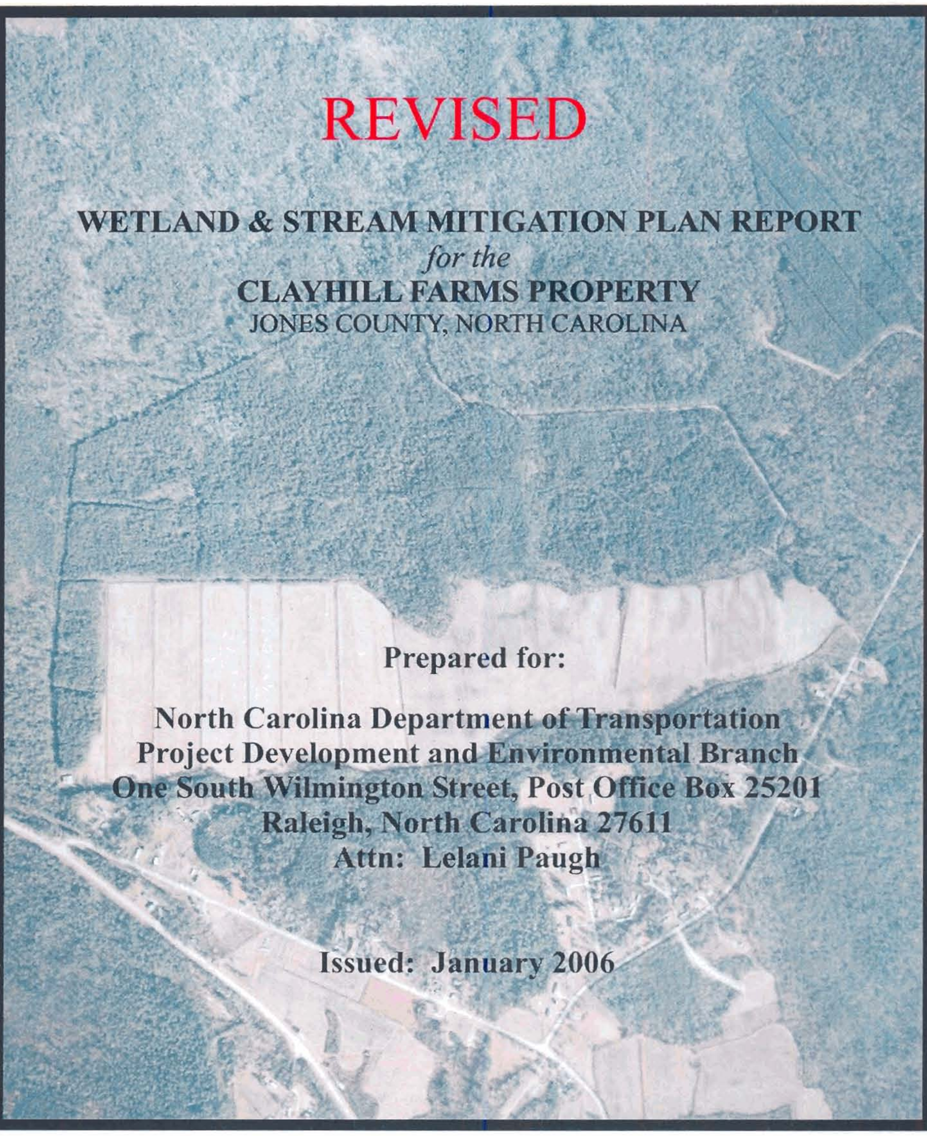
REVISED WETLAND & STREAM MITIGATION PLAN REPORT
for the
CLAYHILL FARMS PROPERTY
JONES COUNTY, NORTH CAROLINA



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for the
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JONES COUNTY, NORTH CAROLINA

Prepared for:

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Project Development and Environmental Branch
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Issued: January 2006

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1.0 DOCUMENT DESCRIPTION & INTENT

The following document represents revisions to the *Final Wetland and Stream Mitigation Plan Report for the Clayhill Farms Property, Jones County, North Carolina* prepared for the North Carolina Department of Transportation Project Development and Environmental Analysis Branch in July 1999 by Langley & McDonald, Inc. (L&M), now LandMark Design Group, Inc., of Virginia Beach, Virginia. This revised plan incorporates comments from meeting minutes dated March 1, 2002, March 4, 2002, April 30, 2002; results of the May 24, 2002 MBRT meeting; and the *Forest Management Plan* (prepared by Carolina Silvics, Inc. in July 2003).

2.0 EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) acquired the 355.6 acre Clayhill Farms property in the summer of 1998 based upon the findings of the *Wetland Mitigation Site Feasibility Study* conducted by L&M in the fall of 1997 (L&M 1998). The following report describes the Clayhill Farms Wetland and Stream Mitigation Site (hereafter referred to as the "Site") in detail and proposes methods for restoring, enhancing, and preserving wetland communities to compensate for wetland impacts associated with future road construction projects. The Site also provides the NCDOT with the opportunity to restore 8,262 linear feet of stream which was channelized to maximize agricultural production in the mid 1970s.

The following major studies were conducted in preparation of this report including:

- Soils delineation and location by Global Positioning System (GPS) survey on certain farm fields,
- Wetland delineation and location by traditional survey of forested area mapped as Class B hydric soils,
- Groundwater table characterization and modeling using DRAINMOD,
- Shallow groundwater monitoring,
- Surface water hydrology and hydraulics of farm field (feeder) ditches,
- Fluvial geomorphological analysis of reference streams and the on-site, channelized reach of Billy's Branch,
- Surface water hydrology and hydraulics of Billy's Branch,
- Importance value calculations for off-site reference plant communities,
- General inventory of on-site vegetation and wildlife, and
- Section 7 consultation for the red-cockaded woodpecker (*Picoides borealis*).

This report also addresses vegetation and stream monitoring protocol, mitigation ratios, and dispensation of the property.

The Site currently contains approximately 155.9 acres of forested wetlands, 199.7 acres of non-wetlands (141.8 acres of Prior Converted cropland and 57.9 acres of forested land), 6,170 linear feet of incised, straightened stream, and 1,280 linear feet natural perennial stream. Following implementation of the mitigation plan, the property will provide the following:

- 97.7 acres of wetland restoration, 1.8 acres of wetland enhancement, and 154.1 acres of wetland preservation;
- 5,132 linear feet of perennial stream restoration, 3,200 linear feet of intermittent stream restoration, 1,280 linear feet of stream preservation; and
- 44.1 acres of upland restoration and 57.9 acres of upland preservation.

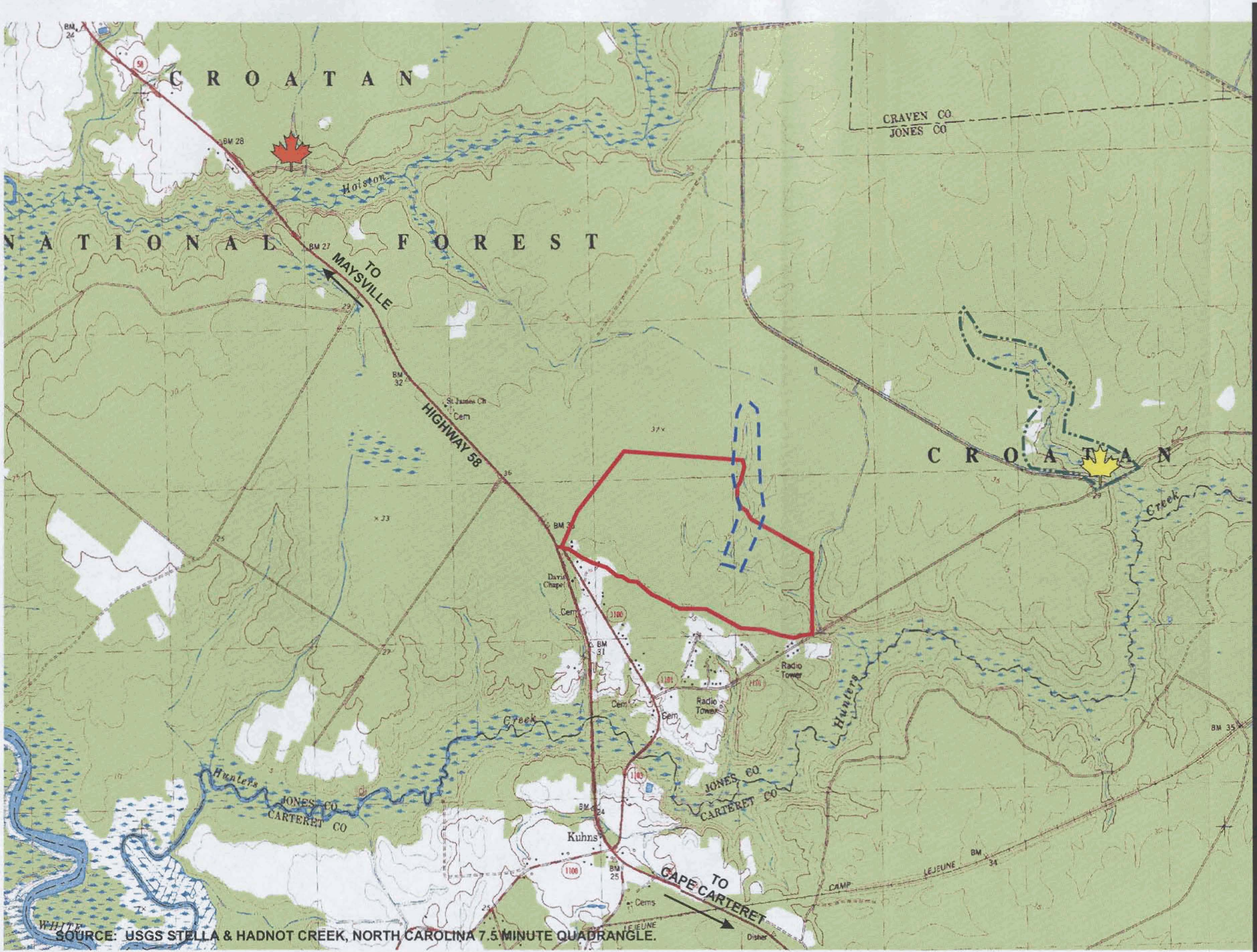
Stream restoration at the Site will be accomplished utilizing Priority 1 methodologies, which calls for re-establishing the stream at an elevation which is compatible with the abandoned floodplain. The stream mitigation plan will allow approximately 65 acres of floodplain to be re-established on-site by decreasing the width and depth of Billy's Branch and increasing the sinuosity (decreasing the slope) of the stream. Hydraulic analysis indicates that there should be no adverse affect of this stream restoration on downstream properties.

3.0 INTRODUCTION

The NCDOT first became aware of Clayhill Farms in early 1997 when the property was identified during the L&M "*Highway 24 Wetland Mitigation Site Search*" (NCDOT Consulting Project Number 96-LM-06, State Project Number 6.169001T). After determining that the owners of Clayhill Farms were willing to negotiate sale of the property to the NCDOT, L&M performed a *Wetland Mitigation Site Feasibility Study* of the property in the fall of 1997 (96-LM-11, State Project Number 6.169001T). The NCDOT purchased the property in the summer of 1998. The following report describes the Site in detail and proposes methods for restoring and preserving the natural communities there to provide compensatory mitigation for wetland and stream impacts associated with future road construction projects in the region.

4.0 EXISTING AND HISTORIC CONDITIONS

The Site (NCDOT Site No. WOKCU0219022, L&M Site Nos. JO-6 and JO-7) includes two adjacent parcels of land totaling 355.6 acres (Jones County Tax Parcels 5369-20-8859-00 and 5369-40-3101-00). The Site is located in southwestern Jones County, North Carolina on the Hadnot Creek, NC and Stella, NC 7.5" U.S.G.S. Topographic Quadrangles (Figure 1, Vicinity Map). It is bordered to the north, east and west by the Croatan National Forest and to the south and east by various forested and residential parcels. It is bisected by Billy's Branch, a tributary to Hunters Creek.



SOURCE: USGS STELLA & HADNOT CREEK, NORTH CAROLINA 7.5 MINUTE QUADRANGLE.

Clayhill Farms
Wetland & Stream Mitigation
Plan Report

Figure 1
Vicinity Map

Legend

- ━━ Subject Property
- – – – On-site Reference Reach
- –··–··– Off-site Reference Reach
- 🍁 Vegetation Reference Area 1
- 🍁 Vegetation Reference Area 2

NORTH

1"=2000'

0 2000 4000

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4.1 Physiography

The Site is located in the Atlantic Coastal Plain physiographic province of North Carolina. This area is comprised of sediments that were deposited during transgressive-regressive cycles caused by past worldwide sea level fluctuations. In part, these fluctuations were the result of the expansion and recession of glacial ice caps. During interglacial periods, relatively high sea levels allowed for deposition of marine and shoreline sediments. Conversely, during glaciation, the falling sea level caused regression and eventual down cutting by streams and rivers (Soller and Mills 1991).

Based upon the *Geologic Map of North Carolina* (NCGS, 1985), the surficial sediments found on the Site are typical of the Duplin Formation. The Duplin Formation consists of bluish gray, shelly, medium-to coarse-grained sand, sandy marl, and limestone. In cross-section, the Site and vicinity are characterized by relatively flat lying sediments that gently fall to the southeast. Elevations on the Site range from approximately 20 to 36 feet above sea level (Figure 2).

4.2 Land Use History

The Site was logged in the early 1970s and portions of it were converted to agriculture. At that time, perimeter ditches and farm drainage ditches were excavated and Billy's Branch was channelized. Parallel drainage ditches in the western (poorly drained) farm fields were excavated 250 to 450 feet apart. Drainage ditches in the well drained eastern half of the property were placed at the bottom of topographic gradients within former drainage swales and stream channels. These ditches range from 600 to 1,700 feet apart.

The approximately 141.8 acres of the Site put into agricultural production in the 1970s were continuously farmed by Mr. Earl Jones and his family until the sale of the property to the NCDOT in 1998. The 213.8 acres of the property that are presently forested contain a mosaic of disturbed and natural communities. Of these 213.8 acres, approximately 19.0 acres remain relatively undisturbed hardwood dominated forest. The remaining 194.8 acres appears to have been clearcut in the 1970s and allowed to regenerate naturally into a mixed community of loblolly pine *(Pinus taeda)* and pond pine *(Pinus serotina)*. Approximately 44 acres of pine forest on the western half of the property have been thinned in the past five years; the remaining forest has not been cut. Approximately 11.7 acres of forest were again clear-cut in early 1998 and have not been replanted.

4.3 Soils

4.3.1 General Soil Boundaries

On February 1 through 3, 1999, L&M supervised the completion of 20 soil borings throughout the Site in order to describe the Site soils/sediments and to facilitate aquifer permeability tests (Bouwer 1989). The soil borings were installed with an all terrain vehicle mounted drill rig. The borings were performed using a 4.25-inch (inside diameter) hollow stem auger and continuous split spoon sampling from the surface to approximately 15 feet below ground surface (bgs).

The *Soil Survey of Jones County, North Carolina* (USDA 1981) identifies five soil types within the Site, all of which are mineral soils. Soils samples were analyzed in the field for texture and color and

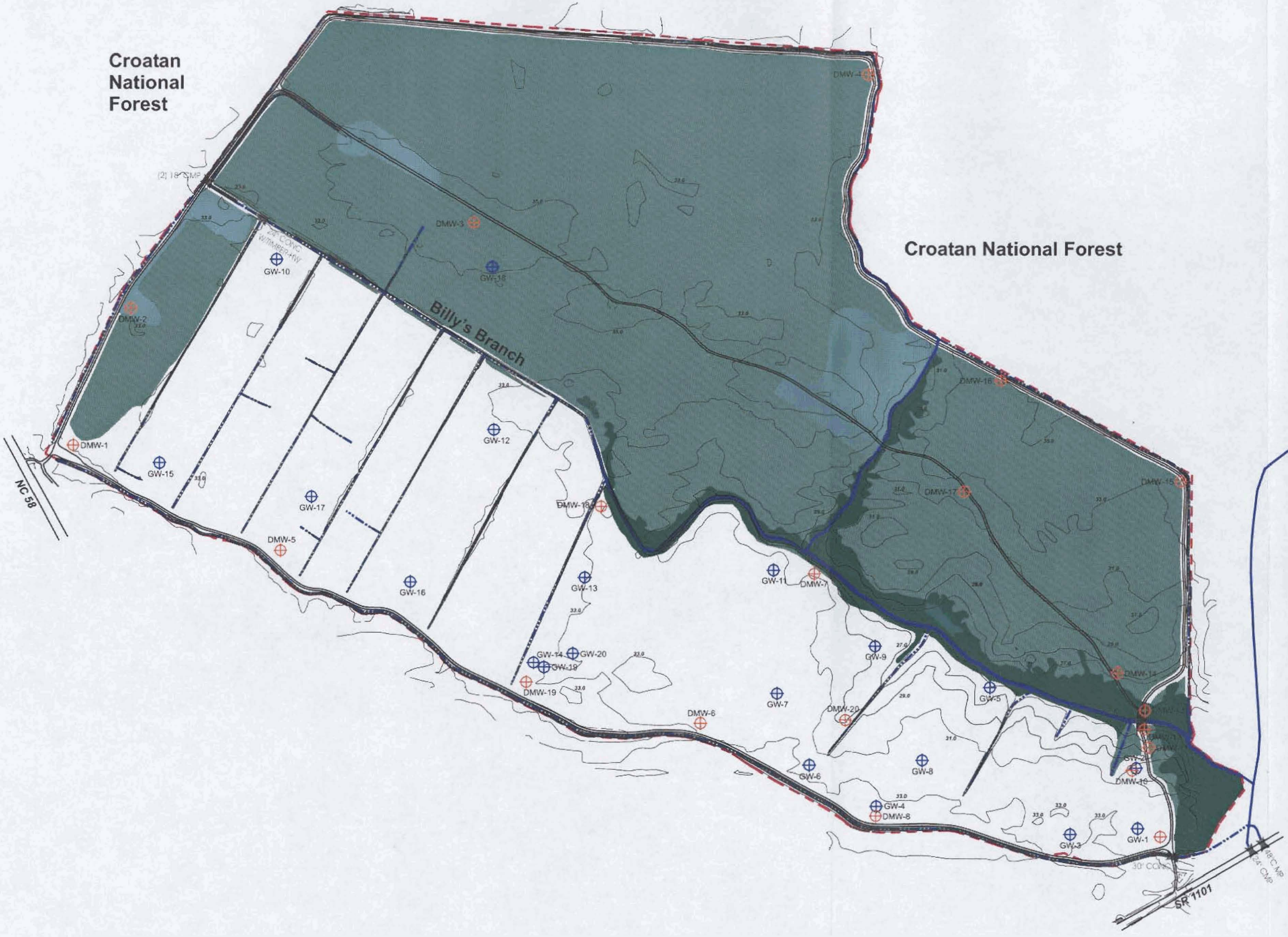

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Figure 2
General Site Map

Legend

- Property Boundary
- Centerline of Stream
- Manmade Ditch
- Road
- Culvert
- Pine Dominated Forest
- Recently Clearcut Forest
- Hardwood Dominated Forest
- ⊕ Groundwater Monitoring Well
- ⊕ DRAINMOD Well

NORTH

1"=500'

0 500 1000

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were found to be as generally described in the soil survey. (Detailed soil boring logs are included as Appendix A). As was expected, however, the soil series boundaries depicted in the soil survey are general, and the actual soil series boundaries were found to vary some from those published. General soil boundaries and boring locations (indicated by the presence of DRAINMOD wells) are depicted on Figure 3. Figure 3 also illustrates where soils sampled for borings differed from soil survey mapping (USDA 1981).

The five soils confirmed to occur at the Site are listed and described as follows (in decreasing order of coverage):

1. **Onslow fine sandy loam (On)** - Spodic Paleudult: A nearly level, moderately well drained soil in interstream areas near drainageways. Typically, the surface layer is dark gray fine sandy loam 9 inches thick. The subsurface layer is pale brown loamy fine sand 6 inches thick. It has an intermittent thin hardpan. The subsoil is 61 inches thick. It is light olive brown and pale brown sandy clay loam in the upper part and gray and light brownish gray sandy loam in the lower part. The underlying material to a depth of 80 inches is light brownish gray sandy clay loam. The seasonal high water table is at a depth of 1.5 to 3.0 feet. It is not listed as a hydric soil in the 3rd Edition of *Hydric Soils of the United States* (USDA 1981, USDA 1991).

2. **Torhunta fine sandy loam (To)** - Typic Humaquept: A nearly level, very poorly drained soil in broad interstream areas and in depressions near shallow drainageways. Typically, the surface layer is fine sandy loam 15 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is 32 inches thick. It is dark gray fine sandy loam in the upper part and grayish brown sandy loam in the lower part. The underlying material to a depth of 72 inches is light brownish gray stratified loamy sand, sandy loam, and sand. The seasonal high water table is at a depth of 0.5 to 1.5 feet from December to May. It is listed as a hydric soil (USDA 1981, USDA 1991).

3. **Pantego loam (Pn)** - Umbric Paleaquult: A nearly level, very poorly drained soil on broad, smooth flats in interstream areas. Typically, the surface layer is black and very dark gray loam 15 inches thick. The subsoil is 53 inches thick. It is grayish brown sandy clay loam in the upper and middle parts and gray sandy clay loam in the lower part. The underlying material to a depth of 80 inches is greenish gray sandy clay loam. The seasonal high water table is at the surface or to a depth of 1.5 feet from December to May. It is listed as a hydric soil (USDA 1981, USDA 1991).

4. **Marvyn loamy sand, 6 to 15 percent slopes (MaC)** - Typic Hapludult: A well drained soil on side slopes near major drainageways. Typically, the surface layer is dark grayish brown loamy sand three inches thick. The subsurface layer is light yellowish brown loamy sand 14 inches thick. The subsoil is strong brown sandy clay loam 31 inches thick. The underlying material to a depth of 70 inches is reddish yellow sandy loam and yellow loamy sand. The seasonal high water table is below a depth of about 6 feet. It is not listed as a hydric soil (USDA 1981, USDA 1991).

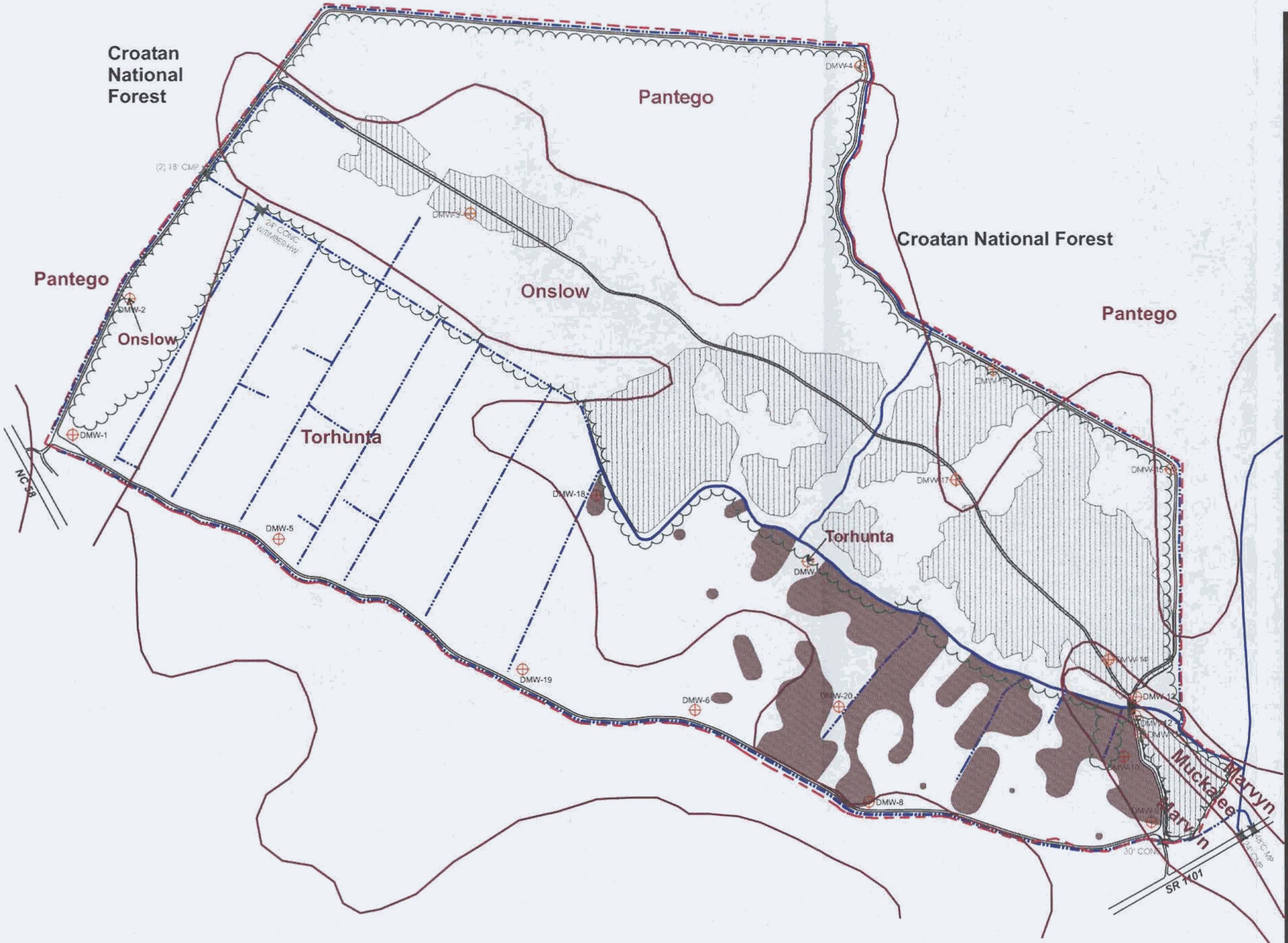

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Figure 3
Soils Map

Legend

- --- Property Boundary
- — Centerline of Stream
- -··- Manmade Ditch
- ═ Road
- ✖ Culvert
- ⊕ DRAINMOD Well (Soil Boring)
- — General Soil Type Boundaries (From Soil Survey)
- ■ Non-Hydric Soils Approximated from Sampling
- ▥ Non-Hydric Soils Approximated from Wetland Delineation
- ⌒⌒ Forested Area

NORTH

1"=500'

0 500 1000

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5. **Muckalee loam (Mk)** - Typic Haplaquod: A nearly level, poorly drained soil in drainageways. Typically, the surface layer is dark grayish brown loam and dark gray sandy loam 24 inches thick. The underlying material to a depth of 65 inches is mottled gray and grayish brown sand and greenish gray loamy sand. The seasonal high water table is at depth of 0.5 to 1.5 feet. It is listed as a hydric soil (USDA 1981, USDA 1991).

4.3.2 Hydric Soil Boundaries

The USDA Natural Resources Conservation Service (NRCS) performed a Prior-Converted (PC) Cropland Determination of the Site on July 19, 1990 (Appendix B). The fields have been in continuous cultivation from the mid-1970s to 1998. All of the fields mapped as containing significant amounts of Torhunta or Pantego were determined to be PC fields; the others were not. Sampling performed during the feasibility study of this property (L&M 1998) revealed that much of the area mapped as Onslow soil, and therefore considered to be non-hydric soil, was actually hydric soil.

In order to determine the location of hydric and non-hydric soils in the eastern farm fields more accurately, soil samples were taken on a 100-foot grid with a two-inch diameter Dutch-style auger to a depth of 24 inches and located by survey using a GPS-. If the soil sample collected met any one of the NRCS field indicators of hydric soils (USDA 1995), that sample was recorded as hydric. Of the 272 samples collected, only 34.1 percent (93) were determined to be non-hydric. Based on these samples, non-hydric soils within the farm fields were approximated as shown on Figure 3. Approximately 120.5 acres of the farm fields are on hydric soil and 21.3 acres are on non-hydric soil.

4.4 Groundwater Hydrology

4.4.1 DRAINMOD Groundwater Monitoring Wells

Subsequent to the soil boring activities, each boring was converted into a groundwater monitoring well for use in DRAINMOD (denoted as DMW on the figures). The wells were constructed with two-inch polyvinyl chloride (PVC) slotted casing from 14 feet bgs to 1.5 feet bgs. Attached to the slotted well casing was a solid section of pipe (riser) from 1.5 feet bgs to approximate 2.5 feet aboveground surface. The annular space was filled with filter sand from 15 feet bgs to 0.5 feet bgs and then the balance was completed with bentonite pellets to the surface (See boring logs for well construction details, Appendix A).

The wells were allowed to equilibrate for a period of approximately one-week before they were gauged with an electronic meter on February 17 and 18, 1999. Measurements were recorded to the nearest 0.01 foot and are listed in Table 1. Groundwater elevations ranged from 34.37 feet mean sea level (msl) to 19.41 feet msl. These water table elevations were extrapolated to produce the groundwater flow map included as Figure 4. As depicted on the map, groundwater at the Site is generally directed toward Billy's Branch and somewhat mimics the topography of the Site.

4.4.2 Remote Shallow Groundwater Monitoring Wells

Remote shallow groundwater monitoring wells were also installed on the Site to take continuous readings of the groundwater table (denoted as GW on figures). These wells are manufactured and sold by Remote Data Systems, Inc. and extend 20 inches below the soil surface. The wells are programmed

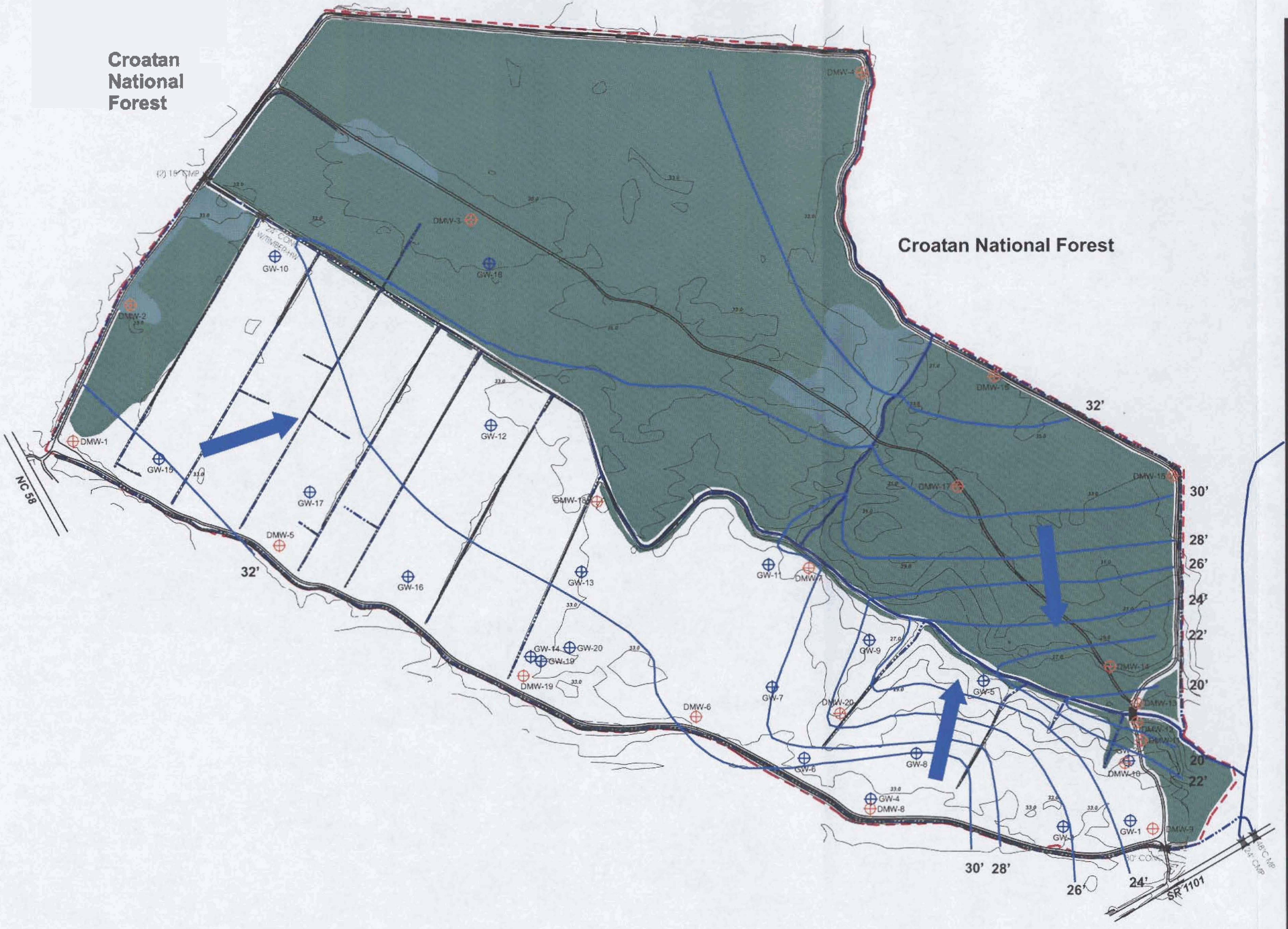

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Figure 4
Groundwater Flow Map

Legend

- Property Boundary
- Centerline of Stream
- Manmade Ditch
- Road
- Culvert
- Forested Area
- Recently Clearcut Area
- ⊕ Groundwater Monitoring Well
- ⊕ DRAINMOD Well
- Groundwater Contour (in feet)
- ➡ Groundwater Flow Direction

NORTH

1"=500'

0 500 1000

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Table 1. DRAINMOD monitoring well water table measurements (February 11, 1999).

Soil Type	Well Number	Depth to Water Table from Ground Surface (inches)
Onslow	DMW-2	19.20
	DMW-3	17.76
	DMW-18	41.76
	DMW-20	38.04
Torhunta	DMW-5	26.50
	DMW-6	34.32
	DMW-7	26.76
	DMW-8	3.24
	DMW-19	20.40
Pantego	DMW-1	17.52
	DMW-4	18.48
	DMW-15	35.76
	DMW-16	23.52
	DMW-17	18.12
Marvyn	DMW-9	104.52
	DMW-10	100.80
	DMW-11	76.56
	DMW-13	24.24
	DMW-14	46.68
Muckalee	DMW-12	44.88

to read the groundwater table once a day. The wells are downloaded once a month but can store data for over a year, as long as the batteries do not run down.

The wells were installed prior to the beginning of the growing season and all but two (GW 17 and 18) have functioned properly since the beginning of the growing season. As would be expected in a poorly drained soil which has been ditched, the water table is erratic. It drops below 12 inches bgs and remains there until a rain event. Following the rain event, the groundwater table recharges, often to the surface, and remains above 12 inches for 7 to 10 days before falling below 12 inches again. At no well has the groundwater table remained within 12 inches of the soil surface for five percent or more of the growing season. As such, none of these sites met the wetland hydrology criterion as detailed in the *Corps of Engineers Wetland Delineation Manual* (EL 1987). Neither well in the Marvyn soil has recorded a water level less than 20 inches from the surface any day since the wells were installed (prior to the beginning of the growing season) on February 19, 1999.

It should be noted that while rainfall was average for the three months, 6 months, and 12 months preceding the growing season (within 25 percent of mean precipitation), rainfall during the first two months of the growing season was abnormally low (68 percent of normal in March 1999 and 55 percent of normal in April 1999).

4.4.3 DRAINMOD

DRAINMOD (version 4.0/5.0, June 1994) is a Fortran based computer model that simulates the performance of drainage, sub-irrigation, and controlled drainage systems. The model was developed at North Carolina State University in the Department of Biological and Agricultural Engineering for application to agricultural drainage and water table management systems (Skaggs 1980). The basic assumptions/requirements for DRAINMOD are (1) the modeled areas are field-sized units with parallel ditches, (2) the region has a humid climate, and (3) the area has a shallow, unconfined aquifer.

DRAINMOD was adapted to wetland studies by including a subroutine calculation that accounts for the wetland hydrology (i.e., the number of consecutive days the water table is less than 12 inches from the ground surface during the growing season). For the purposes of this plan, DRAINMOD was used in the "wetland hydrology mode" in order to:

1. Simulate the existing site drainage to determine the areas effectively drained by present ditching (i.e., the areas not meeting the criteria for wetland hydrology), and
2. Simulate the predicted number of years each field would meet the criteria for wetland hydrology in pre- and post-restoration conditions.

In order to run DRAINMOD, the following previously published information was obtained:

1. 40 years (1951 to 1990) of hourly rainfall data and daily high and low temperature data from New Bern, N.C.,
2. Soil input characteristics as computed by DMSOIL for each soil type (Baumer and Rice 1988): soil-water characteristic curve, volume drained, infiltration/Green-Ampt parameter, and upward flux,
3. Dates of the local growing season (March 15 to November 11),
4. Wetland hydrology criteria (groundwater within 12 inches of the ground surface for 31 consecutive days 20 out of 40 years (12.5 percent of the growing season (EL 1987), and
5. Potential evapotranspiration (PET) factors.

In addition to the above data, L&M collected the following field data for each soil type:

1. Ditch size parameters,
2. Soil horizons and textures (Appendix A),
3. Static water table depths,
4. Average soil hydraulic conductivities (taken as an average over the entire screened section of well casing) (Appendix C-1), and
5. Average surface storage capacity (Appendix C-2).

Wetland hydrology for the site was simulated with DRAINMOD by uniquely modeling each of the five soil types with the present ditch system. DRAINMOD was used in the single ditch mode because of the high variability in ditch depths and widths. In running the program for a single ditch, the software assumes a second equally configured ditch is located parallel to the inputted ditch and that the two ditches are acting as a system. This simulation appeared to produce relatively accurate results when compared with the present site conditions. This is discussed in further detail in Section 5.1.1. Ditch

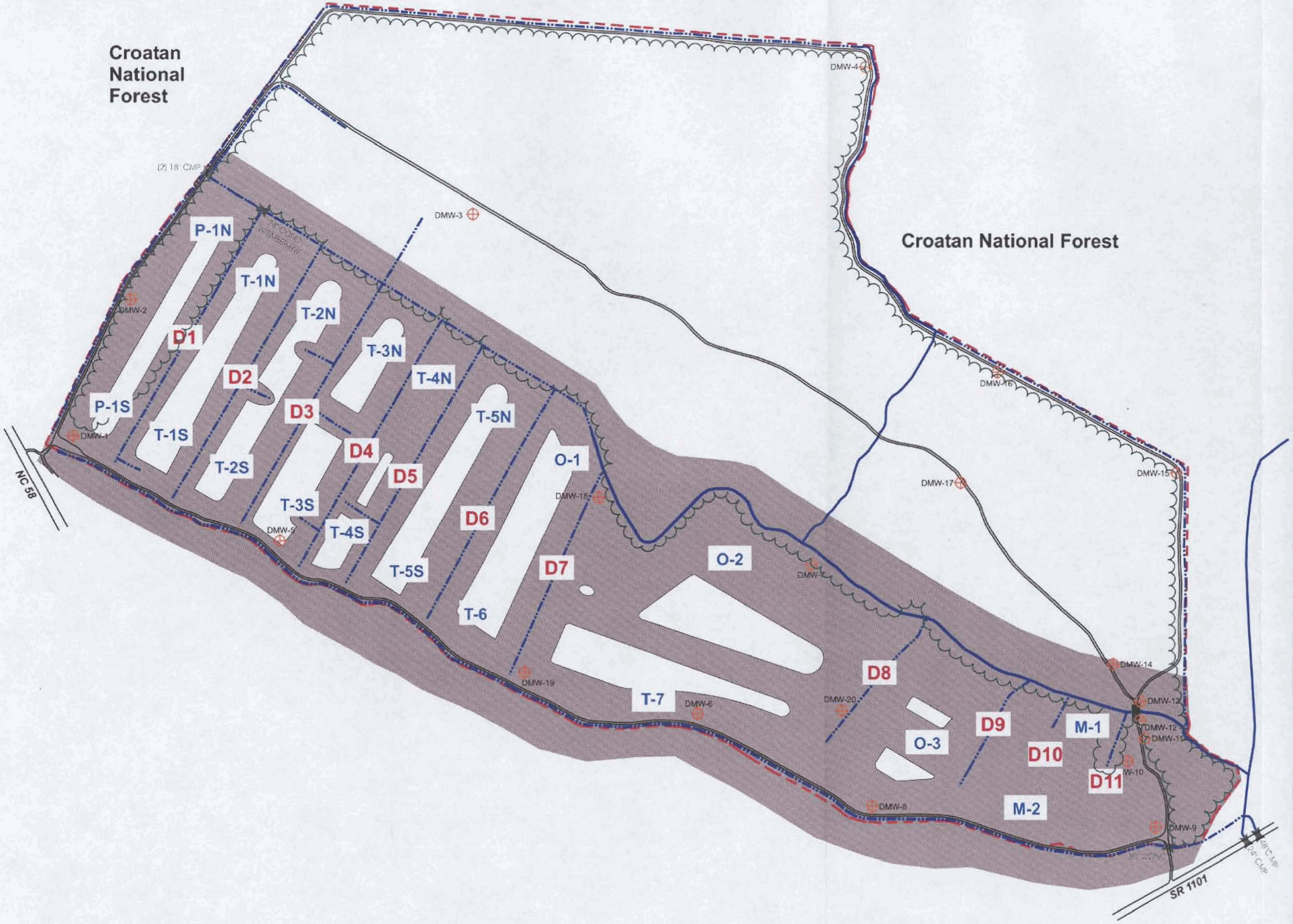

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Figure 5
DRAINMOD
Existing Conditions

Legend

– – –	Property Boundary
──	Centerline of Stream
-··-··-	Manmade Ditch
══	Road
✖	Culvert
⊕	DRAINMOD Well
▨	Effectively Drained Areas (per DRAINMOD)
D1	Ditch Numbers
O-1	Field Numbers
⌒⌒⌒	Forested Area

NORTH

1"=500'

0 500 1000

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spacing was manipulated to determine the current radii of influence of the field ditches (Appendix C-3).

The existing Site conditions modeling shows that ditches currently "effectively drain" portions of the agricultural fields at distances ranging from 43 feet to 312 feet for a total of 107.3 acres (Figure 5). The "effectively drained" areas are dependent upon numerous factors including the soil type, ditch size, topographic relief of the field, and hydraulic conductivity. Effectively drained means that saturation does not occur within 12 inches of the ground surface for 31 consecutive days or longer.

4.5 Surface Water Hydrology

4.5.1 Benthic Macroinvertebrate and Fisheries Resources

Benthic macroinvertebrate and fish samples were collected by NCDOT staff from two locations within the Site and at one location within the off-site reference reach shown on Figure 1 on April 2002. Results of these samplings are included as Appendix D.

4.5.2 Development of Hydraulic Geometry Relationships

Prior to initiating an on-site hydraulic analysis of Billy's Branch, research was conducted to determine whether a regional curve for hydraulic geometry existed for the Upper Coastal Plain of North Carolina. Use of hydraulic geometry relationships is central to fluvial geomorphological restoration techniques developed by Luna Leopold (1994) and Dave Rosgen (1996) and recommended for use in the state of North Carolina by the North Carolina Wildlife Resources Commission (WRC 1998). Regional curves provide a relationship between various streams in a region by correlating drainage area size to bankfull discharge rates, cross-sectional area, width, and mean depth. Conversations with the Natural Resources Conservation Service (NRCS) confirmed that no regional curve existed for the Upper Coastal Plain of North Carolina.

L&M began procedures necessary to develop regional curves. The *Water Resources Data, North Carolina, Water Year 1997* (USGS 1998), was reviewed to identify river gage stations throughout the Upper Coastal Plain Region proximate to the Site. A total of 10 sites were identified for review of detailed data (expanded rating tables, summary of discharge measurement data (Form 9-207) obtained from the United State Geological Survey (USGS) in Raleigh. After a review of data and discussions with representatives of the USGS, eight of the 10 sites were dropped for the following reasons: too deep to be sampled using chest waders (five), shifting bed and thus changing rating curve (one), gage data only available for three years (one) and high levels of fecal coliform due to proximity of hog farm (one).

The remaining two sites were used to develop hydraulic geometry data and included: Contentnea Creek (Neuse River, gage station 02090380) and Mocosin Run (Neuse River gage station 0209096970). While regional curves become more accurate with data from numerous gage stations, data from these two reference sites were deemed sufficient for geometry relationships because the similarity in drainage area and land use characteristics to the restoration reach (Billy's Branch).

4.5.3 Geomorphological Description of the Reference Reaches

Reference reaches are utilized to describe the plan, profile, and cross-sectional attributes of a stable stream channel that is of the same stream type as that proposed at a restoration site. Knowing the dimensions, the bankfull discharge of the reference reach allows for the design of a stable stream at the proposed Site

The primary reference reach selected for this study is an unnamed tributary to Hunters Creek, a tributary of the White Oak River (Figure 1). It is the characteristics of the primary reference reach that were used to develop the restoration parameters for Billy's Branch. A secondary reference reach, located within the Site, is discussed separately and was utilized to further validate the most probable stream type of Billy's Branch prior to disturbance.

Primary Reference Reach

The primary reference reach is located within the Croatan National Forest, in Jones County, approximately 1.4 miles northeast of the Site. As with Billy's Branch, it drains to the White Oak River. The reference reach is located in Valley Type X (Rosgen 1996). These valleys are very wide with low relief typical of coastal plains, broad lacustrine and/or alluvial flats. The reference reach is located in 0.7 square mile watershed. The entire watershed is forested and contains a relatively mature forested wetland within the floodplain.

Based upon the hydraulic analysis generated from the gage station, Hunters Creek is projected to have bankfull discharge of 42 cubic feet per second (cfs), a bankfull cross-sectional area of 17 square feet, a bankfull width of 16 feet, and a bankfull average depth of 1.5 feet. Measurements of bankfull characteristics on-site compared favorably with a bankfull discharge of 40 cfs, a bankfull cross-sectional area of 14 square feet, a bankfull width of 17 feet, and a bankfull average depth of 0.81 feet. Typically cross-sectional area will have the best correlation with the values from the regional curves since it is an integration of width and depth (Dave Rosgen, personal communication). Typically average depth will be the least comparable to the data from reference data. The reference reach dimensions are also believed to be slightly less than those of the on-site reach because of agrarian and suburban land uses.

A complete Level II morphological description was performed on the reference reach. The morphological assessment included cross-sections, longitudinal profile, plan form geometry analysis, and channel material inventory. A summary of these findings and illustration of the channel's typical riffle cross-section are illustrated in Figure 6. The reach was classified as a C6 stream, characterized by a very high width/depth ratio (21) and channel substrates including sand, silt, and clay. Bank materials were identical to channel materials. Hunters Creek had a broad floodplain (entrenchment ratio of 16.4), a relatively low water surface slope (0.002 feet/feet), and a moderate sinuosity (1.2 to 1.8).

The characteristics of Hunters Creek were used as a basis to derive channel cross-sections, slope, and geometry for the restoration of Billy's Branch pursuant to the procedures described in *Applied River Morphology* (Rosgen 1996). This procedure was further simplified since the watershed size of Billy's Branch on-site is virtually identical to this reference reach (0.8 and 0.7 square miles, respectively).

Figure 6

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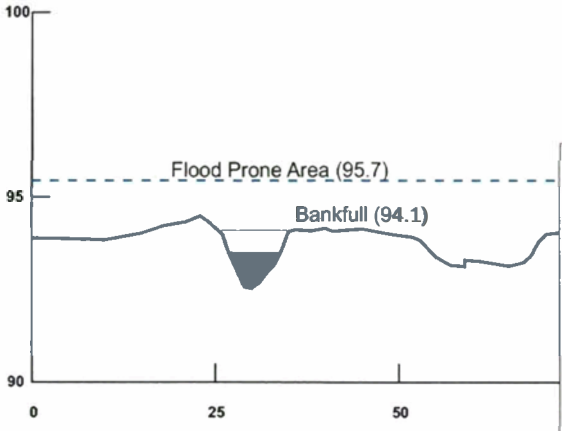
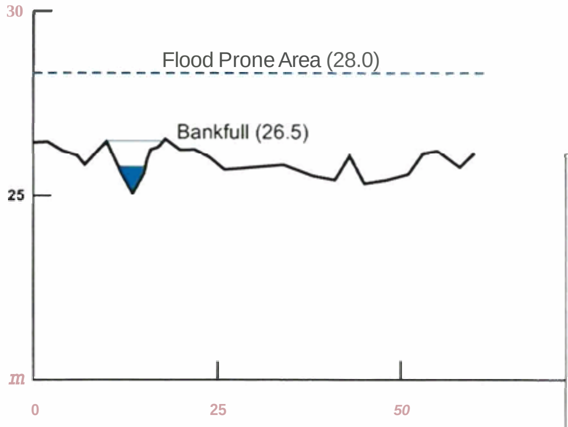
Reference Reach Characteristics



Unnamed Tributary to Hunter's Creek

Stream Characteristics

Stream Type: C6
Bankfull Width (Wbkf): 17'
Mean Depth: 0.8'
Area (Abkf): 14 s.f.
WID Ratio: 21.3'
Maxium Depth: 2.0'
Width Floodplain: 279'
Entrenchment Ratio: 16.4'
Channel Material(D50): <0.062mm
Water Surface Slope: 0.002 ft/ft
Channel Sinuosity: 1.2 -1.8
Meander Length: 107-140' (6-8 Wbkf)
Radius of Curve: 23-34'
Belt Width: 40'
Meander Width Ratio: 2.4
Critical Shear Stress: 0.09 lb/s.f.
Extrains: 6mm particle



Tributary of Billy's Branch

Stream Characteristics

Stream Type: C6
Bankfull Width (Wbkf) 8'
Mean Depth 0 75'
Area (Abkf) 6 s f
WID Ratio. 11 0
Maxium Depth 1 5'
Width Floodplain >60'
Entrenchment Ratio >7 5
Channel Material(D50) 0 62-0 125mm
Water Surface Slope 0 006 ft/ft
Channel Sinuosity 1 04

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SCALE H 1"=25'
V 1"=5'

Secondary Reference Reach

A relatively undisturbed, unnamed tributary to Billy's Branch was identified within the Site. A less complete Level II Assessment was performed on this tributary. The assessed reference reach is located upstream of the head-cut induced by the channelization (i.e., downcutting) of Billy's Branch. The purpose of the abbreviated Level II Assessment was to classify the stream and determine whether it was also a C Type stream. The stream was determined to be a C6 stream as was the primary reference reach (Figure 6). This corroboration of findings further strengthened the conclusion that Billy's Branch was most likely a C6 stream prior to channelization.

4.5.4 Morphological Analysis of Billy's Branch

Billy's Branch and the primary reference reach are located in Valley Type X (Rosgen 1996). Valley Type X is very wide with gentle slopes and extensive flood plains. This valley type includes coastal plains and broad lacustrine (lake) flats, both of which often contain peat bogs and/or extensive wetlands.

The length of Billy's Branch was divided into a total of seven nodes, six on-site and a seventh immediately downstream and off-site. This was done to develop data specific to various reaches of the stream, its watershed, and valley slope (Figure 7). Node points were also intentionally located immediately up stream and downstream of the large meander at the center of the site (nodes 3 and 4). This meander is believed to be a natural response to the valley's characteristics because it was illustrated on the USGS 7.5 minute quadrangle maps (Stella 1988, Hadnot Creek 1984), prior to the Site's conversion to agricultural use. Morphological measurements for nodes 1 through 6 are included in Appendix E.

The slope of the valley varies noticeably from the western half of the site to the eastern half. The slope between nodes 1 and 3 is virtually flat. The slope between node 1 and 2 is zero, with a slope between node 2 and 3 of 0.0009 ft/ft. The slope between node 3, at the top of the large meander, and node 6, at the confluence with the small tributary, is 0.004 ft/ft. It is steepest in the segment immediately below the large meander between nodes 4 and 5 (0.009 ft/ft). The valley is also flat between node 6 (on-site) and node 7 off-site.

As mentioned earlier, Billy's Branch was deepened and straightened in the mid 1970s to facilitate farming. The excavation of the stream also lowered the water table to facilitate the cultivation of commodity crops (see Section 4.4).

Three cross-sections were taken along Billy's Branch to perform a Level II Assessment. These locations roughly correlate with the locations of nodes 4, 5, and 6 (Figure 8). All three of the cross-sections are similar and describe a $G6_c$ stream type (gully). Billy's Branch is narrow (width/depth ratio of five to six) and deep with a low sinuosity (K=1). This stream has been deepened (incised) to such an extent that its entrenchment ratio is very low (typically 1.4). Plotting the floodprone elevation indicated that these Billy's Branch no longer inundates the historic floodplain, relegating these areas as a terrace (abandoned floodplain). This was confirmed from the results of the HEC-2 model. Model results for the existing conditions indicated that the two-year flood is contained within the stream channel (does not exceed the elevations of the top of bank). The results of the HEC-2 model are described in further detail in Section 4.5.5.

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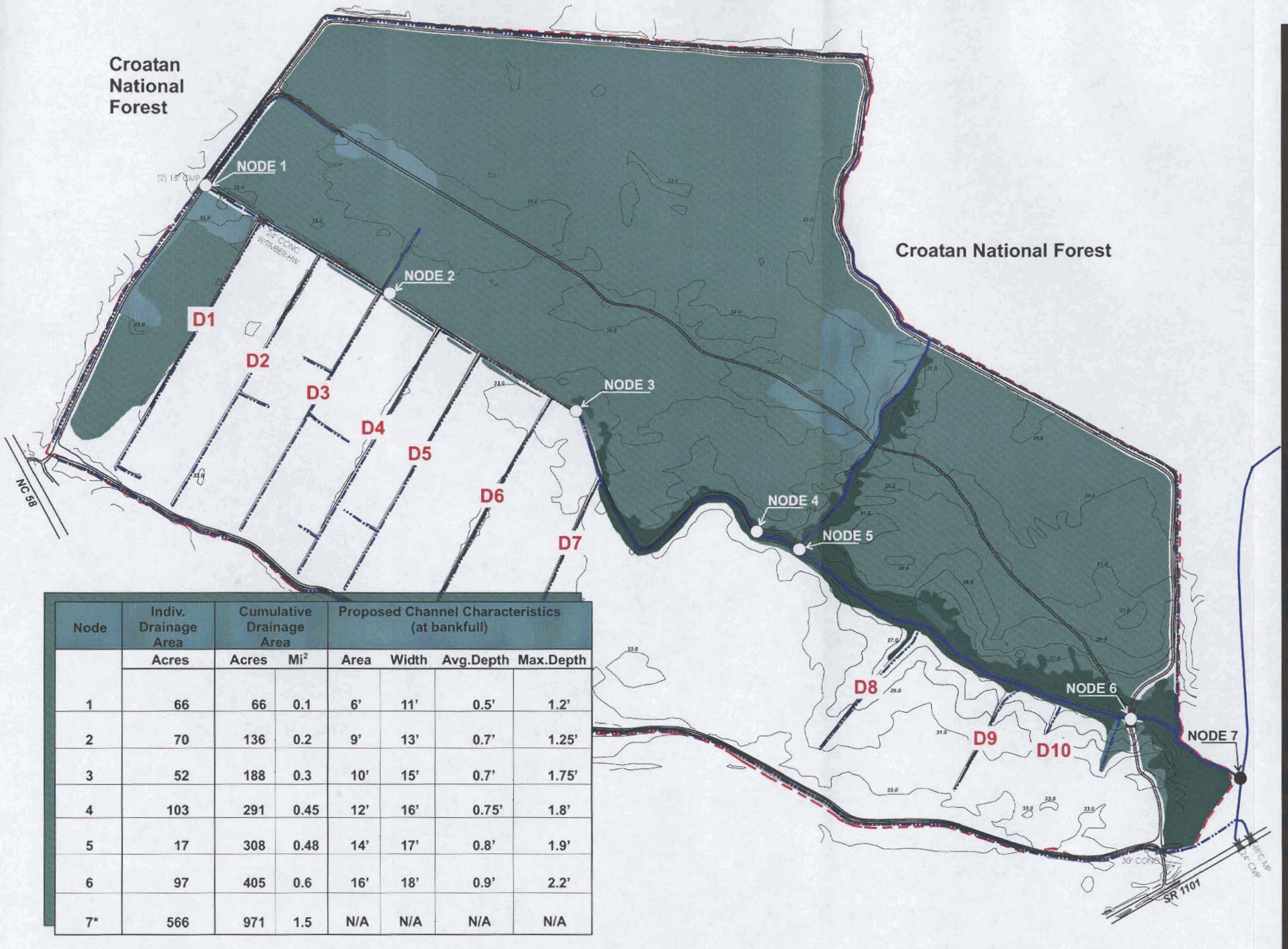
Figure 7
Drainage Areas, Nodes & Proposed Channel Characteristics



Node	Indiv. Drainage Area	Cumulative Drainage Area		Proposed Channel Characteristics (at bankfull)			
	Acres	Acres	Mi^2	Area	Width	Avg.Depth	Max.Depth
1	66	66	0.1	6'	11'	0.5'	1.2'
2	70	136	0.2	9'	13'	0.7'	1.25'
3	52	188	0.3	10'	15'	0.7'	1.75'
4	103	291	0.45	12'	16'	0.75'	1.8'
5	17	308	0.48	14'	17'	0.8'	1.9'
6	97	405	0.6	16'	18'	0.9'	2.2'
7*	566	971	1.5	N/A	N/A	N/A	N/A

** Node 7 is off-site on private property, but was included as a contributing watershed to culverts beneath SR1101*

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Legend

- - - -	Property Boundary
———	Centerline of Stream
-·-··-	Manmade Ditch
═══	Road
✖	Culvert
🟩	Pine Dominated Forest
🟦	Recently Clearcut Forest
■	Hardwood Dominated Forest
D1	Feeder Ditches

NORTH

1"=500'

0 500 1000

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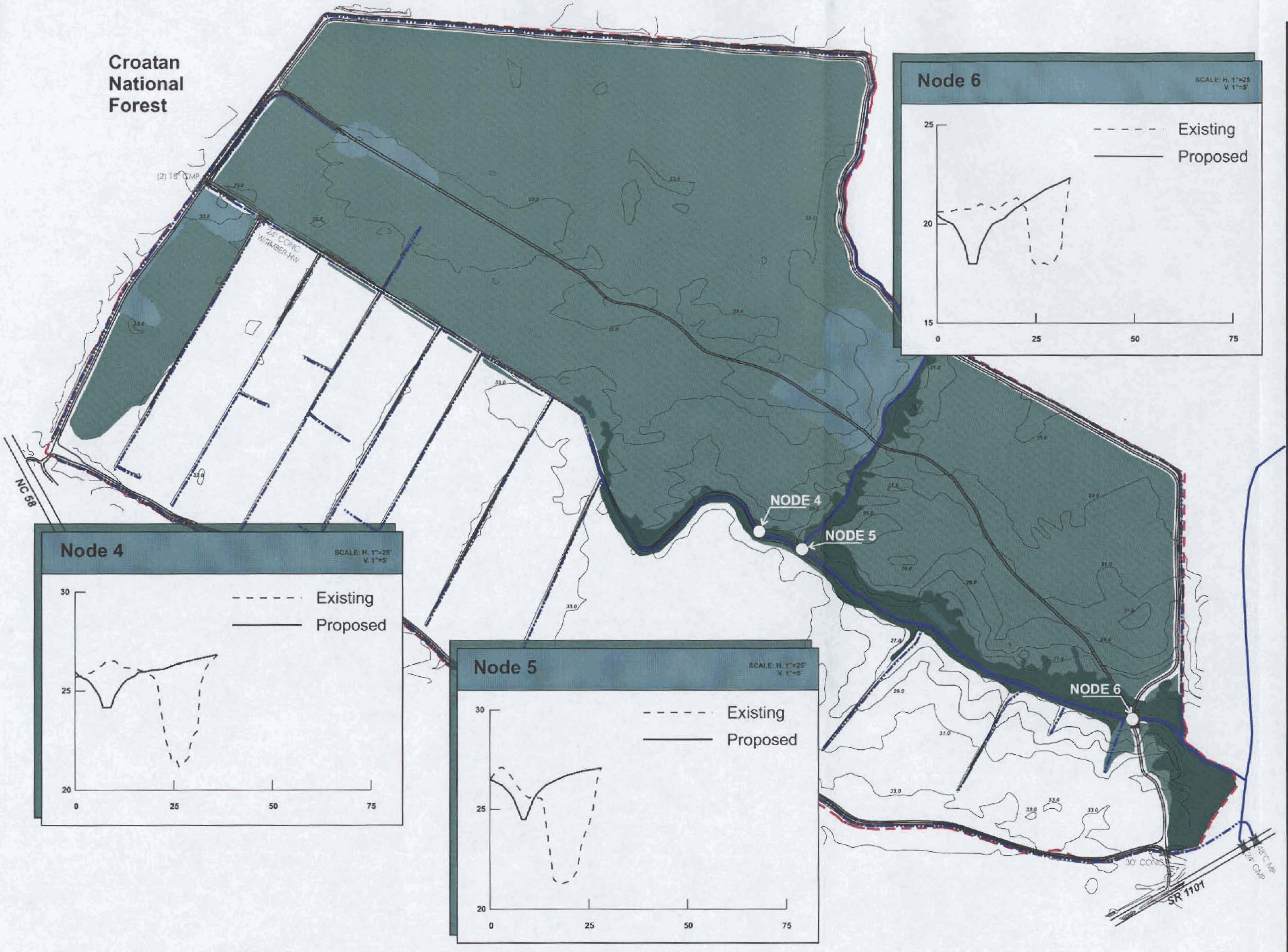

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Figure 8
Existing & Proposed Cross Sections

Legend

- - - - Property Boundary
— Centerline of Stream
-··-··- Manmade Ditch
═ Road
✖ Culvert
▨ Pine Dominated Forest
▨ Recently Clearcut Forest
▨ Hardwood Dominated Forest

NORTH

1"=500'

0 500 1000

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4.5.5 Hydrology and Hydraulics of Billy's Branch and Feeder Ditches

A hydrologic and hydraulic analysis of the proposed wetland and stream mitigation and the adjacent drainage areas was performed to estimate the amount of surface water anticipated on-site during various rainfall events.

Soil Conservation Service TR-55 Method

Soil Conservation Service (SCS) TR-55 methodologies were employed for the hydrologic analysis to estimate the volume of runoff for select rainfall events, and to calculate runoff hydrographs. The design rainfalls of interest include the two-year and ten-year rainfall events of 24-hour duration. The 24-hour rainfall depths used for Jones County, North Carolina are 4.5 inches for the two-year rainfall and 6.72 inches for the ten-year rainfall.

The SCS methodology utilizes the time of concentration and the curve number methods to estimate the volume of runoff anticipated during a rainfall event. The time of concentration for each drainage area was estimated by using the kinematic wave formula for overland flow and estimating the velocity for concentrated flows. Curve numbers were estimated based upon soil types and land use. According to the Soil Survey of the watershed, the majority of the soils within the watershed are Onslow, Torhunta and Pantego. All of these loamy soils are classified as hydrologic soil group (HSG) "D" which indicates soils having very slow infiltration rate when thoroughly wet, and soils that have a permanent high water table.

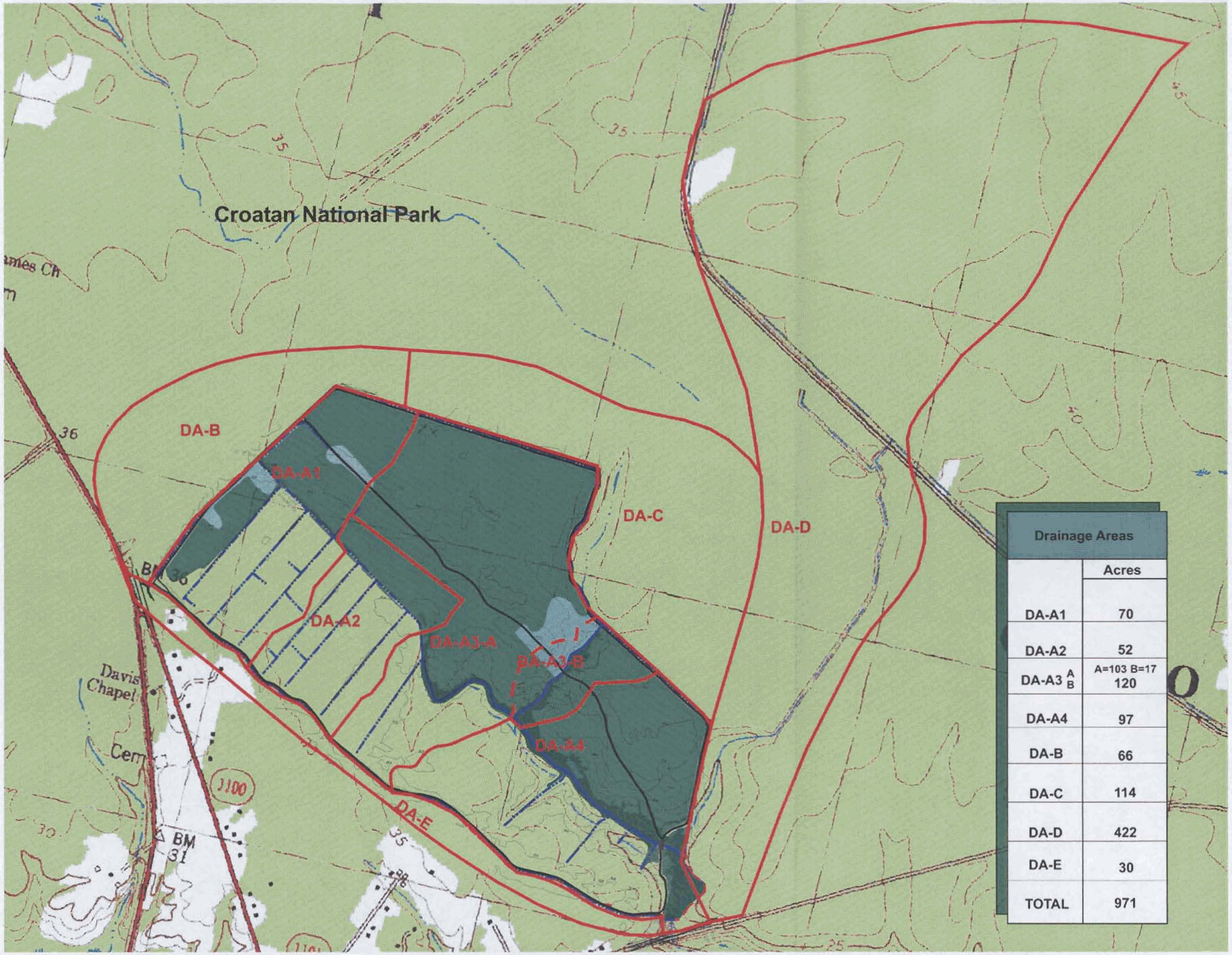
The 971 acre watershed consists mainly of forest and crop land (crop land on-site only). Based upon this land use and the underlying soil conditions, a curve number of 77 was utilized to estimate runoff from the different drainage areas.

The Rational Method

The Rational Method was used for the smaller drainage areas to estimate the volume of runoff anticipated during a rainfall event. The Rational Method utilizes the rainfall intensity, the runoff coefficient and the size of the drainage area to calculate the peak runoff ($Q = CIA$). The rainfall intensity was based on the intensity-duration-frequency tables for Jones County, North Carolina. The runoff coefficient was based upon the type of land use which was predominantly agricultural land for the small drainage areas of the feeder ditches.

The entire watershed drains through a 24-inch and a 48-inch corrugated metal pipe (CMP) that pass under State Road (SR) 1101. A culvert analysis was utilized to estimate the volume of runoff that can pass through these two downstream culverts. These culverts were modeled based upon a no downstream tailwater condition.

The entire 971 acre watershed consists mainly of five drainage areas that are separated by several ditch systems identified as DA (drainage areas) A, B, C, D and E (Figure 9). The drainage area within the Site (DA-A) is approximately 340 acres in size. This drainage area is surrounded on all four sides by drainage ditches. This surrounding ditch system drains south eastward along the north and south of the drainage area and outfalls through the two culverts located under SR 1101. The exterior ditch system establishes the size of the main drainage area, but a network of feeder ditches drains the farm fields to



Drainage Areas	
	Acres
DA-A1	70
DA-A2	52
DA-A3 A B	A=103 B=17 120
DA-A4	97
DA-B	66
DA-C	114
DA-D	422
DA-E	30
TOTAL	971

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Figure 9
Drainage Areas of Billy's Branch

Legend

- Property Boundary
- Centerline of Stream
- Manmade Ditch
- Road
- Culvert
- Pine Dominated Forest
- Recently Clearcut Forest
- Hardwood Dominated Forest

NORTH
1"=1000'
Approximate
0 1000 2000

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Billy's Branch which acts as a collector ditch. Billy's Branch drains southeastward to the two culverts under SR 1101. The remaining four drainage areas are located around all four sides of the Site.

Drainage area "B" is approximately 66 acres in size and is located to the west of the Site. This drainage area drains through Billy's Branch to reach the two outfall culverts.

Drainage area "C" is approximately 114 acres and is located immediately north of the Site property. This area drains southward through the perimeter ditch and into Billy's Branch within the Site immediately downstream of node 6.

Drainage area "D" is approximately 422 acres and located northeast of drainage area "C". This drainage area drains southeastward through a tributary east of the Site. It discharges to Billy's Branch downstream of the Site (off-site) at node 7.

Drainage area "E" is approximately 30 acres and borders the Site to the south. This drainage area drains southeastward through the ditch located along the southern border of the Site and joins with Billy's Branch downstream of the subject property.

Water Surface Profile for Billy's Branch

In order to model the surface water profile of Billy's Branch, the peak flow rates for each individual drainage area had to be calculated along with the total peak flow rate from the watershed. The SCS methodology was used to estimate the peak flow rates for both the two-year and ten-year rainfall event and to estimate the time of concentration for the individual drainage areas. The peak time of concentration of 3.5 hours from drainage area "D" was then used to estimate the peak flow rate for the watershed. The SCS method has a time of concentration (T_c) limit of two hours. In order to represent the hydrograph for the 3.5 hour time of concentration, a modified hydrograph was produced based on the ratio of the peak runoff rates from the T_c of 2.0 hours and the T_c of 3.5 hours. The peak runoff rate of 323 cfs was used for the two-year rainfall event and 614 cfs was used for the ten-year rainfall event. Table 2 below shows the time of concentration and the peak runoff rates for each individual drainage area.

Table 2. Peak flow rates of each drainage area.

Drainage Area	Size of Drainage Area (acres)	Time of Concentration (hours)	Peak Runoff 2-Year Storm (cfs)	Peak Runoff 10-Year Storm (cfs)
A-1	70	1.87	35	67
A-2	52	2.14	57	110
A-3	120	2.38	105	201
A-4	97	2.64	138	264
B	66	1.54	38	73
C	114	1.79	59	113
D	422	3.56	142	270
E	30	2.11	14	27
Peak Runoff Rate Criteria	**971**	**3.56**	**323**	**614**

The two downstream outfall culverts (24-inch CMP and 48-inch CMP) were analyzed to see if they could convey the peak flow rates from the watershed's two-year and ten-year rainfall events. The culvert analysis showed that the peak flow rates will exceed the capacity of the combined two culverts and the stormwater runoff ponds behind the two existing outfall culverts.

The existing culvert condition was therefore modeled as a pond with the two culverts acting as the controlling outfall structures. The top elevation of SR 1101 at the location of the culverts was used as the maximum pond elevation. The model of the pond routing estimated a storage elevation of 22.7 feet for the two-year rainfall event. The estimate for the ten-year rainfall event was a storage elevation that exceeds the elevation of SR 110l.

A telephone conversation with the Regional North Carolina Maintenance Division and the Regional Highway Maintenance Engineer revealed that the Maintenance Division has not received a complaint of stormwater runoff overtopping SR 1101 at the location of these two culverts. Furthermore, the Maintenance Division has not had to perform any repairs at this location for as far back as the Maintenance Division representatives could remember.

Based on the information provided by the Regional Maintenance Division and the Regional Highway Maintenance Engineer, it was decided that the estimated peak flow rates for the ten-year rainfall event were too conservative. The estimated peak flow rates for the two-year rainfall event were therefore believed to be more realistic. The road elevation of SR 1101 is approximately 24.0 feet to 24.5 feet which is approximately 1.3 to 1.8 feet higher then the estimated two-year peak storage elevation 22.7 feet.

HEC-2 Analysis

The surface water profile of Billy's Branch was modeled using the HEC-2 program to analyze the existing and proposed peak flow depths within Billy's Branch and the amount of flooding outside of Billy's Branch as a consequence of modifying the ditch and longitudinal profiles. The model is based on several cross sections (nodes) located along Billy's Branch and the correlating peak stormwater runoff rates at those sections (Figure 9). The HEC-2 calculations and output is provided in Appendix F. As a means of being conservative, the peak runoff rate for each cross section (node) is based on the time of concentration for each smaller drainage area. The peak storage elevation of 22.7 feet (estimated from the pond routing model) was used to establish the tailwater elevation at the downstream end of Billy's Branch. Table 3 shows the estimated water surface elevations at the modeled cross sections (node) and their corresponding top of bank.

Table 3. Existing surface water profile of Billy's Branch.

Node #	Peak Stormwater Runoff (cfs)	Water Surface Elevation (ft)
7	323	22.70
6	176	22.69
5	148	24.57
4	143	24.49
3	95	31.81
2	73	32.71
1	38	32.94

4.6 Plant Communities

Approximately 213.8 acres of Clayhill Farms are presently forested, 11.7 acres have been recently clearcut, and 141.8 acres are fallow agricultural fields. As mentioned earlier, the Site was ditched and subsequently logged in the 1970s. Fire has been excluded from the property for at least the last 30 years, and was farmed continuously until 1998. The result of these manipulations has been that natural communities presently occur on only small, fragmented patches of the property. A list of all plant species identified during field investigations at the Site is included in Appendix G.

4.6.1 Pine Dominated Communities

Approximately 193.8 acres of the Site is 25 to 30 year old pine regeneration (Figure 2). Approximately 44.1 acres of this community (primarily in that area south of the dirt road bisecting the forest and west of the tributary to Billy's Branch) has been thinned in the past five years. The thinned area contains an overstory of loblolly pine and pond pine in the six-inch diameter class. The un-thinned area contains primarily loblolly pine in the four-inch diameter class.

Common understory trees include sweetgum *(Liquidambar styraciflua)*, swamp blackgum *(Nyssa sylvatica* var. *biflora)*, titi *(Cyrilla racemiflora)*, sweet bay *(Magnolia virginiana)*, red bay *(Persea borbonia)*, laurel oak *(Quercus laurifolia)*, and red maple *(Acer rubrum)*. Post oak *(Quercus stellata)* and blackjack oak *(Quercus marilandica)* are present on the drier portions of the Site. The shrub layer is tall and dense, consisting primarily of inkberry *(Ilex glabra)*. The herbaceous layer is sparse except along openings and in the ecotones between the pine and hardwood communities. Herbaceous species include mainly Virginia chain fern *(Woodwardia virginica)*, bracken fern *(Pteridium aquilinum)*, cinnamon fern *(Osmunda cinnamomea)*, and dwarf huckleberry *(Gaylussacia dumosa)*. A well developed vine layer exists, especially in the wetter portions of the site, and is comprised mainly of greenbriers *(Smilax laurifolia, S. rotundifolia,* and *S. bona-nox)* and yellow jessamine *(Gelsemium sempervirens)*.

4.6.2 Hardwood Dominated Communities

About 19.0 acres of the property is hardwood dominated forest (Figure 2). Approximately 15.9 acres of this is mixed mesic hardwood forest with a variety of oaks (including water oak *(Quercus nigra)*, laurel oak, post oak, blackjack oak, swamp chestnut oak *(Quercus michauxii)*, and southern red oak (*Quercus falcata* var. *falcata*)), yellow-poplar *(Liriodendron tulipifera*), sweetgum, red maple and scattered loblolly pine in the overstory. American holly *(Ilex opaca)* is prevalent in the understory. This community occurs at the southeastern corner of the forested area, primarily on Marvyn soil.

The remaining 4.1 acres of hardwood forest is coastal plain bottomland hardwood forest. This forest type is primarily on Onslow and Muckalee soils and is adjacent to Billy's Branch and its tributaries. Due to the channelization of Billy's Branch, portions of this community (1.8 acres) have been drained and are no longer functioning as a floodplain, but rather a terrace. Approximately 2.3 acres of this community exists in its natural state. The 1.8 acres of drained bottomland hardwood forest adjacent to Billy's Branch still meet, marginally, the hydrology requirements of jurisdictional wetlands.

Common overstory trees in the bottomland hardwood forest include swamp blackgum, yellow-poplar, water oak, red maple, sweetgum, and scattered loblolly pine. This community has a fairly open understory with a dense herbaceous layer including cinnamon fern, royal fern *(Osmunda regalis)*, and netted chain fern *(Woodwardia areolata)*.

4.6.3 Recent Clearcuts and Open Areas

Vegetation growth in both the fallow fields and the clearcuts is less than one year old and is typical of early successional communities in the coastal plain of North Carolina. The fields are dominated by field garlic *(Allium vineale)* and wild onion *(Allium canadense)*, with toad-flax *(Linaria canadensis)*, goldenrods (*Solidago* spp.), dog fennel *(Eupatorium capillifolium)*, and ragweed *(Ambrosia artemisiifolia)* beginning to appear. The clearcuts are more diverse, with the seeds and rhizomes of many species having lain dormant in the litter layer until presented with the increased light intensities created by the clearcuts. Species here include those in the fallow fields, as well as pink sundew *(Drosera capillaris)*, bladderwort (*Utricularia* sp.), dwarf azalea *(Rhododendron atlanticum)*, orange milkwort *(Polygala lutea)*, greenbriers, and Japanese honeysuckle *(Lonicera japonica)*. The coppice (regeneration) of hardwood stumps also plays a major role in the clearcut areas.

4.6.4 Protected Species and Ecologically Significant Communities

While no specific protected species surveys were performed at the Site, no protected plant species were observed during the extensive fieldwork performed there. A letter received from the N. C. Natural Heritage Program November 19, 1997 stated that a recorded population of the State Endangered/Federal Species of Concern Carolina goldenrod *(Solidago pulchra)* occurs approximately 1.0 miles northwest of the property (L&M 1998). No plant species requiring Section 7 consultation are listed for Jones County.

The North Carolina Natural Heritage Program (NHP) maintains a list of natural communities they feel have ecological significance due to their rarity or pristineness. The Site is contiguous to the Registered Significant Natural Heritage Area (SNHA), the Croatan National Forest Megasite and lies approximately 1.0 miles northeast (upstream) of the Registered SNHA, the Hunters Creek Upland Forest. The latter contains four high quality natural areas: Dry Mesic Oak/Hickory Forest, Mixed Mesic Hardwood Forest, Cypress-Gum Swamp, and Coastal Plain Small Stream Swamp (Schafale and Weakley 1990).

4.7 Wetlands

The location of all jurisdictional wetland boundaries at the Site were flagged in the field during March and May 1999. All delineations were based on the *Corps of Engineers Wetland Delineation Manual* (EL 1987). Mr. Mike Bell, of the Wilmington District of the USACE, visited the Site in late March 1999 to review the wetland delineation in progress. A field map showing the approximate location of the flagged lines has been forward to Mr. Bell for review. Mr. Bell has indicated no concerns regarding the jurisdictional boundary delineation.

The NCDOT Division 2 Location and Surveys Unit (under the direction of Mr. Terry Wheeler, P.E., R.L.S.) located the flagged lines using GPS in May 1999 (Figure 10). Based upon this survey, 155.9 acres of the Site are presently jurisdictional wetlands. A survey exhibit was be forwarded to Mr. Bell for his signature in early July 1999.

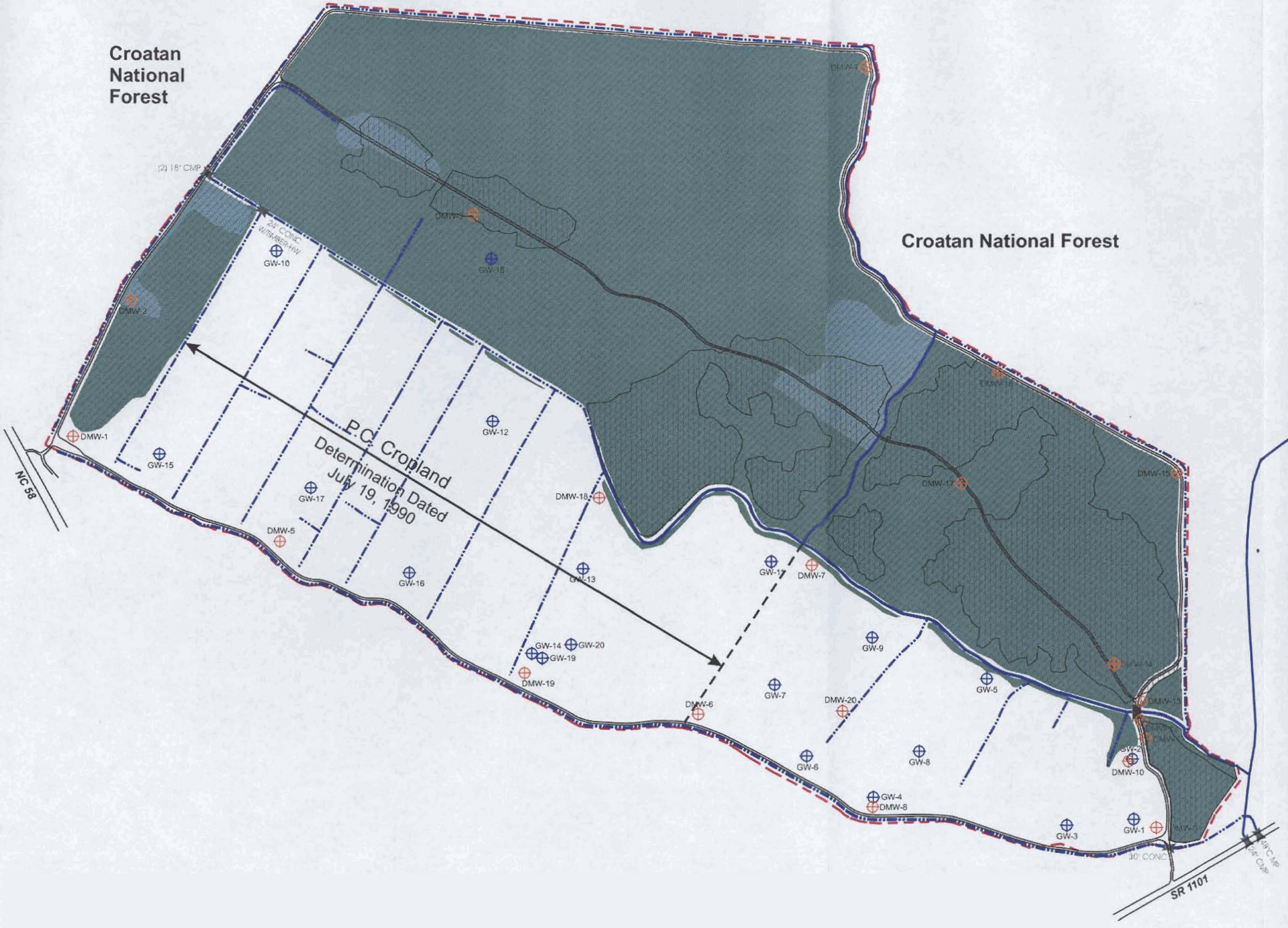

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Figure 10
Wetland Delineation Map

Legend

- - - - Property Boundary
— Centerline of Stream
-··-··- Manmade Ditch
═ Road
✖ Culvert
■ Forested Area
■ Recently Clearcut Area
⊕ Groundwater Monitoring Well
⊕ DRAINMOD Well
▨ Jurisdictional Wetlands
▨ Uplands

NORTH

1"=500'

0 500 1000

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4.8 Wildlife

4.8.1 Commonly Observed Species

The Site provides wildlife habitat typical of coastal plain pine flatwoods and mixed hardwood stands. White-tailed deer *(Odocoileus virginianus)* and black bears *(Ursus americanus)* are commonly observed, as well as many small mammals such as raccoons *(Procyon lotor)*, opossums *(Didelphis virginiana)*, gray foxes *(Urocyon cinereoargenteus)*, red foxes *(Vulpes vulpes)*, gray squirrels *(Sciurus carolinensis)*, and eastern cottontails *(Sylvilagus floridanus)*. There is no doubt that a number of songbirds, woodpeckers, owls and raptors also frequent the Site. A list of all wildlife species identified at the Site during field investigations (from visual observation or evidence of the animals) is included in Appendix G.

4.8.2 Protected Species

No specific protected species surveys have been performed at the Site to date. However, no protected animal species were observed during the extensive fieldwork performed there. A review of NHP records in June 1999 revealed a recorded occurrence of the State Significantly Rare/Federal Species of Concern Croatan crayfish *(Procambarus plumimanus)* at the southeastern corner of the property in 1975. Although not afforded protection under the Endangered Species Act, Federal Species of Concern are rare species which could be listed at any time.

The species description and biological conclusion of "No Effect" is included here for the only animal species requiring Section 7 consultation which is listed for Jones County, the red-cockaded woodpecker.

Picoides borealis (red-cockaded woodpecker) **E**
Family: Picidae
Federally Listed: October 13, 1970
Distribution in N.C.: The sandhills and southern coastal plain; scattered populations also live in the northern coastal plain and the extreme eastern Piedmont.

Species Account: "The red-cockaded woodpecker (RCW) is 18 to 20 centimeters long with a wing span of 35 to 38 centimeters. There are black and white horizontal stripes on its back, and its cheeks and underparts are white. Its flanks are black streaked. The cap and stripe on the side of the neck and the throat are black. The male has a small red spot on each side of the black cap. After the first post fledgling molt, fledgling males have a red crown patch. This woodpecker's diet is composed mainly of insects which include ants, beetles, wood-boring insects, caterpillars, and corn ear worms if available. About 16 to 18 percent of the diet includes seasonal wild fruit."

"Egg laying occurs during April, May, and June with the female utilizing her mate's roosting cavity for a nest. Maximum clutch size is seven eggs with the average being three to five eggs. From egg laying to fledging requires about 38 days, and then another several weeks are needed before the young become completely independent. Most often, the parent birds and some of their male offspring from previous years form a family unit called a group. A group may include one breeding pair and as many as seven other birds. Commonly, these groups are comprised of three to five birds.

Rearing the young birds becomes a shared responsibility of the group. However, a single pair can breed successfully without the benefit of the helpers" (USFWS).

Habitat: "Open stands of pines with a minimum age of 80 to 120 years, depending on the site, provide suitable nesting habitat. Longleaf pines *(Pinus palustris)* are most commonly used, but other species of southern pine are also acceptable. Dense stands (stands that are primarily hardwoods, or that have a dense hardwood understory) are avoided. Foraging habitat is provided in pine and pine hardwood stands 30 years old or older with foraging preference for pine trees 10 inches or larger in diameter. In good, well-stocked, pine habitat, sufficient foraging substrate can be provided on 80 to 125 acres."

"Roosting cavities are excavated in living pines, and usually in those which are infected with a fungus producing what is known as red-heart disease. The cavity tree ages range from 63 to 300 plus years for longleaf, and 62 to 200 plus years for loblolly and other pines. The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Completed cavities in active use have numerous, small resin wells which exude sap. The birds keep the sap flowing apparently as a cavity defense mechanism against rat snakes and possibly other predators. The territory for a group averages about 200 acres, but observers have reported territories running from a low of around 60 acres, to an upper extreme of more than 600 acres. The expanse of territories is related to both habitat suitability and population density" (USFWS).

Biological Conclusion: No Effect

A letter received from the N. C. Natural Heritage Program (NHP) November 19, 1997, stated that a cavity tree was recorded on the southeastern corner of the property in 1975 and that two active colonies were observed on Forest Service Road 144 within one mile of the site in 1992 (L&M 1998). However, a review of NHP records in June 1999 revealed that the recorded occurrence of a cavity tree on the property was incorrect (the record was for the Croatan crayfish *(Procambarus plumimanus)* not the red-cockaded woodpecker).

A RCW assessment was prepared for the Site in August 2000 by Dr. J. H. Carter, III & Associates and is included as Appendix H. The result of this assessment was as follows:

> "No suitable nesting habitat for RCWs was found on the Clayhill Farms property, and, although suitable habitat exists within 0.5 miles of the Clayhill Farms property, no evidence of recent RCW activity was found. The two RCW cavity trees within the 0.5-mile radius have been inactive since 1988 and are therefore considered to be abandoned. Since Clayhill Farms property is more than 0.5 miles away from active RCW clusters and the clusters within a 0.5-mile radius have been in-active for over five years, mitigation activities at Clayhill Farms will have no effect on the RCW."

It is anticipated that due to the perpetual conservation easement that will be placed on the property, foraging and nesting habitat for the RCW will be created at the Site over coming decades. The forest management plan included as Appendix I addresses this issue further.

5.0 PROPOSED CONDITIONS

The following sections detail the proposed methods for restoring and preserving the natural communities at the Site. Conceptual plans are included to further depict the proposed conditions at the Site.

5.1 Hydrology Modifications

5.1.1 DRAINMOD Results

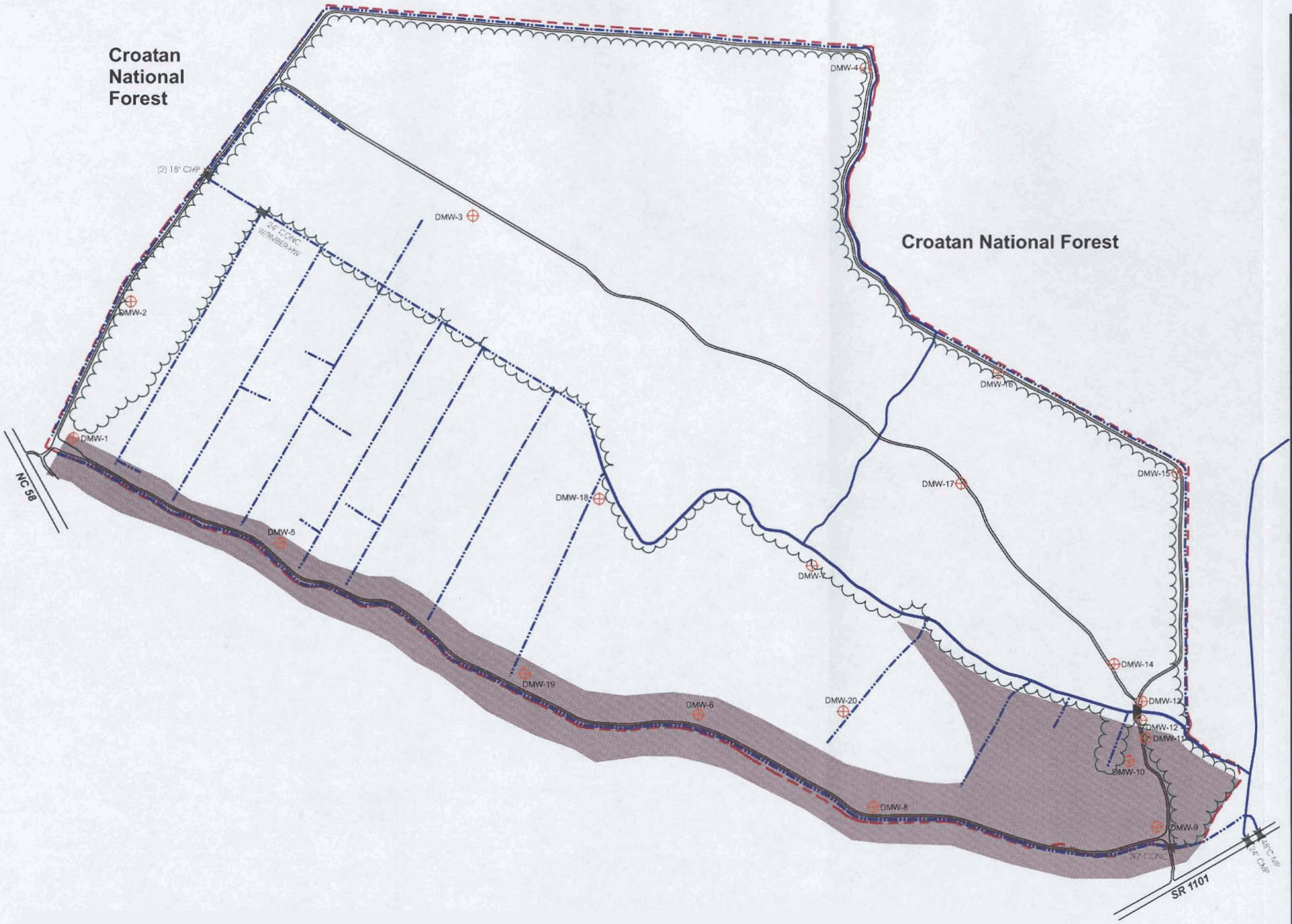
Site conditions at all ditches were simulated for existing and proposed conditions using DRAINMOD (as described in Section 4.3.3). "Wet years" are years in which the groundwater table remains *within 12 inches* of the ground surface for greater than 31 consecutive days (12.5 percent of the growing season). "Ponded years" are years in which the groundwater table remains *above* the ground surface for greater than 31 consecutive days. To be conservative, the 12.5 percent hydrology criterion was chosen instead of the five percent criterion.

All proposed conditions assume that Billy's Branch would be filled to the present top of bank and that each ditch would be blocked to grade at their downstream confluence with Billy's Branch. Table 4 lists the number of years (out of 40) for which the present fields would meet the 12.5 percent wetland criteria. A field was considered to possess wetland hydrology (and therefore no longer be effectively drained) if 50 percent (20 out of 40) or more of the years modeled were "wet years". Figure 11 depicts those areas which would remain effectively drained after restoration. As indicated by the model, only field M-1 was effectively drained both before and after restoration (Figures 5 and 11).

The results of DRAINMOD indicate that under existing conditions many of the fields pond for durations exceeding the 12.5 percent wetland hydrology criterion in a majority of the 40-year modeling period. This finding conflicts with the comments of the previous owner who stated that the fields never had a flooding problem (long duration of inundation impairing crop yields). Unfortunately, the absence of a near surface groundwater table during the early growing season during the site analyses precluded a comparison of groundwater observations and model results.

To standardize DRAINMOD results, absolute values for post-restoration were not considered to be precise but were instead compared in relative terms to the pre-restoration results. For example, the number of years that the fields of Marvyn soil were saturated/ponded under post-restoration conditions did not increase substantially over pre-restoration conditions (an increase of only seven and four years respectfully). Conversely, the response of the Onslow fields was much more substantial) an average of 11 and 12 year increases in saturation and ponding respectively). The increases for Torhunta and Pantego fields were also quite substantial.

Due to the topography of the Site in the vicinity of Billy's Branch, DRAINMOD models Billy's Branch to be six feet deep even if it is completely filled. As such, areas around Billy's Branch are considered effectively drained by the model in post-restoration. However, Billy's Branch will not effectively drain any areas after the Priority 1 restoration but is anticipated to raise the water table of adjacent areas and restore the former floodplain as discussed in Sections 5.1.2 to 5.1.5 below.



Clayhill Farms
Wetland & Stream Mitigation Plan Report

Figure 11
DRAINMOD
Proposed Conditions

Legend

– – – –	Property Boundary
——	Centerline of Stream
–··–··–	Manmade Ditch
═══	Road
✖	Culvert
⊕	DRAINMOD Well
▨	Effectively Drained Areas (per DRAINMOD)
⌒⌒⌒	Forested Area

NORTH

1"=500'

0 500 1000

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Table 4. Pre- and post-restoration DRAINMOD field simulations for the 40-year modeling period.

Soil Type	Field #	Pre-Restoration		Post-Restoration	
		Wet Years	Ponded Years	Wet Years	Ponded Years
Marvyn	M-1	7	2	14	6
	M-1 & 2*	14	6	28	12
Onslow	O-1	32	26	38	38
	O-2	20	15	33	30
	O-3	7	6	22	16
Torhunta	T-1N	29	20	40	39
	T-1S	33	33	40	38
	T-2N	29	20	40	39
	T-2S	33	33	40	38
	T-3N	29	20	40	39
	T-3S	33	33	40	38
	T-4N	25	13	40	39
	T-4S	29	23	40	36
	T-5N	33	27	39	39
	T-5S	33	33	40	39
	T-6	33	33	40	39
	T-7	28	19	40	37
Pantego	P-1N	33	30	40	40
	P-1S	36	34	40	40

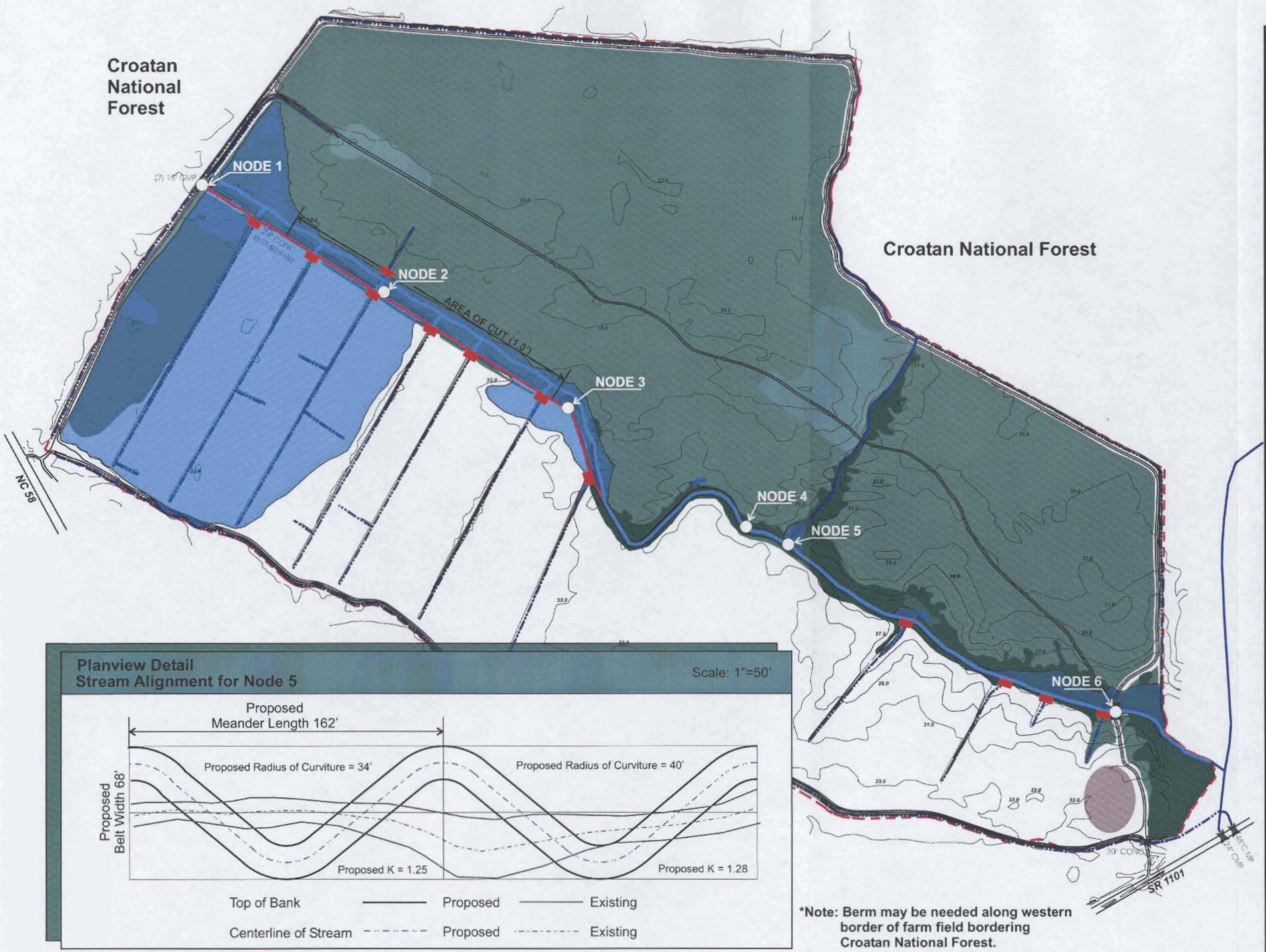
*As shown on Figure 5, M-1 is the northern portion of the easternmost field and M-2 is the southern portion of that field. They were analyzed separately because ditch 11 does not extend into the southern portion of the field.

5.1.2 Proposed Cross-Sections and Geometry of Billy's Branch

The procedures used to develop the proposed restoration of Billy's Branch follow those developed by Dave Rosgen and presented in his course entitled "*Fluvial Geomorphology for Engineers*" and the paper entitled *A Geomorphological Approach to Restoration of Incised Rivers* (Rosgen 1997). Billy's Branch will be restored from a G6c to a C6 stream type. Both the primary reference reach (off-site) and the secondary reference reach (on-site) were C6 streams.

The proposed cross-sectional area of Billy's Branch for each node was derived by relating the area of the contributing watershed to the regional curve for drainage area versus stream cross-sectional area. Widths and average depths were derived for each node point using the width depth ratio calculated for the riffle section at the reference reach. These results and proposed maximum depths are tabulated on Figure 7.

Proposed stream geometry (meander length, radius of curvature, belt width) was then derived for each node of Billy's Branch. This was done by developing ratios from data derived from the reference reach. Each criterion mentioned above was calculated as a ratio of the width of the bankfull cross-section. These ratios were then multiplied by the bankfull width from each node of Billy's Branch to derive the geometry required at each node. An example of these findings is provided on Figure 12.



*Note: Berm may be needed along western border of farm field bordering Croatan National Forest.

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Wetland & Stream Mitigation Plan Report

Figure 12
Existing & Proposed Stream Plan View & Detail

Legend

- Property Boundary
- Centerline of Stream
- Manmade Ditch
- Road
- Culvert
- 🟩 Pine Dominated Forest
- 🟦 Recently Clearcut Forest
- 🟩 Hardwood Dominated Forest
- 🟦 Floodplain Area
- New Stream
- 🟥 Ditch Block/Fills
- Oxbow Lakes
- ● Borrow Area

NORTH

1"=500'

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The geometry for each node was then superimposed on topographic mapping (1 inch = 50 feet) provided by the NCDOT.

Given federal permitting policies and guidance, the NCDOT has documented the amount of perennial and intermittent stream length restored on-site consistent with the NCDOT's recommendation for the limits of perennial streams. Intermittent stream restoration will total 3,200 linear feet while perennial stream restoration will total 5,062 linear feet In addition, the NCDOT believes, based on the Jones County Soil Survey, that the stream extended to the property's western boundary prior to agricultural use. As such, the proposed restoration is a complete ecological-system restoration approach.

5.1.3 Proposed Alignment of Billy's Branch

The assessment of stream restoration options for Billy's Branch followed that of Rosgen *(A Geomorphological Approach to Restoration of Incised Rivers*, 1997). The prioritization of restoration options described in the above mentioned manuscript is as follows (in descending order of preference):

- Convert G and/or F stream types to C and/or E types at elevations sufficient to restore the floodplain at the pre-disturbance elevation,
- Convert G and/or F stream types to C and/or E types and establish floodplain at current elevation or higher, but not as high as the pre-disturbance elevation,
- Stabilize the stream channel in place.

The objectives of this study were to re-establish a stable stream type and floodplain at the pre-disturbance elevation, or a necessary, to create the new stream channel within a newly constructed floodplain. Creation of a new stream channel avoids the problems of stabilizing a new stream bed within an existing channel (Dave Rosgen, personal communication). Material needed to fill the existing stream channel will come from the proposed stream excavation, the excavation of small, oxbow lakes proposed in the immediate vicinity (Dave Rosgen, personal communication), or from on-site borrow areas.

Representatives of Croatan National Forest were contacted and asked if the United States Forest Service (USFS) would be interested in allowing stream restoration on that portion of their property located between the Site and SR 1101. The USFS was not interested in restoring this relatively small reach. Therefore, the proposed stream restoration project will lie entirely within the Site and a grade control structure (e.g., step pool) will be needed to transition the streams slope from the Site to the adjacent Croatan National Forest.

In summary, the restoration goal for Billy's Branch is to restore the stream at elevations which would re-establish use of the historic floodplain or to place the stream in a new location (alignment) wherever possible as discussed above. Figure 12 illustrates the proposed stream's alignment and the typical plan view at node 5 as a representation of the general stream geometry. Final design of stream geometry will vary along each reach where practicable to give the stream a natural appearance. A more detailed analysis of meander geometry is provided below.

The bankfull critical shear stress at each node for Billy's Branch was calculated based on plan view, channel dimensions, and valley slope. These values were compared to the values for the reference reach (0.09 lbs/ft^2) and the particle sizes found within Billy's Branch. Shear stress is an important calculation because it indicates whether the stream has the power to entrain particles smaller, equal to, or larger than the particle sizes available to the channel when the stream is at its bankfull stage. A proposed stream design which generates a shear stress value in excess of that needed to move the particles available to the stream bed indicates that the stream may begin to scour or down-cut. Conversely, a proposed stream design with too little shear stress may not be able to transport its sediment load, causing sedimentation and aggradation in the channel.

The initial meander geometry calculated for nodes 1, 2 and 3 of Billy's Branch generated a shear stress that matched the reference reach and the particle size of the sediment. There is also adequate area upstream of node 3 to place the stream on a new alignment, as is preferred. The new alignment was placed in the woods immediately north of the existing stream. This alignment was selected to avoid losing wetland restoration opportunities in the Prior Converted cropland. This new alignment also allows the dirt road in the woods to be used for construction. Although the berm immediately south of the channelized stream will be used to fill in the existing channel, additional fill material will be needed. This additional fill will come from grading the floodplain along the proposed alignment. Approximately one foot of grading is proposed for floodplain excavation along this reach.

The initially proposed stream geometry between nodes 3 and 4 yielded shear stress values greater than the reference reach (0.3 versus 0.09 lb/ft^2, see Figure 13). Various options are available to decrease shear stress including increasing width/depth ratio, increasing sinuosity (decrease slope), increasing meander width ratio, and decreasing meander length and radius of curvature. Increasing the width/depth ratio were unsuccessful since the values necessary for width and depth were well outside the range observed at the reference reach (i.e., normalized for drainage area). Consequently, increases in sinuosity were attempted to decrease stream slope and thereby reduce shear stress (Figure 13). The only means available to reduce the shear stress was to increase sinuosity from 1.2 to 2.4. This was accomplished by having a meandering plan view follow the large, remnant meander pattern of Billy's Branch. This finding is significant because it confirms that the historic meander pattern (observed on USGS quadrangle maps prior to agricultural use) was needed to maintain a stable stream through this narrowing and relatively steep portion of the valley (see alternative versus proposed stream alignment, Figure 13).

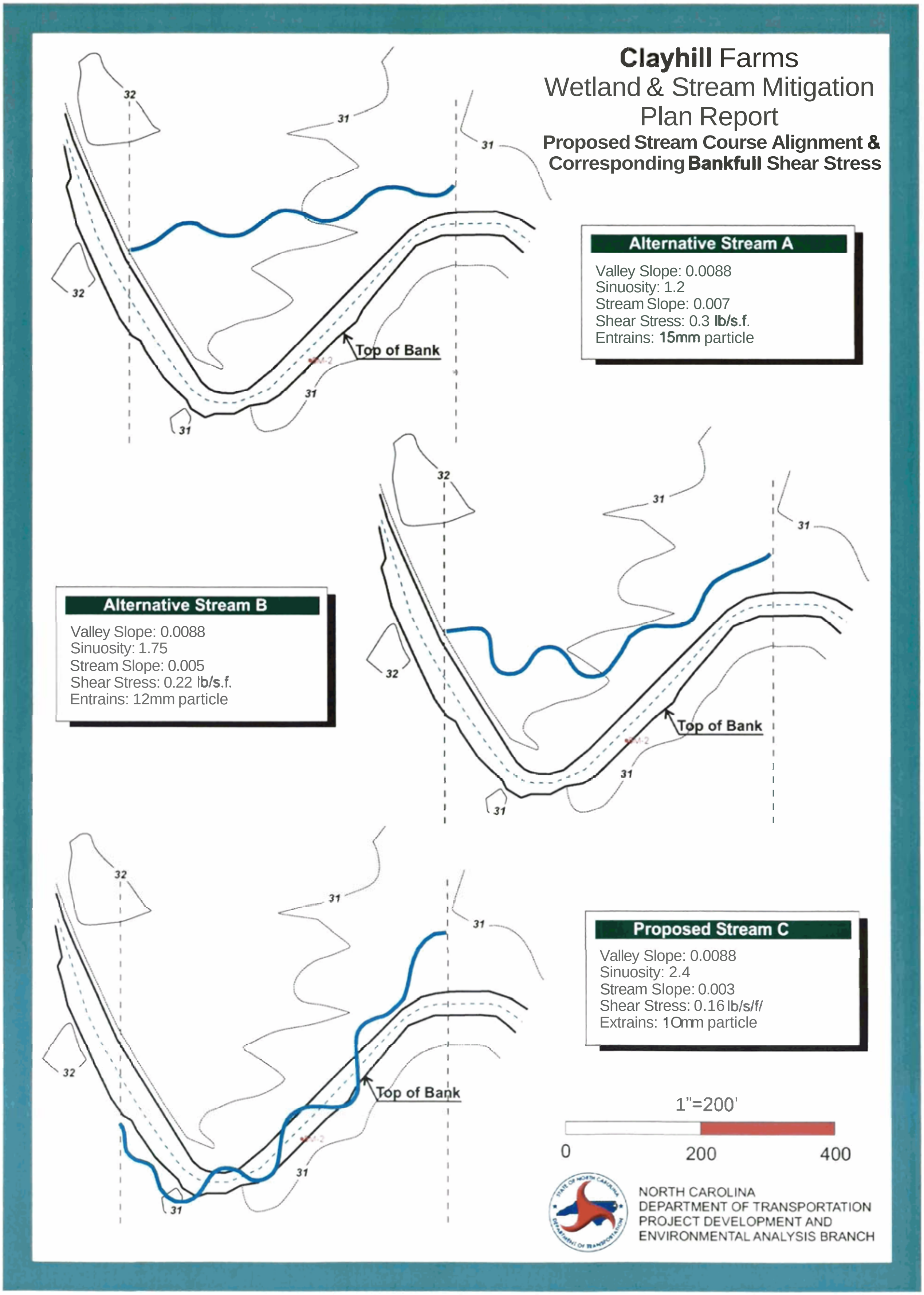
The meander geometry between nodes 4 and 6 only requires a sinuosity of between 1.25 and 1.30 to generate acceptable shear stress values. An illustration of the restoration geometry is provided in Figure 12.

Once the plan, profile and cross sections were calculated, the data was then input into the HEC-2 model to determine peak flood elevations for the two-year storm and the peak discharge rate occurring at the culverts on SR 1101. This is further discussed in the Proposed Hydraulics section (5.1.4) of this report.

5.1.4 Proposed Hydraulics

The individual drainage areas and the time of concentration for the five drainage areas will remain the same under the proposed conditions. The five individual drainage areas will continue to drain into and pond behind the two outfall culverts (24-inch CMP and 48-inch CMP) located under SR 1101. The proposed conditions include 1) reducing the slope of the longitudinal profile, 2) increasing stream

Figure 13



Clayhill Farms
Wetland & Stream Mitigation
Plan Report
Proposed Stream Course Alignment &
Corresponding Bankfull Shear Stress

Alternative Stream A

Valley Slope: 0.0088
Sinuosity: 1.2
Stream Slope: 0.007
Shear Stress: 0.3 lb/s.f.
Entrains: 15mm particle

Alternative Stream B

Valley Slope: 0.0088
Sinuosity: 1.75
Stream Slope: 0.005
Shear Stress: 0.22 lb/s.f.
Entrains: 12mm particle

Proposed Stream C

Valley Slope: 0.0088
Sinuosity: 2.4
Stream Slope: 0.003
Shear Stress: 0.16 lb/s/f/
Extrains: 10mm particle

1"=200'

0 200 400

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length (due to increased sinuosity) and 3) reducing the cross-sectional area of Billy's Branch and 4) partially blocking the eleven feeder ditches that drain to Billy's Branch.

Feeder Ditches
As part of the proposed conditions, it was initially proposed that the existing feeder ditches be blocked only at each of their downstream ends (Figure 12).

The NCDOT's final design plans illustrate plugging and filling the agricultural ditches rather than only blocking them. Each ditch will be plugged with clay material for a distance of 15 to 20 feet. The remainder of the ditch will be backfilled with onsite material taken from the floodplain excavation or other upland areas.

Billy's Branch
The proposed conditions of Billy's Branch were modeled using the HEC-2 program. The existing total drainage area (971 acres) will not change, the peak time of concentration will not change, and the overall runoff curve numbers will remain the same. The runoff curve numbers for the areas that are being converted to wetlands will, over time, decrease under the proposed conditions. In order to be conservative with the model and to represent the early conditions during their conversion to wetlands (fallow fields), the existing curve numbers were used to generate the peak flow rates for the proposed conditions. The existing tailwater condition of 22.7 feet at the culverts beneath SR 1101 will remain the same for the proposed conditions of Billy's Branch. The HEC-2 model was revised to reflect the proposed longitudinal profile, stream length, and cross-sections generated from the fluvial geomorphological analysis. The proposed cross-sections were changed to reflect the smaller depth and width of the proposed Billy's Branch (Figure 8) channel which was based primarily on the data from the primary (off-site) reference reach.

Table 5 shows the peak flow rate, the top of bank elevation, and existing and proposed ditch conditions of Billy's Branch. One result from the HEC-2 model was that it indicated a "hydraulic jump" between nodes 4 and 5. This reflects an increase in velocity (energy) caused by valley slope increasing between these nodes while the stream channel dimensions and sinuosity remain relatively constant and the floodplain narrows. The resulting turbulent condition is a normal condition that generates rapids within streams. To reduce the potential for erosion in this area, the design calls for widening of the floodplain to accommodate an increased sinuosity and for the use of cross vanes as grade control.

Table 5. Proposed surface water profile of Billy's Branch.

	Existing Conditions		**Proposed Conditions**	
Node #	**Peak Stormwater Runoff (cfs)**	**Water Surface Elevation (ft)**	**Peak Stormwater Runoff (cfs)**	**Water Surface Elevation (ft)**
7	323	22.7	323	22.70
6	176	22.69	176	22.72
5	148	24.57	148	26.62
4	143	24.49	143	26.99
3	95	31.81	95	32.26
2	73	32.71	73	33.67
1	38	32.94	38	33.76

5.1.5 Floodplain Restoration

As mentioned previously, the existing geometry of Billy's Branch currently confines the two-year storm which indicates that the stream has abandoned its floodplain. The new floodplain generated by the proposed restoration of Billy's Branch is illustrated on Figure 12. Between nodes 1 and 2, the proposed stream will generate a floodplain approximately one foot higher (Table 6) and 1,650 feet wider than existing conditions (Figure 12).

Table 6. Existing and proposed peak flood elevations.

Node #	Existing Conditions (ft)	Proposed Conditions (ft)	Increase in Peak (ft)
1	32.9	33.8	0.9
2	32.7	33.7	1.0
3	31.8	32.3	0.5
4	24.5	27.0	2.5
5	24.6	26.6	2.0
6	22.7	22.7	0.0
7	22.7	22.7	0.0

Node 3 will generate a floodplain 0.5 feet higher than existing conditions. The 200-foot wide floodplain, while narrower than at nodes 1 and 2, fills the historic floodplain as evidenced by review of the ortho-topographic mapping provided by the NCDOT (Figure 12).

The flood elevations increase sharply between nodes 4 and 5 to approximately 2.3 feet above existing conditions, due to the constriction of the valley in this area. It is due to this constriction in the valley width that the floodplain is only 25 feet wide, except at the confluence with the unnamed tributary to the north. The floodplain of Billy's Branch extends approxiamtely170 feet up the unnamed tributary.

The flood elevations and floodplain widths remain constant between nodes 6 and 7, an area where the floodplain, on average is approximately 125 feet wide (Figure 12). Although the proposed stream channel at node 6 is shallower and narrower than the existing conditions, the floodplain is much wider than at nodes 4 and 5 upstream, providing more storage without a rise in the water elevation.

Node 7 is off-site and neither its cross-section nor slope can be altered. The flood elevation at node 7 is the same under proposed conditions as it is in existing conditions which confirms that the channel, meander and slope adjustments made within the Site appears to have no deleterious effect on downstream properties nor the culverts beneath SR 1101.

5.2 Conceptual Planting Plan

Natural plant communities are dependent primarily upon landscape position, soil type, and hydrology. The first step in determining which natural plant communities likely occurred at the Site was to find naturalized areas with similar characteristics (i.e., soil type, hydrology, and landscape position). These areas were found through review of published references and conversations with Mr. Richard LeBlond, Biologist with the North Carolina Natural Heritage Program (NHP). Once these sites were inventoried, the obtained data was compared to that in *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990). Combined with the data developed from the groundwater and surface water analyses, this data provide the basis for the proposed planting plan.

5.2.1 Reference Forests

Two reference forests were identified which had the same physical characteristics as the Site (Figure 1). Both were located in the Croatan National Forest. Vegetation Reference Area 1 was located on a tributary to Holston Creek approximately 1.7 miles northwest of the Site. Vegetation Reference Area 2 was located at the off-site stream reference reach approximately 1.3 miles east of the Site. The soil types found at the Site are not common in the vicinity and locating reference forests was difficult. All areas of Torhunta soil in the vicinity of the Site have been converted to agriculture or pine plantations. Pantego soil is similar to Torhunta and is found in locations adjacent to the Site. However, because the adjacent forest on these soil types are not considered to be in its natural state, due to past high-grading forestry practices, vegetation on Pantego soil was investigated but not sampled (see Section 5.2.2). A sample plot was not taken in the mesic pine flatwoods community investigated on Onslow soil because it has been burned too frequently to have characteristic vegetation.

A 50-foot diameter circular plot was taken on each soil type within each landscape position at both reference forest locations. The diameter at breast height (dbh) of every stem larger than one inch was measured and recorded, as was the percent cover (by species) of all species in the shrub and herbaceous layers. A total of six plots were sampled. Data from the sample plots are summarized in Table 7.

Table 7. Mean community characteristics for vegetation sample plots.

	Stems per Acre	Basal Area per Acre	Number of Species per Plot	Percent Hydrophytic Species per Plot	Species with IV ≥ 10
Coastal Plain Bottomland Hardwood Forest	658	238	6.3	84	swamp blackgum ironwood American holly water oak sweetgum sweet bay bald cypress
Mixed Mesic Hardwood Forest	322	210	6.5	57	loblolly pine yellow-poplar flowering dogwood ironwood sweetgum water oak longleaf pine

An Importance Value (IV) was calculated for each tree species in each plot as follows. First, the density of all stems greater than one inch dbh was determined for each species on a per acre basis. For example, ironwood *(Carpinus caroliniana)* in plot 4 had 14 stems that were one inch in dbh or larger, therefore the stem density for ironwood is 311 stems per acre. Then, the basal area of each tree species (based on all stems) was determined and expressed in square feet (ft^2) of basal area per acre. The corresponding value of ironwood in plot 4 was 31.02 ft^2/acre. All density and basal area values within a plot were then divided by the total density and basal area for all species in the plot to derive the percentage of total density and basal area each species represented. Thus, the relativized values for ironwood in plot 4 were 311 / 555 x 100 = 11.01 percent and 31.02 / 281.82 x 100 = 56.00 percent for density and basal area, respectively. The IV for each tree species was determined by averaging its relative density and relative basal area, yielding an IV of 33.50 for ironwood in plot 4. Species with an IV greater that ten are listed in Table 10.

5.2.2 Proposed Plant Communities

Mitigation opportunities for the Site will allow for the restoration, enhancement, and/or preservation of both riparian and non-riparian wetland plant communities. The plant communities that likely occurred historically on and around the Site was determined from data collected from the references forests, descriptions of plant communities from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990), and the hydrology modeling. Figure 14 depicts these plant communities and describes their landscape position, dominant species, and typical soil type. Four of these communities are proposed for the Site and include Coastal Plain Small Stream Swamp (32.3 acres), Non-riverine Wet Hardwood Forest (37.4 acres), Mesic Pine Flatwoods (22.4 acres), and Mixed Mesic Hardwood Forest (5.6 acres). In addition, wetland hydrology will be enhanced in (1.8 acres) the Coastal Plain Bottomland Hardwood Forest currently existing at the Site. The following sections detail each of these communities and list the species proposed for planting. Figure 15 depicts the planting zones for each of these communities.

Coastal Plain Small Stream Swamp

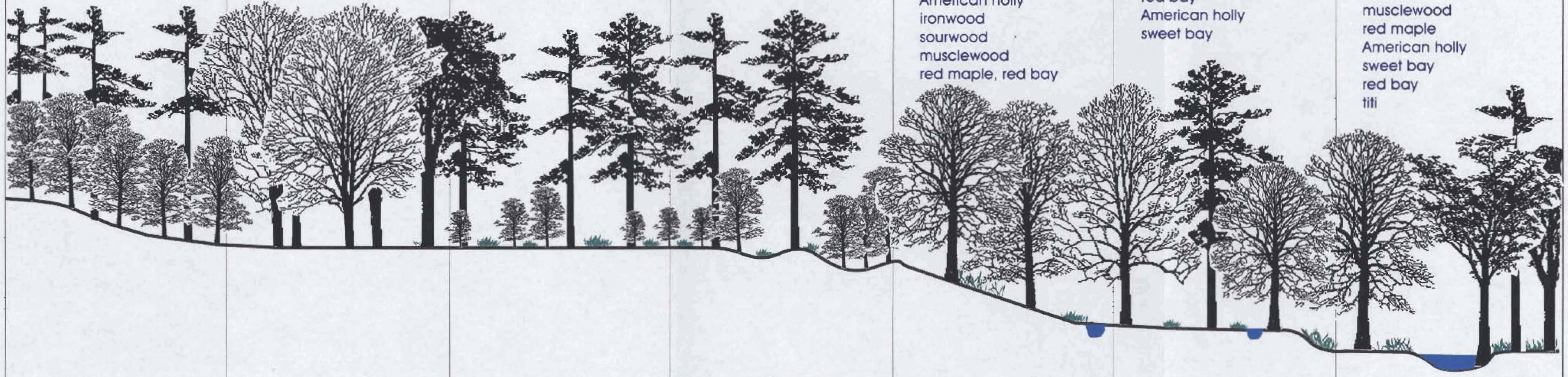
Coastal Plain Small Stream Swamp typically occurs in the floodplains of small, blackwater streams. This community typically grades upstream into an Atlantic White Cedar Forest and away from the channel to Non-riverine Wet Hardwood Forest or uplands. Coastal Plain Small Stream Swamp typically grades into Bottomland Hardwoods as the floodplain size increases downstream. The canopy is dominated by bald cypress (*Taxodium distichum*) and swamp blackgum. As noted in Section 5.1, the western-most fields on Torhunta soils (approximately 32.3 acres) will be located in the floodplain of the new stream and inundated during the two-year event. DRAINMOD predicts flooding/ponding in this area 38 out of 40 years. Therefore, a Coastal Plain Small Stream Swamp community is planned for this area.

Non-Riverine Wet Hardwood Forest

The forests on Pantego soil surrounding the Site presently exist as a Pond Pine Woodland. Pond Pine Woodlands typically occur on the edges of peatland communities, which are mostly absent in the vicinity of the Site. It is therefore, unlikely these forests exist in their natural condition. Historically, the Torhunta and Pantego soils at the Site most likely supported a Non-riverine Wet Hardwood Forest community.

Non-riverine Wet Hardwood Forests occur on poorly drained interstream flats which are saturated part of the year. Typically, these flats are near the highest parts of landscape. They are typically on poorly drained loamy or clayey mineral soils and are almost always jurisdictional wetlands. At least five of the following species should be planted on the Torhunta and Pantego soil: swamp chestnut oak (FACW-), laurel oak (FACW), cherrybark oak (*Quercus falcata* var. *pagodaefolia*, FAC+), yellow-poplar (FAC), American elm (*Ulmus americana*, FACW), swamp blackgum (OBL), and American holly (FAC-). Red maple (FAC) and sweetgum (FAC+) are important components of Non-riverine

NATURAL COMMUNITY	Pond Pine ✱ Woodland (Infrequent Fire)	Non-riverine ◆ Wet Hardwood Forest (Infrequent Fire)	Wet Pine Flatwoods (Moderately Frequent Fire)	Mesic Pine ◆ Flatwoods (Moderately Frequent Fire)	Mixed Mesic ◆ Hardwood Forest (Protected from Fire	Coastal Plain ✱ Bottomland Hardwood Forest	Coastal Plain Small Stream Swamp →)
CANOPY CODOMINANTS	pond pine loblolly bay	swamp chestnut oak laurel oak cherrybark oak yellow poplar sweetgum American elm red maple swamp blackgum	longleaf pine pond pine	longleaf pine pond pine	American beech yellow - poplar so. sugar maple white oak nor. red oak sweetgum swamp chestnut oak cherrybark oak shagbark hickory so. red oak	laurel oak overcup oak willow oak water oak red maple loblolly pine Atlantic white - cedar sweetgum	bald cypress swamp blackgum yellow - poplar red maple laurel oak overcup oak swamp chestnut oak river birch American elm loblolly pine pond pine
UNDERSTORY TREES	sweet bay loblolly pine red bay Atlantic white - cedar	musclewood red maple American holly paw paw		southern red oak water oak post oak blackjack oak bluejack oak pale hickory mockernut hickory sweetgum	flowering dogwood American holly ironwood sourwood musclewood red maple, red bay	red maple red bay American holly sweet bay	musclewood red maple American holly sweet bay red bay titi
LANDSCAPE POSITION	Outer parts of domed peatlands on poorly drained interstream flats	Poorly drained interstream flats saturated part of the year	Flat or nearly flat seasonally wet areas.	Flat or gently rolling areas that are neither excessively dry nor have a significant seasonally high water table.	North facing bluffs or ravines and upland flats	Relatively high parts of the floodplain away from the channel of blackwater streams	Floodplain of small blackwater streams
SOIL TYPE (example)	Shallow histosols or oligotrophic mineral soils with organic surface layers (Torhunta)	Poorly drained loamy of clayey mineral soils (Torhunta/Pantego)	Wet, Sandy Spodosols (Onslow)	Loamy or fine textured soils, sometimes sand (Onslow)	Moist upland soils (Onslow/Marvyn)	Bottomland mineral soils of various textures, often very sandy (Muckalee)	Alluvial or organic soils (Muckalee)



Clayhill Farms Wetland
and Stream Mitigation
Plan Report

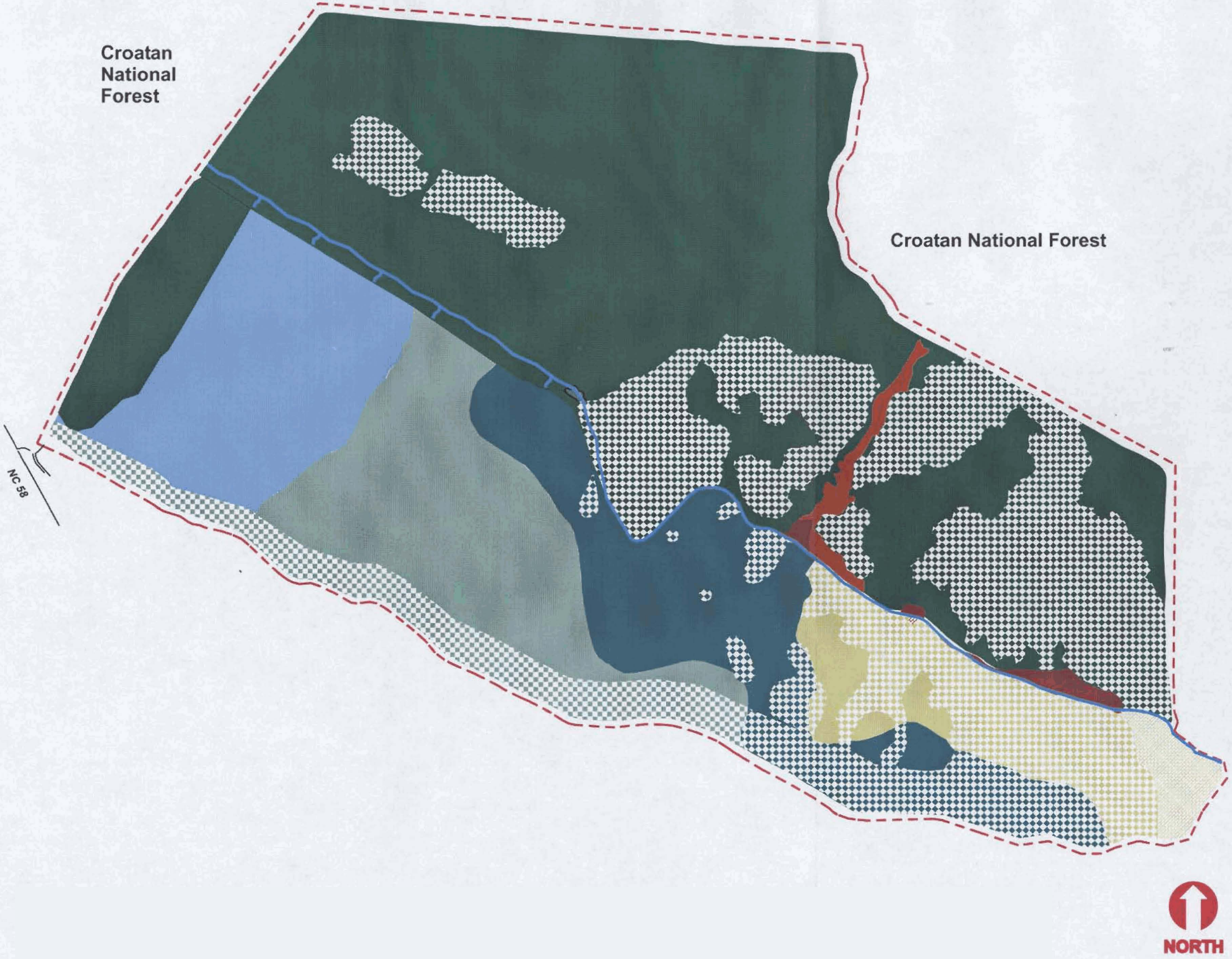
FIGURE 14
LANDSCAPE PROFILE OF NATURAL COMMUNITIES

NOTE: ✱ Exists on site
◆ Proposed for site

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION PROJECT DEVELOPMENT AND ENVIRONMENTAL ANALYSIS BRANCH

Langley and McDonald, P.C.

Adapted from Schafale and Weakley, 1990.



Clayhill Farms
Wetland & Stream Mitigation Plan Report

Figure 15
Proposed Planting Plan

Legend

- - - - Property Boundary
- 🟦 Cypress-GumSwamp Riverine Restoration
- 🟩 Non-Riverine Wet Hdwd Forest Wetland Restoration
- ▦ Non-Riverine Wet Hdwd Forest Upland Restoration
- 🟦 Mesic Pine Flatwoods Wetland Restoration
- ▦ Mesic Pine Flatwoods Upland Restoration
- 🟨 Mixed Mesic Hdwd Forest Wetland Restoration
- ▦ Mixed Mesic Hdwd Forest Upland Restoration
- ▨ Mixed Mesic Hdwd Forest Upland Preservation
- 🟫 Bottomland Hdwd Forest Wetland Enhancement
- 🟥 Bottomland Hdwd Forest Wetland Preservation
- ▨ Bottomland Hdwd Forest Upland Preservation
- 🟩 Mixed Pine Regeneration Wetland Preservation
- ▦ Mixed Pine Regeneration Upland Preservation

1"=500'

0 500 1000

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND
ENVIRONMENTAL ANALYSIS BRANCH

Project #1960024-203.00 & 1960024-019.00

Wet Hardwood Forests but are not recommended for planting as they will likely regenerate naturally on the Site from adjacent areas.

Approximately 11.7 acres of this area is projected by DRAINMOD to remain effectively drained (and thus not exhibit wetland hydrology) because the southern perimeter ditch cannot be plugged (it is not completely owned by the NCDOT). Hydrology monitoring wells are located within this area, and may show this area of upland buffer to be smaller than that suggested by the modeling. If so, credit calculations may be adjusted to depict this area as wetland versus upland.

Mesic Pine Flatwoods

Mesic Pine Flatwoods occur on flat to gently rolling areas which are neither excessively dry nor have a significant seasonally high water table. In general, they are marginal wetlands. Mesic Pine Flatwoods have an open to nearly closed canopy of longleaf pine *(Pinus palustris)* and pond pine *(Pinus serotina)* with a diverse understory of hardwood trees. It is likely that most of the areas on the Site mapped in the soil survey as Onslow soils were this mixed pine community. Recommended plantings for the Onslow portions of the Site include only longleaf pine (FACU+) and pond pine (FACW+). Approximately 11.1 acres of this community is expected to be upland buffer due either to the presence of non-hydric soils or the drainage effect of the southern perimeter ditch. Approximately 2.2 acres of this community will be in the floodplain of the new stream after the ditches are blocked and Billy's Branch is restored.

Mixed Mesic Hardwood Forest (Coastal Plain Subtype)

All of the areas mapped as Marvyn soils and parts of the Onslow soil areas will be planted to reflect a Mixed Mesic Hardwood Forest community. This community will occur primarily below the 31.0-foot contour line on the eastern end of the Site. Parts of this community may become jurisdictional wetlands over time; however, due to the well drained nature of this soil most of it will remain simply as upland riparian buffer. Only 5.6 acres of this community is expected to meet the soil and hydrology criteria for jurisdictional wetlands. Mixed Mesic Hardwood Forests typically occur on north-facing bluffs or ravines on moist upland soils. This is the same landscape position that they will occupy at the Site. At least six of the following species should be planted in this area: yellow-poplar (FAC), water oak (FAC), swamp chestnut oak (FACW-), cherrybark oak (FAC+), ironwood (FAC), laurel oak (FACW), southern sugar maple (NI), and American beech (FACU). Sweetgum (FAC+) is an important component of this community but is not recommended for planting as it will likely regenerate naturally on the Site from adjacent areas.

Coastal Plain Bottomland Hardwood Forest (Blackwater Subtype)

Coastal Plain Bottomland Hardwood Forests occur on the relatively high parts of the floodplain of blackwater creeks and rivers. These portions of the floodplain are inundated in major flood events (i.e. 10-year storm) for as much as a day or two. They are saturated most of the year and are typically jurisdictional wetlands. They occur on bottomland mineral soils of various textures. At the Site, this community originally occurred on the northern side of Billy's Branch and along the north-south tributary of Billy's Branch in the center of the property. As mentioned previously, portions of this community have been drained to the point that it no longer functions as a floodplain due to the incision of Billy's Branch. Approximately 1.8 acres of this community will be enhanced from marginal wetlands to the original floodplain community by the restoration of Billy's Branch. No additional plantings are recommended for this community.

6.0 SITE CONSTRUCTION AND PLANTING REQUIREMENTS

6.1 Site Construction

Site construction will include the following activities:

- Plugging and filling of feeder ditches and removal of crowning in fields.
- Clearing and grading necessary to create new stream alignment.
- Construction of a stable, meandering channel for the on-site reaches of Billy's Branch and unnamed tributary.
- Fill existing stream channel where necessary with on-site materials from excavated floodplain and other upland areas.
- Install a grade control structure at downstream end of Billy's Branch to allow stable transition to the downstream reach located within the Croatan National Forest.
- Removal of the bridge across Billy's Branch at the southeast portion of the Site.

6.2 Site Preparation and Planting Requirements

It is recommended that the Site be randomly shaped to establish irregular contours with high ridged areas (no more than 12 inches above average grade) and depressional furrows (no more than 12 inches below average grade). This will increase surface storage at the mitigation site, restore natural microtopography to the Site, and provide microsites for planting trees to reduce seedling mortally due to high water tables (McKinney and Shear 1997, Tweedy and Evans 1999). In an effort to reduce compaction and create microtopography, the entire Site will be ripped or scarified. No other site preparation is recommended prior to planting.

Bare root seedlings will be planted on eight-foot centers throughout the planting zones, resulting in 680 trees per acre. In hardwood dominated communities, no more than 20 percent of plantings will be of any one species. Planting should occur outside of the growing season (i.e., between November and March) to allow the plants to acclimate during the dormant season.

The NCDOT will perform all of the construction with NCDOT forces and will utilize stream diversions throughout the entire length of the stream restoration project. The restored channel will be stabilized with coir fiber matting, live stakes, and seeding before turning the water into the newly constructed channel. In addition, root wads and other woody debris will be introduced during the construction of Billy's Branch to provide additional aquatic habitat.

7.0 MONITORING PLAN

All monitoring will be performed annually for five years following construction or until all success criteria have been met. An annual monitoring report will be submitted for the Site.

7.1 Wetland Mitigation Monitoring - Hydrology

NCDOT will locate on-site hydrology reference sites. The reference monitoring gauges will be placed at comparable elevations as those monitoring the restoration portions of the Site. Remote shallow groundwater monitoring gauges will be maintained and periodically downloaded until success criteria have been met.

The success criteria for wetland hydrology will include those areas that exhibit a hydroperiod of 12.5 percent or greater. In drought years, those gauges that fail to meet the 12.5 percent success criteria will be deemed successful if the hydroperiod is within 20 percent of the hydroperiod of the average for reference gauges.

7.2 Wetland Mitigation Monitoring - Vegetation

Quantitative vegetation sampling will be performed in the fall of each year. Plots measuring 50-foot by 50-foot will be established in each planting zone.

In each plot, species composition and density will be recorded. Photograph locations will be established for each plot. Any areas of the Site visually observed not meeting the established success criteria will also be noted.

A 320 stems per acre survival criterion for planted seedlings will be used to determine success for the first three years. The required survival criterion will decrease by 10 percent per year after the third year of vegetation monitoring (i.e., for an expected 290 stems per acre for year 5).

7.3 Stream Restoration Monitoring

The NCDOT will provide an "as-built" of the stream reach within 90 days after construction has been completed. The "as-built" will include dimension, profile, and plan view of the completed stream project. The "as-built" will serve as the baseline during the monitoring period.

During the annual review of the stream, the entire stream reach will be visually evaluated for any potential problem area such as stream bank instability, in-stream structure failure, or unsuccessful vegetation establishment. Permanent photo reference points along the stream will be established for annual monitoring.

The annual monitoring report will contain photographs and documentation of the stream during the monitoring period. Any remedial actions to the stream that are necessary will be coordinated with the agencies.

8.0 MITIGATION SUMMARY

8.1 Compensatory Wetland Mitigation Acreage

Table 8 details the wetland mitigation acres at the Site.

Table 8. Compensatory wetland credit calculations for the Clayhill Farms Mitigation Site.

Compensatory Mitigation Type	Acres		
	Riverine	Non-Riverine	Total
Wetland Restoration			
Cypress-gum headwater swamp	32.3		32.3
Non-riverine wet hardwood forest		37.4	37.4
Mesic pine flatwoods		22.4	22.4
Mixed mesic hardwood forest		5.6	5.6
Total Wetland Restoration	*32.3*	*65.4*	*97.7*
Wetland Enhancement			
Coastal Plain BLH	1.8		
Total Wetland Enhancement	*1.8*		*1.8*
Wetland Preservation			
Mixed pine regeneration		252.1	
Coastal Plain BLH	2.0		
Total Wetland Preservation	*2.0*	*152.1*	*154.1*
Upland Buffer Restoration			
Non-riverine wet hardwood forest		11.0	
Mesic pine flatwoods		17.3	
Mixed mesic hardwood forest		15.8	
Total Upland Buffer Restoration		*44.1*	*44.1*
Upland Buffer Preservation			
Mixed pine regeneration		45.3	
Mixed mesic hardwood forest		12.3	
Coastal Plain BLH		0.3	
Total Upland Buffer Preservation		*57.9*	*57.9*
Site Totals	**36.1**	**319.5**	**355.6**

8.2 Compensatory Stream Mitigation Length

Table 9 details the stream length calculations at the Site.

Table 9 . Compensatory stream credit calculations for the Clayhill Farms Mitigation Site.

Compensatory Mitigation Type	Linear Feet		
	Perennial	Intermittent	Total
Stream Restoration			
Billy's Branch	5,062	3,200	8,262
Upper tributary to Billy's Branch	70	0	70
Total Stream Restoration	*5,132*	*3,200*	*8,332*
Stream Preservation			
Upper tributary to Billy's Branch	1,280	0	1,280
Total Stream Preservation	*1,280*	*0*	*1,280*

9.0 DISPENSATION OF PROPERTY

The Site borders the Croatan National Forest to the west, north, and east. Therefore, USFS would be the preferred recipient of the land. Representatives for the Croatan Ranger District have expressed an interest in accepting eventual ownership of the Site and have stated that they see no problems regarding such a transfer.

The NCDOT will retain ownership of the Site until all mitigation activities are completed and the site is determined to be successful. A conservation easement or other restrictive covenant will be established for the property and recorded with the deed when transferred to the USFS to ensure that the property is managed for the purpose of wetland mitigation in perpetuity.

10.0 CONCLUSION

The results of the wetland and stream restoration plan for the Site were a product of an integrated analytical approach that evaluated the soils, groundwater hydrology, surface water hydrology and hydraulics, fluvial geomorphology, landscape position, vegetation, and wildlife. This analysis was further supported by analyzing the least disturbed plant communities endemic to the region located in areas with the same landscape positions, soils and proposed hydrology as that of the Clayhill Farms property. Stream restoration was based upon accepted procedures in fluvial geomorphology and hydraulics and utilized stream gage data and reference streams.

11.0 REFERENCES

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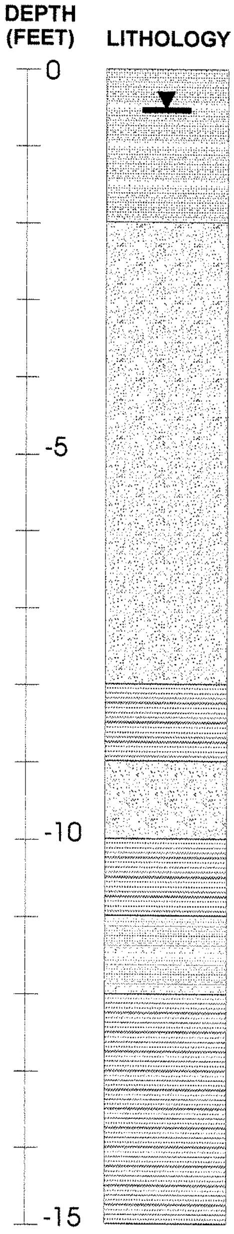
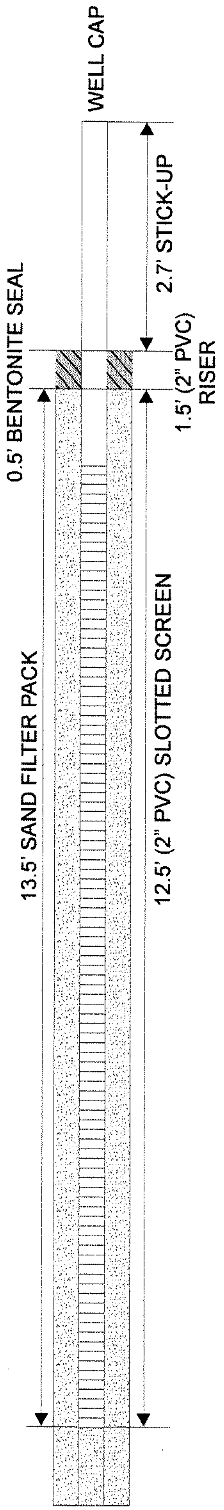
APPENDIX A

SOIL BORING LOGS

WELL No: DMW-1
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/1/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: PANTEGO



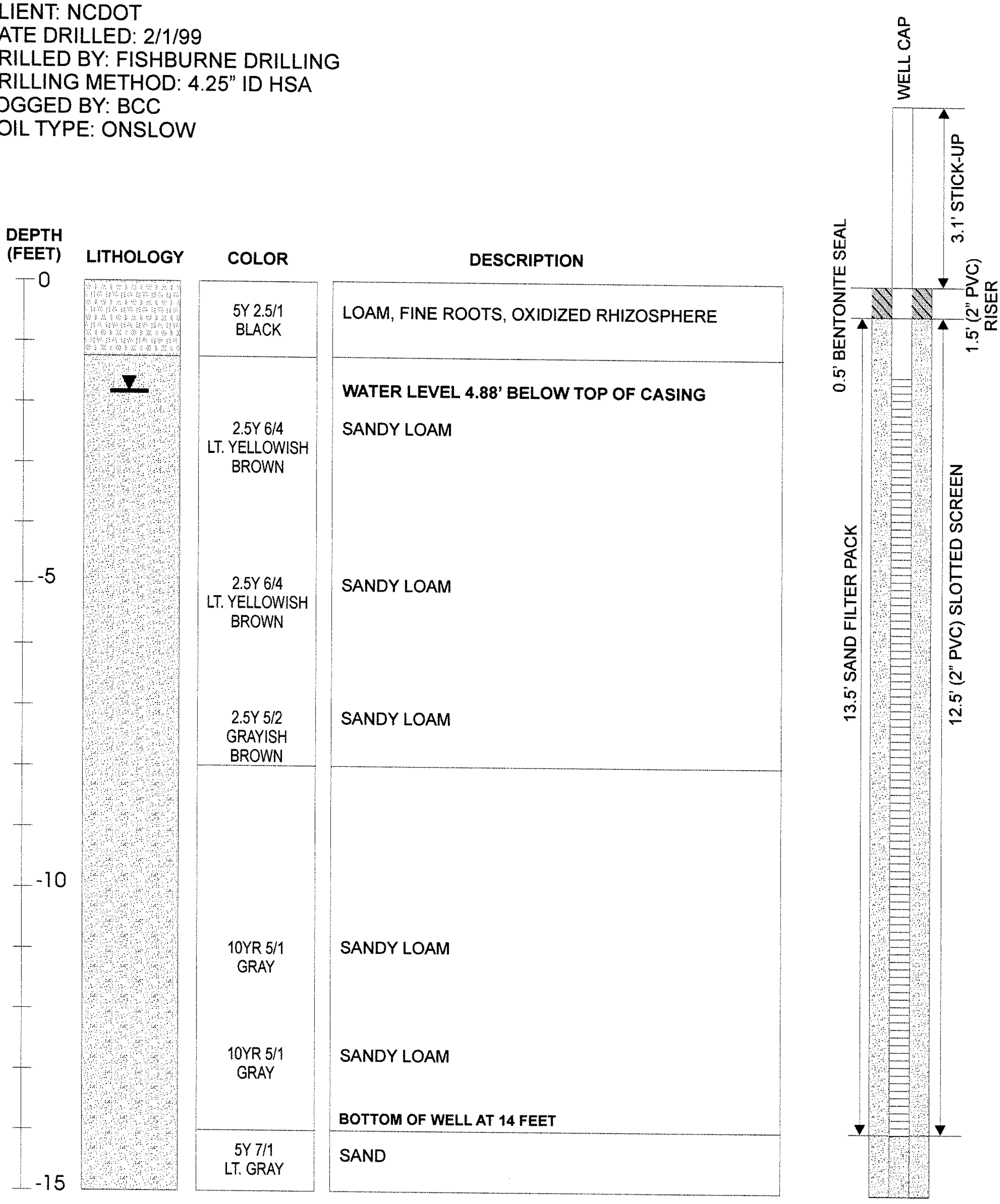
COLOR	DESCRIPTION
2.5Y 3/1 VERY DARK GRAY	**WATER LEVEL: 3.05' BELOW TOP OF CASING** SANDY CLAY LOAM
2.5Y 2.5/1 BLACK	SANDY CLAY
10YR 4/1 DARK GRAY	SANDY LOAM, GRAY MOTTLES (10YR 6/1)
10YR 3/1 VERY DARK GRAY	SANDY LOAM
10YR 3/1 VERY DARK GRAY	LOAMY SAND, FINE ROOTS
10YR 5/1 GRAY	SILTY CLAY
2.5Y 3/1 VERY DARK GRAY	SANDY LOAM
5GY 4/1 DARK GREENISH GRAY	CLAY
5GY 6/2 LT. OLIVE GRAY	SANDY CLAY LOAM
5GY 4/1 DARK GREENISH GRAY	SILTY CLAY
5GY 4/1 DARK GREENISH GRAY	**BOTTOM OF WELL AT 14 FEET** CLAY



SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-2
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/1/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: ONSLOW

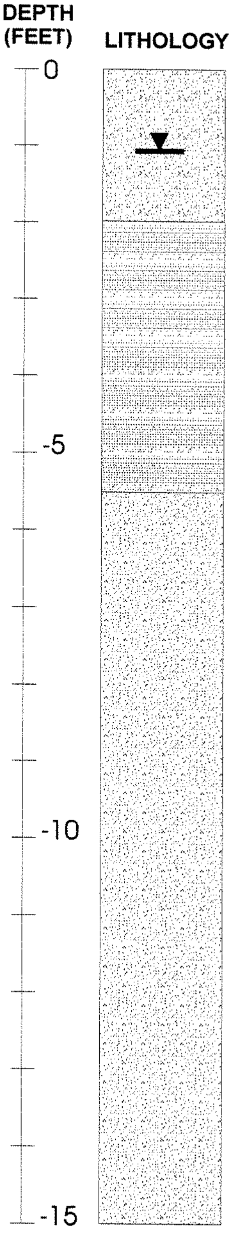


COLOR	DESCRIPTION
5Y 2.5/1 BLACK	LOAM, FINE ROOTS, OXIDIZED RHIZOSPHERE
	WATER LEVEL 4.88' BELOW TOP OF CASING
2.5Y 6/4 LT. YELLOWISH BROWN	SANDY LOAM
2.5Y 6/4 LT. YELLOWISH BROWN	SANDY LOAM
2.5Y 5/2 GRAYISH BROWN	SANDY LOAM
10YR 5/1 GRAY	SANDY LOAM
10YR 5/1 GRAY	SANDY LOAM
	BOTTOM OF WELL AT 14 FEET
5Y 7/1 LT. GRAY	SAND

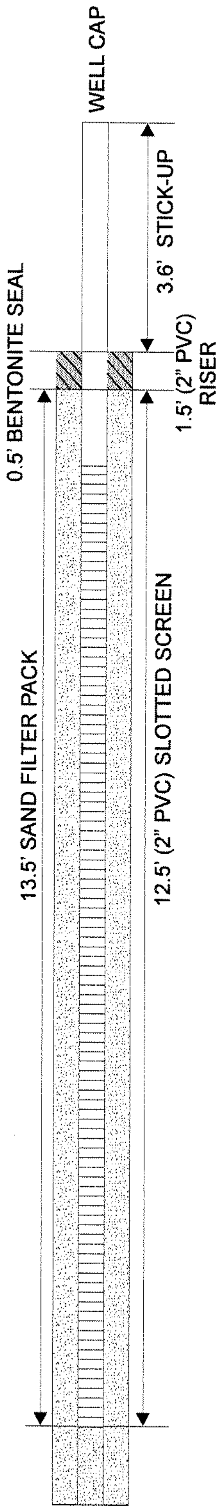
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-3
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/1/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: ONSLOW



COLOR	DESCRIPTION
2.5Y 5/4 LT. OLIVE BROWN	SANDY LOAM, DARK GRAYISH BROWN MOTTLES (2.5Y 4/2) **WATER LEVEL 4.88' BELOW TOP OF CASING**
2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM. BROWNISH YELLOW MOTTLES (10YR 6/8)
2.5Y 6/2 LT. BROWNISH GRAY	SANDY CLAY LOAM (10YR 6/8)
7.5YR 5/2 BROWN	LOAMY SAND
7.5YR 7/1 LT. GRAY	SAND
7.5YR 7/1 LT. GRAY	SAND
7.5YR 7/1 LT. GRAY	SAND
	BOTTOM OF WELL AT 14 FEET
7.5YR 7/1 LT. GRAY	SAND



SOIL BORING LOG
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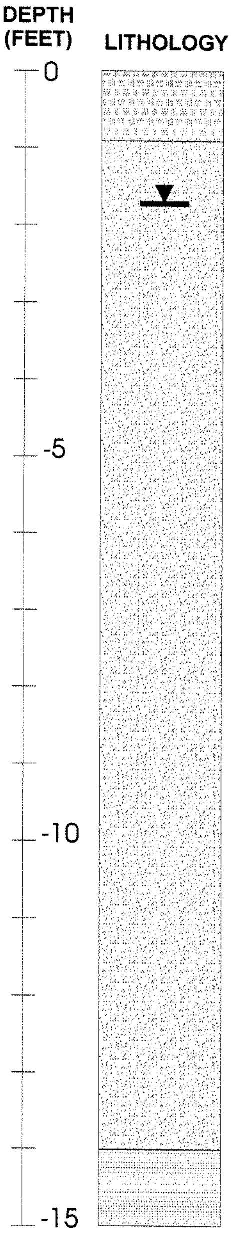
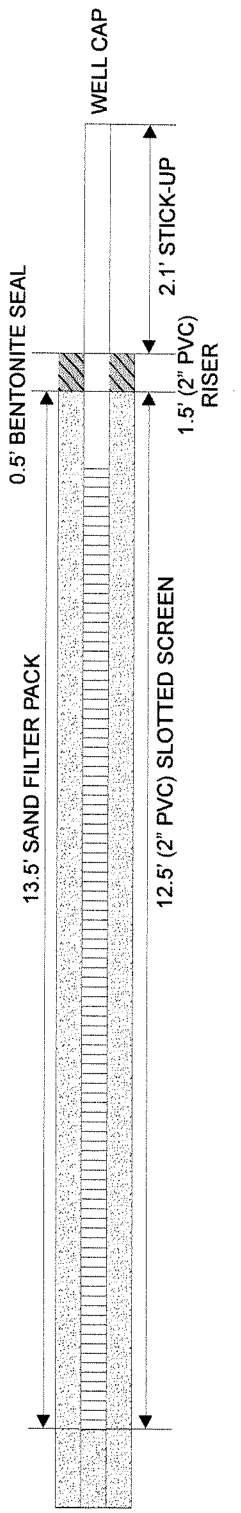
Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-4
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/1/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: PANTEGO



COLOR	DESCRIPTION
10YR 2/1 BLACK	LOAM, FINE ROOTS
2.5Y 5/2 GRAYISH BROWN	SANDY LOAM **WATER LEVEL: 3.80' BELOW TOP OF CASING**
10YR 5/2 GRAYISH BROWN	SANDY LOAM
10YR 5/2 GRAYISH BROWN	SANDY LOAM
10YR 5/2 GRAYISH BROWN	SANDY LOAM
5GY 5/1 LT. GREENISH GRAY	SANDY LOAM
5GY 5/1 GREENISH GRAY	SANDY LOAM, INCREASING CLAY **BOTTOM OF WELL AT 14 FEET**
5GY 5/1 GREENISH GRAY	SANDY CLAY



SOIL BORING LOG
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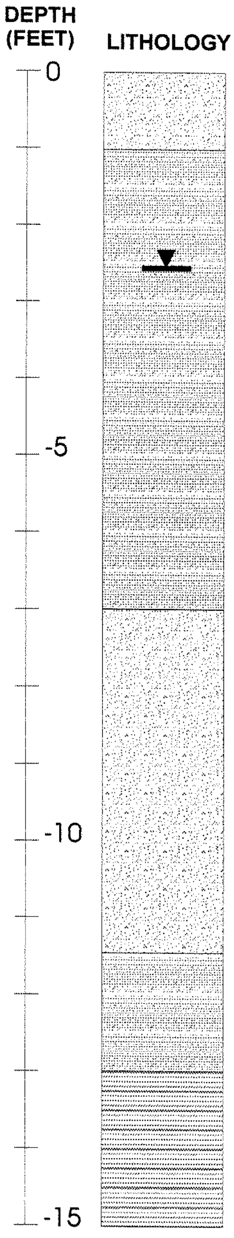
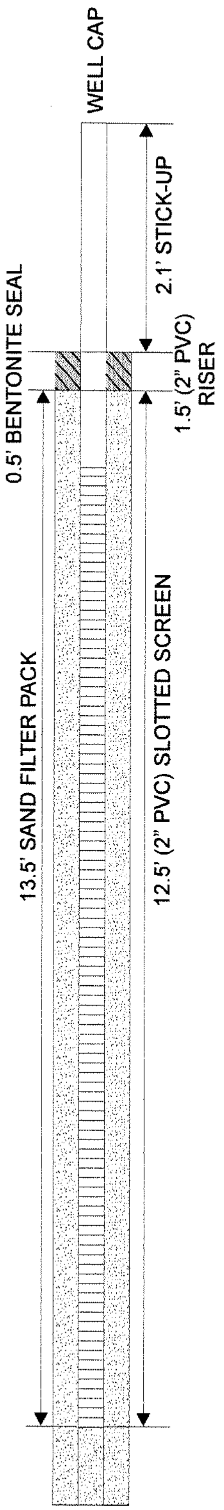
Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-5
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25” ID HSA
LOGGED BY: BCC
SOIL TYPE: TORHUNTA



COLOR	DESCRIPTION
10YR 2/1 BLACK	SANDY LOAM, ROOTS
10YR 3/1 VERY DARK GRAY	SANDY CLAY LOAM, FEW FINE ROOTS, SOME SMALL QUARTZ PEBBLES **WATER LEVEL: 4.43’ BELOW TOP OF CASING**
2.5Y 6/2 LT. BROWNISH GRAY	SANDY CLAY
10YR 3/1 VERY DARK GRAY	SANDY CLAY
7.5YR 5/2 BROWN	LOAMY SAND
2.5YR 2.5/1 BLACK	SANDY LOAM
10Y 5/1 GRAY	SANDY CLAY, VERY DARK GRAY MOTTLES (10Y 3/1)
5GY 5/1 GREENISH GRAY	CLAY **BOTTOM OF WELL AT 14 FEET**

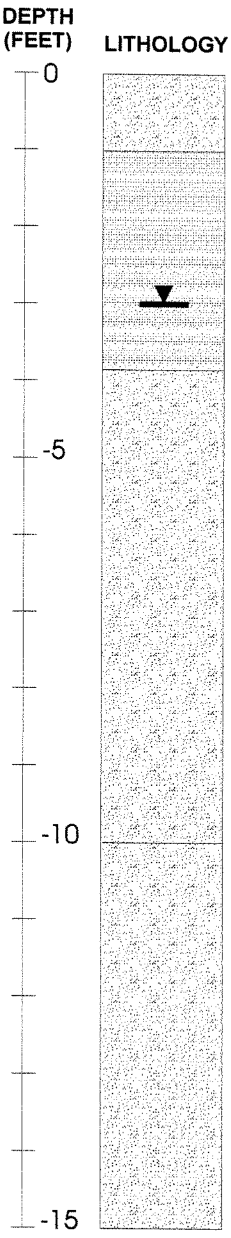


SOIL BORING LOG
CLAYHILL FARMS

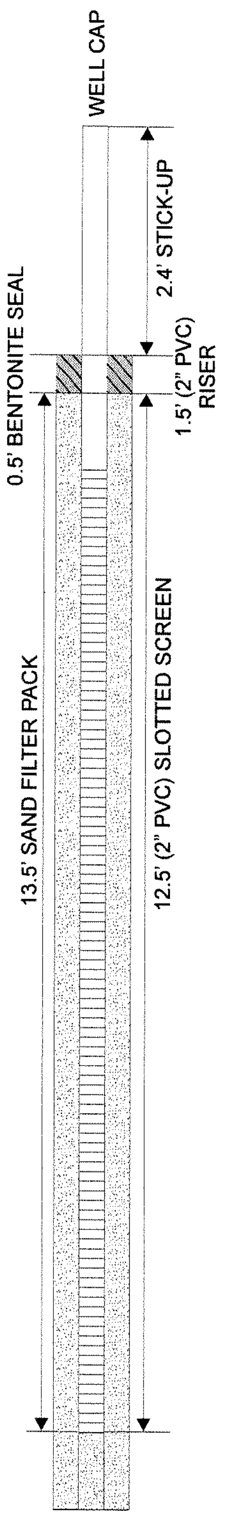
Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-6
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: TORHUNTA

DEPTH (FEET) **LITHOLOGY**



COLOR	DESCRIPTION
10YR 2/1 BLACK	SANDY LOAM
2.5Y 5/2 GRAYISH BROWN	SANDY CLAY LOAM. OXIDIZED RHIZOSPHERE INDISTINCT LARGE MOTTLES (10YR 4/1)
	WATER LEVEL: 5.4' BELOW TOP OF CASING.
2.5Y 6/2 LT. BROWNISH GRAY	SANDY CLAY, LARGE INDISTINCT MOTTLES (10YR 5/2)
5YR 5/1 GRAY	SANDY LOAM
10YR 5/3 BROWN	LOAMY SAND, LARGE INDISTINCT MOTTLES
5GY 3/1 DARK GREENISH GRAY	SANDY LOAM
5GY 3/1 DARK GREENISH GRAY	**BOTTOM OF WELL AT 14 FEET** SANDY LOAM

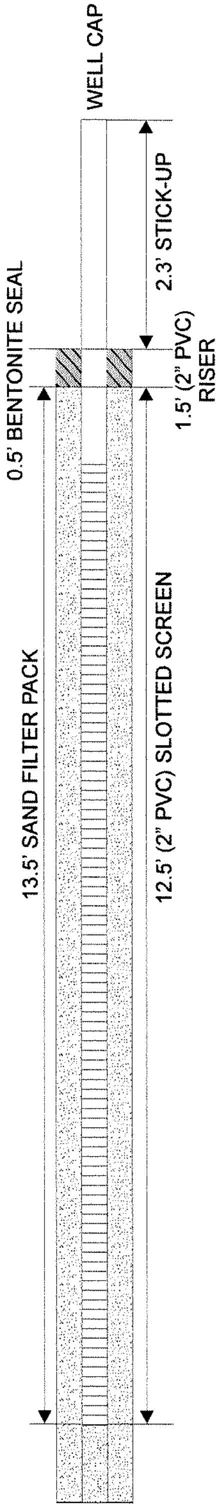


SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-7
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25” ID HSA
LOGGED BY: BCC
SOIL TYPE: TORHUNTA

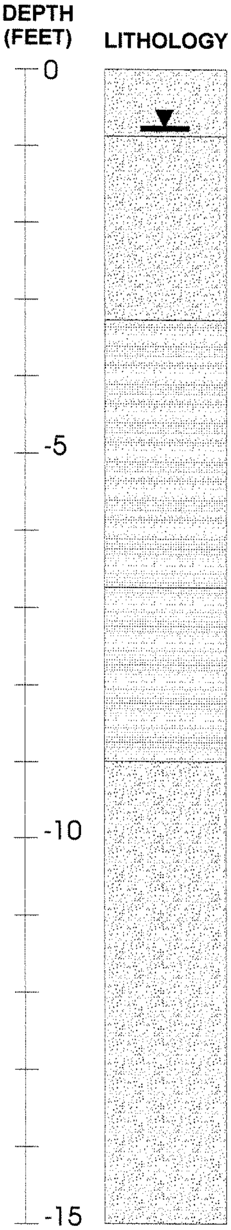
DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10 YR 3/1 VERY DARK GRAY	SANDY LOAM, FINE ROOTS
	▼	2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM, LARGE INDISTINCT MOTTLES (7.5Y 5/8) **WATER LEVEL: 4.85’ BELOW TOP OF CASING.**
		2.5Y 6/2 LT. BROWNISH GRAY	SANDY LOAM, LARGE INDISTINCT MOTTLES (10YR 6/6)
-5		10YR 7/1 LT. GRAY	LOAMY SAND, MEDIUM INDISTINCT GRAY MOTTLES (N5/1)
-10		10YR 7/1 LT. GRAY	LOAMY SAND, MEDIUM INDISTINCT GRAY MOTTLES (N5/1)
-15		10YR 5/1 GRAY	SANDY LOAM **BOTTOM OF WELL AT 14 FEET**



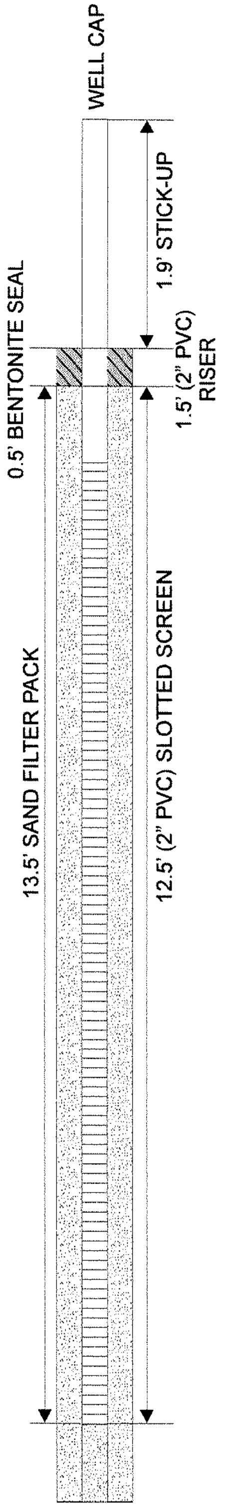
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-8
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: TORHUNTA



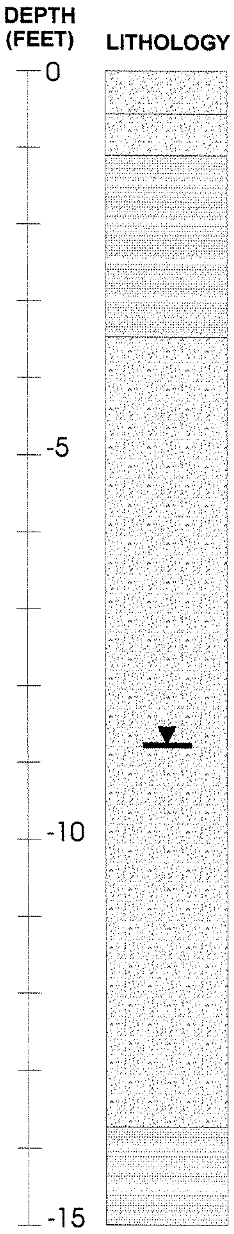
COLOR	DESCRIPTION
10YR 2/1 BLACK	SANDY LOAM, ROOTS, VEGETATION **STATIC WATER LEVEL: 2.59' BELOW TOP OF CASING.**
10YR 5/1 GRAY	SANDY LOAM
2.5Y 7/2 LT. GRAY	SANDY CLAY, FEW FINE MOTTLES, LARGE ROOTS
10Y 5/1 GRAY	SANDY CLAY, LARGE ROOTS
5GY 5/1 GREENISH GRAY	SANDY LOAM
5GY 5/1 GREENISH GRAY	SANDY LOAM
	BOTTOM OF WELL AT 14 FEET GRADES TO SANDY CLAY



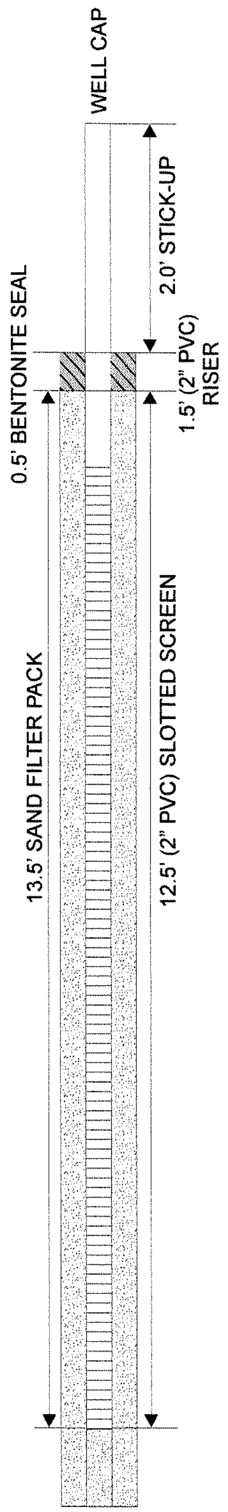
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-9
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: MARVYN



COLOR	DESCRIPTION
10YR 3/1 V. DK. GRAY	SANDY LOAM
2.5Y 5/4 LT. OLIVE BRN.	SANDY LOAM, FEW ROOTS, LARGE INDISTINCT MOTTLES (10YR 2/2)
2.5Y 7/6 YELLOW	SANDY CLAY LOAM, FEW FINE ROOTS
2.5Y 7/2 LT.GRAY	SANDY LOAM, FINE INDISTINCT MOTTLES (10YR 6/6) **WATER LEVEL: 10.96" BELOW TOP OF CASING.** INDISTINCT MOTTLES, EVENTUALLY ALL ORANGE SANDY LOAM
7.5YR 6/8 REDDISH YELLOW	**BOTTOM OF WELL AT 14 FEET** SANDY CLAY LOAM, 7.5YR 7/1 MOTTLES
5GY 4/1 DK. GREENISH GRAY	SANDY CLAY



SOIL BORING LOG
CLAYHILL FARMS

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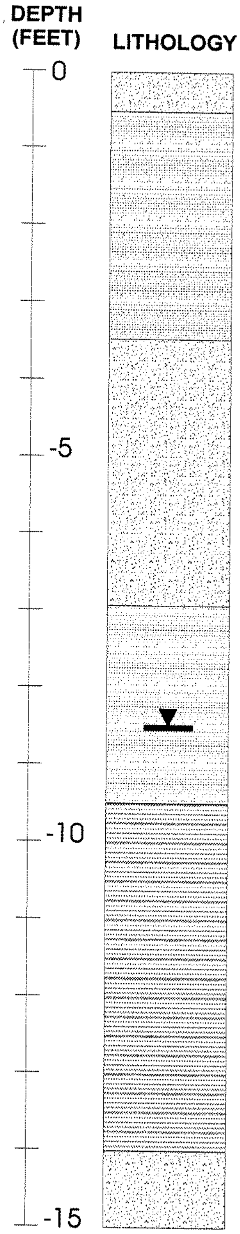
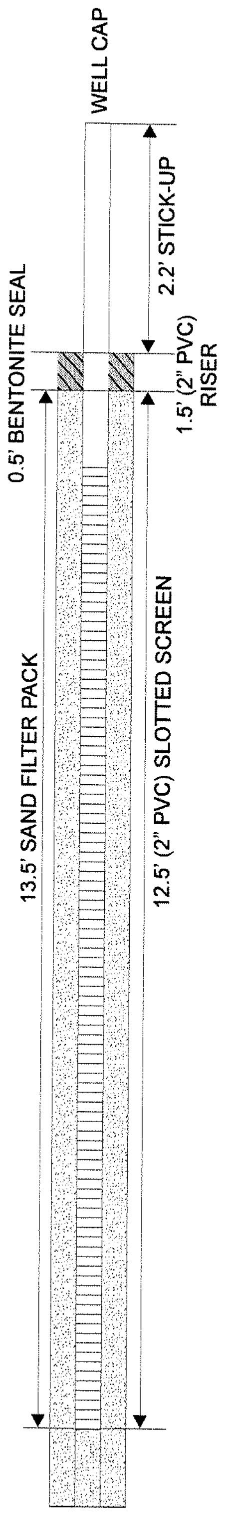
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-10
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: MARVYN



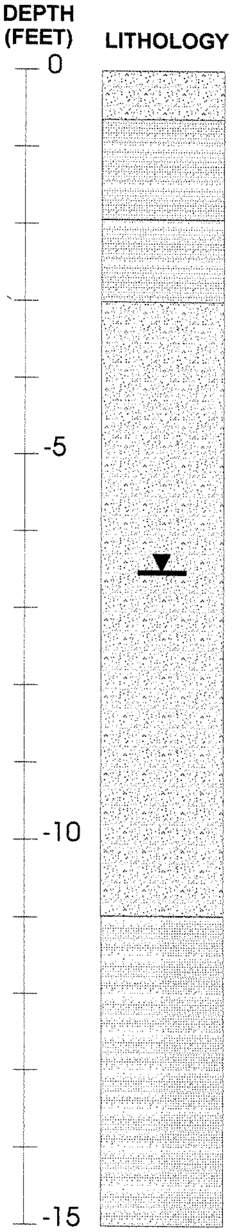
COLOR	DESCRIPTION
2.5Y 3/2 V.DK. GRAYISH BRN.	SANDY LOAM, ROOTS
2.5Y 7/2 LT. GRAY	SANDY CLAY LOAM, MEDIUM INDISTINCT MOTTLES (10YR 2/2)
2.5Y 6/4 LT. YELLOWISH BROWN	SANDY LOAM
10YR 6/6 BROWNISH YELLOW	SANDY CLAY LOAM, SMALL INDISTINCT MOTTLES (10YR 5/1) **STATIC WATER LEVEL: 10.96' BELOW TOP OF CASING.**
10YR 6/6 BROWNISH YELLOW	CLAY, LIGHT GRAY, LARGE INDISTINCT MOTTLES SANDY CLAY LOAM **BOTTOM OF WELL AT 14 FEET**
10YR 6/6 BROWNISH YELLOW	SANDY LOAM



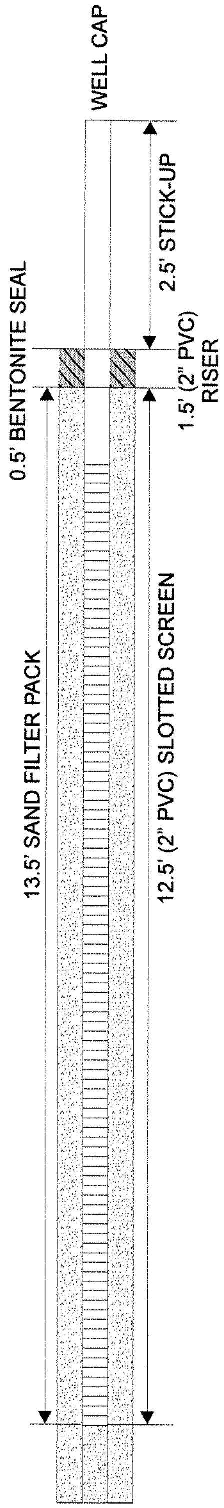
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-11
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: MARVYN



COLOR	DESCRIPTION
10YR 2/2 VY.DRK.BRN	SANDY LOAM, FEW ROOTS
2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM
10YR 6/4 LT. GRAY	SANDY CLAY, STRONG BROWN LARGE DISTINCT MOTTLES (7.5YR 5/8), FEW FINE ROOTS
	LOAMY SAND **WATER LEVEL: 8.98' BELOW TOP OF CASING.** SAND
10YR 6/6 BROWNISH YELLOW	SANDY CLAY LOAM **BOTTOM OF WELL AT 14 FEET**
5YG 4/1 DARK GREENISH GRAY	SANDY CLAY



SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
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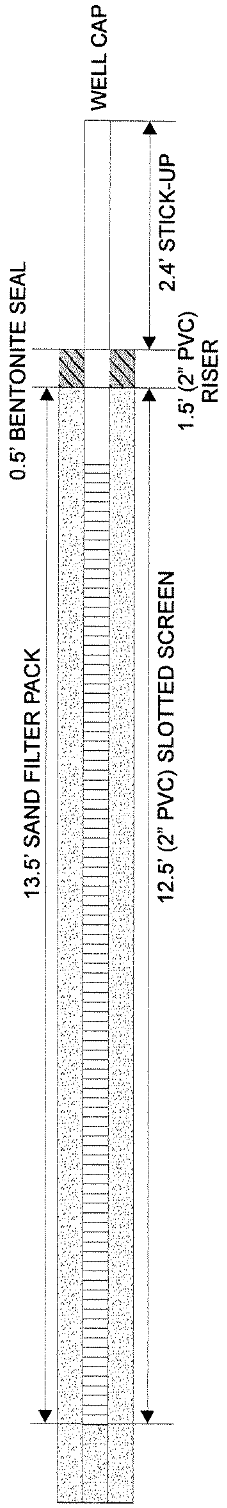
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-12
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: MUCKALEE

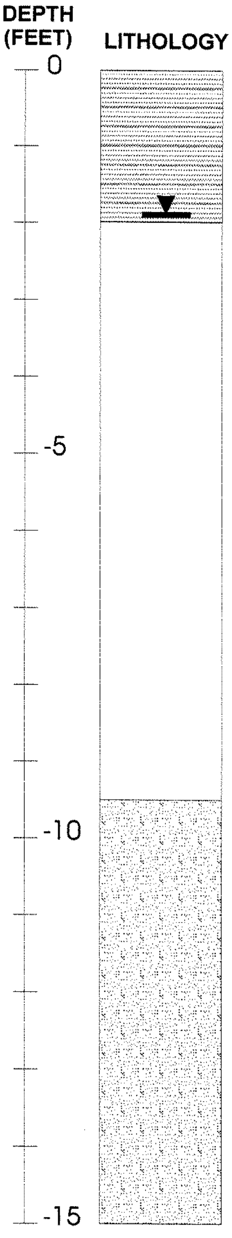
DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLK.	ORGANIC LAYER
		10YR 2/1 BLK.	LOAM, FINE ROOTS
		10YR 4/2 DARK GRAYISH BROWN	SANDY LOAM, VERY DARK BROWN, MEDIUM DISTINCT MOTTLES
	▼		**WATER LEVEL: 6.16' BELOW TOP OF CASING.**
-5		10YR 6/1 GRAY	LOAMY SAND, LARGE DISTINCT GRAY MOTTLES (N 5/1)
-10		10YR 6/1 GRAY	SANDY CLAY
		10B 2.5/1 BLUISH BLACK	SANDY LOAM **BOTTOM OF WELL AT 14 FEET**
-15		10B 2.5/1 BLUISH BLACK	LOAMY SAND



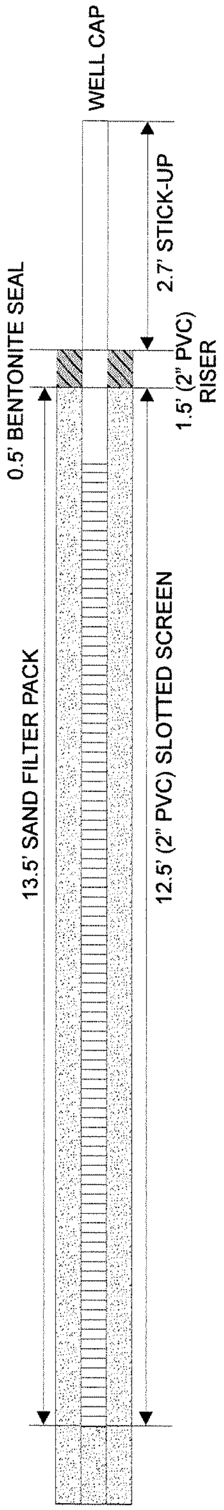
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-13
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: MARVYN



COLOR	DESCRIPTION
10YR 2/1 BLACK	CLAY LOAM, FINE ROOTS
	WATER LEVEL: 4.62' BELOW TOP OF CASING.
10YR 2/2 VERY DARK BROWN	CLAY LOAM
	MANY ROOTS
2.5Y 7/4 PALE YELLOW	LOAMY SAND
10YR 5/1 GRAY	COURSE SAND LAYER
2.5Y 7/4 PALE YELLOW	LOAMY SAND
	BOTTOM OF WELL AT 14 FEET



SOIL BORING LOG
CLAYHILL FARMS

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Engineers - Surveyors - Planners
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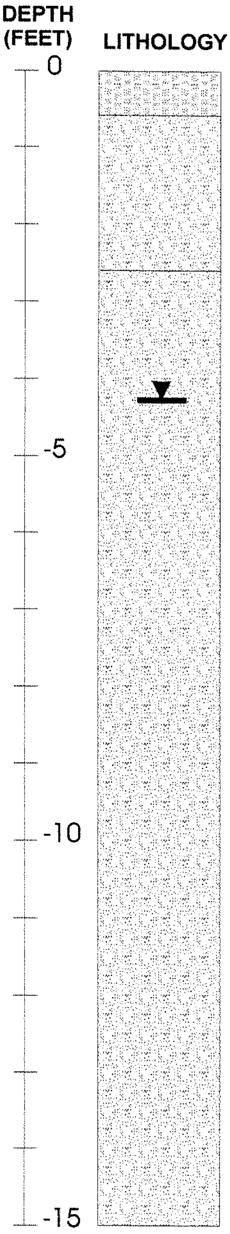
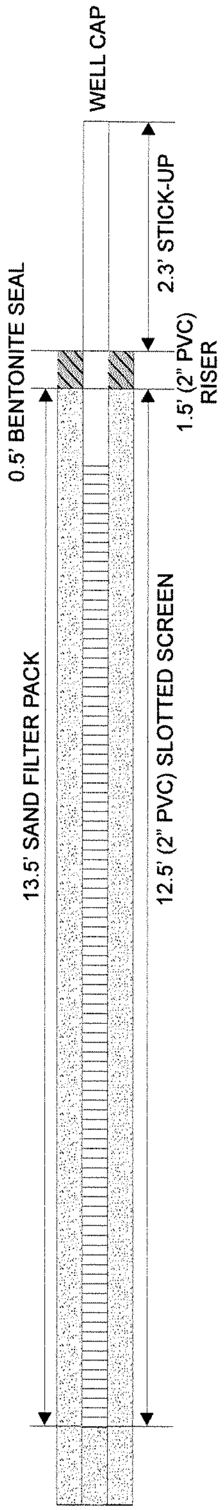
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-14
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/2/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: MARVYN



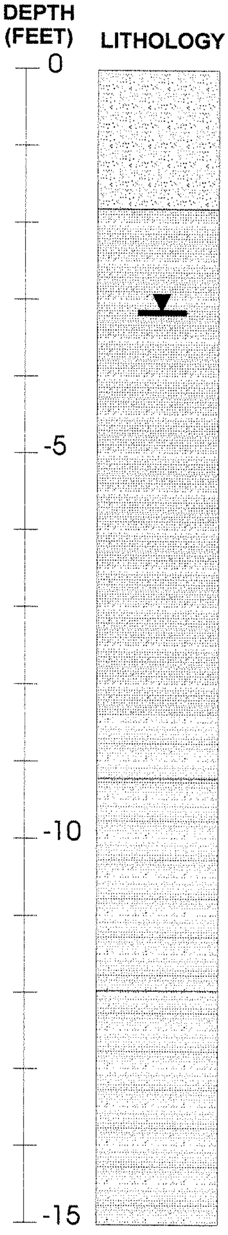
COLOR	DESCRIPTION
10YR 2/2 V.DK.BRN	ORGANIC LAYER
10YR 6/2 LT. BROWNISH GRAY	SANDY LOAM, OXIDIZED RHIZOSPHERE
10YR 7/1 LT. GRAY	LOAMY SAND **WATER LEVEL: 6.61' BELOW TOP OF CASING.** COARSENING SAND COMPONENT
10YR 6/8 BROWNISH YELLOW	LOAMY SAND **BOTTOM OF WELL AT 14 FEET**



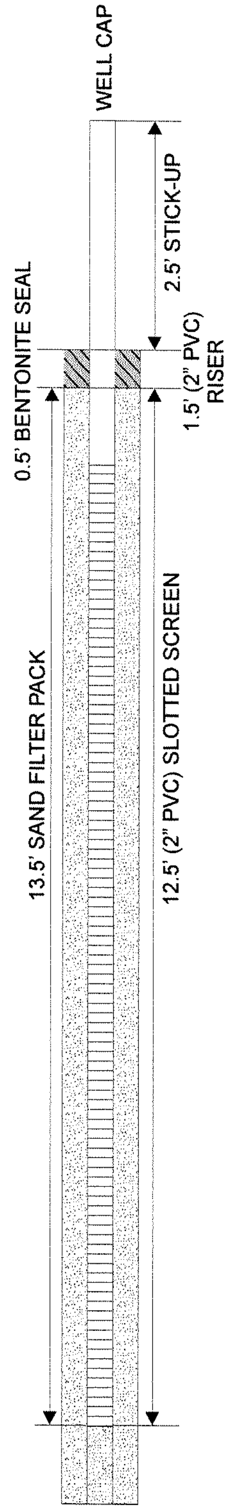
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-15
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/3/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: PANTEGO



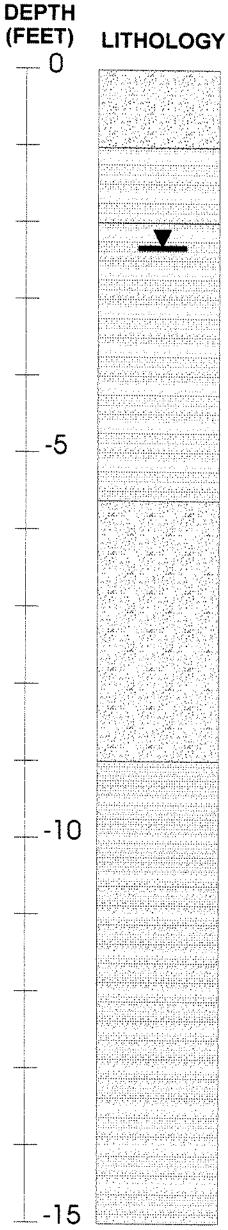
COLOR	DESCRIPTION
10YR 2/1 BLACK	SANDY LOAM, FINE ROOTS COMMON
10YR 5/2 GRAYISH BROWN	SANDY CLAY LOAM, FEW FINE ROOTS **WATER LEVEL: 5.7' BELOW TOP OF CASING.** GRADES TO LOAMY SAND
10YR 5/1 GRAY	SANDY CLAY LOAM, VERY DARK GRAY, LARGE INDISINCT MOTTLES
5GY 4/1 DARK GREENISH GRAY	SANDY CLAY, LARGE INDISTINCT MOTTLES (10B 3/1) **BOTTOM OF WELL AT 14 FEET**



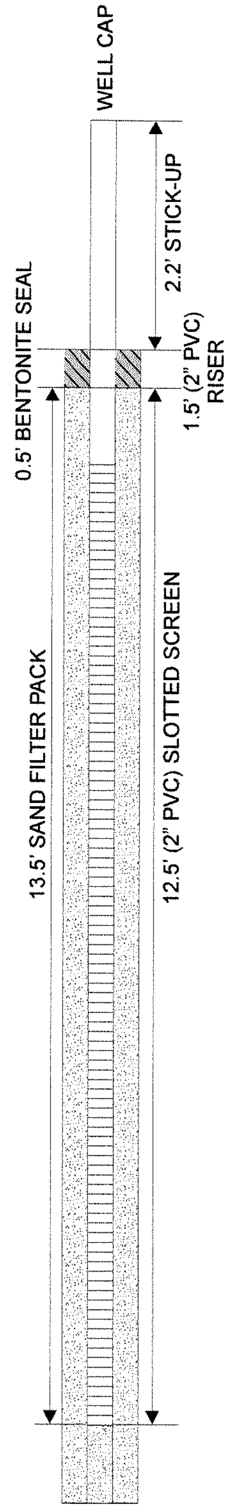
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-16
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/3/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: PANTEGO



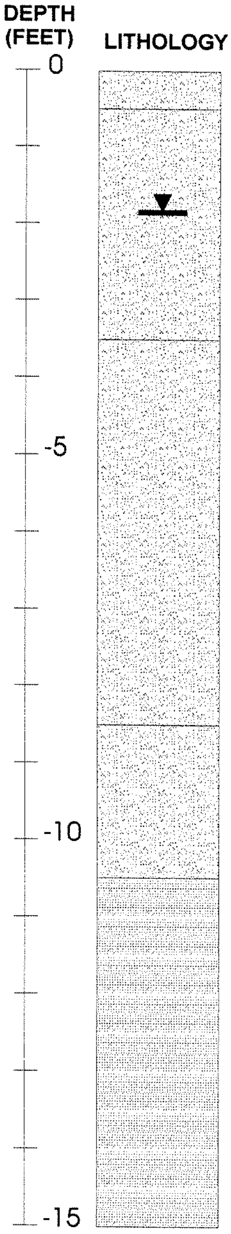
COLOR	DESCRIPTION
10YR 2/1 BLACK	SANDY LOAM, COMMON ROOTS
2.5Y 6/4 LT. YELLOWISH BROWN	SANDY CLAY LOAM, SMALL INDISTINCT MOTTLES (10YR 6/8)
10YR 5/1 GRAY	**STATIC WATER LEVEL: 4.46" BELOW TOP OF CASING.** SANDY CLAY, LARGE INDISTINCT MOTTLES (10YR 6/8)
7.5YR 4/1 DARK GRAY	LOAMY SAND
10GY 3/1 DARK GREENISH GRAY	SANDY CLAY LOAM **BOTTOM OF WELL AT 14 FEET**



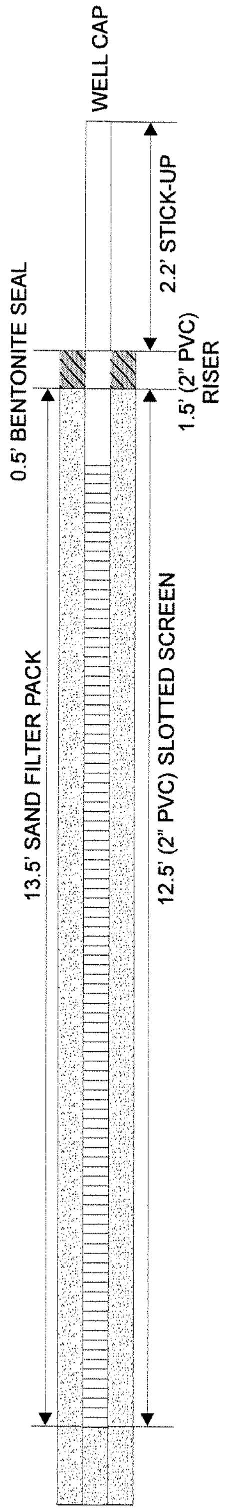
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-17
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/3/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: PANTEGO



COLOR	DESCRIPTION
10YR 2/1 BLK.	LOAM
2.5Y 6/2 LT. YELLOWISH BROWN	**WATER LEVEL: 4.22" BELOW TOP OF CASING.** SANDY LOAM, LARGE INDISTINCT COMMON MOTTLES (10YR 6/8)
7.5YR 4/1 DARK GRAY	LOAMY SAND
5Y 6/1 GRAY	LOAMY FINE SAND
10G 4/1 DARK GREENISH GRAY N 5/1 GRAY	SANDY CLAY **BOTTOM OF WELL AT 14 FEET** COURSE SAND



SOIL BORING LOG
CLAYHILL FARMS

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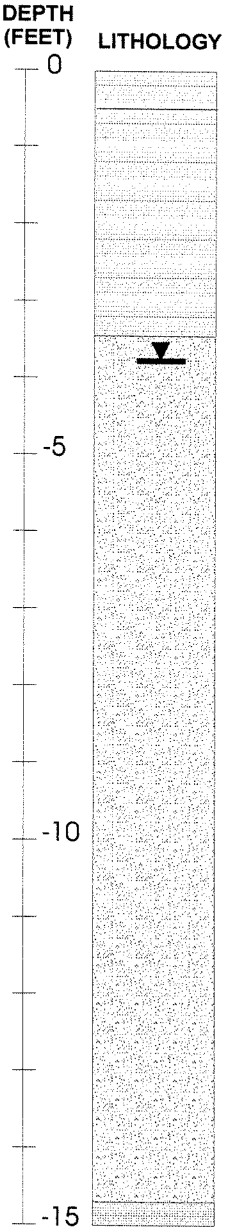
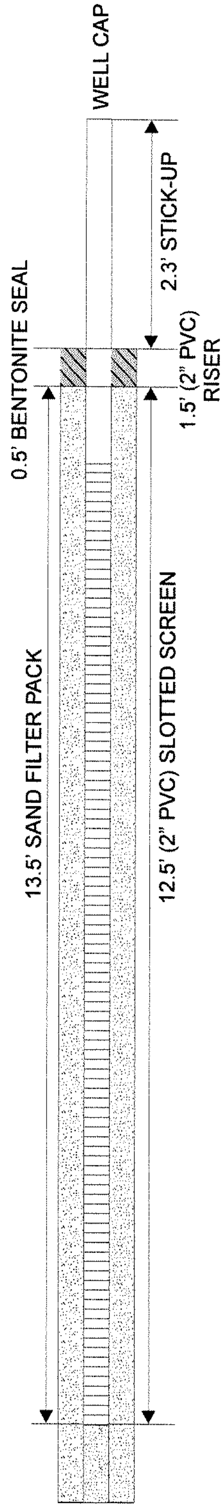
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-18
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/3/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: ONSLOW



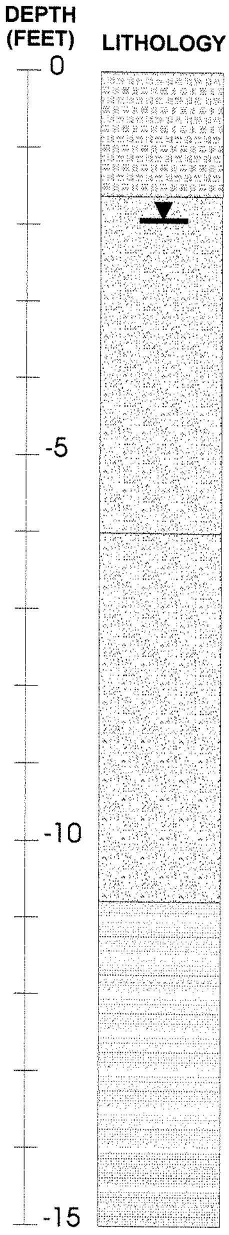
COLOR	DESCRIPTION
10YR 2/1 BLK.	LOAM
10YR 5/2 GRAYISH BROWN	SANDY CLAY LOAM, BROWNISH YELLOW, MEDIUM INDISTINCT MOTTLES (10YR 6/8)
7.5YR 5/3 BROWN	**WATER LEVEL: 6.01' BELOW TOP OF CASING.** LOAMY SAND
7.5YR 5/3 BROWN	LOAMY SAND, SOME DARK GRAY, LARGE INDISTINCT MOTTLES (N 4/1) **BOTTOM OF WELL AT 14 FEET**
10Y 3/1	SANDY CLAY LOAM



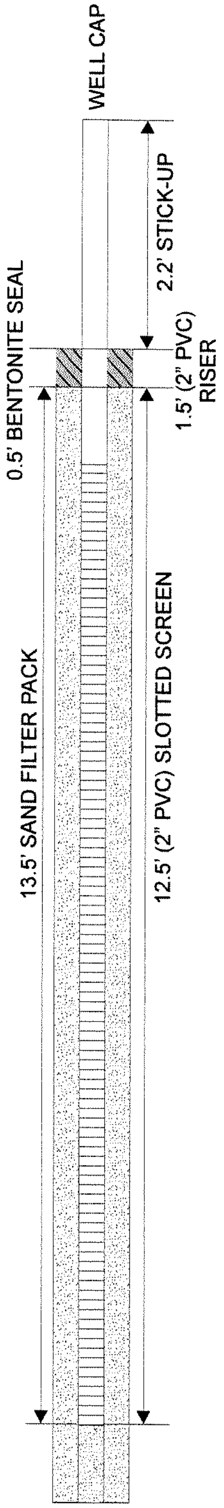
SOIL BORING LOG
CLAYHILL FARMS

Langley and McDonald, P.C.
Engineers - Surveyors - Planners
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-19
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/3/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: TORHUNTA



COLOR	DESCRIPTION
10YR 2/1 BLACK	LOAM, COMMON ROOTS
2.5Y 6/2 LT. BROWNISH GRAY	**WATER LEVEL: 4.16' BELOW TOP OF CASING.** SANDY LOAM, VERY DARK GRAYISH BROWN, LARGE INDISTINCT MOTTLES (10YR 3/2)
2.5Y 6/2 LT. BROWNISH GRAY	LOAMY SAND
10GY 2.5/1 DK. GREENISH GRAY 10GY 2.5/1	SANDY CLAY LOAM **BOTTOM OF WELL AT 14 FEET** SANDY CLAY LOAM



SOIL BORING LOG
CLAYHILL FARMS

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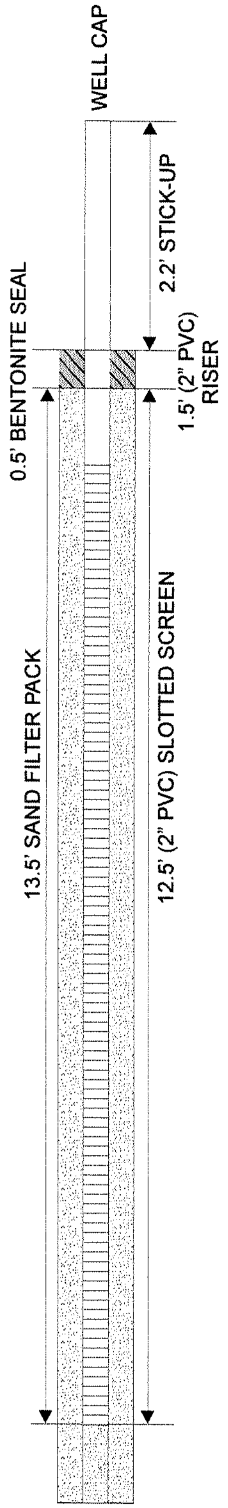
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

WELL No: DMW-20
PROJECT: 1960024-203.00
CLIENT: NCDOT
DATE DRILLED: 2/3/99
DRILLED BY: FISHBURNE DRILLING
DRILLING METHOD: 4.25" ID HSA
LOGGED BY: BCC
SOIL TYPE: ONSLOW

DEPTH (FEET)	LITHOLOGY	COLOR	DESCRIPTION
0		10YR 2/1 BLACK	LOAM, ROOTS COMMON
-5		10YR 4/2 DARK GRAYISH BROWN	SANDY CLAY, YELLOWISH BROWN, SMALL INDISTINCT MOTTLES **WATER LEVEL: 5.79' BELOW TOP OF CASING.**
-10		2.5Y 5/2 GRAYISH BROWN	LOAMY SAND
		2.5Y 6/2 LT. BROWNISH GRAY	FINE MEDIUM SAND **BOTTOM OF WELL AT 14 FEET**
-15		5Y 7/1 LT. GRAY	SAND



SOIL BORING LOG
CLAYHILL FARMS

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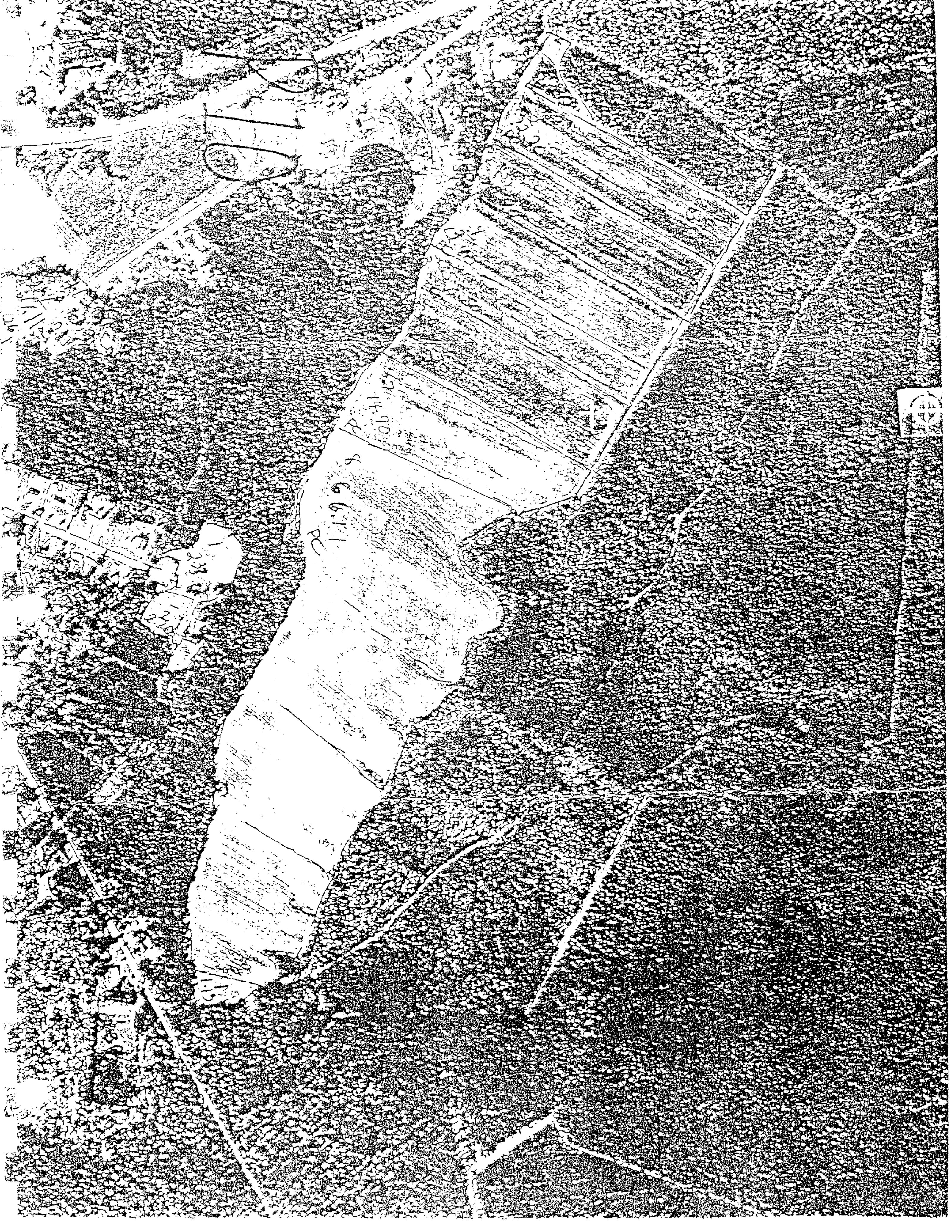
Landscape Architects - Environmental Consultants
VIRGINIA BEACH WILLIAMSBURG

APPENDIX B

NRCS PRIOR-CONVERTED CROPLAND DETERMINATION


R10
1
2.20
2
12.20
PC
3
11.90
4
13.40
PC
5 8.50
PC
6 14.30
~~8.90~~
R
7 14.70
~~8.90~~
R
8
66.11
PC
T1379
1
11.24
2
1.28
3
3.43
4
4.90
5
16.12
6
2.03
1
2.3
2
2.70
T1378
1
1.13
T1345
1
2.30

of
farm
6


232
R
14.70
8
6.11
PC
233
22

APPENDIX C

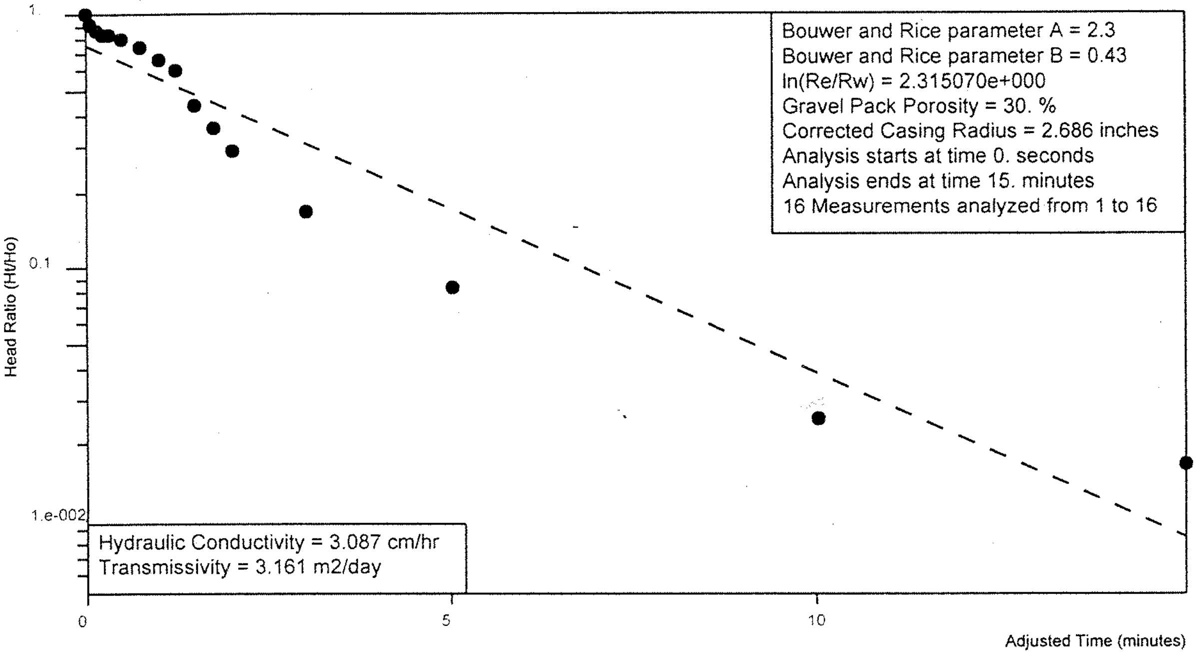
DRAINMOD & SURFACE WATER HYDROLOGY TECHNICAL APPENDIX

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-1



Bouwer and Rice parameter A = 2.3
Bouwer and Rice parameter B = 0.43
ln(Re/Rw) = 2.315070e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 3.087 cm/hr
Transmissivity = 3.161 m2/day

Ho is 1.2 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-1
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	3.05 feet
Water Table to Screen Bottom:	10.95 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

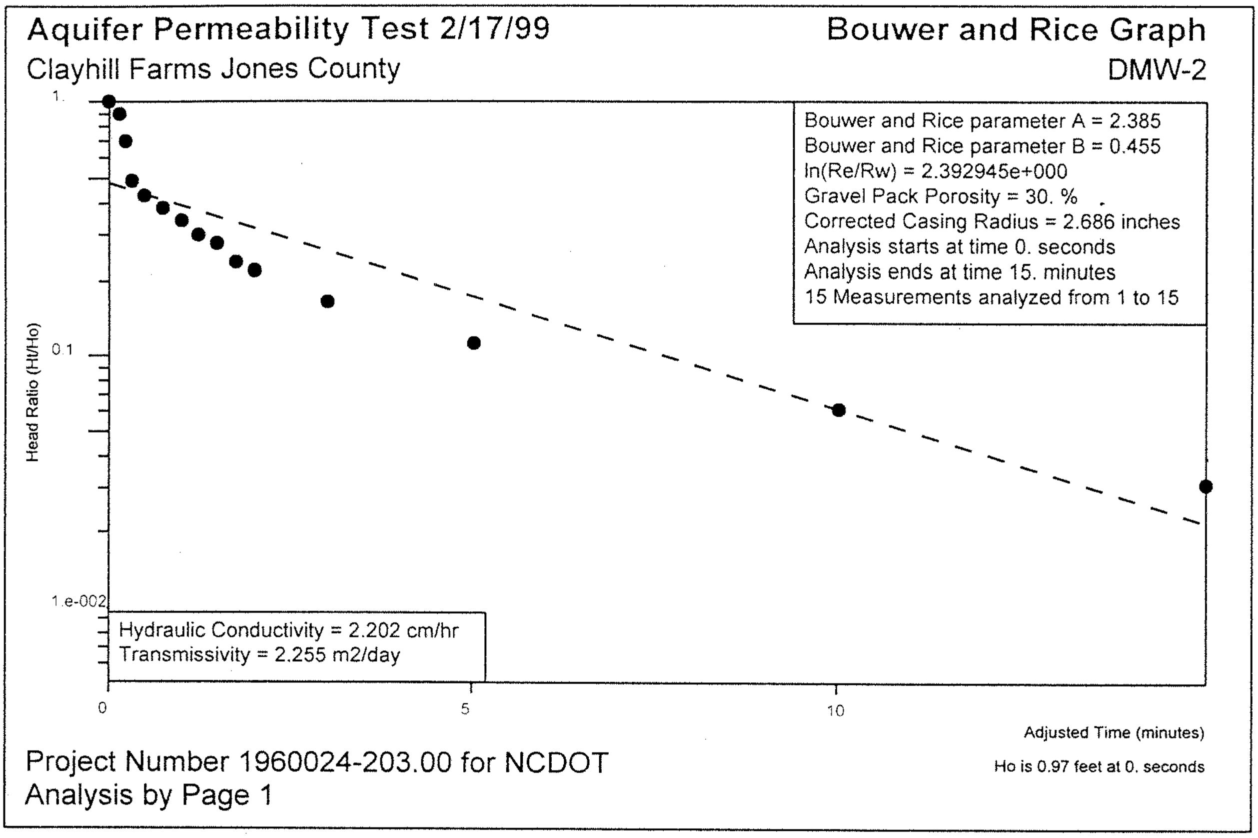
Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.2 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	4.25	1.2	1.
2	8.3e-002	8.3e-002	4.15	1.1	0.9167
3	0.166	0.166	4.1	1.05	0.875
4	0.25	0.25	4.06	1.01	0.8417
5	0.333	0.333	4.05	1.	0.8333
6	0.5	0.5	4.01	0.96	0.8
7	0.75	0.75	3.94	0.89	0.7417
8	1.	1.	3.85	0.8	0.6667
9	1.25	1.25	3.78	0.73	0.6083
10	1.5	1.5	3.58	0.53	0.4417
11	1.75	1.75	3.48	0.43	0.3583
12	2.	2.	3.4	0.35	0.2917
13	3.	3.	3.25	0.2	0.1667
14	5.	5.	3.15	0.1	8.333e-002
15	10.	10.	3.08	3.e-002	2.5e-002
16	15.	15.	3.07	2.e-002	1.667e-002



Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-2

Bouwer and Rice parameter A = 2.385
Bouwer and Rice parameter B = 0.455
ln(Re/Rw) = 2.392945e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 2.202 cm/hr
Transmissivity = 2.255 m2/day

Ho is 0.97 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

11/03/1999

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-2
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.88 feet
Water Table to Screen Bottom:	12.22 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0
There are 15 time and drawdown measurements
Maximum head is 0.97 feet
Minimum head is 0. feet

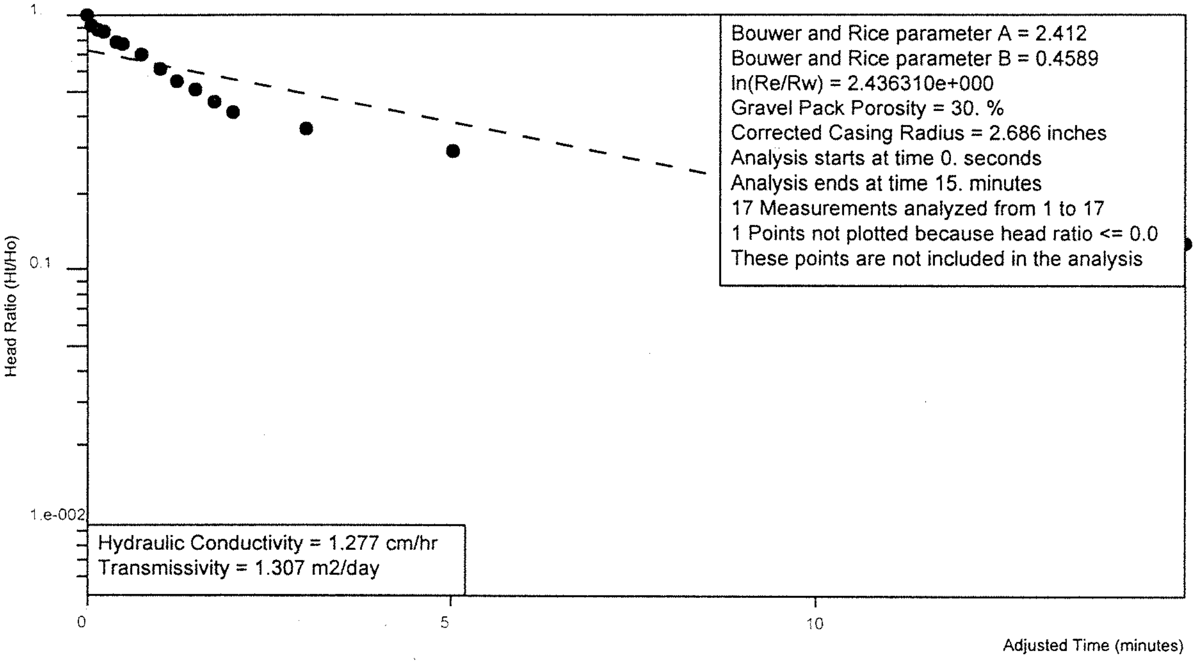
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.85	0.97	1.
2	0.166	0.166	5.76	0.88	0.9072
3	0.25	0.25	5.56	0.68	0.701
4	0.333	0.333	5.36	0.48	0.4948
5	0.5	0.5	5.3	0.42	0.433
6	0.75	0.75	5.25	0.37	0.3814
7	1.	1.	5.21	0.33	0.3402
8	1.25	1.25	5.17	0.29	0.299
9	1.5	1.5	5.15	0.27	0.2784
10	1.75	1.75	5.11	0.23	0.2371
11	2.	2.	5.09	0.21	0.2165
12	3.	3.	5.04	0.16	0.1649
13	5.	5.	4.99	0.11	0.1134
14	10.	10.	4.94	6.e-002	6.186e-002
15	15.	15.	4.91	3.e-002	3.093e-002

Aquifer Permeability Test 2/17/99

Bouwer and Rice Graph

Clayhill Farms Jones County

DMW-3



Bouwer and Rice parameter A = 2.412
Bouwer and Rice parameter B = 0.4589
ln(Re/Rw) = 2.436310e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
17 Measurements analyzed from 1 to 17
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 1.277 cm/hr
Transmissivity = 1.307 m2/day

Ho is 4.9 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-3
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.88 feet
Water Table to Screen Bottom:	12.72 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

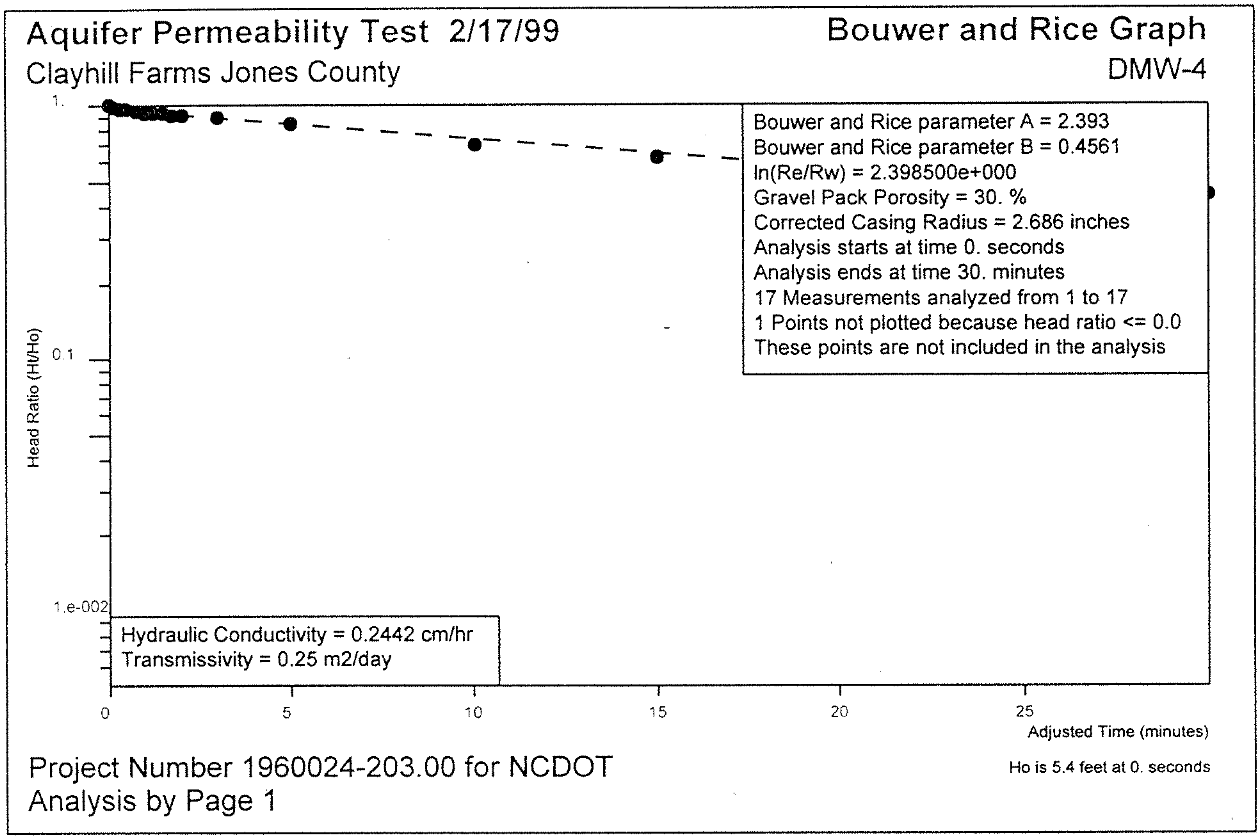
Test starts with trial 0

There are 17 time and drawdown measurements

Maximum head is 4.9 feet

Minimum head is -4.88 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.78	4.9	1.
2	8.3e-002	8.3e-002	9.36	4.48	0.9143
3	0.166	0.166	9.25	4.37	0.8918
4	0.25	0.25	9.1	4.22	0.8612
5	0.416	0.416	8.76	3.88	0.7918
6	0.5	0.5	8.64	3.76	0.7673
7	0.75	0.75	8.32	3.44	0.702
8	1.	1.	7.93	3.05	0.6224
9	1.25	1.25	7.6	2.72	0.5551
10	1.33	1.33	0.	-4.88	-0.9959
11	1.5	1.5	7.39	2.51	0.5122
12	1.75	1.75	7.1	2.22	0.4531
13	2.	2.	6.93	2.05	0.4184
14	3.	3.	6.63	1.75	0.3571
15	5.	5.	6.31	1.43	0.2918
16	10.	10.	5.82	0.94	0.1918
17	15.	15.	5.5	0.62	0.1265



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-4

Bouwer and Rice parameter A = 2.393
Bouwer and Rice parameter B = 0.4561
ln(Re/Rw) = 2.398500e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 30. minutes
17 Measurements analyzed from 1 to 17
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 0.2442 cm/hr
Transmissivity = 0.25 m2/day

Ho is 5.4 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-4
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	3.8 feet
Water Table to Screen Bottom:	12.3 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 17 time and drawdown measurements

Maximum head is 5.4 feet

Minimum head is -3.8 feet

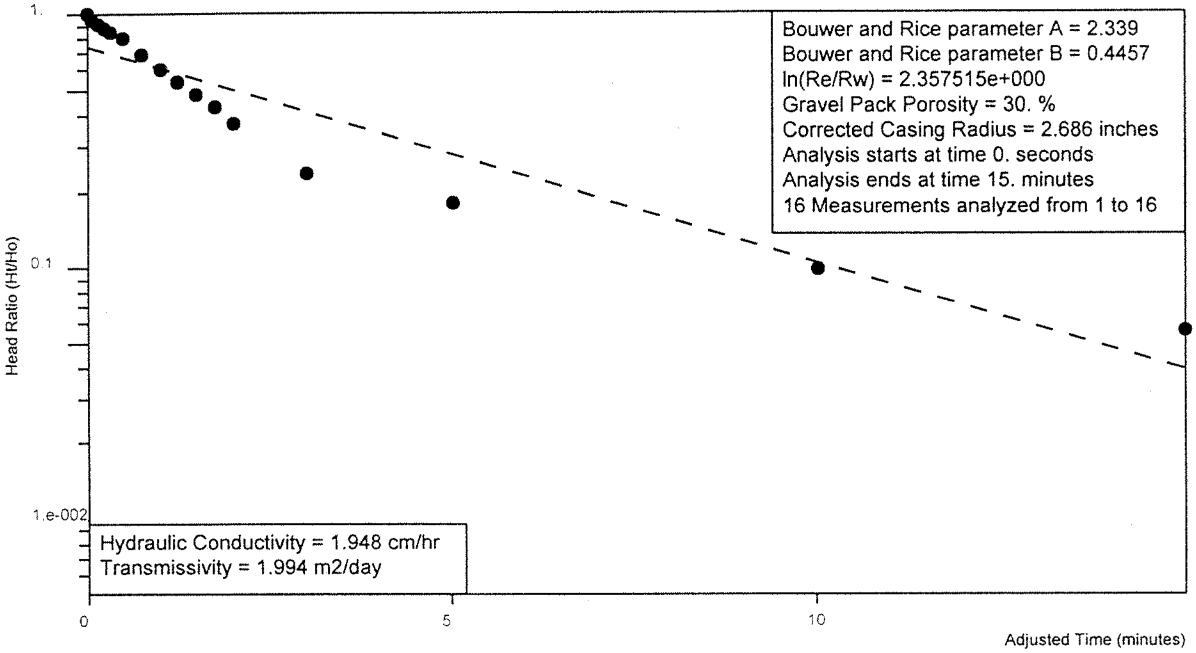
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.2	5.4	1.
2	0.166	0.166	9.12	5.32	0.9852
3	0.25	0.25	0.	-3.8	-0.7037
4	0.333	0.333	9.06	5.26	0.9741
5	0.5	0.5	9.01	5.21	0.9648
6	0.75	0.75	8.95	5.15	0.9537
7	1.	1.	8.9	5.1	0.9444
8	1.25	1.25	8.86	5.06	0.937
9	1.5	1.5	8.81	5.01	0.9278
10	1.75	1.75	8.77	4.97	0.9204
11	2.	2.	8.73	4.93	0.913
12	3.	3.	8.69	4.89	0.9056
13	5.	5.	8.39	4.59	0.85
14	10.	10.	7.62	3.82	0.7074
15	15.	15.	7.2	3.4	0.6296
16	20.	20.	6.84	3.04	0.563
17	30.	30.	6.2	2.4	0.4444

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-5



Bouwer and Rice parameter A = 2.339
Bouwer and Rice parameter B = 0.4457
ln(Re/Rw) = 2.357515e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 1.948 cm/hr
Transmissivity = 1.994 m2/day

Ho is 5.77 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

11/03/1999

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-5
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.43 feet
Water Table to Screen Bottom:	11.67 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 5.77 feet

Minimum head is 0. feet

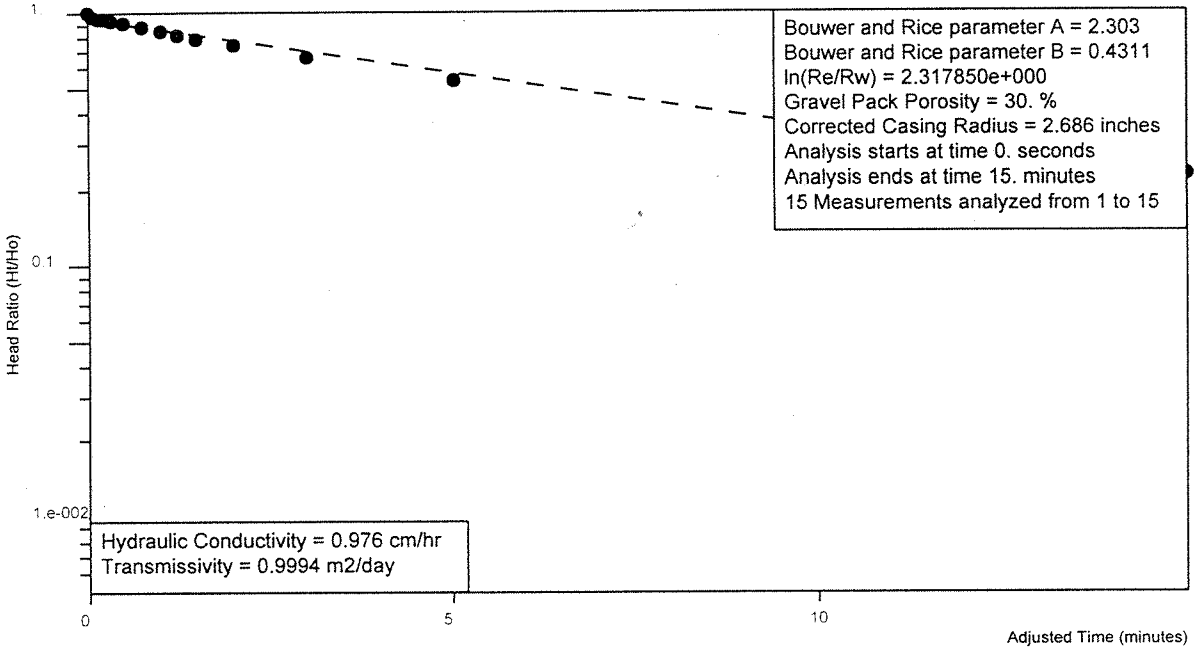
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	10.2	5.77	1.
2	8.3e-002	8.3e-002	9.98	5.55	0.9619
3	0.166	0.166	9.7	5.27	0.9133
4	0.25	0.25	9.5	5.07	0.8787
5	0.333	0.333	9.3	4.87	0.844
6	0.5	0.5	9.04	4.61	0.799
7	0.75	0.75	8.41	3.98	0.6898
8	1.	1.	7.93	3.5	0.6066
9	1.25	1.25	7.53	3.1	0.5373
10	1.5	1.5	7.2	2.77	0.4801
11	1.75	1.75	6.9	2.47	0.4281
12	2.	2.	6.56	2.13	0.3692
13	3.	3.	5.79	1.36	0.2357
14	5.	5.	5.48	1.05	0.182
15	10.	10.	5.	0.57	9.879e-002
16	15.	15.	4.75	0.32	5.546e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-6



Bouwer and Rice parameter A = 2.303
Bouwer and Rice parameter B = 0.4311
ln(Re/Rw) = 2.317850e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 0.976 cm/hr
Transmissivity = 0.9994 m2/day

Ho is 3.23 feet at 0. seconds

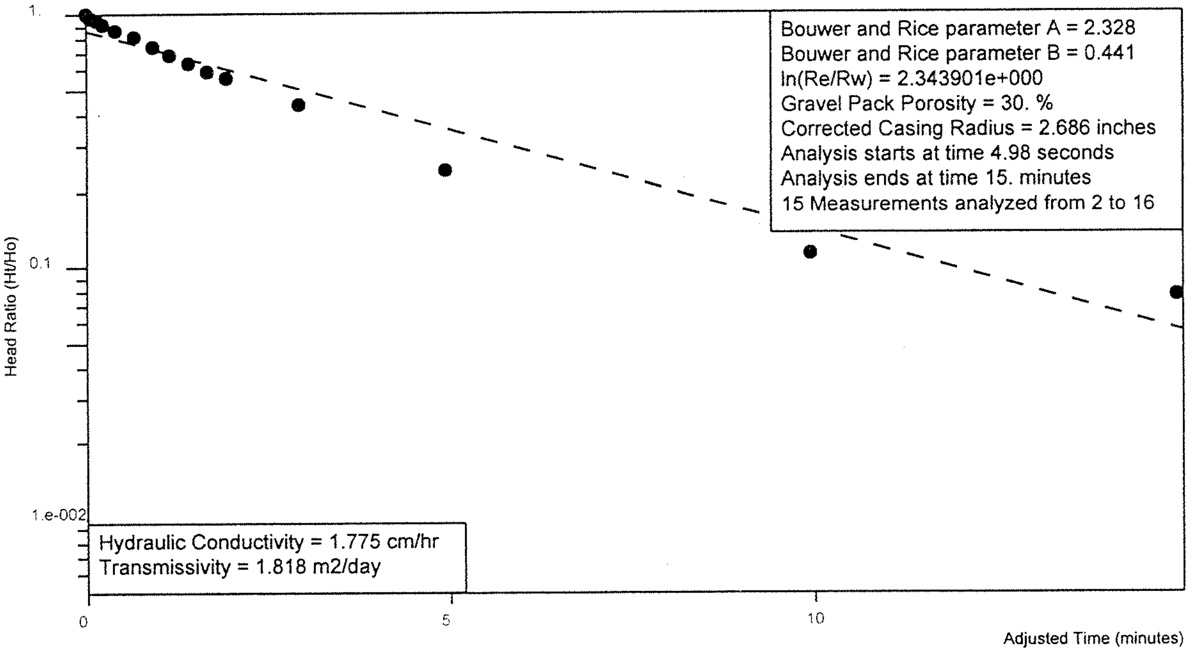
Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-7



Bouwer and Rice parameter A = 2.328
Bouwer and Rice parameter B = 0.441
ln(Re/Rw) = 2.343901e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 4.98 seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 2 to 16

Hydraulic Conductivity = 1.775 cm/hr
Transmissivity = 1.818 m2/day

Ho is 1.68 feet at 4.98 seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-7
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.85 feet
Water Table to Screen Bottom:	11.45 feet
Anisotropy Ratio:	0.
Time Adjustment:	4.98 Seconds

Test starts with trial 1

There are 16 time and drawdown measurements

Maximum head is 1.68 feet

Minimum head is -4.85 feet

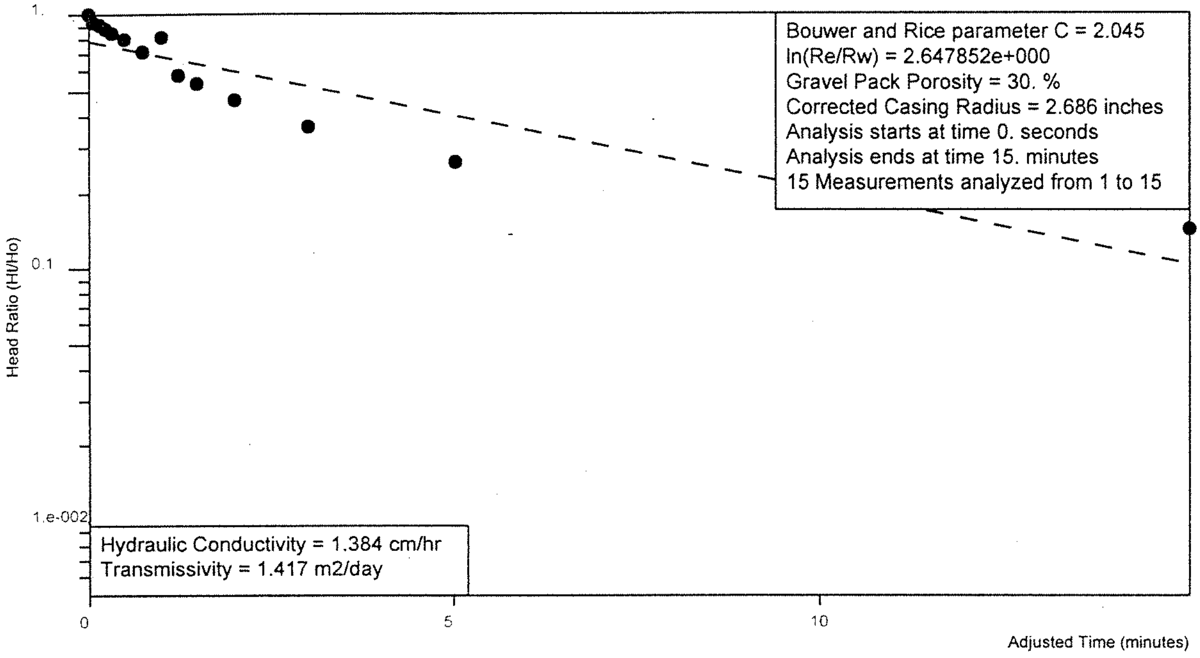
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-4.85	-2.887
2	8.3e-002	0.	6.53	1.68	1.
3	0.166	8.3e-002	6.49	1.64	0.9762
4	0.25	0.167	6.45	1.6	0.9524
5	0.333	0.25	6.38	1.53	0.9107
6	0.5	0.417	6.32	1.47	0.875
7	0.75	0.667	6.22	1.37	0.8155
8	1.	0.917	6.1	1.25	0.744
9	1.25	1.167	6.02	1.17	0.6964
10	1.5	1.417	5.93	1.08	0.6429
11	1.75	1.667	5.85	1.	0.5952
12	2.	1.917	5.8	0.95	0.5655
13	3.	2.917	5.59	0.74	0.4405
14	5.	4.917	5.25	0.4	0.2381
15	10.	9.917	5.04	0.19	0.1131
16	15.	14.92	4.98	0.13	7.738e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-8



Bouwer and Rice parameter C = 2.045
ln(Re/Rw) = 2.647852e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 1.384 cm/hr
Transmissivity = 1.417 m2/day

Ho is 2.91 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name: Clayhill Farms
Location: Jones County
Test Date: 2/17/99
Client: NCDOT
Project Number: 1960024-203.00

Well Label: DMW-8
Aquifer Thickness: 14. feet
Screen Length: 12.5 feet
Casing Radius: 0.8 inches
Effective Radius: 4.75 inches
Gravel Pack Porosity: 30. %
Corrected Casing Radius: 2.686 inches
Static Water Level: 2.59 feet
Water Table to Screen Bottom: 13.31 feet
Anisotropy Ratio: 0.
Time Adjustment: 0. Seconds
Test starts with trial 0
There are 15 time and drawdown measurements
Maximum head is 2.91 feet
Minimum head is 0. feet

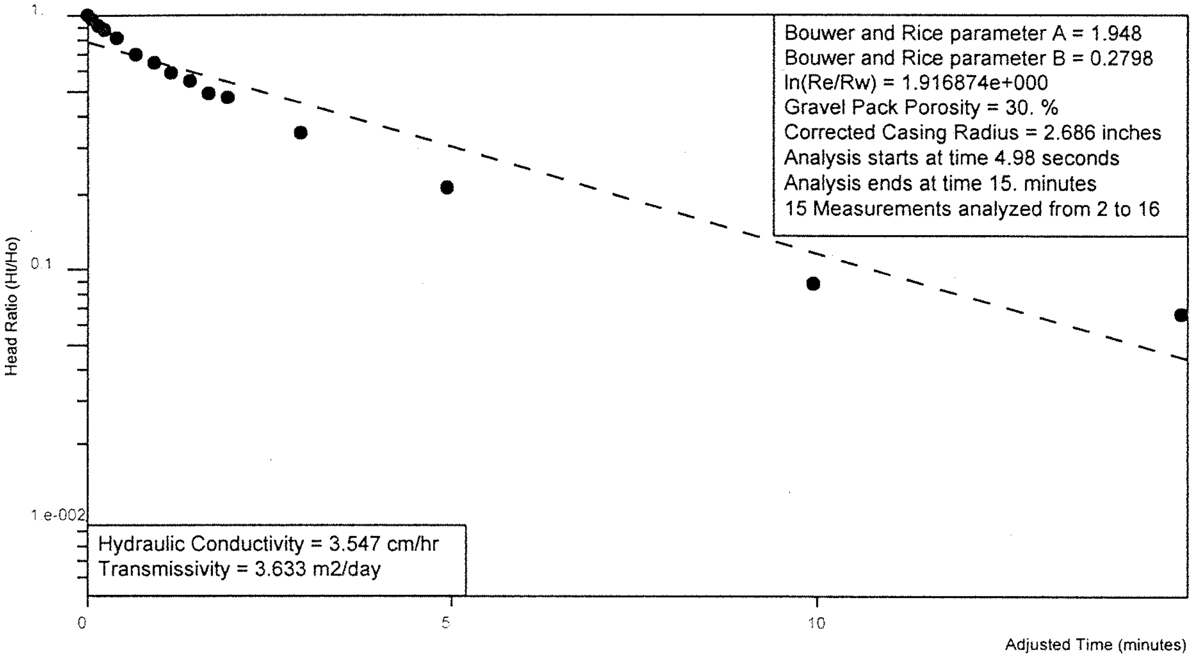
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.5	2.91	1.
2	8.3e-002	8.3e-002	5.32	2.73	0.9381
3	0.166	0.166	5.25	2.66	0.9141
4	0.25	0.25	5.18	2.59	0.89
5	0.333	0.333	5.09	2.5	0.8591
6	0.5	0.5	4.92	2.33	0.8007
7	0.75	0.75	4.69	2.1	0.7216
8	1.	1.	4.98	2.39	0.8213
9	1.25	1.25	4.3	1.71	0.5876
10	1.5	1.5	4.16	1.57	0.5395
11	2.	2.	3.93	1.34	0.4605
12	3.	3.	3.65	1.06	0.3643
13	5.	5.	3.36	0.77	0.2646
14	10.	10.	3.12	0.53	0.1821
15	15.	15.	3.01	0.42	0.1443

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-9



Bouwer and Rice parameter A = 1.948
Bouwer and Rice parameter B = 0.2798
ln(Re/Rw) = 1.916874e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 4.98 seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 2 to 16

Hydraulic Conductivity = 3.547 cm/hr
Transmissivity = 3.633 m2/day

Ho is 0.91 feet at 4.98 seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-9
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	10.96 feet
Water Table to Screen Bottom:	5.04 feet
Anisotropy Ratio:	0.
Time Adjustment:	4.98 Seconds

Test starts with trial 1

There are 16 time and drawdown measurements

Maximum head is 0.91 feet

Minimum head is -10.96 feet

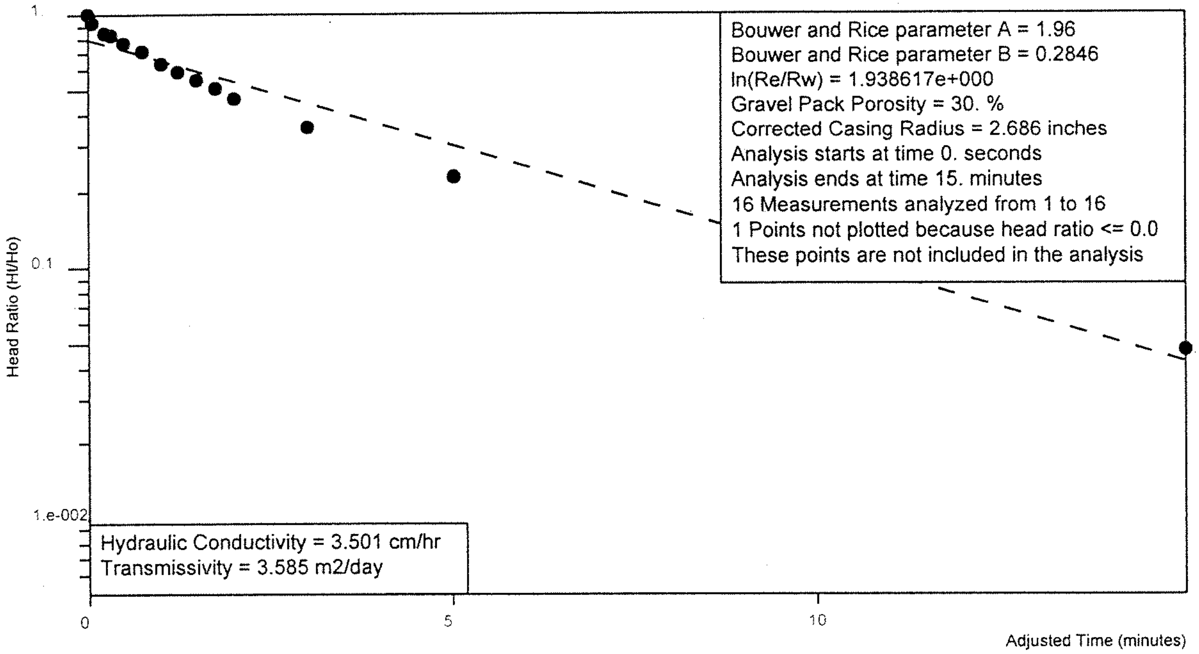
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-10.96	-12.04
2	8.3e-002	0.	11.87	0.91	1.
3	0.166	8.3e-002	11.84	0.88	0.967
4	0.25	0.167	11.8	0.84	0.9231
5	0.333	0.25	11.77	0.81	0.8901
6	0.5	0.417	11.7	0.74	0.8132
7	0.75	0.667	11.6	0.64	0.7033
8	1.	0.917	11.55	0.59	0.6484
9	1.25	1.167	11.5	0.54	0.5934
10	1.5	1.417	11.46	0.5	0.5495
11	1.75	1.667	11.41	0.45	0.4945
12	2.	1.917	11.39	0.43	0.4725
13	3.	2.917	11.27	0.31	0.3407
14	5.	4.917	11.15	0.19	0.2088
15	10.	9.917	11.04	8.e-002	8.791e-002
16	15.	14.92	11.02	6.e-002	6.593e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-10



Bouwer and Rice parameter A = 1.96
Bouwer and Rice parameter B = 0.2846
ln(Re/Rw) = 1.938617e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 3.501 cm/hr
Transmissivity = 3.585 m2/day

Ho is 1.06 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-10
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	10.96 feet
Water Table to Screen Bottom:	5.24 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0
There are 16 time and drawdown measurements
Maximum head is 1.06 feet
Minimum head is -6.e-002 feet

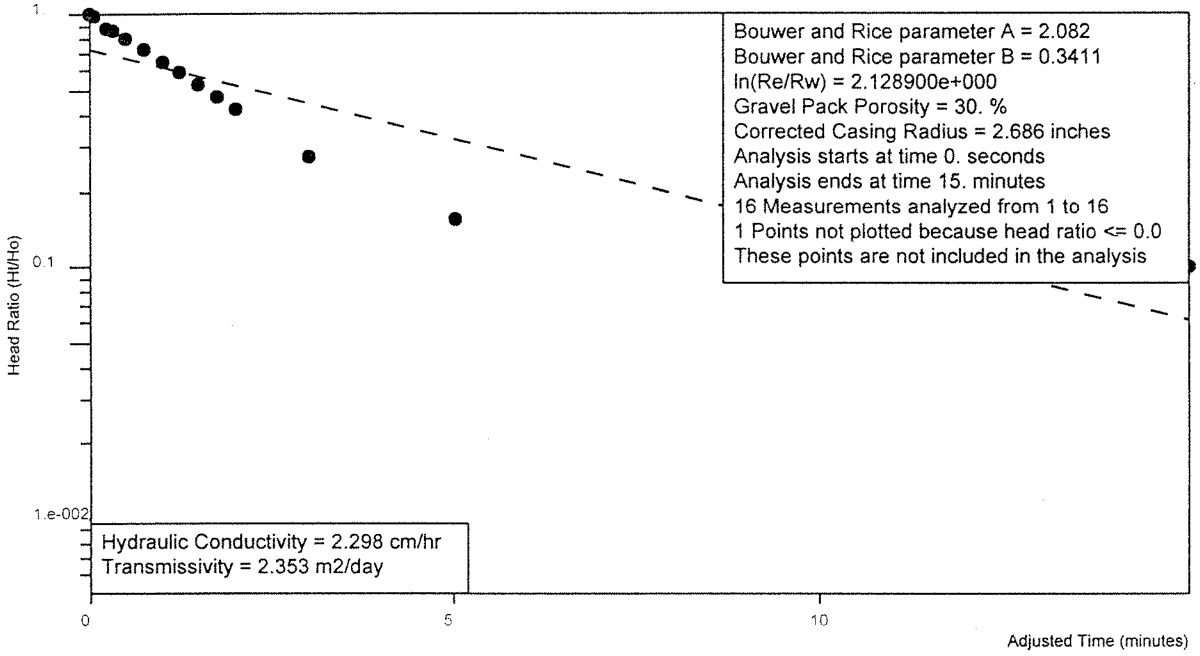
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	12.02	1.06	1.
2	8.3e-002	8.3e-002	11.96	1.	0.9434
3	0.166	0.166	10.9	-6.e-002	-5.66e-002
4	0.25	0.25	11.86	0.9	0.8491
5	0.333	0.333	11.84	0.88	0.8302
6	0.5	0.5	11.78	0.82	0.7736
7	0.75	0.75	11.72	0.76	0.717
8	1.	1.	11.64	0.68	0.6415
9	1.25	1.25	11.59	0.63	0.5943
10	1.5	1.5	11.54	0.58	0.5472
11	1.75	1.75	11.5	0.54	0.5094
12	2.	2.	11.45	0.49	0.4623
13	3.	3.	11.34	0.38	0.3585
14	5.	5.	11.2	0.24	0.2264
15	10.	10.	11.09	0.13	0.1226
16	15.	15.	11.01	5.e-002	4.717e-002

Aquifer Permeability Test 2/17/99

Bouwer and Rice Graph

Clayhill Farms Jones County

DMW-11



Bouwer and Rice parameter A = 2.082
Bouwer and Rice parameter B = 0.3411
ln(Re/Rw) = 2.128900e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 2.298 cm/hr
Transmissivity = 2.353 m2/day

Ho is 5.82 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-11
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	8.98 feet
Water Table to Screen Bottom:	7.52 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0
There are 16 time and drawdown measurements
Maximum head is 5.82 feet
Minimum head is -8.98 feet

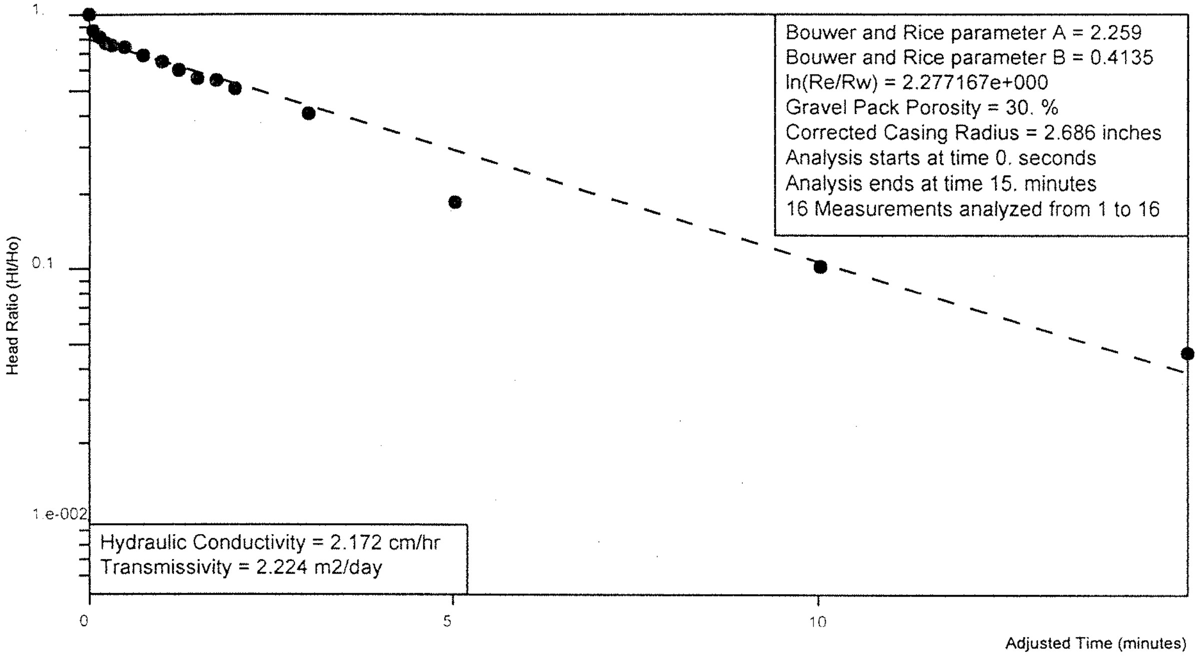
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	14.8	5.82	1.
2	8.3e-002	8.3e-002	14.72	5.74	0.9863
3	0.166	0.166	0.	-8.98	-1.543
4	0.25	0.25	14.15	5.17	0.8883
5	0.333	0.333	14.	5.02	0.8625
6	0.5	0.5	13.67	4.69	0.8058
7	0.75	0.75	13.2	4.22	0.7251
8	1.	1.	12.75	3.77	0.6478
9	1.25	1.25	12.46	3.48	0.5979
10	1.5	1.5	12.08	3.1	0.5326
11	1.75	1.75	11.76	2.78	0.4777
12	2.	2.	11.45	2.47	0.4244
13	3.	3.	10.58	1.6	0.2749
14	5.	5.	9.89	0.91	0.1564
15	10.	10.	9.68	0.7	0.1203
16	15.	15.	9.56	0.58	9.966e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-12



Bouwer and Rice parameter A = 2.259
Bouwer and Rice parameter B = 0.4135
ln(Re/Rw) = 2.277167e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 2.172 cm/hr
Transmissivity = 2.224 m2/day

Ho is 1.08 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-12
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	6.16 feet
Water Table to Screen Bottom:	10.24 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.08 feet

Minimum head is 0. feet

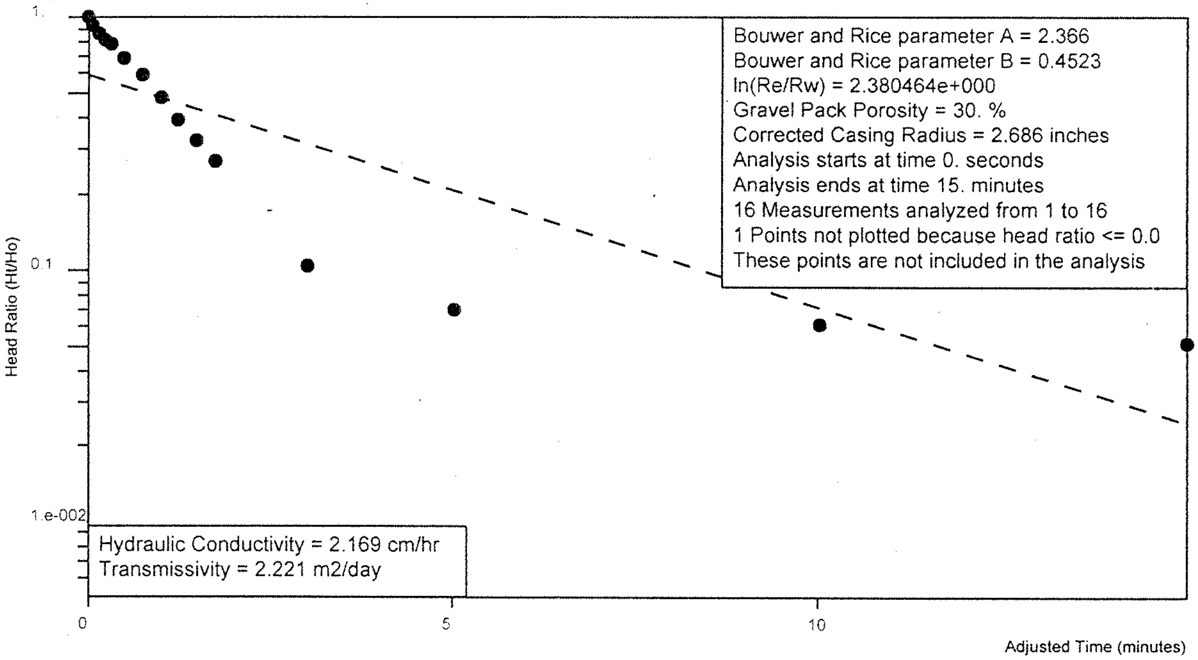
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.24	1.08	1.
2	8.3e-002	8.3e-002	7.09	0.93	0.8611
3	0.166	0.166	7.05	0.89	0.8241
4	0.25	0.25	7.	0.84	0.7778
5	0.333	0.333	6.98	0.82	0.7593
6	0.5	0.5	6.96	0.8	0.7407
7	0.75	0.75	6.91	0.75	0.6944
8	1.	1.	6.86	0.7	0.6481
9	1.25	1.25	6.82	0.66	0.6111
10	1.5	1.5	6.77	0.61	0.5648
11	1.75	1.75	6.75	0.59	0.5463
12	2.	2.	6.71	0.55	0.5093
13	3.	3.	6.6	0.44	0.4074
14	5.	5.	6.36	0.2	0.1852
15	10.	10.	6.27	0.11	0.1019
16	15.	15.	6.21	5.e-002	4.63e-002

Aquifer Permeability Test 2/17/99

Bouwer and Rice Graph

Clayhill Farms Jones County

DMW-13



Bouwer and Rice parameter A = 2.366
Bouwer and Rice parameter B = 0.4523
ln(Re/Rw) = 2.380464e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 2.169 cm/hr
Transmissivity = 2.221 m2/day

Ho is 1.15 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-13
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.62 feet
Water Table to Screen Bottom:	12.03 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.15 feet

Minimum head is -4.62 feet

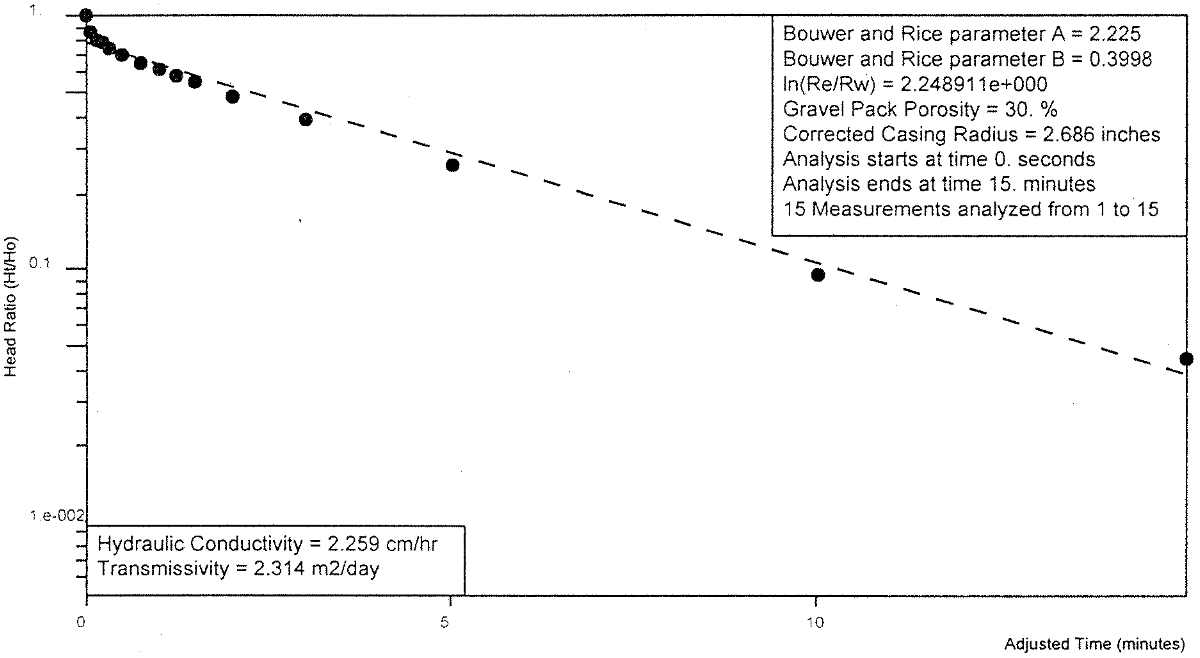
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.77	1.15	1.
2	8.3e-002	8.3e-002	5.7	1.08	0.9391
3	0.166	0.166	5.61	0.99	0.8609
4	0.25	0.25	5.57	0.95	0.8261
5	0.333	0.333	5.52	0.9	0.7826
6	0.5	0.5	5.41	0.79	0.687
7	0.75	0.75	5.3	0.68	0.5913
8	1.	1.	5.17	0.55	0.4783
9	1.25	1.25	5.07	0.45	0.3913
10	1.5	1.5	4.99	0.37	0.3217
11	1.75	1.75	4.93	0.31	0.2696
12	2.	2.	0.	-4.62	-4.017
13	3.	3.	4.74	0.12	0.1043
14	5.	5.	4.7	8.e-002	6.957e-002
15	10.	10.	4.69	7.e-002	6.087e-002
16	15.	15.	4.68	6.e-002	5.217e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-14



Bouwer and Rice parameter A = 2.225
Bouwer and Rice parameter B = 0.3998
ln(Re/Rw) = 2.248911e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 2.259 cm/hr
Transmissivity = 2.314 m2/day

Ho is 1.79 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-14
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	6.61 feet
Water Table to Screen Bottom:	9.69 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

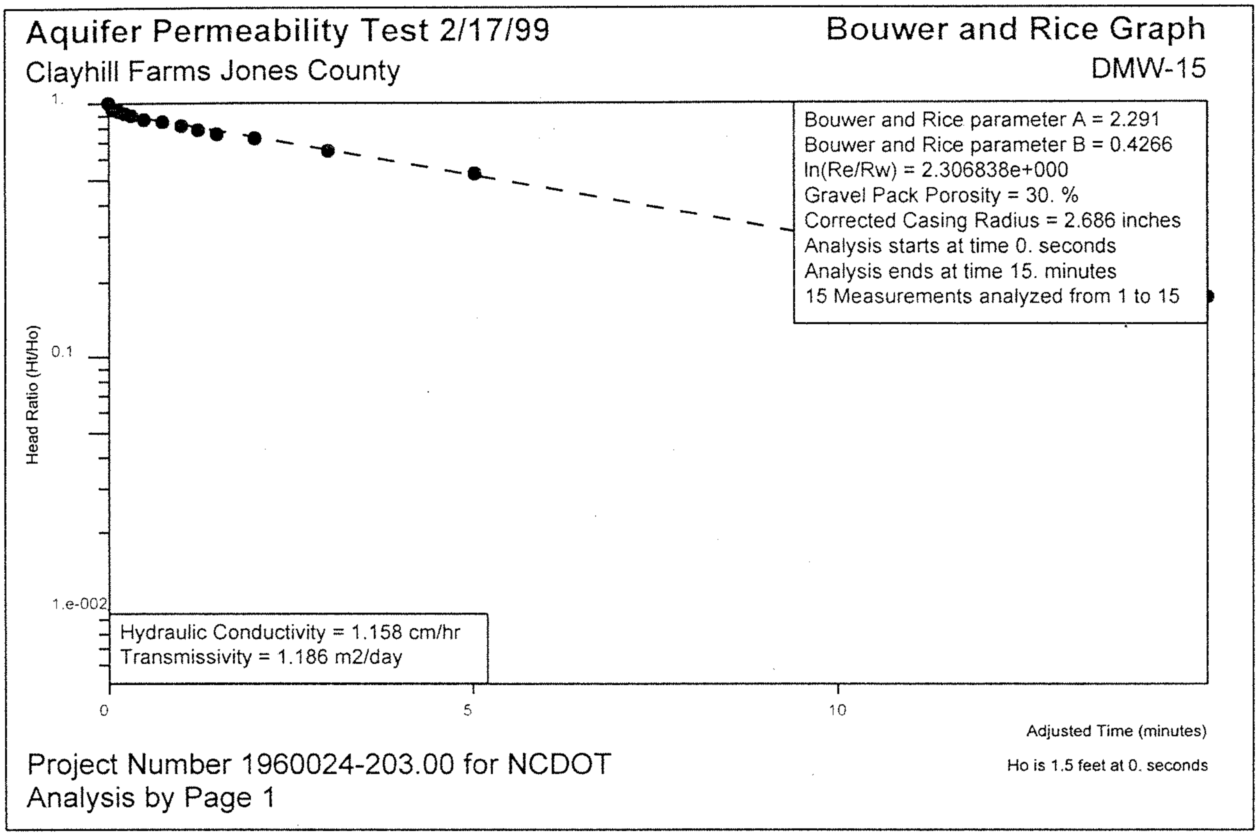
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 1.79 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	8.4	1.79	1.
2	8.3e-002	8.3e-002	8.16	1.55	0.8659
3	0.166	0.166	8.06	1.45	0.8101
4	0.25	0.25	8.01	1.4	0.7821
5	0.333	0.333	7.95	1.34	0.7486
6	0.5	0.5	7.87	1.26	0.7039
7	0.75	0.75	7.78	1.17	0.6536
8	1.	1.	7.71	1.1	0.6145
9	1.25	1.25	7.65	1.04	0.581
10	1.5	1.5	7.59	0.98	0.5475
11	2.	2.	7.48	0.87	0.486
12	3.	3.	7.31	0.7	0.3911
13	5.	5.	7.07	0.46	0.257
14	10.	10.	6.78	0.17	9.497e-002
15	15.	15.	6.69	8.e-002	4.469e-002



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-15

Bouwer and Rice parameter A = 2.291
Bouwer and Rice parameter B = 0.4266
ln(Re/Rw) = 2.306838e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 1.158 cm/hr
Transmissivity = 1.186 m2/day

Ho is 1.5 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

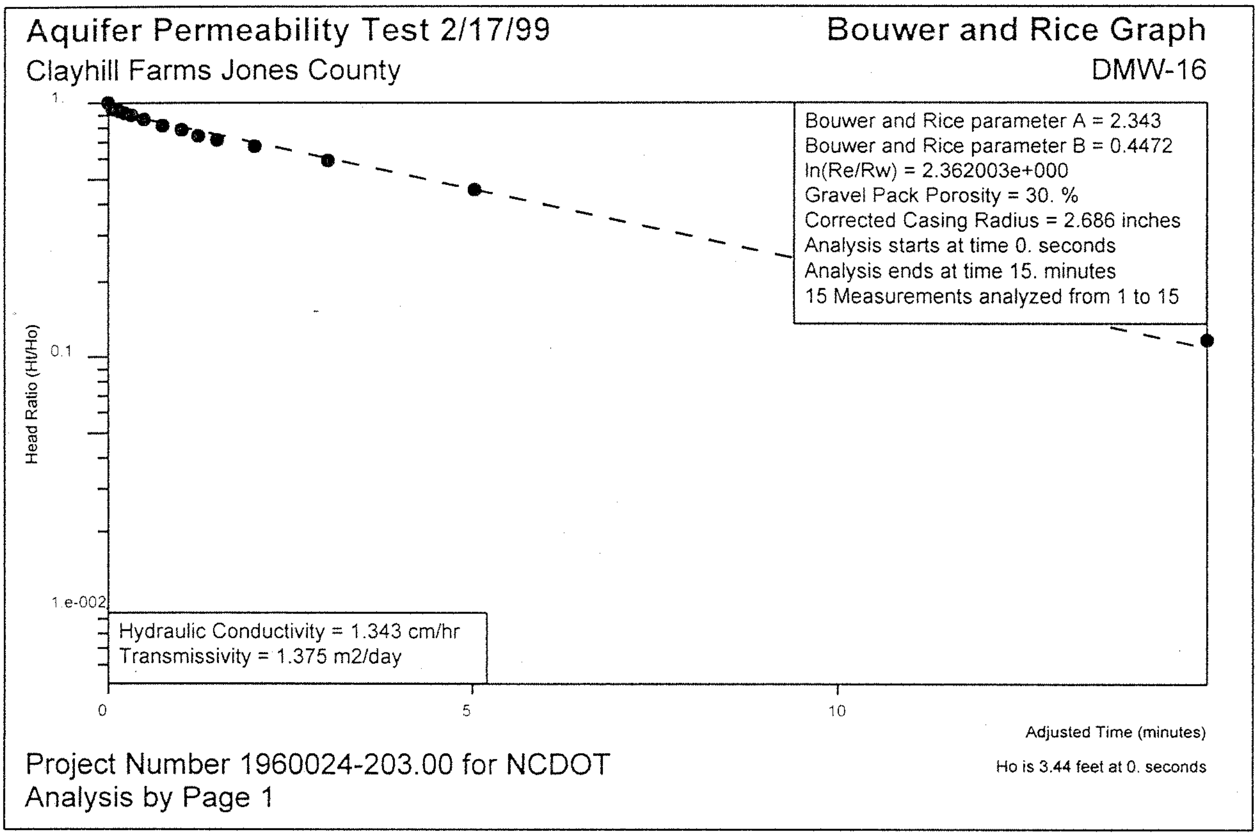
Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-15
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	5.7 feet
Water Table to Screen Bottom:	10.8 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0
There are 15 time and drawdown measurements
Maximum head is 1.5 feet
Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.2	1.5	1.
2	8.3e-002	8.3e-002	7.13	1.43	0.9533
3	0.166	0.166	7.1	1.4	0.9333
4	0.25	0.25	7.07	1.37	0.9133
5	0.333	0.333	7.05	1.35	0.9
6	0.5	0.5	7.01	1.31	0.8733
7	0.75	0.75	6.97	1.27	0.8467
8	1.	1.	6.92	1.22	0.8133
9	1.25	1.25	6.88	1.18	0.7867
10	1.5	1.5	6.84	1.14	0.76
11	2.	2.	6.79	1.09	0.7267
12	3.	3.	6.68	0.98	0.6533
13	5.	5.	6.49	0.79	0.5267
14	10.	10.	6.1	0.4	0.2667
15	15.	15.	5.96	0.26	0.1733



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-16

Bouwer and Rice parameter A = 2.343
Bouwer and Rice parameter B = 0.4472
ln(Re/Rw) = 2.362003e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 1.343 cm/hr
Transmissivity = 1.375 m2/day

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-16
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.46 feet
Water Table to Screen Bottom:	11.74 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 3.44 feet

Minimum head is 0. feet

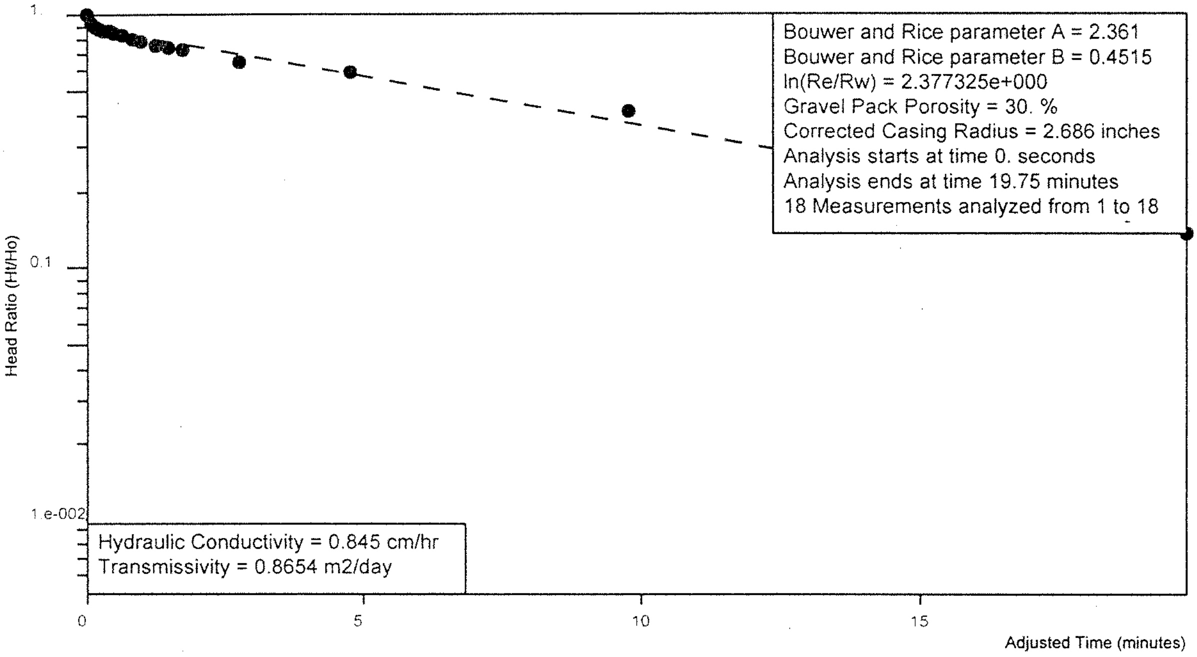
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.9	3.44	1.
2	8.3e-002	8.3e-002	7.75	3.29	0.9564
3	0.166	0.166	7.66	3.2	0.9302
4	0.25	0.25	7.61	3.15	0.9157
5	0.333	0.333	7.55	3.09	0.8983
6	0.5	0.5	7.43	2.97	0.8634
7	0.75	0.75	7.29	2.83	0.8227
8	1.	1.	7.17	2.71	0.7878
9	1.25	1.25	7.04	2.58	0.75
10	1.5	1.5	6.94	2.48	0.7209
11	2.	2.	6.78	2.32	0.6744
12	3.	3.	6.5	2.04	0.593
13	5.	5.	6.03	1.57	0.4564
14	10.	10.	5.16	0.7	0.2035
15	15.	15.	4.86	0.4	0.1163

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-17



Bouwer and Rice parameter A = 2.361
Bouwer and Rice parameter B = 0.4515
ln(Re/Rw) = 2.377325e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 19.75 minutes
18 Measurements analyzed from 1 to 18

Hydraulic Conductivity = 0.845 cm/hr
Transmissivity = 0.8654 m2/day

Ho is 3.23 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-17
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.22 feet
Water Table to Screen Bottom:	11.98 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

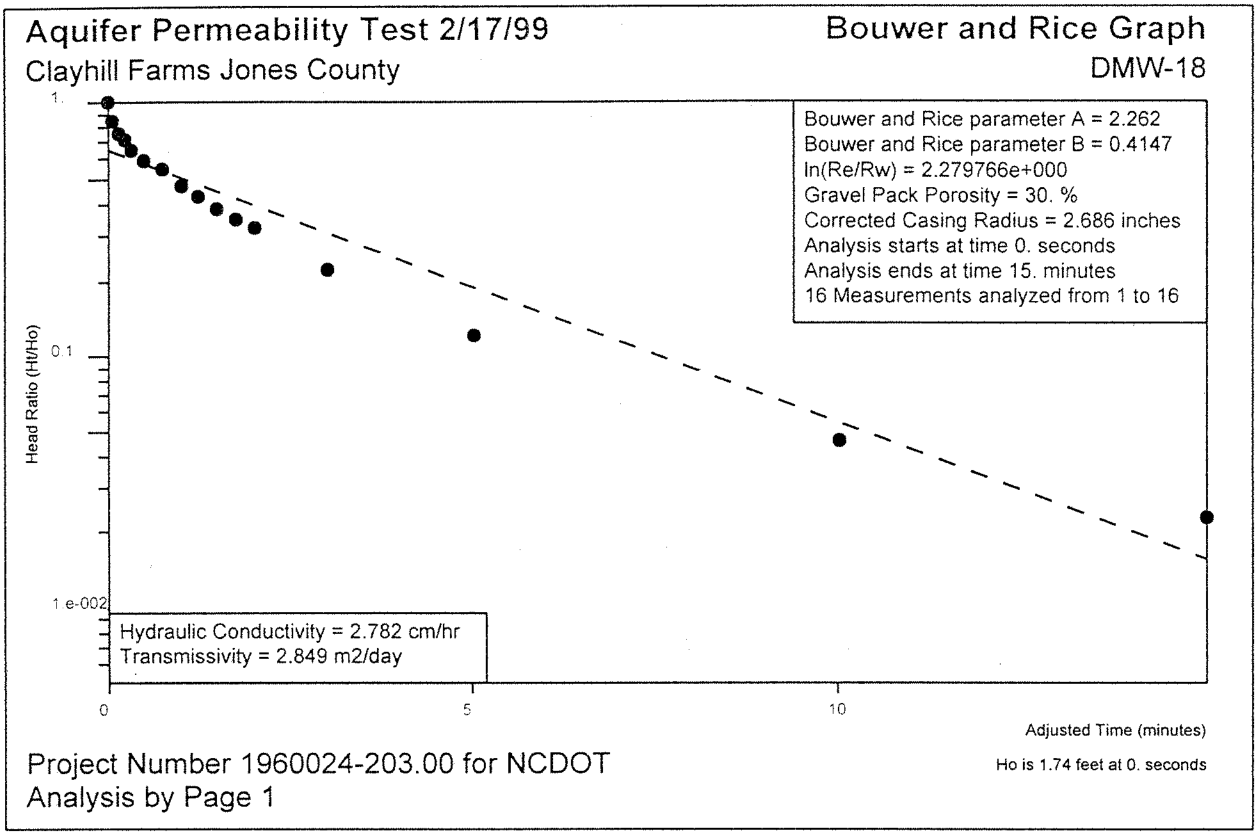
Test starts with trial 0

There are 18 time and drawdown measurements

Maximum head is 3.23 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.45	3.23	1.
2	8.3e-002	8.3e-002	7.22	3.	0.9288
3	0.166	0.166	7.15	2.93	0.9071
4	0.25	0.25	7.09	2.87	0.8885
5	0.333	0.333	7.03	2.81	0.87
6	0.416	0.416	7.	2.78	0.8607
7	0.5	0.5	6.95	2.73	0.8452
8	0.666	0.666	6.9	2.68	0.8297
9	0.833	0.833	6.82	2.6	0.805
10	1.	1.	6.76	2.54	0.7864
11	1.25	1.25	6.69	2.47	0.7647
12	1.5	1.5	6.62	2.4	0.743
13	1.75	1.75	6.58	2.36	0.7307
14	2.75	2.75	6.35	2.13	0.6594
15	4.75	4.75	6.15	1.93	0.5975
16	9.75	9.75	5.55	1.33	0.4118
17	14.75	14.75	5.04	0.82	0.2539
18	19.75	19.75	4.66	0.44	0.1362



Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-18

Bouwer and Rice parameter A = 2.262
Bouwer and Rice parameter B = 0.4147
ln(Re/Rw) = 2.279766e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 2.782 cm/hr
Transmissivity = 2.849 m2/day

Ho is 1.74 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-18
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	6.01 feet
Water Table to Screen Bottom:	10.29 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.74 feet

Minimum head is 0. feet

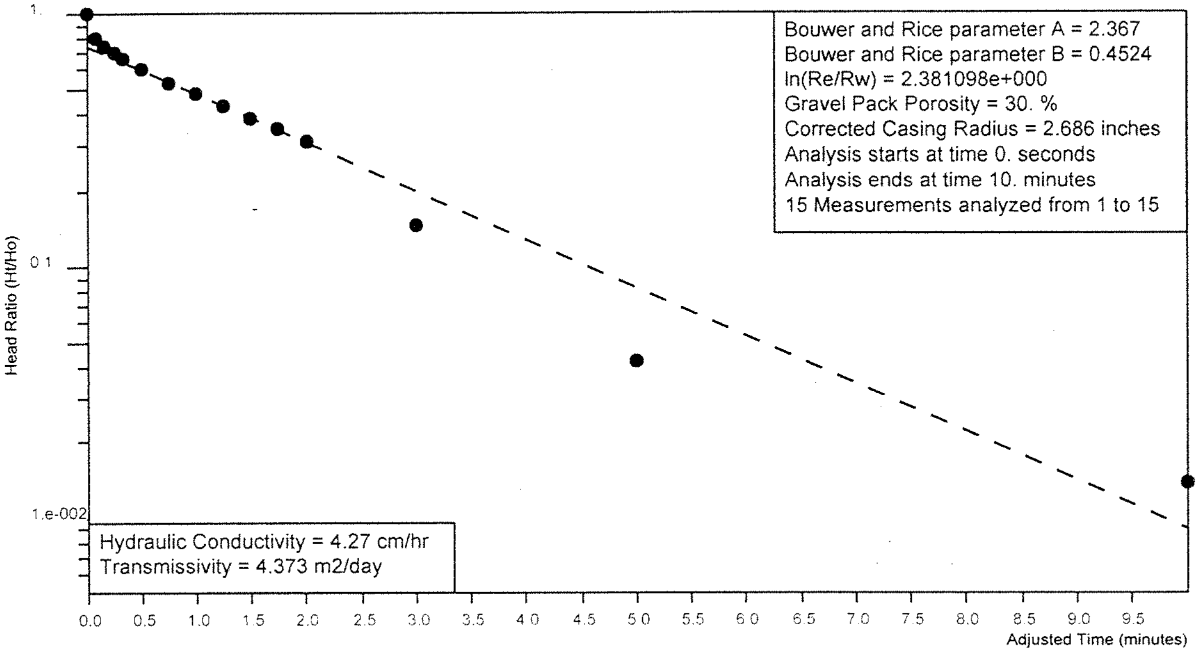
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.75	1.74	1.
2	8.3e-002	8.3e-002	7.5	1.49	0.8563
3	0.166	0.166	7.33	1.32	0.7586
4	0.25	0.25	7.25	1.24	0.7126
5	0.333	0.333	7.15	1.14	0.6552
6	0.5	0.5	7.04	1.03	0.592
7	0.75	0.75	6.96	0.95	0.546
8	1.	1.	6.84	0.83	0.477
9	1.25	1.25	6.76	0.75	0.431
10	1.5	1.5	6.68	0.67	0.3851
11	1.75	1.75	6.62	0.61	0.3506
12	2.	2.	6.57	0.56	0.3218
13	3.	3.	6.4	0.39	0.2241
14	5.	5.	6.22	0.21	0.1207
15	10.	10.	6.09	8.e-002	4.598e-002
16	15.	15.	6.05	4.e-002	2.299e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-19



Bouwer and Rice parameter A = 2.367
Bouwer and Rice parameter B = 0.4524
ln(Re/Rw) = 2.381098e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 10. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 4.27 cm/hr
Transmissivity = 4.373 m2/day

Ho is 1.44 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-19
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.16 feet
Water Table to Screen Bottom:	12.04 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

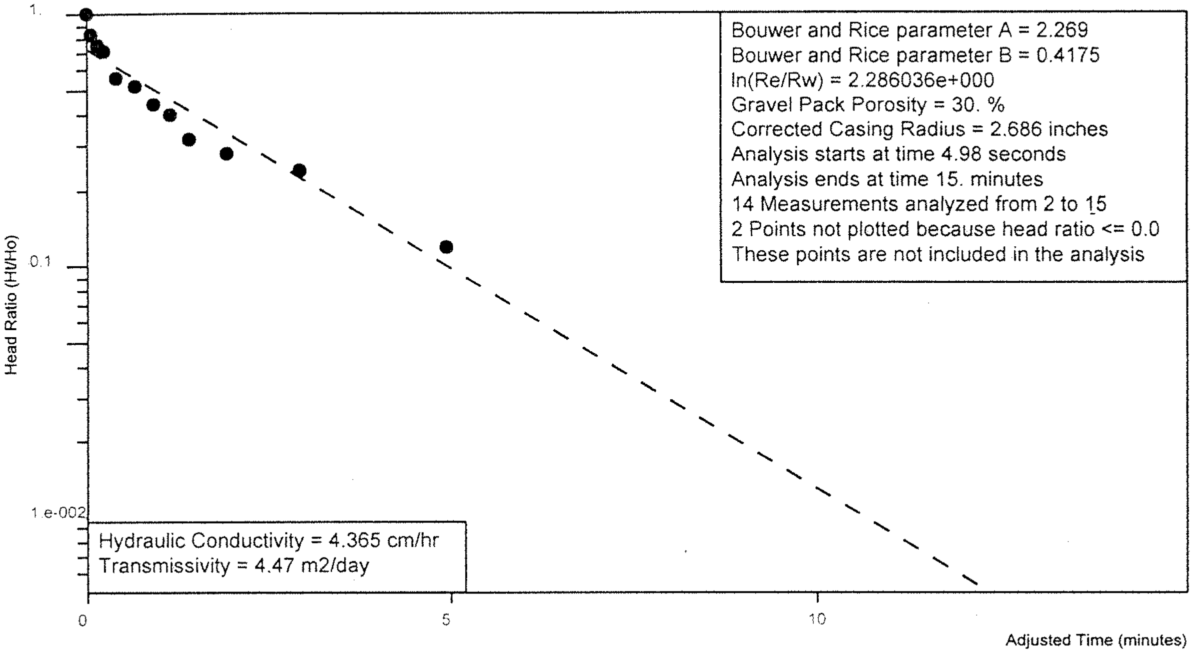
Maximum head is 1.44 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.6	1.44	1.
2	8.3e-002	8.3e-002	5.31	1.15	0.7986
3	0.166	0.166	5.24	1.08	0.75
4	0.25	0.25	5.18	1.02	0.7083
5	0.333	0.333	5.12	0.96	0.6667
6	0.5	0.5	5.03	0.87	0.6042
7	0.75	0.75	4.93	0.77	0.5347
8	1.	1.	4.85	0.69	0.4792
9	1.25	1.25	4.78	0.62	0.4306
10	1.5	1.5	4.71	0.55	0.3819
11	1.75	1.75	4.66	0.5	0.3472
12	2.	2.	4.61	0.45	0.3125
13	3.	3.	4.37	0.21	0.1458
14	5.	5.	4.22	6.e-002	4.167e-002
15	10.	10.	4.18	2.e-002	1.389e-002

Aquifer Permeability Test 2/17/99 **Bouwer and Rice Graph**

Clayhill Farms Jones County DMW-20



Bouwer and Rice parameter A = 2.269
Bouwer and Rice parameter B = 0.4175
ln(Re/Rw) = 2.286036e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 4.98 seconds
Analysis ends at time 15. minutes
14 Measurements analyzed from 2 to 15
2 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 4.365 cm/hr
Transmissivity = 4.47 m2/day

Ho is 0.25 feet at 4.98 seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-20
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	5.79 feet
Water Table to Screen Bottom:	10.41 feet
Anisotropy Ratio:	0.
Time Adjustment:	4.98 Seconds

Test starts with trial 1

There are 15 time and drawdown measurements

Maximum head is 0.25 feet

Minimum head is -5.79 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-5.79	-23.16
2	8.3e-002	0.	6.04	0.25	1.
3	0.166	8.3e-002	6.	0.21	0.84
4	0.25	0.167	5.98	0.19	0.76
5	0.333	0.25	5.97	0.18	0.72
6	0.5	0.417	5.93	0.14	0.56
7	0.75	0.667	5.92	0.13	0.52
8	1.	0.917	5.9	0.11	0.44
9	1.25	1.167	5.89	1.e-001	0.4
10	1.5	1.417	5.87	8.e-002	0.32
11	2.	1.917	5.86	7.e-002	0.28
12	3.	2.917	5.85	6.e-002	0.24
13	5.	4.917	5.82	3.e-002	0.12
14	10.	9.917	5.79	0.	0.
15	15.	14.92	5.79	0.	0.

Pantego Surface Storage Plot - 1 (PP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.5	3.3	
2	21.7	1.5	
3	25.9	5.7	
4	24.7	4.5	
5	25.7	5.5	
6	23.0	2.8	
7	24.0	3.8	
8	25.3	5.1	
9	22.0	1.8	
10	21.4	1.2	
11	21.0	0.8	
12	21.8	1.6	
13	25.0	4.8	
14	25.5	5.3	
15	23.5	3.3	
16	23.7	3.5	
17	25.3	5.1	
18	24.0	3.8	
19	22.0	1.8	
20	25.0	4.8	
21	26.2	6.0	
22	26.8	6.6	
23	27.4	7.2	**max**
24	26.9	6.7	
25	25.2	5.0	
26	22.4	2.2	
27	23.2	3.0	
28	22.7	2.5	
29	24.9	4.7	
30	20.2	0.0	**min**
31	21.7	1.5	
32	20.4	0.2	
33	23.7	3.5	
34	23.0	2.8	
35	22.7	2.5	
36	23.7	3.5	
37	24.9	4.7	
38	23.9	3.7	
39	26.5	6.3	
40	26.0	5.8	

Avg. = 3.71

Pantego Surface Storage Plot - 2 (PP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.5	5.3	
2	24.7	6.5	
3	25.9	7.7	
4	25.4	7.2	
5	25.5	7.3	
6	22.6	4.4	
7	24.7	6.5	
8	23.9	5.7	
9	25.2	7.0	
10	25.6	7.4	
11	26.5	8.3	
12	25.0	6.8	
13	23.0	4.8	
14	18.2	0.0	**min**
15	22.8	4.6	
16	26.5	8.3	
17	25.5	7.3	
18	26.2	8.0	
19	28.7	10.5	
20	29.4	11.2	
21	29.8	11.6	**max**
22	26.9	8.7	
23	28.6	10.4	
24	29.5	11.3	
25	26.5	8.3	
26	28.8	10.6	
27	27.2	9.0	
28	28.0	9.8	
29	25.9	7.7	
30	27.3	9.1	
31	25.7	7.5	
32	26.4	8.2	
33	25.4	7.2	
34	23.9	5.7	
35	23.5	5.3	
36	23.0	4.8	
37	22.5	4.3	
38	23.0	4.8	
39	23.6	5.4	
40	25.0	6.8	

Avg. = 7.28

Torhunta Surface Storage Plot - 1 (TP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.1	5.5	
2	23.6	6.0	
3	22.3	4.7	
4	21.8	4.2	
5	22.8	5.2	
6	20.4	2.8	
7	23.4	5.8	
8	19.1	1.5	
9	23.5	5.9	
10	19.8	2.2	
11	19.1	1.5	
12	23.0	5.4	
13	22.8	5.2	
14	26.2	8.6	**max**
15	17.6	0.0	**min**
16	24.6	7.0	
17	22.2	4.6	
18	23.1	5.5	
19	23.0	5.4	
20	24.2	6.6	
21	21.6	4.0	
22	23.5	5.9	
23	24.4	6.8	
24	22.8	5.2	
25	21.9	4.3	
26	21.2	3.6	
27	23.3	5.7	
28	24.1	6.5	
29	18.8	1.2	
30	24.3	6.7	
31	23.1	5.5	
32	25.3	7.7	
33	22.4	4.8	
34	24.8	7.2	
35	25.6	8.0	
36	26.2	8.6	**max**
37	22.7	5.1	
38	21.5	3.9	
39	20.9	3.3	
40	23.6	6.0	

Avg. = 5.09

Torhunta Surface Storage Plot - 2 (TP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	28.0	7.6	
2	25.0	4.6	
3	24.6	4.2	
4	26.4	6.0	
5	26.0	5.6	
6	25.0	4.6	
7	22.9	2.5	
8	20.4	0.0	min
9	23.0	2.6	
10	22.5	2.1	
11	23.6	3.2	
12	20.8	0.4	
13	25.1	4.7	
14	25.0	4.6	
15	25.0	4.6	
16	22.8	2.4	
17	25.6	5.2	
18	25.4	5.0	
19	29.7	9.3	max
20	26.5	6.1	
21	26.5	6.1	
22	24.0	3.6	
23	26.7	6.3	
24	27.0	6.6	
25	27.0	6.6	
26	24.1	3.7	
27	26.4	6.0	
28	29.3	8.9	
29	27.4	7.0	
30	24.3	3.9	
31	28.0	7.6	
32	28.5	8.1	
33	25.6	5.2	
34	29.0	8.6	
35	29.5	9.1	
36	26.5	6.1	
37	28.0	7.6	
38	28.4	8.0	
39	28.7	8.3	
40	24.9	4.5	

Avg. = 5.43

Onslow Surface Storage Plot - 1 (OP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.8	3.1	
2	24.6	3.9	
3	26.9	6.2	
4	26.2	5.5	
5	24.5	3.8	
6	23.7	3.0	
7	25.1	4.4	
8	25.6	4.9	
9	25.6	4.9	
10	26.4	5.7	
11	26.5	5.8	
12	22.9	2.2	
13	26.3	5.6	
14	28.2	7.5	
15	29.4	8.7	max
16	27.4	6.7	
17	26.2	5.5	
18	27.5	6.8	
19	28.4	7.7	
20	25.9	5.2	
21	26.7	6.0	
22	24.8	4.1	
23	24.2	3.5	
24	23.2	2.5	
25	23.1	2.4	
26	23.0	2.3	
27	20.9	0.2	
28	24.1	3.4	
29	24.2	3.5	
30	21.4	0.7	
31	24.5	3.8	
32	23.6	2.9	
33	21.4	0.7	
34	20.7	0.0	min
35	21.2	0.5	
36	22.4	1.7	
37	23.1	2.4	
38	25.5	4.8	
39	24.4	3.7	
40	24.0	3.3	

Avg. = 3.99

Onslow Surface Storage Plot - 2 (OP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	20.0	1.4	
2	20.5	1.9	
3	20.5	1.9	
4	20.0	1.4	
5	19.4	0.8	
6	21.2	2.6	
7	19.6	1.0	
8	19.5	0.9	
9	20.9	2.3	
10	21.6	3.0	
11	21.8	3.2	
12	22.4	3.8	
13	25.4	6.8	
14	24.0	5.4	
15	24.7	6.1	
16	23.3	4.7	
17	28.3	9.7	
18	27.4	8.8	
19	28.6	10.0	
20	30.4	11.8	**max**
21	30.0	11.4	
22	28.7	10.1	
23	29.8	11.2	
24	29.3	10.7	
25	26.3	7.7	
26	26.7	8.1	
27	27.0	8.4	
28	26.5	7.9	
29	25.8	7.2	
30	24.8	6.2	
31	26.5	7.9	
32	23.8	5.2	
33	24.5	5.9	
34	24.8	6.2	
35	22.9	4.3	
36	23.4	4.8	
37	19.8	1.2	
38	19.2	0.6	
39	18.6	0.0	**min**
40	20.4	1.8	

Avg. = 5.36

Marvyn Surface Storage Plot - 1 (MP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	24.8	4.4	
2	24.1	3.7	
3	27.0	6.6	max
4	24.9	4.5	
5	20.8	0.4	
6	24.1	3.7	
7	22.6	2.2	
8	22.0	1.6	
9	23.7	3.3	
10	21.6	1.2	
11	20.4	0.0	min
12	25.0	4.6	
13	23.0	2.6	
14	22.1	1.7	
15	24.1	3.7	
16	25.1	4.7	
17	25.2	4.8	
18	23.7	3.3	
19	24.1	3.7	
20	24.0	3.6	
21	25.3	4.9	
22	21.4	1.0	
23	22.8	2.4	
24	21.9	1.5	
25	25.0	4.6	
26	22.4	2.0	
27	21.9	1.5	
28	23.3	2.9	
29	23.4	3.0	
30	23.8	3.4	
31	23.6	3.2	
32	24.4	4.0	
33	25.2	4.8	
34	25.4	5.0	
35	25.9	5.5	
36	26.1	5.7	
37	26.3	5.9	
38	26.8	6.4	
39	24.4	4.0	
40	25.0	4.6	

Avg. = 3.52

Marvyn Surface Storage Plot - 2 (MP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	27.5	2.0	
2	28.7	3.2	
3	30.6	5.1	
4	30.4	4.9	
5	30.3	4.8	
6	30.5	5.0	
7	29.8	4.3	
8	30.9	5.4	
9	31.0	5.5	
10	31.4	5.9	
11	30.2	4.7	
12	31.5	6.0	max
13	28.5	3.0	
14	29.7	4.2	
15	29.7	4.2	
16	30.0	4.5	
17	27.3	1.8	
18	27.6	2.1	
19	29.3	3.8	
20	25.6	0.1	
21	27.4	1.9	
22	26.6	1.1	
23	26.4	0.9	
24	25.5	0.0	min
25	26.4	0.9	
26	26.7	1.2	
27	27.3	1.8	
28	28.2	2.7	
29	27.9	2.4	
30	26.6	1.1	
31	26.1	0.6	
32	26.2	0.7	
33	27.8	2.3	
34	27.8	2.3	
35	29.5	4.0	
36	26.8	1.3	
37	27.4	1.9	
38	27.7	2.2	
39	29.6	4.1	
40	30.4	4.9	

Avg. = 2.97

Radii of Influence from Centerline of Ditch, by Soil Type (Effectively Drained Distance).

Soil Type	Ditch Number	Radius of Influence (feet)
Marvyn	M-10	135
	M-11	238
	M Perimeter-4	574
	M Perimeter-5	1,066
Onslow	O-1	160
	O-2	185
	O-3	155
	O-4	80
	O Perimeter-2	135
	O Perimeter-3	312
	O Perimeter-6	200
	O Perimeter-7	125
Pantego	P-1N	123
	P-1S	51
	P Perimeter-8	100
	P Perimeter-9	70
Torhunta	T-1N	123
	T-1S	59
	T-2N	129
	T-2S	59
	T-3N	129
	T-3S	59
	T-4N	129
	T-4S	95
	T-5N	140
	T-5S	58
	T-6	94
	T-7	58
	TP-1	135
	TP-2	136

APPENDIX D

BENTHIC MACROINVERTEBRATE AND FISHERIES SURVEYS

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

February 10, 2004

Memorandum To: Phillip Todd, Environmental Supervisor
Natural Environment Project Management Unit

From: Neil Medlin, Environmental Specialist
Natural Environment Biological Survey Unit

Subject: Benthic Macroinvertebrate Survey for Clayhill Farms
Mitigation Project, Jones County: TIP Number R-2105WM

Benthic macroinvertebrate and fish samples were collected from three locations associated with the Clayhill Farms Mitigation Project. Macroinvertebrates were collected on April 10, 2002, and fish collected on April 23, 2002. Fish collection methods and survey results were summarized in a prior memo (May 13, 2002).

Sampling Locations (Figure 1)

Fish community and macroinvertebrate samples were taken from the same three locations. The most upstream sampling location, Site 1, was located on Billy's Branch below a beaver dam near the middle of the Clayhill Farms project. This location corresponds to Stations 34-37 off baseline as depicted on sheet P-8 of the site plans. Site 2 was the lower end of Billy's Branch in the area of a small metal bridge. This location corresponds to Stations 67-70 off baseline as depicted on sheet P-16 of the site plans. Site 3 on the UT Hunters Creek off Forest Service Road 126 was sampled as a reference location. Another location on the upper end of Billy's Branch had originally been proposed as a macroinvertebrate and fish sampling area. However, after a field evaluation of the area, it was determined that neither macroinvertebrate or fish samples could be effectively or safely collected due to high water levels in Billy's Branch caused by the beaver dam.

Macroinvertebrate Sample Methods

The Qual 5 method employed for sample collection was originally developed by the North Carolina Division of Water Quality (NCDWQ). This method should only be used for very small streams that will likely have few Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa but where other data are needed to assess differences in the benthic communities. This method includes one kick, one sweep, one leaf-pack sample, one log or rock wash and visual search inspection. Macroinvertebrates are separated from the rest of the sample material in the field ("picked") using forceps and white plastic

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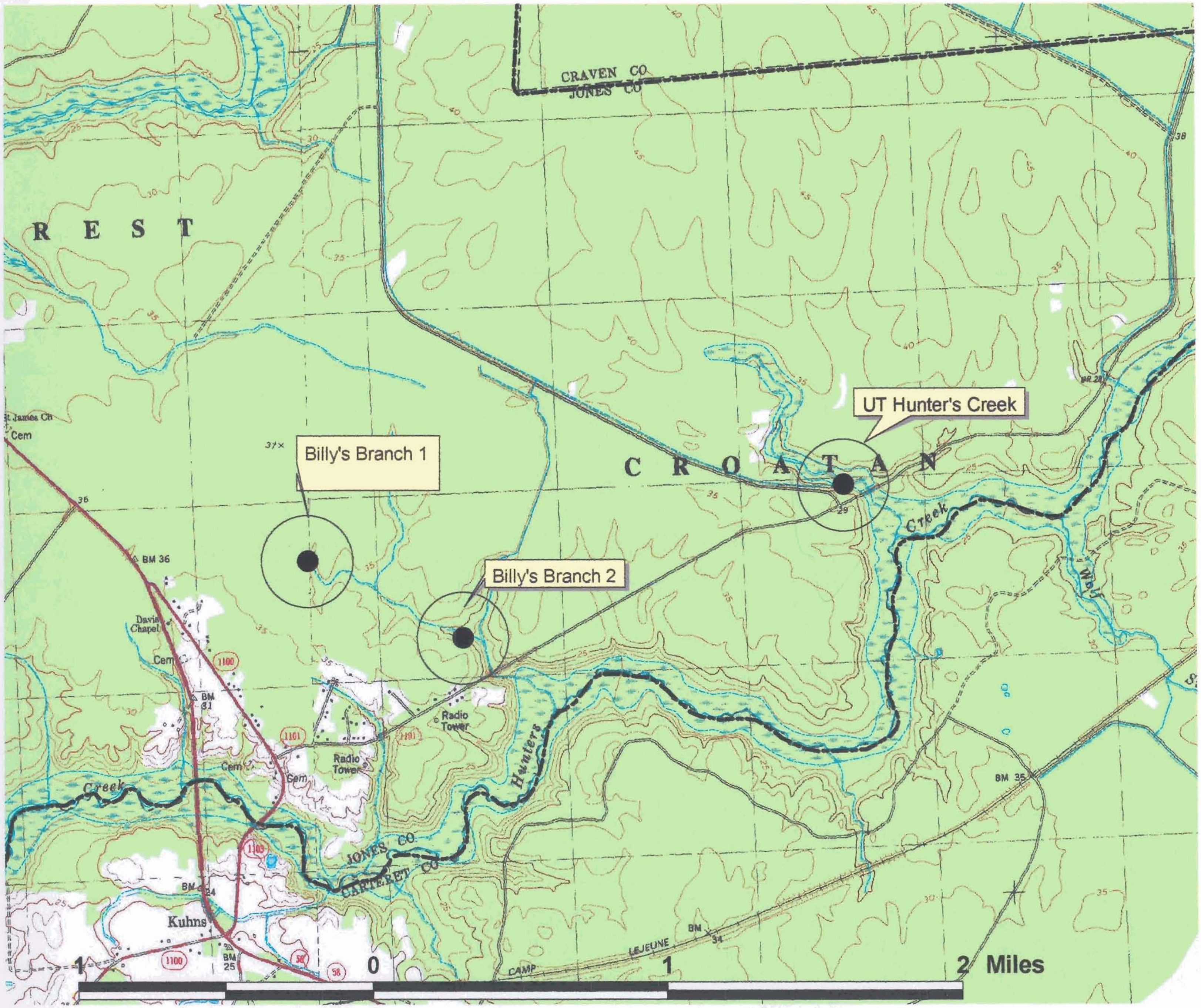
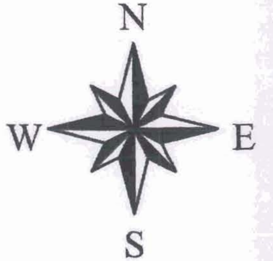
LOCATION:
TRANSPORTATION BUILDING
1 SOUTH WILMINGTON STREET
RALEIGH NC

Figure 1. Clayhilll Farms Sampling Locations





trays and preserved in glass vials containing 95% ethanol. Although NCDWQ now uses a Qual 4 collection method in lieu of the Qual 5 (NCDWQ SOP Manual, July 2003), NCDOT continues to use the Qual 5 method to maintain data consistency on long term monitoring projects and to maximize the number of taxa collected from sample locations.

Results (Table 1, Appendix 1)

The macroinvertebrate results for this survey were consistent with those found in other small coastal plain streams. Total taxa counts were low at all three sampling locations and EPT taxa were rare. The upstream site on Billy's Branch (Billy's Branch 1) had the lowest total taxa count but also had the only abundant EPT taxa (*Wormaldia sp.*, a Trichoptera) found during the survey. The upstream site had a nick point in the streambed that produced a small waterfall and area of high flow velocity. All of the *Wormaldia* were collected in or near this fast flow section. This unique microhabitat was not present at the other two sampling locations.

The downstream site on Billy's Branch (Billy's Branch 2) had the highest total taxa count of the three sites. However, this location also had the highest North Carolina Biotic Index (NCBI) values, indicating the most pollution tolerant macroinvertebrate community of the survey. Conversely, the reference location, UT Hunters Creek had the lowest NCBI value, indicating the least tolerant macroinvertebrate community.

Table 1. Taxa Richness

Taxa	Billy's Branch 1	Billy's Branch 2	UT Hunters
Trichoptera	2	1	3
Coleoptera	1	1	3
Odonata	2	2	0
Megaloptera	0	1	0
Diptera: Chiromidae	0	1	0
Misc. Diptera	3	7	6
Oligochaeta	1	4	2
Crustaea	3	2	2
Hemiptera	0	1	0
Total Taxa	12	20	16
NC Biotic Index	6.35	7.27	4.50

Appendix 1. Macroinvertebrate Taxa Richness and Relative Abundance

A=Abundant, C=Common, R=Rare

Taxa	Billys Br 1	Billys Br 2	UT Hunters
Oligochaeta			
Lumbricidae	R	C	C
Naididae		C	
Tubificidae w.h.c.		R	
Spirosperma sp.		R	R
Crustaea			
Cyclopoida	R		
Caecidotea sp.	C	A	C
Crangonyx sp.	A	A	A
Odonata			
Boyeria vinosa	R		
Cordulegaster sp.		R	
Neurocordulia sp.		R	
Somatochlora sp.	R		
Hemiptera			
Hydrometra sp.		R	
Megaloptera			
Sialis sp.		R	
Trichoptera			
Cheumatopsyche sp.			R
Lepidostoma sp.			C
Ironoquia sp.	R	R	
Wormaldia sp.	A		
Ptilostomis sp.			C
Coleoptera			
Hydaticus sp.			R
Hydroporus sp.	C	C	C
Stenelmis sp.			C
Diptera			
Atrichopogon sp.		R	
Chironomus sp.		R	
Cricotopus sp.			R
Polypedilum illinoense		C	
Psectrocladius sp.		R	C
Unniella multivirga		C	A
Simulium sp.	C	C	A
Chrysops sp.			R
Molophilus sp.	R		
Pseudolimnophila sp.		C	R
Tipula sp.	R	C	

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

May 13, 2002

Memorandum To: Phillip Todd

From: Neil Medlin, NM Environmental Biologist
Project Development and Environmental Analysis Branch

Subject: Benthic Macroinvertebrate and Fisheries Surveys for Clayhill Farms Mitigation Project, Jones County; TIP Number R-2105WM

Benthic macroinvertebrate and fish samples have been collected from three locations associated with the Clayhill Farms Mitigation project. Macroinvertebrates were collected on April 10, 2002, and fish were collected on April 23, 2002. The macroinvertebrate samples were preserved and will be identified by a NC Division of Water Quality (NCDWQ) certified laboratory. Collection methods and results will be addressed in a separate memo when the macroinvertebrate identifications are completed.

Sampling Locations (Figure 1, from Wetland and Stream Mitigation Report)

Fish community samples were collected from the same three locations as the macroinvertebrates. Site 1 was located on Billy's Branch below a beaver dam approximately midway of the Clayhill Farms project. This location corresponds to Stations 34-37 of baseline as depicted on sheet P-8 of the site plans. Site 2 was at the lower end of Billy's Branch in the area of the metal bridge. This location corresponds to Stations 67-70 of baseline as depicted on sheet P-16 of the site plans. Site 3 on UT Hunters Creek off Forest Service Road 126 was sampled as a reference location. Another location on the upper end of Billy's Branch had originally been proposed as a macroinvertebrate and fish sampling location. However, after a field evaluation of the area, it was determined that neither macroinvertebrate or fish samples could be effectively or safely collected due to high water levels in Billy's Branch caused by the beaver dam.

Methods

Fish were collected from 150 feet reaches from all three sample sites using a backpack electrofishing unit. A block net or natural barrier was used at the upstream end of each segment to prevent fish from leaving the reach. Two upstream passes were made at each location with the exception of Site 1. Due to the wet width of the stream being less than one meter and the unlikelyhood of any fish escaping the electrofishing field,

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TELEPHONE: 919-733-3141
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WEBSITE: WWW.DOH.DOT.STATE.NC.US

LOCATION:
TRANSPORTATION BUILDING
1 SOUTH WILMINGTON STREET
RALEIGH NC

only one pass was made at this site. All fish were collected, identified, measured, and then released.

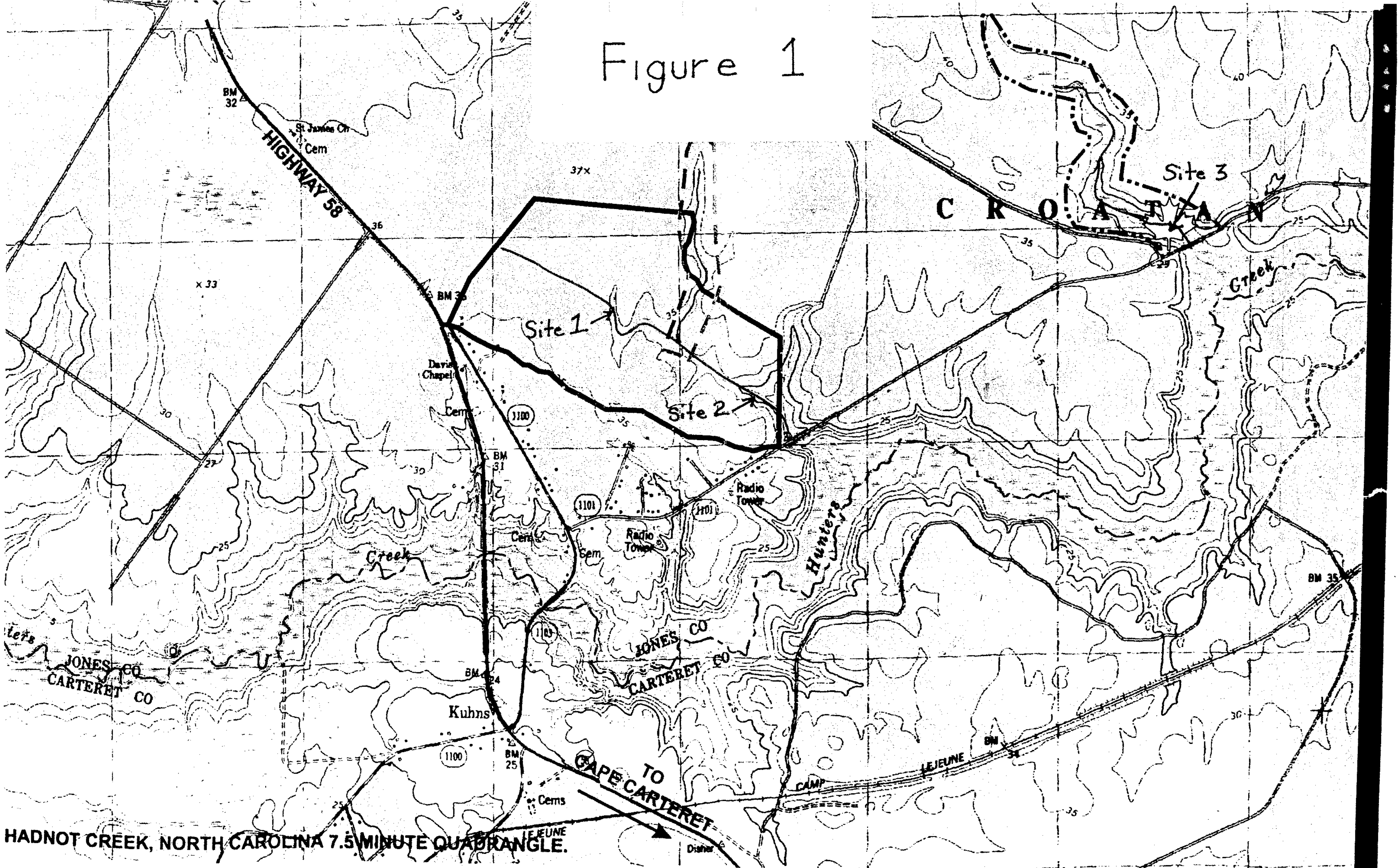
Results

Very few fish were collected from either location on Billy's Branch and only slightly more from the reference site on UT Hunters Creek. All species collected were typical outer coastal plain fish. Low species diversity and abundance are common in very small outer coastal plain streams as flows in these systems vary seasonally. Water levels and flows at the time the fish surveys were conducted were appreciably lower than roughly two weeks prior, when the macroinvertebrate samples were collected. Given the decrease in stream flows observed during the two week period in April, it is probable that during the minimal flow periods of summer and fall the number of fish in Billy's Branch and UT Hunters Creek would be even less than documented during this survey.

Fisheries Survey Results by Species with Number of Individuals Collected, Clayhill Farms Project, April 23, 2002. Site 1=Billy's Branch below beaver dam, Site 2=Billy's Branch at lower end of project, Site 3=UT Hunters Creek (Reference)

		Location	
Species	Site 1	Site 2	Site 3
Banded sunfish, *Enneacanthus obesus*	1		
Eastern mudminnow, *Umbra pygmaea*		1	1
Redfin pickerel, *Esox americanus*		1	
Pirate perch, *Aphredoderus sayanus*			1
Swampfish, *Chologaster cornuta*			5

Figure 1



HADNOT CREEK, NORTH CAROLINA 7.5 MINUTE QUADRANGLE.

APPENDIX E

MORPHOLOGICAL MEASUREMENT TABLE FOR BILLY'S BRANCH

NCDOT Clayhill Farms Wetland and Stream Mitigation Bank
Morphological Measurement Table
Format: NCDENR Internal Technical Guide for Stream Work (April 2001)
Prepared By: LandMark Design Group LMDG NO 1960024-210.00

March 4, 2002
TIP R-2105 WM
State Project No. 169005T
Preparer: Robert Kerr

Variables	Existing Channel	Reference Reach	Node 1 Station 10+00	Node 2 Station 23+00	Node 3 Station 35+00	Node 4 Station 57+00	Node 5 Station 62+00	Node 6 Station 91+00
1 Stream Type	G6	C6	C6	C6	C6	C6	C6	C6
2 Drainage Area (mi^2)	0.8	0.7	0.1	0.2	0.3	0.45	0.48	0.6
3 Bankful Width	10	9	5.7	7.3	8.2	9.5	9.7	10.6
4 Bankful Mean Depth	2	0.98	0.6	0.8	0.9	1.0	1.1	1.2
5 Width/Depth Ratio*	5	9.2	9.1	9.2	9.2	9.2	9.2	9.2
6 Bankfill Cross-Sectional Area	19	8.84	3.6	5.9	7.3	9.9	10.2	12.3
7 Bank Mean Velocity	2.45	2.8	1.4	1.6	1.5	1.6	1.7	1.7
8 Bankfull Discharge, cfs	47	42	12.0	20.0	23.0	31.0	33.0	39.0
9 Bankfull Max Depth	2.6	1.46	1.0	1.3	1.4	1.6	1.7	1.8
10 Width of Floodprone Area	15	278.5	95	240	440	78	66	215
11 Entrenchment Ratio	1.5	30.9	16.6	32.7	53.7	8.2	6.8	20.2
12 Meander Length (avg)	NA	120	77	98	105	112	119	126
13 Ratio of Meander Length to Bankfull Width**	NA	13.3	13.4	13.4	12.8	11.8	12.3	11.9
14 Radius of Curvature	NA	31	20	25	27	28	31	32
15 Radius of Curvature to Bankfull Width	NA	3.44	3.5	3.4	3.3	2.9	3.2	3.0
16 Belt Width	NA	40	13.0	33.6	36.0	38.4	40.8	43.2
17 Meander Width Ratio (MWR)***	NA	4.4	2.3	4.6	4.4	4.0	4.2	4.1
18 Sinuosity (Stream Length/ Valley Length)	1.2	1.4	1.2	1.2	1.25	1.4	1.5	1.6
19 Valley Slope	0.004-0.009	0.0031	0.0006	0.0006	0.0024	0.0038	0.0033	0.0033
20 Average Slope	0.003-0.008	0.0020	0.0022	0.0005	0.0005	0.0019	0.0027	0.0022
21 Pool Slope	NA	0.0012	0.00132	0.00132	0.00132	0.00132	0.00132	0.00132
22 Ratio of Pool Slope to Average Slope	NA	0.6	0.6	0.6	0.6	0.6	0.6	0.6
23 Maximum Pool Depth	NA	2	1.4	1.8	2	2.3	2.4	2.6
24 Ratio of Pool Depth to Average Bankfull Depth	NA	2.0	2.2	2.2	2.2	2.2	2.3	2.2
25 Pool Width	NA	11.5	7.0	9.0	10.1	11.7	12.1	13.1
26 Ratio of Pool Width to Bankfull Width	NA	1.3	1.2	1.2	1.2	1.2	1.2	1.2
27 Ratio of Pool to Pool Spacing****	NA	51	35	49	53	56	60	63
28 Ratio of Pool-Pool Spacing to Bankfull Width**	NA	5.7	6.1	6.7	6.4	5.9	6.1	5.9
29 Ratio of Lowest Bank height to Bankfull height (or Max Bankfull Depth)	1.14	1	1	1	1	1	1	1

NA - Detailed design parameters were not measured on impacted reach since data would not be used for future design, therefore data as "Not Applicable".

* Width/Depth Ratio - C6 streams display lower W/D ratio than all other C stream types due to cohesive nature or stream bank materials (Applied River Morphology, D. Rosgen,1996, pg 5-104).

** Lm/Wbkf = can be extremely high, as high as 15-16 for streams with cohesive banks (personal communication, D. Rosgen, November 2001).

*** MWR = can go above 4.0 for C6 streams (personal communicat., D. Rosgen, November 2001).

**** Ratio of Pool Width to Bankfull Width will be higher for C6 streams since Lm/Wbkf is higher.

***** Ratio of Pool-Pool Spacing to Bankfull Width can be higher for C6 streams since Lm/Wbkf is higher.

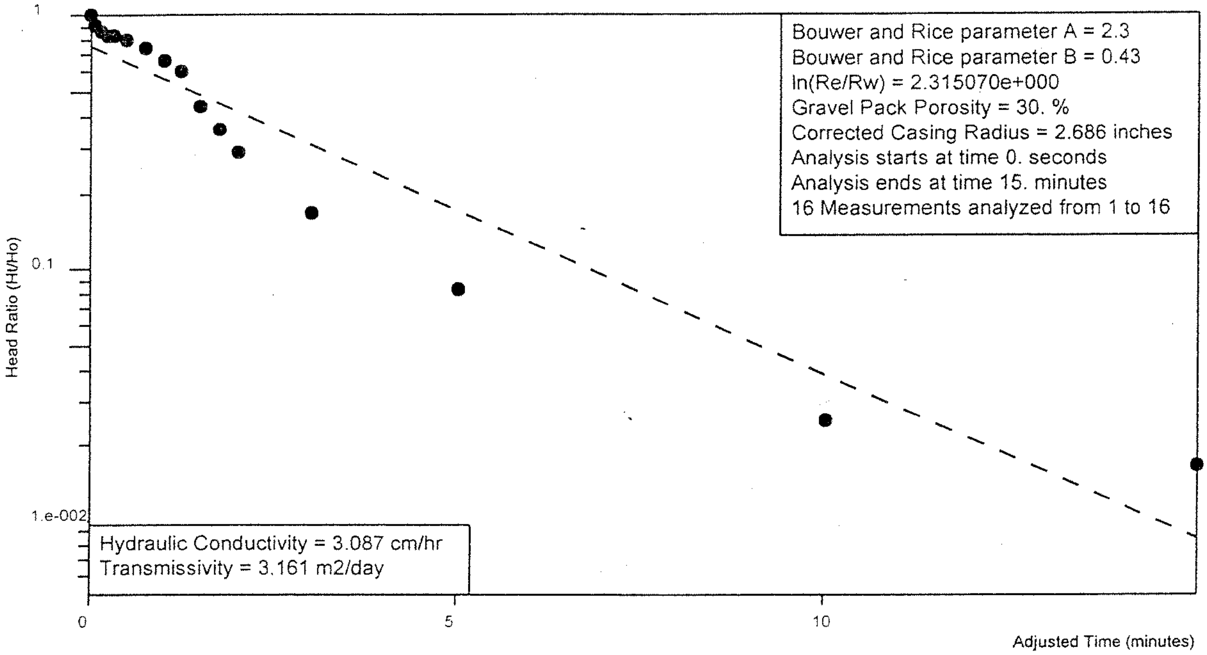
DESIGN CRITERIA

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-1



Bouwer and Rice parameter A = 2.3
Bouwer and Rice parameter B = 0.43
ln(Re/Rw) = 2.315070e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 3.087 cm/hr
Transmissivity = 3.161 m2/day

Ho is 1.2 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-1
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	3.05 feet
Water Table to Screen Bottom:	10.95 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0
There are 16 time and drawdown measurements
Maximum head is 1.2 feet
Minimum head is 0. feet

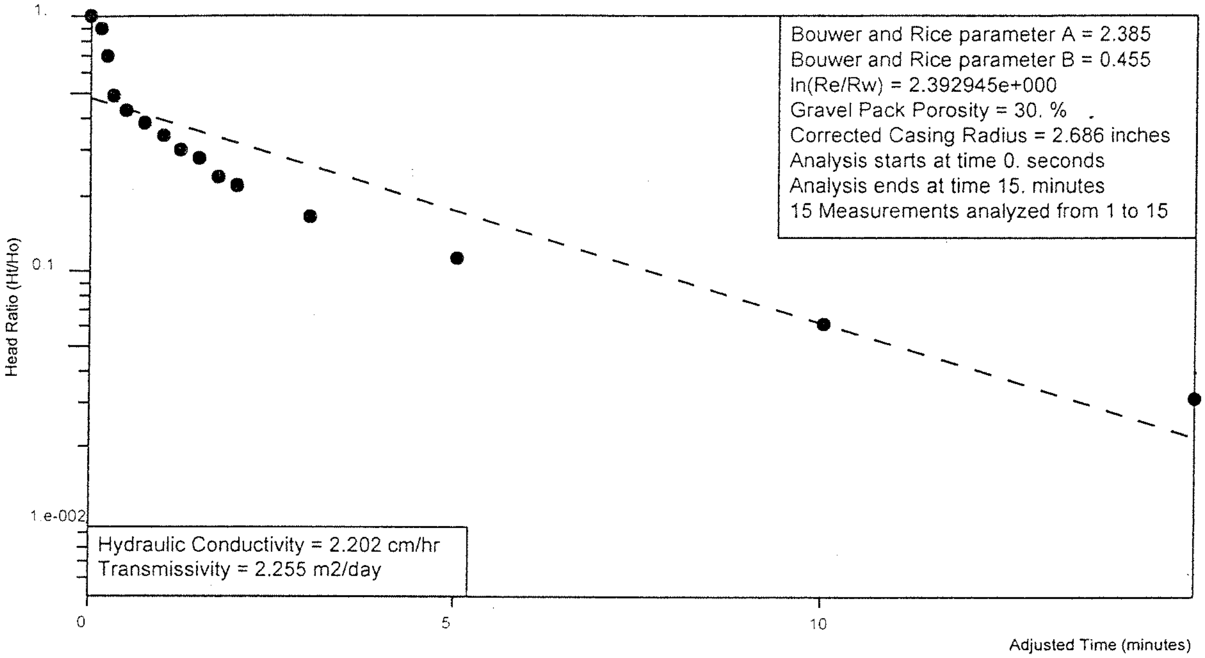
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	4.25	1.2	1.
2	8.3e-002	8.3e-002	4.15	1.1	0.9167
3	0.166	0.166	4.1	1.05	0.875
4	0.25	0.25	4.06	1.01	0.8417
5	0.333	0.333	4.05	1.	0.8333
6	0.5	0.5	4.01	0.96	0.8
7	0.75	0.75	3.94	0.89	0.7417
8	1.	1.	3.85	0.8	0.6667
9	1.25	1.25	3.78	0.73	0.6083
10	1.5	1.5	3.58	0.53	0.4417
11	1.75	1.75	3.48	0.43	0.3583
12	2.	2.	3.4	0.35	0.2917
13	3.	3.	3.25	0.2	0.1667
14	5.	5.	3.15	0.1	8.333e-002
15	10.	10.	3.08	3.e-002	2.5e-002
16	15.	15.	3.07	2.e-002	1.667e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-2



Bouwer and Rice parameter A = 2.385
Bouwer and Rice parameter B = 0.455
ln(Re/Rw) = 2.392945e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 2.202 cm/hr
Transmissivity = 2.255 m2/day

Ho is 0.97 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-2
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.88 feet
Water Table to Screen Bottom:	12.22 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

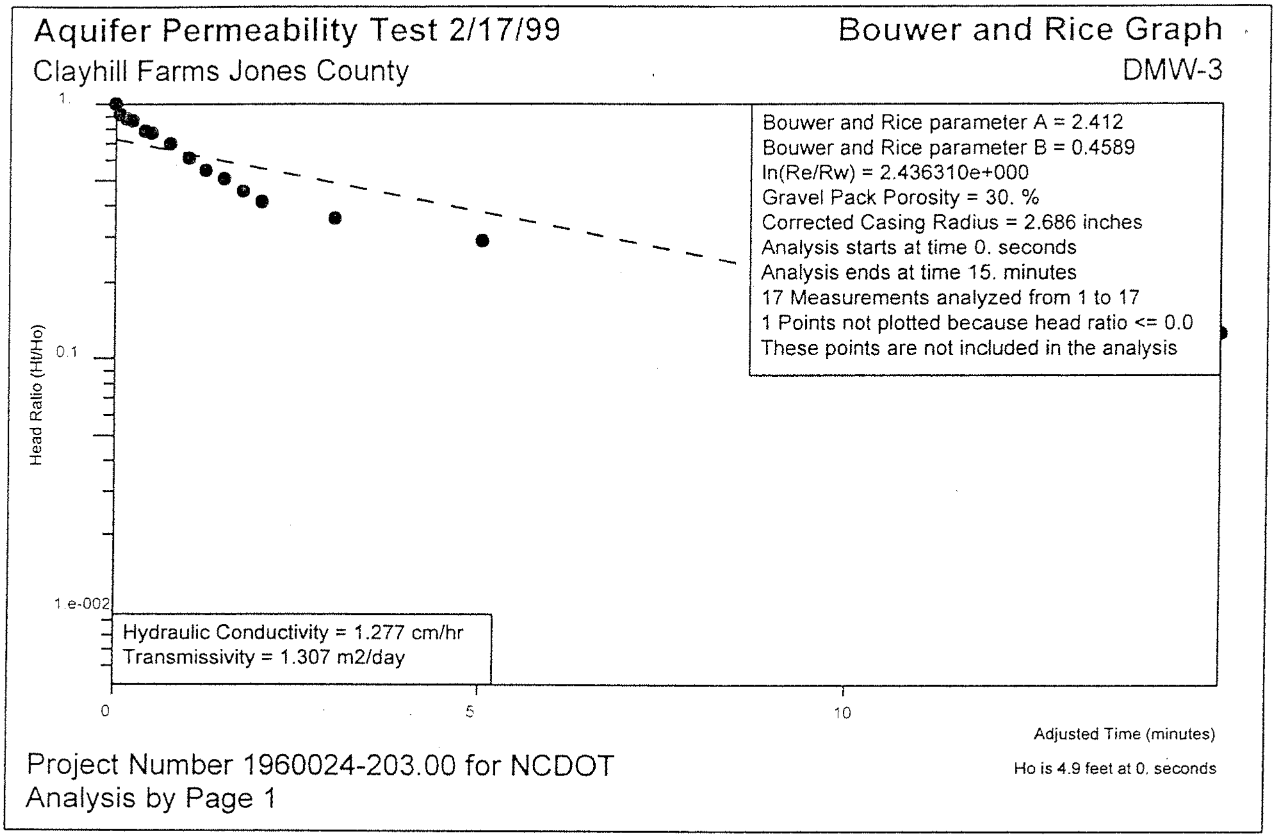
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 0.97 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.85	0.97	1.
2	0.166	0.166	5.76	0.88	0.9072
3	0.25	0.25	5.56	0.68	0.701
4	0.333	0.333	5.36	0.48	0.4948
5	0.5	0.5	5.3	0.42	0.433
6	0.75	0.75	5.25	0.37	0.3814
7	1.	1.	5.21	0.33	0.3402
8	1.25	1.25	5.17	0.29	0.299
9	1.5	1.5	5.15	0.27	0.2784
10	1.75	1.75	5.11	0.23	0.2371
11	2.	2.	5.09	0.21	0.2165
12	3.	3.	5.04	0.16	0.1649
13	5.	5.	4.99	0.11	0.1134
14	10.	10.	4.94	6.e-002	6.186e-002
15	15.	15.	4.91	3.e-002	3.093e-002



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-3

Bouwer and Rice parameter A = 2.412
Bouwer and Rice parameter B = 0.4589
ln(Re/Rw) = 2.436310e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
17 Measurements analyzed from 1 to 17
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 1.277 cm/hr
Transmissivity = 1.307 m2/day

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 4.9 feet at 0. seconds

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-3
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.88 feet
Water Table to Screen Bottom:	12.72 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

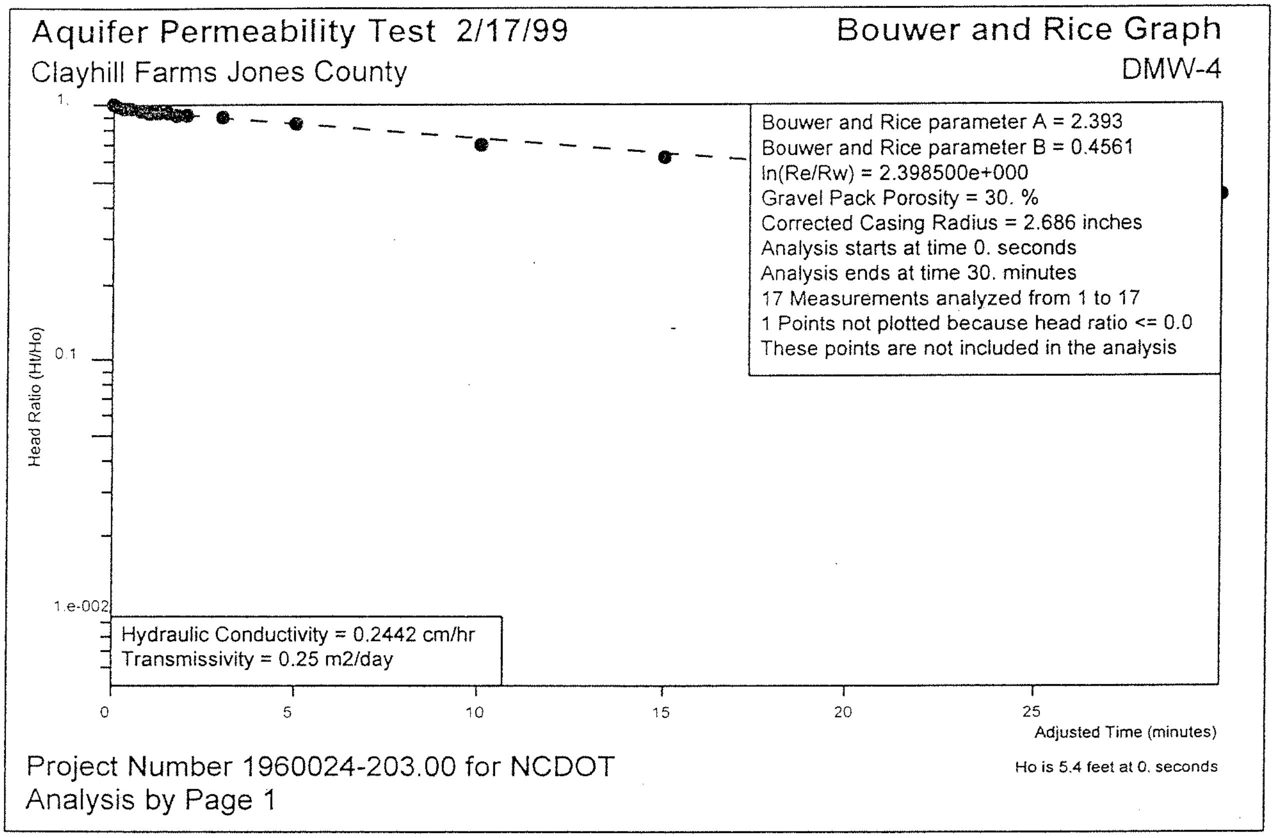
Test starts with trial 0

There are 17 time and drawdown measurements

Maximum head is 4.9 feet

Minimum head is -4.88 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.78	4.9	1.
2	8.3e-002	8.3e-002	9.36	4.48	0.9143
3	0.166	0.166	9.25	4.37	0.8918
4	0.25	0.25	9.1	4.22	0.8612
5	0.416	0.416	8.76	3.88	0.7918
6	0.5	0.5	8.64	3.76	0.7673
7	0.75	0.75	8.32	3.44	0.702
8	1.	1.	7.93	3.05	0.6224
9	1.25	1.25	7.6	2.72	0.5551
10	1.33	1.33	0.	-4.88	-0.9959
11	1.5	1.5	7.39	2.51	0.5122
12	1.75	1.75	7.1	2.22	0.4531
13	2.	2.	6.93	2.05	0.4184
14	3.	3.	6.63	1.75	0.3571
15	5.	5.	6.31	1.43	0.2918
16	10.	10.	5.82	0.94	0.1918
17	15.	15.	5.5	0.62	0.1265



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-4

Bouwer and Rice parameter A = 2.393
Bouwer and Rice parameter B = 0.4561
ln(Re/Rw) = 2.398500e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 30. minutes
17 Measurements analyzed from 1 to 17
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 0.2442 cm/hr
Transmissivity = 0.25 m2/day

Ho is 5.4 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT

Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-4
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	3.8 feet
Water Table to Screen Bottom:	12.3 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

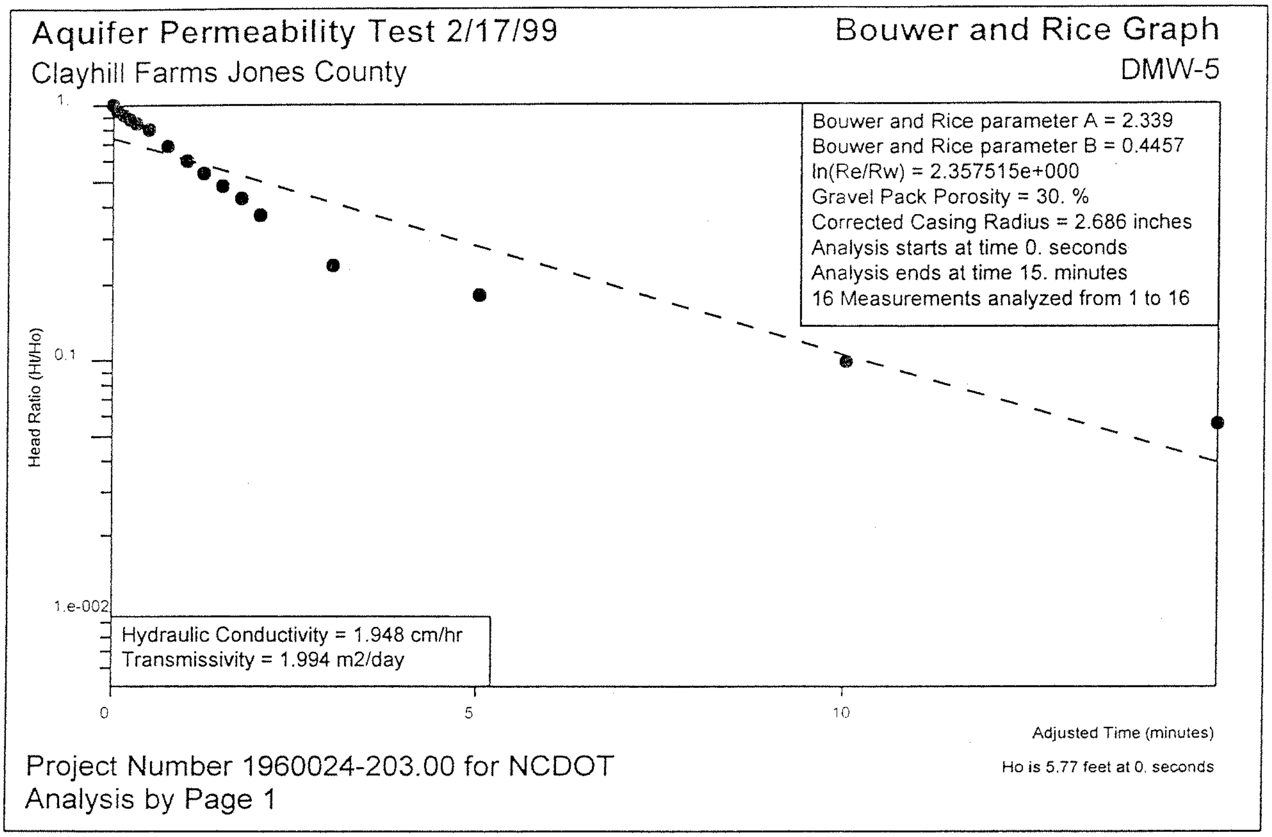
Test starts with trial 0

There are 17 time and drawdown measurements

Maximum head is 5.4 feet

Minimum head is -3.8 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	9.2	5.4	1.
2	0.166	0.166	9.12	5.32	0.9852
3	0.25	0.25	0.	-3.8	-0.7037
4	0.333	0.333	9.06	5.26	0.9741
5	0.5	0.5	9.01	5.21	0.9648
6	0.75	0.75	8.95	5.15	0.9537
7	1.	1.	8.9	5.1	0.9444
8	1.25	1.25	8.86	5.06	0.937
9	1.5	1.5	8.81	5.01	0.9278
10	1.75	1.75	8.77	4.97	0.9204
11	2.	2.	8.73	4.93	0.913
12	3.	3.	8.69	4.89	0.9056
13	5.	5.	8.39	4.59	0.85
14	10.	10.	7.62	3.82	0.7074
15	15.	15.	7.2	3.4	0.6296
16	20.	20.	6.84	3.04	0.563
17	30.	30.	6.2	2.4	0.4444



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-5

Bouwer and Rice parameter A = 2.339
Bouwer and Rice parameter B = 0.4457
ln(Re/Rw) = 2.357515e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 1.948 cm/hr
Transmissivity = 1.994 m2/day

Ho is 5.77 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-5
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.43 feet
Water Table to Screen Bottom:	11.67 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 5.77 feet

Minimum head is 0. feet

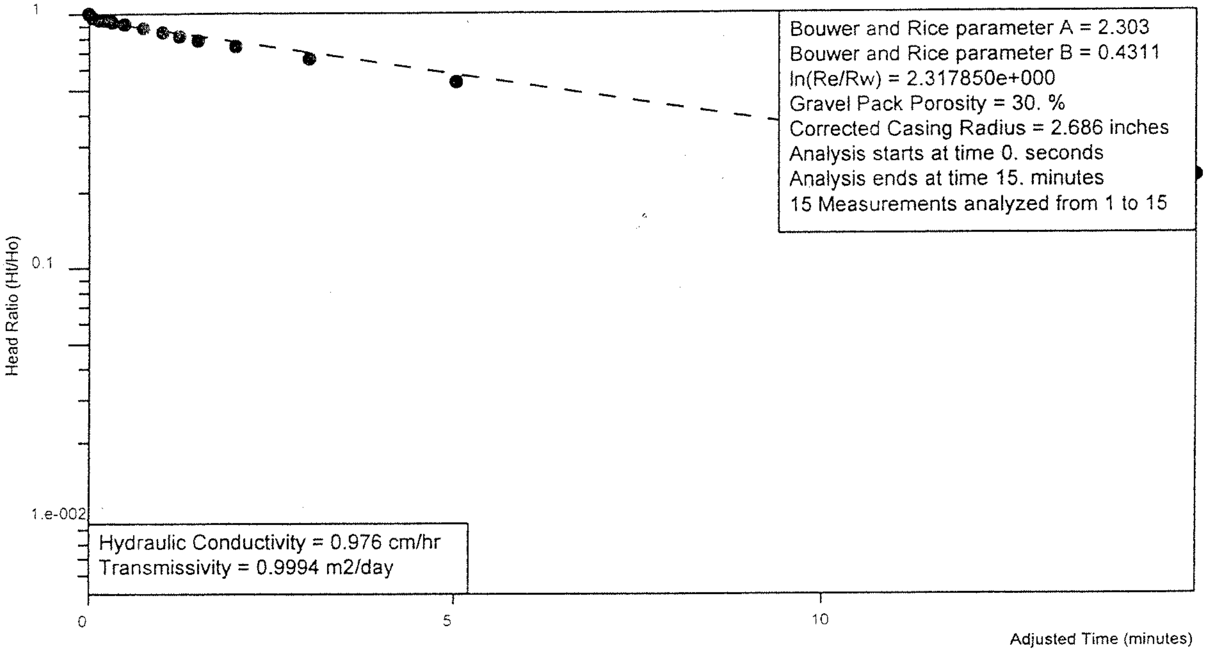
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	10.2	5.77	1.
2	8.3e-002	8.3e-002	9.98	5.55	0.9619
3	0.166	0.166	9.7	5.27	0.9133
4	0.25	0.25	9.5	5.07	0.8787
5	0.333	0.333	9.3	4.87	0.844
6	0.5	0.5	9.04	4.61	0.799
7	0.75	0.75	8.41	3.98	0.6898
8	1.	1.	7.93	3.5	0.6066
9	1.25	1.25	7.53	3.1	0.5373
10	1.5	1.5	7.2	2.77	0.4801
11	1.75	1.75	6.9	2.47	0.4281
12	2.	2.	6.56	2.13	0.3692
13	3.	3.	5.79	1.36	0.2357
14	5.	5.	5.48	1.05	0.182
15	10.	10.	5.	0.57	9.879e-002
16	15.	15.	4.75	0.32	5.546e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-6

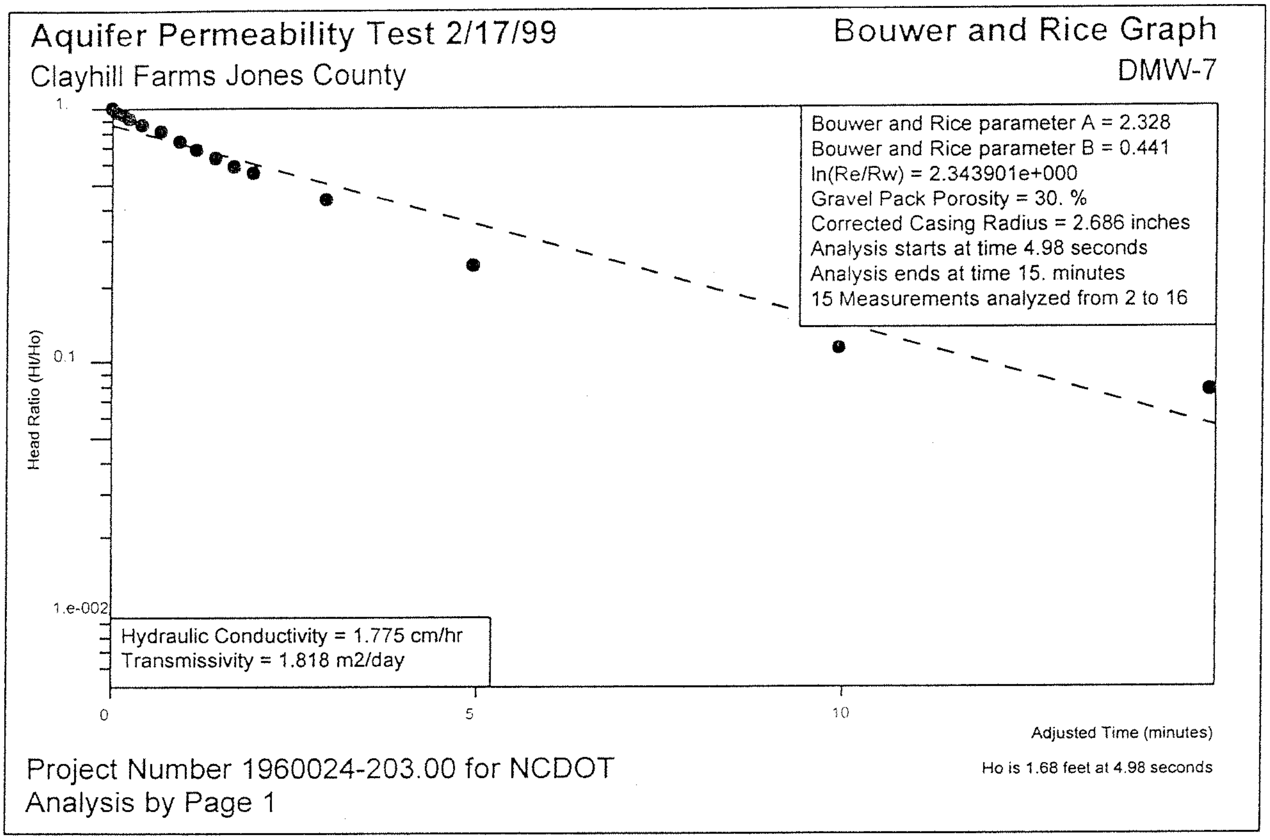


Bouwer and Rice parameter A = 2.303
Bouwer and Rice parameter B = 0.4311
ln(Re/Rw) = 2.317850e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 0.976 cm/hr
Transmissivity = 0.9994 m2/day

Ho is 3.23 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-7

Bouwer and Rice parameter A = 2.328
Bouwer and Rice parameter B = 0.441
ln(Re/Rw) = 2.343901e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 4.98 seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 2 to 16

Hydraulic Conductivity = 1.775 cm/hr
Transmissivity = 1.818 m2/day

Ho is 1.68 feet at 4.98 seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-7
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.85 feet
Water Table to Screen Bottom:	11.45 feet
Anisotropy Ratio:	0.
Time Adjustment:	4.98 Seconds

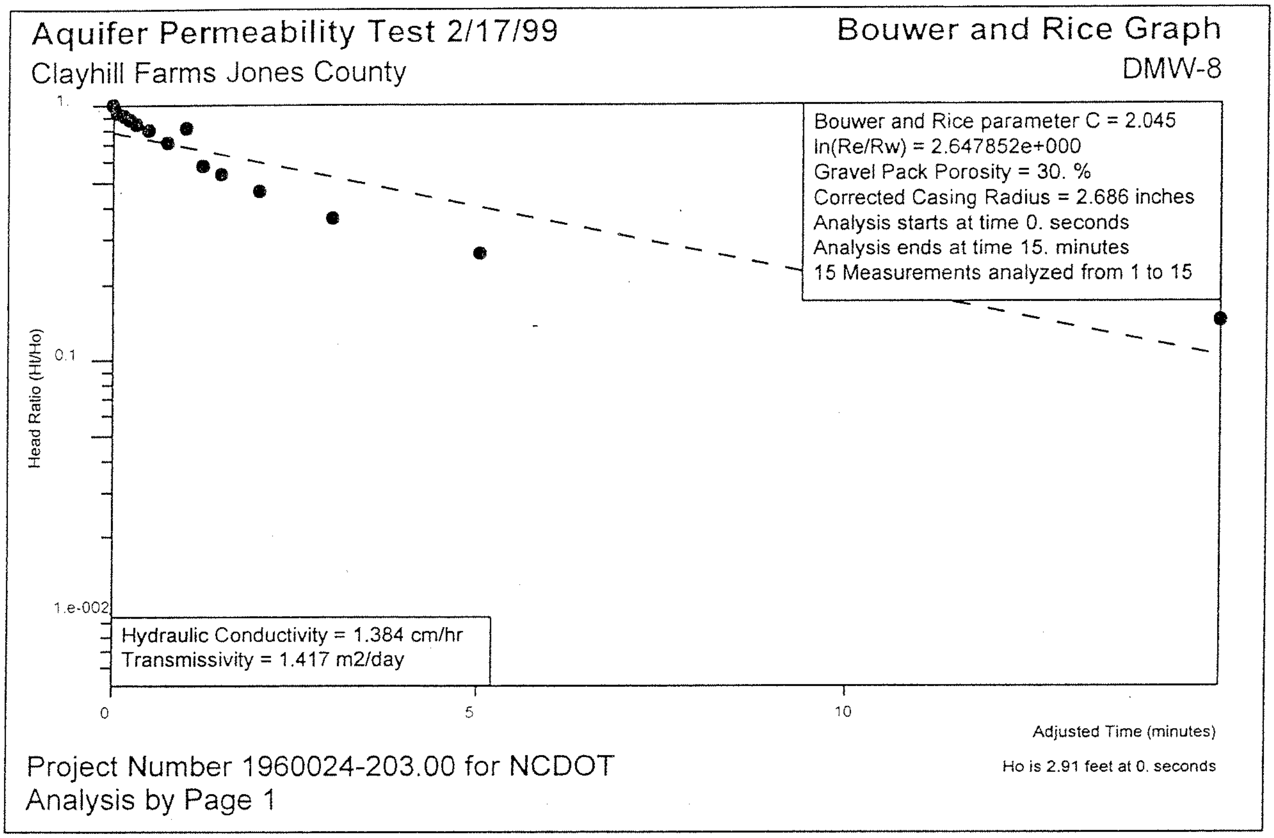
Test starts with trial 1

There are 16 time and drawdown measurements

Maximum head is 1.68 feet

Minimum head is -4.85 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-4.85	-2.887
2	8.3e-002	0.	6.53	1.68	1.
3	0.166	8.3e-002	6.49	1.64	0.9762
4	0.25	0.167	6.45	1.6	0.9524
5	0.333	0.25	6.38	1.53	0.9107
6	0.5	0.417	6.32	1.47	0.875
7	0.75	0.667	6.22	1.37	0.8155
8	1.	0.917	6.1	1.25	0.744
9	1.25	1.167	6.02	1.17	0.6964
10	1.5	1.417	5.93	1.08	0.6429
11	1.75	1.667	5.85	1.	0.5952
12	2.	1.917	5.8	0.95	0.5655
13	3.	2.917	5.59	0.74	0.4405
14	5.	4.917	5.25	0.4	0.2381
15	10.	9.917	5.04	0.19	0.1131
16	15.	14.92	4.98	0.13	7.738e-002



Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-8

Bouwer and Rice parameter C = 2.045
ln(Re/Rw) = 2.647852e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 1.384 cm/hr
Transmissivity = 1.417 m2/day

Ho is 2.91 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-8
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	2.59 feet
Water Table to Screen Bottom:	13.31 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

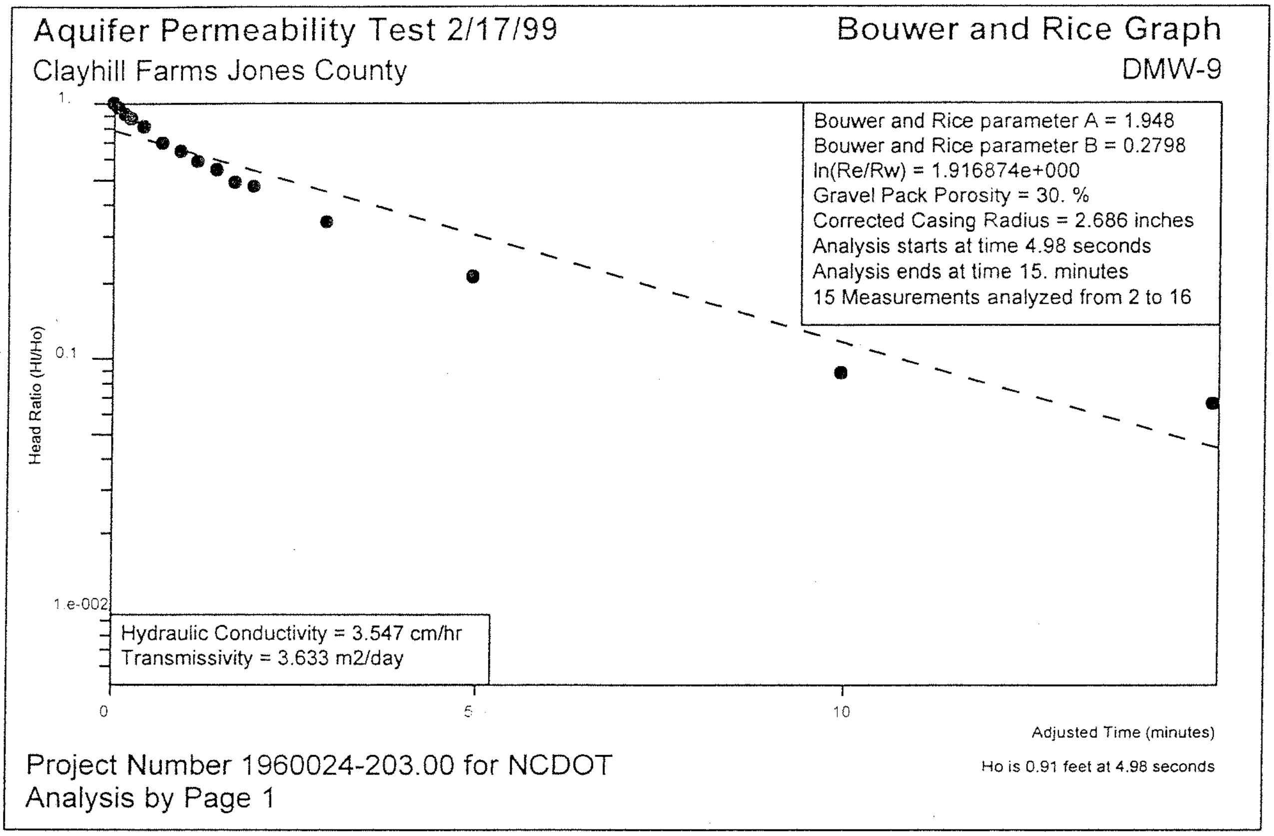
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 2.91 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.5	2.91	1.
2	8.3e-002	8.3e-002	5.32	2.73	0.9381
3	0.166	0.166	5.25	2.66	0.9141
4	0.25	0.25	5.18	2.59	0.89
5	0.333	0.333	5.09	2.5	0.8591
6	0.5	0.5	4.92	2.33	0.8007
7	0.75	0.75	4.69	2.1	0.7216
8	1.	1.	4.98	2.39	0.8213
9	1.25	1.25	4.3	1.71	0.5876
10	1.5	1.5	4.16	1.57	0.5395
11	2.	2.	3.93	1.34	0.4605
12	3.	3.	3.65	1.06	0.3643
13	5.	5.	3.36	0.77	0.2646
14	10.	10.	3.12	0.53	0.1821
15	15.	15.	3.01	0.42	0.1443



Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-9

Bouwer and Rice parameter A = 1.948
Bouwer and Rice parameter B = 0.2798
ln(Re/Rw) = 1.916874e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 4.98 seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 2 to 16

Hydraulic Conductivity = 3.547 cm/hr
Transmissivity = 3.633 m2/day

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 0.91 feet at 4.98 seconds

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-9
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	10.96 feet
Water Table to Screen Bottom:	5.04 feet
Anisotropy Ratio:	0.
Time Adjustment:	4.98 Seconds

Test starts with trial 1

There are 16 time and drawdown measurements

Maximum head is 0.91 feet

Minimum head is -10.96 feet

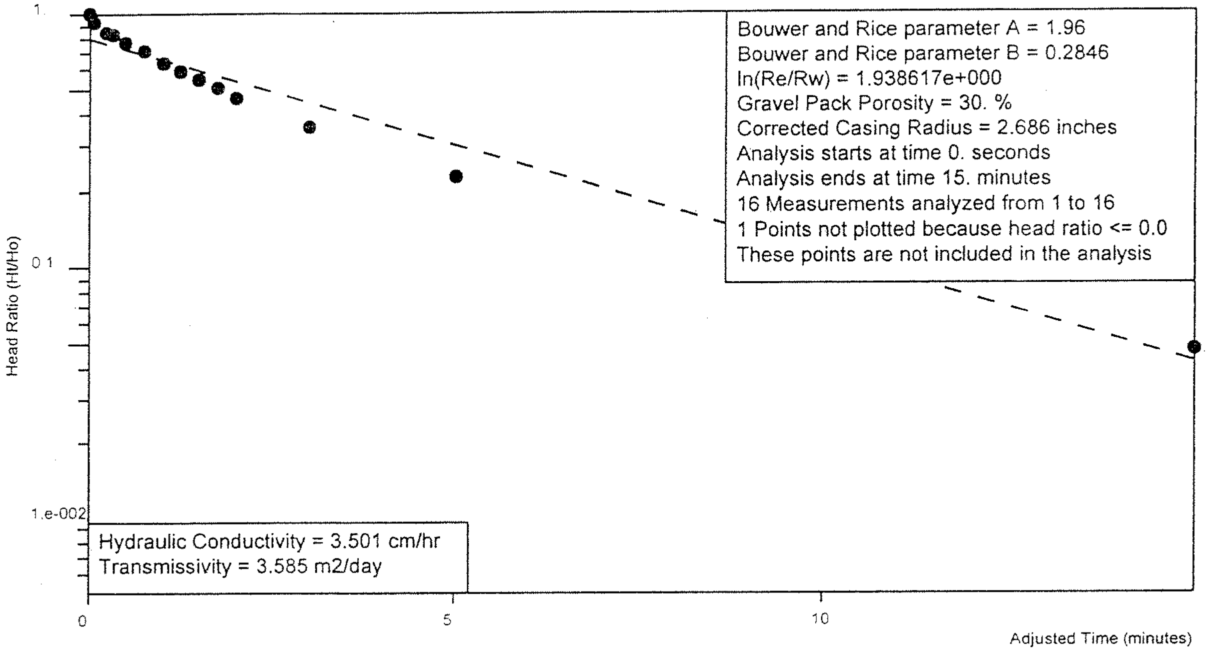
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-10.96	-12.04
2	8.3e-002	0.	11.87	0.91	1.
3	0.166	8.3e-002	11.84	0.88	0.967
4	0.25	0.167	11.8	0.84	0.9231
5	0.333	0.25	11.77	0.81	0.8901
6	0.5	0.417	11.7	0.74	0.8132
7	0.75	0.667	11.6	0.64	0.7033
8	1.	0.917	11.55	0.59	0.6484
9	1.25	1.167	11.5	0.54	0.5934
10	1.5	1.417	11.46	0.5	0.5495
11	1.75	1.667	11.41	0.45	0.4945
12	2.	1.917	11.39	0.43	0.4725
13	3.	2.917	11.27	0.31	0.3407
14	5.	4.917	11.15	0.19	0.2088
15	10.	9.917	11.04	8.e-002	8.791e-002
16	15.	14.92	11.02	6.e-002	6.593e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-10



Bouwer and Rice parameter A = 1.96
Bouwer and Rice parameter B = 0.2846
ln(Re/Rw) = 1.938617e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 3.501 cm/hr
Transmissivity = 3.585 m2/day

Ho is 1.06 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-10
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	10.96 feet
Water Table to Screen Bottom:	5.24 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.06 feet

Minimum head is -6.e-002 feet

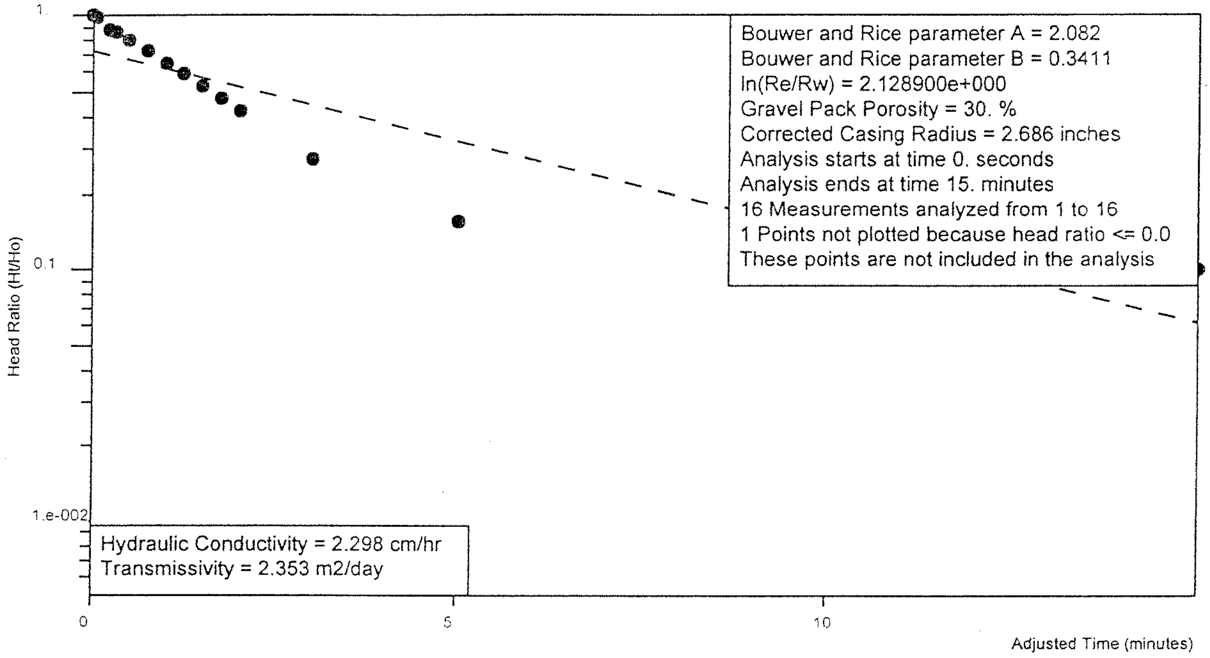
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	12.02	1.06	1.
2	8.3e-002	8.3e-002	11.96	1.	0.9434
3	0.166	0.166	10.9	-6.e-002	-5.66e-002
4	0.25	0.25	11.86	0.9	0.8491
5	0.333	0.333	11.84	0.88	0.8302
6	0.5	0.5	11.78	0.82	0.7736
7	0.75	0.75	11.72	0.76	0.717
8	1.	1.	11.64	0.68	0.6415
9	1.25	1.25	11.59	0.63	0.5943
10	1.5	1.5	11.54	0.58	0.5472
11	1.75	1.75	11.5	0.54	0.5094
12	2.	2.	11.45	0.49	0.4623
13	3.	3.	11.34	0.38	0.3585
14	5.	5.	11.2	0.24	0.2264
15	10.	10.	11.09	0.13	0.1226
16	15.	15.	11.01	5.e-002	4.717e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-11



Bouwer and Rice parameter A = 2.082
Bouwer and Rice parameter B = 0.3411
ln(Re/Rw) = 2.128900e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 2.298 cm/hr
Transmissivity = 2.353 m2/day

Ho is 5.82 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-11
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	8.98 feet
Water Table to Screen Bottom:	7.52 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 5.82 feet

Minimum head is -8.98 feet

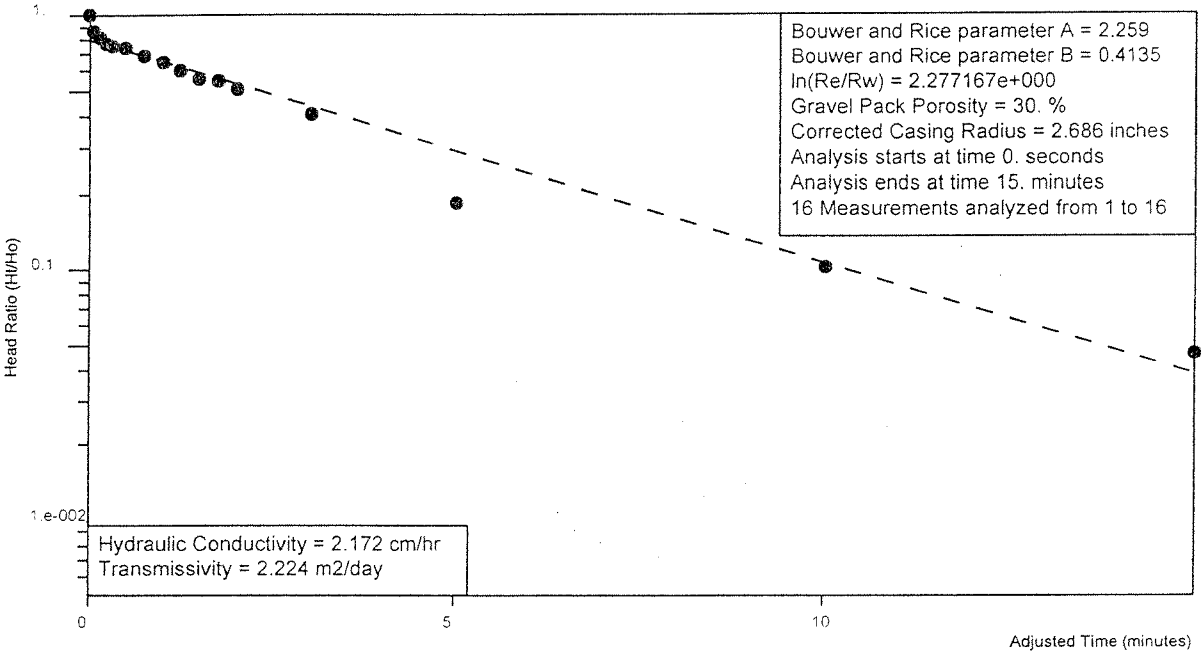
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	14.8	5.82	1.
2	8.3e-002	8.3e-002	14.72	5.74	0.9863
3	0.166	0.166	0.	-8.98	-1.543
4	0.25	0.25	14.15	5.17	0.8883
5	0.333	0.333	14.	5.02	0.8625
6	0.5	0.5	13.67	4.69	0.8058
7	0.75	0.75	13.2	4.22	0.7251
8	1.	1.	12.75	3.77	0.6478
9	1.25	1.25	12.46	3.48	0.5979
10	1.5	1.5	12.08	3.1	0.5326
11	1.75	1.75	11.76	2.78	0.4777
12	2.	2.	11.45	2.47	0.4244
13	3.	3.	10.58	1.6	0.2749
14	5.	5.	9.89	0.91	0.1564
15	10.	10.	9.68	0.7	0.1203
16	15.	15.	9.56	0.58	9.966e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-12



Bouwer and Rice parameter A = 2.259
Bouwer and Rice parameter B = 0.4135
ln(Re/Rw) = 2.277167e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 2.172 cm/hr
Transmissivity = 2.224 m2/day

Ho is 1.08 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-12
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	6.16 feet
Water Table to Screen Bottom:	10.24 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.08 feet

Minimum head is 0. feet

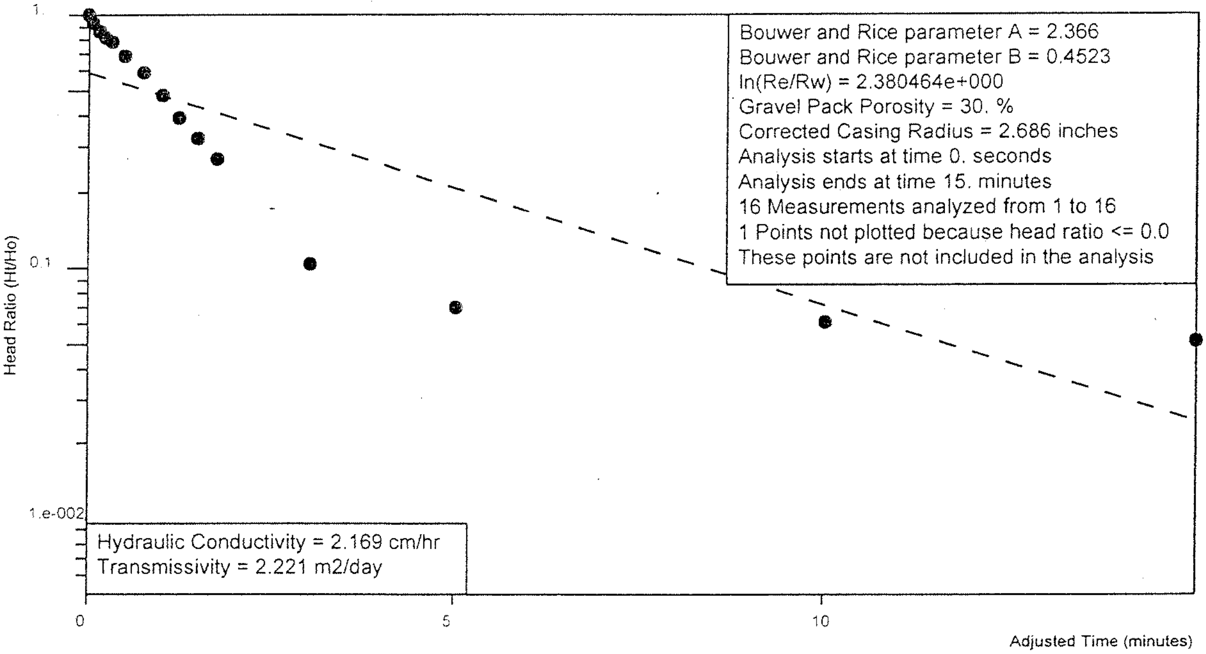
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.24	1.08	1.
2	8.3e-002	8.3e-002	7.09	0.93	0.8611
3	0.166	0.166	7.05	0.89	0.8241
4	0.25	0.25	7.	0.84	0.7778
5	0.333	0.333	6.98	0.82	0.7593
6	0.5	0.5	6.96	0.8	0.7407
7	0.75	0.75	6.91	0.75	0.6944
8	1.	1.	6.86	0.7	0.6481
9	1.25	1.25	6.82	0.66	0.6111
10	1.5	1.5	6.77	0.61	0.5648
11	1.75	1.75	6.75	0.59	0.5463
12	2.	2.	6.71	0.55	0.5093
13	3.	3.	6.6	0.44	0.4074
14	5.	5.	6.36	0.2	0.1852
15	10.	10.	6.27	0.11	0.1019
16	15.	15.	6.21	5.e-002	4.63e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-13



Bouwer and Rice parameter A = 2.366
Bouwer and Rice parameter B = 0.4523
ln(Re/Rw) = 2.380464e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16
1 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 2.169 cm/hr
Transmissivity = 2.221 m2/day

Ho is 1.15 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-13
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.62 feet
Water Table to Screen Bottom:	12.03 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

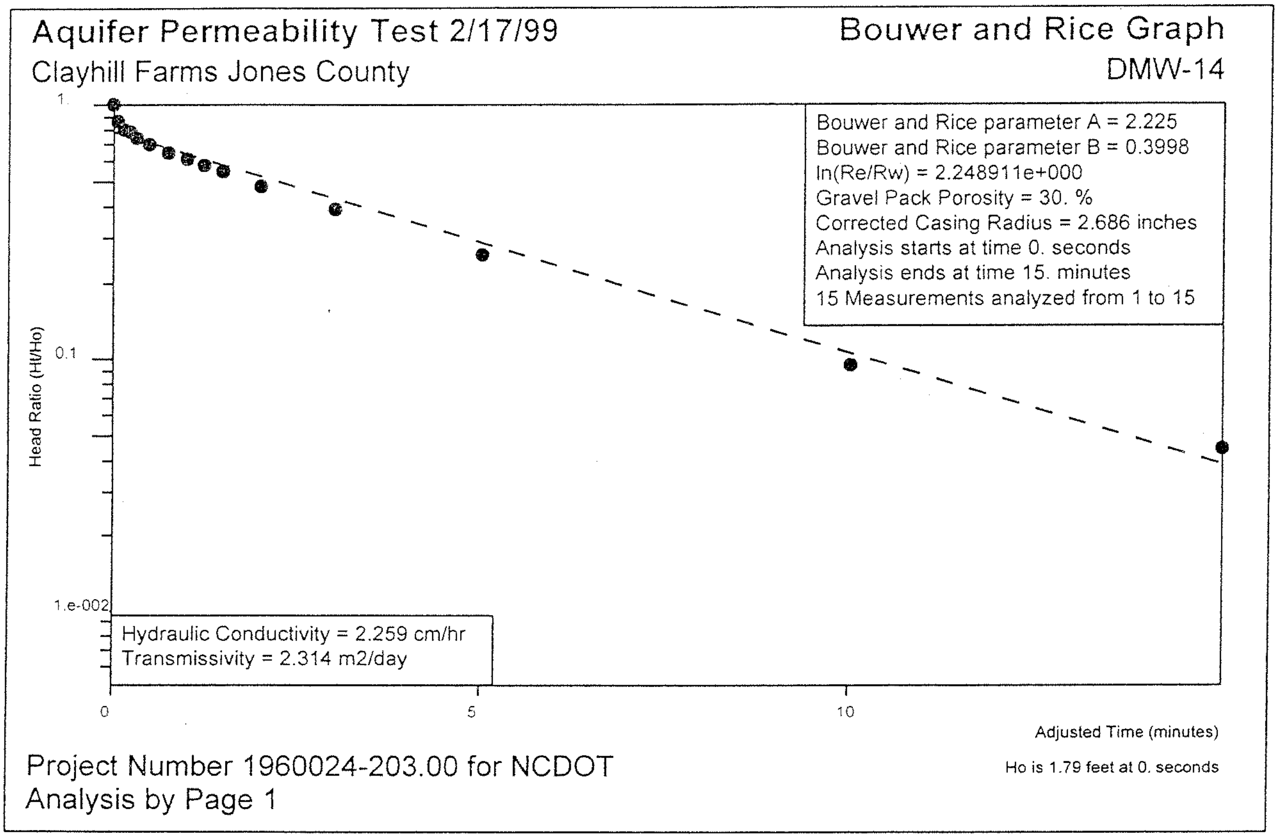
Test starts with trial 0

There are 16 time and drawdown measurements

Maximum head is 1.15 feet

Minimum head is -4.62 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.77	1.15	1.
2	8.3e-002	8.3e-002	5.7	1.08	0.9391
3	0.166	0.166	5.61	0.99	0.8609
4	0.25	0.25	5.57	0.95	0.8261
5	0.333	0.333	5.52	0.9	0.7826
6	0.5	0.5	5.41	0.79	0.687
7	0.75	0.75	5.3	0.68	0.5913
8	1.	1.	5.17	0.55	0.4783
9	1.25	1.25	5.07	0.45	0.3913
10	1.5	1.5	4.99	0.37	0.3217
11	1.75	1.75	4.93	0.31	0.2696
12	2.	2.	0.	-4.62	-4.017
13	3.	3.	4.74	0.12	0.1043
14	5.	5.	4.7	8.e-002	6.957e-002
15	10.	10.	4.69	7.e-002	6.087e-002
16	15.	15.	4.68	6.e-002	5.217e-002



Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-14

Bouwer and Rice parameter A = 2.225
Bouwer and Rice parameter B = 0.3998
ln(Re/Rw) = 2.248911e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 2.259 cm/hr
Transmissivity = 2.314 m2/day

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Ho is 1.79 feet at 0. seconds

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-14
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	6.61 feet
Water Table to Screen Bottom:	9.69 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

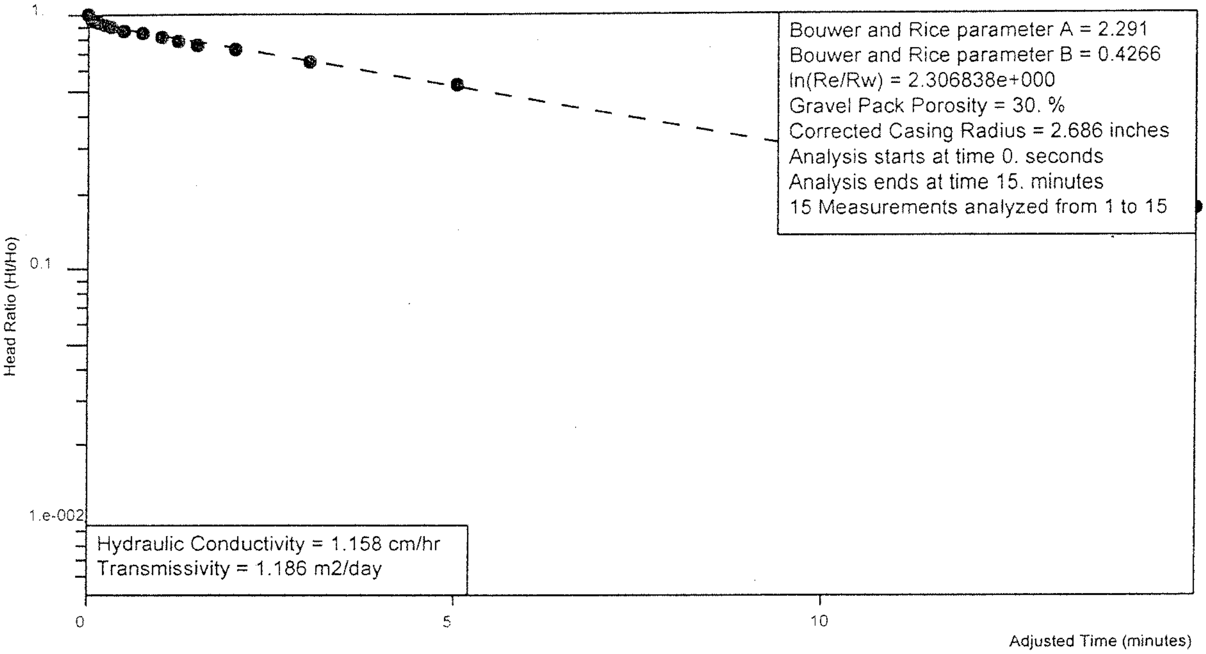
Maximum head is 1.79 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	8.4	1.79	1.
2	8.3e-002	8.3e-002	8.16	1.55	0.8659
3	0.166	0.166	8.06	1.45	0.8101
4	0.25	0.25	8.01	1.4	0.7821
5	0.333	0.333	7.95	1.34	0.7486
6	0.5	0.5	7.87	1.26	0.7039
7	0.75	0.75	7.78	1.17	0.6536
8	1.	1.	7.71	1.1	0.6145
9	1.25	1.25	7.65	1.04	0.581
10	1.5	1.5	7.59	0.98	0.5475
11	2.	2.	7.48	0.87	0.486
12	3.	3.	7.31	0.7	0.3911
13	5.	5.	7.07	0.46	0.257
14	10.	10.	6.78	0.17	9.497e-002
15	15.	15.	6.69	8.e-002	4.469e-002

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-15



Bouwer and Rice parameter A = 2.291
Bouwer and Rice parameter B = 0.4266
ln(Re/Rw) = 2.306838e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 1.158 cm/hr
Transmissivity = 1.186 m2/day

Ho is 1.5 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-15
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	5.7 feet
Water Table to Screen Bottom:	10.8 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

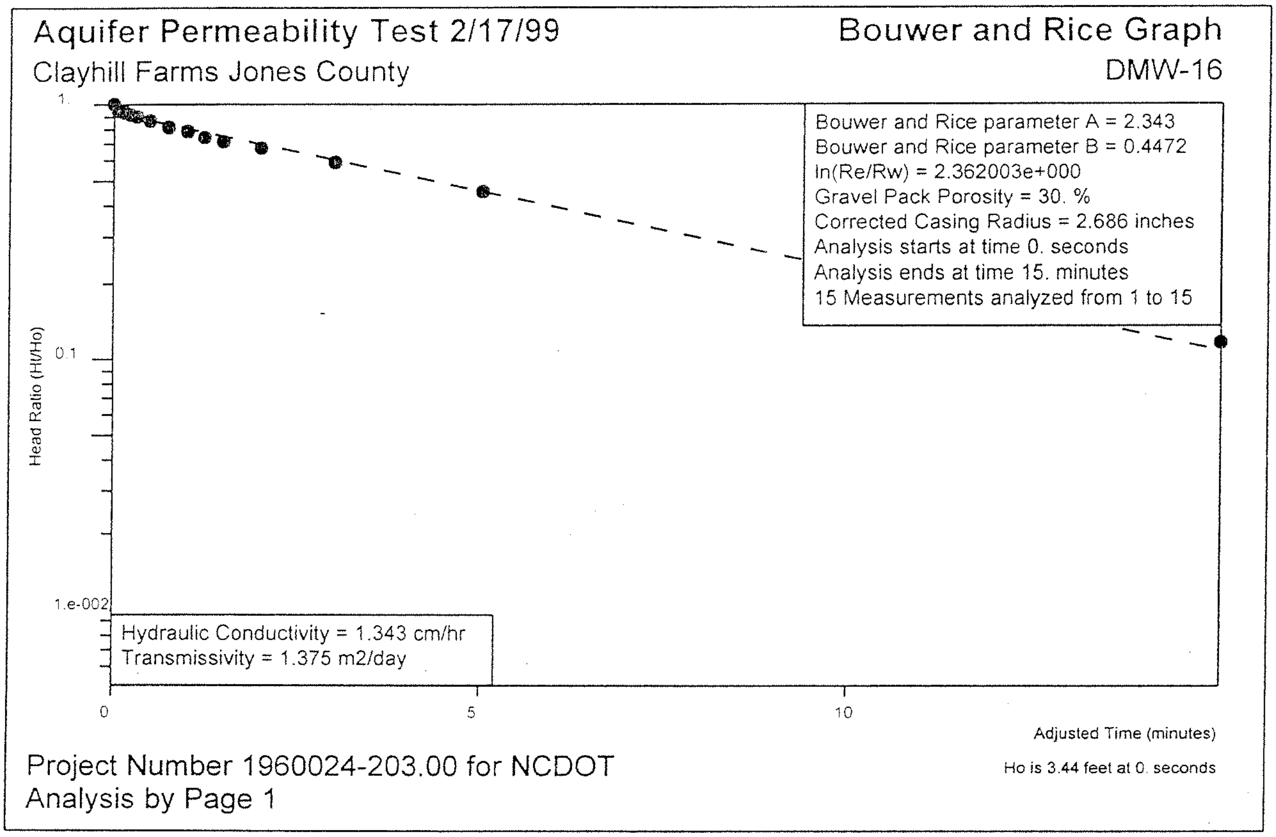
Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 1.5 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.2	1.5	1.
2	8.3e-002	8.3e-002	7.13	1.43	0.9533
3	0.166	0.166	7.1	1.4	0.9333
4	0.25	0.25	7.07	1.37	0.9133
5	0.333	0.333	7.05	1.35	0.9
6	0.5	0.5	7.01	1.31	0.8733
7	0.75	0.75	6.97	1.27	0.8467
8	1.	1.	6.92	1.22	0.8133
9	1.25	1.25	6.88	1.18	0.7867
10	1.5	1.5	6.84	1.14	0.76
11	2.	2.	6.79	1.09	0.7267
12	3.	3.	6.68	0.98	0.6533
13	5.	5.	6.49	0.79	0.5267
14	10.	10.	6.1	0.4	0.2667
15	15.	15.	5.96	0.26	0.1733



Bouwer and Rice parameter A = 2.343
Bouwer and Rice parameter B = 0.4472
ln(Re/Rw) = 2.362003e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 1.343 cm/hr
Transmissivity = 1.375 m2/day

Ho is 3.44 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-16
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.46 feet
Water Table to Screen Bottom:	11.74 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 3.44 feet

Minimum head is 0. feet

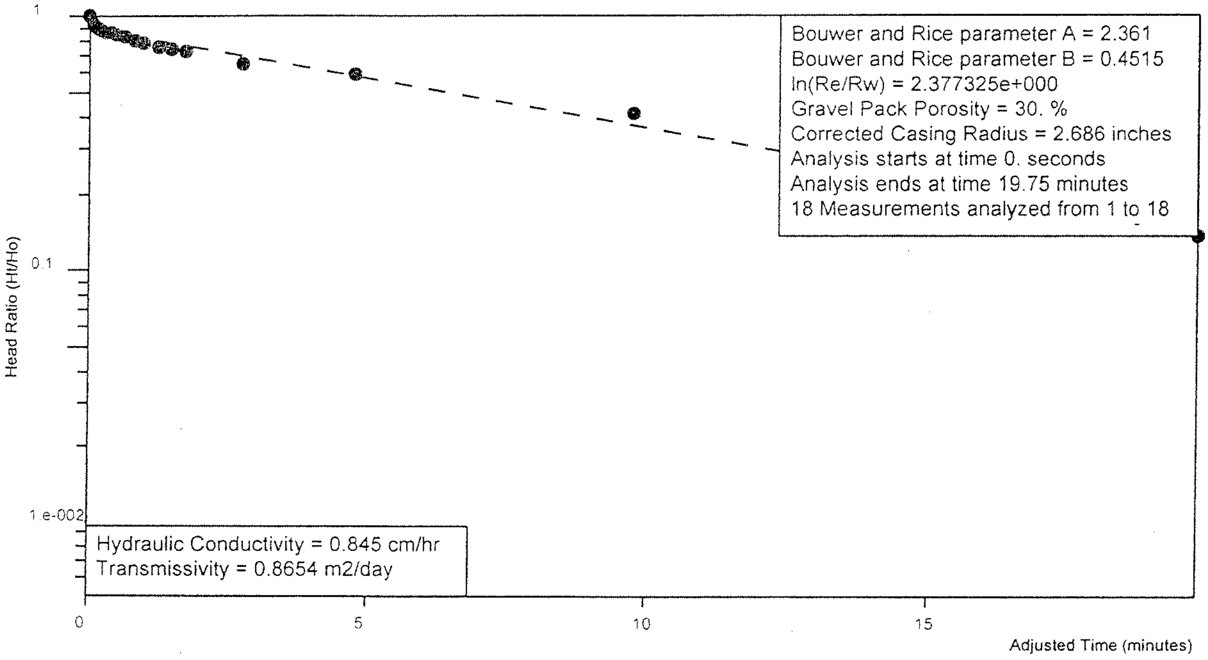
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.9	3.44	1.
2	8.3e-002	8.3e-002	7.75	3.29	0.9564
3	0.166	0.166	7.66	3.2	0.9302
4	0.25	0.25	7.61	3.15	0.9157
5	0.333	0.333	7.55	3.09	0.8983
6	0.5	0.5	7.43	2.97	0.8634
7	0.75	0.75	7.29	2.83	0.8227
8	1.	1.	7.17	2.71	0.7878
9	1.25	1.25	7.04	2.58	0.75
10	1.5	1.5	6.94	2.48	0.7209
11	2.	2.	6.78	2.32	0.6744
12	3.	3.	6.5	2.04	0.593
13	5.	5.	6.03	1.57	0.4564
14	10.	10.	5.16	0.7	0.2035
15	15.	15.	4.86	0.4	0.1163

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-17



Bouwer and Rice parameter A = 2.361
Bouwer and Rice parameter B = 0.4515
ln(Re/Rw) = 2.377325e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 19.75 minutes
18 Measurements analyzed from 1 to 18

Hydraulic Conductivity = 0.845 cm/hr
Transmissivity = 0.8654 m2/day

Ho is 3.23 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-17
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.22 feet
Water Table to Screen Bottom:	11.98 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 18 time and drawdown measurements

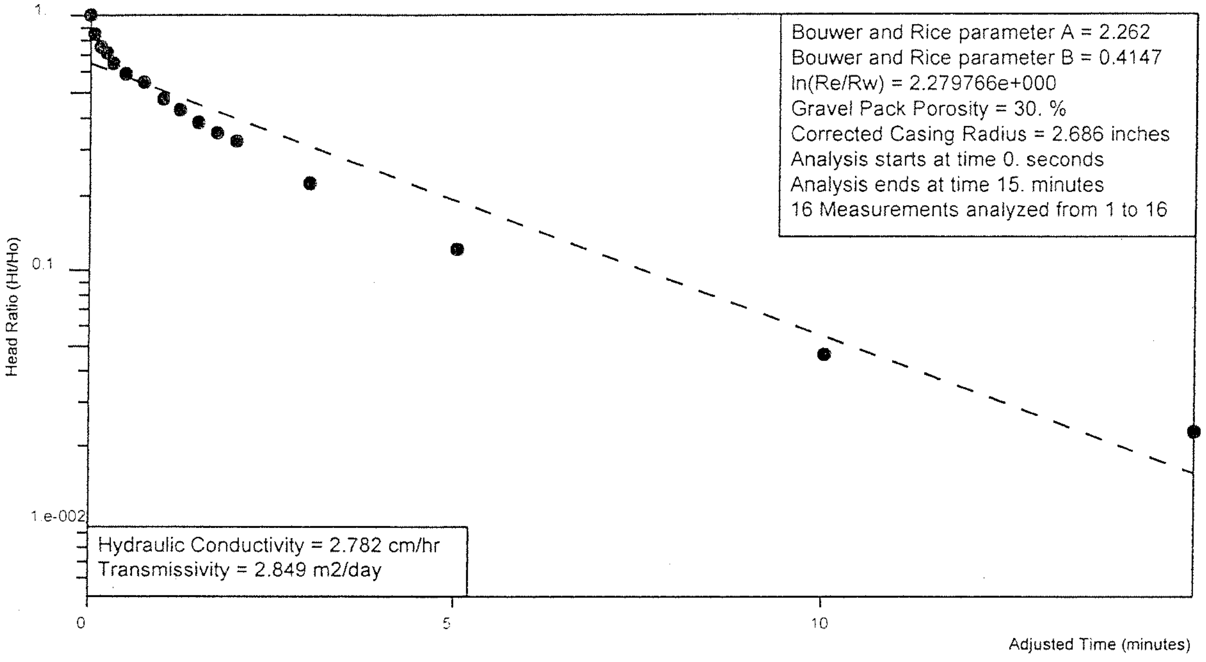
Maximum head is 3.23 feet

Minimum head is 0. feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.45	3.23	1.
2	8.3e-002	8.3e-002	7.22	3.	0.9288
3	0.166	0.166	7.15	2.93	0.9071
4	0.25	0.25	7.09	2.87	0.8885
5	0.333	0.333	7.03	2.81	0.87
6	0.416	0.416	7.	2.78	0.8607
7	0.5	0.5	6.95	2.73	0.8452
8	0.666	0.666	6.9	2.68	0.8297
9	0.833	0.833	6.82	2.6	0.805
10	1.	1.	6.76	2.54	0.7864
11	1.25	1.25	6.69	2.47	0.7647
12	1.5	1.5	6.62	2.4	0.743
13	1.75	1.75	6.58	2.36	0.7307
14	2.75	2.75	6.35	2.13	0.6594
15	4.75	4.75	6.15	1.93	0.5975
16	9.75	9.75	5.55	1.33	0.4118
17	14.75	14.75	5.04	0.82	0.2539
18	19.75	19.75	4.66	0.44	0.1362

Aquifer Permeability Test 2/17/99
Clayhill Farms Jones County

Bouwer and Rice Graph
DMW-18



Bouwer and Rice parameter A = 2.262
Bouwer and Rice parameter B = 0.4147
ln(Re/Rw) = 2.279766e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 15. minutes
16 Measurements analyzed from 1 to 16

Hydraulic Conductivity = 2.782 cm/hr
Transmissivity = 2.849 m2/day

Ho is 1.74 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-18
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	6.01 feet
Water Table to Screen Bottom:	10.29 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0
There are 16 time and drawdown measurements
Maximum head is 1.74 feet
Minimum head is 0. feet

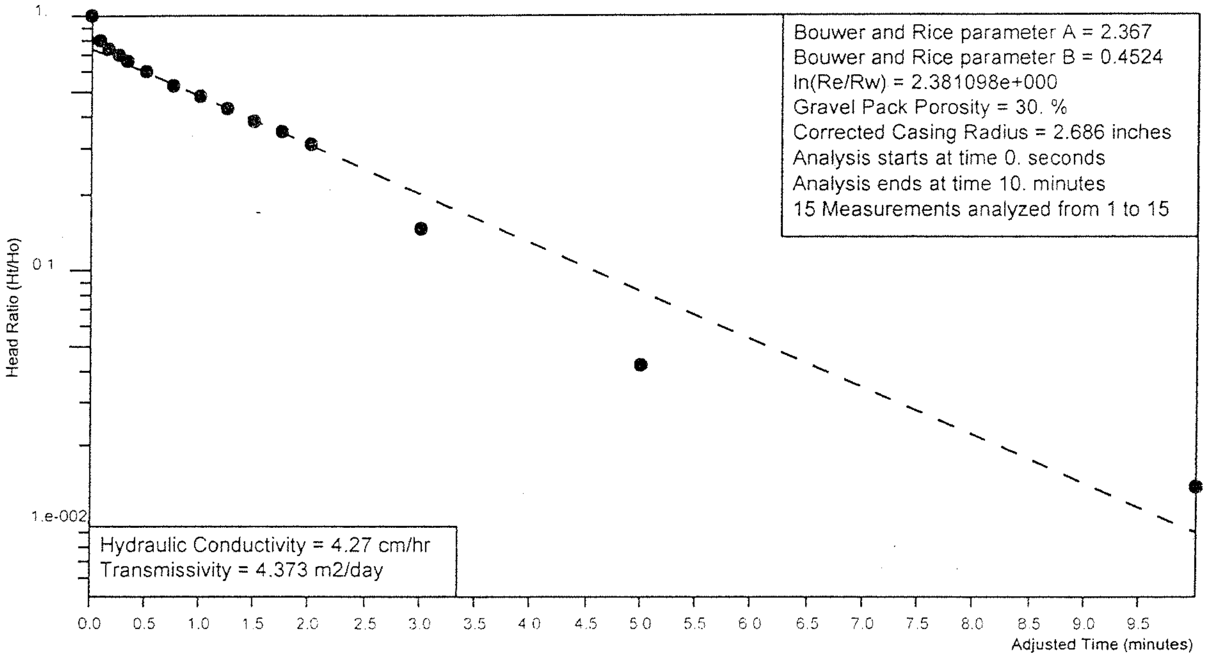
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	7.75	1.74	1.
2	8.3e-002	8.3e-002	7.5	1.49	0.8563
3	0.166	0.166	7.33	1.32	0.7586
4	0.25	0.25	7.25	1.24	0.7126
5	0.333	0.333	7.15	1.14	0.6552
6	0.5	0.5	7.04	1.03	0.592
7	0.75	0.75	6.96	0.95	0.546
8	1.	1.	6.84	0.83	0.477
9	1.25	1.25	6.76	0.75	0.431
10	1.5	1.5	6.68	0.67	0.3851
11	1.75	1.75	6.62	0.61	0.3506
12	2.	2.	6.57	0.56	0.3218
13	3.	3.	6.4	0.39	0.2241
14	5.	5.	6.22	0.21	0.1207
15	10.	10.	6.09	8.e-002	4.598e-002
16	15.	15.	6.05	4.e-002	2.299e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-19



Bouwer and Rice parameter A = 2.367
Bouwer and Rice parameter B = 0.4524
ln(Re/Rw) = 2.381098e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 0. seconds
Analysis ends at time 10. minutes
15 Measurements analyzed from 1 to 15

Hydraulic Conductivity = 4.27 cm/hr
Transmissivity = 4.373 m2/day

Ho is 1.44 feet at 0. seconds

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-19
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	4.16 feet
Water Table to Screen Bottom:	12.04 feet
Anisotropy Ratio:	0.
Time Adjustment:	0. Seconds

Test starts with trial 0

There are 15 time and drawdown measurements

Maximum head is 1.44 feet

Minimum head is 0. feet

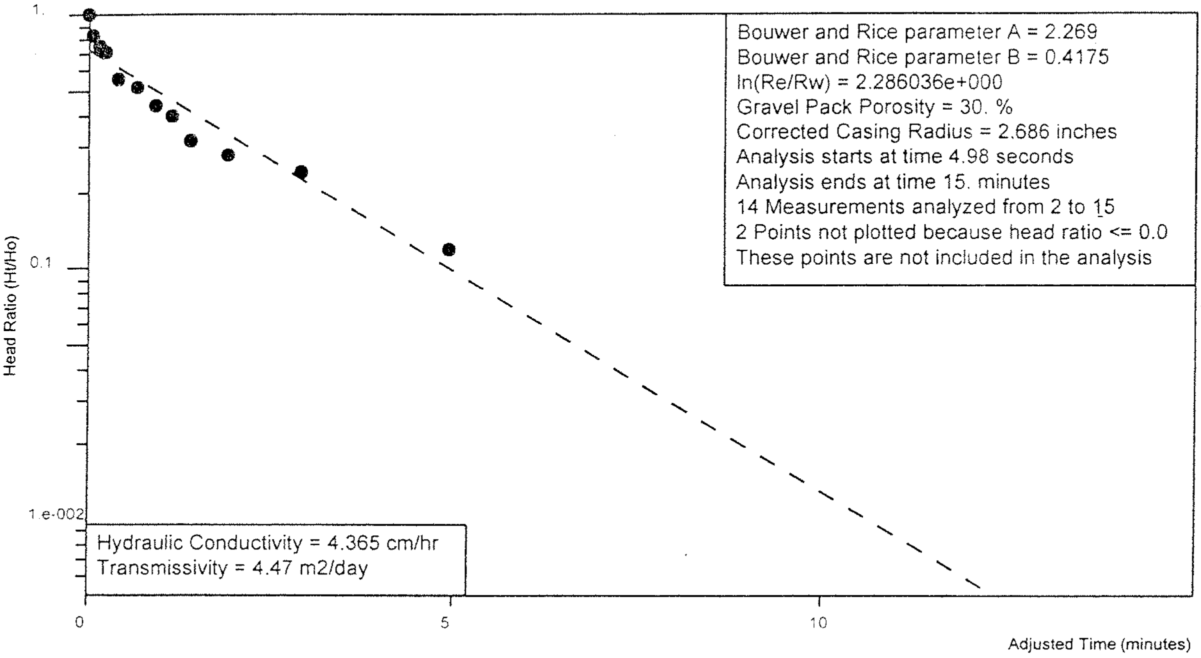
Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	0.	5.6	1.44	1.
2	8.3e-002	8.3e-002	5.31	1.15	0.7986
3	0.166	0.166	5.24	1.08	0.75
4	0.25	0.25	5.18	1.02	0.7083
5	0.333	0.333	5.12	0.96	0.6667
6	0.5	0.5	5.03	0.87	0.6042
7	0.75	0.75	4.93	0.77	0.5347
8	1.	1.	4.85	0.69	0.4792
9	1.25	1.25	4.78	0.62	0.4306
10	1.5	1.5	4.71	0.55	0.3819
11	1.75	1.75	4.66	0.5	0.3472
12	2.	2.	4.61	0.45	0.3125
13	3.	3.	4.37	0.21	0.1458
14	5.	5.	4.22	6.e-002	4.167e-002
15	10.	10.	4.18	2.e-002	1.389e-002

Aquifer Permeability Test 2/17/99

Clayhill Farms Jones County

Bouwer and Rice Graph

DMW-20



Bouwer and Rice parameter A = 2.269
Bouwer and Rice parameter B = 0.4175
ln(Re/Rw) = 2.286036e+000
Gravel Pack Porosity = 30. %
Corrected Casing Radius = 2.686 inches
Analysis starts at time 4.98 seconds
Analysis ends at time 15. minutes
14 Measurements analyzed from 2 to 15
2 Points not plotted because head ratio <= 0.0
These points are not included in the analysis

Hydraulic Conductivity = 4.365 cm/hr
Transmissivity = 4.47 m2/day

Project Number 1960024-203.00 for NCDOT
Analysis by Page 1

Aquifer Permeability Test

Site Name:	Clayhill Farms
Location:	Jones County
Test Date:	2/17/99
Client:	NCDOT
Project Number:	1960024-203.00

Well Label:	DMW-20
Aquifer Thickness:	14. feet
Screen Length:	12.5 feet
Casing Radius:	0.8 inches
Effective Radius:	4.75 inches
Gravel Pack Porosity:	30. %
Corrected Casing Radius:	2.686 inches
Static Water Level:	5.79 feet
Water Table to Screen Bottom:	10.41 feet
Anisotropy Ratio:	0.
Time Adjustment:	4.98 Seconds

Test starts with trial 1

There are 15 time and drawdown measurements

Maximum head is 0.25 feet

Minimum head is -5.79 feet

Trial	Time (minutes)	Adjusted Time (minutes)	Drawdown (feet)	Head (feet)	Head Ratio
1	0.	-8.3e-002	0.	-5.79	-23.16
2	8.3e-002	0.	6.04	0.25	1.
3	0.166	8.3e-002	6.	0.21	0.84
4	0.25	0.167	5.98	0.19	0.76
5	0.333	0.25	5.97	0.18	0.72
6	0.5	0.417	5.93	0.14	0.56
7	0.75	0.667	5.92	0.13	0.52
8	1.	0.917	5.9	0.11	0.44
9	1.25	1.167	5.89	1.e-001	0.4
10	1.5	1.417	5.87	8.e-002	0.32
11	2.	1.917	5.86	7.e-002	0.28
12	3.	2.917	5.85	6.e-002	0.24
13	5.	4.917	5.82	3.e-002	0.12
14	10.	9.917	5.79	0.	0.
15	15.	14.92	5.79	0.	0.

DESIGN CRITERIA

```
Jones County, NC

                                                                     03/18/99
DEPTH-DURATION-FREQUENCY TABLE                                       02:14 PM
===================================================================
               2-yr     5-yr     10-yr     25-yr     50-yr    100-yr
DURATION       [in]     [in]      [in]      [in]      [in]      [in]
===================================================================
 5 min         0.49     0.55      0.60      0.68      0.74      0.80
10 min         0.82     0.94      1.03      1.17      1.29      1.40
15 min         1.05     1.21      1.33      1.52      1.66      1.81
30 min         1.52     1.84      2.07      2.41      2.67      2.93
60 min         2.00     2.49      2.83      3.33      3.72      4.10
 2 hr          2.28     2.85      3.26      3.84      4.30      4.75
 3 hr          2.55     3.22      3.69      4.36      4.88      5.40
 6 hr          3.25     4.15      4.78      5.67      6.36      7.05
12 hr          3.88     4.98      5.75      6.84      7.68      8.53
24 hr          4.50     5.81      6.72      8.01      9.01     10.00
===================================================================

INTENSITY-DURATION-FREQUENCY TABLE
===================================================================
               2-yr     5-yr     10-yr     25-yr     50-yr    100-yr
DURATION    [in/hr]  [in/hr]   [in/hr]   [in/hr]   [in/hr]   [in/hr]
===================================================================
5 min          5.88     6.63      7.23      8.15      8.87      9.60
10 min         4.92     5.65      6.20      7.05      7.71      8.38
15 min         4.20     4.84      5.33      6.07      6.66      7.24
30 min         3.03     3.67      4.14      4.81      5.34      5.86
60 min         2.00     2.49      2.83      3.33      3.72      4.10
 2 hr          1.14     1.43      1.63      1.92      2.15      2.37
 3 hr          0.85     1.07      1.23      1.45      1.63      1.80
 6 hr          0.54     0.69      0.80      0.94      1.06      1.18
12 hr          0.32     0.42      0.48      0.57      0.64      0.71
24 hr          0.19     0.24      0.28      0.33      0.38      0.42
===================================================================

IDF  EQUATIONS
    R         g         h
===========================            Ir = g/(h + Td)
       2       163        23
       5       211        27           VALID ONLY UP
      10       245        29           TO 2 HOURS
      25       293        31
      50       331        33           Td = duration (mins)
     100       369        34
===========================

INPUT
============================================
              2-yr P 100-yr P
Duration        [in]      [in]    Source
============================================
 5 min         0.49      0.80 NOAA HYDRO-35
15 min         1.05      1.81 NOAA HYDRO-35
60 min         2.00      4.10 NOAA HYDRO-35
24 hr          4.50     10.00 USWB TP-40
============================================
```

Langley and McDonald, P.C.
ENGINEERS • SURVEYORS • PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS
VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject NC - CLAYHILL
Computed By MWM Checked by
Project No.
Client
Date Sheet No.

MANNING ROUGHNESS COEFFICIENT

	N
OPEN CHANNEL, EXCAVATED - CHANNELS NOT MAINTAINED, CLEAN BOTTOM BRUSH ON SIDES	0.05
OPEN CHANNEL, EXCAVATED - EARTH UNIFORM SECTION, GRASS & WEEDS	0.022

SHEET FLOW MANNINGS ROUGHNESS COEF

WOODS	0.40
FALLOW (≤ 20%)	0.06

RATIONAL FORMULA

RUNOFF COEF (C)

AGRICULTURAL LAND BARE PAKED SOIL (ROUGH)	0.35
AGRICULTURAL LAND CULTIVATED ROWS HEAVY SOIL, NO CROP	0.35

RUNOFF CURVE NO. (SCS METHOD)

WOODS - GOOD (HYDRO-SOIL GROUP "D")	77

GOOD = WOODS ARE PROTECTED FROM GRAZING, AND LITTER AND BRUSH ADEQUATELY COVER THE SOIL.

Langley and McDonald, P.C.
ENGINEERS • SURVEYORS • PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS
VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject NC - CLAYHILL
Computed By MWM Checked by ______

Project No. ______
Client ______
Date ______ Sheet No. ______

MANNING ROUGHNESS COEFFICIENT

	N
OPEN CHANNEL, EXCAVATED - CHANNEL NOT MAINTAINED, WEEDS & BRUSH UNCUT CLEAN BOTTOM, BRUSH ON SIDES	0.05
OPEN CHANNEL, EXCAVATED - EARTH UNIFORM SECTION, GRASS & WEEDS	0.022
OPEN CHANNEL, EXCAVATED - EARTH FAIRLY UNIFORM SECTION, DENSE WEEDS OR AQUATIC PLANTS	0.035
NATURAL STREAM CHANNEL - MINOR STREAM - DENSE GROWTH OF WEEDS	0.035
NATURAL STREAM CHANNEL - FLOOD PLAINS - CULTIVATED - NO CROPS	0.04
NATURAL STREAM CHANNEL - BRUSH & TREES	0.06

TABLE 2.8.2

Manning roughness coefficients, n[1]

	Manning's n range[2]	
I. Closed conduits:		
A. Concrete pipe	0.011–0.013	
B. Corrugated-metal pipe or pipe-arch:		
1. 2⅔ by ½-in. corrugation (riveted pipe):[3]		
a. Plain or fully coated	0.024	
b. Paved invert (range values are for 25 and 50 percent of circumference paved):		
(1) Flow full depth	0.021–0.018	
(2) Flow 0.8 depth	0.021–0.016	
(3) Flow 0.6 depth	0.019–0.013	
2. 6 by 2-in. corrugation (field bolted)	0.03	
C. Vitrified clay pipe	0.012–0.014	
D. Cast-iron pipe, uncoated	0.013	
E. Steel pipe	0.009–0.011	
F. Brick	0.014–0.017	
G. Monolithic concrete:		
1. Wood forms, rough	0.015–0.017	
2. Wood forms, smooth	0.012–0.014	
3. Steel forms	0.012–0.013	
H. Cemented rubble masonry walls:		
1. Concrete floor and top	0.017–0.022	
2. Natural floor	0.019–0.025	
I. Laminated treated wood	0.015–0.017	
J. Vitrified clay liner plates	0.015	
II. Open channels, lined[4] (straight alinement):[5]		
A. Concrete, with surfaces as indicated:		
1. Formed, no finish	0.013–0.017	
2. Trowel finish	0.012–0.014	
3. Float finish	0.013–0.015	
4. Float finish, some gravel on bottom	0.015–0.017	
5. Gunite, good section	0.016–0.019	
6. Gunite, wavy section	0.018–0.022	
B. Concrete, bottom float finished, sides as indicated:		
1. Dressed stone in mortar	0.015–0.017	
2. Random stone in mortar	0.017–0.020	
3. Cement rubble masonry	0.020–0.025	
4. Cement rubble masonry, plastered	0.016–0.020	
5. Dry rubble (riprap)	0.020–0.030	
C. Gravel bottom, sides as indicated:		
1. Formed concrete	0.017–0.020	
2. Random stone in mortar	0.020–0.023	
3. Dry rubble (riprap)	0.023–0.033	
D. Brick	0.014–0.017	
E. Asphalt:		
1. Smooth	0.013	
2. Rough	0.016	
F. Wood, planed, clean	0.011–0.013	
G. Concrete-lined excavated rock:		
1. Good section	0.017–0.020	
2. Irregular section	0.022–0.027	
III. Open channels, excavated[4] (straight alinement,[5] natural lining):		
A. Earth, uniform section:		
1. Clean, recently completed	0.016–0.018	
2. Clean, after weathering	0.018–0.020	
3. With short grass, few weeds	0.022–0.027	0.022
4. In gravelly soil, uniform section, clean	0.022–0.025	
B. Earth, fairly uniform section:		
1. No vegetation	0.022–0.025	
2. Grass, some weeds	0.025–0.030	
3. Dense weeds or aquatic plants in deep channels	0.030–0.035	0.035
4. Sides clean, gravel bottom	0.025–0.030	
5. Sides clean, cobble bottom	0.030–0.040	
C. Dragline excavated or dredged:		
1. No vegetation	0.028–0.033	
2. Light brush on banks	0.035–0.050	
D. Rock:		
1. Based on design section	0.035	
2. Based on actual mean section:		
a. Smooth and uniform	0.035–0.040	
b. Jagged and irregular	0.040–0.045	
E. Channels not maintained, weeds and brush uncut:		
1. Dense weeds, high as flow depth	0.08–0.12	
2. Clean bottom, brush on sides	0.05–0.08	0.05
3. Clean bottom, brush on sides, highest stage of flow	0.07–0.11	
4. Dense brush, high stage	0.10–0.14	

	Manning's n range[2]	
IV. Highway channels and swales with maintained vegetation[6] [7] (values shown are for velocities of 2 and 6 f.p.s.):		
A. Depth of flow up to 0.7 foot:		
1. Bermudagrass, Kentucky bluegrass, buffalograss:		
a. Mowed to 2 inches	0.07–0.045	
b. Length 4–6 inches	0.09–0.05	
2. Good stand, any grass:		
a. Length about 12 inches	0.18–0.09	
b. Length about 24 inches	0.30–0.15	
3. Fair stand, any grass:		
a. Length about 12 inches	0.14–0.08	
b. Length about 24 inches	0.25–0.13	
B. Depth of flow 0.7–1.5 feet:		
1. Bermudagrass, Kentucky bluegrass, buffalograss:		
a. Mowed to 2 inches	0.05–0.035	
b. Length 4 to 6 inches	0.06–0.04	
2. Good stand, any grass:		
a. Length about 12 inches	0.12–0.07	
b. Length about 24 inches	0.20–0.10	
3. Fair stand, any grass:		
a. Length about 12 inches	0.10–0.06	
b. Length about 24 inches	0.17–0.09	
V. Street and expressway gutters:		
A. Concrete gutter, troweled finish	0.012	
B. Asphalt pavement:		
1. Smooth texture	0.013	
2. Rough texture	0.016	
C. Concrete gutter with asphalt pavement:		
1. Smooth	0.013	
2. Rough	0.015	
D. Concrete pavement:		
1. Float finish	0.014	
2. Broom finish	0.016	
E. For gutters with small slope, where sediment may accumulate, increase above values of n by	*0.002*	
VI. Natural stream channels:[8]		
A. Minor streams[9] (surface width at flood stage less than 100 ft.):		
1. Fairly regular section:		
a. Some grass and weeds, little or no brush	0.030–0.035	
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05	0.035
c. Some weeds, light brush on banks	0.035–0.05	
d. Some weeds, heavy brush on banks	0.05–0.07	
e. Some weeds, dense willows on banks	0.06–0.08	
f. For trees within channel, with branches submerged at high stage, increase all above values by	*0.01–0.02*	
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	*0.01–0.02*	
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:		
a. Bottom of gravel, cobbles, and few boulders	0.04–0.05	
b. Bottom of cobbles, with large boulders	0.05–0.07	
B. Flood plains (adjacent to natural streams):		
1. Pasture, no brush:		
a. Short grass	0.030–0.035	
b. High grass	0.035–0.05	
2. Cultivated areas:		
a. No crop	0.03–0.04	0.04
b. Mature row crops	0.035–0.045	
c. Mature field crops	0.04–0.05	
3. Heavy weeds, scattered brush	0.05–0.07	
4. Light brush and trees:[10]		
a. Winter	0.05–0.06	0.06
b. Summer	0.06–0.08	
5. Medium to dense brush:[10]		
a. Winter	0.07–0.11	
b. Summer	0.10–0.16	
6. Dense willows, summer, not bent over by current	0.15–0.20	
7. Cleared land with tree stumps, 100–150 per acre:		
a. No sprouts	0.04–0.05	
b. With heavy growth of sprouts	0.06–0.08	
8. Heavy stand of timber, a few down trees, little undergrowth:		
a. Flood depth below branches	0.10–0.12	
b. Flood depth reaches branches	0.12–0.16	
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited[8] if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028–0.033	

TABLE 5-2
VALUES OF RUNOFF COEFFICIENT (C) FOR RATIONAL FORMULA

Land Use	C	Land Use	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighborhood areas	0.50-0.70	Sandy soil, average, 2-7%	0.10-0.15
		Sandy soil, steep, 7%	0.15-0.20
		Heavy soil, flat, 2%	0.13-0.17
		Heavy soil, average, 2-7%	0.18-0.22
		Heavy soil, steep, 7%	0.25-0.35
Residential:		Agricultural land:	
Single-family areas	0.30-0.50	Bare packed soil	
Multi units, detached	0.40-0.60	* Smooth	0.30-0.60
Multi units, attached	0.60-0.75	* Rough	0.20-0.50
Suburban	0.25-0.40	Cultivated rows	
		* Heavy soil, no crop	0.30-0.60
		* Heavy soil, with crop	0.20-0.50
		* Sandy soil, no crop	0.20-0.40
		* Sandy soil, with crop	0.10-0.25
		Pasture	
		* Heavy soil	0.15-0.45
		* Sandy soil	0.05-0.25
		Woodlands	0.05-0.25
Industrial:		Streets:	
Light areas	0.50-0.80	Asphaltic	0.70-0.95
Heavy areas	0.60-0.90	Concrete	0.80-0.95
		Brick	0.70-0.85
Parks, cemeteries	0.10-0.25	Unimproved areas	0.10-0.30
Playgrounds	0.20-0.35	Drives and walks	0.75-0.85
Railroad yard areas	0.20-0.40	Roofs	0.75-0.95

Note: The designer must use judgement to select the appropriate "C" value within the range. Generally, larger areas with permeable soils, flat slopes and dense vegetation should have the lowest C values. Smaller areas with dense soils, moderate to steep slopes, and sparse vegetation should be assigned the highest C values.

Source: American Society of Civil Engineers

TABLE 5-3
ROUGHNESS COEFFICIENTS (MANNING'S "N") FOR SHEET FLOW

Surface Description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods[3]:	
Light underbrush	0.40
Dense underbrush	0.80

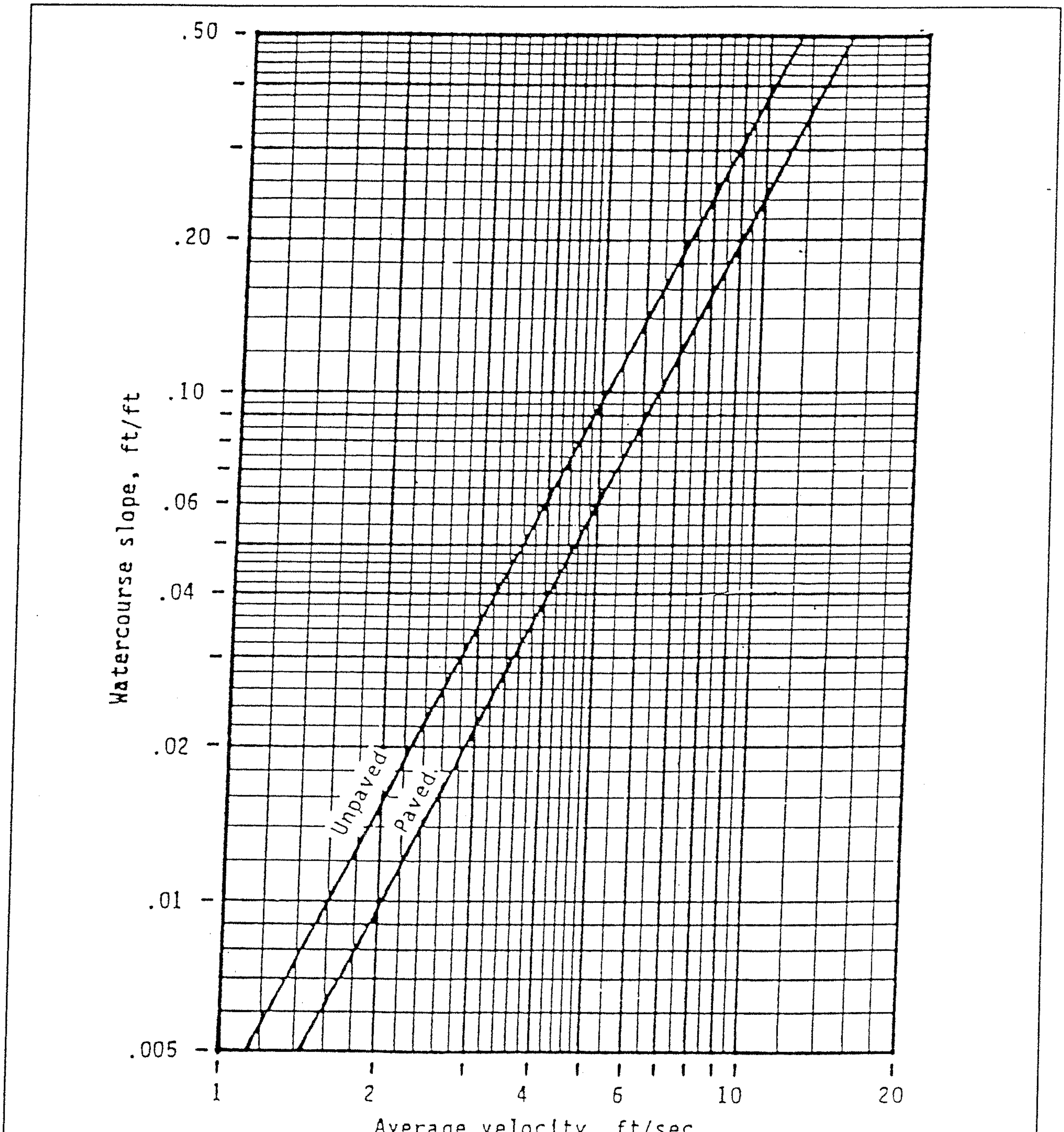
[1] The "n" values are a composite of information compiled by Engman (1986).

[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Source: USDA-SCS

AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR SHALLOW CONCENTRATED FLOW



Source: USDA-SCS

Plate 5-23

APPENDIX F

STORMWATER CALCULATIONS (HEC-2 ANALYSIS)

STORMWATER CALCULATIONS

TABLE OF CONTENTS

HEC 2

(Existing conditions and proposed conditions)

HEC 2 RUNS

EXISTING CONDITIONS – 2 YEAR

STARTING PROFILE NUMBER 1

		Computed Water Surface Elev.
CWSEL – Cross Section	7	22.70
	6	22.69
	5	24.57
	4	24.49
	3	31.81
	2	32.71
	1	32.94

PROPOSED CONDITIONS

CWSEL – Cross Section	7	22.70
	6	22.72
	5	26.62
	4	26.99
	3	32.26
	2	33.67
	1	33.76

```
HEC2 S/N: 1126230079      HMVersion: 6.20    Data File: A:EXIST2B.TXT

*****************************************                    **************************************
* HEC-2 WATER SURFACE PROFILES          *                    * U.S. ARMY CORPS OF ENGINEERS       *
*                                       *                    * HYDROLOGIC ENGINEERING CENTER      *
* Version  4.6.0; February 1991         *                    * 609 SECOND STREET, SUITE D         *
*                                       *                    * DAVIS, CALIFORNIA 95616-4687       *
* RUN DATE   3JUN99   TIME  11:59:27    *                    *       (916) 756-1104               *
*****************************************                    **************************************




                    X     X  XXXXXXX   XXXXX          XXXXX
                    X     X  X        X     X        X     X
                    X     X  X        X                    X
                    XXXXXXX  XXXX     X        XXXXX   XXXXX
                    X     X  X        X               X
                    X     X  X        X     X        X
                    X     X  XXXXXXX   XXXXX          XXXXXXX




                    :::::::::::::::::::::::::::::::::::::::
                    :::::::::::::::::::::::::::::::::::::::
                    :::                                 :::
                    :::  FULL MICRO-COMPUTER IMPLEMENTATION  :::
                    :::                                 :::
                    :::::::::::::::::::::::::::::::::::::::
                    :::::::::::::::::::::::::::::::::::::::

                       ==============================
                        H A E S T A D   M E T H O D S
                       ==============================

       37 Brookside Road  *  Waterbury, Connecticut  06708  *  (203) 755-1666
```

```
                                          THIS RUN EXECUTED  3JUN99   11:59:27
***********************************
HEC-2 WATER SURFACE PROFILES

Version  4.6.0; February 1991
***********************************


T1    CLAYHILL STREAM RESTORATION
T2    L&M JOB
T3    EXISTING CONDITIONS - 2-YR STORM

J1  ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q       WSEL    FQ

     0      0      0      0      0      0      0     323    22.7     0

NC    0.06     0.06    0.035     0.1      0.3
X1     7       9     43.0    195.0       0        0        0
GR    25.0     0.0     21.0     97.0     20.0    125.0     16.0    137.0    16.0    146.0
GR    18.0    152.0    20.0    187.0     20.0    335.0     25.0    390.0

X1     6      13     44.5     54.5      300      300      300
X2    176      0        0        0
GR    25.0     0.0     19.0     38.5     22.6     42.5     20.5     44.5    18.5     45.5
GR    18.0    48.0     18.0     52.0     18.9     53.5     20.8     54.5    21.0     66.0
GR    24.0    165.0    24.0    235.0     25.0    250.0

X1     5      10     10.0    193.0     1920     1920     1920
X2    148      0        0        0
GR    31.0     0.0     30.0    100.0     27.0    165.0     24.2    168.0    21.5    172.0
GR    21.5    177.0    25.9    187.0     26.5    193.0     27.0    227.0    30.0    350.0

X1     4       8     86.0    100.  0   23  0    23  0    23  0
X2    143      0        0        0
GR    31.0     0.0     30.0     35.0     26.1     86.0     21.5     90.5    21.8     95.0
GR    25.8    100.0    26.0    103.0     32.0    221.0

NC    0.04     0.06    0.035     0.1      0.3
X1     3       7      7.0    240.0     1520     1520     1520
X2     95      0        0        0
GR    33.0     0.0     32.0    168.0     31.0    223.0     28.0    229.0    28.0    232.0
GR    32.0    240.0    33.0    463.0

X1     2      12    590.0    608.0     1160     1160     1160
X2     73      0        0        0
GR    33.5     0.0     33.5    500.0     33.5    560.0     33.1    578.0    33.0    590.0
GR    29.0    592.0    29.0    602.0     34.0    608.0     35.0    615.0    34.1    630.0
GR    34.0    730.0    35.0    860.0
```

```
X1     1      10    590.0    608.0     1040     1040     1040
X2     38      0        0        0
GR    33.5     0.0     33.0    400.0     33.1    578.0     33.0    590.0    29.0    592.0
GR    29.0    602.0    34.0    608.0     33.0    617.0     33.5    700.0    34.0    775.0
```

```
 SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG      HV      HL      OLOSS   L-BANK ELEV
 Q        QLOB     QCH      QROB     ALOB     ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME     VLOB     VCH      VROB     XNL      XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC     ICONT   CORAR   TOPWID  ENDST


*PROF 1



CCHV=   .100 CEHV=   .300
*SECNO 7.000
   7.000    6.70   22.70     .00   22.70   22.70     .00     .00     .00   25.00
   323.0      .0   197.7   125.3      .0   377.0   439.7      .0      .0   20.00
     .00     .00     .52     .29    .000    .035    .060    .000   16.00   55.77
 .000038      0.      0.      0.       0       0       0     .00  308.93  364.70


*SECNO 6.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =  .15

   6.000    4.69   22.69     .00     .00   22.74     .04     .02     .01   20.50
   176.0    43.4    91.2    41.4    53.9    42.4    68.6     3.4     1.4   20.80
     .06     .81    2.15     .60    .060    .035    .060    .000   18.00   14.74
 .000514    300.    300.    300.       1       0       0     .00  107.45  122.19


*SECNO 5.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =  .27

   5.000    3.07   24.57     .00     .00   24.89     .31    2.07     .08   31.00
   148.0      .0   148.0      .0      .0    33.1      .0     7.7     4.2   26.50
     .18     .00    4.48     .00    .000    .035    .000    .000   21.50  167.60
 .004940   1920.   1920.   1920.       4       0       0     .00   16.38  183.98


*SECNO 4.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =  .62

   4.000    2.99   24.49     .00     .00   25.16     .67     .17     .11   26.10
   143.0      .0   143.0      .0      .0    21.7      .0     7.8     4.2   25.80
     .18     .00    6.59     .00    .000    .035    .000    .000   21.50   87.57
 .012173     23.     23.     23.       2       0       0     .00   10.79   98.37


CCHV=   .100 CEHV=   .300
```

```
 SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG     HV     HL     OLOSS  L-BANK ELEV
 Q       QLOB    QCH     QROB    ALOB    ACH    AROB   VOL    TWA    R-BANK ELEV
 TIME    VLOB    VCH     VROB    XNL     XNCH   XNR    WTN    ELMIN  SSTA
 SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC    ICONT  CORAR  TOPWID ENDST


*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =  1.78

  3.000    3.81   31.81     .00     .00   31.85     .04    6.62     .06   33.00
   95.0      .0    95.0      .0      .0    57.5      .0     9.1     5.4   32.00
    .43     .00    1.65     .00    .000    .035    .000    .000   28.00  178.79
 .001693   1520.   1520.   1520.      6       0       0     .00   60.82  239.61


*SECNO 2.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO =  1.63

  2.000    3.71   32.71     .00     .00   32.74     .03     .89     .00   33.00
   73.0      .0    73.0      .0      .0    48.8      .0    10.6     6.4   34.00
    .65     .00    1.50     .00    .000    .035    .000    .000   29.00  590.15
 .000377   1160.   1160.   1160.      4       0       0     .00   16.30  606.45


*SECNO 1.000
  1.000    3.94   32.94     .00     .00   32.95     .01     .20     .00   33.00
   38.0      .0    38.0      .0      .0    52.7      .0    11.8     6.8   34.00
   1.05     .00     .72     .00    .000    .035    .000    .000   29.00  590.03
 .000082   1040.   1040.   1040.      2       0       0     .00   16.71  606.74
```

```
PROFILE FOR STREAM  EXISTING CONDITIONS - 2-

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT
BANK,M-LOWER END STA

ELEVATION  16.    18.    20.    22.    24.    26.    28.    30.    32.    34.
  SECNO  CUMDIS

   7.00    0. I      .      R      . E   .  L  .      .      .      .      .      .
         100. C I    .      .R      . E  L .  M  .      .      .      .      .      .
         200. C   I  .      . R    L  E   .  M  .      .      .      .      .      .
   6.00  300. C      I      . LR   . E    .  M  .      .      .      .      .      .
         400. C     .I      .  L  . E   .  M  .      .      .      .      .      .
         500. C     .I      .  RL . WE   .   M .      .      .      .      .      .
         600. C     . I     .  R.L  E   .    M.       .      .      .      .      .
         700. C     . I     .   R L WE  .     M       .      .      .      .      .
         800. C     .  I    .   .R  E  .     .M       .      .      .      .      .
         900. C     .  I    .    . R WE L.      . M      .      .      .      .      .
        1000. C     .   I   .    . R WE . L     . M      .      .      .      .      .
        1100. C     .   I  .     .  RWE .  L    .  M     .      .      .      .      .
        1200. C     .   I  .     .  RWE.    L  .   M     .      .      .      .      .
        1300. C     .    I.      .   WE.     L     M .     .      .      .      .
        1400. C     .    I       .   WE      . L    M.     .      .      .      .
        1500. C     .    .I      .   WE R     .  L  .M     .      .      .      .
        1600. C     .    . I     .    WE R    .    L . M    .      .      .      .
        1700. C     .    .  I    .    W E  R  .     .L M    .      .      .      .
        1800. C     .    .  I    .   .WE   R  .     . LM    .      .      .      .
        1900. C     .    .   I  .    .W E   R.      .  L .      .      .      .
        2000. C     .    .   I   .    . WE    R.     .   M L.      .      .      .
        2100. C     .    .    I  .    . W E   .R     .    M . L   .      .      .
        2200. C     .    .    I .     . WE    .R     .     M  L   .      .      .
   5.00 2300. C     .     .     I .     . WE    . R     .      M   L  .      .      .
   4.00 2400. C     .     .     I .     . W  E R.L      .      .  M  .      .      .
        2500. C     .    .     I     .  W E.RL      .     .  M  .      .      .
        2600. C     .    .    . I    .   W  E RL    .     .  M  .      .      .
        2700. C     .    .    .  I  .      W E RL .      .   M .      .      .
        2800. C     .    .    .   I .     . W ER L       .   M .      .      .
        2900. C     .    .    .    I.     .  W ER.L   .      M.      .      .
        3000. C     .    .    .     I      .   W E.R L   .    M.      .      .
        3100. C     .    .    .     .I     .    W.E R L .     M      .      .
        3200. C     .    .    .     .  I  .     . WE R  L.     M      .      .
        3300. C     .    .    .     .   I .      . W ER .L     .M      .      .
        3400. C     .    .    .     .    I.      .  W ER. L    . M      .      .
        3500. C     .    .    .     .    .I      .    WER  L  . M      .      .
        3600. C     .    .    .     .    . I     .    .WER  L . M      .      .
        3700. C     .    .    .     .    .  I    .     . ER  L  M    .      .
   3.00 3800. C     .     .     .     .     .      I       .    ER   L  .      .
        3900. C     .    .    .     .    .     I      .    WER  L  .      .
        4000. C     .    .    .     .    .     .I     .    E R L  .      .
        4100. C     .    ..   .     .    .     .I     .    E R LM  .      .
        4200. C     .    .    .     .    .     . I    .    .E R LM  .      .
        4300. C     .    .    .     .    .     . I    .    .E  RLM  .      .
        4400. C     .    .    .     .    .     .  I   .    .WE  LM  .      .
        4500. C     .    .    .     .    .     .  I   .    . E  LRM .      .
        4600. C     .    .    .     .    .     .  I   .    . E L R .      .
        4700. C     .    .    .     .    .     .   I  .     . E L MR . .    .
        4800. C     .    .    .     .    .     .   I  .     . E L M R.     .
        4900. C     .    .    .     .    .     .    I  .     . E L M R.     .
```

```
2.00 5000. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5100. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5200. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5300. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5400. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5500. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5600. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5700. C   .   .   .   .   .   .   . I  .   . EL  M R    .
     5800. C   .   .   .   .   .   .   . I  .   . WE  M R    .
     5900. C   .   .   .   .   .   .   . I  .   . E  M R    .
1.00 6000. C   .   .   .   .   .   .   . I  .   . E  M R    .
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Run Date:  3JUN99   Run Time: 11:59:27   HMVersion: 6.20   Data File:  A:EXIST2B.TXT          Page   5

                                              THIS RUN EXECUTED  3JUN99    11:59:27
***********************************
HEC-2 WATER SURFACE PROFILES

Version  4.6.0;  February 1991
***********************************


NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST


EXISTING CONDITIONS - 2-

SUMMARY PRINTOUT TABLE  150

    SECNO   XLCH    ELTRD   ELLC    ELMIN      Q     CWSEL   CRIWS    EG     10*KS    VCH    AREA    .01K

    7.000     .00     .00     .00   16.00  323.00   22.70     .00   22.70     .38     .52  816.74  525.78

*   6.000  300.00     .00     .00   18.00  176.00   22.69     .00   22.74    5.14    2.15  164.86   77.62

*   5.000 1920.00     .00     .00   21.50  148.00   24.57     .00   24.89   49.40    4.48   33.07   21.06

*   4.000   23.00     .00     .00   21.50  143.00   24.49     .00   25.16  121.73    6.59   21.70   12.96

*   3.000 1520.00     .00     .00   28.00   95.00   31.81     .00   31.85   16.93    1.65   57.47   23.09

*   2.000 1160.00     .00     .00   29.00   73.00   32.71     .00   32.74    3.77    1.50   48.77   37.59

    1.000 1040.00     .00     .00   29.00   38.00   32.94     .00   32.95     .82     .72   52.71   41.90
```

```
EXISTING CONDITIONS - 2-

SUMMARY PRINTOUT TABLE 150

    SECNO      Q     CWSEL  DIFWSP  DIFWSX  DIFKWS  TOPWID    XLCH

    7.000  323.00   22.70    .00     .00     .00   308.93     .00

*   6.000  176.00   22.69    .00    -.01     .00   107.45   300.00

*   5.000  148.00   24.57    .00    1.88     .00    16.38  1920.00

*   4.000  143.00   24.49    .00    -.09     .00    10.79    23.00

*   3.000   95.00   31.81    .00    7.32     .00    60.82  1520.00

*   2.000   73.00   32.71    .00     .90     .00    16.30  1160.00

    1.000   38.00   32.94    .00     .23     .00    16.71  1040.00
```

```
SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO=    6.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    5.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    4.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    3.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=    2.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

Normal program termination
```

```
HEC2 S/N: 1126230079      HMVersion: 6.20   Data File: A:FUT2A.TXT

*****************************************                  **************************************
* HEC-2 WATER SURFACE PROFILES          *                  * U.S. ARMY CORPS OF ENGINEERS       *
*                                       *                  * HYDROLOGIC ENGINEERING CENTER      *
* Version  4.6.0; February 1991         *                  * 609 SECOND STREET, SUITE D         *
*                                       *                  * DAVIS, CALIFORNIA 95616-4687       *
* RUN DATE    3JUN99   TIME  13:30:10   *                  *       (916) 756-1104               *
*****************************************                  **************************************




                 X     X  XXXXXXX   XXXXX             XXXXX
                 X     X  X        X     X           X     X
                 X     X  X        X                       X
                 XXXXXXX  XXXX     X         XXXXX    XXXXX
                 X     X  X        X                 X
                 X     X  X        X     X           X
                 X     X  XXXXXXX   XXXXX            XXXXXXX



                 :::::::::::::::::::::::::::::::::::::::
                 :::::::::::::::::::::::::::::::::::::::
                 :::                                 :::
                 :::  FULL MICRO-COMPUTER IMPLEMENTATION  :::
                 :::                                 :::
                 :::::::::::::::::::::::::::::::::::::::
                 :::::::::::::::::::::::::::::::::::::::

                    ============================
                    H A E S T A D   M E T H O D S
                    ============================

        37 Brookside Road  *  Waterbury, Connecticut  06708  *  (203) 755-1666
```

```
                                                  THIS RUN EXECUTED 3JUN99   13:30:10
************************************
HEC-2 WATER SURFACE PROFILES

Version  4.6.0; February 1991
************************************
     -

T1    CLAYHILL STREAM RESTORATION
T2    L&M JOB
T3    FUTURE CONDITIONS - 2-YR STORM

J1 ICHECK   INQ    NINV    IDIR    STRT    METRIC   HVINS    Q      WSEL    FQ

    0      0      0      0      0      0      0     323     22.7     0

NC   0.06     0.06    0.035     0.1      0.3
X1     7       10     43.0    195.0       0        0        0
GR   25.0     0.0     21.0     97.0     20.0     130.0     19.0     137.0     17.5     139.0
GR   17.5    141.0    19.0    143.0     20.0     150.0     20.0     335.0     25.0     390.0

X1     6       13     44.5     54.5      300      300      390
X2   176       0        0       0
GR   25.0     0.0     19.0     38.0     20.5     41.0     20.0     45.0     18.0     49.0
GR   18.0     51.0    20.0     55.0     20.5     59.0     20.8     63.0     21.0     66.0
GR   24.0    165.0    24.0    235.0     25.0     250.0

X1     5       10     10.0    193.0     1920     1920     2500
X2   148       0        0       0
GR   31.0     0.0     30.0    100.0     26.0     166.5    25.5     171.5    24.2     173.5
GR   24.2    176.5    25.5    178.5     26.0     183.5    27.0     227.0    30.0     350.0

X1     4       10     86.0    100. 0    23  0    23  0    30  0
X2   143       0        0       0
GR   31.0     0.0     30.0     35.0     26.0     85.0     25.5     89.0     24.3     92.0
GR   24.3     94.0    25.5     97.0     26.0     101.0    26.0     103.0    32.0     221.0

NC   0.04     0.06    0.035     0.1      0.3
X1     3       9       7.0    240.0     1520     1520     1980
X2    95       0        0       0
GR   33.0     0.0     32.0    168.0     31.0     223.0    30.9     227.0    29.8     229.0
GR   29.8    230.5    30.9    233.0     31.5     237.0    33.0     463.0

X1     2       12    590.0    608.0     1160     1160     1180
X2    73       0        0       0
GR   33.5     0.0     33.5    500.0     33.5     560.0    33.0     593.5    32.5     597.5
GR   31.8    599.5    31.8    600.5     32.5     602.5    33.0     606.5    34.1     630.0
GR   34.0    730.0    35.0    860.0
```

```
X1    1     11   590.0   608.0     1040     1040     1060
X2   38      0       0       0
GR  33.5   0.0    33.0   400.0    33.1    578.0    33.0    594.5    32.5    597.0
GR  32.0  599.5   32.0   600.5    32.5    603.0    33.0    605.5    33.5    700.0
GR  34.0  775.0
```

```
 Run Date: 3JUN99   Run Time: 13:30:10   HMVersion: 6.20   Data File: A:FUT2A.TXT      -     Page 3

  SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG     HV     HL     OLOSS   L-BANK ELEV
  Q       QLOB    QCH     QROB    ALOB    ACH    AROB   VOL    TWA     R-BANK ELEV
  TIME    VLOB    VCH     VROB    XNL     XNCH   XNR    WTN    ELMIN   SSTA
  SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC    ICONT  CORAR  TOPWID  ENDST


*PROF 1



CCHV=    .100 CEHV=    .300
*SECNO 7.000
   7.000     5.20    22.70     .00    22.70    22.70     .00      .00      .00    25.00
   323.0      .0     102.6    220.4     .0     180.6    539.6     .0       .0     20.00
    .00      .00      .57      .41     .000     .035     .060    .000    17.50    55.77
  .000076     0.       0.       0.       0        0        0      .00    308.93   364.70


*SECNO 6.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .22

   6.000     4.72    22.72     .00      .00    22.75     .03      .04      .01    20.50
   176.0     44.4     68.9     62.7     52.9     34.3     87.7     3.3      1.5    18.00
    .07      .84     2.01      .71     .060     .035     .060    .000    18.00    14.41
  .000465    300.     390.     300.      0        0        0      .00   108.53   122.93


*SECNO 5.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   5.000     2.42    26.62    26.62     .00    27.00     .38     2.77      .11    31.00
   148.0      .0     135.8     12.2      .0     26.3      8.5      8.3      5.4    26.00
    .21      .00     5.16     1.45     .000     .035     .060    .000    24.20   156.13
  .016160   1920.    2500.    1920.     20       11        0      .00    54.49   210.63


*SECNO 4.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.63

   4.000     2.69    26.99     .00      .00    27.28     .28      .26      .01    26.00
   143.0      7.2    110.0     25.7      6.2     22.9     16.7      8.4      5.4    25.50
    .21     1.17     4.80     1.55     .060     .035     .060    .000    24.30    72.58
  .005694     23.      30.      23.      2        0        0      .00    49.95   122.53


CCHV=    .100 CEHV=    .300
```

```
 SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS   L-BANK ELEV
 Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA     R-BANK ELEV
 TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN   SSTA
 SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID  ENDST


*SECNO 3.000

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 1.44

  3.000    2.46   32.26     .00     .00   32.27     .01    4.97     .03   33.00
   95.0      .0    74.7    20.3      .0    70.2    44.5    11.6    11.0   31.50
    .77     .00    1.06     .46    .000    .035    .060    .000   29.80  122.92
 .001210   1520.   1980.   1520.      8       0       0     .00  229.85  352.76


*SECNO 2.000
3280 CROSS SECTION    2.00 EXTENDED     .18 FEET

  2.000    1.87   33.67     .00     .00   33.68     .01    1.40     .00   33.50
   73.0    39.2    31.8     2.0    98.0    29.6     4.9    15.0    22.3   33.00
   1.23     .40    1.08     .41    .040    .035    .060    .000   31.80     .00
 .001180   1160.   1180.   1160.      5       0       0     .00  620.92  620.92


*SECNO 1.000
3280 CROSS SECTION    1.00 EXTENDED     .26 FEET

3302 WARNING: CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE, KRATIO = 4.93

  1.000    1.76   33.76     .00     .00   33.76     .00     .08     .00   33.10
   38.0    31.2     3.9     2.9   331.2    26.1    53.5    21.5    38.6   33.00
   4.24     .09     .15     .05    .040    .035    .060    .000   32.00     .00
 .000013   1040.   1060.   1040.      4       0       0     .00  739.22  739.22
```

PROFILE FOR STREAM FUTURE CONDITIONS - 2-YR

PLOTTED POINTS (BY PRIORITY) E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,M-LOWER END STA

```
ELEVATION  18.    20.    22.    24.    26.    28.    30.    32.    34.    36.
  SECNO  CUMDIS

  7.00    0. I      . R    .  E  .   L .    .     .     .     .     .     .
      200. CI   R .      .  E  .   M .    .     .     .     .     .     .
  6.00  400. C I    .  L  .  E  .   M .    .     .     .     .     .     .
      600. C  IR .    L.    E .     M     .     .     .     .     .     .
      800. C   I R.     . L   WE     .M     .     .     .     .     .     .
     1000. C     I R    .    L .E    .  M  .     .     .     .     .     .
     1200. C     . I R  .     . WE   .   M  .     .     .     .     .     .
     1400. C      .  I  R.     .  WEL  .   M .     .     .     .     .     .
     1600. C      .   I . R    .   WE  L      M     .     .     .     .     .
     1800. C      .    I  R  .    WE . L   .M     .     .     .     .     .
     2000. C      .    . I   R .      WE     L.  M     .     .     .     .     .
     2200. .     C .     .  I  .R      W E    . L M  .     .     .     .     .
     2400. .      .     C.   I .   R   . WE    .   LM .     .     .     .     .
     2600. .      .     .    I      R . W E  .     ML     .     .     .     .
     2800. .      .     .    .I     CR  W E .      .M  L  .     .     .     .
  5.00 3000. .      .     .     . I    . R W E .     . M   L.     .     .     .
  4.00 3200. C      .     .      . I    R L  W E.      .    M .     .     .     .
      3400. C      .     .     .    I . R L  WE     .     M.     .     .     .
      3600. C      .     .     .     I    R  L WE  .     M     .     .     .
      3800. C      .     .     .     .I     R. L WE .      .M     .     .     .
      4000. C      .     .     .     .   I   .R   LWE.      . M     .     .     .
      4200. C      .     .     .     .     I .  R   LWE      . M     .     .     .
      4400. C      .     .     .     .     .I    R . WE   .  M     .     .     .
      4600. C      .     .     .     .     . I    .R   WE .   M  .     .     .
      4800. C      .     .     .     .     .    I  .  R   E.L   M .     .     .
  3.00 5000. C      .     .     .     .     .     .     .I       R  E  L .     .     .
      5200. C      .     .     .     .     .     .    . I    .R  E L .     .     .
      5400. C      .     .     .     .     .     .     .  I   . R E L .     .     .
      5600. C      .     .     .     .     .     .     .   I  .  R E L.     .     .
      5800. C      .     .     .     .     .     .     .    I.   R  E.     .     .
      6000. C      .     .     .     .     .     .     .     I    R   E     .     .
  2.00 6200. C      .     .     .     .     .     .     .     .I     R LE     .     .
      6400. C      .     .     .     .     .     .     .     . I     R LE     .     .
      6600. C      .     .     .     .     .     .     .     . I     RLME     .     .
      6800. C      .     .     .     .     .     .     .     . I     RLME     .     .
      7000. C      .     .     .     .     .     .     .     . I      L ME     .     .
  1.00 7200. C      .     .     .     .     .     .     .     . I     L ME     .     .
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                                        THIS RUN EXECUTED 3JUN99   13:30:10
************************************
HEC-2 WATER SURFACE PROFILES

Version  4.6.0; February 1991
************************************

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

FUTURE CONDITIONS - 2-YR

SUMMARY PRINTOUT TABLE 150

    SECNO   XLCH    ELTRD   ELLC    ELMIN    Q     CWSEL   CRIWS    EG    10*KS    VCH    AREA   .01K
    7.000    .00     .00     .00   17.50  323.00  22.70     .00   22.70    .76     .57  720.24  369.35
*   6.000  390.00    .00     .00   18.00  176.00  22.72     .00   22.75   4.65    2.01  174.81   81.65
*   5.000 2500.00    .00     .00   24.20  148.00  26.62   26.62   27.00  161.60   5.16   34.79   11.64
*   4.000   30.00    .00     .00   24.30  143.00  26.99     .00   27.28   56.94   4.80   45.75   18.95
*   3.000 1980.00    .00     .00   29.80   95.00  32.26     .00   32.27   12.10   1.06  114.66   27.31
    2.000 1180.00    .00     .00   31.80   73.00  33.67     .00   33.68   11.80   1.08  132.53   21.25
*   1.000 1060.00    .00     .00   32.00   38.00  33.76     .00   33.76    .13     .15  410.78  104.72
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FUTURE CONDITIONS - 2-YR

SUMMARY PRINTOUT TABLE 150

    SECNO      Q     CWSEL  DIFWSP  DIFWSX  DIFKWS  TOPWID    XLCH

    7.000  323.00    22.70     .00     .00     .00  308.93     .00

*   6.000  176.00    22.72     .00     .02     .00  108.53  390.00

*   5.000  148.00    26.62     .00    3.90     .00   54.49 2500.00

*   4.000  143.00    26.99     .00     .37     .00   49.95   30.00

*   3.000   95.00    32.26     .00    5.27     .00  229.85 1980.00

    2.000   73.00    33.67     .00    1.41     .00  620.92 1180.00

*   1.000   38.00    33.76     .00     .09     .00  739.22 1060.00
```

```
SUMMARY OF ERRORS AND SPECIAL NOTES

WARNING SECNO=   6.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

CAUTION SECNO=   5.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   5.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION SECNO=   5.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

WARNING SECNO=   4.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   3.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

WARNING SECNO=   1.000  PROFILE= 1  CONVEYANCE CHANGE OUTSIDE ACCEPTABLE RANGE

Normal program termination
```

Langley and McDonald, P.C.

ENGINEERS • SURVEYORS• PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS

VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject ____________

Computed By ________ Checked by ________

Project No. ________

Client ________

Date ________ Sheet No. ________

DISTANCE BETWEEN NODES.

	LENGTH OF	STREAMS		
NODE	FLOODPLAIN	EXIST. DIST.	Sinuosity	PROPOSED DISTANCE
1 TO 2	1,040	1,040'	x 1.02	1060
2 " 3	1,160	1,160	x 1.02	1180
3 " 4	1520	1,520	1.3	1980
4 " 5	230'	230	1.3	300
5 " 6	1920	1920	1.3	2500
6 " 7	300	300	1.3	390
7 to Culverts	≈600	≈600	→	NO Δ's (OFF SITE)

Σ of Stream length on site Node 1-7 = 6,170 l.f.

7,410 l.f.
(overall 1.20 increase.

NODE 1

FACING UPSTREAM

EXIST

	HOR			VERT	
1	2	L	592	29.0	
2	10	L	590	33.0	
3	22	L	578	33.1	
	~~20' L~~			~~32.5~~	
4	200		400	33.0	
5	600		0	33.5	
6	2	R	602	29.0	
7	8	R	608	34.0	Berm.
8	17R		617	33.0	Wetl.
9	100'R		700	33.5	
10	175' R		775	34.0	

PROPOSED

	HOR		VERTIC.
599.5	0.5'	L	32' elev
597	3.0'	L	32.5
594.5	5.5'	L	33.0
578	22	l	33.1
400	200	L	33.0
600.5	0.5'	R	32'
603	3.0'	R	32.5
605.5	5.5'	R	33.0

NODE 2 FACING UPSTREAM.

EXIST.

	HOR		VER
1	2 L	592	29.0
2	10 L	590	33,0
3	22 L	578	33,1
4	40'	560	33.5
5	100'	500	33.5
6	600	0	33.5

PROPOSED

	H	V
599,5	0.5'L	31.75
597,5	2.5 L	32.5
593.5	6.5'L	33

7	2 R	602	29,0	
8	8 R	608	34,0	
9	15 R	615	35.0	Bsm.
10	30 R	630	34,1	
11	130'R	730	34	
12	260'R	860	35	

600.5	0.5' R	31.75
602.5	2.5' R	32.5
606.5	6.5' R	33

NODE 3

L = FACING UPSTREAM

EXIST.

	HOR.		V.
1	1'L	229	28'
2	7'L	223	31
	/ / / /	/	/ /
3	62'L	168	32
4	230'L	0	33
5	2'R	232	28'
6	10 R	240	32'
7	233	463	33'

PROP

	HOR		V
	0.5'L	229.5	29.75
	3. L	227	30.9
	7' L	223	31.0
	62	168	32
	230	0	33
230.5	0.5'R		29.75
233	3' R		30.9
237	7'R		31.5
463	233		33

Subject ______

Computed By ______ Checked by ______

Project No. ______

Client ______

Date ______ Sheet No. ______

NODE 4.

EXISTING
facing Upstream

	Horiz.		Vertical
1	2.5'L	90.5	21.5
2	7.0 L	86.0	26.1
3	58.0 L	35.0	30.0
4	93'	0	31.0 elev.
5	2 R	95	21.8
6	7' R	100	25.8
7	10'R	103	26.0
8	128'R	221	32

Proposed

H		V
1'L	92	24.3
4'L	89	25.5
8'L	85	26.0
58	35	30
93	0	31
1 R	92	24.3
4 R	97	25.5
8 R	101	26.0
10'R	103	26
128 R	221	32.

Subject ______________________

Computed By __________ Checked by ______

Project No. __________

Client __________

Date __________ Sheet No. ______

NODE 5

Existing
L side facing Upstream

Proposed

	Horiz		Vertical		H. -		V -
1	3'L	172	21.5		1.5'L	173.5	24.2
2	7'L	168	24.2		3.5'L	171.5	25.5
3	10'L	165	27.0		8.5 L.	166.5	26.0
4	75'L	100	30.0		} same		
5	175'L	0	31.				
6	2'R	177	21.5		1.5'R	176.5	24.2
7	10' R	187	25.9		3.5 R	178.5	25.5
8	18' R	193	26.5		8.5 R	183.5	26.0
9	52' R	227	27.0	} ← off-set to avoid Creeks floodplain.	} same →		
10	175'R	350	30.0				

Langley and McDonald, P.C.

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VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject ______________________
____
Computed By __________ Checked by ______

Project No. ______________
Client ______________
Date __________ Sheet No. ______

NODE. 6

Horizontal location
L facing upstream

Location ℄.	Distance Σ From ℄	Existing Elev.		PROPOSED DISTANCE.	DISTANCE OF NO	PROPOSED ELEV.S
48	2L	18.0	1	1L	49	18
45.5	4.5'L	18.9	2	5L	45	20
44.5	5.5'L	20.5	3	—		—
42.5	7.5'L	22.6	4	9L	41	20.5
38	12.0'L	19.0	5	12	38	19.
0	50.0'L	25.0	6	50	0	25
52	2.0R	18.0	7	1R	51	18
53.5	3.5R	18.9	8	5R	55	20
54.5	4.5R	20.8	9	9R	59	20.5
66.0	16.0R	21.0	10		66	21.0
165.0	115.0R	24.0	11		63	20.8
235.0	185.0R	24.0	12			
250.0	200.0R	25.0	13			

NODE 7

EXISTING				PROPOSED		
HORIZONTAL from ℄ L facing Upstream		VERTICAL		HORIZ		VERTICAL.
3'L	137'	16 elev	1	1'L	139'	17.5
15'L	125	20	2	3'L	137	19.0
43'L	97	21	3	10'L	130	20.0
140'L	0	25	4			
6'R	146	16	5	1'R	141	17.5
12'R	152	18	6	3'R	143	19.0
47'R	187	20	7	10'R	150	20.0
195 R	335	20	8			
250	390	25	9			

Pantego Surface Storage Plot - 1 (PP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.5	3.3	
2	21.7	1.5	
3	25.9	5.7	
4	24.7	4.5	
5	25.7	5.5	
6	23.0	2.8	
7	24.0	3.8	
8	25.3	5.1	
9	22.0	1.8	
10	21.4	1.2	
11	21.0	0.8	
12	21.8	1.6	
13	25.0	4.8	
14	25.5	5.3	
15	23.5	3.3	
16	23.7	3.5	
17	25.3	5.1	
18	24.0	3.8	
19	22.0	1.8	
20	25.0	4.8	
21	26.2	6.0	
22	26.8	6.6	
23	27.4	7.2	max
24	26.9	6.7	
25	25.2	5.0	
26	22.4	2.2	
27	23.2	3.0	
28	22.7	2.5	
29	24.9	4.7	
30	20.2	0.0	min
31	21.7	1.5	
32	20.4	0.2	
33	23.7	3.5	
34	23.0	2.8	
35	22.7	2.5	
36	23.7	3.5	
37	24.9	4.7	
38	23.9	3.7	
39	26.5	6.3	
40	26.0	5.8	

Avg. = 3.71

Pantego Surface Storage Plot - 2 (PP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.5	5.3	
2	24.7	6.5	
3	25.9	7.7	
4	25.4	7.2	
5	25.5	7.3	
6	22.6	4.4	
7	24.7	6.5	
8	23.9	5.7	
9	25.2	7.0	
10	25.6	7.4	
11	26.5	8.3	
12	25.0	6.8	
13	23.0	4.8	
14	18.2	0.0	min
15	22.8	4.6	
16	26.5	8.3	
17	25.5	7.3	
18	26.2	8.0	
19	28.7	10.5	
20	29.4	11.2	
21	29.8	11.6	max
22	26.9	8.7	
23	28.6	10.4	
24	29.5	11.3	
25	26.5	8.3	
26	28.8	10.6	
27	27.2	9.0	
28	28.0	9.8	
29	25.9	7.7	
30	27.3	9.1	
31	25.7	7.5	
32	26.4	8.2	
33	25.4	7.2	
34	23.9	5.7	
35	23.5	5.3	
36	23.0	4.8	
37	22.5	4.3	
38	23.0	4.8	
39	23.6	5.4	
40	25.0	6.8	

Avg. = 7.28

Torhunta Surface Storage Plot - 1 (TP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.1	5.5	
2	23.6	6.0	
3	22.3	4.7	
4	21.8	4.2	
5	22.8	5.2	
6	20.4	2.8	
7	23.4	5.8	
8	19.1	1.5	
9	23.5	5.9	
10	19.8	2.2	
11	19.1	1.5	
12	23.0	5.4	
13	22.8	5.2	
14	26.2	8.6	max
15	17.6	0.0	min
16	24.6	7.0	
17	22.2	4.6	
18	23.1	5.5	
19	23.0	5.4	
20	24.2	6.6	
21	21.6	4.0	
22	23.5	5.9	
23	24.4	6.8	
24	22.8	5.2	
25	21.9	4.3	
26	21.2	3.6	
27	23.3	5.7	
28	24.1	6.5	
29	18.8	1.2	
30	24.3	6.7	
31	23.1	5.5	
32	25.3	7.7	
33	22.4	4.8	
34	24.8	7.2	
35	25.6	8.0	
36	26.2	8.6	max
37	22.7	5.1	
38	21.5	3.9	
39	20.9	3.3	
40	23.6	6.0	

Avg. = 5.09

Torhunta Surface Storage Plot - 2 (TP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	28.0	7.6	
2	25.0	4.6	
3	24.6	4.2	
4	26.4	6.0	
5	26.0	5.6	
6	25.0	4.6	
7	22.9	2.5	
8	20.4	0.0	min
9	23.0	2.6	
10	22.5	2.1	
11	23.6	3.2	
12	20.8	0.4	
13	25.1	4.7	
14	25.0	4.6	
15	25.0	4.6	
16	22.8	2.4	
17	25.6	5.2	
18	25.4	5.0	
19	29.7	9.3	max
20	26.5	6.1	
21	26.5	6.1	
22	24.0	3.6	
23	26.7	6.3	
24	27.0	6.6	
25	27.0	6.6	
26	24.1	3.7	
27	26.4	6.0	
28	29.3	8.9	
29	27.4	7.0	
30	24.3	3.9	
31	28.0	7.6	
32	28.5	8.1	
33	25.6	5.2	
34	29.0	8.6	
35	29.5	9.1	
36	26.5	6.1	
37	28.0	7.6	
38	28.4	8.0	
39	28.7	8.3	
40	24.9	4.5	

Avg. = 5.43

Onslow Surface Storage Plot - 1 (OP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	23.8	3.1	
2	24.6	3.9	
3	26.9	6.2	
4	26.2	5.5	
5	24.5	3.8	
6	23.7	3.0	
7	25.1	4.4	
8	25.6	4.9	
9	25.6	4.9	
10	26.4	5.7	
11	26.5	5.8	
12	22.9	2.2	
13	26.3	5.6	
14	28.2	7.5	
15	29.4	8.7	max
16	27.4	6.7	
17	26.2	5.5	
18	27.5	6.8	
19	28.4	7.7	
20	25.9	5.2	
21	26.7	6.0	
22	24.8	4.1	
23	24.2	3.5	
24	23.2	2.5	
25	23.1	2.4	
26	23.0	2.3	
27	20.9	0.2	
28	24.1	3.4	
29	24.2	3.5	
30	21.4	0.7	
31	24.5	3.8	
32	23.6	2.9	
33	21.4	0.7	
34	20.7	0.0	min
35	21.2	0.5	
36	22.4	1.7	
37	23.1	2.4	
38	25.5	4.8	
39	24.4	3.7	
40	24.0	3.3	

Avg. = 3.99

Onslow Surface Storage Plot - 2 (OP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	20.0	1.4	
2	20.5	1.9	
3	20.5	1.9	
4	20.0	1.4	
5	19.4	0.8	
6	21.2	2.6	
7	19.6	1.0	
8	19.5	0.9	
9	20.9	2.3	
10	21.6	3.0	
11	21.8	3.2	
12	22.4	3.8	
13	25.4	6.8	
14	24.0	5.4	
15	24.7	6.1	
16	23.3	4.7	
17	28.3	9.7	
18	27.4	8.8	
19	28.6	10.0	
20	30.4	11.8	max
21	30.0	11.4	
22	28.7	10.1	
23	29.8	11.2	
24	29.3	10.7	
25	26.3	7.7	
26	26.7	8.1	
27	27.0	8.4	
28	26.5	7.9	
29	25.8	7.2	
30	24.8	6.2	
31	26.5	7.9	
32	23.8	5.2	
33	24.5	5.9	
34	24.8	6.2	
35	22.9	4.3	
36	23.4	4.8	
37	19.8	1.2	
38	19.2	0.6	
39	18.6	0.0	min
40	20.4	1.8	

Avg. = 5.36

Marvyn Surface Storage Plot - 1 (MP-1)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	24.8	4.4	
2	24.1	3.7	
3	27.0	6.6	max
4	24.9	4.5	
5	20.8	0.4	
6	24.1	3.7	
7	22.6	2.2	
8	22.0	1.6	
9	23.7	3.3	
10	21.6	1.2	
11	20.4	0.0	min
12	25.0	4.6	
13	23.0	2.6	
14	22.1	1.7	
15	24.1	3.7	
16	25.1	4.7	
17	25.2	4.8	
18	23.7	3.3	
19	24.1	3.7	
20	24.0	3.6	
21	25.3	4.9	
22	21.4	1.0	
23	22.8	2.4	
24	21.9	1.5	
25	25.0	4.6	
26	22.4	2.0	
27	21.9	1.5	
28	23.3	2.9	
29	23.4	3.0	
30	23.8	3.4	
31	23.6	3.2	
32	24.4	4.0	
33	25.2	4.8	
34	25.4	5.0	
35	25.9	5.5	
36	26.1	5.7	
37	26.3	5.9	
38	26.8	6.4	
39	24.4	4.0	
40	25.0	4.6	

Avg. = 3.52

Marvyn Surface Storage Plot - 2 (MP-2)

Measurement Number	Depth (cm)	Corrected Depth (cm)	
1	27.5	2.0	
2	28.7	3.2	
3	30.6	5.1	
4	30.4	4.9	
5	30.3	4.8	
6	30.5	5.0	
7	29.8	4.3	
8	30.9	5.4	
9	31.0	5.5	
10	31.4	5.9	
11	30.2	4.7	
12	31.5	6.0	max
13	28.5	3.0	
14	29.7	4.2	
15	29.7	4.2	
16	30.0	4.5	
17	27.3	1.8	
18	27.6	2.1	
19	29.3	3.8	
20	25.6	0.1	
21	27.4	1.9	
22	26.6	1.1	
23	26.4	0.9	
24	25.5	0.0	min
25	26.4	0.9	
26	26.7	1.2	
27	27.3	1.8	
28	28.2	2.7	
29	27.9	2.4	
30	26.6	1.1	
31	26.1	0.6	
32	26.2	0.7	
33	27.8	2.3	
34	27.8	2.3	
35	29.5	4.0	
36	26.8	1.3	
37	27.4	1.9	
38	27.7	2.2	
39	29.6	4.1	
40	30.4	4.9	

Avg. = 2.97

Radii of Influence from Centerline of Ditch, by Soil Type (Effectively Drained Distance).

Soil Type	Ditch Number	Radius of Influence (feet)
Marvyn	M-10	135
	M-11	238
	M Perimeter-4	574
	M Perimeter-5	1,066
Onslow	O-1	160
	O-2	185
	O-3	155
	O-4	80
	O Perimeter-2	135
	O Perimeter-3	312
	O Perimeter-6	200
	O Perimeter-7	125
Pantego	P-1N	123
	P-1S	51
	P Perimeter-8	100
	P Perimeter-9	70
Torhunta	T-1N	123
	T-1S	59
	T-2N	129
	T-2S	59
	T-3N	129
	T-3S	59
	T-4N	129
	T-4S	95
	T-5N	140
	T-5S	58
	T-6	94
	T-7	58
	TP-1	135
	TP-2	136

TAILWATER CONDITION UPSTREAM OF OUTFALL CULVERTS

(Calculated as a pond with existing culverts
acting as control outfall structures)

```
POND-2 Version: 5.20 S/N:                                    Page 1
EXECUTED: 06-02-1999   16:58:19       2 Year         Return Freq:   2 years

        ***********************************************************
        *                                                         *
        * North Carolinia - Clayhill Farmhill Farm Mitigation     *
        *              Existing Drainage Conditions               *
        *                  Total Drainage Area                    *
        *                                                         *
        *                       2 - YEAR                          *
        ***********************************************************

     Inflow Hydrograph: NC-MFY2 .HYD
     Rating Table file: NC-CLY  .PND

     ----INITIAL CONDITIONS----
     Elevation =    14.00 ft
     Outflow   =     0.50 cfs
     Storage   =     0.00 ac-ft

                                               INTERMEDIATE ROUTING
              GIVEN POND DATA                      COMPUTATIONS
     ------------------------------       -------------------------
    |ELEVATION| OUTFLOW  |  STORAGE  |     |   2S/t     |  2S/t  + 0  |
    |  (ft)   |  (cfs)   |  (ac-ft)  |     |   (cfs)    |   (cfs)     |
    |---------|----------|-----------|     |------------|-------------|
    |  14.00  |    0.5   |   0.000   |     |     0.0    |      0.5    |
    |  14.50  |    3.8   |   0.004   |     |     0.3    |      4.1    |
    |  15.00  |    9.9   |   0.018   |     |     1.5    |     11.4    |
    |  15.50  |   18.7   |   0.067   |     |     5.4    |     24.1    |
    |  16.00  |   30.5   |   0.192   |     |    15.5    |     46.0    |
    |  16.50  |   44.3   |   0.430   |     |    34.7    |     79.0    |
    |  17.00  |   58.9   |   0.816   |     |    65.8    |    124.7    |
    |  17.50  |   74.2   |   1.387   |     |   111.8    |    186.0    |
    |  18.00  |   88.7   |   2.178   |     |   175.7    |    264.4    |
    |  18.50  |  102.1   |   3.226   |     |   260.3    |    362.4    |
    |  19.00  |  114.8   |   4.568   |     |   368.5    |    483.3    |
    |  19.50  |  125.9   |   6.238   |     |   503.2    |    629.1    |
    |  20.00  |  134.6   |   8.273   |     |   667.4    |    802.0    |
    |  20.50  |  142.7   |  10.689   |     |   862.3    |   1005.0    |
    |  21.00  |  150.3   |  13.496   |     |  1088.7    |   1239.0    |
    |  21.50  |  157.5   |  16.724   |     |  1349.0    |   1506.5    |
    |  22.00  |  164.5   |  20.401   |     |  1645.7    |   1810.2    |
    |  22.50  |  171.0   |  24.557   |     |  1980.9    |   2151.9    |
    |  23.00  |  177.4   |  29.222   |     |  2357.2    |   2534.6    |
    |  23.50  |  183.6   |  34.425   |     |  2776.9    |   2960.5    |
    |  24.00  |  189.6   |  40.195   |     |  3242.4    |   3432.0    |
    |  24.50  |  195.4   |  46.561   |     |  3755.9    |   3951.3    |
     ------------------------------       -------------------------

                   Time increment (t) = 0.300 hrs.
```

```
POND-2 Version: 5.20 S/N:                                      Page 2
EXECUTED: 06-02-1999   16:58:19       2 Year        Return Freq:   2 years

 ond File:             NC-CLY   .PND
Inflow Hydrograph:     NC-MFY2  .HYD
Outflow Hydrograph:    NC-OUT2  .HYD

INFLOW HYDROGRAPH                      ROUTING COMPUTATIONS
------------------     ----------------------------------------------------------
|  TIME   |  INFLOW  |  |  I1+I2  |  2S/t - O  |  2S/t + O  |  OUTFLOW | ELEVATION|
|  (hrs)  |  (cfs)   |  |  (cfs)  |   (cfs)    |   (cfs)    |   (cfs)  |   (ft)   |
---------- ---------     --------- ------------ ------------ ---------- ----------
  11.000       4.00        -----          -0.5          0.5       0.50      14.00
  11.300       6.00         10.0          -7.1          9.5       8.33      14.87
  11.600       8.00         14.0          -5.3          6.9       6.10      14.69
  11.900      10.00         18.0          -8.9         12.7      10.77      15.05
  12.200      13.00         23.0          -9.5         14.1      11.78      15.11
  12.500      20.00         33.0         -13.1         23.5      18.31      15.48
  12.800      23.00         43.0         -13.7         29.9      21.84      15.63
  13.100      32.00         55.0         -14.6         41.3      27.94      15.89
  13.400      44.00         76.0         -12.5         61.4      36.94      16.23
  13.700      73.50        117.5          -0.2        105.0      52.61      16.78
  14.000     126.00        199.5          46.0        199.3      76.65      17.58
  14.300     206.00        332.0         170.5        378.0     103.74      18.56
  14.600     287.00        493.0         408.2        663.5     127.63      19.60
  14.900     333.50        620.5         741.8       1028.7     143.47      20.55
  15.200     338.20        671.7        1103.5       1413.5     155.00      21.33
  15.500     322.00        660.2        1436.8       1763.7     163.43      21.92
  15.800     275.20        597.2        1696.5       2034.0     168.76      22.33
  16.100     231.00        506.2        1859.0       2202.7     171.85      22.57
  16.400     192.00        423.0        1935.7       2282.0     173.18      22.67
  16.700     160.60        352.6        1941.7       2288.3     173.28      22.68
  17.000     133.00        293.6        1890.5       2235.3     172.39      22.61
  17.300     116.80        249.8        1798.8       2140.3     170.78      22.48
  17.600     102.00        218.8        1680.7       2017.6     168.44      22.30
  17.900      90.00        192.0        1541.3       1872.7     165.69      22.09
  18.200      80.80        170.8        1387.6       1712.1     162.24      21.84
  18.500      73.00        153.8        1224.8       1541.4     158.30      21.56
  18.800      65.20        138.2        1055.7       1363.0     153.64      21.23
  19.100      58.40        123.6         882.6       1179.3     148.36      20.87
  19.400      53.60        112.0         710.0        994.6     142.29      20.47
  19.700      48.80        102.4         542.4        812.4     135.02      20.03
  20.000      44.00         92.8         382.8        635.2     126.21      19.52
  20.300      41.80         85.8         242.1        468.6     113.26      18.94
  20.600      39.50         81.3         129.8        323.4      96.77      18.30
  20.900      37.30         76.8          50.6        206.6      78.01      17.63
  21.200      35.00         72.3           6.3        122.9      58.33      16.98
  21.500      32.80         67.8         -10.4         74.1      42.25      16.43
  21.800      30.50         63.3         -13.9         52.9      33.37      16.10
  22.100      28.70         59.2         -14.9         45.3      30.13      15.98
  22.400      27.80         56.5         -14.7         41.6      28.10      15.90
  22.700      26.90         54.7         -14.5         40.0      27.29      15.86
  23.000      26.00         52.9         -14.4         38.4      26.38      15.83
  23.300      25.10         51.1         -14.3         36.7      25.48      15.79
  23.600      24.20         49.3         -14.1         35.0      24.58      15.75
  23.900      23.30         47.5         -14.0         33.4      23.68      15.71
  24.200      22.40         45.7         -13.9         31.7      22.78      15.67
------------------     ----------------------------------------------------------
```

```
POND-2 Version: 5.20 S/N:                                     Page 3
EXECUTED: 06-02-1999   16:58:19        2 Year         Return Freq:   2 years

Pond File:            NC-CLY   .PND
Inflow Hydrograph:    NC-MFY2  .HYD
Outflow Hydrograph:   NC-OUT2  .HYD

INFLOW HYDROGRAPH                         ROUTING COMPUTATIONS
------------------     --------------------------------------------------------------
|  TIME    |  INFLOW  |   |  I1+I2   |  2S/t - O  |  2S/t + O  |  OUTFLOW  |ELEVATION|
|  (hrs)   |  (cfs)   |   |  (cfs)   |   (cfs)    |   (cfs)    |   (cfs)   |  (ft)   |
 ---------  ----------     ---------- ------------ ------------ ---------- ----------
|  24.500  |   21.50  |   |   43.9   |     -13.7  |      30.0  |   21.88   |  15.63  |
|  24.800  |   20.60  |   |   42.1   |     -13.6  |      28.4  |   20.98   |  15.60  |
|  25.100  |   19.70  |   |   40.3   |     -13.5  |      26.7  |   20.08   |  15.56  |
|  25.400  |   18.80  |   |   38.5   |     -13.4  |      25.0  |   19.18   |  15.52  |
|  25.700  |   17.90  |   |   36.7   |     -13.0  |      23.3  |   18.17   |  15.47  |
|  26.000  |   17.00  |   |   34.9   |     -12.4  |      21.9  |   17.18   |  15.41  |
-----------------      --------------------------------------------------------------
```

```
 ***************** SUMMARY OF ROUTING COMPUTATIONS *****************

 Pond File:           NC-CLY  .PND
 Inflow Hydrograph:   NC-MFY2 .HYD
 Outflow Hydrograph:  NC-OUT2 .HYD


 Starting Pond W.S. Elevation =    14.00 ft

         ***** Summary of Peak Outflow and Peak Elevation *****

                   Peak Inflow     =   338.20 cfs
                   Peak Outflow    =   173.28 cfs
                   Peak Elevation  =    22.68 ft

         ***** Summary of Approximate Peak Storage *****

             Initial Storage          =     0.00 ac-ft
             Peak Storage From Storm  =    26.22 ac-ft
                                        ---------------
             Total Storage in Pond    =    26.22 ac-ft

         Warning: Inflow hydrograph truncated on left side.
         Warning: Inflow hydrograph truncated on right side.
```

```
                    TR-55 TABULAR HYDROGRAPH METHOD
                         Type III Distribution
                        (24 hr. Duration Storm)

                    Executed:  06-02-1999  15:47:09
            Watershed file:  --> NC-CLY2 .WSD
            Hydrograph file: --> NC-CLY2 .HYD

              NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                     Existing Drainage Conditions
                            Total Drainage


            >>>> Input Parameters Used to Compute Hydrograph <<<<
-------------------------------------------------------------------------
 Subarea           AREA      CN      Tc     * Tt    Precip. |  Runoff   Ia/p
Description      (acres)            (hrs)   (hrs)    (in)   |   (in)  input/used
-------------------------------------------------------------------------
 total           971.40    77.0    2.00    1.50     4.50   |   2.21    .13   .10
-------------------------------------------------------------------------
 * Travel time from subarea outfall to composite watershed outfall point.
                Total area = 971.40 acres  or  1.5178 sq.mi
                         Peak discharge =  604 cfs


           >>>> Computer Modifications of Input Parameters <<<<<
-------------------------------------------------------------------------
                 Input Values     Rounded Values      Ia/p
 Subarea         Tc     * Tt       Tc     * Tt    Interpolated        Ia/p
Description      (hr)    (hr)     (hr)     (hr)     (Yes/No)        Messages
-------------------------------------------------------------------------
total            2.00    1.56     2.00     1.50        No              --
-------------------------------------------------------------------------
 * Travel time from subarea outfall to composite watershed outfall point.
```

SCS ALOWS A MAX T_c OF 2.0 HRS
MODIFIED GENERATED HYDROGRAPH TO REPRESENT
THE PEAK FLOW RATE OF 349 cfs FOR A
TIME OF CONCENTRATION (T_c) OF 3.5 HOURS.

```
                    TR-55 TABULAR HYDROGRAPH METHOD
                         Type III Distribution
                       (24 hr. Duration Storm)

                    Executed:  06-02-1999  15:47:09
            Watershed file:  --> NC-CLY2 .WSD
            Hydrograph file: --> NC-CLY2 .HYD

              NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                     Existing Drainage Conditions
                            Total Drainage
```

MODIFY HYDROGRAPH TO
REPRESENT THE PEAK FLOW
RATE OF 349 cfs,

```
                  Composite Hydrograph Summary (cfs)
-------------------------------------------------------------------------
  Subarea        11.0   11.3   11.6   11.9   12.0   12.1   12.2   12.3   12.4
 Description      hr     hr     hr     hr     hr     hr     hr     hr     hr
-------------------------------------------------------------------------
Total              7     10     13     17     20     23     23     27     30
-------------------------------------------------------------------------
Total (cfs)        7     10     13     17     20     23     23     27     30
                   4      6      8     10     12     13     13     16     17

-------------------------------------------------------------------------
  Subarea        12.5   12.6   12.7   12.8   13.0   13.2   13.4   13.6   13.8
 Description      hr     hr     hr     hr     hr     hr     hr     hr     hr
-------------------------------------------------------------------------
Total             34     34     37     40     50     60     77    104    151
-------------------------------------------------------------------------
Total (cfs)       34     34     37     40     50     60     77    104    151
                  20     20     21     23     29     35     44     60     87

-------------------------------------------------------------------------
  Subarea        14.0   14.3   14.6   15.0   15.5   16.0   16.5   17.0   17.5
 Description      hr     hr     hr     hr     hr     hr     hr     hr     hr
-------------------------------------------------------------------------
Total            218    356    496    604    557    423    309    231    184
-------------------------------------------------------------------------
Total (cfs)      218    356    496    604    557    423    309    231    184
                 126    206    287    349    322    244    179    133    106

-------------------------------------------------------------------------
  Subarea        18.0   19.0   20.0   22.0   26.0
 Description      hr     hr     hr     hr     hr
-------------------------------------------------------------------------
Total            148    104     77     50     30
-------------------------------------------------------------------------
 tal (cfs)       148    104     77     50     30
                  86     60     44     29     17
```

```
POND-2 Version: 5.20 S/N:

                        >>>>> HYDROGRAPH PRINTOUT <<<<<

                           06-03-1999    16:41:29


Hydrograph file: NC-MFY2 .HYD

                             HYDROGRAPH ORDINATES (cfs)
  Time   |                  Time increment = 0.300 Hours
 Hours   |        Time on left represents time for first Q in each row.
-------- |---------------------------------------------------------------
 11.000  |      4.00      6.00      8.00     10.00     13.00     20.00     23.00
 13.100  |     32.00     44.00     73.50    126.00    206.00    287.00    333.50
 15.200  |    338.20    322.00    275.20    231.00    192.00    160.60    133.00
 17.300  |    116.80    102.00     90.00     80.80     73.00     65.20     58.40
 19.400  |     53.60     48.80     44.00     41.80     39.50     37.30     35.00
 21.500  |     32.80     30.50     28.70     27.80     26.90     26.00     25.10
 23.600  |     24.20     23.30     22.40     21.50     20.60     19.70     18.80
 25.700  |     17.90     17.00
```

```
POND-2 Version: 5.20 S/N:                                   Page 1
EXECUTED: 06-02-1999   16:53:51       10 Year         Return Freq:  10 years

        *******************************************************
        *                                                     *
        * North Carolinia - Clayhill Farmhill Farm Mitigation *
        *            Existing Drainage Conditions             *
        *                Total Drainage Area                  *
        *                                                     *
        *                    10 - YEAR                        *
        *******************************************************

     Inflow Hydrograph: NC-MFY10.HYD
     Rating Table file: NC-CLY   .PND

     ----INITIAL CONDITIONS----
     Elevation =     14.00 ft
     Outflow   =      0.50 cfs
     Storage   =      0.00 ac-ft

                                                INTERMEDIATE ROUTING
            GIVEN POND DATA                         COMPUTATIONS
     ------------------------------           -------------------------
    |ELEVATION| OUTFLOW  |  STORAGE  |       |   2S/t     |  2S/t  + 0  |
    |  (ft)   |  (cfs)   |  (ac-ft)  |       |   (cfs)    |   (cfs)     |
    |---------|----------|-----------|       |------------|-------------|
    |  14.00  |     0.5  |    0.000  |       |       0.0  |        0.5  |
    |  14.50  |     3.8  |    0.004  |       |       0.3  |        4.1  |
    |  15.00  |     9.9  |    0.018  |       |       1.5  |       11.4  |
    |  15.50  |    18.7  |    0.067  |       |       5.4  |       24.1  |
    |  16.00  |    30.5  |    0.192  |       |      15.5  |       46.0  |
    |  16.50  |    44.3  |    0.430  |       |      34.7  |       79.0  |
    |  17.00  |    58.9  |    0.816  |       |      65.8  |      124.7  |
    |  17.50  |    74.2  |    1.387  |       |     111.8  |      186.0  |
    |  18.00  |    88.7  |    2.178  |       |     175.7  |      264.4  |
    |  18.50  |   102.1  |    3.226  |       |     260.3  |      362.4  |
    |  19.00  |   114.8  |    4.568  |       |     368.5  |      483.3  |
    |  19.50  |   125.9  |    6.238  |       |     503.2  |      629.1  |
    |  20.00  |   134.6  |    8.273  |       |     667.4  |      802.0  |
    |  20.50  |   142.7  |   10.689  |       |     862.3  |     1005.0  |
    |  21.00  |   150.3  |   13.496  |       |    1088.7  |     1239.0  |
    |  21.50  |   157.5  |   16.724  |       |    1349.0  |     1506.5  |
    |  22.00  |   164.5  |   20.401  |       |    1645.7  |     1810.2  |
    |  22.50  |   171.0  |   24.557  |       |    1980.9  |     2151.9  |
    |  23.00  |   177.4  |   29.222  |       |    2357.2  |     2534.6  |
    |  23.50  |   183.6  |   34.425  |       |    2776.9  |     2960.5  |
    |  24.00  |   189.6  |   40.195  |       |    3242.4  |     3432.0  |
    |  24.50  |   195.4  |   46.561  |       |    3755.9  |     3951.3  |
     ------------------------------           -------------------------

                    Time increment (t) = 0.300 hrs.
```

```
POND-2 Version: 5.20 S/N:                                          Page 2
EXECUTED: 06-02-1999    16:53:51        10 Year           Return Freq:  10 years

 ond File:             NC-CLY   .PND
Inflow Hydrograph:     NC-MFY10.HYD
Outflow Hydrograph:    NC-OUT10.HYD

INFLOW HYDROGRAPH                        ROUTING COMPUTATIONS
-----------------     -----------------------------------------------------
|  TIME   |  INFLOW  |  |  I1+I2  |  2S/t - O   |  2S/t + O  | OUTFLOW  |ELEVATION|
|  (hrs)  |  (cfs)   |  |  (cfs)  |   (cfs)     |   (cfs)    |  (cfs)   |  (ft)   |
 --------  ---------    ---------  -----------   -----------  ---------  ---------
  11.000       8.00       -----          -0.5           0.5       0.50      14.00
  11.300      11.00        19.0         -11.1          18.5      14.82      15.28
  11.600      15.00        26.0          -9.7          14.9      12.30      15.14
  11.900      18.00        33.0         -13.0          23.3      18.11      15.47
  12.200      26.00        44.0         -13.8          31.0      22.43      15.66
  12.500      37.00        63.0         -14.5          49.2      31.83      16.05
  12.800      44.00        81.0         -11.7          66.5      39.09      16.31
  13.100      61.50       105.5          -4.3          93.8      49.05      16.66
  13.400      85.00       146.5          15.7         142.2      63.27      17.14
  13.700     140.50       225.5          72.4         241.2      84.41      17.85
  14.000     240.00       380.5         229.7         452.9     111.61      18.87
  14.300     392.00       632.0         587.7         861.7     136.98      20.15
  14.600     548.00       940.0        1211.7        1527.7     157.99      21.53
  14.900     636.50      1184.5        2046.1        2396.2     175.09      22.82
  15.200     645.20      1281.7        2951.2        3327.8     188.27      23.89
  15.500     614.00      1259.2        3819.6        4210.4     195.40      24.50
  15.800     525.20      1139.2        4568.0        4958.8     195.40      24.50
  16.100     440.80       966.0        5143.2        5534.0     195.40      24.50
  16.400     365.20       806.0        5558.4        5949.2     195.40      24.50
  16.700     306.00       671.2        5838.8        6229.6     195.40      24.50
  17.000     255.00       561.0        6009.0        6399.8     195.40      24.50
  17.300     223.80       478.8        6097.0        6487.8     195.40      24.50
  17.600     195.00       418.8        6125.0        6515.8     195.40      24.50
  17.900     171.00       366.0        6100.2        6491.0     195.40      24.50
  18.200     153.40       324.4        6033.8        6424.6     195.40      24.50
  18.500     139.00       292.4        5935.4        6326.2     195.40      24.50
  18.800     124.60       263.6        5808.2        6199.0     195.40      24.50
  19.100     112.00       236.6        5654.0        6044.8     195.40      24.50
  19.400     103.00       215.0        5478.2        5869.0     195.40      24.50
  19.700      94.00       197.0        5284.4        5675.2     195.40      24.50
  20.000      85.00       179.0        5072.6        5463.4     195.40      24.50
  20.300      80.70       165.7        4847.5        5238.3     195.40      24.50
  20.600      76.30       157.0        4613.7        5004.5     195.40      24.50
  20.900      72.00       148.3        4371.2        4762.0     195.40      24.50
  21.200      67.60       139.6        4120.0        4510.8     195.40      24.50
  21.500      63.30       130.9        3860.1        4250.9     195.40      24.50
  21.800      58.90       122.2        3591.5        3982.3     195.40      24.50
  22.100      55.40       114.3        3320.5        3705.8     192.66      24.26
  22.400      53.70       109.1        3050.5        3429.6     189.57      24.00
  22.700      52.00       105.7        2784.0        3156.2     186.09      23.71
  23.000      50.30       102.3        2521.2        2886.3     182.52      23.41
  23.300      48.50        98.8        2262.7        2620.0     178.64      23.10
  23.600      46.80        95.3        2009.2        2358.0     174.45      22.77
  23.900      45.10        91.9        1761.0        2101.1     170.03      22.43
  24.200      43.40        88.5        1519.0        1849.5     165.25      22.06
-----------------     -----------------------------------------------------
```

```
POND-2 Version: 5.20 S/N:                                   Page 3
EXECUTED: 06-02-1999   16:53:51      10 Year        Return Freq:  10 years

 ond File:            NC-CLY  .PND
Inflow Hydrograph:    NC-MFY10.HYD
Outflow Hydrograph:   NC-OUT10.HYD

INFLOW HYDROGRAPH                       ROUTING COMPUTATIONS
------------------       -------------------------------------------------------
|  TIME   |  INFLOW  |    |  I1+I2  |  2S/t - O  |  2S/t + O |  OUTFLOW |ELEVATION|
|  (hrs)  |  (cfs)   |    |  (cfs)  |   (cfs)    |   (cfs)   |  (cfs)   |  (ft)   |
 --------  ---------       ---------  -----------  ----------  ---------  ---------
| 24.500  |   41.60  |    |   85.0  |    1284.5  |    1604.0 |  159.75  |   21.66 |
| 24.800  |   39.90  |    |   81.5  |    1058.6  |    1366.0 |  153.72  |   21.24 |
| 25.100  |   38.20  |    |   78.1  |     842.7  |    1136.7 |  146.98  |   20.78 |
| 25.400  |   36.50  |    |   74.7  |     639.0  |     917.4 |  139.21  |   20.28 |
| 25.700  |   34.70  |    |   71.2  |     450.2  |     710.2 |  129.98  |   19.73 |
| 26.000  |   33.00  |    |   67.7  |     283.1  |     517.9 |  117.44  |   19.12 |
-----------------        -------------------------------------------------------
```

```
    ****************** SUMMARY OF ROUTING COMPUTATIONS ******************

    Pond File:           NC-CLY  .PND
    Inflow Hydrograph:   NC-MFY10.HYD
    Outflow Hydrograph:  NC-OUT10.HYD


    Starting Pond W.S. Elevation =    14.00 ft

             ***** Summary of Peak Outflow and Peak Elevation *****

                         Peak Inflow    =   645.20 cfs
                         Peak Outflow   =   195.40 cfs
                         Peak Elevation =    24.50 ft

             >>>>>> Warning, pond overtopped during routing. <<<<<<
               The calculated peak outflow/elevation is invalid.
```

```
                    TR-55 TABULAR HYDROGRAPH METHOD
                          Type III Distribution
                        (24 hr. Duration Storm)

                    Executed:  06-02-1999  14:10:00
           Watershed file:  --> NC-CLY  .WSD
           Hydrograph file: --> NC-CLY  .HYD

             NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                      Existing Drainage Conditions
                             Total Drainage


          >>>> Input Parameters Used to Compute Hydrograph <<<<
----------------------------------------------------------------------
 Subarea         AREA      CN      Tc     * Tt    Precip. | Runoff    Ia/p
Description     (acres)           (hrs)   (hrs)    (in)   |  (in)  input/used
----------------------------------------------------------------------
 total          971.40    77.0    2.00    1.50    6.72    |  4.12    .09  .10
----------------------------------------------------------------------
 * Travel time from subarea outfall to composite watershed outfall point.
               Total area = 971.40 acres  or  1.5178 sq.mi
                        Peak discharge =  1126 cfs


          >>>> Computer Modifications of Input Parameters <<<<<
----------------------------------------------------------------------
               Input Values    Rounded Values     Ia/p
  Subarea        Tc   * Tt       Tc   * Tt    Interpolated        Ia/p
Description     (hr)   (hr)     (hr)   (hr)     (Yes/No)        Messages
----------------------------------------------------------------------
total           2.00   1.56     2.00   1.50        No      Computed Ia/p < .1
----------------------------------------------------------------------
 * Travel time from subarea outfall to composite watershed outfall point.
```

SCS ALLOWS A MAXIMUM T_c OF 2.0 HRS
MODIFIED GENERATED HYDROGRAPH TO REPRESENT
THE PEAK FLOW RATE OF 666 cfs FOR A
TIME OF CONCENTRATION (T_c) OF 3.5 HOURS.

```
                    TR-55 TABULAR HYDROGRAPH METHOD
                         Type III Distribution
                       . (24 hr. Duration Storm)

                     Executed:  06-02-1999  14:10:00
            Watershed file:  --> NC-CLY   .WSD
            Hydrograph file: --> NC-CLY   .HYD

           NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                    Existing Drainage Conditions
                          Total Drainage -



                  Composite Hydrograph Summary (cfs)
------------------------------------------------------------------------
  Subarea         11.0   11.3   11.6   11.9   12.0   12.1   12.2   12.3   12.4
 Description       hr     hr     hr     hr     hr     hr     hr     hr     hr
------------------------------------------------------------------------
:otal              13     19     25     31     38     44     44     50     56
------------------------------------------------------------------------
Total (cfs)        13     19     25     31     38     44     44     50     56
MODIFY             8      11     15     18     22     26     26     30     33

------------------------------------------------------------------------
  Subarea         12.5   12.6   12.7   12.8   13.0   13.2   13.4   13.6   13.8
 Description       hr     hr     hr     hr     hr     hr     hr     hr     hr
------------------------------------------------------------------------
:otal              63     63     69     75     94    113    144    194    281
------------------------------------------------------------------------
Total (cfs)        63     63     69     75     94    113    144    194    281
                   37     37     41     44     56     67     85    115    166

------------------------------------------------------------------------
  Subarea         14.0   14.3   14.6   15.0   15.5   16.0   16.5   17.0   17.5
 Description       hr     hr     hr     hr     hr     hr     hr     hr     hr
------------------------------------------------------------------------
'otal             406    663    926   1126   1038    788    575    431    344
------------------------------------------------------------------------
Total (cfs)       406    663    926   1126   1038    788    575    431    344
                  240    392    548    666    614    466    340    255    203

------------------------------------------------------------------------
  Subarea         18.0   19.0   20.0   22.0   26.0
 Description       hr     hr     hr     hr     hr
------------------------------------------------------------------------
-otal             275    194    144     94     56
------------------------------------------------------------------------
 tal (cfs)        275    194    144     94     56
                  163    115     85     56     33

                                                          = 0.59
```

```
                    Executed 06-02-1999     16:46:31
                             Constructed file:
                             NC-MFY10.HYD

               File Summary for Constructed Hydrograph

               VOLUME = 8,456,580 cu.ft. =    194.14 ac-ft

Warning: Left  side of hydrograph truncated. Hydrograph volume incomplete.
Warning: Right side of hydrograph truncated. Hydrograph volume incomplete.


                       Time         Flow
                       (hrs)        (cfs)
                       -----       -------
                       11.00         8.0
                       11.30        11.0
                       11.60        15.0
                       11.90        18.0
                       12.20        26.0
                       12.50        37.0
                       12.80        44.0
                       13.10        61.5
                       13.40        85.0
                       13.70       140.5
                       14.00       240.0
                       14.30       392.0
                       14.60       548.0
                       14.90       636.5
                       15.20       645.2
                       15.50       614.0
                       15.80       525.2
                       16.10       440.8
                       16.40       365.2
                       16.70       306.0
                       17.00       255.0
                       17.30       223.8
                       17.60       195.0
                       17.90       171.0
                       18.20       153.4
                       18.50       139.0
                       18.80       124.6
                       19.10       112.0
                       19.40       103.0
                       19.70        94.0
                       20.00        85.0
                       20.30        80.7
                       20.60        76.3
                       20.90        72.0
                       21.20        67.6
                       21.50        63.3
                       21.80        58.9
                       22.10        55.4
```

```
                    Executed 06-02-1999     16:46:31
                             Constructed file:
                             NC-MFY10.HYD

              File Summary for Constructed Hydrograph

              VOLUME = 8,456,580 cu.ft. =    194.14 ac-ft

Warning: Left  side of hydrograph truncated. Hydrograph volume incomplete.
Warning: Right side of hydrograph truncated. Hydrograph volume incomplete.


                        Time        Flow
                        (hrs)        (cfs)
                        -----       -------
                        22.40        53.7
                        22.70        52.0
                        23.00        50.3
                        23.30        48.5
                        23.60        46.8
                        23.90        45.1
                        24.20        43.4
                        24.50        41.6
                        24.80        39.9
                        25.10        38.2
                        25.40        36.5
                        25.70        34.7
                        26.00        33.0

     >>>>>>>>>>>>>>>>>> WARNING MESSAGES <<<<<<<<<<<<<<<<<<

     Peak flow in hydrograph does not match peak flow input point.
```

```
POND-2 Version: 5.20
S/N:

              North Carolinia - Clayhill Farm Mitigation Site
                       Existing Drainage Conditions
                           Total Drainage Area


                       CALCULATED    06-02-1999    17:32:14
                       DISK FILE: NC-CLY   .VOL

                       Planimeter scale: 1 inch = 1 ft.

                                                              *
Elevation   Planimeter    Area   A1+A2+sqr(A1*A2)            Volume     Volume Sum
  (ft)       (sq.in.)   (acres)     (acres)                (acre-ft)    (acre-ft)
--------------------------------------------------------------------------------
   13.77         0.00      0.00        0.00                    0.00         0.00
   15.00     1,960.00      0.04        0.04                    0.02         0.02
   20.00   194,280.00      4.46        4.95                    8.26         8.27
   22.50   415,780.00      9.54       20.53                   17.11        25.38
   25.00   637,285.00     14.63       35.99                   29.99        55.38

                                                                               2
   IA = (sq.rt(Area1) + ((Ei-E1)/(E2-E1))*(sq.rt(Area2)-sq.rt(Area1)))

   where: E1, E2        = Closest two elevations with planimeter data
          Ei            = Elevation at which to interpolate area
          Area1,Area2   = Areas computed for E1, E2, respectively
          IA            = Interpolated area for Ei


 *  Incremental volume computed by the Conic Method for Reservoir Volumes.

    Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

    where: EL1, EL2      = Lower and upper elevations of the increment
           Area1,Area2   = Areas computed for EL1, EL2, respectively
           Volume        = Incremental volume between EL1 and EL2
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20            S/N:
Date Executed:                  Time Executed:


    ************************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ************************************************



         ***** COMPOSITE OUTFLOW SUMMARY ****


Elevation (ft)    Q (cfs)    Contributing  Structures
--------------    -------    ------------------------
     14.00          0.5       4
     14.50          3.8       4
     15.00          9.9       4
     15.50         18.7       4
     16.00         30.5       4
     16.50         44.3       4
     17.00         58.9       4
     17.50         74.2       4
     18.00         88.7       4
     18.50        102.1       4
     19.00        114.8       4
     19.50        125.9       4
     20.00        134.6       4
     20.50        142.7       4
     21.00        150.3       4
     21.50        157.5       4
     22.00        164.5       4
     22.50        171.0       4
     23.00        177.4       4
     23.50        183.6       4
     24.00        189.6       4
     24.50        195.4       4
     25.00          0.0
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20            S/N:
Date Executed:                  Time Executed:


    ***********************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ***********************************************


       Outlet Structure File:     NC-CLY  .STR
       Planimeter Input File:     NC-CLY  .VOL
       Rating Table Output File:  NC-CLY  .PND


Min. Elev.(ft) = 14   Max. Elev.(ft) = 25   Incr.(ft) = .5

   Additional elevations (ft) to be included in table:
   * * * * * * * * * * * * * * * * * * * * * * * * * *


     **********************************************
                   SYSTEM CONNECTIVITY
     **********************************************

          Structure     No.   Q Table   Q Table
          ----------    ---    ------   -------
          TABLE          1            ->   1
          CULVERT-CR     2            ->   2
          CULVERT-CR     3   +   2    ->   4
          NULL STRUC     4   ?   1    ->   5

Outflow rating table summary was stored in file:
NC-CLY  .PND
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20            S/N:
Date Executed:                  Time Executed:


    ************************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ************************************************


             >>>>>> Structure No. 1 <<<<<<
                      (Input Data)

              TABLE
              Input your own rating table.
              E1 (ft) =13.77     E2 (ft) =14.5

              Constant (ft) added to each elevation was:

                  Elev. (ft)    Q (cfs)
                  ----------    -------
                     13.77        0
                     14.5         5
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20             S/N:
Date Executed:                   Time Executed:


    ***********************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ***********************************************


              >>>>>> Structure No. 2 <<<<<<
                      (Input Data)

               CULVERT-CR
               Circular Culvert (With Inlet Control)


               E1 elev.(ft)?            13.77
               E2 elev.(ft)?            25
               Diam. (ft)?              4
               Inv. el.(ft)?            13.77
               Slope (ft/ft)?           .0208
               T1 ratio?
               T2 ratio?
               K Coeff.?                0.0340
               M Coeff.?                1.5
               c Coeff.?                .0553
               Y Coeff.?                .54
               Form 1 or 2?             1
               Slope factor?            -0.5
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20             S/N:
Date Executed:                   Time Executed:


    ***********************************************
    North Carolinia - Clayhill Farm Mitigation Site
             Existing Drainage Conditions
                    Total Drainage

    ***********************************************


                  >>>>>> Structure No. 3 <<<<<<
                          (Input Data)

                   CULVERT-CR
                   Circular Culvert (With Inlet Control)


                   E1 elev.(ft)?           15.08
                   E2 elev.(ft)?           25
                   Diam. (ft)?             2
                   Inv. el.(ft)?           15.08
                   Slope (ft/ft)?          .0042
                   T1 ratio?
                   T2 ratio?
                   K Coeff.?               .0340
                   M Coeff.?               1.5
                   c Coeff.?               .0553
                   Y Coeff.?               .54
                   Form 1 or 2?            1
                   Slope factor?           -0.5
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20                S/N:
Date Executed:                      Time Executed:


    ************************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ************************************************


              >>>>>> NULL Structure <<<<<<
                      (Input Data)

               NULL STRUC
               Null Structure -- Add/check between tables

                       4 ? 1 -> 5
```

```
Outlet Structure File: NC-CLY   .STR

POND-2 Version: 5.20             S/N:
Date Executed:                   Time Executed:


   ***********************************************
   North Carolinia - Clayhill Farm Mitigation Site
             Existing Drainage Conditions
                    Total Drainage

   ***********************************************


Outflow Rating Table for Structure #1
TABLE       Input your own rating table.


Elevation (ft)     Q (cfs)     Computation  Messages
--------------     -------     ------------------------
     14.00           1.6        Interpolated from input table
     14.50           0.0       E = or > E2=14.5
     15.00           0.0       E = or > E2=14.5
     15.50           0.0       E = or > E2=14.5
     16.00           0.0       E = or > E2=14.5
     16.50           0.0       E = or > E2=14.5
     17.00           0.0       E = or > E2=14.5
     17.50           0.0       E = or > E2=14.5
     18.00           0.0       E = or > E2=14.5
     18.50           0.0       E = or > E2=14.5
     19.00           0.0       E = or > E2=14.5
     19.50           0.0       E = or > E2=14.5
     20.00           0.0       E = or > E2=14.5
     20.50           0.0       E = or > E2=14.5
     21.00           0.0       E = or > E2=14.5
     21.50           0.0       E = or > E2=14.5
     22.00           0.0       E = or > E2=14.5
     22.50           0.0       E = or > E2=14.5
     23.00           0.0       E = or > E2=14.5
     23.50           0.0       E = or > E2=14.5
     24.00           0.0       E = or > E2=14.5
     24.50           0.0       E = or > E2=14.5
     25.00           0.0       E = or > E2=14.5
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20              S/N:
Date Executed:                    Time Executed:


    ***********************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ***********************************************


Outflow Rating Table for Structure #2
CULVERT-CR  Circular Culvert (With Inlet Control)

         ***** INLET CONTROL ASSUMED *****

Elevation (ft)    Q (cfs)    Computation  Messages
--------------    -------    ------------------------
     14.00          0.5       Equ.1: HW =.23     dc=.197    Ac=.23
     14.50          3.8       Equ.1: HW =.73     dc=.564    Ac=1.081
     15.00          9.9       Equ.1: HW =1.23    dc=.918    Ac=2.175
     15.50         17.9       Equ.1: HW =1.73    dc=1.244   Ac=3.332
     16.00         27.1       Equ.1: HW =2.23    dc=1.54    Ac=4.459
     16.50         37.4       Equ.1: HW =2.73    dc=1.822   Ac=5.57
     17.00         48.1       Equ.1: HW =3.23    dc=2.078   Ac=6.594
     17.50         59.5       Equ.1: HW =3.73    dc=2.324   Ac=7.572
     18.00         70.6       Equ.1: HW =4.23    dc=2.539   Ac=8.415
     18.50         81.6       Equ.1: HW =4.73    dc=2.737   Ac=9.164
     19.00         92.3       Transition: HW =5.23
     19.50        101.5       Submerged:  HW =5.73
     20.00        108.3       Submerged:  HW =6.23
     20.50        114.8       Submerged:  HW =6.73
     21.00        120.9       Submerged:  HW =7.23
     21.50        126.6       Submerged:  HW =7.73
     22.00        132.2       Submerged:  HW =8.23
     22.50        137.3       Submerged:  HW =8.73
     23.00        142.5       Submerged:  HW =9.23
     23.50        147.4       Submerged:  HW =9.73
     24.00        152.2       Submerged:  HW =10.23
     24.50        156.8       Submerged:  HW =10.73
     25.00          0.0       E = or > E2=25

  Used Unsubmerged Equ. Form (1) for  elev. less than 18.78 ft
  Used Submerged Equation for elevations greater than 19.43 ft
  HW=Headwater (ft)  dc=Critical depth (ft)  Ac=Area (sq.ft) at dc

  Transition flows interpolated from the following values:
  E1=18.78 ft; Q1=87.96 cfs;  Dc=2.84 ft; E2=19.43 ft; Q2=100.53 cfs
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20              S/N:
Date Executed:                    Time Executed:


    ************************************************
    North Carolinia - Clayhill Farm Mitigation Site
              Existing Drainage Conditions
                     Total Drainage

    ************************************************


Outflow Rating Table for Structure #3
CULVERT-CR  Circular Culvert (With Inlet Control)

         ***** INLET CONTROL ASSUMED *****

Elevation (ft)    Q (cfs)    Computation  Messages
--------------    -------    ------------------------
     14.00          0.0       E < Inv.El.= 15.08
     14.50          0.0       E < Inv.El.= 15.08
     15.00          0.0       E < Inv.El.= 15.08
     15.50          0.8       Equ.1: HW =.42    dc=.309   Ac=.309
     16.00          3.4       Equ.1: HW =.92    dc=.647   Ac=.880
     16.50          6.9       Equ.1: HW =1.42   dc=.929   Ac=1.43
     17.00         10.9       Equ.1: HW =1.92   dc=1.182  Ac=1.932
     17.50         14.7       Equ.1: HW =2.42   dc=1.381  Ac=2.313
     18.00         18.1       Submerged:  HW =2.92
     18.50         20.5       Submerged:  HW =3.42
     19.00         22.5       Submerged:  HW =3.92
     19.50         24.4       Submerged:  HW =4.42
     20.00         26.2       Submerged:  HW =4.92
     20.50         27.8       Submerged:  HW =5.42
     21.00         29.4       Submerged:  HW =5.92
     21.50         30.9       Submerged:  HW =6.42
     22.00         32.3       Submerged:  HW =6.920
     22.50         33.7       Submerged:  HW =7.420
     23.00         35.0       Submerged:  HW =7.920
     23.50         36.2       Submerged:  HW =8.42
     24.00         37.4       Submerged:  HW =8.92
     24.50         38.6       Submerged:  HW =9.42
     25.00          0.0       E = or > E2=25

 Used Unsubmerged Equ. Form (1) for  elev. less than 17.6 ft
 Used Submerged Equation for elevations greater than 17.93 ft
 HW=Headwater (ft)  dc=Critical depth (ft)  Ac=Area (sq.ft) at dc

 Transition flows interpolated from the following values:
 E1=17.6 ft; Q1=15.55 cfs;  Dc=1.42 ft; E2=17.93 ft; Q2=17.77 cfs
```

```
Outlet Structure File: NC-CLY  .STR

POND-2 Version: 5.20                S/N:
Date Executed:                      Time Executed:


     ***********************************************
     North Carolinia - Clayhill Farm Mitigation Site
               Existing Drainage Conditions
                      Total Drainage

     ***********************************************



                Outflow Rating Table 4
                  Table 4  =  2  +  3


Elevation (ft)     Q (cfs)    Contributing  Structures
--------------     -------    ------------------------
     14.00           0.5       2
     14.50           3.8       2
     15.00           9.9       2
     15.50          18.7       2 +3
     16.00          30.5       2 +3
     16.50          44.3       2 +3
     17.00          58.9       2 +3
     17.50          74.2       2 +3
     18.00          88.7       2 +3
     18.50         102.1       2 +3
     19.00         114.8       2 +3
     19.50         125.9       2 +3
     20.00         134.6       2 +3
     20.50         142.7       2 +3
     21.00         150.3       2 +3
     21.50         157.5       2 +3
     22.00         164.5       2 +3
     22.50         171.0       2 +3
     23.00         177.4       2 +3
     23.50         183.6       2 +3
     24.00         189.6       2 +3
     24.50         195.4       2 +3
     25.00           0.0       -
```

```
Outlet Structure File: NC-CLY   .STR

POND-2 Version: 5.20               S/N:
Date Executed:                     Time Executed:


      ********************************************
      North Carolinia - Clayhill Farm Mitigation Site
               Existing Drainage Conditions
                     Total Drainage

      ********************************************


                 Outflow Rating Table 5
                   Table 5  =  1  ?  4

Elevation (ft)     Q (cfs)    Contributing  Structures
--------------     -------    ------------------------
     14.00           0.5       4
     14.50           3.8       4
     15.00           9.9       4
     15.50          18.7       4
     16.00          30.5       4
     16.50          44.3       4
     17.00          58.9       4
     17.50          74.2       4
     18.00          88.7       4
     18.50         102.1       4
     19.00         114.8       4
     19.50         125.9       4
     20.00         134.6       4
     20.50         142.7       4
     21.00         150.3       4
     21.50         157.5       4
     22.00         164.5       4
     22.50         171.0       4
     23.00         177.4       4
     23.50         183.6       4
     24.00         189.6       4
     24.50         195.4       4
     25.00           0.0       -
```

WATERSHED TO
THE OUTFALL CULVERTS

(Individual drainage area – peak runoff rates)

Storm Drain Design Computations

Langley and McDonald, P.C.

2 & 10 YEAR DESIGN STORMS
EXISTING LAND USE

STORM DRAIN DESIGN COMPUTATIONS

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

Job No. 1960024-203.00 Date: 05/07/97 File Name: Exist Cond - Main Ditch.xls
Computed By: MWM Checked By:

Drainage Area	Drainage AREA AC.	CURVE No.	Tc CONC. hrs	RUNOFF "Q" 2 Yr cfs	10 Yr cfs
A1	70	77.00	1.87	35	67
A2	122	77.00	2.14	57	110
A3	243	77.00	2.38	105	201
A4	340	77.00	2.64	138	264
B	66	77.00	1.54	38	73
C	114	77.00	1.79	59	113
D	422	77.00	3.56	142	270
E	30	77.00	2.11	14	27
Total	972				
Total Drainage D.A. (A + B + C+ D + E =)			3.56	323	614
Total Drainage (Minus Drainage Area D)			2.64	349	666

Sheet Flow						**Shallow**			**Channel Flow**						
Drainage Area	Mnings	Flow Length	2-Yr Rainfall	Slope	Time of Concentration	**Conc. Flow**	Crss Sec Area	Wetted perimeter	Hydraulic Radius	Slope	Mannings	velocity	Flow Length	Travel Time	**Total Travel Time**
D	0.40	200.00	4.50	0.0036	**1.04**	**1.08**	28.00	18.90	1.48	0.0009	0.050	1.16	6000	1.43	3.56
B	0.40	200.00	4.50	0.0020	**1.32**	**0.22**	0.00	0.00	#DIV/0!			#DIV/0!		0.00	1.54
C	0.40	200.00	4.50	0.0020	**1.32**	**0.47**	0.00	0.00	#DIV/0!			#DIV/0!		0.00	1.79
Alt. C	0.40	200.00	4.50	0.0020	**1.32**	**0.05**	22.00	14.90	1.48	0.0010	0.050	1.22	2900	0.66	2.03
E	0.40	100.00	4.50	0.0100	**0.40**	**0.00**	12.00	11.70	1.03	0.0010	0.050	0.96	5900	1.71	2.11
Alt. E	0.40	200.00	4.50	0.0100	**0.69**	**0.00**	12.00	11.70	1.03	0.0010	0.050	0.96	2400	0.70	1.39
A1	0.40	200.00	4.50	0.0020	**1.32**	**0.17**	18.00	14.00	1.29	0.0015	0.050	1.37	1850	0.38	1.87
lt. A	Drainage Ditch				0.73										0.73
A2	Include travel time of A1						18.00	14.00	1.29	0.0013	0.050	1.27	1250	0.27	2.14
A3	Include travel time of A2						18.00	14.00	1.29	0.0030	0.050	1.93	1650	0.24	2.38
A4	Include travel time of A3						30.00	18.00	1.67	0.0032	0.050	2.37	2250	0.26	2.64

```
Quick TR-55 Version: 5.46 S/N:

               >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


           NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                    EXISTING DRAINAGE CONDITIONS
           DRAINAGE AREA - TOTAL OF (DA A,B,C,& E Minus D)


                   CALCULATED
                   DISK FILE: DA-TTL-1.GPD


       Drainage Area            (acres)   858.4 --->   1.3413 sq.mi.
       Runoff Curve Number        (CN)    77
       Time of Concentration,Tc (hrs)     2.64
       Rainfall Distribution    (Type)    III
       Pond and Swamp Areas        (%)    5     --->     42.9 acres

                                         Storm #1    Storm #2    Storm #3
                                         --------    --------    --------
  Frequency (years)                       2           10
  Rainfall, P, 24-hr (in)                 4.5         6.72


  Initial Abstraction, Ia (in)            0.597       0.597       0.597
  Ia/p Ratio                              0.133       0.089       0.000
  Unit Discharge, * qu (csm/in)            164         168           0
  Runoff, Q (in)                          2.21        4.12        0.00
  Pond & Swamp Adjustment Factor          0.72        0.72        0.72

  PEAK DISCHARGE, qp (cfs)                 349         666           0
  ------------------------------------------------------------------

  Summary of Computations for qu
  ------------------------------
         Ia/p      #1                    0.100       0.100       0.000
         C0        #1                    2.473       2.473       0.000
         C1        #1                   -0.518      -0.518       0.000
         C2        #1                   -0.171      -0.171       0.000
         qu (csm)  #1                  167.576     167.576       0.000

         Ia/p      #2                    0.300       0.100       0.000
         C0        #2                    2.396       2.473       0.000
         C1        #2                   -0.512      -0.518       0.000
         C2        #2                   -0.132      -0.171       0.000
         qu (csm)  #2                  143.505     167.576       0.000

       * qu (csm)                          164         168           0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                  2
  log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

              >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


          NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                    EXISTING DRAINAGE CONDITIONS
                DRAINAGE AREA - TOTAL OF (DA A,B,C,D & E)


                      CALCULATED
                      DISK FILE: DA-TTL   .GPD


     Drainage Area              (acres)   971.4 --->   1.5178 sq.mi.
     Runoff Curve Number          (CN)    77
     Time of Concentration,Tc (hrs)   3.56
     Rainfall Distribution      (Type)    III
     Pond and Swamp Areas         (%)     5     --->     48.6 acres

                                          Storm #1    Storm #2    Storm #3
                                          --------    --------    --------
Frequency (years)                          2           10
Rainfall, P, 24-hr (in)                    4.5         6.72


Initial Abstraction, Ia (in)               0.597       0.597       0.597
Ia/p Ratio                                 0.133       0.089       0.000
Unit Discharge, * qu (csm/in)               134         137            0
Runoff, Q (in)                              2.21        4.12        0.00
Pond & Swamp Adjustment Factor              0.72        0.72        0.72

PEAK DISCHARGE, qp (cfs)                    323         614            0
----------------------------------------------------------------------------

Summary of Computations for qu
------------------------------
        Ia/p      #1                       0.100       0.100       0.000
        C0        #1                       2.473       2.473       0.000
        C1        #1                      -0.518      -0.518       0.000
        C2        #1                      -0.171      -0.171       0.000
        qu (csm)  #1                     136.554     136.554       0.000

        Ia/p      #2                       0.300       0.100       0.000
        C0        #2                       2.396       2.473       0.000
        C1        #2                      -0.512      -0.518       0.000
        C2        #2                      -0.132      -0.171       0.000
        qu (csm)  #2                     118.481     136.554       0.000

     * qu (csm)                             134         137            0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                          2
 log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
 qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

              >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


           NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                    EXISTING DRAINAGE CONDITIONS
                        DRAINAGE AREA - A1


                  CALCULATED
                  DISK FILE: DA-A1   .GPD


       Drainage Area             (acres)   70    --->   0.1094 sq.mi.
       Runoff Curve Number          (CN)   77
       Time of Concentration,Tc  (hrs)     1.9
       Rainfall Distribution     (Type)    III
       Pond and Swamp Areas         (%)    5     --->       3.5 acres
                                         Storm #1    Storm #2    Storm #3
                                         --------    --------    --------
Frequency (years)                         2           10
Rainfall, P, 24-hr (in)                   4.5         6.72


Initial Abstraction, Ia (in)              0.597       0.597       0.597
Ia/p Ratio                                0.133       0.089       0.000
Unit Discharge, * qu (csm/in)              202         207           0
Runoff, Q (in)                            2.21        4.12        0.00
Pond & Swamp Adjustment Factor            0.72        0.72        0.72

PEAK DISCHARGE, qp (cfs)                    35          67           0
-----------------------------------------------------------------------

Summary of Computations for qu
------------------------------
        Ia/p     #1                      0.100       0.100       0.000
        C0       #1                      2.473       2.473       0.000
        C1       #1                     -0.518      -0.518       0.000
        C2       #1                     -0.171      -0.171       0.000
        qu (csm) #1                    206.713     206.713       0.000

        Ia/p     #2                      0.300       0.100       0.000
        C0       #2                      2.396       2.473       0.000
        C1       #2                     -0.512      -0.518       0.000
        C2       #2                     -0.132      -0.171       0.000
        qu (csm) #2                    175.090     206.713       0.000

      * qu (csm)                           202         207           0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                       2
  log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

            >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


          NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                    EXISTING DRAINAGE CONDITIONS
                        DRAINAGE AREA - A2


                   CALCULATED
                   DISK FILE: DA-A2   .GPD


        Drainage Area            (acres)   122    --->   0.1906 sq.mi.
        Runoff Curve Number         (CN)   77
        Time of Concentration,Tc (hrs)    2.1
        Rainfall Distribution    (Type)    III
        Pond and Swamp Areas        (%)    5      --->      6.1 acres

                                         Storm #1    Storm #2    Storm #3
                                         --------    --------    --------
   Frequency (years)                      2           10
   Rainfall, P, 24-hr (in)                4.5         6.72


   Initial Abstraction, Ia (in)           0.597       0.597       0.597
   Ia/p Ratio                             0.133       0.089       0.000
   Unit Discharge, * qu (csm/in)           189         194           0
   Runoff, Q (in)                         2.21        4.12        0.00
   Pond & Swamp Adjustment Factor         0.72        0.72        0.72

   PEAK DISCHARGE, qp (cfs)                 57         110           0
   ------------------------------------------------------------------

   Summary of Computations for qu
   ------------------------------
         Ia/p      #1                    0.100       0.100       0.000
         C0        #1                    2.473       2.473       0.000
         C1        #1                   -0.518      -0.518       0.000
         C2        #1                   -0.171      -0.171       0.000
         qu (csm)  #1                  194.254     194.254       0.000

         Ia/p      #2                    0.300       0.100       0.000
         C0        #2                    2.396       2.473       0.000
         C1        #2                   -0.512      -0.518       0.000
         C2        #2                   -0.132      -0.171       0.000
         qu (csm)  #2                  165.023     194.254       0.000

      * qu (csm)                           189         194           0

 * Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
   If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                2
  log(qu)   = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

              >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


            NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                     EXISTING DRAINAGE CONDITIONS
                          DRAINAGE AREA - A3


                    CALCULATED
                    DISK FILE: DA-A3    .GPD


     Drainage Area            (acres)   243    --->    0.3797 sq.mi.
     Runoff Curve Number         (CN)   77
     Time of Concentration,Tc  (hrs)    2.4
     Rainfall Distribution     (Type)   III
     Pond and Swamp Areas         (%)   5      --->      12.2 acres

                                        Storm #1    Storm #2    Storm #3
                                        --------    --------    --------
Frequency (years)                        2           10
Rainfall, P, 24-hr (in)                  4.5         6.72


Initial Abstraction, Ia (in)             0.597       0.597       0.597
Ia/p Ratio                               0.133       0.089       0.000
Unit Discharge, * qu (csm/in)             174         178           0
Runoff, Q (in)                           2.21        4.12        0.00
Pond & Swamp Adjustment Factor           0.72        0.72        0.72

PEAK DISCHARGE, qp (cfs)                  105         201           0
--------------------------------------------------------------------

Summary of Computations for qu
------------------------------
       Ia/p     #1                     0.100       0.100       0.000
       C0       #1                     2.473       2.473       0.000
       C1       #1                    -0.518      -0.518       0.000
       C2       #1                    -0.171      -0.171       0.000
       qu (csm) #1                   178.379     178.379       0.000

       Ia/p     #2                     0.300       0.100       0.000
       C0       #2                     2.396       2.473       0.000
       C1       #2                    -0.512      -0.518       0.000
       C2       #2                    -0.132      -0.171       0.000
       qu (csm) #2                   152.215     178.379       0.000

     * qu (csm)                          174         178           0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                        2
  log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

             >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


        NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                  EXISTING DRAINAGE CONDITIONS
                      DRAINAGE AREA - A4


                 CALCULATED
                 DISK FILE: DA-A4   .GPD


      Drainage Area           (acres)   340   --->   0.5313 sq.mi.
      Runoff Curve Number        (CN)   77
      Time of Concentration,Tc (hrs)   2.64
      Rainfall Distribution    (Type)   III
      Pond and Swamp Areas        (%)   5     --->     17.0 acres

                                      Storm #1    Storm #2    Storm #3
                                      --------    --------    --------
Frequency (years)                      2           10
Rainfall, P, 24-hr (in)                4.5         6.72


Initial Abstraction, Ia (in)           0.597       0.597       0.597
Ia/p Ratio                             0.133       0.089       0.000
Unit Discharge, * qu (csm/in)           164         168           0
Runoff, Q (in)                          2.21        4.12        0.00
Pond & Swamp Adjustment Factor          0.72        0.72        0.72

PEAK DISCHARGE, qp (cfs)                 138         264           0
------------------------------------------------------------------

Summary of Computations for qu
----------------------------
       Ia/p      #1                    0.100       0.100       0.000
       C0        #1                    2.473       2.473       0.000
       C1        #1                   -0.518      -0.518       0.000
       C2        #1                   -0.171      -0.171       0.000
       qu (csm)  #1                  167.576     167.576       0.000

       Ia/p      #2                    0.300       0.100       0.000
       C0        #2                    2.396       2.473       0.000
       C1        #2                   -0.512      -0.518       0.000
       C2        #2                   -0.132      -0.171       0.000
       qu (csm)  #2                  143.505     167.576       0.000

     * qu (csm)                          164         168           0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                2
  log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

              >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


         NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                   EXISTING DRAINAGE CONDITIONS
                        DRAINAGE AREA - B


                CALCULATED
                DISK FILE: DA-B    .GPD


      Drainage Area           (acres)   66    --->   0.1031 sq.mi.
      Runoff Curve Number        (CN)   77
      Time of Concentration,Tc  (hrs)   1.5
      Rainfall Distribution    (Type)   III
      Pond and Swamp Areas        (%)   5     --->      3.3 acres

                                       Storm #1    Storm #2    Storm #3
                                       --------    --------    --------
 Frequency (years)                      2           10
 Rainfall, P, 24-hr (in)                4.5         6.72


 Initial Abstraction, Ia (in)           0.597       0.597       0.597
 Ia/p Ratio                             0.133       0.089       0.000
 Unit Discharge, * qu (csm/in)           232         238           0
 Runoff, Q (in)                          2.21        4.12        0.00
 Pond & Swamp Adjustment Factor          0.72        0.72        0.72

 PEAK DISCHARGE, qp (cfs)                  38          73           0
 ----------------------------------------------------------------------

 Summary of Computations for qu
 ------------------------------
        Ia/p     #1                     0.100       0.100       0.000
        C0       #1                     2.473       2.473       0.000
        C1       #1                    -0.518      -0.518       0.000
        C2       #1                    -0.171      -0.171       0.000
        qu (csm) #1                   237.998     237.998       0.000

        Ia/p     #2                     0.300       0.100       0.000
        C0       #2                     2.396       2.473       0.000
        C1       #2                    -0.512      -0.518       0.000
        C2       #2                    -0.132      -0.171       0.000
        qu (csm) #2                   200.452     237.998       0.000

      * qu (csm)                          232         238           0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                        2
  log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

                >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


            NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                     EXISTING DRAINAGE CONDITIONS
                           DRAINAGE AREA - C


                    CALCULATED
                    DISK FILE: DA-C    .GPD


          Drainage Area          (acres)   114    --->   0.1781 sq.mi.
          Runoff Curve Number       (CN)   77
          Time of Concentration,Tc (hrs)   1.8
          Rainfall Distribution   (Type)   III
          Pond and Swamp Areas       (%)   5      --->      5.7 acres

                                          Storm #1    Storm #2    Storm #3
                                          --------    --------    --------
    Frequency (years)                      2           10
    Rainfall, P, 24-hr (in)                4.5         6.72


    Initial Abstraction, Ia (in)           0.597       0.597       0.597
    Ia/p Ratio                             0.133       0.089       0.000
    Unit Discharge, * qu (csm/in)           208         214           0
    Runoff, Q (in)                         2.21        4.12        0.00
    Pond & Swamp Adjustment Factor         0.72        0.72        0.72

    PEAK DISCHARGE, qp (cfs)                 59         113           0
    --------------------------------------------------------------------

    Summary of Computations for qu
    ------------------------------
            Ia/p      #1                   0.100       0.100       0.000
            C0        #1                   2.473       2.473       0.000
            C1        #1                  -0.518      -0.518       0.000
            C2        #1                  -0.171      -0.171       0.000
            qu (csm)  #1                 213.641     213.641       0.000

            Ia/p      #2                   0.300       0.100       0.000
            C0        #2                   2.396       2.473       0.000
            C1        #2                  -0.512      -0.518       0.000
            C2        #2                  -0.132      -0.171       0.000
            qu (csm)  #2                 180.694     213.641       0.000

         * qu (csm)                          208         214           0

   * Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
     If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                             2
     log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
     qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

               >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


          NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                    EXISTING DRAINAGE CONDITIONS
                          DRAINAGE AREA - D


                  CALCULATED
                  DISK FILE: DA-D    .GPD


       Drainage Area           (acres)   422    --->   0.6594 sq.mi.
       Runoff Curve Number        (CN)   77
       Time of Concentration,Tc (hrs)   3.5
       Rainfall Distribution    (Type)   III
       Pond and Swamp Areas        (%)   5      --->     21.1 acres

                                        Storm #1    Storm #2    Storm #3
                                        --------    --------    --------
Frequency (years)                        2           10
Rainfall, P, 24-hr (in)                  4.5         6.72


Initial Abstraction, Ia (in)             0.597       0.597       0.597
Ia/p Ratio                               0.133       0.089       0.000
Unit Discharge, * qu (csm/in)              135         138           0
Runoff, Q (in)                            2.21        4.12        0.00
Pond & Swamp Adjustment Factor            0.72        0.72        0.72

PEAK DISCHARGE, qp (cfs)                   142         270           0
----------------------------------------------------------------------

Summary of Computations for qu
------------------------------
        Ia/p      #1                     0.100       0.100       0.000
        C0        #1                     2.473       2.473       0.000
        C1        #1                    -0.518      -0.518       0.000
        C2        #1                    -0.171      -0.171       0.000
        qu (csm) #1                    138.202     138.202       0.000

        Ia/p      #2                     0.300       0.100       0.000
        C0        #2                     2.396       2.473       0.000
        C1        #2                    -0.512      -0.518       0.000
        C2        #2                    -0.132      -0.171       0.000
        qu (csm) #2                    119.812     138.202       0.000

      * qu (csm)                           135         138           0

* Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
  If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                           2
  log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
  qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

```
Quick TR-55 Version: 5.46 S/N:

              >>>>> GRAPHICAL PEAK DISCHARGE METHOD <<<<<


           NORTH CAROLINIA - CLAYHILL FARM MITIGATION SITE
                   EXISTING DRAINAGE CONDITIONS
                        DRAINAGE AREA - E


                  CALCULATED
                  DISK FILE: DA-E    .GPD


         Drainage Area           (acres)   30    --->   0.0469 sq.mi.
         Runoff Curve Number        (CN)   77
         Time of Concentration,Tc (hrs)   2.1
         Rainfall Distribution    (Type)   III
         Pond and Swamp Areas        (%)   5     --->      1.5 acres

                                          Storm #1    Storm #2    Storm #3
                                          --------    --------    --------
   Frequency (years)                       2           10
   Rainfall, P, 24-hr (in)                 4.5         6.72


   Initial Abstraction, Ia (in)            0.597       0.597       0.597
   Ia/p Ratio                              0.133       0.089       0.000
   Unit Discharge, * qu (csm/in)            189         194           0
   Runoff, Q (in)                          2.21        4.12        0.00
   Pond & Swamp Adjustment Factor          0.72        0.72        0.72

   PEAK DISCHARGE, qp (cfs)                  14          27           0
   -------------------------------------------------------------------

   Summary of Computations for qu
   ------------------------------
          Ia/p      #1                     0.100       0.100       0.000
          C0        #1                     2.473       2.473       0.000
          C1        #1                    -0.518      -0.518       0.000
          C2        #1                    -0.171      -0.171       0.000
          qu (csm)  #1                   194.254     194.254       0.000

          Ia/p      #2                     0.300       0.100       0.000
          C0        #2                     2.396       2.473       0.000
          C1        #2                    -0.512      -0.518       0.000
          C2        #2                    -0.132      -0.171       0.000
          qu (csm)  #2                   165.023     194.254       0.000

        * qu (csm)                           189         194           0

 * Interpolated for computed Ia/p ratio (between Ia/p #1 & Ia/p #2)
   If computed Ia/p exceeds Ia/p limits, bounding limit for Ia/p is used.

                                                    2
   log(qu)  = C0 + ( C1 * log(Tc) ) + ( C2 * (log(Tc)) )
   qp (cfs) = qu(csm) * Area(sq.mi.) * Q(in.) * (Pond & Swamp Adj.)
```

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________ By MWM Date 5/19/99

Location DRAINAGE AREA - A1 Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

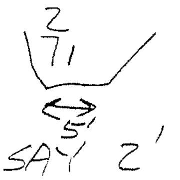
NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID	ALT 1		ALT 2		
1. Surface description (table 3-1)		WOODS		DRAINAGE DITCH-3		
2. Manning's roughness coeff., n (table 3-1) ..		0.40				
3. Flow length, L (total L ≤ 300 ft)	ft	200				
4. Two-yr 24-hr rainfall, P_2	in	4.5				
5. Land slope, s	ft/ft	0.001				
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	0.73	=	

Shallow concentrated flow	Segment ID					
7. Surface description (paved or unpaved)		UNPVD				
8. Flow length, L	ft	600				
9. Watercourse slope, s	ft/ft	0.001				
10. Average velocity, V (figure 3-1)	ft/s	1.0				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=	

Channel flow	Segment ID					
12. Cross sectional flow area, a	ft^2	18				
13. Wetted perimeter, p_w	ft	14				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	0.78				
15. Channel slope, s	ft/ft	0.0015				
16. Manning's roughness coeff., n		0.05				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s					
18. Flow length, L	ft	1850				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr					



SAY 2' DEPTH

MANNINGS EXCAVATED OPEN CHANNEL CLEAN BOTTOM, BRUSH ON SIDES

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________ By MWM Date 5/25/99

Location DRAINAGE AREA "A2" Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

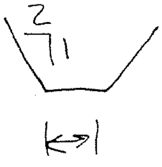
NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		A1	+A2	
1. Surface description (table 3-1)				
2. Manning's roughness coeff., n (table 3-1) ..				
3. Flow length, L (total L $\leq$ 300 ft)	ft			
4. Two-yr 24-hr rainfall, P_2	in			
5. Land slope, s	ft/ft			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2		18	
13. Wetted perimeter, p_w	ft		14	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft		0.0013	
16. Manning's roughness coeff., n			0.05	
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft		1250	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			



SAY 2' DEPTH

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ________________ By MWM Date 5/25/99

Location DRAINAGE AREA "A3" Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		A2	+ A3	
1. Surface description (table 3-1)				
2. Manning's roughness coeff., n (table 3-1) ..				
3. Flow length, L (total L $\leq$ 300 ft)	ft			
4. Two-yr 24-hr rainfall, P_2	in			
5. Land slope, s	ft/ft			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2		18	
13. Wetted perimeter, p_w	ft		14	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft		0.0030	
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft		1650	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

SAY 2' DEPTH

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______ By MWM Date 5/25/99

Location DRAINAGE AREA "A4" Checked ______ Date ______

Circle one: Present Developed

Circle one: T_c T_t through subarea

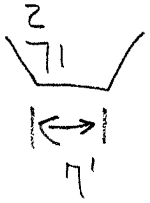
NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		A3 +	A4	
1. Surface description (table 3-1)				
2. Manning's roughness coeff., n (table 3-1) ..				
3. Flow length, L (total L $\leq$ 300 ft)	ft			
4. Two-yr 24-hr rainfall, P_2	in			
5. Land slope, s	ft/ft			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2		30	
13. Wetted perimeter, p_w	ft		18	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft		0,0032	
16. Manning's roughness coeff., n				
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft		2250	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=



SAY 2.5' DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______ By MWM Date 5/19/99

Location DRAINAGE AREA "B" Checked ______ Date ______

Circle one: Present Developed ______

Circle one: T_c T_t through subarea ______

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID					
1. Surface description (table 3-1)		WOODS			
2. Manning's roughness coeff., n (table 3-1) ..		0.40			
3. Flow length, L (total L $\leq$ 300 ft)	ft	200			
4. Two-yr 24-hr rainfall, P_2	in	4.5			
5. Land slope, s	ft/ft	0.002			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+		=
Shallow concentrated flow Segment ID					
7. Surface description (paved or unpaved)		UNPVD			
8. Flow length, L	ft	800			
9. Watercourse slope, s	ft/ft	0.002			
10. Average velocity, V (figure 3-1)	ft/s	1.0			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.22	+		=
Channel flow Segment ID					
12. Cross sectional flow area, a	ft^2				
13. Wetted perimeter, p_w	ft				
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft				
15. Channel slope, s	ft/ft				
16. Manning's roughness coeff., n					
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s				
18. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				

(210-VI-TR-55, Second Ed., June 1986)

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ____________ By MWM Date 5/21/99

Location DRAINAGE AREA "C" Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID					
1. Surface description (table 3-1)		WOODS				
2. Manning's roughness coeff., n (table 3-1) ..		0.40				
3. Flow length, L (total L $\le$ 300 ft)	ft	200				
4. Two-yr 24-hr rainfall, P_2	in	4.5				
5. Land slope, s	ft/ft	0.002				
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ Compute T_t	hr		+		=	

Shallow concentrated flow	Segment ID					
7. Surface description (paved or unpaved)		UNPVD				
8. Flow length, L	ft	1700				
9. Watercourse slope, s	ft/ft	0.002				
10. Average velocity, V (figure 3-1)	ft/s	1.0				
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.47	+		=	

Channel flow	Segment ID					
12. Cross sectional flow area, a	ft^2					
13. Wetted perimeter, p_w	ft					
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft					
15. Channel slope, s	ft/ft					
16. Manning's roughness coeff., n						
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s					
18. Flow length, L	ft					
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=	

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By MWM Date 5/20/99

Location DRAINAGE AREA - D Checked ______ Date ______

Circle one: [✓ Present] Developed 415 Ac

Circle one: [✓ T_c] T_t through subarea

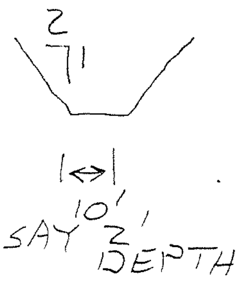
NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Segment ID		
1. Surface description (table 3-1)		WOODS	
2. Manning's roughness coeff., n (table 3-1) ..		0.40	
3. Flow length, L (total L $\leq$ 300 ft)	ft	200	
4. Two-yr 24-hr rainfall, P_2	in	4.5	
5. Land slope, s	ft/ft	0.0036	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t	hr		+ =

Shallow concentrated flow	Segment ID		
7. Surface description (paved or unpaved)			
8. Flow length, L	ft	3900	
9. Watercourse slope, s	ft/ft	0.0016	
10. Average velocity, V (figure 3-1)	ft/s	1.0	
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	1.08	+ =

Channel flow	Segment ID		
12. Cross sectional flow area, a	ft^2	28	
13. Wetted perimeter, p_w	ft	18.9	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.0009	
16. Manning's roughness coeff., n		0.05	
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	6000	
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+ =



20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______ By MWM Date 5/19/99

Location DRAINAGE AREA "E" Checked ______ Date ______

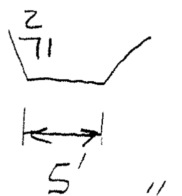
Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		ALT 1	ALT 2	
1. Surface description (table 3-1)		WOODS	WOODS	
2. Manning's roughness coeff., n (table 3-1) ..				
3. Flow length, L (total L $\leq$ 300 ft)	ft	100	200	
4. Two-yr 24-hr rainfall, P_2	in	4.5	4.5	
5. Land slope, s	ft/ft	0.01	0.01	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr		+	=
Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2	12	12	
13. Wetted perimeter, p_w	ft	11.7	11.7	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n		0.05		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	5,900	2,400	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			



SAY 18" DEPTH

FLOW RATES THROUGH EXISTING DOWNSTREAM CULVERTS

Rating Table Report
Location-1

Range Data:

	Minimum	Maximum	Increment
Allowable HW Elev	15.00	25.00	0.50 ft

HW Elev (ft)	Discharge (cfs)	(1) HW Elev	(1) Discharge	(1) Dn V	(2) HW Elev	(2) Discharge	(2) Dn V
15.00	6.52	15.00	6.52	4.87	-9,999.00	0.00	0.00
15.50	13.05	15.50	12.49	5.90	15.50	0.56	2.38
16.00	22.66	16.00	20.06	6.76	16.00	2.61	3.60
16.50	34.78	16.50	28.99	7.50	16.50	5.79	4.55
17.00	48.66	17.00	39.04	8.11	17.00	9.62	5.38
17.50	63.53	17.50	49.95	8.64	17.50	13.59	6.14
18.00	78.15	18.00	61.45	9.10	18.00	16.70	6.73
18.50	92.51	18.50	73.29	9.50	18.50	19.22	7.23
19.00	106.74	19.00	85.21	9.83	19.00	21.54	7.73
19.50	120.67	19.50	96.98	10.06	19.50	23.69	8.22
20.00	134.07	20.00	108.36	10.21	20.00	25.72	8.71
20.50	142.37	20.50	114.76	10.54	20.50	27.62	9.20
21.00	150.22	21.00	120.82	10.87	21.00	29.40	9.68
21.50	157.47	21.50	126.59	11.19	21.50	30.88	10.09
22.00	164.40	22.00	132.11	11.51	22.00	32.30	10.50
22.50	171.05	22.50	137.41	11.82	22.50	33.65	10.89
23.00	177.46	23.00	142.51	12.13	23.00	34.95	11.28
23.50	183.64	23.50	147.43	12.44	23.50	36.20	11.65
24.00	189.61	24.00	152.20	12.74	24.00	37.42	12.02
24.50	195.41	24.50	156.82	13.05	24.50	38.59	12.38
25.00	201.03	25.00	161.30	13.35	25.00	39.73	12.73

Culvert Designer/Analyzer Report
Location-1

Analysis Component			
Storm Event	Design	Discharge	45.00 cfs

Peak Discharge Method: User-Specified			
Design Discharge	45.00 cfs	Check Discharge	0.00 cfs

Tailwater Conditions: Constant Tailwater	
Tailwater Elevation	N/A ft

Name	Description	Discharge	HW Elev	Velocity
Culvert-1	1-48 inch Circular	36.40 cfs	16.87 ft	7.97 ft/s
Culvert-2	1-24 inch Circular	8.61 cfs	16.87 ft	5.17 ft/s
Weir	Not Considered	N/A	N/A	N/A
Total	----------------	45.01 cfs	16.87 ft	N/A

Culvert Designer/Analyzer Report
Location-1

Component:Culvert-1

Culvert Summary

Computed Headwater Elevation	16.87 ft	Discharge	36.40 cfs
Inlet Control HW Elev	16.45 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.78		

Grades

Upstream Invert	13.77 ft	Downstream Invert	13.04 ft
Length	35.00 ft	Constructed Slope	0.020857 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.57 ft
Slope Type	Steep	Normal Depth	1.57 ft
Flow Regime	Supercritical	Critical Depth	1.80 ft
Velocity Downstream	7.97 ft/s	Critical Slope	0.012693 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.69 ft
Ke	0.90	Entrance Loss	0.62 ft

Inlet Control Properties

Inlet Control HW Elev	16.45 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Culvert Designer/Analyzer Report
Location-1

Component:Culvert-2

Culvert Summary

Computed Headwater Elevation	16.87 ft	Discharge	8.61 cfs
Inlet Control HW Elev	16.72 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.90		

Grades

Upstream Invert	15.08 ft	Downstream Invert	14.97 ft
Length	26.00 ft	Constructed Slope	0.004231 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	1.05 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.05 ft
Velocity Downstream	5.17 ft/s	Critical Slope	0.016950 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.21 ft
Ke	0.90	Entrance Loss	0.19 ft

Inlet Control Properties

Inlet Control HW Elev	16.72 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	3.1 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Rating Table Report
Culvert-1

Range Data:

	Minimum	Maximum	Increment
Allowable HW Elev	15.00	25.00	0.50 ft

HW Elev (ft)	Discharge (cfs)	(I) HWi	(O) HWo	(D) Dn V	(D) Dn depth
15.00	6.52	14.74	15.00	4.87	0.65
15.50	12.49	15.18	15.50	5.90	0.90
16.00	20.06	15.62	16.00	6.76	1.14
16.50	28.99	16.09	16.50	7.50	1.39
17.00	39.04	16.57	17.00	8.11	1.63
17.50	49.95	17.08	17.50	8.64	1.87
18.00	61.45	17.59	18.00	9.10	2.12
18.50	73.29	18.12	18.50	9.50	2.36
19.00	85.21	18.66	19.00	9.83	2.61
19.50	96.98	19.24	19.50	10.06	2.87
20.00	108.36	20.00	19.99	10.21	3.15
20.50	114.76	20.50	20.19	10.54	3.23
21.00	120.82	21.00	20.42	10.87	3.31
21.50	126.59	21.50	20.68	11.19	3.37
22.00	132.11	22.00	20.98	11.51	3.43
22.50	137.41	22.50	21.37	11.82	3.49
23.00	142.51	23.00	21.77	12.13	3.53
23.50	147.43	23.50	22.15	12.44	3.58
24.00	152.20	24.00	22.53	12.74	3.61
24.50	156.82	24.50	22.90	13.05	3.65
25.00	161.30	25.00	23.27	13.35	3.68

Project Title: NC Clayhill
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LANGLEY & MCDONALD
37 Brookside Road Waterbury, CT 06708 (203) 755-1666

Project Engineer: LANGLEY & MCDONALD
CulvertMaster v1.0

Culvert Analysis Report
Culvert-1

Culvert Summary

Computed Headwater Elevation	16.87 ft	Discharge	36.40 cfs
Inlet Control HW Elev	16.45 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.78		

Grades

Upstream Invert	13.77 ft	Downstream Invert	13.04 ft
Length	35.00 ft	Constructed Slope	0.020857 ft/ft

Hydraulic Profile

Profile	S2	Depth, Downstream	1.57 ft
Slope Type	Steep	Normal Depth	1.57 ft
Flow Regime	Supercritical	Critical Depth	1.80 ft
Velocity Downstream	7.97 ft/s	Critical Slope	0.012693 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.69 ft
Ke	0.90	Entrance Loss	0.62 ft

Inlet Control Properties

Inlet Control HW Elev	16.45 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Project Title: NC Clayhill
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LANGLEY & MCDONALD

Project Engineer: LANGLEY & MCDONALD
CulvertMaster v1.0

Rating Table Report
Culvert-2

Range Data:

	Minimum	Maximum	Increment
Allowable HW Elev	15.00	25.00	0.50 ft

HW Elev (ft)	Discharge (cfs)	(I) HWi	(O) HWo	(D) Dn V	(D) Dn depth
15.00	0.00	-9,999.00	-9,999.00	0.00	0.00
15.50	0.56	15.42	15.50	2.38	0.26
16.00	2.61	15.87	16.00	3.60	0.56
16.50	5.79	16.35	16.50	4.55	0.85
17.00	9.62	16.85	17.00	5.38	1.11
17.50	13.59	17.35	17.50	6.14	1.33
18.00	16.70	17.77	18.00	6.73	1.47
18.50	19.22	18.23	18.50	7.23	1.58
19.00	21.54	18.75	19.00	7.73	1.66
19.50	23.69	19.30	19.50	8.22	1.73
20.00	25.72	19.86	20.00	8.71	1.78
20.50	27.62	20.43	20.50	9.20	1.82
21.00	29.40	21.00	21.00	9.68	1.85
21.50	30.88	21.50	21.43	10.09	1.88
22.00	32.30	22.00	21.86	10.50	1.89
22.50	33.65	22.50	22.28	10.89	1.91
23.00	34.95	23.00	22.71	11.28	1.92
23.50	36.20	23.50	23.14	11.65	1.93
24.00	37.42	24.00	23.56	12.02	1.94
24.50	38.59	24.50	23.98	12.38	1.94
25.00	39.73	25.00	24.41	12.73	1.95

Culvert Analysis Report
Culvert-2

Culvert Summary

Computed Headwater Elevation	16.87 ft	Discharge	8.61 cfs
Inlet Control HW Elev	16.72 ft	Tailwater Elevation	N/A ft
Outlet Control HW Elev	16.87 ft	Control Type	Outlet Control
Headwater Depth/ Height	0.90		

Grades

Upstream Invert	15.08 ft	Downstream Invert	14.97 ft
Length	26.00 ft	Constructed Slope	0.004231 ft/ft

Hydraulic Profile

Profile	M2	Depth, Downstream	1.05 ft
Slope Type	Mild	Normal Depth	N/A ft
Flow Regime	Subcritical	Critical Depth	1.05 ft
Velocity Downstream	5.17 ft/s	Critical Slope	0.016950 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.024
Section Material	CMP	Span	2.00 ft
Section Size	24 inch	Rise	2.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev	16.87 ft	Upstream Velocity Head	0.21 ft
Ke	0.90	Entrance Loss	0.19 ft

Inlet Control Properties

Inlet Control HW Elev	16.72 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	3.1 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Project Title: NC Clayhill
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LANGLEY & MCDONALD

© Haestad Methods, Inc. 37 Brookside Road Waterbury, CT 06708 (203) 755-1666

Project Engineer: LANGLEY & MCDONALD
CulvertMaster v1.0

FUTURE CONDITIONS OF THE FEEDER DITCHES

(Weir set within downstream
end of the ditches)

Storm Drain Design Computations

Langley and McDonald, P.C.

2 YEAR DESIGN STORM
PROPOSED LAND USE

STORM DRAIN DESIGN COMPUTATIONS

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

File Name: Future Cond - 2yr - Weir.xls

Job No. 1960024-203.00 Date: 05/07/97
Computed By: MWM Checked By:

DITCH	Drainage AREA AC. Ac.	Runoff COEF. (C)	C x A INCR.	C x A ACC.	Tc CONC. Min.	INTEN In/Hr	RUNOFF "Q" INCR. cfs	Weir LENGTH Ft	Weir Eq. Head over Weir Ft	Weir Set below Top of Bank Ft	Height Over Top of Bank Ft
1	12.10	0.35	4.24	4.24	13.45	4.47	18.94	10.0	0.74	0.5000	0.2
2	12.60	0.35	4.41	4.41	14.75	4.32	19.04	10.0	0.74	0.5000	0.2
3	12.40	0.35	4.34	4.34	31.79	2.97	12.91	12.0	0.50	0.5000	0.0
4	8.70	0.35	3.05	3.05	13.88	4.42	13.46	11.0	0.55	0.5000	0.0
5	9.50	0.35	3.33	3.33	14.78	4.31	14.35	14.0	0.49	0.5000	0.0
6	15.50	0.35	5.43	5.43	18.05	3.97	21.54	14.5	0.63	0.5000	0.1
7	8.60	0.35	3.01	3.01	19.70	3.82	11.49	14.0	0.42	0.5000	-0.1
8	11.64	0.35	4.07	4.07	14.75	4.32	17.59	16.0	0.51	0.5000	0.0
9	4.30	0.35	1.51	1.51	11.92	4.67	7.03	18.0	0.26	0.5000	-0.2
10	3.70	0.35	1.30	1.30	15.37	4.25	5.50	24.0	0.18	0.5000	-0.3

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

Ir = g/(h = Td)

Weir Equation Q=Cw L H ^(3/2)
Cw = 3.0

Sheet Flow

Channel Flow Channel flow is disregarded in the proposed condition.

DITCH	Mnings	Flow Length	2-Yr Rainfall	Slope	Time of Concentration	Shallow Conc. Flow	*Crss Sec Area*	*Wetted perimeter*	*Hydraulic Radius*	*Slope*	*Mannings*	*velocity*	*Flow Length*	*Travel Time*	Total Travel Time
1	0.06	175.00	4.50	0.0029	0.22		2.50	6.00	0.42	0.0009	0.022	1.13	1250	0.31	0.22
2	0.06	175.00	4.50	0.0023	0.25		3.10	5.80	0.53	0.0016	0.022	1.78	1300	0.20	0.25
3	0.06	165.00	4.50	0.0003	0.53		3.30	6.80	0.49	0.0018	0.022	1.77	1300	0.20	0.53
4	0.06	200.00	4.50	0.0035	0.23		5.00	7.00	0.71	0.0017	0.022	2.23	1300	0.16	0.23
5	0.06	210.00	4.50	0.0033	0.25		4.00	6.50	0.62	0.0028	0.022	2.59	1300	0.14	0.25
6	0.06	230.00	4.50	0.0024	0.30		3.50	6.40	0.55	0.0017	0.022	1.86	1250	0.19	0.30
7	0.06	240.00	4.50	0.0021	0.33		5.00	7.50	0.67	0.0037	0.022	3.14	1000	0.09	0.33
8	0.06	240.00	4.50	0.0100	0.18	0.07	4.20	5.70	0.74	0.0078	0.022	4.87	450	0.03	0.25
9	0.06	250.00	4.50	0.0080	0.20		6.00	8.40	0.71	0.0110	0.022	5.67	500	0.02	0.20
10	0.06	200.00	4.50	0.0037	0.23	0.03	25.10	22.80	1.10	0.0150	0.022	8.85	130	0.00	0.26
											0.022				

Storm Drain Design Computations

Langley and McDonald, P.C.

10 YEAR DESIGN STORM
PROPOSED LAND USE

STORM DRAIN DESIGN COMPUTATIONS

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

File Name Future Cond - 10yr - Weir.xls

Job No. 1960024-203.00 Date: 05/07/97
Computed By: MWM Checked By:

DITCH	Drainage AREA AC. Ac.	Runoff COEF. (C)	C x A INCR.	C x A ACC.	Tc CONC. Min.	INTEN In/Hr	RUNOFF "Q" INCR. cfs	Weir LENGTH Ft	Weir Eq. Head over Weir Ft	Weir Set below Top of Bank Ft	Height Over Top of Bank Ft
1	12.10	0.35	4.24	4.24	13.45	5.77	**24.44**	10.0	**0.87**	0.5000	0.4
2	12.60	0.35	4.41	4.41	14.75	5.60	**24.69**	10.0	**0.88**	0.5000	0.4
3	12.40	0.35	4.34	4.34	31.79	4.03	**17.49**	12.0	**0.62**	0.5000	0.1
4	8.70	0.35	3.05	3.05	13.88	5.71	**17.40**	11.0	**0.65**	0.5000	0.2
5	9.50	0.35	3.33	3.33	14.78	5.60	**18.61**	14.0	**0.58**	0.5000	0.1
6	15.50	0.35	5.43	5.43	18.05	5.21	**28.25**	14.5	**0.75**	0.5000	0.2
7	8.60	0.35	3.01	3.01	19.70	5.03	**15.14**	14.0	**0.51**	0.5000	0.0
8	11.64	0.35	4.07	4.07	14.75	5.60	**22.81**	16.0	**0.61**	0.5000	0.1
9	4.30	0.35	1.51	1.51	11.92	5.99	**9.01**	18.0	**0.30**	0.5000	-0.2
10	3.70	0.35	1.30	1.30	15.37	5.52	**7.15**	24.0	**0.21**	0.5000	-0.3

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

Ir = g/(h = Td)

Weir Equation $Q=C_w L H^{(3/2)}$

$C_w = 3.0$

Sheet Flow

Channel Flow Channel flow is disregarded in the proposed condition.

DITCH	Mnings	Flow Length	2-Yr Rainfall	Slope	Time of Concentration	**Shallow Conc. Flow**	Crss Sec Area	Wetted perimeter	Hydraulic Radius	Slope	Mannings	velocity	Flow Length	Travel Time	**Total Travel Time**
1	0.06	175.00	4.50	0.0029	**0.22**		2.50	6.00	0.42	0.0009	0.022	1.13	1250	0.31	0.22
2	0.06	175.00	4.50	0.0023	**0.25**		3.10	5.80	0.53	0.0016	0.022	1.78	1300	0.20	0.25
3	0.06	165.00	4.50	0.0003	**0.53**		3.30	6.80	0.49	0.0018	0.022	1.77	1300	0.20	0.53
4	0.06	200.00	4.50	0.0035	**0.23**		5.00	7.00	0.71	0.0017	0.022	2.23	1300	0.16	0.23
5	0.06	210.00	4.50	0.0033	**0.25**		4.00	6.50	0.62	0.0028	0.022	2.59	1300	0.14	0.25
6	0.06	230.00	4.50	0.0024	**0.30**		3.50	6.40	0.55	0.0017	0.022	1.86	1250	0.19	0.30
7	0.06	240.00	4.50	0.0021	**0.33**		5.00	7.50	0.67	0.0037	0.022	3.14	1000	0.09	0.33
8	0.06	240.00	4.50	0.0100	**0.18**	0.07	4.20	5.70	0.74	0.0078	0.022	4.87	450	0.03	0.25
9	0.06	250.00	4.50	0.0080	**0.20**		6.00	8.40	0.71	0.0110	0.022	5.67	500	0.02	0.20
10	0.06	200.00	4.50	0.0037	**0.23**	0.03	25.10	22.80	1.10	0.0150	0.022	8.85	130	0.00	0.26
											0.022				

FLOW RATE WITHIN EXISTING FEEDER DITCHES

(Located within proposed wetland area)

Storm Drain Design Computations

Langley and McDonald, P.C.

2 YEAR DESIGN STORM
EXISTING LAND USE

STORM DRAIN DESIGN COMPUTATIONS

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

File Name: Exist Cond - 2yr - Ditches.xls

Job No. 1960024-203.00
Date: 05/07/97
Computed By: MWM
Checked By:

DITCH	Drainage AREA AC. Ac.	Runoff COEF.(C)	C x A		Tc CONC. Min.	INTEN In/Hr	RUNOFF "Q"		INVERTS		LENGTH Ft	SLOPE Ft/Ft	DITCH CAPACITY cfs	VELOCITY fps	WATER SURFACE ELEV.	TOP OF BANK ELEV.
			INCR.	ACC.			INCR. cfs	ACC. cfs	UP	DOWN						
1	12.10	0.35	4.24	4.24	31.88	2.97	**12.58**	12.58	32.00	31.00	1090.00	0.0009	41.6	1.7	32.0	33.0
2	12.60	0.35	4.41	4.41	26.92	3.27	**14.40**	14.40	32.00	30.00	1270.00	0.0016	79.8	2.4	31.3	33.0
3	12.40	0.35	4.34	4.34	44.03	2.43	**10.55**	10.55	32.20	30.00	1250.00	0.0018	101.1	2.2	31.0	33.0
4	8.70	0.35	3.05	3.05	23.60	3.50	**10.65**	10.65	32.00	29.90	1260.00	0.0017	62.0	2.2	31.0	33.1
5	9.50	0.35	3.33	3.33	23.15	3.53	**11.75**	11.75	32.40	29.10	1180.00	0.0028	136.4	2.7	30.6	33.2
6	15.50	0.35	5.43	5.43	29.23	3.12	**16.93**	16.93	31.00	29.00	1200.00	0.0017	95.4	2.4	30.5	32.0
7	8.60	0.35	3.01	3.01	25.01	3.40	**10.22**	10.22	32.20	28.60	970.00	0.0037	167.3	2.8	29.7	32.0
8	11.64	0.35	4.07	4.07	16.29	4.15	**16.90**	16.90	26.30	22.00	550.00	0.0078	127.7	4.0	22.9	25.0
9	4.30	0.35	1.51	1.51	13.39	4.48	**6.74**	6.74	29.30	24.00	480.00	0.0110	230.6	2.2	24.2	26.0
10	3.70	0.35	1.30	1.30	15.62	4.22	**5.47**	5.47	27.00	25.00	130.00	0.0154	415.0	1.9	24.1	26.2

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

Ir = g/(h = Td)

	Sheet Flow					**Shallow**			**Channel Flow**						
DITCH	Mnings	Flow Length	2-Yr Rainfall	Slope	Time of Concentration	**Conc. Flow**	Crss Sec Area	Wetted perimeter	Hydraulic Radius	Slope	Mannings	velocity	Flow Length	Travel Time	**Total Travel Time**
1	0.06	175.00	4.50	0.0029	**0.22**		2.50	6.00	0.42	0.0009	0.022	1.13	1250	0.31	**0.53**
2	0.06	175.00	4.50	0.0023	**0.25**		3.10	5.80	0.53	0.0016	0.022	1.78	1300	0.20	**0.45**
3	0.06	165.00	4.50	0.0003	**0.53**		3.30	6.80	0.49	0.0018	0.022	1.77	1300	0.20	**0.73**
4	0.06	200.00	4.50	0.0035	**0.23**		5.00	7.00	0.71	0.0017	0.022	2.23	1300	0.16	**0.39**
5	0.06	210.00	4.50	0.0033	**0.25**		4.00	6.50	0.62	0.0028	0.022	2.59	1300	0.14	**0.39**
6	0.06	230.00	4.50	0.0024	**0.30**		3.50	6.40	0.55	0.0017	0.022	1.86	1250	0.19	**0.49**
7	0.06	240.00	4.50	0.0021	**0.33**		5.00	7.50	0.67	0.0037	0.022	3.14	1000	0.09	**0.42**
8	0.06	240.00	4.50	0.0100	**0.18**	**0.07**	4.20	5.70	0.74	0.0078	0.022	4.87	450	0.03	**0.27**
9	0.06	250.00	4.50	0.0080	**0.20**		6.00	8.40	0.71	0.0110	0.022	5.67	500	0.02	**0.22**
10	0.06	200.00	4.50	0.0037	**0.23**	**0.03**	25.10	22.80	1.10	0.0150	0.022	8.85	130	0.00	**0.26**
											0.022				

Storm Drain Design Computations

Langley and McDonald, P.C.

10 YEAR DESIGN STORM
EXISTING LAND USE

STORM DRAIN DESIGN COMPUTATIONS

Subject: N. C. CLAYHILL
Location CLAYHILL, North Carolina

File Name: Exist Cond - 10yr - Ditches.xls

Job No. 1960024-203.00 Date: 05/07/97
Computed By: MWM Checked By:

DITCH	Drainage AREA AC. Ac.	Runoff COEF. (C)	C x A INCR.	C x A ACC.	Tc CONC. Min.	INTEN In/Hr	RUNOFF "Q" INCR. cfs	RUNOFF "Q" ACC. cfs	INVERTS UP	INVERTS DOWN	LENGTH Ft	SLOPE Ft/Ft	DITCH CAPACITY cfs	VELOCITY fps	WATER SURFACE ELEV.	TOP OF BANK ELEV.
1	12.10	0.35	4.24	4.24	31.88	4.02	**17.04**	17.04	32.00	31.00	1090.00	0.0009	41.6	1.7	32.3	33.0
2	12.60	0.35	4.41	4.41	26.92	4.38	**19.32**	19.32	32.00	30.00	1270.00	0.0016	79.8	2.4	31.6	33.0
3	12.40	0.35	4.34	4.34	44.03	3.35	**14.56**	14.56	32.20	30.00	1250.00	0.0018	101.1	2.2	31.2	33.0
4	8.70	0.35	3.05	3.05	23.60	4.66	**14.18**	14.18	32.00	29.90	1260.00	0.0017	62.0	2.2	31.3	33.1
5	9.50	0.35	3.33	3.33	23.15	4.70	**15.62**	15.62	32.40	29.10	1180.00	0.0028	136.4	2.7	30.7	33.2
6	15.50	0.35	5.43	5.43	29.23	4.21	**22.83**	22.83	31.00	29.00	1200.00	0.0017	95.4	2.4	30.6	32.0
7	8.60	0.35	3.01	3.01	25.01	4.54	**13.65**	13.65	32.20	28.60	970.00	0.0037	167.3	2.8	29.8	32.0
8	11.64	0.35	4.07	4.07	16.29	5.41	**22.04**	22.04	26.30	22.00	550.00	0.0078	127.7	4.0	23.6	25.0
9	4.30	0.35	1.51	1.51	13.39	5.78	**8.70**	8.70	29.30	24.00	480.00	0.0110	230.6	2.2	24.3	26.0
10	3.70	0.35	1.30	1.30	15.62	5.49	**7.11**	7.11	27.00	25.00	130.00	0.0154	415.0	1.9	24.2	26.2

IDF EQUATION

R	g	h
2.00	163.00	23.00
5.00	211.00	27.00
10.00	245.00	29.00

Ir = g/(h = Td)

	Sheet Flow					**Shallow**	**Channel Flow**								
DITCH	Mnings	Flow Length	2-Yr Rainfall	Slope	Time of Concentration	**Conc. Flow**	Crss Sec Area	Wetted perimeter	Hydraulic Radius	Slope	Mannings	velocity	Flow Length	Travel Time	**Total Travel Time**
1	0.06	175.00	4.50	0.0029	**0.22**		2.50	6.00	0.42	0.0009	0.022	1.13	1250	0.31	**0.53**
2	0.06	175.00	4.50	0.0023	**0.25**		3.10	5.80	0.53	0.0016	0.022	1.78	1300	0.20	**0.45**
3	0.06	165.00	4.50	0.0003	**0.53**		3.30	6.80	0.49	0.0018	0.022	1.77	1300	0.20	**0.73**
4	0.06	200.00	4.50	0.0035	**0.23**		5.00	7.00	0.71	0.0017	0.022	2.23	1300	0.16	**0.39**
5	0.06	210.00	4.50	0.0033	**0.25**		4.00	6.50	0.62	0.0028	0.022	2.59	1300	0.14	**0.39**
6	0.06	230.00	4.50	0.0024	**0.30**		3.50	6.40	0.55	0.0017	0.022	1.86	1250	0.19	**0.49**
7	0.06	240.00	4.50	0.0021	**0.33**		5.00	7.50	0.67	0.0037	0.022	3.14	1000	0.09	**0.42**
8	0.06	240.00	4.50	0.0100	**0.18**	**0.07**	4.20	5.70	0.74	0.0078	0.022	4.87	450	0.03	**0.27**
9	0.06	250.00	4.50	0.0080	**0.20**		6.00	8.40	0.71	0.0110	0.022	5.67	500	0.02	**0.22**
10	0.06	200.00	4.50	0.0037	**0.23**	**0.03**	25.10	22.80	1.10	0.0150	0.022	8.85	130	0.00	**0.26**
											0.022				

Worksheet ditch -1
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 1
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope 0.000900 ft/ft

Water Surface Elevation 32.03 ft

Elevation range: 31.00 ft to 33.90 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-12.00	33.30	-12.00	30.00	0.022
0.00	33.90			
3.50	31.00			
9.00	31.00			
12.50	33.00			
30.00	33.00			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	12.58	cfs
Flow Area	7.27	ft²
Wetted Perimeter	9.20	ft
Top Width	8.56	ft
Height	1.03	ft
Critical Depth	31.52	ft
Critical Slope	0.009682	ft/ft
Velocity	1.73	ft/s
Velocity Head	0.05	ft
Specific Energy	32.08	ft
Froude Number	0.33	

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Ditch 1 Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 1
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.000900 ft/ft

Input Data	Minimum	Maximum	Increment
Water Surface Elevation	31.00	33.00	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
31.00	0.022	0.00	0.00
31.25	0.022	1.11	0.76
31.50	0.022	3.59	1.15
31.75	0.022	7.19	1.45
32.00	0.022	11.86	1.70
32.25	0.022	17.61	1.92
32.50	0.022	24.46	2.11
32.75	0.022	32.43	2.29
33.00	0.022	41.56	2.46

Worksheet DA 2
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 2
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope	0.001600	ft/ft
Water Surface Elevation	31.33	ft

Elevation range: 30.00 ft to 33.70 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-12.00	33.70	-12.00	38.00	0.022
0.00	33.70			
6.00	33.00			
11.00	30.00			
13.50	30.00			
18.00	33.00			
25.00	33.50			
38.00	33.60			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	14.40	cfs
Flow Area	6.10	ft²
Wetted Perimeter	7.47	ft
Top Width	6.70	ft
Height	1.33	ft
Critical Depth	30.84	ft
Critical Slope	0.009311	ft/ft
Velocity	2.36	ft/s
Velocity Head	0.09	ft

Specific Energy	31.41	ft
Froude Number	0.44	
Flow is subcritical.		

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 2
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001600 ft/ft

Input Data

	Minimum	Maximum	Increment
Water Surface Elevation	30.00	33.50	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
30.00	0.022	0.00	0.00
30.25	0.022	0.69	0.96
30.50	0.022	2.32	1.41
30.75	0.022	4.84	1.75
31.00	0.022	8.31	2.03
31.25	0.022	12.81	2.29
31.50	0.022	18.42	2.52
31.75	0.022	25.23	2.73
32.00	0.022	33.30	2.94
32.25	0.022	42.72	3.13
32.50	0.022	53.56	3.32
32.75	0.022	65.90	3.50
33.00	0.022	79.82	3.67

Table
Rating Table for Irregular Channel

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
33.25	0.022	82.41	3.24
33.50	0.022	94.27	3.08

Worksheet DA 3
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 3
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope	0.001800	ft/ft
Water Surface Elevation	31.00	ft

Elevation range: 30.00 ft to 33.10 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-19.50	33.00	-19.50	30.50	0.022
0.00	33.00			
7.00	30.00			
10.00	30.00			
14.00	33.00			
30.50	33.10			

Results

Wtd. Mannings Coefficient	0.022	
Discharge	10.55	cfs
Flow Area	4.81	ft²
Wetted Perimeter	7.19	ft
Top Width	6.66	ft
Height	1.00	ft
Critical Depth	30.63	ft
Critical Slope	0.009681	ft/ft
Velocity	2.19	ft/s
Velocity Head	0.07	ft
Specific Energy	31.07	ft
Froude Number	0.45	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 3
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001800 ft/ft

Input Data

	Minimum	Maximum	Increment
Water Surface Elevation	31.00	33.00	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
31.00	0.022	10.55	2.19
31.25	0.022	16.27	2.47
31.50	0.022	23.39	2.72
31.75	0.022	32.02	2.96
32.00	0.022	42.25	3.18
32.25	0.022	54.18	3.39
32.50	0.022	67.90	3.59
32.75	0.022	83.51	3.78
33.00	0.022	101.10	3.97

Worksheet DA 4
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope 0.001700 ft/ft

Water Surface Elevation 31.01 ft

Elevation range: 29.90 ft to 33.30 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-17.00	33.10	-17.00	33.00	0.022
0.00	33.10			
5.50	29.90			
8.00	29.90			
13.00	33.10			
19.50	33.30			
33.00	33.30			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	10.65	cfs
Flow Area	4.81	ft²
Wetted Perimeter	6.77	ft
Top Width	6.15	ft
Height	1.11	ft
Critical Depth	30.60	ft
Critical Slope	0.009658	ft/ft
Velocity	2.22	ft/s
Velocity Head	0.08	ft
Specific Energy	31.09	ft

Froude Number	0.44

Flow is subcritical.

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 4
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001700 ft/ft

Input Data

	Minimum	Maximum	Increment
Water Surface Elevation	29.90	33.10	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
29.90	0.022	0.00	0.00
30.15	0.022	0.72	0.98
30.40	0.022	2.41	1.45
30.65	0.022	5.04	1.80
30.90	0.022	8.68	2.10
31.15	0.022	13.41	2.36
31.40	0.022	19.32	2.60
31.65	0.022	26.50	2.82
31.90	0.022	35.04	3.03
32.15	0.022	45.01	3.23
32.40	0.022	56.50	3.42
32.65	0.022	69.59	3.61
32.90	0.022	84.36	3.79

Table
Rating Table for Irregular Channel

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
33.15	0.022	62.52	2.37

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Worksheet DA 5
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 5
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.002800	ft/ft
Water Surface Elevation	30.57	ft

Elevation range: 29.10 ft to 33.20 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-18.00	33.20	-18.00	32.00	0.022
0.00	33.10			
10.00	29.10			
16.00	33.00			
32.00	33.20			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	11.75	cfs
Flow Area	4.36	ft²
Wetted Perimeter	6.65	ft
Top Width	5.93	ft
Height	1.47	ft
Critical Depth	30.26	ft
Critical Slope	0.009848	ft/ft
Velocity	2.70	ft/s
Velocity Head	0.11	ft
Specific Energy	30.68	ft
Froude Number	0.55	

Flow is subcritical.

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 5
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.002800 ft/ft

Input Data

	Minimum	Maximum	Increment
Water Surface Elevation	29.10	33.20	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
29.10	0.022	0.00	0.00
29.35	0.022	0.10	0.83
29.60	0.022	0.66	1.31
29.85	0.022	1.96	1.72
30.10	0.022	4.21	2.09
30.35	0.022	7.64	2.42
30.60	0.022	12.42	2.73
30.85	0.022	18.74	3.03
31.10	0.022	26.75	3.31
31.35	0.022	36.62	3.58
31.60	0.022	48.50	3.84
31.85	0.022	62.53	4.10
32.10	0.022	78.86	4.34

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Table

Rating Table for Irregular Channel

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
32.35	0.022	97.63	4.58
32.60	0.022	118.96	4.81
32.85	0.022	142.99	5.04
33.10	0.022	136.43	4.17

Worksheet DA 6
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 6
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope	0.001700	ft/ft
Water Surface Elevation	30.49	ft

Elevation range: 29.00 ft to 32.00 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-21.00	32.00	-21.00	29.00	0.022
0.00	32.00			
8.00	29.00			
9.00	29.00			
16.50	32.00			
29.00	32.00			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	16.93	cfs
Flow Area	7.18	ft²
Wetted Perimeter	9.23	ft
Top Width	8.67	ft
Height	1.49	ft
Critical Depth	30.04	ft
Critical Slope	0.009037	ft/ft
Velocity	2.36	ft/s
Velocity Head	0.09	ft
Specific Energy	30.57	ft
Froude Number	0.46	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 6
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.001700 ft/ft

Input Data	Minimum	Maximum	Increment
Water Surface Elevation	29.00	32.00	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
29.00	0.022	0.00	0.00
29.25	0.022	0.36	0.86
29.50	0.022	1.44	1.26
29.75	0.022	3.48	1.58
30.00	0.022	6.68	1.86
30.25	0.022	11.24	2.13
30.50	0.022	17.33	2.37
30.75	0.022	25.14	2.60
31.00	0.022	34.82	2.82
31.25	0.022	46.53	3.04
31.50	0.022	60.43	3.24
31.75	0.022	76.65	3.44
32.00	0.022	95.35	3.63

Worksheet DA 7
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 7
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope 0.003700 ft/ft

Water Surface Elevation 29.67 ft

Elevation range: 28.60 ft to 33.10 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-13.00	32.50	-13.00	37.00	0.022
0.00	32.60			
3.00	32.10			
10.00	28.60			
11.00	29.00			
13.00	29.00			
19.00	33.10			
37.00	32.70			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	10.22	cfs
Flow Area	3.69	ft²
Wetted Perimeter	6.66	ft
Top Width	6.12	ft
Height	1.07	ft
Critical Depth	29.49	ft
Critical Slope	0.010001	ft/ft
Velocity	2.77	ft/s
Velocity Head	0.12	ft

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Specific Energy	29.79	ft
Froude Number	0.63	

Flow is subcritical.

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 7
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.003700 ft/ft

Input Data

	Minimum	Maximum	Increment
Water Surface Elevation	28.60	32.60	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
28.60	0.022	0.00	0.00
28.85	0.022	0.14	0.97
29.10	0.022	0.97	1.28
29.35	0.022	3.91	2.06
29.60	0.022	8.58	2.63
29.85	0.022	15.02	3.10
30.10	0.022	23.33	3.52
30.35	0.022	33.64	3.89
30.60	0.022	46.06	4.24
30.85	0.022	60.73	4.56
31.10	0.022	77.77	4.87
31.35	0.022	97.30	5.16
31.60	0.022	119.44	5.44

Table
Rating Table for Irregular Channel

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
31.85	0.022	144.32	5.71
32.10	0.022	172.06	5.98
32.35	0.022	196.87	6.03
32.60	0.022	167.33	4.45

Worksheet DA 8
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 8
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope	0.007800	ft/ft
Water Surface Elevation	22.93	ft

Elevation range: 22.00 ft to 26.10 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-14.50	25.70	-14.50	36.00	0.022
0.00	25.10			
9.00	23.70			
11.00	22.00			
12.50	22.00			
13.50	23.60			
21.00	25.00			
36.00	26.10			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	8.64	cfs
Flow Area	2.18	ft²
Wetted Perimeter	4.04	ft
Top Width	3.18	ft
Height	0.93	ft
Critical Depth	22.85	ft
Critical Slope	0.011154	ft/ft
Velocity	3.96	ft/s
Velocity Head	0.24	ft

Specific Energy	23.18	ft
Froude Number	0.84	

Flow is subcritical.

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 8
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.007800 ft/ft

Input Data	Minimum	Maximum	Increment
Water Surface Elevation	22.00	25.70	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
22.00	0.022	0.00	0.00
22.25	0.022	0.87	2.02
22.50	0.022	2.84	2.91
22.75	0.022	5.80	3.56
23.00	0.022	9.83	4.09
23.25	0.022	14.98	4.56
23.50	0.022	21.35	4.99
23.75	0.022	27.06	4.97
24.00	0.022	34.32	4.75
24.25	0.022	47.52	4.88
24.50	0.022	66.98	5.16
24.75	0.022	93.44	5.51
25.00	0.022	127.71	5.89

Table
Rating Table for Irregular Channel

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
25.25	0.022	156.43	5.67
25.50	0.022	200.70	5.61
25.75	0.022	271.36	5.86

Worksheet
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 9
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data

Channel Slope	0.011000	ft/ft
Water Surface Elevation	24.19	ft

Elevation range: 24.00 ft to 27.10 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-17.00	27.10	-17.00	33.00	0.022
0.00	26.00			
8.00	24.00			
15.00	24.00			
20.50	26.10			
33.00	26.70			

Results

Wtd. Mannings Coefficient	0.022	
Discharge	3.11	cfs
Flow Area	1.42	ft²
Wetted Perimeter	8.29	ft
Top Width	8.24	ft
Height	0.19	ft
Critical Depth	24.18	ft
Critical Slope	0.012974	ft/ft
Velocity	2.19	ft/s
Velocity Head	0.07	ft
Specific Energy	24.26	ft
Froude Number	0.93	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\sample\project1.fm2
Worksheet	Ditch 9
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.011000 ft/ft

Input Data

	Minimum	Maximum	Increment
Water Surface Elevation	24.00	26.70	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
24.00	0.022	0.00	0.00
24.25	0.022	5.11	2.61
24.50	0.022	17.02	3.93
24.75	0.022	35.16	4.94
25.00	0.022	59.76	5.80
25.25	0.022	91.18	6.55
25.50	0.022	129.83	7.23
25.75	0.022	176.14	7.87
26.00	0.022	230.56	8.46
26.25	0.022	260.88	7.89
26.50	0.022	310.71	7.56
26.75	0.022	395.02	7.70

Worksheet DA 10
Worksheet for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 10
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Channel Slope	0.015400	ft/ft
Water Surface Elevation	24.11	ft

Elevation range: 24.00 ft to 26.50 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
-15.00	26.50	-15.00	35.00	0.022
0.00	26.10			
7.50	24.00			
18.50	24.00			
27.00	26.00			
35.00	26.30			

Results		
Wtd. Mannings Coefficient	0.022	
Discharge	2.43	cfs
Flow Area	1.28	ft²
Wetted Perimeter	11.90	ft
Top Width	11.88	ft
Height	0.11	ft
Critical Depth	24.11	ft
Critical Slope	0.014808	ft/ft
Velocity	1.90	ft/s
Velocity Head	0.06	ft
Specific Energy	24.17	ft
Froude Number	1.02	

Table
Rating Table for Irregular Channel

Project Description	
Project File	c:\l&m\projects\nc clayhill\exist co.fm2
Worksheet	Ditch 10
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Discharge

Constant Data	
Channel Slope	0.015400 ft/ft

Input Data			
	Minimum	Maximum	Increment
Water Surface Elevation	24.00	26.30	0.25 ft

Rating Table

Water Surface Elevation (ft)	Wtd. Mannings Coefficient	Discharge (cfs)	Velocity (ft/s)
24.00	0.022	0.00	0.00
24.25	0.022	9.42	3.15
24.50	0.022	30.97	4.78
24.75	0.022	63.18	6.05
25.00	0.022	106.05	7.11
25.25	0.022	159.91	8.05
25.50	0.022	225.22	8.90
25.75	0.022	302.51	9.69
26.00	0.022	392.31	10.42
26.25	0.022	418.82	9.18

Langley and McDonald, P.C.

ENGINEERS • SURVEYORS • PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS

VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject CLAYHILL

Computed By DBS Checked by ______

Project No. ______

Client ______

Date 3/16/99 Sheet No. 1

Length bet. X-S 32 + 36 = 4950'

X-S 32 inv = 17.0
X-S 36 inv = 29.0

$$\text{Slope} = \frac{29-17}{4950} = 0.002$$

DITCH 1: DA = 12.1 AC

$$\text{SLOPE OF DITCH} = \frac{32.0-31.0}{1090} = 0.0009$$

DITCH 2: DA = 12.6 AC

$$\text{SLOPE OF DITCH} = \frac{32.0-30.0}{1270} = 0.0016$$

DITCH 3: DA = 12.4 AC

$$\text{SLOPE OF DITCH} = \frac{32.2-30.0}{1250} = 0.0018$$

DITCH 4: DA = 8.7 AC

$$\text{SLOPE OF DITCH} = \frac{32.0-29.9}{1260} = 0.0017$$

DITCH 5: DA = 9.5 AC

$$\text{SLOPE OF DITCH} = \frac{32.4-29.1}{1180} = 0.0028$$

DITCH 6: DA = 15.5 AC

$$\text{SLOPE OF DITCH} = \frac{31.0-29.0}{1200} = 0.0017$$

Langley and McDonald, P.C.

ENGINEERS • SURVEYORS • PLANNERS
LANDSCAPE ARCHITECTS • ENVIRONMENTAL CONSULTANTS

VIRGINIA BEACH • WILLIAMSBURG, VIRGINIA

Subject CLAYHILL

Computed By DBS Checked by

Project No.
Client
Date 3/16/99 Sheet No. 2

DITCH 7: DA = 8.6 AC

SLOPE OF DITCH = $\frac{32.2 - 28.6}{970} = 0.0037$

DITCH 8: DA = 11.6 AC

SLOPE OF DITCH = $\frac{26.3 - 22.0}{550} = 0.0078$

DITCH 9: DA = 4.3 AC

SLOPE OF DITCH = $\frac{29.3 - 24.0}{480} = 0.011$

DITCH 10: DA = 3.7 AC

SLOPE OF DITCH = $\frac{27 - 25}{130} = 0.015$

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By MWM Date 5/19/99

Location INTERIOR DITCH #1 Checked _____ Date _____

Circle one: [✓ Present] Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

INV. UP = 33.5
T.B. 33.0

Sheet flow (Applicable to T_c only)

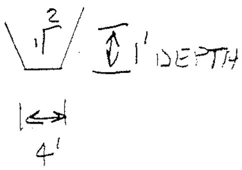
Segment ID				
1. Surface description (table 3-1)		FALLOW ≤20%		
2. Manning's roughness coeff., n (table 3-1) ..		0.06		
3. Flow length, L (total L ≤ 300 ft)	ft	175		
4. Two-yr 24-hr rainfall, P_2	in	4.5		
5. Land slope, s	ft/ft	0.0029		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow

Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow

Segment ID				
12. Cross sectional flow area, a	ft^2	2.5		
13. Wetted perimeter, p_w	ft	6		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft	0.0009		
16. Manning's roughness coeff., n		0.022		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	1250		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=



SAY HALF FULL 0.5' DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________ By MWM Date 5/19/99

Location INTERIOR DITCH #2 Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

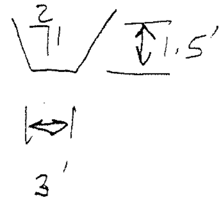
Include a map, schematic, or description of flow segments.

INV UP
33.4
TOP OF
BANK
33.0

Sheet flow (Applicable to T_c only) Segment ID				
1. Surface description (table 3-1)		FALLOW ≤20%		
2. Manning's roughness coeff., n (table 3-1)		0.06		
3. Flow length, L (total L ≤ 300 ft)	ft	175		
4. Two-yr 24-hr rainfall, P_2	in	4.5		
5. Land slope, s	ft/ft	0.0023		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2	3.1		
13. Wetted perimeter, p_w	ft	5.8		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft	0.0016		
16. Manning's roughness coeff., n		0.022		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	1300		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			



SAY
0.7' DEPTH

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ________________ By MWM Date 5/19/99

Location INTERIOR DITCH #3 Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)

Segment ID			
1. Surface description (table 3-1)		FALLOW ≤20%	
2. Manning's roughness coeff., n (table 3-1) ..		0,06	
3. Flow length, L (total L $\leq$ 300 ft)	ft	165'	
4. Two-yr 24-hr rainfall, P_2	in	4,5	
5. Land slope, s	ft/ft	0,003	

6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t ...... hr ______ + ______ = ______

INV UP 33,5

TOP OF BANK 33,0

Shallow concentrated flow

Segment ID			
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		

11. $T_t = \frac{L}{3600\ V}$ Compute T_t ...... hr ______ + ______ = ______

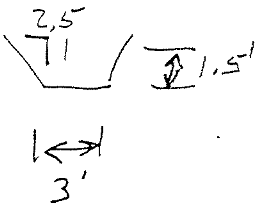
Channel flow

Segment ID			
12. Cross sectional flow area, a	ft^2	3,3	
13. Wetted perimeter, p_w	ft	6,8	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0,0018	
16. Manning's roughness coeff., n		0,022	
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	1300	

19. $T_t = \frac{L}{3600\ V}$ Compute T_t ...... hr ______ + ______ = ______

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

SAY 0,7' DEPTH



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________ By MWM Date 5/19/99

Location INTERIOR DITCH #4 Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

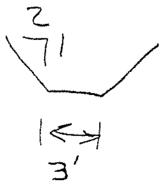
INV 33.7

INV 33.0

Sheet flow (Applicable to T_c only) Segment ID				
1. Surface description (table 3-1)		FALLOW ≤20%		
2. Manning's roughness coeff., n (table 3-1) ..		0.06		
3. Flow length, L (total L $\leq$ 300 ft)	ft	200		
4. Two-yr 24-hr rainfall, P_2	in	4.5		
5. Land slope, s	ft/ft	0.0035		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2	5		
13. Wetted perimeter, p_w	ft	7		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	0.71		
15. Channel slope, s	ft/ft	0.0017		
16. Manning's roughness coeff., n		0.022		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	1300		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			



SAY 1.0' DEPTH

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By MWM Date 5/19/99

Location INTERIOR DITCH #5 Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

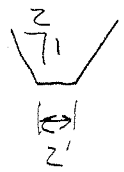
INV 33.7

TB 33.0

Sheet flow (Applicable to T_c only)				
Segment ID				
1. Surface description (table 3-1)		FALLOW ≤20%		
2. Manning's roughness coeff., n (table 3-1) ..		0.06		
3. Flow length, L (total L ≤ 300 ft)	ft	210		
4. Two-yr 24-hr rainfall, P_2	in	4.5		
5. Land slope, s	ft/ft	0.0033		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr		+	=

Shallow concentrated flow				
Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

Channel flow				
Segment ID				
12. Cross sectional flow area, a	ft^2	4		
13. Wetted perimeter, p_w	ft	6.5		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft	0.0028		
16. Manning's roughness coeff., n		0.022		
17. $V = \frac{1.49\, r^{2/3}\, s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	1300		
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=



SAY 1' DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By MWM Date 5/19/99

Location INTERIOR DITCH #6 Checked _____ Date _____

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

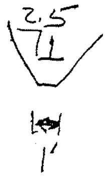
INV 33.5

TB 33.0

Sheet flow (Applicable to T_c only) Segment ID			
1. Surface description (table 3-1)		FALLOW ≤20%	
2. Manning's roughness coeff., n (table 3-1) ..		0.06	
3. Flow length, L (total L $\leq$ 300 ft)	ft	230	
4. Two-yr 24-hr rainfall, P_2	in	4.5	
5. Land slope, s	ft/ft	0.0024	
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ Compute T_t	hr	+	=

Shallow concentrated flow Segment ID			
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	+	=

Channel flow Segment ID			
12. Cross sectional flow area, a	ft^2	3.5	
13. Wetted perimeter, p_w	ft	6.4	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.0017	
16. Manning's roughness coeff., n		0.022	
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	1250	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	+	=



SAY 1' DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________ By MWM Date 5/19/99

Location INTERIOR DITCH #7 Checked ______ Date ______

Circle one: [✓ Present] Developed

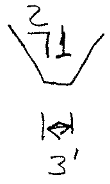
Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

INV 33.5
TOP OF BANK 33.0

Sheet flow (Applicable to T_c only) Segment ID				
1. Surface description (table 3-1)		FALLOW ≤20%		
2. Manning's roughness coeff., n (table 3-1) ..		0.06		
3. Flow length, L (total L ≤ 300 ft)	ft	240		
4. Two-yr 24-hr rainfall, P_2	in	4.5		
5. Land slope, s	ft/ft	0.0021		
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\, s^{0.4}}$ Compute T_t	hr		+	=
Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2	5		
13. Wetted perimeter, p_w	ft	7.5		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft	0.0037		
16. Manning's roughness coeff., n		0.022		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	1000		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			



SAY 1' DEPTH.

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By MWM Date 5/19/99

Location INTERIOR DITCH #8 Checked _____ Date _____

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

<u>Sheet flow</u> (Applicable to T_c only) Segment ID					ELEV. 34.0
1. Surface description (table 3-1)		WOODS			ELEV. 31.7
2. Manning's roughness coeff., n (table 3-1)		0.40			
3. Flow length, L (total L ≤ 300 ft)	ft	240			
4. Two-yr 24-hr rainfall, P_2	in	4.5			
5. Land slope, s	ft/ft	0.01			
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{\,0.5}\, s^{0.4}}$ Compute T_t	hr		+	=	

<u>Shallow concentrated flow</u> Segment ID					ELEV 31.7
7. Surface description (paved or unpaved)		UNPVD			TB 28.0
8. Flow length, L	ft	380			
9. Watercourse slope, s	ft/ft	0.01			
10. Average velocity, V (figure 3-1)	ft/s	1.6			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.07	+	=	

<u>Channel flow</u> Segment ID				
12. Cross sectional flow area, a	ft^2	4.2		
13. Wetted perimeter, p_w	ft	5.7		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft			
15. Channel slope, s	ft/ft	0.0078		
16. Manning's roughness coeff., n		0.022		
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft	450		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

SAY 1.5' DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______ By MWM Date 5/19/99

Location INTERIOR DITCH #9 Checked ______ Date ______

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

ELEV 34.0

TB 32

Sheet flow (Applicable to T_c only)

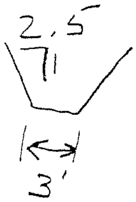
Segment ID			
1. Surface description (table 3-1)		WOODS	
2. Manning's roughness coeff., n (table 3-1) ..		0.40	
3. Flow length, L (total L $\leq$ 300 ft)	ft	250	
4. Two-yr 24-hr rainfall, P_2	in	4.5	
5. Land slope, s	ft/ft	0.008	
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ Compute T_t	hr		+ =

Shallow concentrated flow

Segment ID			
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+ =

Channel flow

Segment ID			
12. Cross sectional flow area, a	ft^2	6.0	
13. Wetted perimeter, p_w	ft	8.4	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.011	
16. Manning's roughness coeff., n		0.022	
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	500	
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+ =



SAY 1.0 DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr ______

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ____________________ By MWM Date 5/19/99

Location INTERIOR DITCH #10 Checked _____ Date _____

Circle one: [✓ Present] Developed

Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

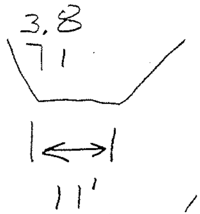
Sheet flow (Applicable to T_c only)			
Segment ID			
1. Surface description (table 3-1)		WOODS	
2. Manning's roughness coeff., n (table 3-1) ..		0.40	
3. Flow length, L (total L ≤ 300 ft)	ft	200	
4. Two-yr 24-hr rainfall, P_2	in	4.5	
5. Land slope, s	ft/ft	0.0037	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	+	=

ELEV. 32.2

TB 28.0

Shallow concentrated flow			
Segment ID			
7. Surface description (paved or unpaved)			
8. Flow length, L	ft	230	
9. Watercourse slope, s	ft/ft	0.018	
10. Average velocity, V (figure 3-1)	ft/s	2.2	
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	+	=

Channel flow			
Segment ID			
12. Cross sectional flow area, a	ft^2	25.1	
13. Wetted perimeter, p_w	ft	22.8	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft		
15. Channel slope, s	ft/ft	0.015	
16. Manning's roughness coeff., n		0.022	
17. $V = \frac{1.49\,r^{2/3}\,s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft	130	
19. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	+	=



SAY 1.5' DEPTH

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr

APPENDIX G

SPECIES LISTS

Vegetation Identified at Clayhill Farms

Acer rubrum	red maple
Aronia arbutifolia	red chokeberry
Arundinaria gigantea	giant cane
Clethra alnifolia	sweet pepperbush
Cornus alternifolia	alternate leaved dogwood
Cyrilla racemiflora.	titi
Diospyros virginiana	persimmon
Drosera capillaris	pink sundew
Euonymus americanus	strawberry bush
Gaylussacia frondosa	dwarf huckleberry
Gelsemium sempervirens	yellow jessamine
Gordonia lasianthus	loblolly bay
Ilex coriacea	gallberry
Ilex glabra	inkberry
Leucothoe axillaris	dog hobble
Liquidambar styraciflua	sweetgum
Liriodendron tulipifera	yellow-poplar
Lyonia lucida	fetterbush
Magnolia virginiana	sweet bay
Myrica cerifera	wax myrtle
Nyssa sylvatica var. *biflora*	swamp blackgum
Osmunda cinnamomea	cinnamon fern
Osmunda regalis	royal fern
Persea borbonia	red bay
Pinus serotina	pond pine
Pinus taeda	loblolly pine
Polygala lutea	orange milkwort
Polystichum acrosticoides	Christmas fern
Pteridium aquilinum	bracken fern
Quercus nigra	water oak
Quercus marilandica	blackjack oak
Quercus phellos	willow oak
Quercus stellata	post oak
Rhododendron atlanticum	dwarf azalea
Sambucus canadensis	elderberry
Sassafras albidum	sassafras
Smilax bona-nox	saw greenbrier
Smilax laurifolia	laurel-leaf greenbrier
Smilax rotundifolia	common greenbrier
Symplocos tinctoria	sweet leaf
Toxicodendron radicans	poison ivy
Utricularia sp.	bladderwort
Vaccinium corymbosum	highbush blueberry
Viola sp.	violet
Vitis aestivalis	fox grape
Woodwardia areolata	netted chain fern
Woodwardia virginica	Virginia chain fern

Wildlife Observed at Clayhill Farms

(from visual observation or indication of animals)

Agelaius phoeniceus	red-winged blackbird
Anolis carolinensis	green anole
Buteo jamaicensis	red-tail hawk
Canis domesticus	feral dog
Cardinalis cardinalis	cardinal
Cathartes aura	turkey vulture
Chelydra serpentina	common snapping turtle
Chrysemys picta	eastern painted turtle
Clemmys guttata	spotted turtle
Cnemidophorus sexlineatus	six-lined racerunner
Colinus virginianus	bobwhite quail
Coluber constrictor	northern black racer
Didelphis virginiana	Virginia opossum
Elaphe guttata	corn snake
Elaphe obsoleta	black rat snake
Eumeces fasciatus	five-lined skink
Eumeces laticeps	broadhead skink
Felis familiaris	feral cat
Lampropeltis getula	eastern kingsnake
Melanerpes carolinus	red-bellied woodpecker
Meleagris gallopavo	turkey
Odocoileus virginianus	white-tailed deer
Opheodrys aestivus	rough green snake
Picoides pubescens	downy woodpecker
Procyon lotor	raccoon
Sceloporus undulatus	northern fence lizard
Sciurus carolinensis	gray squirrel
Sialia sialis	eastern blue bird
Sternotherus odoratus	common musk turtle
Sylvilagus floridanus	eastern cottontail rabbit
Thamnophis sirtalis	eastern garter snake
Urocyon cinereoargenteus	gray fox
Ursus americanus	black bear
Vulpes vulpes	red fox
Zenaida macroura	mourning dove

APPENDIX H

RED-COCKADED WOODPECKER ASSESSMENT – PREPARED BY DR. J. H. CARTER III & ASSOCIATES INC.

RED-COCKADED WOODPECKER ASSESSMENT
FOR
CLAYHILL FARMS MITIGATION SITE
NCDOT T.I.P. NO. R-2105WM
JONES COUNTY, NORTH CAROLINA

Prepared by:
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P.O. Box 891
Southern Pines, N.C. 28388

Submitted 14 August 2000
to:
N.C. Department of Transportation
Project Development and Environmental Analysis Branch
P.O. Box 25201
Raleigh, NC 27611

RED-COCKADED WOODPECKER ASSESSMENT
FOR
CLAYHILL FARMS MITIGATION SITE
JONES COUNTY, NORTH CAROLINA
NCDOT T.I.P. NO. R-2105WM

INTRODUCTION

The North Carolina Department of Transportation (NCDOT) purchased Clayhill Farms, a 355.6 acre (ac.) property in Jones County, North Carolina, as a wetlands mitigation site for future NCDOT construction projects (Figure 1). A wetland and stream mitigation plan was written for the property, which includes plans to restore drained farm and timberland to its probable natural condition via rerouting an existing stream, filling in ditches and planting natural hydrophytic vegetation in former croplands (Langley and McDonald, P.C. 1999). This Assessment reports findings of a red-cockaded woodpecker (*Picoides borealis*) (RCW) survey on the Clayhill Farms property and the surrounding 0.5 mile radius, and addresses the possibility of using the property for RCW mitigation in the future.

PROJECT AREA

The project area is located in southwestern Jones County, in the east-central Coastal Plain of North Carolina. The topography is nearly level except for gentle to moderate slopes along drainages. Sandy loams and loamy sands are the predominant soil types in the project area.

Historically, the principal upland community type was Mesic Pine Flatwoods, which was dominated by longleaf pine (*Pinus palustris*). This community occurred on coarse to fine sands, sandy loams and loamy sands and was characterized by frequent fires, a sparse to open understory and a diverse herbaceous flora dominated by Carolina wiregrass (*Aristida stricta*). Mesic Mixed Hardwood Forest (Coastal Plain Subtype) occurred in upland areas that were protected from fire by topography and moisture. Soils were sandy loams and loamy sands and vegetation consisted of varying mixtures of mesophytic trees, shrubs and herbs.

Historical wetland communities in the immediate project area included Coastal Plain Small Stream Swamp (Blackwater Subtype), Cypress/Gum Swamp, Pond Pine Woodland, Wet

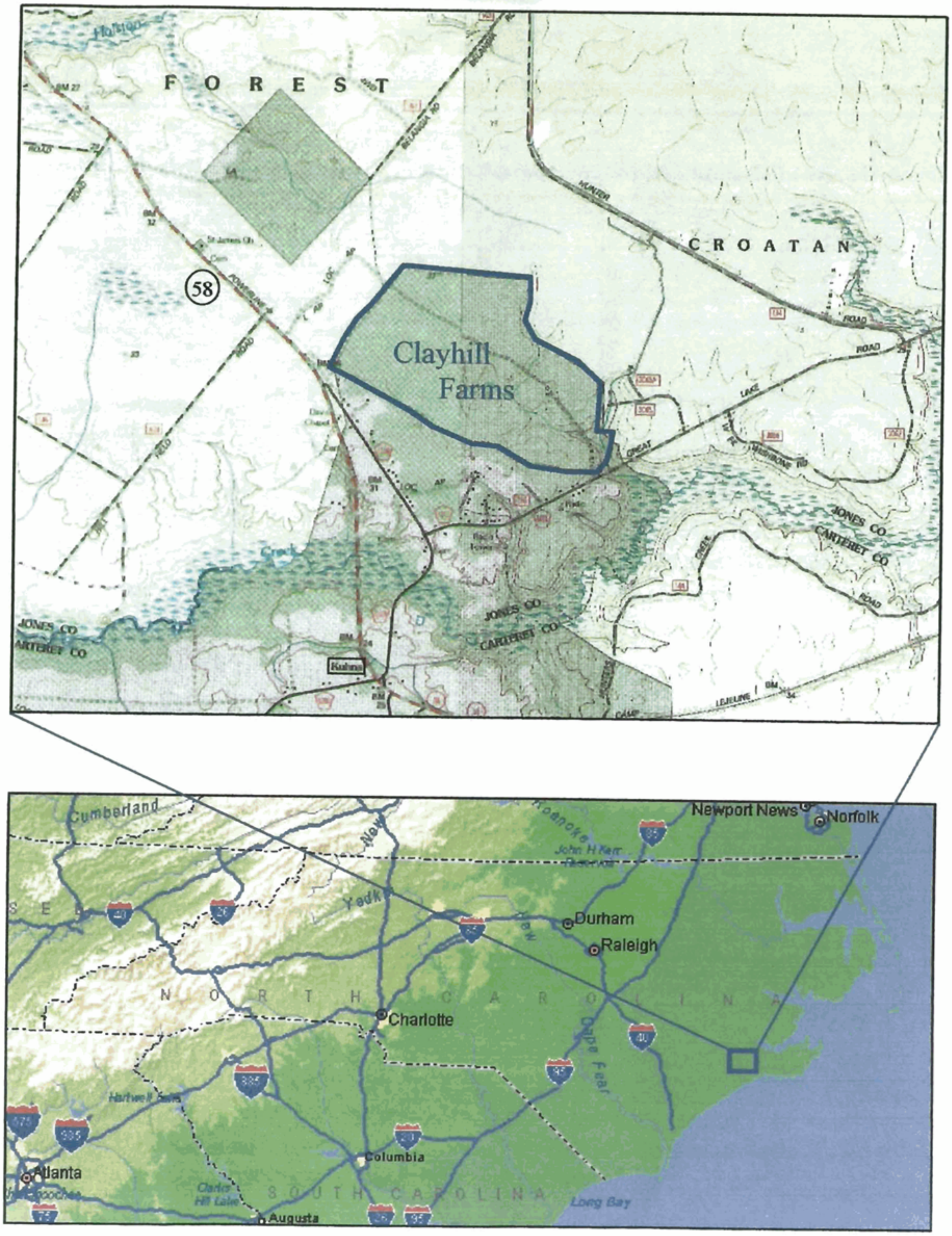

Figure 1. Clayhill Farms project site, Jones County, North Carolina.

Pine Flatwoods and High Pocosin. These communities occurred on wet, acidic, sandy and/or organic soils.

PROJECT SITE/ HISTORY

Clayhill Farms is located in southwestern Jones County, North Carolina, near the intersection of N.C. Highway 58 and SR 1101 (Figure 1). It is bordered to the east, north and west by the Croatan National Forest (CNF) and to the south by private property. It is divided by Billy's Branch, a tributary of Hunter's Creek.

The entire 355.6 ac. property appears to have been clearcut in the mid-1970s, with the exception of 19.0 ac. of hardwoods around Billy's Branch and a small tributary in the west-central portion of the property. The southern portion was used as agricultural fields, while the remaining land was allowed to regenerate with pines. Wetter areas were drained via ditches around the property and perpendicular to the stream through the portion south of Billy's Branch (Langley and McDonald, P.C. 1999).

Clayhill Farms now consists of 19.0 ac. of hardwood forest, 141.8 ac. of fallow agricultural land and 193.8 ac. of natural pine regeneration (Langley and McDonald, P.C. 1999).

Hydric soils on the property and surrounding area are fine sandy loams and loams, primarily the Pantego, Torhunta and Rains series. Non-hydric soils are Onslow fine sandy loam and Goldsboro loamy sand.

Natural conditions have been significantly altered by ditching, clearcuts and fire suppression, making determination of natural community types more difficult. Mapped soil types (National Cooperative Soil Survey 1981, Langley and McDonald, P.C. 1999), the composition of neighboring vegetative communities and the known history of the property suggest the following natural community types historically occurred onsite: Mesic Pine Flatwoods, Wet Pine Flatwoods, Pond Pine Woodland and High Pocosin. Today, existing conditions most closely resemble these community types, though vegetation and natural hydrology have been altered.

PROJECT DESCRIPTION

Clayhill Farms will be used by NCDOT to mitigate for wetlands altered in future NCDOT construction projects. The mitigation plan involves restoring an existing stream channel, filling ditches and planting native vegetation, thereby restoring approximately 65 acres of wetland on prior-converted croplands. Approximately 1.8 acres of forested land will be cleared to reroute Billy's Branch, which was channelized and deepened in the 1970s. This change will increase the length of the stream onsite from 6170 linear feet (ft.) to 7410 linear ft., more closely resembling the natural curvature of the stream (Langley and McDonald, P.C. 1999).

METHODS

Between 5 July and 27 July 2000, employees of Dr. J.H. Carter III & Associates, Inc. (JCA Inc.) surveyed potential RCW habitat on the project site and within the surrounding 0.5 mi. radius for evidence of RCW activity. Ground survey methodology varied according to size of the area and vegetation. Generally, 2 biologists walked parallel transects 50 to 100 feet apart. Transects were spaced to provide visual coverage for all potential cavity trees. Treeless residential areas, clearcuts and hardwood stands were not surveyed due to lack of potential RCW habitat. Generally, pine plantations less than 30 years old containing no older trees were not surveyed, however, wide transects were walked through such stands to confirm the absence of older trees.

RESULTS AND DISCUSSION

The red-cockaded woodpecker is a small black and white bird endemic to mature, fire-maintained pine forests in the southeastern United States, where it was historically common. It excavates nest and roost cavities in live pines generally >100 years old and requires a large area of mature (≥30 years old) pines for foraging habitat. The RCW is listed as endangered by the U.S. Fish and Wildlife Service (USFWS) and the State of North Carolina.

Suitable RCW nesting habitat is defined as pine or pine-hardwood stands (>50% pine) containing at least scattered pines over 60 years of age, hardwood-pine (≥50% hardwood) stands over 60 years of age and adjacent to pine or pine-hardwood stands ≥30 years of age or stands containing sawtimber-sized pines (≥9.0 inches diameter at breast height (dbh)). Foraging habitat is defined as pine or pine-hardwood stands over 30 years of age contiguous to and within 0.5 mi. of an RCW colony (Henry 1989).

Clayhill Farms and suitable RCW habitat within a 0.5 mi. radius were surveyed for evidence of RCWs between 5 and 27 July 2000. No active RCW cavity trees were found in the survey area.

RESULTS- CLAYHILL FARMS PROPERTY

The wooded portion of the Clayhill Farms property is forested with either pines 20-30 years old or mature hardwoods, neither of which is considered suitable habitat for RCW nesting or foraging.

Existing pine regeneration stands on the property have been significantly altered from their natural state, but most closely resemble the Mesic Pine Flatwoods, Wet Pine Flatwoods and Pond Pine Woodland community types. These stands are densely forested with pines 4-6 in. dbh, 20-30 years of age.

Areas resembling Mesic Pine Flatwoods communities have a dense overstory of loblolly pine (*Pinus taeda*), a moderately dense midstory of sweetgum *(Liquidambar styraciflua)*, a moderately dense understory of wax myrtle (*Myrica cerifera*) and water oak (*Quercus nigra*), and a moderately dense vine layer of muscadine grape (*Vitis rotundifolia*) (Figure 2).

Areas resembling Wet Pine Flatwoods communities, though greatly altered from their original state, have a moderate to dense overstory of loblolly pine, a moderately dense sweetgum midstory (20-30 ft. tall), a dense understory containing gallberry (*Ilex glabra*), sweetgum, sweet pepperbush (*Clethra alnifolia*), water oak, sweetleaf (*Symplocos tinctoria*), red maple (*Acer rubrum*), wax myrtle, blackgum (*Nyssa sylvatica*) and titi (*Cyrilla racemiflora*) and a sometimes dense vine layer of muscadine grape and greenbriers (*Smilax* spp.). One Wet Pine Flatwoods site north of the dirt road bisecting the property and east of the small clearcut has been thinned within the past few years. This area has the same dominant species, but has a more open midstory, denser understory and denser low shrub/herbaceous layer (Figure 3). There are some patches of dead trees in Wet Pine Flatwoods on the property, most likely killed by southern pine beetles (*Dendroctonus frontalis*). The overstory is dead in these areas, allowing the understory to become very thick, especially the vine layer (Figure 4).

[redacted]

Figure 2. Mesic Pine Flatwoods behind equipment shed on center road.

[redacted]

Figure 3. Thinned Wet Pine Flatwoods on Clayhill Farms property.

Areas resembling Pond Pine Woodland contain a moderate to dense canopy of pond pine (*Pinus serotina*) and loblolly pine, a dense midstory of sweetgum, red maple and swamp blackgum (*Nyssa biflora*) and loblolly bay (*Gordonia lasianthus*), and a dense understory of gallberry, redbay (*Persea palustris*), blueberry (*Vaccinium* sp.), fetterbush (*Lyonia lucida*) and switchcane (*Arundinaria tecta*). Parts of this community, south of the dirt road bisecting the property, have been thinned. These thinned areas have a more open midstory and denser understory and low shrub/ herbaceous layers, with rushes (*Juncus* spp.), meadow-beauties (*Rhexia* spp.), pennywort (*Hydrocotyle* sp.), orange milkwort (*Polygala lutea*) and sphagnum moss (*Sphagnum* sp.).

Langley and McDonald, P.C. (1999) describes the pines on Clayhill Farms as 25-30 years old. JCA Inc. staff aged 6 trees across the property that ranged from 20 to 24 years of age. The 1974 U.S. Geological Survey orthophotographs for Stella and Hadnot Creek quads show the site clearcut, with areas of bare soil and patches of vegetation, but it is not possible to determine if the vegetation is pine regeneration or shrubs.

Hardwood stands occur around Billy's Branch and its tributaries and on 15.9 ac. in the southeast corner of the property. These areas were not cut with the rest of the property and can be seen on the 1974 U.S. Geological Survey orthophotographs. These stands have a hardwood overstory with scattered second-growth loblolly pines and a dense hardwood midstory. These areas contain the only pines old enough to support a natural RCW cavity, but there are very few pines and the hardwood component is higher than that typically considered as RCW habitat (Henry 1989).

RESULTS- SURROUNDING AREA

Residential areas south of the property are partially cleared and generally forested with sparse loblolly pine ranging in age from sapling to second-growth and various ornamentals. The forested area south of SR 1101 and west of the radio tower was cut 3-4 years ago and is now vegetated with dense loblolly and pond pine regeneration $\leq$10 ft. tall, blackgum, sweet pepperbush, waxmyrtle, sweetgum, gallberry and titi.

The majority of suitable RCW habitat was found on the approximately 160,000 ac. Croatan National Forest (CNF), which is comprised mostly of extensive loblolly, longleaf and pond pine stands. Areas surveyed are the same community types as on the Clayhill Farms property, with the addition of High Pocosin, but are more mature and closer to their natural condition.

Mesic Pine Flatwoods areas on the Croatan typically have an uneven-aged, moderately dense canopy of longleaf pine mixed with some loblolly pine. Fire suppressed areas have a moderately dense midstory of sweetgum, red maple, water oak and a dense 10-15 ft. tall understory of midstory species, gallberry, blueberry, redbay and pine regeneration. A sparse to moderately dense low shrub/ herbaceous layer consists of cane, some Carolina wiregrass and dangleberry (*Gaylussacia frondosa*). Areas that have been burned within the past few years have similar species composition, but with a light to moderately dense understory 3-10 ft. tall and a moderately dense to dense low shrub/ herbaceous layer with more wiregrass. One area on the CNF east of CNF Forest Route 163 has a moderately dense to dense overstory of uneven-aged longleaf and pond pine (Figure 5). This area has been burned regularly so that a dense understory of switchcane has become established, with scattered 3-6 ft. tall sweet pepperbush, gallberry and sweetleaf, and a sparse low shrub/ herbaceous layer of dangleberry and bracken fern (*Pteridium aquilinum*). Several Mesic Pine Flatwoods areas contain scattered old-growth pines, with trees averaging 70-80 years of age, but ranging to 108+.

Wet Pine Flatwoods on the CNF typically have an uneven-aged loblolly, longleaf and pond pine overstory. Some Wet Pine Flatwoods areas have been burned within the past 3-4 years. These areas have a light midstory of sweetgum and red maple and a light understory of fetterbush, sweetleaf, redbay and bayberry (*Myrica heterophylla*). The low shrub/ herbaceous layer ranges from moderately dense to dense and contains gallberry, sweet pepperbush, switchcane, blueberry and cinnamon fern (*Osmunda cinnamomea*). Fire-suppressed Wet Pine Flatwoods habitats on the CNF have a midstory denser with species as listed above, and a dense understory 10-15 ft. tall consisting of species listed above, loblolly pine saplings and water oak. Many of these areas contain at least scattered old-growth pines.

Two abandoned RCW cavity trees were found by JCA staff in 1999 in Wet Pine Flatwoods on the CNF, within 0.5 mile of Clayhill Farms. These trees are located west of the property and east of N.C. 58, and are considered to be part of Cluster CNF 63 (Carter and Pegram 1999). The tree with tag number FS 229 was relocated in this survey and was found to be a relic start with pileated woodpecker (*Dryocopus pileatus*) damage. This tree was considered to have inactive starts with pileated damage in 1999. The other cavity tree was not found in this

Figure 4. Southern pine beetle-killed stand in Wet Pine Flatwoods in the northwest section of Clayhill Farms, south of the perimeter road.

Figure 5. Longleaf/ pond pine Mesic Pine Flatwoods stand east of CNF Forest Route 163, north of Clayhill Farms.

survey, but had a possibly complete inactive cavity with some pileated damage in 1999. These cavity trees are in an area that has been burned relatively regularly.

Pond Pine Woodland habitats on the CNF are forested with pond pine. Areas that have been burned within the past few years, in particular an area west of N.C. 58 and south of Hill Field Rd. (CNF Forest Route 603), have dead standing pines, a sparse overstory and a dense, 5 ft. tall understory primarily of redbay and laurel-leaf greenbrier (*Smilax laurifolia*). The majority of the Pond Pine Woodland communities in the area have not been burned and contain a light to moderately dense pond pine canopy, a sparse red maple and sweetgum midstory and a dense 10-30 ft. tall understory of fetterbush, titi, red maple, loblolly bay, redbay and sweetbay (*Magnolia virginiana*). Herbaceous ground cover is sparse except in openings and ditches, where netted chain-fern (*Woodwardia areolata*), cinnamon fern and sphagnum moss occur.

High pocosins within the 0.5 mi. radius of the property have a sparse overstory of pond pine, red maple, loblolly bay and swamp blackgum and a moderately dense to dense understory of fetterbush, gallberry, titi, sweetbay and redbay. Trees in pocosins are typically smaller in height and dbh than those in other habitat types.

NEIGHBORING RCW CLUSTERS

At the end of 1999, 55 active RCW clusters s were located on the CNF, including approximately 44 breeding groups (Simon 2000). The closest known active RCW clusters to Clayhill Farms are at least 1.0 mile away (Figure 6). Cluster CNF 44, approximately 1.5 mi north-northwest of Clayhill Farms, has contained a solitary male since 1996 and CNF 69, approximately 1.1 mi. southeast of Clayhill, had a breeding pair in 1999. CNF 63 is approximately 0.2 mi. west of the property, but since it has been inactive since before 1988 it is considered to be abandoned. The two cavity trees found by JCA, Inc. in 1999 were considered to be part of this cluster (See Results- Surrounding Area). CNF E4 (also CNF 904) is an artificial cavity cluster approximately 0.5 mi. east of the property that has been inactive since its creation in 1990-1991. CNF 59, approximately 1.1 mi west of the property, has been inactive since 1993 (Walters and Goodson 1991; Walters, Meekins and Zaebst 1996; Simon 2000; map provided by Croatan National Forest).

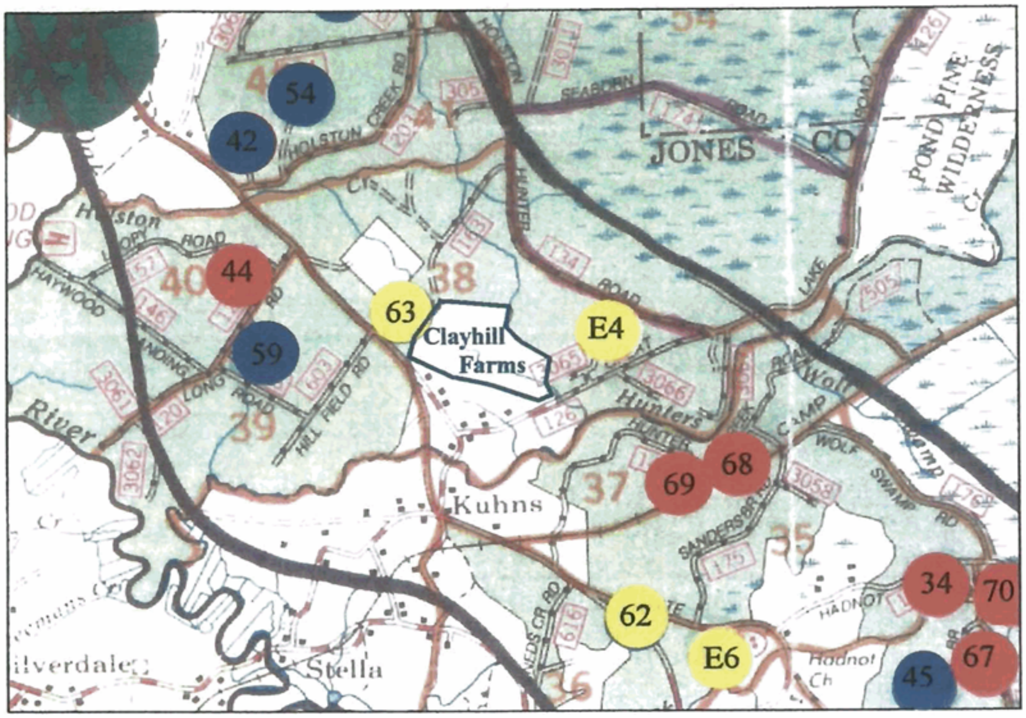

Figure 6. Location and status of neighboring RCW clusters on the Croatan National Forest (CNF), from CNF map dated 8/95 and updated with CNF 1999 data

- ● Active
- ● Inactive
- ● Abandoned

Since Clayhill Farms is more than 0.5 miles away from any active RCW clusters and the clusters within a 0.5 radius have been inactive for over 5 years, mitigation activities at Clayhill Farms will have *no effect* on the RCW.

Biological Conclusion- No Effect

MITIGATION POTENTIAL

Clayhill Farms currently contains 194.8 ac. of pine forest. Since these pines are between 20 and 30 years of age, there is currently little to no suitable nesting or foraging habitat for the RCW on the Clayhill Farms property.

Artificial cavities for RCWs can be excavated 2 ways: drilling cavities or inserting artificial nest boxes (inserts). To be suitable for drilling, a pine has to be at least 10.5 in. diameter at cavity height (generally 22 ft. above ground) with a minimum of 7 inches of heartwood and a maximum of 3.5 in. sapwood. These requirements are seldom met by trees under 75 years of age; generally, suitable trees are over 95 years of age (Copeyon 1990, Taylor and Hooper 1991). For inserts, the main requirement is a minimum diameter of 15 in. at cavity height, regardless of age (Allen 1991).

The only pines currently on the Clayhill Farms property large and old enough to support an RCW cavity are the very sparse, scattered second-growth loblolly pines in the hardwood drains and in the southeast corner of the property. These areas would naturally be hardwood-dominated forest and are to be managed as Mixed Mesic Hardwood Forest and Coastal Plain Bottomland Hardwood Forest in the mitigation plan by Langley & McDonald (1994).

Using an average age of 25 years, the trees on Clayhill Farms could meet the minimum RCW foraging habitat requirements as early as 2005. Most likely, the pines on the property will not be suitable for cavity provisioning by drilling until 2050. Since age is not as much of a factor with cavity inserts, provisioning of cavities using this technique would be possible as soon as the trees reach 15 inches in diameter at cavity height and other general RCW habitat requirements are met. It is difficult to predict when the trees will reach this diameter, since growth is affected by water availability, soil nutrients, basal area of the stand and length of growing season.

Federal guidelines for RCW foraging habitat require a minimum pine basal area (BA) of 8,490 sq. ft. and 6,350 pine stems ≥ 10 inches dbh for each RCW cluster (USFWS 1985). This requirement can be met with a minimum of 125 acres in preferred habitat, which is defined as pine stands over 30 years of age with a BA $\geq$60 ft.^{2}/ac., more than 24 pines/ac. $\geq$10 in. dbh, and with $\geq$40 percent in stands at least 60 years of age. More acreage is needed when the habitat does not meet these conditions (Henry 1989).

It is unlikely that Clayhill Farms itself will have enough pines $\geq$10 in. dbh by 2005 to be considered as sufficient foraging habitat for a RCW cluster. However, areas on the CNF within a 0.5 mile radius of Clayhill Farms do have suitable RCW nesting and foraging habitat, and some areas appear to be burned regularly. Many of these stands could support an artificial RCW cluster with either drilled cavities or inserts. If RCWs were to colonize a cluster within 0.5 mile of Clayhill Farms, they could use Clayhill Farms for foraging when the trees are an average of 30 years old, or in 5-10 years. Also, if RCWs were to eventually colonize an artificial cluster on Clayhill Farms, they would have access to foraging substrate on the surrounding CNF property.

Recommended management of the pine stands on the property to improve or create RCW habitat includes periodic thinning and maintaining 20-25 ft. between pines to minimize the risk of infestation and spread of southern pine beetles. The hardwood understory should be controlled via mechanical means or burning. Encroachment of hardwoods in pine stands is generally not tolerated by RCWs, so it is recommended that the hardwood BA be kept below 20 ft.^{2}/ ac. Burning regularly is the most effective, natural and least costly means of maintaining the open understory preferred by RCWs, but mechanical clearing and herbicides are also used. Care must be taken to ensure that the fire does not get so hot as to damage the overstory trees (U.S. Fish and Wildlife Service 1985).

The wetland mitigation plan for Clayhill Farms includes plans to restore 41.9 ac. of Mesic Pine Flatwoods on fallow agricultural lands (Langley & McDonald, P.C.). If this area is properly managed, it too could eventually be foraging and/ or nesting habitat for RCWs. However, this is a naturally fire-maintained community type and the surrounding areas are to be managed as Non-Riverine Wet Hardwood Forest and Mesic Mixed Hardwood Forest, both fire-sensitive communities (Langley & McDonald 1994). For this reason, care must be taken to keep the fire out of these hardwood communities.

CONCLUSIONS

Restoration activities on the Clayhill Farms Mitigation property will have **no effect** on the endangered RCW. No suitable nesting habitat for RCWs was found on the Clayhill Farms property, and although suitable habitat exists within 0.5 miles of the Clayhill Farms property, no evidence of recent RCW activity was found. The two RCW cavity trees within the 0.5 mile radius have been inactive since 1988 and are therefore considered to be abandoned.

Clayhill Farms could be suitable for RCW mitigation credits in a minimum of 30 years. However, if a neighboring RCW cluster on the CNF was to become active, or if a new cluster was created on the CNF, Clayhill Farms could possibly be used as foraging habitat in 5-10 years, with appropriate management.

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APPENDIX I

FOREST MANAGEMENT PLAN

FOREST MANAGEMENT PLAN

for the

CLAYHILL FARMS MITIGATION SITE
JONES COUNTY, NORTH CAROLINA

PREPARED FOR THE

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
Project Development & Environmental Analysis Unit
One South Wilmington Street
Raleigh, North Carolina 27611
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Issued: July 2004

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1.0 SITE LOCATION & VICINITY

The North Carolina Department of Transportation (NCDOT) Clayhill Farms Mitigation Site is located in southwestern Jones County, North Carolina on the Hadnot Creek, NC and Stella, NC 7.5" USGS topographic quadrangle (Figure 1, Vicinity Map). It is bordered to the north, east, and west by the Croatan National Forest and the south and east by various privately owned forested and residential parcels. The 355.60-acre property currently consists of approximately 214 acres of pine forest (a mixture of both loblolly pine *(Pinus taeda)* and pond pine *(Pinus serotina)*) and ±141 acres of fallow agricultural fields.

2.0 OBJECTIVES & METHODOLOGY

A forest inventory was conducted on the Clayhill Farms site by Carolina Silvics, Inc. in August 2003 to quantify habitat suitability for the federally endangered red-cockaded woodpecker *(Picoides borealis)* (RCW). The property was divided into seven inventory areas (stands) delineated by roads, paths, canals, and/or management history (Figure 2, Forest Stand Map). The inventory consisted of 47 measurement points located throughout the forested portion of the property.

At each point, variable plots were measured using a 10-factor prism. The diameter at breast height (DBH), total height, and species was recorded for each tree counted as "in." All "in" trees were measured regardless of size or species. The distance to any borderline trees was measured using a 75-foot logger's tape. DBH's were taken with tree calipers; a hypsometer was used to measure height. At least one tree per measurement point was aged using an increment borer with three years added to the number of rings at DBH to determine age. Additionally, a 1/500-acre plot was established at each point to count the number of woody plants in the understory. The complete inventory data can be found in Appendix A.

3.0 EXISTING RCW HABITAT CONDITIONS

Inventory data important to the management of RCWs are summarized in Table 1.

There are two types of habitat requirements for the RCW: nesting and foraging. Nesting habitat requires the presence of suitable cavity trees. In general, the birds prefer open pine stands at least 60 years of age. The stand may be even-aged or have clumps of older trees contained within it (Henry 1989, p.6). Stands that have a dense hardwood understory are avoided. There is currently no nesting habitat available at the Clayhill Farms site due to the young tree age (5 to 25) and the density of the hardwood understory and midstory.

Foraging habitat may be managed under two sets of guidelines; the recovery standard and the managed stability standard(USFWS 2003, p.292). The recovery standard is for management with a goal of increasing population size used primarily on federal and state lands. The managed stability standard is used primarily on private lands to maintain population size. The recovery standard is more restrictive with respect to the pine stocking level requirements. It also requires a minimum tree age of 60,

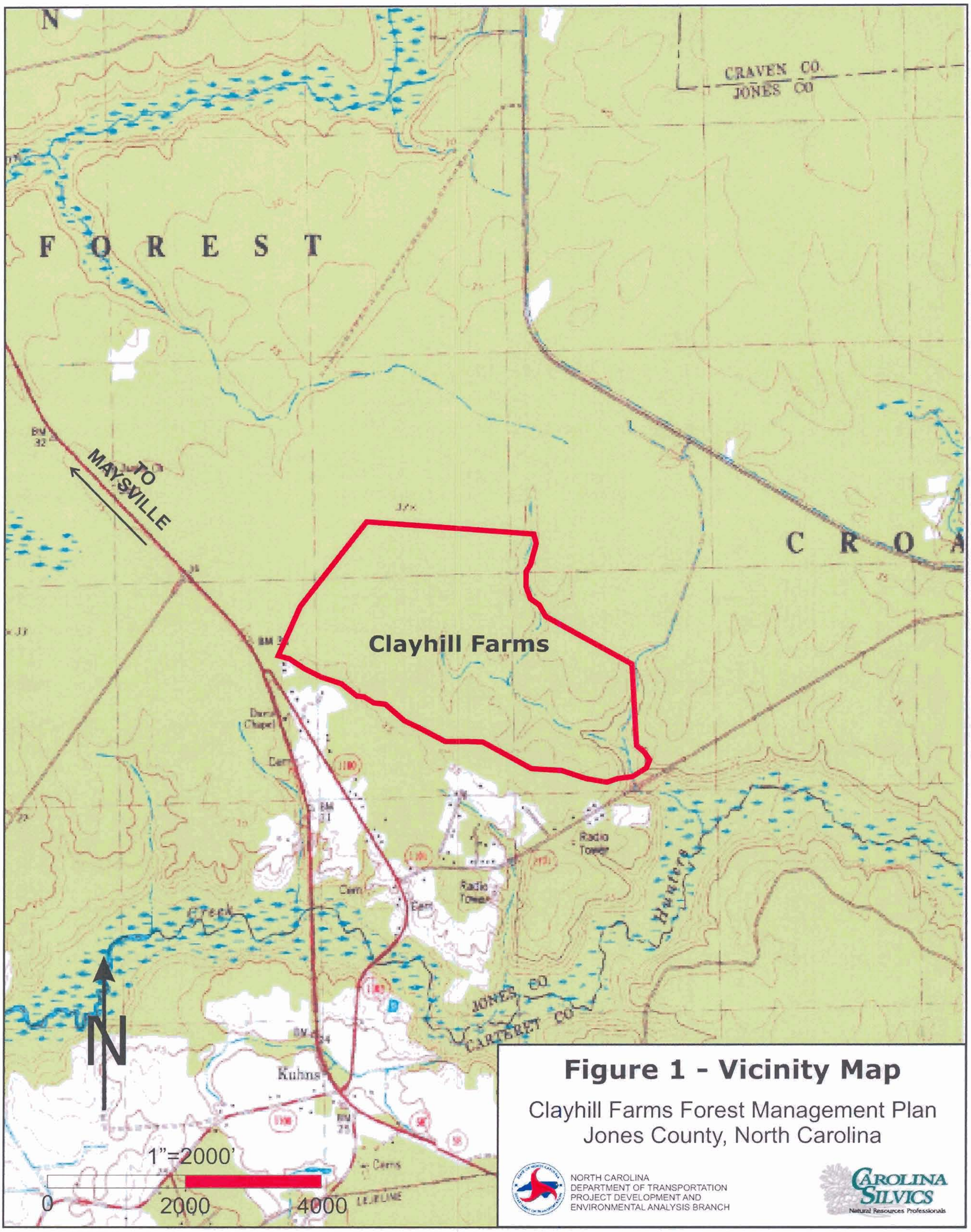

Figure 1 - Vicinity Map

Clayhill Farms Forest Management Plan
Jones County, North Carolina

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND
ENVIRONMENTAL ANALYSIS BRANCH

CAROLINA SILVICS
Natural Resources Professionals

SOURCE: USGS STELLA & HADNOT CREEK, NORTH CAROLINA 7.5 MINUTE QUADRANGLE.

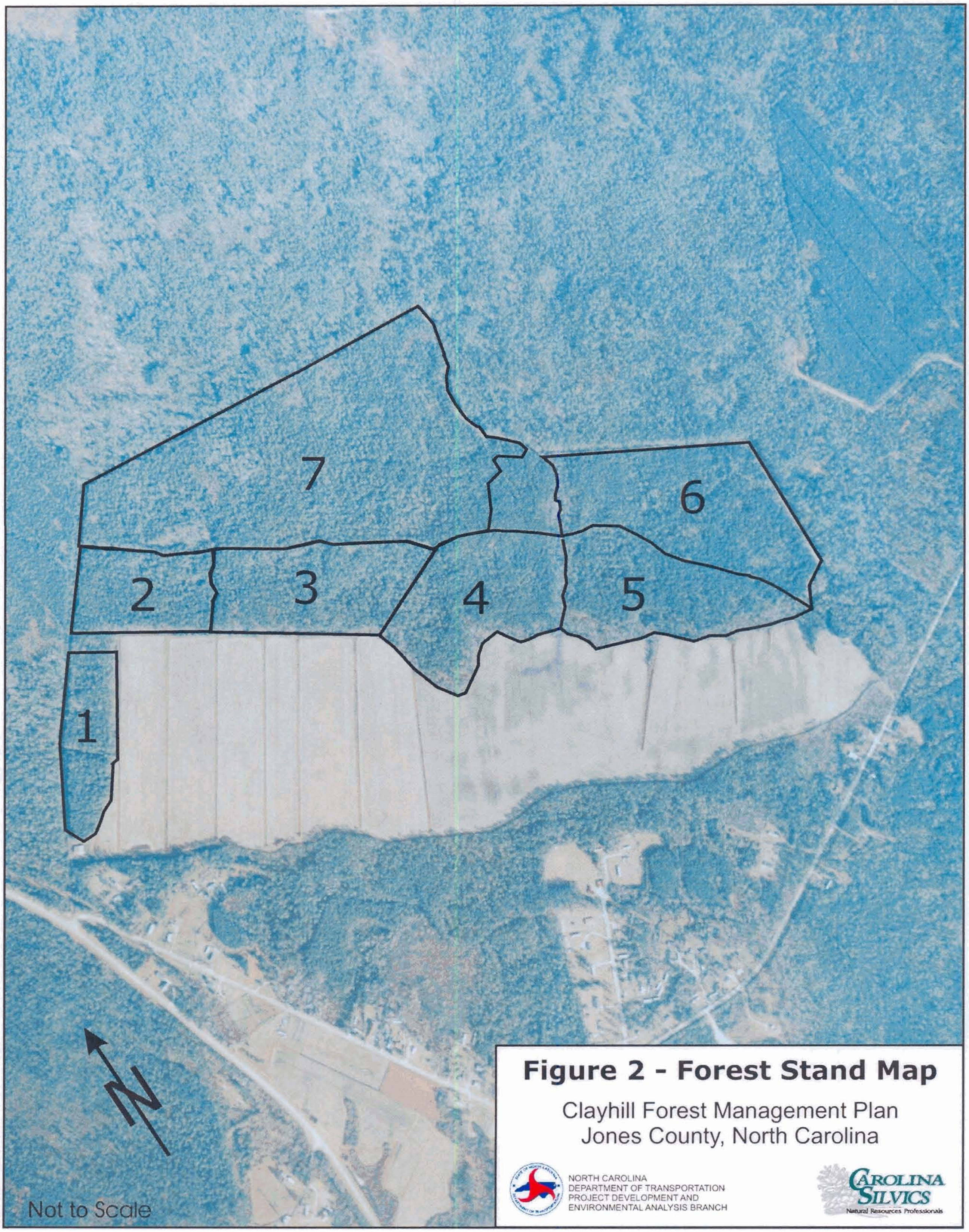

Figure 2 - Forest Stand Map

Clayhill Forest Management Plan
Jones County, North Carolina

NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND
ENVIRONMENTAL ANALYSIS BRANCH

CAROLINA SILVICS
Natural Resources Professionals

SOURCE: NCDOT PHOTOGRAMMETRY

whereas the managed stability standard requires a minimum stand age of 30. Since the recovery standard requires 20 ft^2 of basal area to be pines 60 years old or older, none of the acreage will qualify until the stands have reached that age. The stand ages are close to the minimum age of 30 years as specified in the managed stability standard; therefore, the goal should be to maintain the stands to meet the less restrictive standard while insuring that the recovery standard guidelines will be met when the trees have reached sufficient age. Table 1 provides general stand composition details. Table 2 shows which stands currently meet the various parameters under the managed stability guidelines. Table 3 gives the same information for the recovery standard. In tables 2 and 3, if a parameter is not met by a particular stand, management techniques are given which, if applied correctly, bring the stand into compliance. These techniques are detailed in section 4 of this document and are as follows: prescribed burning (designated by the letter B in the tables), natural stand aging and development (A), and tree removal (ie. Thinning, R).

Table 1. Forest inventory data for RCW-specific density parameters.

		Overstory & Midstory				Woody Understory	
Stand		**Pine**	**Hardwood**	**Total**	**Average Age**	**Stems per acre**	**Most Common Spp.**
1	TPA <10”	29	273	302	22	4,250	red maple
	TPA>=10”	67	7	74			
	BA <10”	10	22.5	32.5			
	BA>=10”	50	0	50			
2	TPA <10”	32	752	784	23	5,667	sweetgum ink berry
	TPA>=10”	62	0	62			
	BA <10”	3	30	33			
	BA>=10”	47	0	47			
3	TPA <10”	81	116	197	22	6,000	sweetgum red maple
	TPA>=10”	42	0	42			
	BA <10”	16	10	26			
	BA>=10”	32	0	32			
4	TPA <10”	165	42	207	25	9,500	sweetgum red maple wax myrtle
	TPA>=10”	65	0	65			
	BA <10”	48	4	52			
	BA>=10”	44	0	44			
5	TPA <10”	85	7	92	23	4,400	sweetgum ink berry
	TPA>=10”	71	5	76			
	BA <10”	26	2	28			
	BA>=10”	48	2	0			
6	TPA <10”	134	60	194	23	4,750	sweetgum ink berry red maple
	TPA>=10”	67	0	67			
	BA <10”	36	10	46			
	BA>=10”	43	0	43			
7	TPA <10”	118	70	188	25	7,055	sweetgum ink berry red maple
	TPA>=10”	53	1	54			
	BA <10”	31	9	40			
	BA>=10”	34	1	35			

*TPA = trees per acre BA = basal area

Table 2. Current conditions--Managed Stablility Parameters

				Stand			
	1	2	3	4	5	6	7
Stands 30 yrs old or older	A	A	A	A	A	A	A
40-70 ft^2 of pines at least 10" DBH	√	√	A	√	√	√	A
<20 ft^2 of pines less than 10" DBH	√	√	√	A,R	A,R	A,R	A,R
Hardwood understory sparse	B	B	B	B	B	B	B
Total basal area less than 80 ft^2	√	R	√	R	√	R	√

Table 3. Current conditions--Recovery Standard Parameters

				Stand			
	1	2	3	4	5	6	7
Stands 60 yrs old or older	A	A	A	A	A	A	A
At least 20 ft^2 of pines at least 14" DBH	A	A	A	√	A	A	A
At least 18 TPA of pines at least 14" DBH	A	A	A	√	A	A	A
0-40 ft^2 of pines 10-14" DBH	A,R	√	√	A,R	A,R	√	√
Less than 10 ft^2 and 20 TPA of pines <10"	A,R	A,R	A,R	A,R	A,R	A,R	A,R
At least 40 ft^2 of pines 10" DBH or greater	√	√	A	√	√	√	A
Hardwood understory sparse	B	B	B	B	B	B	B
Overstory hardwood TPA <30% total TPA	B,R	B,R	B,R	√	√	√	√

Approximately 43 acres of the Clayhill Farms site have been thinned by removing pine pulpwood from the overstory (stands 1, 2, and 3 – Figure 2, Forest Stand Map). These stands have a larger percentage of stocking with pines 10 inches or greater than the unthinned stands (stands 4 through 7); however, there is no evidence that the hardwoods have been controlled, and, as such, they exhibit the dense understory characteristics that RCWs avoid.

Clayhill Farms contains a contiguous pine forest with approximately 10,000 pine stems over 10 inches DBH and 11,000 sq.ft. of pine basal area. The foraging range for birds in a colony site is given as 0.5 miles (Henry 1989, p.7). At its widest, the forested portion of Clayhill Farms is about 2700 feet, or 0.51 miles, wide. If suitable nesting habitat is available on adjacent land, birds should be able to utilize part or all of any suitable foraging habitat provided on the Clayhill Farms property. In the process of conducting the forest inventory, the path along the property line shared with the Croatan National Forest was traveled by all-terrain vehicle (ATV). Portions of the national forest adjoining the Clayhill property appeared to contain suitable nesting habitat characterized by large pines with an open understory. Since there is currently no suitable nesting habitat on Clayhill Farms, the best prospect for use by RCWs is to provide a high quality foraging habitat for any birds nesting on adjacent property.

4.0 PROPOSED MANAGEMENT GOALS & ACITIVITIES

Prescribed burning, thinning, and natural stand development should provide foraging habitat in about 5 years. Time will provide the required nesting habitat. In about 35 years, the current trees will old enough to be utilized for cavity trees. In addition, the current young pine regeneration and any pine planted as part of restoration activities will provide additional foraging habitat. To maximize RCW habitat potential on newly planted pine areas in the wetland restoration area, these areas should be located no further than 300 feet away from existing pine stands. In addition, they should be at least 10 acres in size and 5 chains (330 feet) wide. RCWs will utilize pond, longleaf *(Pinus palustris)*, or loblolly pines. Of these three species, longleaf pine is the most tolerant to frequent burning, especially at a young age. Growth time to 10 inches DBH may be shortened by silvicultural techniques such as chemical weed control and fertilization.

4.1 Prescribed Burning

Since adequate pine stocking is currently available at the site, the most pressing course of action is to control the midstory and understory hardwoods by prescribed burning. Burning should begin as soon as possible and continue yearly until the hardwoods are controlled. If there is adequate fuel to burn every year, this should be done for 2 or 3 years. Once the understory is controlled, burning should continue at 2 to 3 year intervals in perpetuity.

Creation of a burning plan is recommended. A burning plan will identify any smoke sensitive areas off property, specify appropriate weather parameters such as wind speed and direction, and address any other issues such as problem soils. The burning plan will also set guidelines for evaluation of burning success and specific timing for subsequent burns.

Fire line maintenance will not be difficult due to the presence of old roads and paths around and through the property. A bulldozer may be required to initially install fire lines adjacent to the cutover stream corridor and young pine regeneration. An agricultural type tractor can be used to disk the fire lines prior to burning. Figure 3 shows the proposed locations of fire lines. Pine regeneration in the recently clear-cut areas and the wetland restoration area (currently fallow agricultural fields) should be protected from fire until they are big enough to include in the burning program (about age 15).

In addition to controlling hardwoods, prescribed burning reduces the risk of wildfire by lowering the amount of fuel on the tract. Creation of the above-described fire lines on the property and semi-annual prescribed burning should eliminate any wildfire concerns on the property. Also, other animal species such as northern bobwhite quail *(Colinus virginianus)* and wild turkey *(Meleagris gallopara)* will benefit from periodic burning.

4.2 Thinning

Some parts of Clayhill Farms can be commercially thinned (Figure 4). Stands 4, 5, and 6 are especially suited to this due to a high percentage of upland soils (Langley & McDonald, PC 1999, Section 3.3). Pines less than 10 inches DBH and all merchantable hardwoods should be removed. In these three stands, if only pines greater than 10-inches DBH are left, the stands will have 44, 48, and 43 sq.ft. respectively, of basal area remaining in suitable RCW trees(managed stability standard). Stands 1, 2, and 3 have already been thinned and should be left to grow for the time being. Stand 7 may be thinned, but some trees less than 10 inches DBH should be left due to the lower overall stocking of this stand.

The logging contractor should be made aware of the size limitations before beginning work so that removal of 10-inch or greater DBH pines can be minimized. If desired, the trees not to be harvested can be marked with paint. Typically, trees are marked at ground level with a spot of paint and at DBH

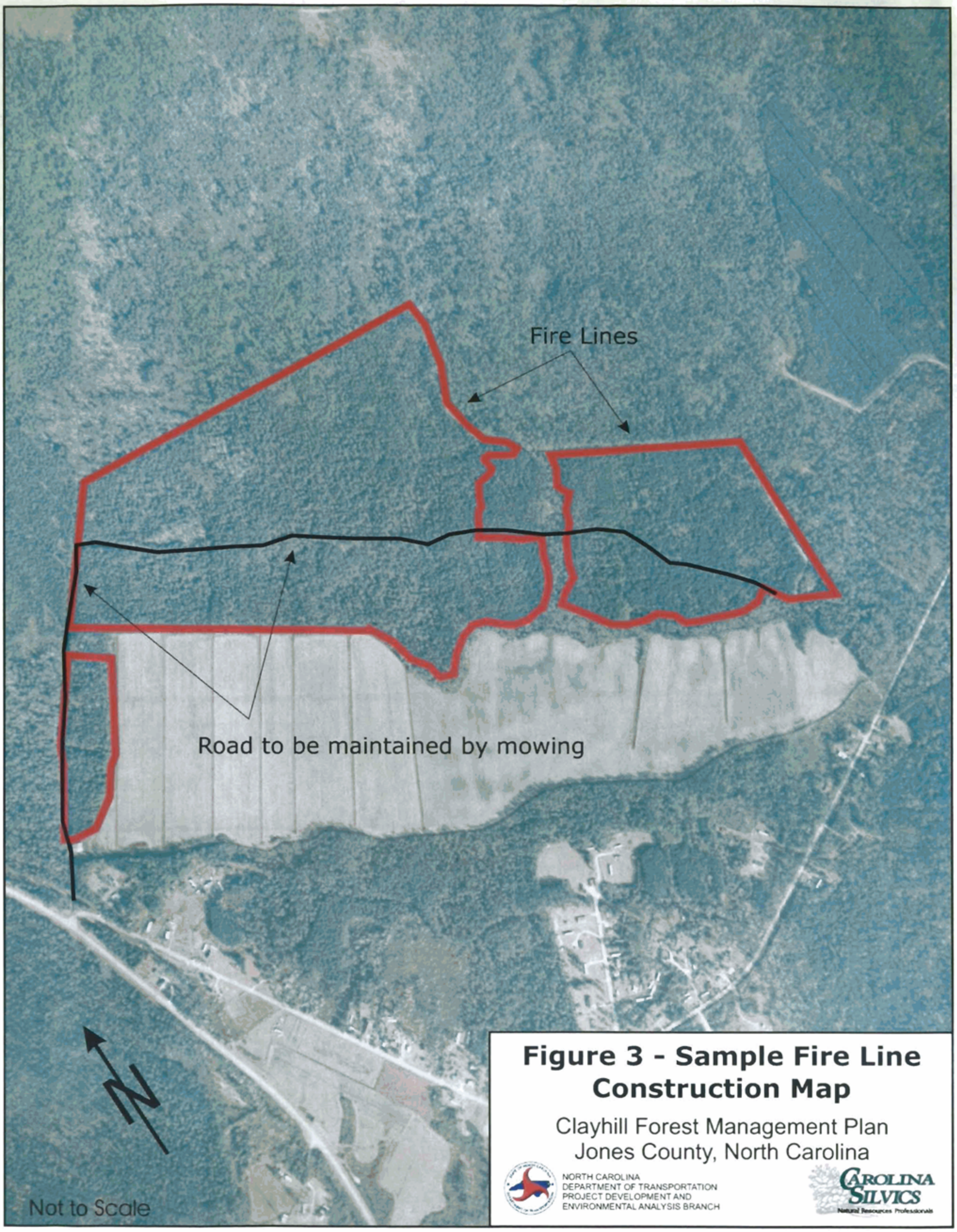

Figure 3 - Sample Fire Line Construction Map

Clayhill Forest Management Plan
Jones County, North Carolina

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SOURCE: NCDOT PHOTOGRAMMETRY

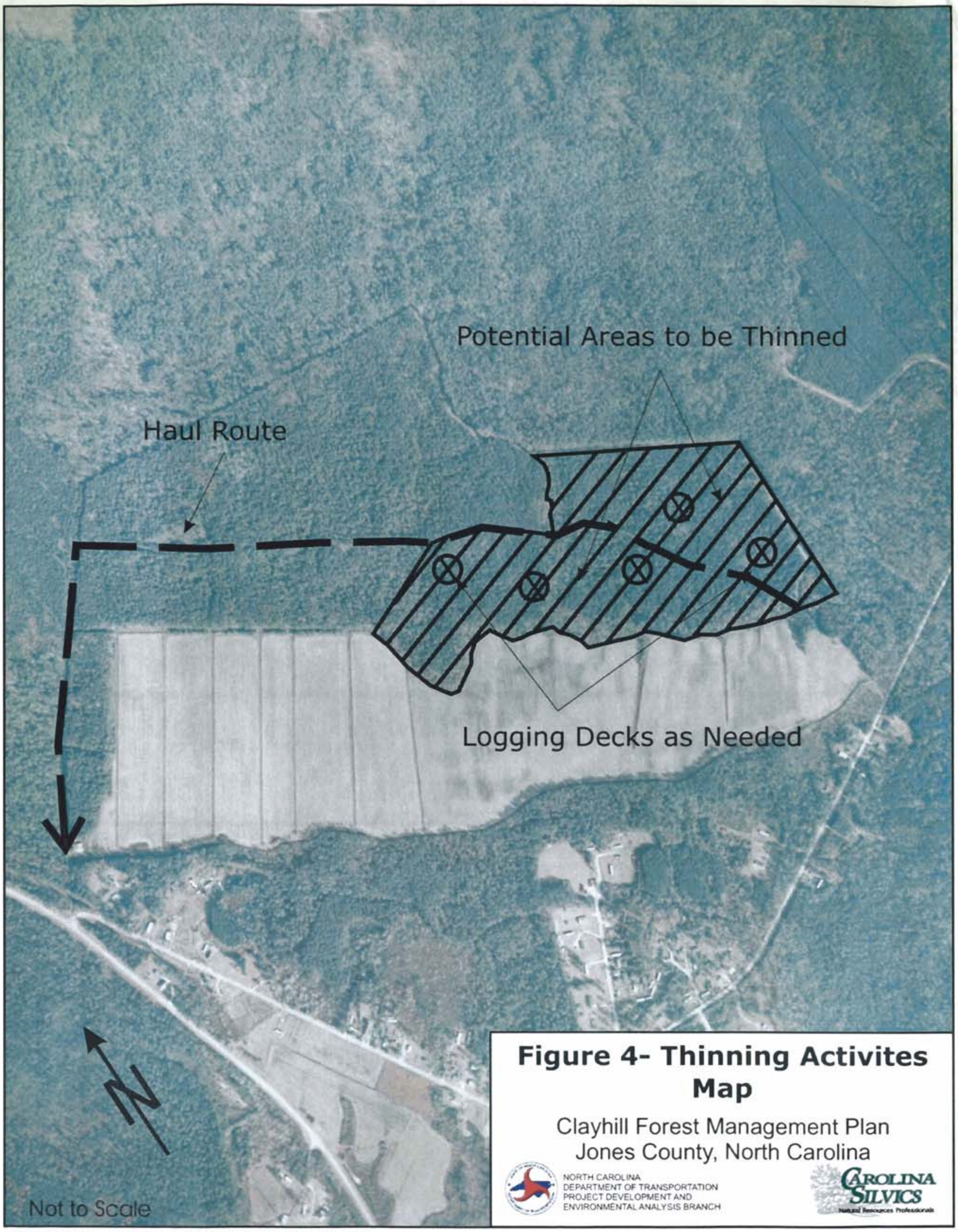

Figure 4- Thinning Activites Map

Clayhill Forest Management Plan
Jones County, North Carolina

SOURCE: NCDOT PHOTOGRAMMETRY

with a band of paint encircling the tree. This allows the equipment operator to easily identify which trees not to cut, and also allows identification of stumps of trees which are mistakenly harvested.

Road work should be allowed in order to facilitate the logging operation, including periodic mowing of the interior road. This will also maintain the interior road as a fire break. Logging decks should be allowed as needed and left up to the logging contractor. These small areas will have only an insignificant impact on the RCW habitat. In addition, conveniently placed decks lead to shorter and fewer skid trails, thereby reducing rutting and soil compaction.

4.3 Natural stand development

Stands naturally change over time. In general, in fully stocked stands like the ones at Clahill Farms, the aging process tends to reduce the number of trees per acre of shade intolerant species like southern yellow pines. Tree diameter of these same species is increased. In the absence of fire, species composition also changes to include more shade tolerant hardwood species. With some stands, like stand #7, the aging process along with burning is all that is necessary to create foraging habitat. Since the management goal is to have a pine forest at least 60 years of age, all of the stands will undergo significant natural changes by the time the recovery standard guidelines are met. The aging process, along with fire, will increase the habitat for RCW over the coming decades.

4.4 Management Activity Schedule

Year 1
Create a burning plan
Establish fire lines in accordance with plan
Maintain/repair interior logging road
Acquire a thinning contractor/contract
Mark trees for thinning
Thin and burn as weather conditions allow
Coordinate management activities with adjacent landowners

Years 2 and subsequent
Burn as per schedule established in burning plan

Year 15
Evaluate young pines for potential thinning and entry into burning program
Re-asses management plan and adjust as conditions dictate
Re-inventory all stands to evaluate stocking levels and progress towards the recovery standard

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