.

WELL SEARCH DISTANCE INFORMATION

DATABASE	SEARCH DISTANCE (miles)
Federal USGS	1.000
Federal FRDS PWS	Nearest PWS within 1 mile
State Database	1.000

FEDERAL USGS WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
No Wells Found		

FEDERAL FRDS PUBLIC WATER SUPPLY SYSTEM INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A2	NC0351629	1/4 - 1/2 Mile ENE

Note: PWS System location is not always the same as well location.

STATE DATABASE WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A1	NC00007041	1/4 - 1/2 Mile ENE

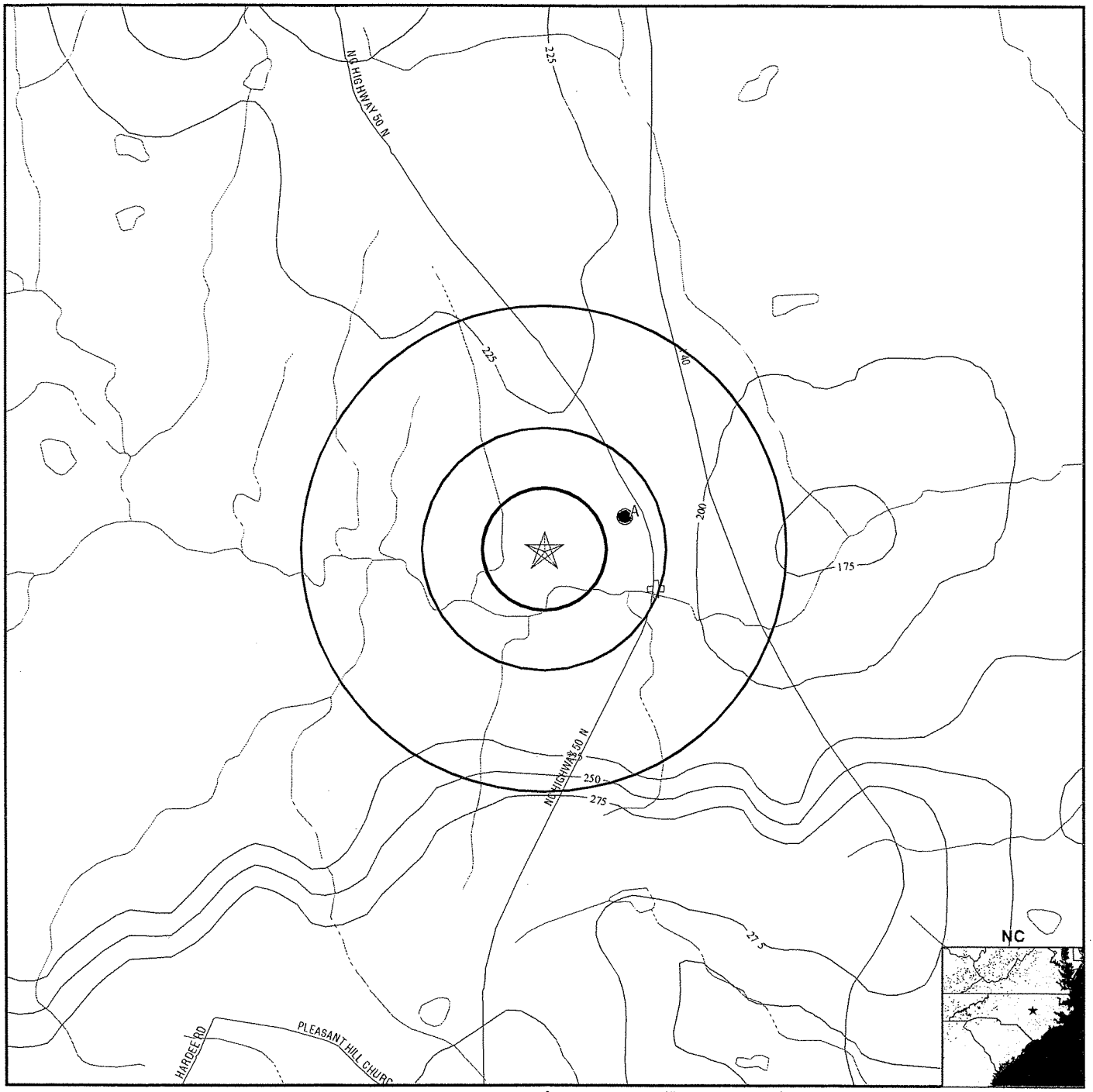
GEOCHECK - PHYSICAL SETTING SOURCE SUMMARY

OTHER STATE DATABASE INFORMATION

NORTH CAROLINA LOCATIONS OF NATURAL HERITAGE DATABASE

ID	Class
0081905	Invertebrate

PHYSICAL SETTING SOURCE MAP - 571114.3s



- Major Roads
- Contour Lines
- Water Wells
- Public Water Supply Wells
- Groundwater Flow Direction
- Indeterminate Groundwater Flow at Location
- Groundwater Flow Varies at Location
- Cluster of Multiple Icons
- Earthquake epicenter, Richter 5 or greater
- Wildlife Areas
- Natural Areas
- Rare & Endangered Species

TARGET PROPERTY:	Benson Grove Wetland Mitigation Site	CUSTOMER:	Rummel, Klepper & Kahl
ADDRESS:	SR 1319	CONTACT:	Marc Seelinger
CITY/STATE/ZIP:	Benson NC 27504	INQUIRY #:	571114.3s
LAT/LONG:	35.4647 / 78.5600	DATE:	December 05, 2000 5:54 pm

GEOCHECK® - PHYSICAL SETTING SOURCE MAP FINDINGS

Map ID Direction Distance Elevation	Database	EDR ID Number
A1 **ENE** **1/4 - 1/2 Mile** **Higher**	**NC WELLS**	**NC00007041**

Site Name:	BARBOURTOWN CH GOD		
Public Water Sys. ID:	0351629	PWS Type:	Transient Non-community
Latitude:	352800.000	Longitude:	783315.000
Source Name:	WELL	Source Type:	Ground
Responsible Party Tel.:	(919) 894-7409	Source Availability:	Permanent
Retail Population:	25		

A2 **ENE** **1/4 - 1/2 Mile** **Higher**	**FRDS PWS**	**NC0351629**

PWS ID:	NC0351629	PWS Status:	Active
Date Initiated:	June / 77	Date Deactivated:	Not Reported
PWS Name:	BARBOURTOWN CH GOD BENSON, NC 27504		
Addressee / Facility:	System Owner/Responsible Party BARBOURTOWN CH GOD RT 3 BENSON, NC 27504		
Addressee / Facility:	System Owner/Responsible Party BARBOURTOWN CH GOD RT 3 BENSON, NC 27504		
Facility Latitude:	Not Reported	Facility Longitude:	Not Reported
City Served:	BENSON		
Treatment Class:	Untreated	Population:	25

PWS currently has or had major violation(s) or enforcement: No

GEOCHECK® - PHYSICAL SETTING SOURCE MAP FINDINGS

OTHER STATE DATABASE INFORMATION

Site ID:		0081905
Latitude / Longitude:		35.4625 / -78.5519
Classification by Type:		Invertebrate
Degree of Accuracy associated with coordinate:		Minutes
Occurrence Status:	Extant	
State Status:	Significantly Rare	

GEOCHECK®- PHYSICAL SETTING SOURCE MAP FINDINGS
RADON

AREA RADON INFORMATION

Federal EPA Radon Zone for JOHNSTON County: 3

Note: Zone 1 indoor average level > 4 pCi/L.
: Zone 2 indoor average level >= 2 pCi/L and <= 4 pCi/L.
: Zone 3 indoor average level < 2 pCi/L.

Zip Code: 27504

Number of sites tested: 1

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor	-0.200 pCi/L	100%	0%	0%
Living Area - 2nd Floor	Not Reported	Not Reported	Not Reported	Not Reported
Basement	Not Reported	Not Reported	Not Reported	Not Reported

PHYSICAL SETTING SOURCE RECORDS SEARCHED

HYDROLOGIC INFORMATION

Flood Zone Data: This data, available in select counties across the country, was obtained by EDR in 1999 from the Federal Emergency Management Agency (FEMA). Data depicts 100-year and 500-year flood zones as defined by FEMA.

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 1999 from the U.S. Fish and Wildlife Service.

HYDROGEOLOGIC INFORMATION

AQUIFLOW[R] Information System
Source: EDR proprietary database of groundwater flow information
EDR has developed the AQUIFLOW Information System (AIS) to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted to regulatory authorities at select sites and has extracted the date of the report, hydrogeologically determined groundwater flow direction and depth to water table information.

GEOLOGIC INFORMATION

Geologic Age and Rock Stratigraphic Unit
Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - A digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

STATSGO: State Soil Geographic Database
The U.S. Department of Agriculture's (USDA) Soil Conservation Service (SCS) leads the national Cooperative Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps.

ADDITIONAL ENVIRONMENTAL RECORD SOURCES

FEDERAL WATER WELLS

PWS: Public Water Systems
Source: EPA/Office of Drinking Water
Telephone: 202-260-2805
Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data
Source: EPA/Office of Drinking Water
Telephone: 202-260-2805
Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: In November 1971 the United States Geological Survey (USGS) implemented a national water resource information tracking system. This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on more than 900,000 wells, springs, and other sources of groundwater.

PHYSICAL SETTING SOURCE RECORDS SEARCHED

STATE RECORDS

North Carolina Wildlife Resources/Game Lands
Source: Center for Geographic Information and Analysis
Telephone: 919-733-2090
All publicly owned game lands managed by the North Carolina Wildlife Resources Commission and as listed in Hunting and Fishing Maps for North Carolina Game Lands, 1989-90.

North Carolina Rare/Endangered Species and Natural Areas
Source: Natural Heritage Occurrence Sites Center for Geographic Information and Analysis
Telephone: 919-733-2090

North Carolina Public Water Supply Wells
Source: Department of Environmental Health
Telephone: 919-715-3243

RADON

Area Radon Information: The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 - 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

EPA Radon Zones: Sections 307 & 309 of IRAA directed EPA to list and identify areas of U.S. with the potential for elevated indoor radon levels.

OTHER

Epicenters: World earthquake epicenters, Richter 5 or greater
Source: Department of Commerce, National Oceanic and Atmospheric Administration

Final Report

on

Soil Delineation and Shallow Subsurface Characterization at the Benson Grove Church Wetland Mitigation Site Johnston County, North Carolina

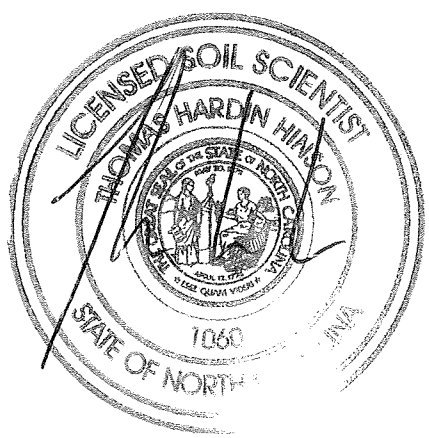
Submitted to

Rummel, Klepper, and Kahl, P.A.
5800 Faringdon Place
Suite 105
Raleigh, North Carolina 27609-9560.

from

Cpec Environmental Inc. (Cpec)
1103 Poole Road
Garner, NC 27529

1503 Front Street
Beaufort, NC 28516



Cpec Job Number 1179
August 2001

CPEC ENVIRONMENTAL INC. 1103 Poole Dr., Garner, NC 27529 voice:(919)661-2387/fax: 773-0599
1503 Front Street, Beaufort, NC 28516 voice/fax:(919) 728-6360

August 15, 2001

Kimberly S. Leight, P.E. (Project Manager)
Rummel, Klepper, and Kahl, P.A.
5800 Faringdon Place, Suite 105
Raleigh, North Carolina 27609-9560
phone: 919-878-9560 / fax: 919-790-8382

Subject: Final report on soil delineation and shallow subsurface characterization at the Benson Grove Church Wetland Mitigation Site
Johnston County, North Carolina
Cpec Job #1179

Dear Ms. Leight,

One copy of the subject report is attached. Should you have any questions or comments on the report, please contact us at your convenience.

Sincerely,

Thomas H. Hinson, PG, LSS
Chief Environmental Consultant

LICENSED SOIL SCIENTIST
THOMAS HARDIN HINSON
1060
STATE OF NORTH CAROLINA

Attachment: Report

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1.0 INTRODUCTION

Cpec Environmental, Inc. (Cpec) was contracted by Rummel, Klepper, and Kahl, P.A. (RKK) to perform a soil delineation and shallow subsurface characterization at the Benson Grove Church Wetland Mitigation Site in Johnston County, North Carolina. Cpec prepared this report with information collected from on-site surface and subsurface investigations, survey maps, aerial photographs, technical publications, geological maps, and county, state, and federal records. Appendix A contains Cpec's field procedures and methods.

1.1 Site location and general description

The site is located off US Hwy 50, north of the Town of Benson, in Johnston County, North Carolina (Figures 1 and 2). The evaluation area was approximately 54 acres (Figure 3).

1.2 Purpose and scope

In June 2001, Cpec initiated this evaluation to delineate by major soil units of similar character (e.g., hydric/non-hydric, subsoil texture, etc.) and perform morphological and hydraulic characterization of the shallow subsurface (< 8.0 below land surface (bls)).

Specific tasks undertaken to achieve these objectives were:

- Collect / compile existing site data / information, arrange and execute on-site conference between Rummel, Klepper, and Kahl representatives and Cpec personnel, and propose a plan of work;
- Using industry-standard methods, group soils into major units of similar character (e.g., hydric/non-hydric, subsoil texture, etc.) and delineate major soil-unit boundaries with ground flagging;
- Perform subsurface characterization (soil-profile descriptions to 8-ft bls) and perform in-situ saturated hydraulic conductivity (Ksat) measurements within two (2) soil horizons at selective locations within each major soil unit;
- Locate soil borings and soil-delineation boundaries with global-positioning system (GPS) methods to sub-meter accuracy, and generate digital soil maps (overlays) in the NC State Plane Projection; and
- Compile a report summarizing methods, observations, results, and conclusions for the investigation.

2.0 SITE CHARACTERIZATION

2.1 Regional geology and local topography

The site was located in the Middle Coastal Plain geomorphic region. The predominant lithology consists of Cretaceous-age sandstones and mudstones of the Cape Fear Formation (Winner et al., 1989) overlain by Quaternary-age alluvial deposits of sands, silts, and clays (Beyer, 1991). General topography of the site is shown on Figure 3. The geomorphology was floodplain and low stream terrace.

2.2 Soils

Traversing the site, Cpec personnel observed landforms (slope, drainage patterns, past use, etc.) and noted the location of existing property boundaries, vegetation, roads, etc. Following the site walkover, we advanced numerous hand-augered soil borings to characterize and assess subsurface conditions. Subsurface observations included: soil morphological properties (e.g., texture, structure, color, presence and type of redoximorphic features, etc.), types and thicknesses of restrictive horizons, and soil wetness conditions. Figure 4 and Table 1 present the soil mapping results.

Within the evaluation area, Cpec grouped soils into two main categories: (1) Hydric and (2) Non-hydric. The hydric soils occupied 97% (52.0 ac.) of the evaluation area and were sub-divided into three broad sub-units:

(a) Tomotley Series Taxadjuncts (32.7 ac.),
(b) Tomotley/Wehadkee Associations (18.1 ac.), and
(c) Tomotley Variants (1.1 ac.).

The non-hydric soils occupied only 3% (1.9 ac.) of the evaluation area and were sub-divided into three broad sub-units:

(a) Gilead Series (0.5 ac.), and
(b) Augusta Series Taxadjuncts (1.4 ac.).

All of the soils, with the exception of the Gilead Soils, were derived from recent fluvial/alluvial sediments of the Black Creek Riverine System. The Gilead Soils were moderately well drained, the Augusta Soils were somewhat poorly drained, and the remaining hydric soils (97%) were poorly to very poorly drained and occasionally to frequently flooded.

2.3 Subsurface characterization

2.3.1 Soil profile descriptions

Cpec performed 10 deep borings (8-ft bls) across the evaluation area (Figure 4). Qualitative subsurface descriptions at each deep boring included: soil morphological properties (e.g., texture, structure, color, presence and type of redoximorphic features, etc.), types and respective thickness of restrictive horizons, and soil wetness conditions. Deep boring field descriptions are included in Appendix B and representative deep boring descriptions for various soil units are presented on Tables 2a through 2e.

2.3.2 Shallow stratigraphy

Generally, the shallow stratigraphy (< 8.0 ft bls) consists of a thin surface horizon (A-horizon) with a texture ranging from sandy loam to fine sandy clay loam. The subsoil (B-horizon) was weakly-developed with a texture ranging from sandy clay loam to sandy clay. The substratum (C-horizon) was fine sandy to coarse loamy in the upper part and graded to coarse sandy (alluvium) with depth.

2.3.3 Hydraulic conductivity estimates

Due to distinctly contrasting morphological nature between the upper and lower parts of the substratum, we partitioned our hydraulic characterization into upper and lower "zones". We installed 1-in diameter observation (test) wells at selected deep boring locations with the well screens isolated in these target zones to measure hydraulic properties. Observation well identification numbers corresponded to the deep boring location and the relative zone location (shallow or deep) within the substratum. For example, TW-1s was located in the shallow (upper) zone at boring location DB-1. Table 3 provides well construction details and well installation methods are presented in Appendix A.

Based on the site conditions, Cpec used the rising-head slug test method. Field measurements were solved for saturated hydraulic conductivity (K_{sat}) via the Hvorslev method (Fetter, C.W., 1988). Minimums of two (2) field tests were conducted at each slug test location. A total of 16 field tests were recorded between 06-29-01 and 06-30-01. Field results are presented in Appendix C and summaries of tests results are located on Tables 4a and 4b, respectively.

From a population of 16 recorded slug tests (Appendix C), the estimated K_{sat} of the upper C-horizon ranged from 0.38 in/hr. (0.77 ft/d) to 0.71 in/hr. (1.42 ft/d) with a mean value of 0.49 in/hr. (0.97 ft/d). In the lower C-horizon, the estimated K_{sat} ranged from 1.23 in/hr. (2.46 ft/d) to 3.01 in/hr. (6.03 ft/d) with a mean value of 1.83 in/hr. (3.66 ft/d).

3.0 LIMITS OF INVESTIGATION

Data presented in this report represent isolated data points. Conclusions of this report, including maps and calculations, are based on extrapolations between data points and on subjective hydrogeologic, soils, and geologic interpretation. Therefore, our conclusions may not be completely representative of all conditions in the evaluation area.

4.0 REFERENCES

Amoozegar, A. and A. W. Warrick. 1986. Hydraulic Conductivity of Saturated Soils: Field Methods. In Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd ed. American Society of Agronomy, Madison, WI.

Beyer, F. 1991. North Carolina: The Years Before Man. Carolina Academic Press. Durham, NC.

Bouwer, H. and R. C. Rice. 1976. A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells. Water Resources. Res. V. 12, no. 3.

Butler, J. J., C. D. McElwee and Wenzhi Liu. 1996. Improving the quality of parameter estimates obtained from slug tests. Groundwater. V.34. no. 3.

Cooper, H. H., J. D. Bredehoeft, and I. S. Papadopulos. 1967. Response of a finite-diameter well to an instantaneous charge of water. Water Resources. Res. V. 3, no. 1.

Fetter, C.W. 1988. Applied Hydrogeology. Macmillan Publishing Company, New York.

Hyder, Z. and J. J. Butler. 1995. Slug tests in unconfined formations: An assessment of the Bouwer and Rice technique. Groundwater. V.33. no. 1.

Hvorslev, M.J., 1951. Time lag and soil permeability in groundwater observations: U.S. Army Corps of Eng. Waterway Exp. Stat. Bull. 36, Vicksburg, MS.

United States Department of Agriculture, Natural Resources Conservation Service. 1996. National Soil Survey Handbook, Title 430-VI.

United States Department of Agriculture, Soil Conservation Service. 1994. Soil Survey of Johnston County, North Carolina.

Winner, M.D., Jr. And R.W. Coble. 1989 Hydrologeologic framework of the North Carolina Coastal Plain aquifer system. USGS Open-File Report 87-690, Plate 8.

TABLES

Table 1. Soil mapping results and hydric soil classification.

Soil Mapping Unit	map symbol	hydric soil classification	Area (ft^2)	(acre)
Tomotley Series Taxadjuncts	To	hydric	1,424,564	32.7
Tomotley Variant	ToV	hydric	49,743	1.1
Tomotley/Wehadkee Association	To/Wt	hydric	788,961	18.1
Augusta Series Taxadjuncts	As	non-hydric	22,236	0.5
Gilead Series	Ge	non-hydric	59,136	1.4
		totals =	**2,344,640**	**53.8**

Table 2a. Representative deep boring description of the Tomotley Soils

horizon (USDA)	depth (ft-bls)	soil structure* (USDA)	soil texture* (USDA)	soil color*, mottling*, and comments
A	0.0-0.8	weak subangular blocky; very friable	fine sandy loam to fine sandy clay loam	dark gray (10YR 4/1)
Btg1	0.8-2.0	weak subangular blocky; friable to firm	fine sandy clay loam to fine sandy clay	gray (10YR 5/1)
Cg1	2.0-5.0	massive; friable	fine sandy clay loam to fine sandy loam	gray (10YR 6/1); common medium distinct brownish yellow (10YR 6/8) mottles
Cg2	5.0-8.0	single-grained; loose	coarse sand	light brownish gray (10YR 6/2); few medium distinct yellowish brown (10YR 5/6) mottles

estimated average seasonal high water table: <1.0' below land surface (bls)*

* determined via standard USDA field methods

Table 2b. Representative deep boring description of the Augusta Soils

horizon (USDA)	**depth** (ft-bls)	**soil structure*** (USDA)	**soil texture*** (USDA)	**soil color*, mottling*, and comments**
A	0.0-0.6	weak coarse subangular blocky; very friable	fine sandy clay loam to sandy loam	dark grayish brown (2.5Y 4/2)
Bt	0.6-1.5	moderate medium subangular blocky; friable	fine sandy clay loam to sandy clay	light olive brown (2.5Y 5/4); few fine distinct yellowish red (5YR 5/8) mottles
Btg	1.5-2.5	moderate coarse subangular blocky; friable	fine sandy clay loam	gray (2.5Y 6/1); common medium, prominent yellowish brown (10YR 5/8) mottles
Cg1	2.5-4.5	massive; very friable	loamy sand	gray (2.5Y 6/1); many coarse prominent yellowish brown (10YR 5/8) mottles
Cg2	4.5-6.0	single-grained; very friable	sand	gray (2.5Y 6/1); many coarse distinct light olive brown (2.5Y 5/4) mottles
Cg3	6.0-8.0	single-grained; loose	coarse sand	gray (2.5Y 6/1)

estimated average seasonal high water table: 1.5' below land surface (bls)*

* determined via standard USDA field methods

Table 2c. Representative deep boring description of the Tomotley Variant Soils

horizon (USDA)	**depth** (ft-bls)	**soil structure*** (USDA)	**soil texture*** (USDA)	**soil color*, mottling*, and comments**
A1	0.0-0.5	weak medium crumb; very friable	loamy sand	light olive brown (2.5Y 5/6)
A2	0.5-2.0	single-grained; loose	sand	olive yellow (2.5Y 6/8)
Btgb	2.0-4.0	weak coarse subangular blocky; friable	fine sandy clay loam	dark gray (2.5Y 4/1); few fine distinct light olive brown (2.5Y 5/6) mottles
Cg1	4.0-6.0	massive; very friable	fine sandy clay	gray (2.5Y 5/1); common medium prominent reddish yellow (7.5YR 6/8) mottles
Cg2	6.0-8.0	massive; firm	fine sandy clay	gray (2.5Y 6/1); few fine prominent reddish yellow (7.5YR 6/8) mottles

estimated average seasonal high water table: <1.0' below land surface (bls)*

* determined via standard USDA field methods

Table 2d. Representative deep boring description of the Wehadkee Soils.

horizon (USDA)	**depth** (ft-bls)	**soil structure*** (USDA)	**soil texture*** (USDA)	**soil color*, mottling*, and comments**
A	0.0-0.5	weak medium granular; friable	loam to clay loam	dark brown (10YR 4/3)
Btg1	0.5-2.5	weak coarse prismatic; friable; sticky and slightly plastic	clay loam	gray (10YR 6/1); many medium distinct yellowish brown (10YR 5/6) mottles
Btg2	2.5-4.0	weak coarse prismatic; friable; sticky and slightly plastic	clay loam	gray (10YR 6/1); many coarse brown (7.5YR 4/4) mottles
Cg1	4.0-6.0	massive; friable and firm; sticky and plastic	clay loam	gray (10YR 6/1) to variegated

estimated average seasonal high water table: <1.0' below land surface (bls)*

* determined via standard USDA field methods

Table 2e. Representative deep boring description of the Gilead Soils.

horizon (USDA)	**depth** (ft-bls)	**soil structure*** (USDA)	**soil texture*** (USDA)	**soil color*, mottling*, and comments**
A	0.0-0.6	weak fine granular; very friable	sandy loam	brown (10YR 4/3)
Bt1	0.6-1.3	weak medium subangular blocky; friable	sandy clay loam	yellowish brown (10YR 5/6)
Bt2	1.3-2.2	weak medium subangular blocky; friable	sandy clay loam	yellowish brown (10YR 5/6); medium distinct strong brown (7.5YR 5/6) mottles
Bt3	2.2-3.5	weak medium subangular blocky; friable	clay loam	yellowish brown (10YR 5/6); common fine prominent light brownish gray (2.5Y 6/2) and red (2.5YR 4/6) mottles
Btg	3.5-5.4	moderate medium and coarse angular blocky; firm	sandy clay	light gray (10YR 6/1); common medium prominent strong brown (7.5Y/R 5/6) and red (2.5YR 4/6) mottles
Cg	5.4-6.0	massive; firm	sandy clay loam	light gray (10YR 7/1); common medium prominent strong brown (7.5YR 5/8) and red (2.5YR 4/6) mottles

estimated average seasonal high water table: 2.5' below land surface (bls)*

* determined via standard USDA field methods

Table 3. Well construction details and data.

Well ID	screen diameter (in)	boring diameter (in)	casing length (ft)	screen length (ft)	casing HAS (ft)	WT DBC (ft)	total depth (ft)	WT DBS (ft)	screen interval DBS (ft)		(ft)
TW-1s	1	3.25	3.58	1.00	1.67	2.90	2.91	1.23	1.91	to	2.91
TW-2d	1	3.25	3.67	1.00	0.83	2.40	3.84	1.57	2.84	to	3.84
TW-3s	1	3.25	6.92	1.00	1.67	3.22	6.25	1.55	5.25	to	6.25
TW-3d	1	3.25	6.92	1.00	0.33	2.15	7.59	1.82	6.59	to	7.59
TW-4s	1	3.25	3.50	1.00	1.67	3.23	2.83	1.56	1.83	to	2.83
TW-4d	1	3.25	3.92	1.00	0.50	1.83	4.42	1.33	3.42	to	4.42
TW-7s	1	3.25	2.92	2.00	0.58	2.48	4.34	1.90	2.34	to	4.34
TW-7d	1	3.25	7.42	2.00	0.83	2.73	8.59	1.90	6.59	to	8.59
								mean =	1.61		

casing HAS - casing height above land surface
WT DBC - water table depth below measurement pt. (i.e., well casing)
total depth - from land surface
WT DBS - depth to water table below land surface
screen interval - vertical interval occupied by well screen below land surface

Table 4a. Hydraulic conductivity estimates in the upper C horizon.

Location	Well ID	screen interval DBS (ft)		(ft)	soil horizon (USDA)	predominate soil texture (USDA)	mean *e* Ksat (ft/d)	(in/hr)
DB-1	TW-1s	1.91	to	2.91	Cg1	fine sandy clay loam to fine sandy	0.91	0.46
DB-3	TW-3s	5.25	to	6.25	Cg2	fine sandy loam	0.78	0.39
DB-4	TW-4s	1.83	to	2.83	Cg1	fine loamy sand	0.81	0.41
DB-7	TW-7s	2.34	to	4.34	Cg1	fine sandy loam	1.39	0.70
						mean =	0.97	0.49

location - field location (see Figures)
screen interval - vertical interval occupied by well screen below land surface
soil horizon - soil horizon designation at well screen location
predominate soil texture - predominate soil texture at well screen location

Table 4b. Hydraulic conductivity estimates in the lower C horizon.

Location	Well ID	screen interval DBS (ft)		(ft)	soil horizon (USDA)	predominate soil texture (USDA)	mean *e* Ksat (ft/d)	(in/hr)
DB-2	TW-2d	2.84	to	3.84	C	coarse sand	3.09	1.55
DB-3	TW-3d	6.59	to	7.59	C	coarse sand	2.52	1.26
DB-4	TW-4d	3.42	to	4.42	Cg2	coarse sand	3.27	1.64
DB-7	TW-7d	6.59	to	8.59	Cg3	very coarse sand	5.74	2.87
						mean =	3.66	1.83

location - field location (see Figures)
screen interval - vertical interval occupied by well screen below land surface
soil horizon - soil horizon designation at well screen location
predominate soil texture - predominate soil texture at well screen location

FIGURES

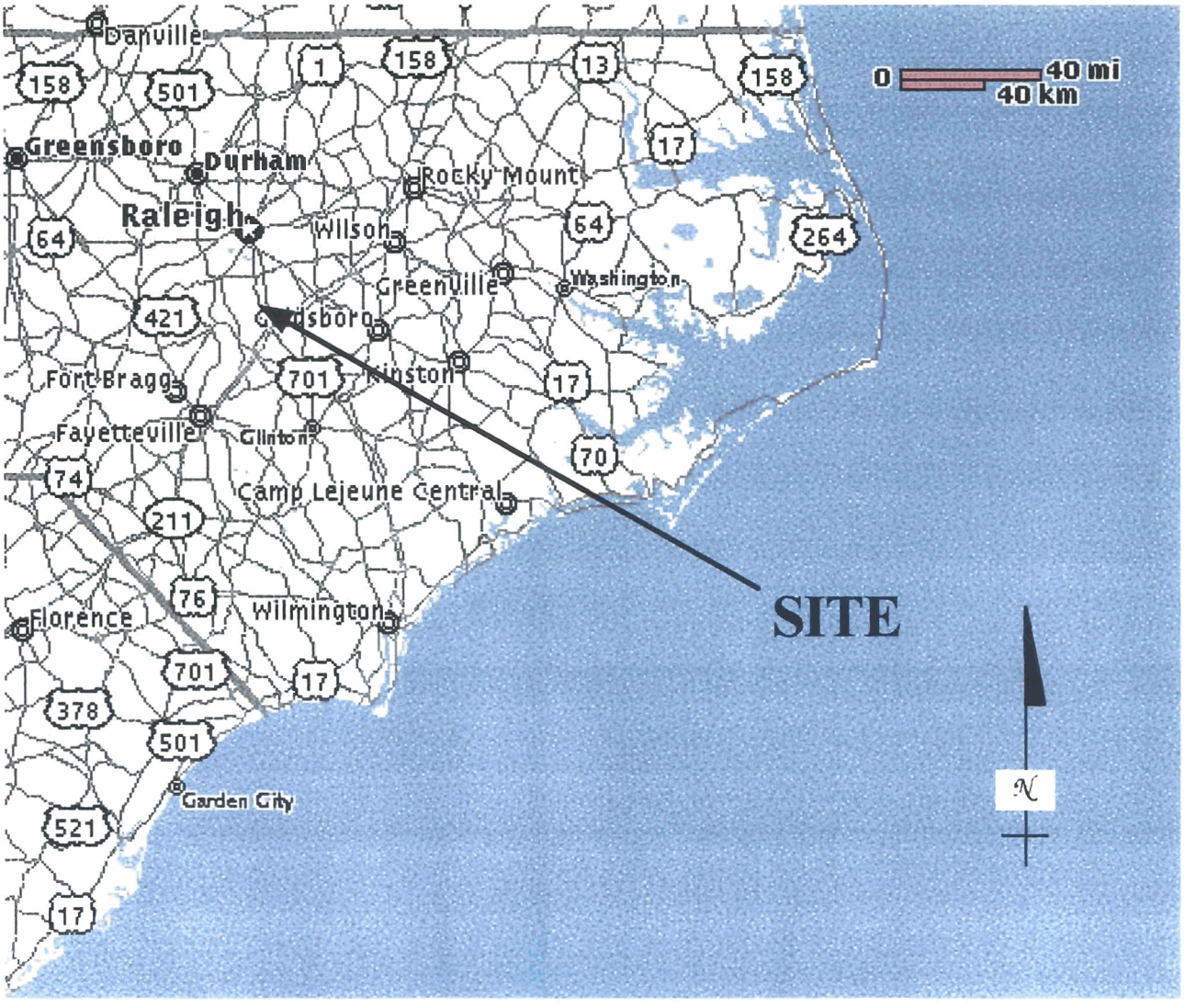

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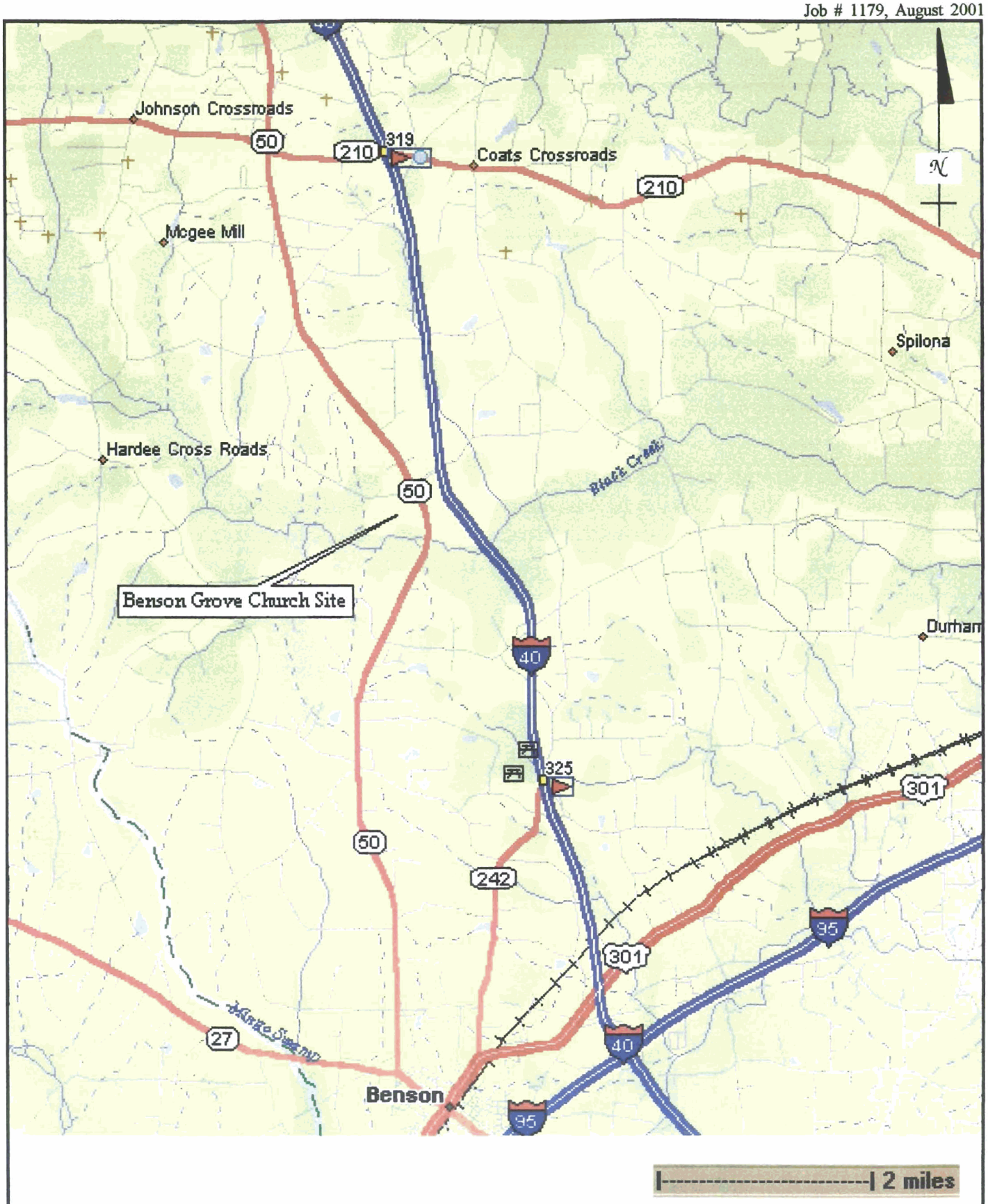
Figure 1. Location of the Benson Grove Church Wetland Mitigation Site, Johnston Co., NC (regional scale).



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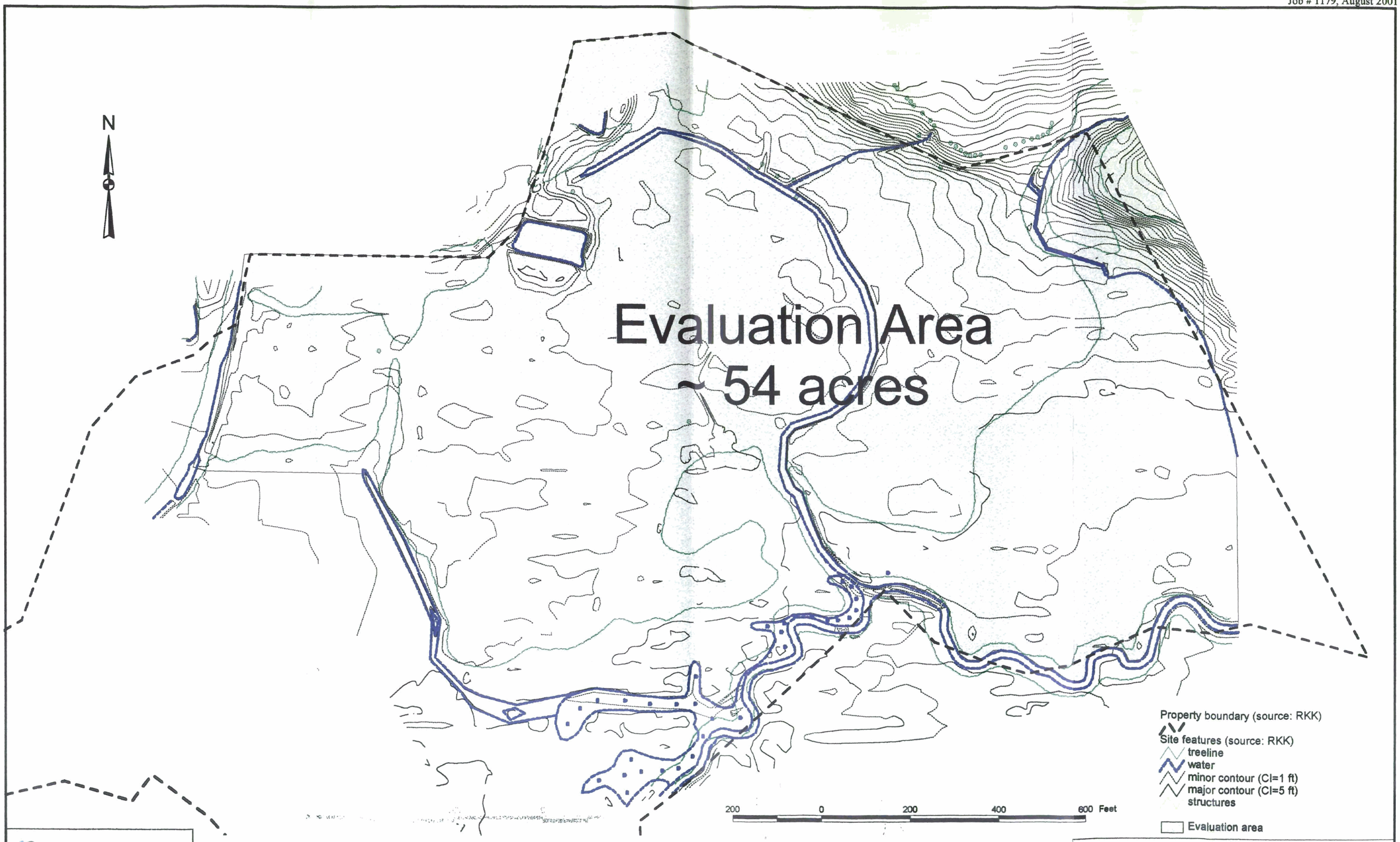
1503 Front Street, Beaufort, North Carolina 28516

Figure 2. Location of the Benson Grove Church Wetland Mitigation Site, Johnston Co., NC (local scale).



GPEC ENVIRONMENTAL INC.
1103 Poole Drive, Garner, North Carolina 27529
1503 Front Street, Beaufort, North Carolina 28516

Scale: 1" = 200'	By: T. Hinson
Date: 08-15-01	Job ID: 1179

Figure 3. General site map of the Benson Grove Church Wetland Mitigation Site

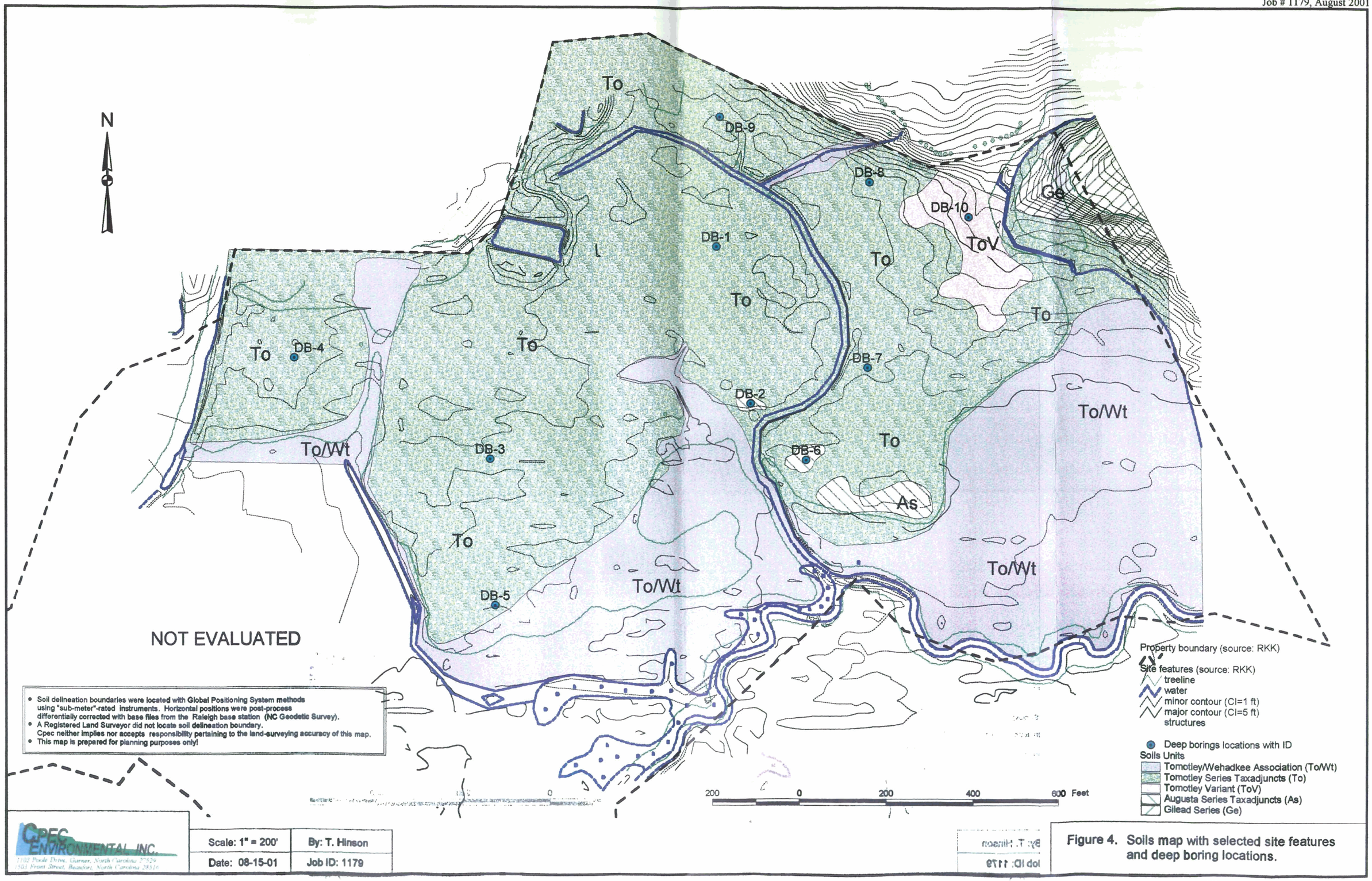


Figure 4. Soils map with selected site features and deep boring locations.

APPENDICES

Appendix A - Field Procedures
Appendix B - Detailed deep boring field descriptions
Appendix C - In-situ saturated hydraulic conductivity (K_{sat}) estimates

Appendix A

Field Procedures

Site Survey and Mapping A-1
Subsurface Descriptions A-1
Observation Well Installation A-1
In-situ Saturated Hydraulic Conductivity Estimates A-2

Site Survey and Mapping

Before the site visit, Cpec Environmental, Inc. (Cpec) compiled all relevant site information (ownership, site maps, USGS topographic maps, tax maps, aerial photographs, etc. The location of property boundaries and other site elements such as structures, roads, fences, utilities, wells, ditches, creeks, etc. were provided by RKK in a digital format.

Subsurface Descriptions

Soil-profile descriptions and bore logs were described from boring cuttings. Representative samples were collected from selected soil horizons and at abrupt lithologic or hydraulic boundaries. Subsurface samples reside in Cpec's archives and will be held for one year beyond this report date.

Qualitative subsurface characterizations included: soil morphological properties (e.g., texture, structure, color, presence and type of redoximorphic features, etc.), thickness and type of restrictive horizons, depth to saprolite and bedrock (parent material), lithologic character of saprolite and bedrock, ambient soil wetness conditions, and seasonal high water table estimates. Detailed soil-profile descriptions are presented in Appendix B.

Observation Well Installation

Cpec installed several one-inch diameter observation wells for static water table measurements, aquifer transmissivity tests, and groundwater sampling (if applicable). Observation wells are "temporary" wells and <u>not</u> intended to be used for long-term groundwater monitoring.

Observation wells were constructed of flush-jointed PVC casings with 0.010-inch slot screens and no glues or solvents were used. After the well (riser and screen) was inserted into the borehole, the well annulus was backfilled with coarse silica sand to ~0.25-ft above the well screen. Bentonite was used to fill the annular space above the sand-pack to the ground surface. The bentonite seal prevents cross-contamination from above the well's screened interval. All wells were similarly constructed and completed above the finished grade. Upon completion, each well was "developed" by withdrawing five bore volumes of groundwater or until groundwater was relatively clear. After achieving atmospheric equilibrium, a static water table measurement was made. Installation methods are described below.

<u>Hand-auger method</u>

Cpec used hand augers (three-inch diameter) to bore to the target depth. The observation well was inserted into the open borehole.

In-situ Saturated Hydraulic Conductivity (K_{sat}) Estimates

Saturated Zone K_{sat}'s - Slug Test Method

Cpec conducted "slug" tests on eight (8) observation wells to obtain saturated hydraulic conductivity (K_{sat}) estimates of the host geologic material. The tests measured the rate at which the screened interval of a water-bearing formation released or accepted a specific volume of water introduced into, or withdrawn from, the well as a single slug. The water levels were continuously changing and were measured with a pressure transducer/data logger or manually. Water level changes were analyzed against static water table measurements. Data collection was terminated when the water level had achieved at least a 95% recovery to pre-test levels. Field data and results are presented in Appendix C.

The slug test is one of the most commonly used field methods for obtaining in situ estimates of K_{sat}. Despite its prevalence, the method has received a considerable amount of criticism in the ground-water environmental consulting community. A primary cause of criticism is a discrepancy often observed between slug test estimates and other information collected during more detailed site investigations (e.g., geologic and geophysical logs, core samples, pumping tests, etc.). Although spatial variability and different data-acquisition scales can explain a portion of the observed discrepancies, a significant component of this difference undoubtedly is a product of a somewhat casual attitude that was often directed at the performance and analysis of slug tests. Since slug tests have considerable logistical and economic advantages over other alternative approaches, it was imperative that these tests be done in such a manner so to yield parameter estimates of the highest possible quality.

A recently published 5-year study (Butler et al, 1996) proposed practices for improving the quality and reliability of slug tests. Butler et al. (1996) proposed numerous guidelines to achieve higher quality estimates but stresses the most significant ones as:

1) considerable attention should be given to well construction and development;
2) three or more slug tests should be performed at a given well during a given test period;
3) two or more different initial head displacements (H_0) should be used at each well;
4) use of data-acquisition equipment (e.g., pressure transducers) that enables collection of a large quantity of high-quality data;
5) the slug method, whether rising-head ("slug-out") or falling-head ("slug-in"), should be designed to allow the "slug" to be introduced in a near-instantaneous manner;
6) the number of tests performed across the site, slug method, data interpretation method, and data-acquisition equipment should be carefully chosen and appropriate for site conditions.
7) Site condition considerations included aquifer anisotropy and heterogeneity; deep water tables vs. shallow water tables; unconfined vs. confined aquifers; well-screen interval below or across the static water table; highly permeable vs. hydraulically-tight materials; etc.

A common field application of the slug test was in shallow wells that partially penetrate unconfined aquifers. Most slug test analysis methods in unconfined aquifers were based on several simplifying assumptions:

1) the specific storage of the formation was negligible;
2) changes in the position of the water table due to a slug test were so small that the water table can be represented as a constant-head boundary;
3) flow above the water table can be ignored;
4) there was no near-well zone of disturbance created by drilling or development;
5) the formation was isotropic with respect to hydraulic conductivity.

In 1995, Hyder and Butler assessed the most significant well and formation parameters that introduce error into hydraulic conductivity estimates from slug tests on partially-penetrating wells in unconfined aquifers. Their assessment includes: aspect ratio [screen length (b)/screen radius (r_w)], aquifer anisotropy [vertical K_{sat} (K_z)/radial K_{sat} (K_r)], aquifer specific storage (α), well-screen distance from boundaries (e.g., water table, confining units, etc.), and low/high permeability well skins (i.e., disturbed near-well zones created by well drilling and development). Although a comprehensive article review is not possible here, several important generalizations or "rules of thumb" derived from the article, allow the best possible estimate of K_{sat} from slug tests. These included

1) a moderate to high aspect ratio (b/r_w = 40-200) will yield the best results in most situations and should be achieved whenever possible;
2) in homogeneous, isotropic formations with low storage coefficients (α<0.001) and moderate aspect ratios (b/r_w = 40-100), the Bouwer and Rice Method (Bouwer and Rice, 1976) should provide estimates that were within 10% of the formation K_{sat}. There will, however, be considerable variation in the quality of the estimates as a function of the distance of the screened interval from aquifer boundaries;
3) when aquifer specific storage coefficients are suspected to be high (α>0.001)(e.g., low permeability, clay-rich formations) and within homogenous, anisotropic formations, the Cooper et al. Method (Cooper, et al., 1967) should provide the best K_{sat} estimates;
4) in cases of a high-conductivity well skin and moderate aspect ratios (b/r_w = 40-100), the Bouwer and Rice Method will provide estimates within 25% (+ or -) of the formation K_{sat};
5) in cases of a low-conductivity well skin, the Bouwer and Rice Method estimates can be heavily weighted towards the conductivity of the skin. However, proper well development can eliminate high contrast between the formation and the well skin, therefore, reducing parameter estimate error.

Understanding the significance of compounded error, Cpec attempts to eliminate error whenever possible via following suggestions outlined above. However, error can only be minimized, not eliminated. Cpec customizes the slug method (rising-head or falling-head), data-interpretation method [Cooper et al., Bouwer and Rice, Hvorslev (Hvorslev, 1951), Auger-hole (Amoozegar and Warrick, 1986), etc.], and data-acquisition equipment (pressure transducer vs. manual readings) to each site's unique subsurface conditions.

In general, within confined aquifers, Cpec utilizes the Cooper et al. Method. Within unconfined aquifers with wells screened below the static water table, we utilize either the Cooper et al.

Method, Bouwer and Rice Method, or Hvorslev Method. Within unconfined aquifers with wells screened across the static water table, we utilize either the Hvorslev Method or the Auger-hole Method. The slug method (rising-head or falling-head) was chosen based on three primary criteria: static water-table depth, well screen location relative to the static water table, and perceived recovery rates. It is not uncommon for Cpec to utilize many combinations of the aforementioned slug and interpretation methods for results comparisons.

Appendix B

Detailed deep boring field descriptions

DB-1 ..... B-1
DB-2 ..... B-2
DB-3 ..... B-3
DB-4 ..... B-4
DB-5 ..... B-5
DB-6 ..... B-6
DB-7 ..... B-7
DB-8 ..... B-8
DB-9 ..... B-9
DB-10 ..... B-10

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-1

Client:	RKK	**NRCS series:**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
Location:	(see Figures)	**Landscape position:**	Terrace/Floodplain	**Date:**	6/27/01
		Slope:	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A	0-4	1,c,sbk	vfr,ns,np	fsl	10YR 4/1	f,1,f	10YR4/6		<12"		
Btg	4-18	1,c,sbk	fr,ss,sp	fscl	10YR5/1	c,2,f	10YR5/6				
Cg1	18-48	0,massive	fi,ss,sp	fscl-fsl	10YR5/1	c,2,d	10YR6/8				
Cg2	48-96	0,massive	fr,ns,np	fsl	10YR6/1	f,2,d	10YR5/6				rounded rocks
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

			Sand grain modifiers
s - sand	scl - sandy clay loam	si - silt	vf - very fine (0.1 - 0.05 mm)
ls - loamy sand	sil - silt Loam	sc - sandy clay	f - fine (0.25 - 0.1 mm)
sl - sandy Loam	cl - clay loam	sic - silty clay	m - medium (0.5 - 0.25 mm)
l - loam	sicl - silty clay loam	c - clay	c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
\- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-2

Client:	RKK	**NRCS Series (mapped):**	Augusta Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Aeric Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	SPD	**Elevation:**	150'
		Landscape position:	Terrace/Floodplain	**Date:**	6/27/01
Location:	(see Figures)	**Slope:**	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A	0-8	1,c,sbk	fr,ns,sp	fscl-sl	2.5Y4/3		N/A				free H2O @ 16"
B1	8-18	1,c,sbk	fr,ns,sp	fscl	2.5Y5/6	f,1,d	5YR5/8		18		
B2	18-30	2,m,sbk	vfr,ns,np	fsl-fscl	2.5Y5/6	m,3,d	2.5Y6/2				
C	30-52	0,sg	vfr,ns,np	cs	2.5Y6/4	c,3,d	N/A				
	EOB	too loose to excavate									

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

			Sand grain modifiers
s - sand	scl - sandy clay loam	si - silt	vf - very fine (0.1 - 0.05 mm)
ls - loamy sand	sil - silt Loam	sc - sandy clay	f - fine (0.25 - 0.1 mm)
sl - sandy Loam	cl - clay loam	sic - silty clay	m - medium (0.5 - 0.25 mm)
l - loam	sicl - silty clay loam	c - clay	c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-3

Client:	RKK	**NRCS series:**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
Location:	(see Figures)	**Landscape position:**	Terrace/Floodplain	**Date:**	6/27/01
		Slope:	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A1	0-4	1,c,sbk	fr,ns,sp	fscl	10YR4/1				<12		
A2	4-18	1,m,sbk	fr,ns,sp	fscl	2.5Y7/1	f,2,p	10YR5/8				
Btg	18-39	1,c,sbk	fi,ns,sp	fsc	2.5Y6/1	m,3,p	10YR5/8				
Cg1	39-63	0,massive	vfr,ns,np	fscl	10YR6/2	f,1,p	10YR5/8				
Cg2	63-74	0,massive	vfr,ns,np	fsl	10YR6/2	m,3,p	10YR5/8				
C	74-84	0,sg	vfr,ns,np	cs	10YR5/8	N/A	N/A				many rocks and flat,
	EOB										circular silt lenses

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

s - sand	scl - sandy clay loam	si - silt	
ls - loamy sand	sil - silt Loam	sc - sandy clay	
sl - sandy Loam	cl - clay loam	sic - silty clay	
l - loam	sicl - silty clay loam	c - clay	

Sand grain modifiers
vf - very fine (0.1 - 0.05 mm)
f - fine (0.25 - 0.1 mm)
m - medium (0.5 - 0.25 mm)
c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-4

Client:	RKK	**NRCS series:**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
Location:	(see Figures)	**Landscape position:**	Terrace/Floodplain	**Date:**	6/28/01
		Slope:	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A horizon absent											
Btg1	0-5	1,c,sbk	vfr, ss, sp	fscl	10YR 4/1	f,1,p	5YR5/8		<12		free water @ 8"
Btg2	5-12	1,c,sbk	vfr,ss,sp	fscl	10YR5/1	f,1,p	5YR5/8				
Cg1	12-36	0-massive	vfr,ns,np	fls	2.5Y6/2	f,1,d	2.5Y5/6				
Cg2	36-58	0-massive	vfr,ns,np	cs	2.5Y7/1						
	EOB	too loose to excavate									

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

			Sand grain modifiers
s - sand	scl - sandy clay loam	si - silt	vf - very fine (0.1 - 0.05 mm)
ls - loamy sand	sil - silt Loam	sc - sandy clay	f - fine (0.25 - 0.1 mm)
sl - sandy Loam	cl - clay loam	sic - silty clay	m - medium (0.5 - 0.25 mm)
l - loam	sicl - silty clay loam	c - clay	c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-5

Client:	RKK	**NRCS series:**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
Location:	(see Figures)	**Landscape position:**	Terrace/Floodplain	**Date:**	6/28/01
		Slope:	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A	0-4	1,c,sbk	vfr,ss,sp	fscl-sl	2.5Y5/1	f,1,p	5YR5/8		<12		
Btg	4-24	1,c,sbk	fi,ss,p	fsc	2.5Y6/1	c,2,d	10YR5/6				
Cg1	24-60	0-massive	vfi,ss,p	fsc	2.5Y6/1	c,2,d	10YR5/6				
Cg2	60-84	0-massive	fr,ns,sp	fscl	2.5Y6/1	c,3,d	10YR5/6				free H2O @ 66"
C3	84-96	0-massive	vfr,ns,np	fsl	2.5Y6/1	c,3,d	10YR5/6				
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

s - sand	scl - sandy clay loam	si - silt	
ls - loamy sand	sil - silt Loam	sc - sandy clay	
sl - sandy Loam	cl - clay loam	sic - silty clay	
l - loam	sicl - silty clay loam	c - clay	

Sand grain modifiers

vf - very fine (0.1 - 0.05 mm)
f - fine (0.25 - 0.1 mm)
m - medium (0.5 - 0.25 mm)
c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-6

Client:	RKK	**NRCS series:**	Augusta Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Aeric Endoaqualt	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	SPD	**Elevation:**	150'
Location:	(see Figures)	**Landscape position:**	Terrace/Floodplain	**Date:**	6/28/01
		Slope:	<2%	**Described by:**	Chagaris/Hinson

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A	0-6	1,vc,sbk	vfr,ns,sp	fscl	2.5Y4/2	N/A	N/A				free H2O @ 30"
Bt1	6-18	2,m,sbk	fr,ss,sp	scl-sc	2.5Y5/4	N/A	N/A		18		
Bt2	18-24	2,c,sbk	fr,ss,p	fscl-scl	10YR5/8	m,2,p	2.5Y6/1				
Btg	24-36	2,c,sbk	fr-fi,ns,np	fscl	2.5Y6/1	c,2,p	10YR5/8				
Cg1	36-54	0-massive	vfr,ns,np	fls	2.5Y6/1	m,3,p	10YR5/8				
Cg2	54-72	0-sg	vfr,ns,np	s	2.5Y6/1	m,3,d	2.5Y5/4				
Cg3	72-96	0-sg	vfr,ns,np	cs	2.5Y6/1	N/A	N/A				
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

s - sand	scl - sandy clay loam	si - silt	
ls - loamy sand	sil - silt Loam	sc - sandy clay	
sl - sandy Loam	cl - clay loam	sic - silty clay	
l - loam	sicl - silty clay loam	c - clay	

Sand grain modifiers

vf - very fine (0.1 - 0.05 mm)
f - fine (0.25 - 0.1 mm)
m - medium (0.5 - 0.25 mm)
c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
\- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-7

Client:	RKK	**NRCS series:**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
Location:	(see Figures)	**Landscape position:**	Terrace/Floodplain	**Date:**	6/28/01
		Slope:	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A	0-12	1,c,sbk	vfr,ns,sp	fscl	2.5Y5/1	f,1,p	5YR5/8		<12		free H2O @ 36"
Btg1	12-21	1,c,sbk	fr,ss,sp	fsc	2.5Y6/1	f,1,d	2.5Y6/8				
Btg2	21-32	1,c,sbk	fr,ss,sp	fsc-fscl	2.5Y6/1	c,2,d	2.5Y6/8				
Cg1	32-52	0-massive	fr-fi,ns,np	fsl	2.5Y6/1	N/A	N/A				
Cg2	52-80	0-sg	vfr,ns,np	cs	2.5Y6/2	m,3,d	2.5Y6/8				
Cg3	80-96	0-sg	vfr,ns,np	vcs	2.5Y5/1	N/A	N/A				
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

			Sand grain modifiers
s - sand	scl - sandy clay loam	si - silt	vf - very fine (0.1 - 0.05 mm)
ls - loamy sand	sil - silt Loam	sc - sandy clay	f - fine (0.25 - 0.1 mm)
sl - sandy Loam	cl - clay loam	sic - silty clay	m - medium (0.5 - 0.25 mm)
l - loam	sicl - silty clay loam	c - clay	c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
\- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-8

Client:	RKK	**NRCS Series (mapped):**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
		Landscape position:	Terrace/Floodplain	**Date:**	6/28/01
Location:	(see Figures)	**Slope:**	2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A1	0-8	1,vc,sbk	vfr,ss,sp	sl-scl	2.5Y4/2	f,1,p	5YR5/8		<12"		free H20 @ 36"
A2	8-19	2,m,sbk	vfr,ns,np	sl	2.5Y7/1	f,1,p	7.5YR5/8				
Btg1	19-30	1,c,sbk	fi,ss,vp	sc	10YR5/8	m,3,p	2.5Y7/1				sc ribboned to 6"
Cg1	30-36	0-massive	vfi,ss,vp	sc	2.5Y7/1	m,2,p	10YR5/8				
Cg2	36-52	0-massive	fi,ss,sp	fsc	GLAY 7 N	f,1,p	10YR5/8				
Cg3	52-60	0-massive	fr,vs,sp	scl	GLAY 7 N	f,1,p	10YR5/8				varigated with coarse s
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

s - sand	scl - sandy clay loam	si - silt	
ls - loamy sand	sil - silt Loam	sc - sandy clay	
sl - sandy Loam	cl - clay loam	sic - silty clay	
l - loam	sicl - silty clay loam	c - clay	

Sand grain modifiers

vf - very fine (0.1 - 0.05 mm)
f - fine (0.25 - 0.1 mm)
m - medium (0.5 - 0.25 mm)
c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
\- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-9

Client:	RKK	**NRCS Series (mapped):**	Tomotley Taxadjunct	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
		Landscape position:	Terrace/Floodplain	**Date:**	6/28/01
Location:	(see Figures)	**Slope:**	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A	0-5	1,c,sbk	vfr,ss,sp	cl	2.5Y5/4	f,1,p	5YR5/8		<12		
Bg	5-14	1,c,sbk	vfr,ss,sp	cl	10YR4/1	N/A	N/A				
Cg1	14-56	0-massive	vfi,vs,p	c	10YR4/1	N/A	N/A				
Cg2	56-96	0-sg	vfr,ns,np	fs	2.5Y6/1	N/A	N/A				few clay lenses
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

			Sand grain modifiers
s - sand	scl - sandy clay loam	si - silt	vf - very fine (0.1 - 0.05 mm)
ls - loamy sand	sil - silt Loam	sc - sandy clay	f - fine (0.25 - 0.1 mm)
sl - sandy Loam	cl - clay loam	sic - silty clay	m - medium (0.5 - 0.25 mm)
l - loam	sicl - silty clay loam	c - clay	c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
\- no data

Cpec

Appendix C - Detailed deep boring description field sheets.

Detailed deep boring description at DB-10

Client:	RKK	**NRCS Series (mapped):**	Tomotley Variant	**Disturbance:**	Agricultural
Project #:	1179	**Classification:**	Typic Endoaquult	**Geologic region:**	middle CP
Prj. Name:	Benson-Grove mitigation site	**Drainage Class:**	VPD	**Elevation:**	150'
		Landscape position:	Terrace/Floodplain toeslope	**Date:**	6/28/01
Location:	(see Figures)	**Slope:**	<2%	**Described by:**	Chagaris/Hinson

FIELD PARAMETERS

Horizon	Depth (in)	Structure (grd/sz/typ)	Consistence	Texture (USDA-NRCS)	Color (matrix)	Mottles (ab/sz/cntrst)	Color (mottles)	*ePermR* (in/hr)	*eSHWT* (in)	DTS (ft)	Comments
A1	0-6	1,m,cr	vfr,ns,np	ls	2.5Y5/6	N/A	N/A		<12		24" of transported mat
A2	6-24	0-sg	vfr,ns,np	s	2.5Y6/8	N/A	N/A				
Btgb	24-46	1,c,sbk	fr,ss,sp	fscl	2.5Y4/1	f,1,d	2.5Y5/6				buried horizon
Cg1	46-72	0-massive	vfi,s,vp	fsc	2.5Y5/1	c,2,p	7.5YR6/8				
Cg2	72-96	0-massive	fi,ns,sp	fsc	2.5Y6/1	f,1,p	7.5YR6/8				
	EOB										

Structure

grd - grade	sz - size	typ - type	
0 - structureless	vf - very fine (< 1 mm)	gr - granular	p - platy
1 - weak	f - fine (1-2 mm)	abk - angular blocky	pr - prismatic
2 - moderate	m - medium (2-5 mm)	sbk - sub-angular blocky	c - columnar
3 - strong	c - coarse (5-10 mm)	m - massive	sg-single grained
	vc - v.coarse (>10 mm)		

Consistence

w - wet		m - moist	d - dry
stickiness	plasticity	0 - loose (l)	0 - loose (l)
0 - nonsticky (ns)	0 - nonplastic (np)	1 - very friable (vfr)	1 - soft (s)
1 - slightly sticky (ss)	1 - slightly plastic (sp)	2 - friable (fr)	2 - slightly hard (sh)
2 - sticky (s)	2 - plastic (p)	3 - firm (f)	3 - hard (h)
3 - very sticky (vs)	3 - very plastic (vp)	4 - very firm (vf)	4 - very hard (vh)
		5 - Extremely firm (xf)	5 - extremely hard (xh)

Texture

			Sand grain modifiers
s - sand	scl - sandy clay loam	si - silt	vf - very fine (0.1 - 0.05 mm)
ls - loamy sand	sil - silt Loam	sc - sandy clay	f - fine (0.25 - 0.1 mm)
sl - sandy Loam	cl - clay loam	sic - silty clay	m - medium (0.5 - 0.25 mm)
l - loam	sicl - silty clay loam	c - clay	c - coarse (1.0 - 0.5 mm)

Mottles

ab - abundance	sz - size	contrst - constrast
f - few (< 2%)	1 - fine (< 5 mm)	f - faint
c - common (2 - 20%)	2 - medium (5-15 mm)	d - distinct
m - many (> 20%)	3 - coarse (> 15 mm)	p - prominent

Color (matrix)/(mottles)
Munsell color scheme - hue, value/chroma

Comments

ePermR estimated permeability range (NRCS, 1996)
eSHWT estimated depth below land surface to the seasonal high water table (estimates made from redoximorphic soil characteristics)
DTS depth below land surface to saturated conditions
- no data

Cpec

Appendix C

In-situ Saturated Hydraulic Conductivity (Ksat) Estimates

Saturated Zone Ksat Estimates – Hvorslev Method C-1

Saturated Zone K_{sat} Estimates
Hvorslev Method (6/29 - 6/30/01)

Benson Grove Church Wetland Mitigation Site
Johnston Co.,NC
Job # 1179, August 2001

Fld test ID	DTW (static) (ft)	DTW (max DD) (ft)	Head displacement (ft)	DTW @37% recovery (ft)	Elapsed Time to 37% recovery (sec)	(days)	Well diameter (in)	Bore diameter (in)	Screen Length (Le) (ft)	*e* Ksat (ft/d)	(in/hr)
TW-1sA	2.90	3.93	1.03	3.55	414	0.0048	1	3.25	1.00	**0.95**	**0.47**
TW-1sB	2.90	3.93	1.03	3.55	446	0.0052	1	3.25	1.00	**0.88**	**0.44**
TW-2dA	2.40	4.40	2.00	3.66	111	0.0013	1	3.25	1.00	**3.53**	**1.77**
TW-2dB	2.40	4.40	2.00	3.66	148	0.0017	1	3.25	1.00	**2.65**	**1.32**
TW-3sA	3.22	8.40	5.18	6.48	510	0.0059	1	3.25	1.00	**0.77**	**0.38**
TW-3sB	3.22	8.40	5.18	6.48	489	0.0057	1	3.25	1.00	**0.80**	**0.40**
TW-3dA	2.15	8.25	6.10	5.99	152	0.0018	1	3.25	1.00	**2.58**	**1.29**
TW-3dB	2.15	8.25	6.10	5.99	159	0.0018	1	3.25	1.00	**2.46**	**1.23**
TW-4sA	3.23	4.35	1.12	3.94	493	0.0057	1	3.25	1.00	**0.79**	**0.40**
TW-4sB	3.23	4.35	1.12	3.94	475	0.0055	1	3.25	1.00	**0.83**	**0.41**
TW-4dA	1.83	4.95	3.12	3.80	115	0.0013	1	3.25	1.00	**3.41**	**1.70**
TW-4dB	1.83	4.95	3.12	3.80	125	0.0014	1	3.25	1.00	**3.14**	**1.57**
TW-7sA	2.48	4.95	2.47	4.04	290	0.0034	1	3.25	1.00	**1.35**	**0.68**
TW-7sB	2.48	4.95	2.47	4.04	276	0.0032	1	3.25	1.00	**1.42**	**0.71**
TW-7dA	2.73	5.65	2.92	4.57	65	0.0008	1	3.25	1.00	**6.03**	**3.01**
TW-7dB	2.73	5.65	2.92	4.57	72	0.0008	1	3.25	1.00	**5.44**	**2.72**

-data entry fields

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