Mitigation Plan for the proposed Juniper Bay Wetland Mitigation Site

Robeson County, North Carolina
R-513WM
6.439004T

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Project Development and Environmental Analysis Branch
Natural Systems Unit
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Executive Summary

The North Carolina Department of Transportation (NCDOT) has recently acquired a large, drained Carolina bay in Robeson County which the department proposes to develop as a wetland mitigation site. This bay, locally referred to as Juniper Bay, will be restored to provide compensatory wetland mitigation in the Lumber River Basin of southeastern North Carolina, to offset wetland impacts resulting from road construction projects in this basin. The NCDOT plans to develop the Juniper Bay Mitigation Site in advance of proposed road projects, thus providing completed wetland mitigation prior to highway construction impacts. The goal of the Juniper Bay mitigation project is to restore the site both hydrologically and vegetatively to the greatest extent possible, and thereby to recreate the functions and values provided by the wetland system.

Juniper Bay is located in Cataloging Unit 03040203 of the Lumber River Basin, approximately 7.5 miles south of Lumberton, North Carolina, 1.0 miles southwest of US 74. The property owned by NCDOT is approximately 728 acres in size and encompasses over 95 percent of the original Carolina bay area. In its current condition, Juniper Bay has been extensively drained by a network of parallel ditches which has removed significant hydrology from the site and rendered it non-jurisdictional. Ditching activities were performed from approximately 1968 to 1981 in order to develop the site for agriculture, and the site remained in agricultural production until January 2000 when it was purchased by the NCDOT. The most recent crops grown at the site were soybeans and cotton. These past clearing and draining activities have eliminated wetland functions from the site, resulting in a degradation of water quality and loss of wetland habitat.

Tatum Millpond Bay in Bladen Lakes State Forest has been identified as a reference system for the Juniper Bay project. Tatum Millpond Bay, comprising approximately 2040 acres, is located 30 miles to the northeast of Juniper Bay and consists of a largely undisturbed Carolina bay system currently in public ownership. Tatum Millpond Bay will be studied to provide appropriate hydrologic and vegetative targets for the restoration of Juniper Bay.

The NCDOT proposes to restore the hydrology and natural vegetative communities of Juniper Bay by systematically plugging and backfilling the ditch network on site, and by planting the site with tree species typical of the target natural communities. Hydrology restoration activities should raise the ground water table sufficiently to create saturated soil conditions at or near the ground surface for much of the growing season. In addition, the soil surface will be resculpted where possible to eliminate field crowns and restore more natural microtopography. Appropriate wetland tree species will be planted to accelerate the development of typical Carolina bay forest communities, including Peatland Atlantic White Cedar Forest, Bay Forest, and Pond Pine Woodland. The proposed restoration activities may be completed in phases to maximize the likelihood of successful vegetation establishment. Such activities should provide approximately 568 acres of wetland restoration to mitigate for impacts in the Lumber River Basin.

The site offers a high likelihood of success because of its large size and high degree of control of the existing drainage network (i.e. self-contained, one outlet). Relic, drained hydric soils are present, and groundwater modeling projections indicate that water table recovery will occur if ditches are eliminated. Good access throughout the site exists along the farm road system which connects directly to Fire Tower Road (SR 2233). No significant constraints are present which would prohibit implementation of the proposed mitigation activities.

In addition to the NCDOT efforts, research activities initiated with North Carolina State University (NCSU) will study the long term evolution of the site toward stable community structure. NCSU will investigate the long term hydrologic, soil, and vegetative changes that occur at Juniper Bay as a result of the restoration efforts. This research project will provide a unique opportunity to study the before and after effects of wetland restoration work on a large Coastal Plain system with significant hydrologic control.

Restoration of Juniper Bay will provide water quality benefits to Big Indian Swamp and the Lumber River to which the site eventually drains. The site presently serves as a source of significant ground water discharge, sediment loss, and possible chemical contaminants. Following restoration, the site will have a high capacity for surface and groundwater storage, sediment and nutrient retention, and groundwater recharge. In addition, Juniper Bay once completed will comprise approximately 750 acres of contiguous forest habitat.

Introduction

The North Carolina Department of Transportation (NCDOT) proposes to restore the Juniper Bay mitigation site to provide compensatory wetland mitigation credits in the Lumber River Basin. Unavoidable impacts to wetlands in the region are likely to occur over the next ten years as a result of the construction of planned highway projects, including Transportation Improvement Projects (TIP) R-513, R-2593, and R-3333. In order to meet state and federal regulations, compensatory mitigation will be required to offset unavoidable impacts to wetlands which may result from the construction of these road projects. Juniper Bay is being developed by NCDOT to provide up-front compensatory wetland mitigation in the Lumber River Basin to be debited as future permit needs arise.

Juniper Bay was first identified by NCDOT as a potential wetland mitigation site in 1997 as part of a comprehensive mitigation site search of the Lumber River basin. A site feasibility study was completed in April 1998. The property was purchased fee simple in January 2000 and mitigation planning activities were initiated. Regulatory review agencies were introduced to the site at an on site meeting held on February 15, 2000. Comments and recommendations were solicited. At that time, the review agencies verbally agreed that the site appeared to be suitable as a wetland mitigation site. Field investigations for mitigation planning were initiated in January 2000, and included soils mapping, hydraulic conductivity testing, groundwater monitoring, biological inventory, and reference system assessments.

This document presents the results and findings of the mitigation planning activities completed to date. The document includes: 1) a description of existing site conditions; 2) a synthesis of collected data and analyses and the results of hydrologic modeling; 3) observations from the reference system; 4) a proposed mitigation plan for restoring wetlands on site; and 5) a plan for monitoring and measuring the success of restoration efforts.

Site Description

Juniper Bay is located in Robeson County, approximately 7.5 miles south of Lumberton and 4.5 miles east of Fairmont, in the Coastal Plain physiographic region of North Carolina (Figure 1). The site is located immediately north of Fire Tower Road (SR 2233) and southwest of US 74, and is identified on USGS quadrangle maps (and USFWS NWI maps) Southwest Lumberton, N.C. (1982) and Fairmont, N.C. (1962). The headwaters of the Big Indian Swamp drainageway occur east of the property.

The general topography of Robeson County is described as flat to gently rolling, and the soils are typically sandy or loamy, acidic, and low in natural fertility (NRCS 1978). The natural vegetation of Robeson County likely existed as broad expanses of longleaf pine flats and savannas, dotted with wet Carolina bays of various sizes

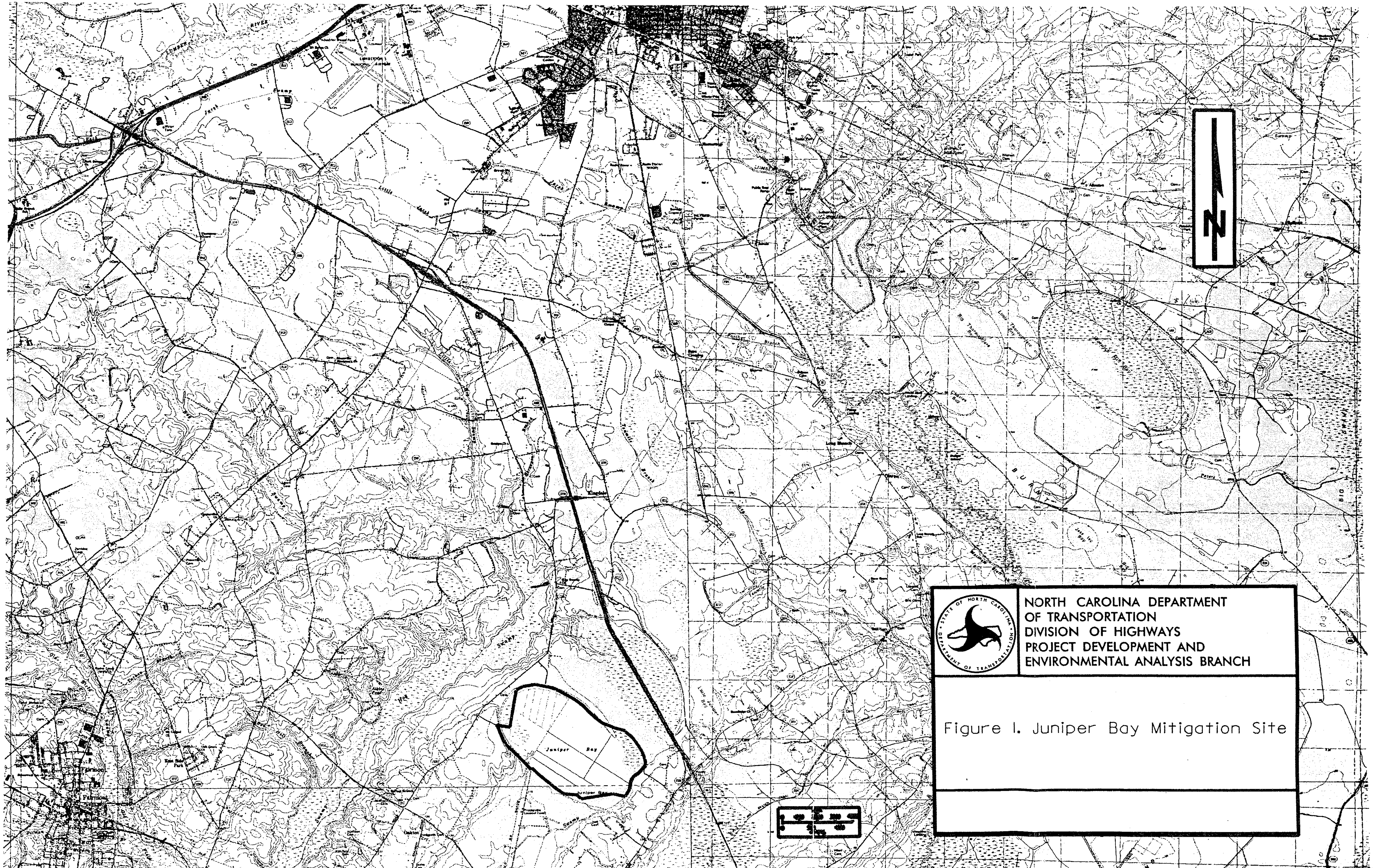

Figure 1. Juniper Bay Mitigation Site

supporting pocosins or dense flatwoods, and drained via a network of swampy streams and rivers. In the vicinity of Juniper Bay, regional topography is generally flat, though more pronounced slopes occur along larger floodplains. The site basically occurs on a narrow interstream divide between two large streams, Hog Swamp and Big Branch Canal, which occur to the west and east, respectively.

The Juniper Bay Mitigation Site comprises 728.52 acres and is approximately 1.58 miles long along its long axis and 0.89 miles long along its short axis. While referred to as a single Carolina bay, Juniper Bay may actually be comprised of two overlapping bays, one much smaller than the other. The smaller bay appears to be located along the northeast corner of the primary bay. Because both bays comprise the same property and are hydrologically interconnected, they will be referred to as a single site. The total area of the original bay system is approximately 755.70 acres, of which the NCDOT property comprises 96.4 percent. Approximately 27.18 acres of the Juniper Bay system lie outside of the NCDOT property boundary.

Infrared aerial photography and topographic mapping of Juniper Bay was developed by the NCDOT Photogrammetry Unit through controlled aerial photography of the project site. The NCDOT Location and Surveys Unit provided supplemental information on ditch cross sections and elevations. Contour mapping was developed at one-foot contour intervals (Figure 2). As expected, the rim of the bay is slightly higher than the interior of the site, causing the site to slope inward. The lowest elevations in the bay are approximately 117.5 feet above mean sea level (msl). The outer rim of the bay occurs at approximately 125.0 feet msl. Thus, Juniper Bay represents a depression of approximately 7.5 feet, with an average slope of 0.18 percent along the long axis of the bay and an average slope of 0.32 percent along the short axis. Discounting the somewhat steeper slopes which occur along the bay perimeter, the flat interior of the bay exhibits an average slope of less than 0.10 percent.

An extensive network of parallel ditches has been established within the bay to facilitate drainage of groundwater offsite to promote agricultural productivity. Several large collector ditches run perpendicular to the parallel ditch network, rerouting water flow to a single outlet along the south rim. This outlet flows under SR 2233 (Fire tower Road) and joins a regional drainage system which eventually connects with Big Indian Swamp 1.0 miles downstream. In addition, a perimeter ditch runs the entire length of the agricultural area, serving as a collector system and isolating the bay from offsite groundwater inputs. Including the perimeter ditch and the primary collectors, a total length of 33.85 miles of ditches have been excavated in the Juniper Bay property. Ditch spacing between parallel ditches varies from approximately 284 feet to 102 feet.

According to U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) mapping, the majority of Juniper Bay is mapped as palustrine, scrub-shrub, needle-leaved evergreen, saturated, partially drained/ditched (PSS4Bd) (Figure 3). Smaller areas of palustrine, emergent, persistent, saturated, partially drained/ditched (PEM1Bd) and palustrine, forested, broad-leaved deciduous / needle-leaved evergreen, temporarily flooded, partially drained/ditched (PFO1/4Ad) are also mapped. All of these

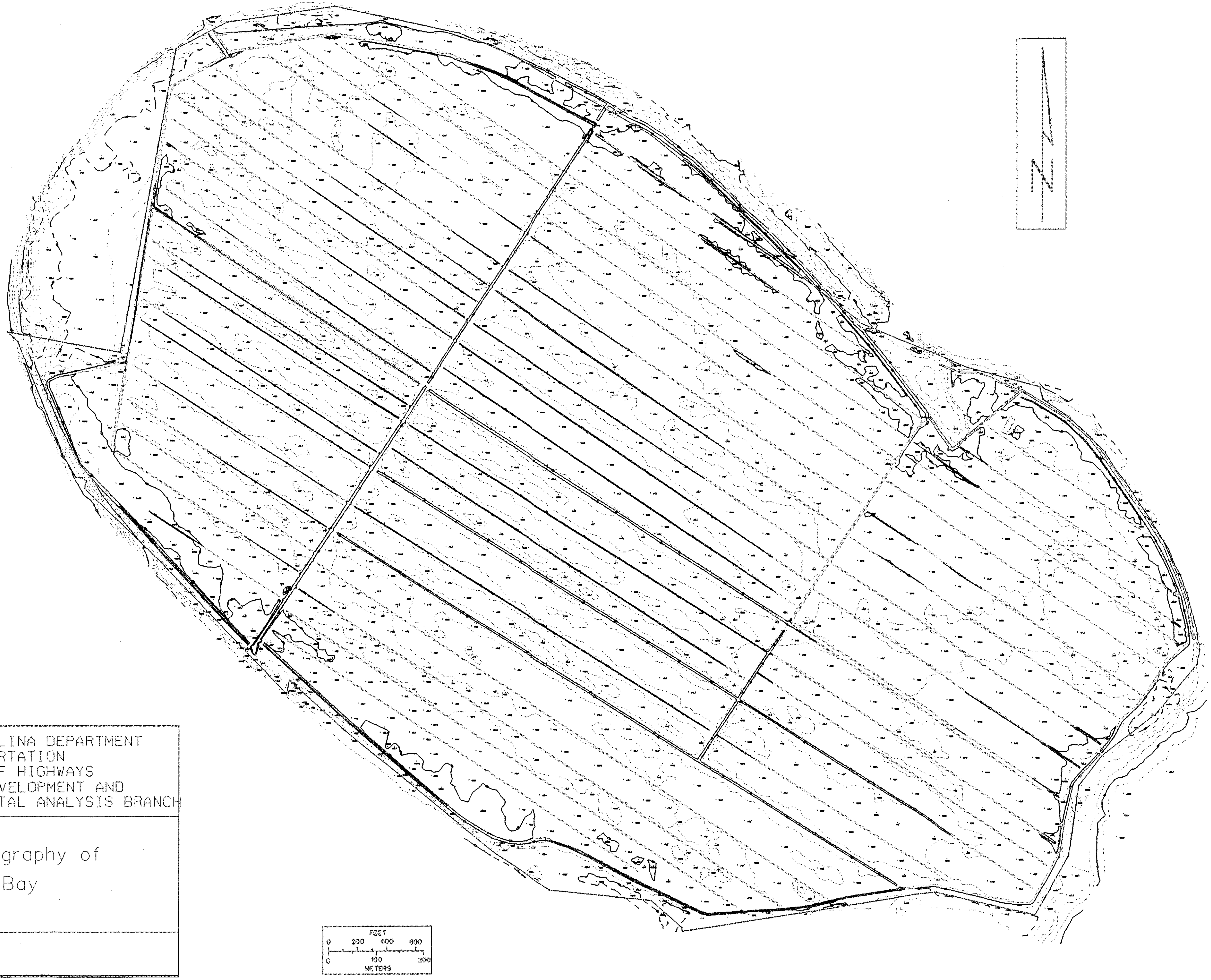

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Figure 2. Topography of Juniper Bay

designations recognize the current drained status of the site. The vegetation classifications are generally not consistent with the current status of the property due to agricultural activities. Nearly all of the areas mapped by USFWS are presently being used as cropland.

According to historic aerial photographs and records at the Robeson County NRCS, the natural forest vegetation of Juniper Bay was cleared in conjunction with ditching activities. The majority of this vegetation was windrowed and burned. The name "Juniper Bay" suggests that Atlantic white cedar may have been a significant component of the original forests. Clearing and draining activities occurred over a period of approximately 15 years. The initial ditching efforts and agricultural production began on the western third of the property between 1966 and 1972. The original ditch network ran approximately north-south as a series of parallel ditches. By 1981, virtually all of the existing ditch network had been established in its present location, and all of the site had been cleared of forest vegetation. The ditch pattern established in the initial effort had been filled and recreated in its current northwest-southeast orientation. Once the natural vegetation of the site had been removed, the property remained under agricultural production until it was purchased by NCDOT in January 2000. A few barns and out-buildings related to past agricultural activities are present on the north side of the site. In addition, longleaf pine was planted in 1994 in three large fields on the southern portion of the property.

The properties surrounding Juniper Bay are primarily in managed forest or agricultural production. Agricultural fields occur on adjacent properties to the east and west, while large forested tracts adjoin the northern and southern boundaries. Some limited residential areas occur along Wiregrass Road (SR 2208) and Fire Tower Road.

Carolina Bays

Carolina bays are geologic formations which consist of elliptical surface depressions oriented along a northwest to southeast axis. These features occur throughout the Coastal Plain region of the southeastern United States, but are particularly abundant in North Carolina and South Carolina. The Robeson County Soil Survey (NRCS 1978) states that thousands of such bays occur in Robeson County alone. The origin of these formations is still a subject of debate among ecologists and geologists. Theories range from marine scouring to a comet explosion. Regardless, Carolina bays are an important landscape feature in the Coastal Plain of North Carolina where they often form heterogeneous wetland pockets in the typically flat landscape.

Carolina bays in Robeson County can range in size from less than one acre to more than 1700 acres. Most support hydric soils and would be classified as jurisdictional wetlands under natural conditions. However, the hydroperiod of Carolina bays can vary significantly, from marginally wet pine flatwoods, to dense pocosin shrublands, to actual open water lakes. Carolina bays typically have a low interior which slopes outward to a dry sand ridge which encloses the bay. This sand ridge is often most pronounced along the southeast margin of the formation. However, weathering and erosion over time may wear away at the sand rim of the bay, reducing its prominence. Carolina bays are most common and most intact where they occur as local depressions within a larger flat interstream divide. In such cases, bays collect and store precipitation in the headwaters of a watershed. Larger bays may have small stream outlets which drain surface and ground water to regional drainageways. Smaller bays typically do not have natural outlets.

Cultural Resources

Available records were reviewed by the North Carolina Department of Cultural Resources to determine the presence of historic preservation sites or sites of archeological importance on or near the subject site. According to Ms. Susan Myers of the archeological section of the State Historic Preservation Office, there are three archeological sites located across SR 2208 (Wiregrass Road) near the Juniper Bay property. They are considered to be of low research potential and are not recommended for additional investigation. These sites are also beyond the range of potential mitigation activities. According to Ms. Debra Bevin and Ms. Ellen Turco of the State Historic Preservation Office, there are no historic sites located on or in the vicinity of the Juniper Bay property. This project is not expected to adversely affect any known significant historic or archeological resources.

Phase I Environmental Site Assessment

A Phase I Environmental Site Assessment (ESA) of the subject property was conducted in order to evaluate the presence of potentially harmful environmental hazards. Environmental concerns under review include past or present storage of hazardous or regulated materials or waste and illicit dumping of solids or hazardous waste. Visual screening for objects such as storage tanks, debris, hazardous materials and evidence of waste burial was conducted through field reconnaissance of the study area. Cursory field surveys revealed evidence of one above ground storage tank which has been removed. This tank was empty and there was no evidence of leakage or spills.

In addition to cursory field surveys, environmental database records were researched under contract to EnviroData, Inc. in order to evaluate environmental conditions in the general area of the subject property. No mapped sites were identified by the EnviroData record search within the mitigation property or within the search radius.

Utility Easements

No water or sewer lines are present in the interior of the Juniper Bay property. Utility lines have been installed along Fire Tower Road, but these areas are not subject to any proposed mitigation activities. No power lines or other utilities were observed on the property. A former railroad line, previously operated by the Raleigh and Charleston Railroad Company, crossed the property on the western end in a northerly direction along a line parallel to Fire Tower Road. However, this railroad line has been abandoned since 1933 and the tracks were subsequently removed and the bed leveled.

Threatened and Endangered Species Habitat

As of February 27, 2001, the USFWS lists three federally protected species for Robeson County (Table 1). These species are protected under Section 7 and Section 9 of the Endangered Species Act, as amended.

Table 1. Federally protected species listed for Robeson County.

Scientific Name	Common Name	Federal Status
Alligator mississippiensis	American alligator	Threatened (S/A)
Picoides borealis	Red-cockaded woodpecker	Endangered
Rhus michauxii	Michaux's sumac	Endangered

Note: (S/A) – Similarity of Appearance

No habitat for any of the federally listed species presently occurs at Juniper Bay. The canals and ditches on site are not of sufficient size to support the American alligator. Also, the young longleaf pine plantations on the south side of the property are not of sufficient age or size to provide foraging or nesting habitat for the red-cockaded woodpecker, and no suitable open, upland habitat for Michaux's sumac exists. A review of the North Carolina Natural Heritage Program (NCNHP) database revealed no known populations of federally protected species in or near the project area. Therefore, no impacts to any federally protected species are expected to occur.

In addition, the USFWS lists eleven Federal Species of Concern (FSC) for Robeson County as of February 27, 2001 (Table 2). These species are not afforded federal protection under the Endangered Species Act, but their continued survival is still at risk.

Table 2. Federal species of concern listed for Robeson County.

Scientific Name	**Common Name**	**State Status**
Aimophila aestivalis	Bachman's sparrow	SC
Corynorhinus rafinesquii	Rafinesque's big-eared bat	SC/PT
Heterodon simus	Southern hognose snake	SR/PSC
Rana capito capito	Carolina gopher frog	SC/PT
Amorpha georgiana var. *georgiana*	Georgia indigo-bush	E
Astragalus michauxii	Sandhills milkvetch	T
Dionaea muscipula	Venus flytrap	C – SC
Echinodorus parvulus	Dwarf burhead	C
Lindera subcoriacea	Bog spicebush	E
Macbridea caroliniana	Carolina bogmint	T
Rhexia aristosa	Awned meadowbeauty	T

Note: SC – Special Concern
PT – Proposed Threatened
SR – Significantly Rare
PSC – Proposed Special Concern
E – Endangered
T – Threatened
C – Candidate

No habitat for any of the Federal Species of Concern presently occurs at Juniper Bay. A review of the NCNHP database revealed no known populations of Federal Species of Concern within the project area. Therefore, no impacts to any of these species are expected to occur.

Soils

According to the NRCS (1978), the parent material for the soils of Robeson County is unconsolidated rock material, sand, silt, and clay that were deposited as marine sediments during periods of high sea level. Also present are alluvial materials which have been eroded from upland areas and redeposited along the floodplains of streams and rivers. Most soils in Robeson County are highly leached by water from the abundant rainfall and are low in organic matter content. Only wet soils typically contain a significant quantity of organic matter.

NRCS Soil Survey Mapping

The Robeson County Soil Survey (NRCS 1978) identifies four primary soil series as occurring at Juniper Bay. These series are listed in Table 3, and soil taxonomy is provided in Table 4. A brief description of the four primary soil series is provided following Table 4. Several non-hydric soils were identified by NRCS along the elevated rim around the perimeter of the bay principally on adjacent properties. Small areas of these soils are included within the property boundary, but these soils are not proposed for wetland restoration. As a result, they were not described or studied. Figure 4 depicts the soils as mapped by NRCS.

Table 3. Soil series identified at Juniper Bay (NRCS 1978).

Soil Series	**Mapping Unit**	**Acres**	**Percent of Site**	**Hydric Status**
Ponzer muck	Pr	291.69	38.60	Hydric
Leon sand	Le	264.26	34.97	Hydric
Rutledge loamy sand	Ru	130.20	17.23	Hydric
Pantego fine sandy loam	Pg	67.56	8.94	Hydric
Upland soils		1.96	0.26	Non-hydric

Table 4. Taxonomy of soil series identified at Juniper Bay by NRCS

Series	**Subgroup**	**Order**
Leon	Aeric haplaquods	Spodosols
Pantego	Umbric paleaquults	Ultisols
Ponzer	Terric medisaprists	Histosols
Rutledge	Typic humaquepts	Inceptisols

Ponzer muck

Ponzer muck, siliceous subsoil variant is described as a level, very poorly drained organic soil found in large bays (NRCS 1978). Because of flooding and wetness, it is generally unsuited to crops unless drained. The seasonal high water table is at or near the

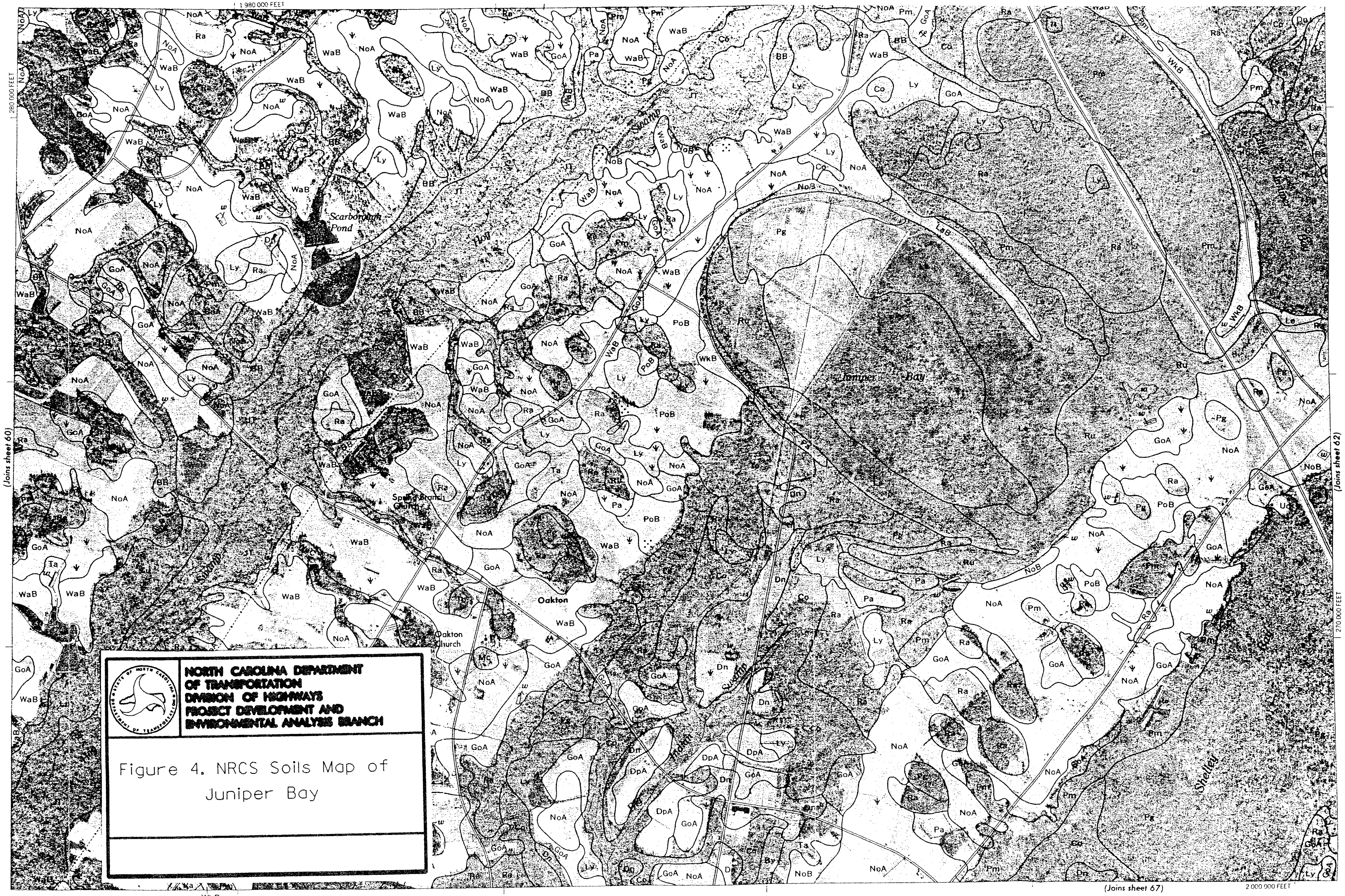


Figure 4. NRCS Soils Map of Juniper Bay

This map is compiled on 1972 and 1973 aerial photography by the U.... Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

surface from November through July and the soil is subject to ponding for long periods. Natural fertility is low, permeability is moderate, and the potential for subsidence is high if the soils are drained. In a typical profile the organic surface layer is a very dark brown muck approximately 18 inches thick, underlain by a layer of yellow silt loam 3 inches thick. Below this is a black mucky loam to a depth of approximately 31 inches. The underlying material is comprised of layers of loam and sand to a depth of 60 inches.

Leon sand

Leon sand is described as a nearly level, poorly drained soil on interbay divides and stream terraces or around the outer rim of bays. This soil can support agriculture if drained. Soil wetness is a very severe limitation to agriculture in winter in spring, although the soil is droughty in summer. A seasonal high water table, very low natural fertility, and leaching of soil nutrients are the primary limitations to agricultural use. Permeability is moderate and organic matter content is very low. In a representative profile, the surface layer is black sand approximately 5 inches thick, underlain by a layer of white sand 18 inches thick. The subsoil is spodic horizon of dark brown sand 23 inches thick. The underlying material is sand to a depth of approximately 82 inches.

Rutledge loamy sand

Rutledge loamy sand is described as a nearly level, very poorly drained soil on stream terraces and in large bays. Rutledge soils are very low in natural fertility and permeability is rapid. The seasonal high water table is at or near the surface from November through April, and the soil is subject to ponding for very brief periods. This soil can support agriculture if drained. A seasonal high water table, ponding, very low natural fertility, and leaching of soil nutrients are the primary limitations to agricultural use. A typical profile has a surface layer of black loamy sand to a depth of approximately 20 inches. The underlying material is gray sand to a depth of 72 inches.

Pantego fine sandy loam

Pantego fine sandy loam is described as a nearly level, very poorly drained soil which is found on the lower parts of bays. Natural soil fertility is low, organic matter content is medium, and permeability is moderate. The seasonal high water table is at the surface from November through April, and the soil is subject to ponding for very brief periods. A seasonal high water table and ponding are the primary limitations to agricultural use. Drainage is needed for most uses. In a representative profile, the surface layer is black fine sandy loam to a depth of approximately 4 inches. The subsoil is mottled sandy clay loam to a depth of 80 inches.

Hydric Soils Classification

Hydric soils are defined as "soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper soil layer" (USDA, 1991). The NRCS further states that hydric soils in Robeson County cannot be farmed under natural conditions without removing woody vegetation and altering hydrology. Some map units listed as hydric soils may not presently meet the definition of wetland because the hydrology has been altered through drainage or other manipulations.

All four mapping units identified at Juniper Bay by the NRCS are defined to be comprised fully of hydric soils or to have hydric soils as a major component. All support woody vegetation under natural conditions. All are defined as hydric soils under natural conditions because of saturation for a significant period during the growing season, although Ponzer muck is also ponded for long or very long periods during the growing season. However, ditch systems within the site have drained most of the soil units to the extent that anaerobic conditions in the upper soil horizons are currently limited. Table 5 presents the natural hydrologic characteristics of the soils identified by NRCS.

Table 5. Hydrologic properties of soils identified at Juniper Bay by NRCS.

Series	Flooding Frequency	Duration	High Water Table	Months
Leon	none		1.5 ft	Nov-Apr
Pantego	1	Very brief	0.0 ft	Nov-Apr
Ponzer	1	Long	0.0 ft	Nov-Jul
Rutledge	1	Brief	0.0 ft	Nov-Apr

Note: 1 – Not subject to flooding, but shallow water stands on the surface during or soon after a rain.

Revised Soil Mapping

Soils at Juniper Bay were mapped by a NCDOT registered soil scientist to verify the occurrence of the soil series identified by the Robeson County Soil Survey and to more precisely locate the boundary between soil types. Based on these extensive field studies, it was determined that the soils identified on the site do not precisely match the series presented in the soil survey. In fact, for some mapping units the soil profiles observed do not correlate well to any soil series recognized by NRCS for Robeson County. Mr. William Spruill of the Robeson County NRCS office concurred with this determination. Ultimately, identification of the precise soil series for the mapping units observed was not undertaken because it was determined to be unnecessary to meet the mitigation objectives of the project. Thus, the mapping units are identified by texture and mineral content. Table 6 identifies each mapping unit and its extent across the site. Muck soils have been split according to subsoil characteristics (clay vs. sand), while the Rutledge and Pantego series identified by NRCS have been combined into a single mapping unit identified as a sand over clay. A typical soil profile for each mapping unit identified is included in Appendix A.

Table 6. Soil mapping units identified at Juniper Bay by NCDOT.

Soil Series	Mapping Unit	Acres	Percent of Site	Hydric Status
Sand / Sand	SS	366.49	50.31	Hydric
Sand / Clay	SC	93.68	12.86	Hydric
Muck / Clay	OC	215.11	29.53	Hydric
Muck / Sand	OS	44.53	6.11	Hydric
Upland soils	Up	8.68	1.19	Non-hydric

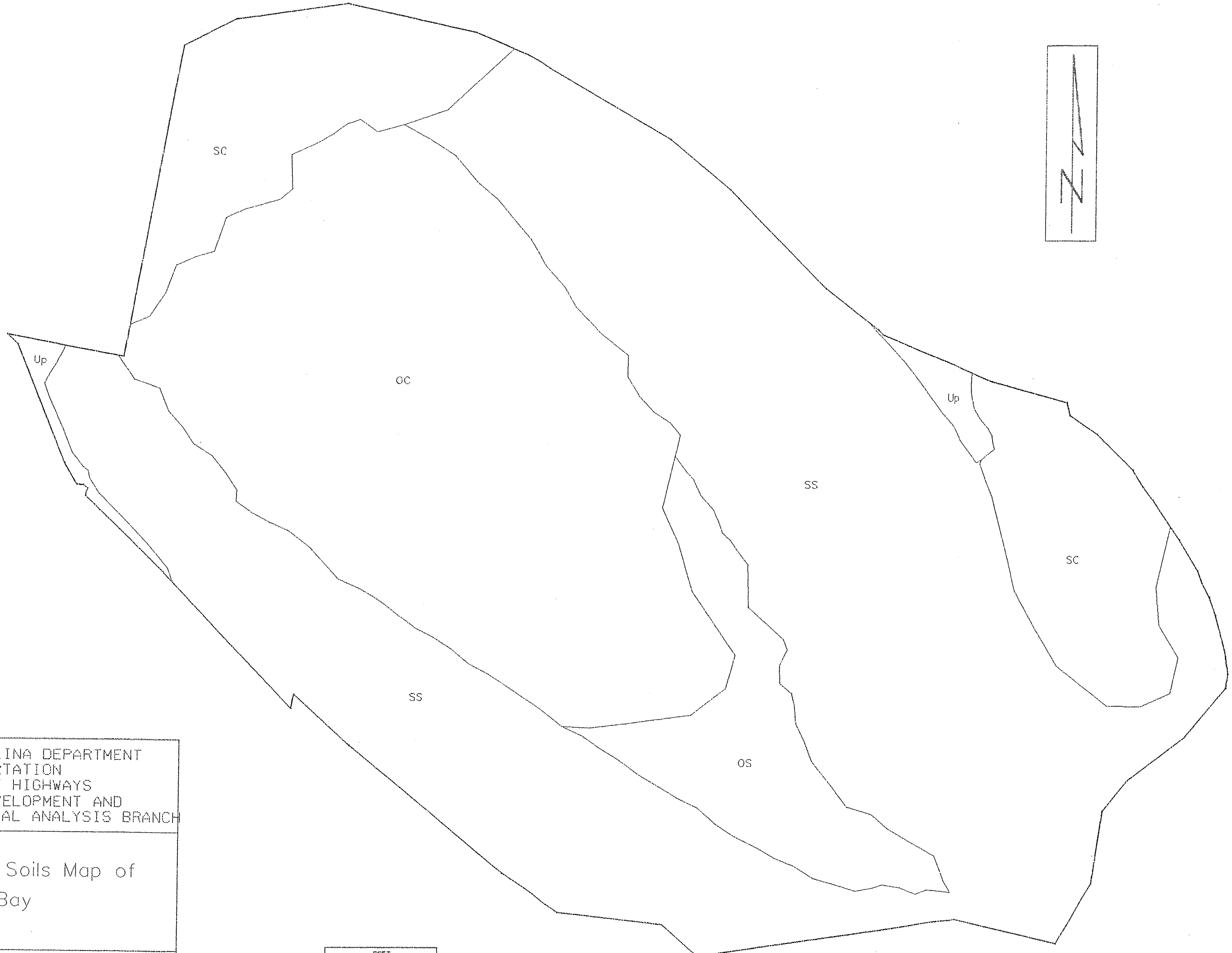
The wet sand soil (Spodosol) mapping unit corresponds closely to the Leon sand unit identified by NRCS. The two muck soil (Histosol) mapping units generally correspond to the Pamlico muck series described by NRCS, though a differentiation has been made based on subsoil characteristics. And lastly, the sand/clay mapping unit basically occurs in the same portions of the site as the Pantego and Rutledge series identified by NRCS, though this mapping unit does not closely represent either series.

The revised soil map developed by NCDOT is indicated in Figure 5. As compared to the NRCS mapping in Figure 4, sandy soils were mapped to a greater extent, increasing from 34.97 to 50.31 percent of the total area (Table 3 and 6). Loam soils were reduced in total percentage from 26.17 to 12.86 percent, while muck soils were nearly equivalent proportional area. However, the boundary line between muck soils and adjacent soils has shifted significantly in the north-central portion of the site.

Hydraulic Conductivity

Hydraulic conductivity is a measure of the rate at which water will pass through a soil in response to a given gradient. Hydraulic conductivity is most directly related to the texture and structure of a given soil. Relatively homogeneous soils with small pores or small particle size, such as clays, typically exhibit low hydraulic conductivity rates. Conversely, course textured soils with large pores or large particle size, such as sands or fluvial material, exhibit high hydraulic conductivity rates.

Hydraulic conductivity was measured for each soil mapping unit to quantify the average rate of water movement through the soil profile. Hydraulic conductivity sampling points were located within each soil series and holes were bored with hand augers. Hydraulic conductivity was measured with two different methodologies, depending on the saturated condition of the soil on the sampling date. When soils were saturated, hydraulic conductivity was measured via the auger hole method. Hydraulic conductivity tests were conducted by removing a large volume of water from the boring and recording the rate at which the groundwater returned to equilibrium. When soils were not saturated, hydraulic conductivity was measured with an amoozemeter. The results of these studies are included below in Table 7.



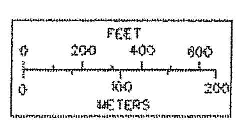


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Figure 5. Revised Soils Map of Juniper Bay

Table 7. Hydraulic conductivity of soils at Juniper Bay.

Soil Series	Horizon Depth	Hydraulic Conductivity
Sand/Sand		
Sand/Clay		
Muck/Sand		
Muck/Clay		

Hydraulic conductivity data were incorporated into the DRAINMOD groundwater model which was utilized to predict water table conditions on site due to the existing drainage network. Hydrologic modeling methodology and results are included in the Hydrology section.

Soil Fertility

Soil samples were collected within each soil series and submitted to the North Carolina Department of Agriculture Agronomic Division Soil Test Lab office in Raleigh, NC. Within each soil type, three individual samples were taken, along with a composite representing an equal mixture of the three. The results of the soil fertility analyses are provided in Table 8.

Table 8. Fertility status of soils at Juniper Bay.

Soil Sample	HM %	W/V	CEC	pH	BS %
Sand / Sand 1	3.77	1.33	9.1	5.2	69.0
Sand / Sand 2	4.69	1.33	8.8	4.5	50.0
Sand / Sand 3	6.58	1.19	12.3	5.3	72.0
Sand / Sand Composite	5.23	1.27	9.6	5.1	67.0
Sand / Clay 1	4.81	1.22	9.8	5.6	80.0
Sand / Clay 2	10.00+	1.07	11.9	4.6	48.0
Sand / Clay 3	10.00+	0.94	14.3	4.8	59.0
Sand / Clay Composite	8.54	1.08	11.9	4.8	62.0
Muck 1	10.00+	0.68	23.9	4.5	66.0
Muck 2	10.00+	0.81	18.0	4.4	60.0
Muck 3	10.00+	0.64	20.7	4.2	54.0
Muck Composite	10.00+	0.70	19.6	4.5	60.0

Note: HM % Percent humic matter
W/V Weight/volume (Density)
CEC Cation Exchange Capacity
pH Acidity
BS % Percent base saturation

The results of the fertility analyses are as expected given the texture and organic matter content of the three primary soil types. Cation Exchange Capacity increased with increasing organic matter content, while pH varied inversely with organic matter content. Although the laboratory tests conducted do not distinguish organic matter content above 10.00+, the differences in density (W/V) clearly indicate the high organic matter content of the muck soils. The muck soil composite had approximately one-half the density of the sand/sand composite. Percent base saturation showed only slight differences between soil types, likely related to pH.

Soil Disturbance

Compaction in the soil surface horizons may have occurred in places due to the extended use of mechanized equipment in the agricultural fields. Use of heavy equipment in fields, particularly when soils are wet, can result in the compression of soil horizons and the loss of pore space. Effects are typically most pronounced in loam or clay soils where compressed hardpans can develop below the plow zone. To reduce the potential for such soil compaction, the site will be deep ripped to a depth of 1-2 feet prior to planting. Deep ripping will also create a rough soil surface with the potential for microtopography and surface water storage.

Several fields within Juniper Bay appear to have been crowned to provide adequate rooting depth for agricultural crops. Crowning occurs where surface soil material is scraped and piled in the central portions of fields where the distance to ditches is greatest and thus the drainage effect most limited. Crowned fields are thus highest in the middle and sloped toward the ditches on each side. This agricultural practice increases the available rooting depth for crop species in these portions of the fields. Evidence suggests that crowning is most common within the muck soil mapping unit, as indicated on Figure 2. Crowns will be leveled where possible and the material used to backfill ditches.

Excavation and fill activities have occurred where ditches have been established and the soil material side cast into the adjacent fields. Additional fill may have also occurred along primary roads and work pads to provide a more stable surface for equipment and structures. Where practicable, this displaced material will be used to back fill ditches during restoration implementation.

Subsidence of the soil surface in the muck soil mapping unit may have occurred. Because this series has a primarily organic surface layer, artificial drainage has likely promoted accelerated organic matter oxidation and the loss of organic depth. Although the possibility of subsidence does not appear to be extreme, precise soil surface elevations prior to site manipulation are unknown. A loss of soil depth may be a concern in mitigation planning as it relates to projecting post-restoration groundwater levels. Loss of organic matter content may have likewise occurred in non-organic soils, however the potential for soil subsidence in mineral soils is significantly less.

Hydrology

Regional Hydrology Features

Juniper Bay is located in Cataloging Unit 03040203 of the Lumber River Basin. The site and the surrounding area are part of the watershed for Big Indian Swamp (Figure 6). The Big Indian Swamp watershed originates in an area of Carolina bay wetlands immediately to the northeast of Juniper Bay. As a defined channel, Big Indian Swamp is shown to originate along the eastern property boundary where it appears to have been locally channelized. From there, it drains mostly southward, passing immediately to the east of the mitigation site, before continuing southward to its confluence with Indian Swamp, 4.0 miles downstream. Indian Swamp continues southward, joining Ashpole Swamp 7.5 miles downstream. Ashpole Swamp then joins the Lumber River in South Carolina.

In the vicinity of Juniper Bay, Big Indian Swamp (Index No. 14-30-8-1) has a Best Usage Classification of C Sw (DWQ 12/1/63) from its source to its confluence with Indian Swamp. Class C waters are suitable for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture. Sw is a supplemental classification indicating Swamp Waters, or waters which exhibit slow velocity. Downstream of Big Indian Swamp, both Indian Swamp (Index No. 14-30-8) and Ashpole Swamp (Index No. 14-30) are also designated as Class C Sw waters. Ashpole Swamp eventually drains into the Lumber River south of the South Carolina state line.

The Juniper Bay watershed is comprised almost exclusively of the bay itself. Very little area exists outside of the bay which could provide surface or groundwater inputs to the site. Most of the area around the bay drains away from the site toward other drainageways. Approximately 148 acres of potential watershed exist outside Juniper Bay which could contribute limited inputs of groundwater to the site. This watershed is currently occupied primarily by agricultural/silvicultural land. Some limited residential/commercial development occurs along roadways to the west and south of the site.

From a regional perspective, Juniper Bay is located within a relatively narrow flat at an elevation of approximately 118 feet between to larger regional drainage systems. Two low sand ridges separate this flat from the larger drainageways to the east and west. Hog Swamp (Index No. 14-30-7) is located approximately 0.3 miles to the west of Juniper Bay with an approximate floodplain elevation of 97 feet. Hog Swamp flows southwestward into Ashpole Swamp 9.5 miles downstream. Shelley Bay/Big Branch Canal (Index No. 14-18-1) is located to the east of the mitigation site. Big Branch Canal has an approximate floodplain elevation of 107 feet and flows northeastward to the Lumber River. Thus, a regional hydrologic divide occurs immediately to the east of the Juniper Bay mitigation site separating waters which flow eastward toward the Lumber River and waters which flow southward toward Ashpole Swamp. Both Hog Swamp and Big Branch Canal are designated Class C Sw waters.

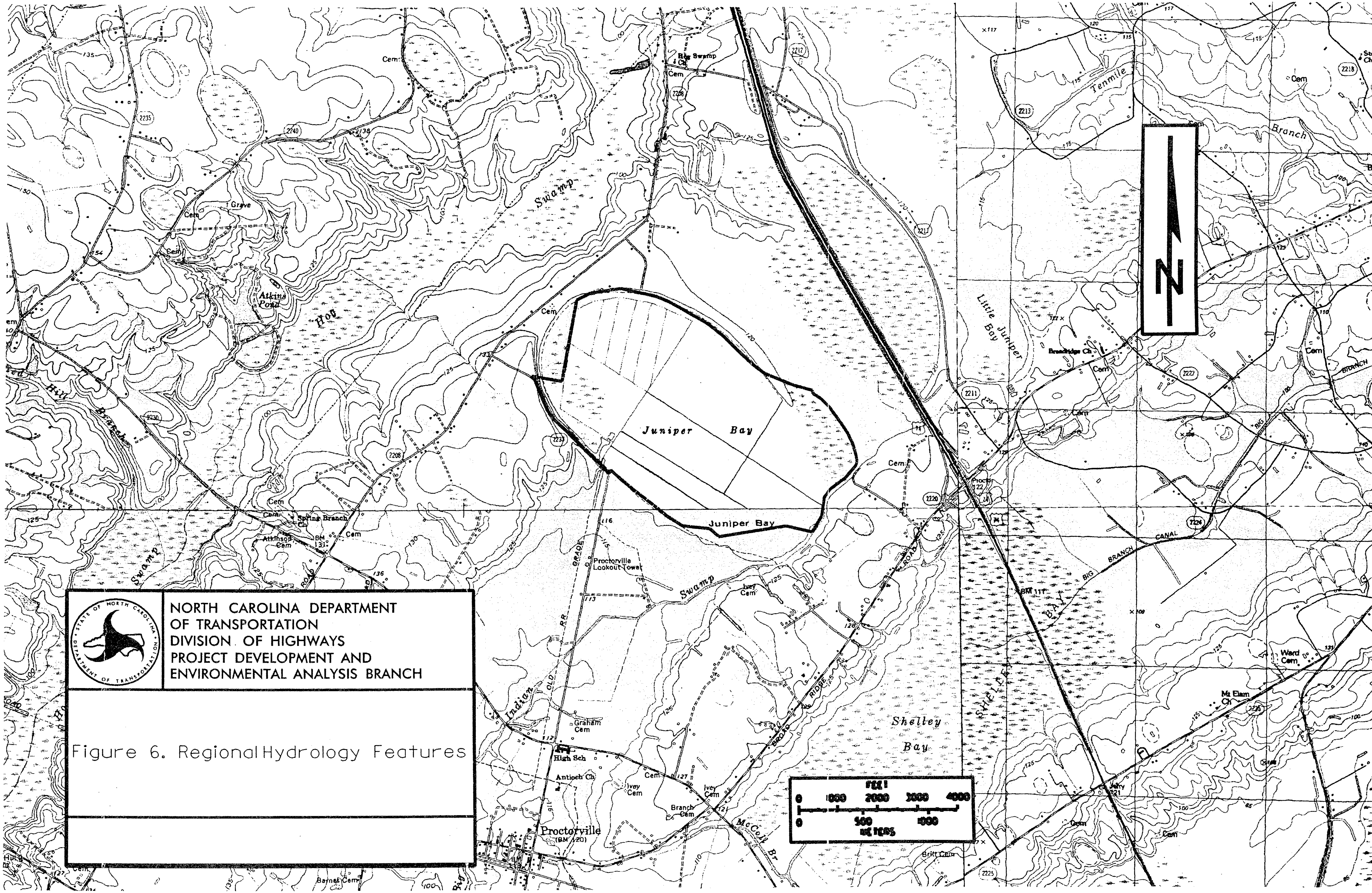

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Figure 6. Regional Hydrology Features

Carolina Bay Hydrology

Carolina bays are elliptical surface depressions, and as such, they typically function to collect and store surface and ground water within their perimeter. Carolina bays are defined as depressional wetlands according to the hydrogeomorphic classification system of Brinson (1993). As such, the primary direction of water movement is vertical. Secondary water movements may be radial toward the center of the bay or minor subsurface lateral flows along a groundwater gradient.

The principal hydrologic input into Carolina bays is direct precipitation and the principal output is via evapotranspiration. Thus, water fluctuations tend to be vertical, as water elevations rise following precipitation events and fall gradually as water is transpired. Groundwater inflow may occur from a surrounding watershed in some cases, depending on the location of the bay within the regional landscape and the surrounding topography. Regardless, restrictive subsurface soil horizons tend to limit deep infiltration of water and promote shallow groundwater tables. Also, the generally flat topography in the interior of Carolina bays inhibits the development of natural surface drainage patterns. Where small stream outlets do occur in Carolina bays, they are often small, low gradient channels with limited discharge potential.

Natural Hydrology of Juniper Bay

Predictions have been developed concerning the hydrology of Juniper Bay prior to human disturbance based on regional topography, soils, and historic information. Given its topographic location, the primary hydrologic input to Juniper Bay is precipitation. Only very limited potential watershed area exists outside of Juniper Bay which would contribute hydrology to the site. Most of the surrounding landscape drains toward Hog Swamp in the west, Shelley Bay/Big Branch Canal in the east, and to Big Indian Swamp to the south. The local Juniper Bay watershed is comprised of approximately 904 acres, of which 756 acres (84 percent) is within the perimeter of the bay itself. Only 148 acres exists outside the bay rim which would tend to drain toward Juniper Bay. Such a limited area would not likely contribute significant quantities of water to the 756 acre bay. Thus, the Juniper Bay formation comprises a nearly independent headwater watershed supported by direct precipitation.

Prior to ditching, groundwater was most likely close to the ground surface during much of the early growing season (March-April) and following significant rain events during the summer. Restrictive subsurface soil layers, along with a lack of defined natural channel conveyances, caused water to accumulate on-site until it was lost to evapotranspiration or very slow lateral groundwater movement. When water levels within the bay were very high during late winter or early spring or following high rainfall events, surface water or shallow groundwater would tend to drain toward the lower elevations at the center of the bay. A natural low spot in the sand rim occurs in the southeast corner of the site where surface water may tend to drain toward Big Indian

Swamp. Lateral movement of deep groundwater would likely tend to occur toward Hog Swamp to the west, Shelley Bay/Big Branch Canal to the east, and Big Indian Swamp to the south. The precise direction and proportion of such deep groundwater flows are undetermined at this time, but regardless would not affect the wetland characteristics of the site.

Existing Hydrology of Juniper Bay

The existing hydrology of Juniper Bay has been fundamentally altered by an extensive network of drainage ditches which were excavated throughout the site from 1968 to 1981 (Figure 7). The effort and resources invested to drain the bay for agriculture is impressive. A total length of 33.85 miles of ditches has been excavated on the site. A large perimeter ditch encircles the site, roughly along the property boundary. Two main collector ditches run primarily north-south, dividing the site into approximate thirds. From these collectors a parallel network of lateral ditches were installed perpendicular to the two main collectors along the primary axis of the bay (northwest to southeast). The entire ditch network discharges through a single pipe on the southwest boundary of the property under SR 2233, connecting to on off-site ditch system that drains to Big Indian Swamp approximately 1.0 miles south. This network of ditches serves to collect surface runoff and discharged groundwater and to convey them off-site, thereby lowering average groundwater levels. In addition, the perimeter ditch, which encircles the property and follows the interior base of the bay's sand rim, functions as a barrier to any off-site inputs of groundwater or surface runoff from large precipitation events.

Ditch spacing between parallel lateral ditches varies from approximately 284 feet to 102 feet. Lateral ditch depths are also highly variable across the site, from 2 to 4 feet. The perimeter ditch averages 4 feet in depth and 18 feet in width, while the central collector ditches average 6 feet deep and 25 feet wide. Both the perimeter ditch and the central collector widen and deepen at the discharge point under SR 2233. Several flashboard riser systems have been installed at the main outlet and other points along primary collector ditches to allow agricultural manipulation of water table depths to provide subsurface irrigation during the growing season. Use of these flashboard risers allowed management of groundwater levels within the bay to retain water on-site during periods of low rainfall and thus to increase available water for crop growth. Such systems are indicative of the hydrologic influence the drainage system exerts across the bay.

Despite the significant efforts expended on drainage, Juniper Bay can still experience elevated water table levels in the winter and after large storm events. In the winter, evapotranspiration is very low and water levels in regional drainageways like Big Indian Swamp are higher, resulting in reduced hydraulic head for off-site drainage. After large precipitation events, fields are often wet because of the time delay required for infiltration and off-site drainage. As a result, water still occasionally ponds in some

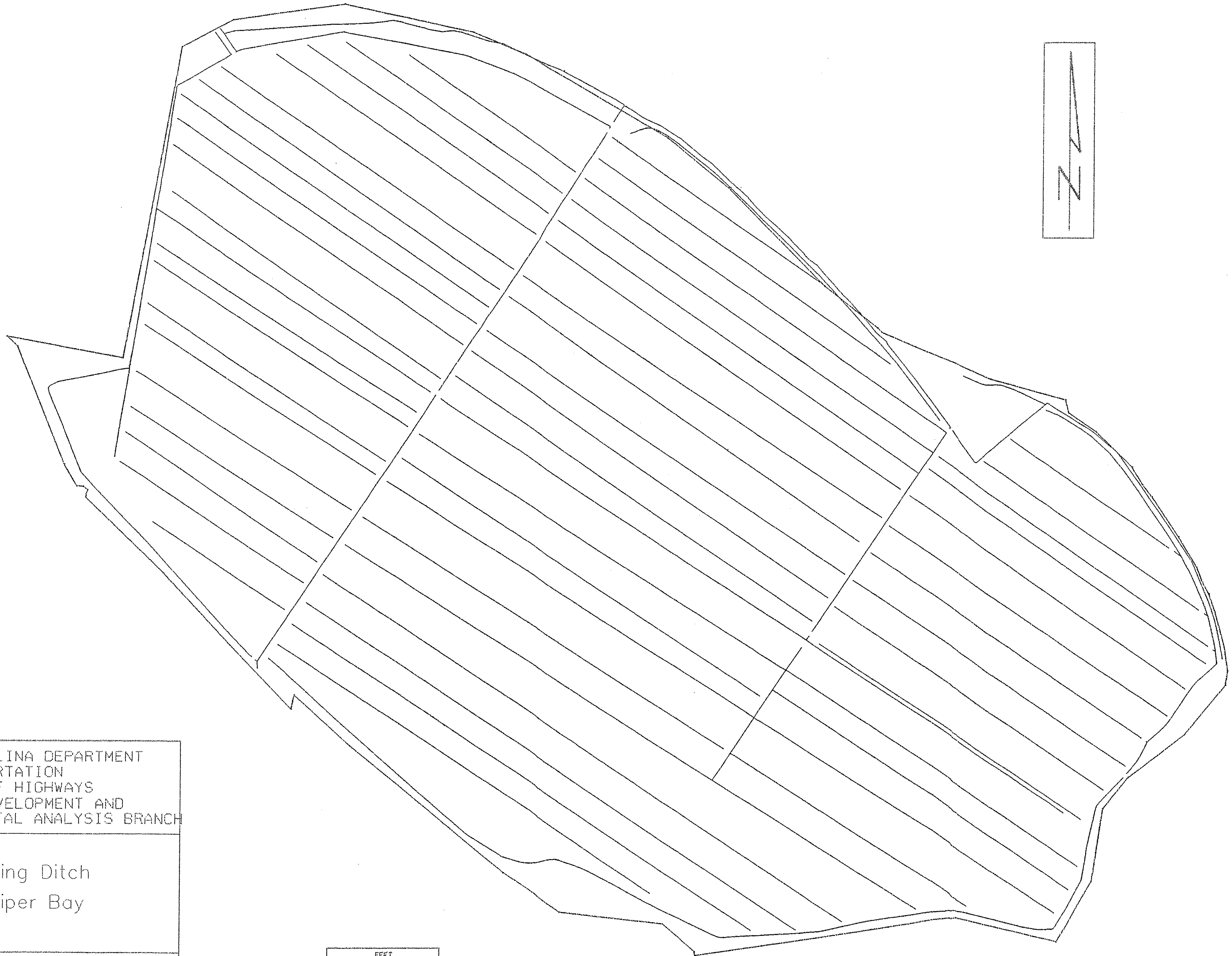

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Figure 7. Existing Ditch Network at Juniper Bay

fields, particularly in low spots between ditches or in organic soils, resulting in some crop loss and deep rutting of farm machinery.

Hydrologic trespass issues on adjacent properties remain a significant concern to mitigation planning. The perimeter ditch which encircles the property runs along the property boundary or in close proximity, such that the drainage effect of this ditch extends across to adjacent properties. Because this ditch has been in place for many years, NCDOT would likely be liable for any flooding or increased saturation which would limit the land use of adjacent landowners. However, acquisition and protection of the site in perpetuity will prevent the potential for future ditch cleaning along the perimeter ditch, and over time it should fill in naturally as it becomes blocked with debris and collapsed ditch bank material.

Recent beaver activity is present on the property at various locations which has affected the drainage capacity of the ditch network. While the property was under cultivation, owners and leasers cleared such beaver dams to maintain crop production. However, under recent NCDOT ownership beaver activity has increased because of less frequent on-site activities and other demands on mechanized equipment. In particular, during the growing season of 2001, beaver have become active at the primary outlet under SR 2233. The effectiveness of such activities and the resulting changes in hydrology data demonstrate the drainage capacity of the existing ditches.

Groundwater Monitoring

Water table monitoring gauges were installed on January 11, 2000 across site in representative locations in relation to each soil type identified by NRCS and to apparent topographic gradients (Figure 8). A total of 18 RDS continuous monitoring gauges were installed to a depth of 40 inches. Monitoring gauge elevations were surveyed to establish an absolute elevation of recorded water table measurements. Gauge numbers and elevations are indicated in Appendix B.

Five sets of paired gauges were installed to record the effect of soil type and ditch spacing on water table depth. One of the paired gauges was installed at the midpoint between the parallel ditches, while the other gauge was installed between the ditch and the first midpoint ditch. With this system, data should indicate the highest expression of the water table between ditches (midpoint gauge) and the angle of the sloped water table (quarter point gauge).

Gauges were also placed in relation to topography to record the effect of general site elevation on water table depth. Two gauges were placed at the approximate 117.5 foot elevation while two other gauges were placed at the approximate 119.5 foot elevation.

Two staff gauges were installed within the ditch system to record the water level in ditches across the site. One staff gauge was placed at the culvert opening at the

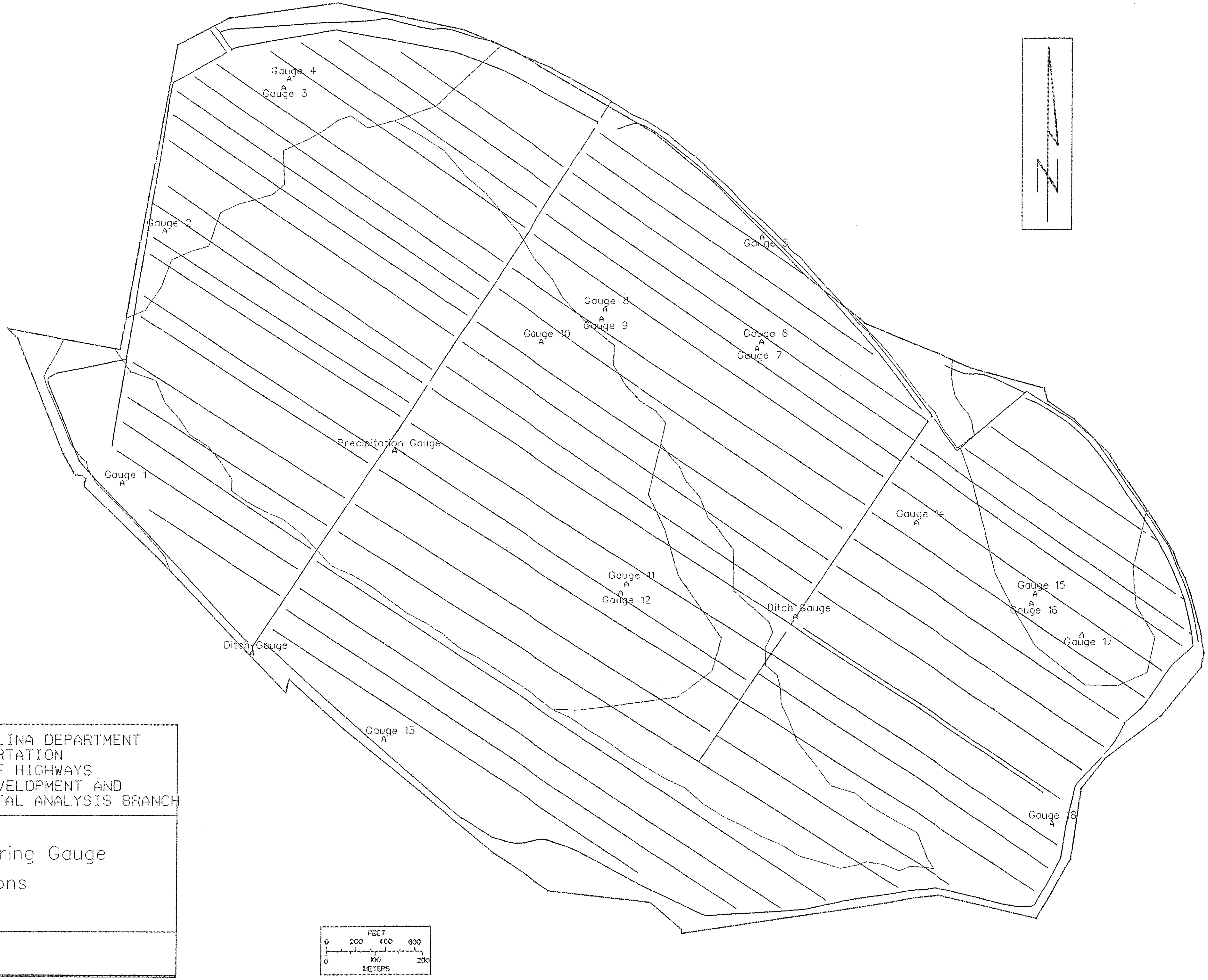

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Figure 8. Monitoring Gauge Locations

drainage outlet under SR 2233. A second staff gauge was installed in the second primary north-south collector ditch on the east side of the property.

According to the NRCS (1978), the growing season for Robeson County is between March 25 and November 4, a period of 225 days. Assuming that a hydroperiod of 12.5% of the growing season is necessary to guarantee jurisdictional hydrology, 28 days of continuous saturation within 12 inches of the surface is required to meet jurisdictional status. Also, given the normal seasonal fluctuations in groundwater levels, the early spring period from March 25 to April 21 would typically be the critical period during the growing season for meeting jurisdictional status. Table 9 indicates the longest hydroperiod exhibited by each gauge during the two growing seasons (2000 and 2001). Hydrographs for each gauge and be found in Appendix B.

Table 9. Longest hydroperiod exhibited by each monitoring gauge at Juniper Bay.

	2000		2001	
Gauge	**Days**	**% GS**	**Days**	**% GS**
1	3	1.3	0	0.0
2	9	4.0	3	1.3
3	3	1.3	0	0.0
4	3	1.3	0	0.0
5	11	4.9	7	3.1
6	11	4.9	7	3.1
7	16	7.1	NA	NA
8	11	4.9	4	1.8
9	11	4.9	4	1.8
10	16	7.1	14	6.2
11	16	7.1	13	5.8
12	8	3.6	2	0.9
13	10	4.4	3	1.3
14	14	6.2	8	3.6
15	10	4.4	8	3.6
16	14	6.2	9	4.0
17	78	34.7	67+	29.8+
18	11	4.9	5	2.2

Note: + - Gauge exhibited wetland hydrology on the last date of available data (August 7, 2001) and likely would have continued for additional days

As indicated in Table 9, only one gauge (Gauge 17) currently exhibit jurisdictional hydrology as defined by 12.5% of the growing season. As expected, the observed hydroperiod is correlated to gauge elevation and to the distance from the nearest drainage ditch. Gauges at lower elevations and further from existing ditches tend to be wetter than those at higher elevation or closer to ditches. These monitoring gauge data generally correspond with DRAINMOD results under current conditions.

The hydrograph of the staff gauge at the primary ditch outlet (JBSG1) indicates a minimum stage of approximately 20 inches above the ditch bottom. High water elevations in the ditch network are very short-lived. Also, the data show a general trend of increase from June through August 2001 resulting from beaver activity at the outlet pipe. Beaver have attempted to block this outlet and have succeeded in raising the water elevation approximately 25 inches. The interior staff gauge (JBSG2) exhibits no such trend.

Precipitation

Long-term precipitation records were obtained from the N.C. State Climate Office for the weather station located at Lumberton, N.C. (Station number 315177). Data include monthly precipitation averages for the years 1971 through 2001, and daily data for the years 2000 and 2001. Precipitation data are included in Appendix C. As indicated, data are lacking for 1991 and much of 1990. Also, data for 2001 are current up to August when the data were requested.

These data indicate that over the past 30 years Robeson County has received an average of 47.96 inches of precipitation a year. In general, the precipitation is spread evenly throughout the year, though slightly more precipitation occurs in the summer months. The minimum annual precipitation observed during this period was 36.28 inches in 1986. The maximum annual precipitation observed was 62.73 inches in 1999, primarily resulting from extreme rainfall generated by Hurricane Floyd.

The Robeson County Soil Survey (NRCS 1978) additionally notes that much of the rainfall during the growing season is associated with summer thunderstorms, and therefore is highly variable from year to year, month to month, or place to place in the county. Also, tropical storms occasionally occur in late summer or autumn which can significantly affect precipitation records. Rainfall in the winter tends to be less variable.

Hydrology Modeling

DRAINMOD

DRAINMOD was developed to simulate the performance of agricultural drainage and water table control systems on sites with shallow water table conditions (Skaggs, 1980). The model was subsequently modified for application to wetland studies by recording the number of events wherein the water table meets certain criteria of depth and duration. Model results are analyzed to determine if wetland criteria are satisfied for sufficient duration during the growing season of most years. Through this methodology, DRAINMOD can be used to characterize water table elevations under current drained conditions and then to predict groundwater levels under post-restoration conditions. Simulation parameters include the threshold water table depth, required duration of high water tables, and beginning and ending dates of the growing season. For this application, wetland hydrology is defined as groundwater within 12 inches of the surface for 28 consecutive days (12.5 percent of the growing season). The growing season is defined as the period between March 25 and November 4.

DRAINMOD predicts water balances in the soil-water regime at the midpoint between two drains of equal elevation. The model is capable of calculating hourly values for water table depth, surface runoff, subsurface drainage, infiltration, and actual evapotranspiration over long periods of climatological data. The model can be used to reliably predict water table elevations and drain flow rates, and to evaluate wetland hydrology.

Model Data

- Length of Growing Season
- Rainfall Data
- Surface Storage Parameters
- Evapotranspiration rates
- Ditch depth and spacing
- Soil Hydraulic Conductivity Values

The water balance in DRAINMOD involves two basic equations. The first equation is a water balance in the soil profile:

$$Va = D + ET + DS - F$$

Where:

	Va	= change in volume of air
	D	= drainage from the profile
	ET	= actual evapotranspiration from the profile
	DS	= deep seepage from the profile
	F	= infiltration into the profile

The second equation is a water balance at the soil surface:

$$S = P - F - RO$$

Where:

	S	= change in volume of water stored at the soil surface
	P	= precipitation
	F	= infiltration volume
	RO	= surface runoff

Methods for evaluating equation variables are discussed in detail in Skaggs (1980).

Model Results

DRAINMOD simulations were conducted for the time period from 1971 to 2000, using climatological data from Lumberton, N.C. (Appendix C). According to the study parameters, wetland hydrology is achieved in the model if target hydroperiods are met for one half of the years modeled.

Hydrology of various soil-water conditions applicable to the Site was simulated using DRAINMOD. Each hydric soil type was evaluated. Table 10 indicates the radii of influence for existing ditches in each hydric soil series. DRAINMOD simulation results indicate that hydric soils do not currently meet wetland hydrology criteria during at least XXX of the XXX years simulated. These areas are lacking wetland hydrology due to ditching which ranges from XX feet to XX feet in depth. The area in which jurisdictional wetland hydrology is removed (radius of influence) ranges from approximately XXX feet adjacent to the shallowest ditches to XXX feet adjacent to the deepest ditches. DRAINMOD simulations for existing conditions indicate that XX-foot deep ditches effectively drain wetlands (i.e. saturation less than 12.5% of the growing season) at a distance of XX feet from the ditch edge.

Table 10. Projected radii of influence of various ditch depths as forecast by DRAINMOD in hydric soils at Juniper Bay.

		Radii of Influence (ft.)	
Soil Series	Ditch Depth (ft.)	12.5%	5%
Muck	1		
	2		
	3		
	4		
	5		
Sand	1		
	2		
	3		
	4		
	5		

Note: Radius of influence refers to a distance, perpendicular to a ditch, from which that ditch is expected to remove wetland hydrology.

Zone of influence is equal to one-half of the modeled ditch spacing.

The model predicts that a one-foot deep ditch exhibits negligible impact on drainage.

Based upon DRAINMOD simulations, approximately XXX acres of hydric soils are presently lacking jurisdictional wetland hydrology. Figure XX suggests that approximately XX acres will support wetland hydrology for greater than 12.5 % of the growing season after restoration is completed. This estimate represents a XXX acre increase in wetlands relative to model predictions for existing conditions. For the model, the perimeter ditch is project to remain open to accommodate drainage from adjacent properties.

Natural Communities

Currently, Juniper Bay primarily supports agricultural fields that have been used in the cultivation of soybeans and cotton. Virtually no vegetation typical of natural Carolina bays presently exists on the site. A few species of herbaceous plants occurred interspersed among the crop plants, however, growth of these non-crop species on the site had been extensively controlled through periodic plowing and herbicide applications. Immediately following these activities most of the soil surface was devoid of vegetation. The site has currently been abandoned for agricultural purposes, and the fields are vegetated with various herbs and grasses. In addition, there are small areas of the site which support other natural communities as indicated in Figure 9. Each primary community type is described below. A complete listing of the species observed at Juniper Bay is included in Appendix D.

Agricultural Fields/Ditches

Agricultural fields and ditches occupy the vast majority of the site, comprising 641.4 acres, or 88 percent, of the total property. At this time, agricultural activities on the site have been terminated and the fallow fields are regenerating with various pioneer herbs. In particular, there has been a proliferation of dog fennel (*Eupatorium capillifolium*), morning glory (*Ipomea purpurea*), Johnson grass (*Sorghum halepense*), and goldenrod (*Solidago* spp.) on site in the fallow drained fields. A variety of other herbs and grasses are also present.

The network of drainage ditches across the site contains some shrub and tree species which are periodically mowed to reduce their height. These ditches support a much greater diversity of species than the adjacent fields because of the less frequent disturbance and the wet soil conditions at the bottom of the ditches. Dominant species observed in the drainage ditches include red maple (*Acer rubrum*), black willow (*Salix nigra*), blackberry (*Rubus* sp.), poison ivy (*Toxicodendron radicans*), tearthumb (*Polygonum* spp.), and winged sumac (*Rhus copallina*). Additional species observed are listed in Appendix D.

Longleaf Pine Plantation

Approximately 43.9 acres of the site along the south rim were planted with longleaf pine (*Pinus palustris*) in 1994 and have developed into an open, young pine plantation. In addition to the longleaf pine canopy, this area supports an understory of dog fennel (*Eupatorium capillifolium*), goldenrod (*Solidago* spp.), broomsedge (*Andropogon virginicus*), and trumpet creeper (*Campsis radicans*), along with various other herbs and grasses.

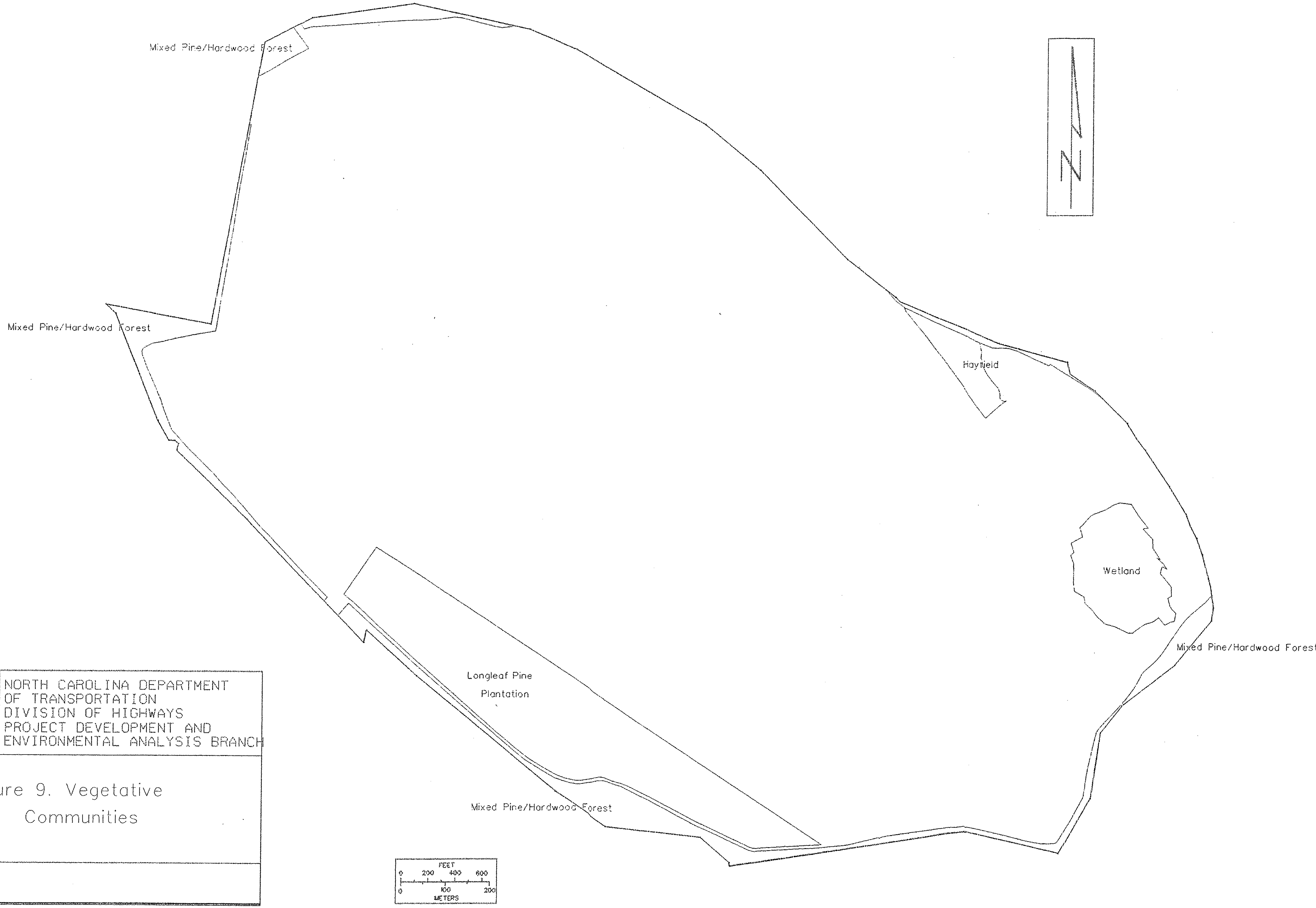

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Figure 9. Vegetative Communities

Emergent Marsh

A small portion of the site in the northeast corner currently supports an emergent wetland system. This emergent wetland comprising 11.8 acres occurs in a topographic depression underlain by a clay subsoil which is too distant from the primary ditch outlet to receive complete drainage, and as a result has maintained sufficient hydrology to be jurisdictional. Despite its wet condition, the area was still periodically plowed and planted as part of the overall agricultural activities on site. As a result, it has developed into an emergent marsh system dominated by woolgrass (*Scirpus cyperinus*), tearthumb (*Polygonum pensylvanicum*), red-root flatsedge (*Cyperus erythrorhizos*), plume grass (*Erianthus giganteus*), and soft rush (*Juncus effusus*).

Mixed Pine/Hardwood Forest

Small areas of mixed pine/hardwood forests exist around the rim of the bay immediately outside of the perimeter ditch totaling 31.5 acres. The largest zone of this forest occurs in the southwest corner of the bay which is outside of the NCDOT property line. These perimeter forests appear to have had timber harvested in the past and have subsequently been altered in their species composition. These forests often exist as narrow strips between agricultural fields or along roadsides. Species observed include loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*), water oak (*Quercus nigra*), sweetgum (*Liquidambar styraciflua*), wax myrtle (*Myrica cerifera*), sweetbay (*Magnolia virginiana*), and red bay (*Persea borbonia*). Because of their occurrence on the slopes of the bay rim or on adjacent properties, none of these areas are proposed for wetland restoration activities.

Wildlife

Wildlife observed at Juniper Bay includes species typical of early successional habitats. In addition, some wildlife associated with wetlands and stream habitats has been observed utilizing the extensive ditch network throughout the site. A complete list of the wildlife species observed at the site is included in Appendix D.

Summary

None of these communities described represents the probable natural vegetation of Juniper Bay prior to disturbance. Even the small emergent marsh community has been significantly disturbed in both hydrology and vegetative composition. Species observed in the ditch network are a mixture of wetland trees and shrubs along with opportunistic early successional species. As a result, none of the existing communities observed at Juniper Bay represents a reasonable target community for the proposed restoration activities. All vegetation on site is assumed to be too disturbed to be indicative of natural conditions.

Reference System

A reference wetland was identified to aid in the planning and design of the proposed mitigation site. It is the intent of the mitigation project to attempt to mimic the natural communities, soils, topography, and hydrology found in the reference system to the greatest extent possible. However, some degree of natural variability is to be expected between the two sites. Attempts to reproduce exactly the precise conditions which exist at the reference site are likely to be unsuccessful. Reference systems can serve as a useful guide to the general soils, hydrology, and natural communities which exist in undisturbed conditions. In addition, water table monitoring gauges at the reference site will be used to evaluate conditions at Juniper Bay when annual or seasonal climatic conditions may be atypical.

The site selected for study is Tatum Millpond Bay located in Bladen County within the Bladen Lakes State Forest. This Carolina bay site is located approximately 30 miles to the northeast of Juniper Bay and is part of the Cape Fear River drainage basin (Figure 10). However, because both Juniper Bay and Tatum Millpond Bay occur in broad interstream flats that are not subject to overbank flooding, comparison between the two should still be valid despite these differences in drainage basin.

Tatum Millpond Bay was selected as a reference system based on its general similarity of soil types and landscape features to Juniper Bay, and because of its public ownership and protected status. However, it is important to note that while the two sites are similar, they are not identical and reasonable judgment must be used in making comparisons between sites. Tatum Millpond Bay comprises approximately 2040 acres and is 2.8 miles long along its long axis and 1.4 miles long along its short axis. Thus, Tatum Millpond Bay is nearly three times larger than Juniper Bay which suggests that some important differences between the two sites may occur.

Tatum Millpond Bay is a Registered Natural Heritage Area in North Carolina because of its exemplary condition as an undisturbed Carolina bay. The NCNHP has identified Tatum Millpond Bay and others within the Bladen Lakes State Forest as among the best representations of Carolina bays in public ownership in the state. The Registered Natural Heritage Area designation assures that Tatum Millpond Bay will remain in an undisturbed condition in perpetuity and so will serve as a constant indicator of appropriate steady-state characteristics.

Despite its current protected status, evidence of past selective timber harvesting may have altered species composition somewhat, particularly along the margins of the bay. The North Carolina Forest Service has indicated that Tatum Millpond Bay had been logged selectively for Atlantic white cedar and pond pine until 1954. Also, disruption of the natural fire regime may have also played a role in current forest stand development. The site is not known to have burned since 1935. Fire exclusion reduces the occurrence of fire dependent species such as pond pine, Atlantic white cedar, and longleaf pine and, conversely, allows fire intolerant species including red maple and sweetgum to become

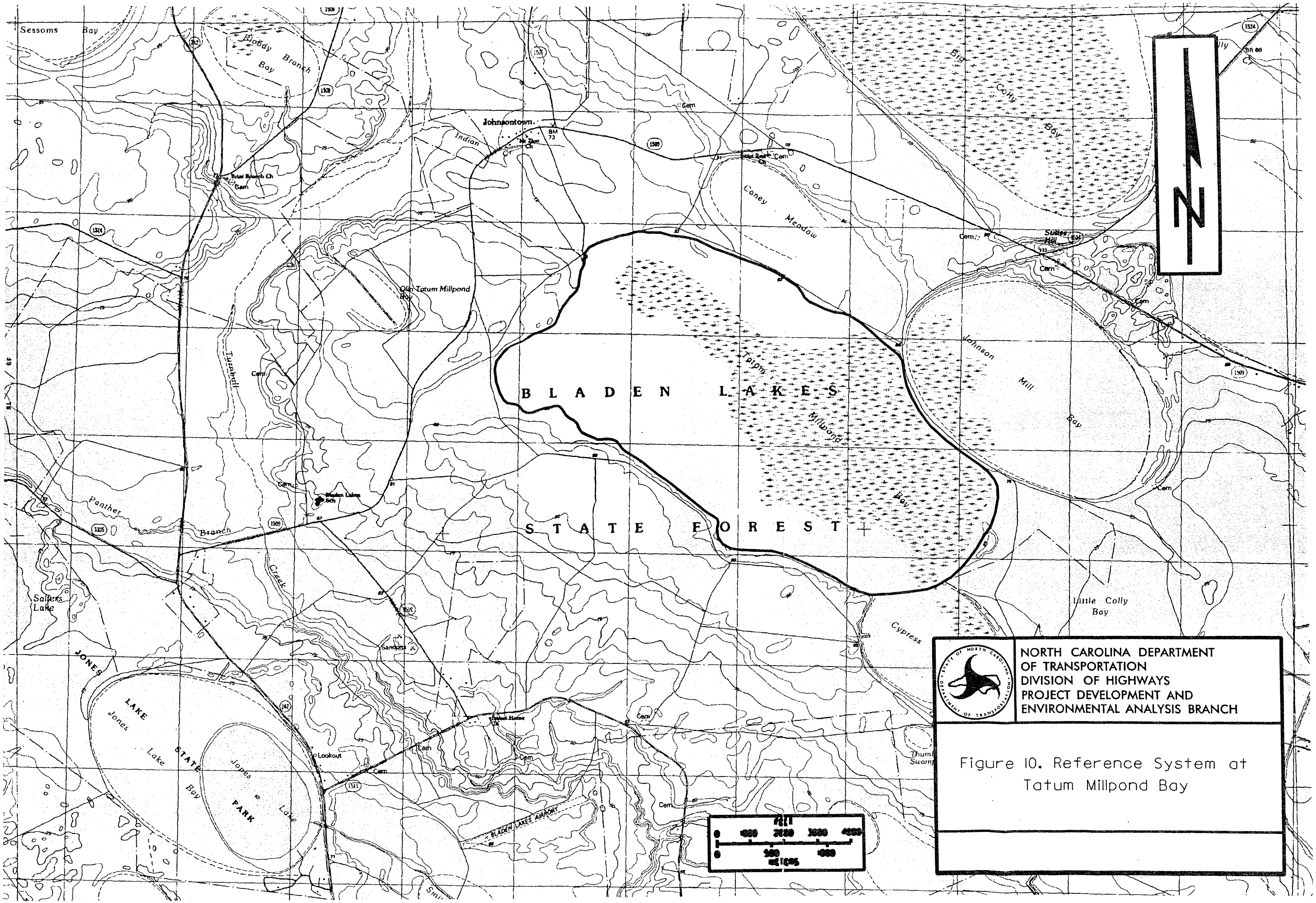

Figure 10. Reference System at Tatum Millpond Bay

more dominant. Therefore, some degree of professional judgment may be required in interpreting natural community composition and structure.

Soils

The Bladen County soil survey (NRCS 1990) identifies six dominant soil types as occurring in Tatum Millpond Bay (Table 11). Of these, three were studied for comparison to the soils of Juniper Bay: Croatan muck, Torhunta, and Lynn Haven. Pamlico muck, Johnston, and various non-hydric soil types were identified by NRCS in the bay but were not studied because they did not appear to be representative of soils found at Juniper Bay. Figure 11 depicts the soils at Tatum Millpond Bay as mapped by NRCS. The taxonomy of the soil series studied is described in Table 12.

The three soils studied generally correspond to the principal soils observed at Juniper Bay. Organic muck soils occur in the interior of the bay, while sand and loam soils occur around the perimeter. However, Tatum Millpond Bay does have a greater proportion of muck soil, especially Croatan muck. This suggests that the interior of the bay may be wetter than Juniper Bay under natural conditions. Also, the depths of organic horizons at Juniper Bay are not as deep as those described for Pamlico muck soils. A brief description of the three primary soil types is provided following Table 12.

Table 11. Soil series identified at Tatum Millpond Bay (NRCS 1990).

Soil Series	Mapping Unit	Area (acres)	Percent of Site	Hydric Status
Pamlico muck	Pa	1327.2	65.1	Hydric
Croatan muck	Cr	312.8	15.3	Hydric
Torhunta	Tr	188.0	9.2	Hydric
Lynn Haven	Ly	173.6	8.5	Hydric
Johnston	Jo	8.6	0.4	Hydric
Non-hydric soils		30.1	1.5	Non-hydric
Total		**2040.3**		

Table 12. Taxonomy of soil series identified at Tatum Millpond Bay by NRCS.

Series	Subgroup	Order
Croatan	Terric medisaprists	Histosols
Lynn Haven	Typic haplaquods	Spodosols
Torhunta	Typic humaquepts	Inceptisols

Croatan muck

The Croatan series consists of highly decomposed organic material underlain by loamy sediment. Croatan muck, rarely flooded (Cr) is a very poorly drained soil found in Carolina bays, irregular depressions, or stream terraces. Slopes are less than 2 percent.

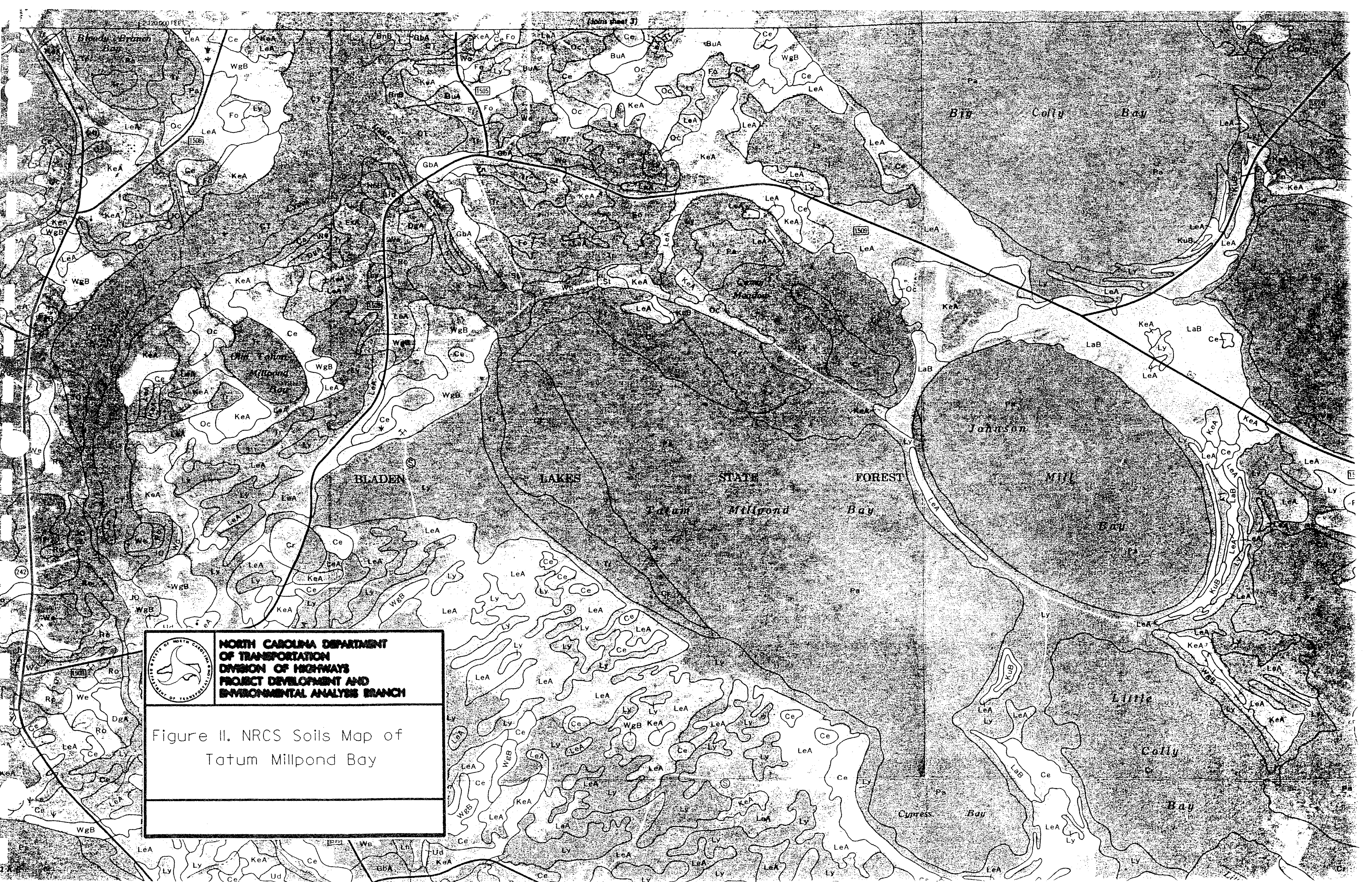

Figure 11. NRCS Soils Map of Tatum Millpond Bay

This soil has an organic horizon of muck 32 inches thick at the surface. The underlying material is brown clay loam to a depth of 62 inches. Permeability is slow to moderately rapid in the organic layers and moderately slow to moderately rapid in the mineral layers. The soil is extremely acid, and the seasonal high water table is at or near the surface for 6 to 10 months of the year. Some areas may be ponded.

Lynn Haven

Lynn Haven and Torhunta soils (Ly) are poorly drained and very poorly drained soils in low flats, slight depressions, and Carolina bays. Slopes are less than 2 percent. Lynn Haven soils formed in sandy sediments, Torhunta soils formed in loamy sediments. Most soils in this mapping unit are approximately 60 percent Lynn Haven, 20 percent Torhunta, and 20 percent other soils. Lynn Haven soil has a black sand surface layer 9 inches thick. The subsurface layer is grayish brown sand to a depth of 12 inches. The subsoil is sand to 80 inches in depth. Permeability is rapid, and the soil is extremely acid to strongly acid. The seasonal high water table is at or near the surface. Torhunta soil has a black mucky sandy loam surface 8 inches thick. The subsurface is black sandy loam to a depth of 16 inches. The subsoil is grayish brown sandy loam and loamy sand to a depth of 47 inches. Below this to 74 inch depth is gray sand. Permeability is moderate, and the soil is extremely acid to strongly acid. The seasonal high water table is at or near the surface for long periods from winter to early spring. Some areas may be ponded.

Torhunta

Torhunta mucky sandy loam (Tr) is a poorly drained soil found in Carolina bays, on broad irregularly shaped flats, and in long narrow drainages. Slopes are less than 2 percent. Torhunta soil has a black mucky sandy loam surface 8 inches thick. The subsurface is black sandy loam to a depth of 16 inches. The subsoil is grayish brown sandy loam and loamy sand to a depth of 47 inches. Below this to 74 inch depth is gray sand. Permeability is moderately rapid, and the soil is extremely acid to strongly acid. The seasonal high water table is at or near the surface for long periods from winter to early spring. Some areas may be ponded for brief periods.

Hydric Soils Classification

All four of the primary mapping units identified at Tatum Millpond Bay by the NRCS are defined to be comprised fully of hydric soils or to have hydric soils as a major component. All are defined as hydric soils under natural conditions because of saturation for a significant period during the growing season, although Croatan muck and Pamlico muck are also ponded for long or very long periods during the growing season. Table 13 presents the natural hydrologic characteristics of the soils identified by NRCS.

Table 13. Hydrologic properties of soils identified at Tatum Millpond Bay.

Series	Flood Frequency	High Water Table	Months
Croatan	Rare	+1.0-1.0 ft.	Nov-Jul
Lynn Haven	None	0.0-1.0	Nov-Apr
Pamlico	Rare	0.0-1.0	Dec-May
Torhunta	Rare	0.5-1.5	Dec-May

Hydrology

Natural Hydrology of Tatum Millpond Bay

From a hydrologic perspective, Tatum Millpond Bay is fundamentally undisturbed. There are no significant ditches on the site and no apparent alterations to water levels or movement. Primary hydrologic inputs appear to be from direct precipitation, though some lateral groundwater input may occur from surrounding uplands to the south and west.

A small headwater stream, Indian Creek, leaves the bay on the northwest corner, draining toward Turnbull Creek. This stream appears to have limited channel development which extends only marginally into the bay. The area of the bay under the direct influence of these channels is less than 5-10 percent of the total bay area.

Tatum Millpond Bay occurs within a large complex of Carolina bays in central Bladen County. Four other bays overlap Tatum Millpond Bay or are immediately adjacent to it. Because the elevation of all of these bays is likely similar, their hydrology is interconnected, forming a broader expanse of flats, depressions, and sloughs. Though interconnected, each bay would no doubt exhibit wetland characteristics on its own, even if isolated. Tatum Millpond Bay is the largest Carolina bay in this grouping, and its hydrology likely predominates.

The larger size and greater extent of muck soils present at Tatum Millpond Bay suggest that the central interior of this site may be naturally wetter than that expected at Juniper Bay. Therefore, it was determined that the central portion of the site would not serve as an appropriate reference system. Studies of hydrology, soils, and vegetation were thus limited to the perimeter of the bay, to a distance of approximately 600 feet into the interior.

Groundwater Monitoring

Six water table monitoring gauges were installed on site along three transects to begin recording fluctuations in water table levels (Figure 12). Gauges were installed in locations which corresponded to representative soil types as shown in the Bladen County Soil Survey (NRCS 1990). Most gauges were installed somewhat near the perimeter of the bay because of the dense vegetation present on site and the extreme difficulty of

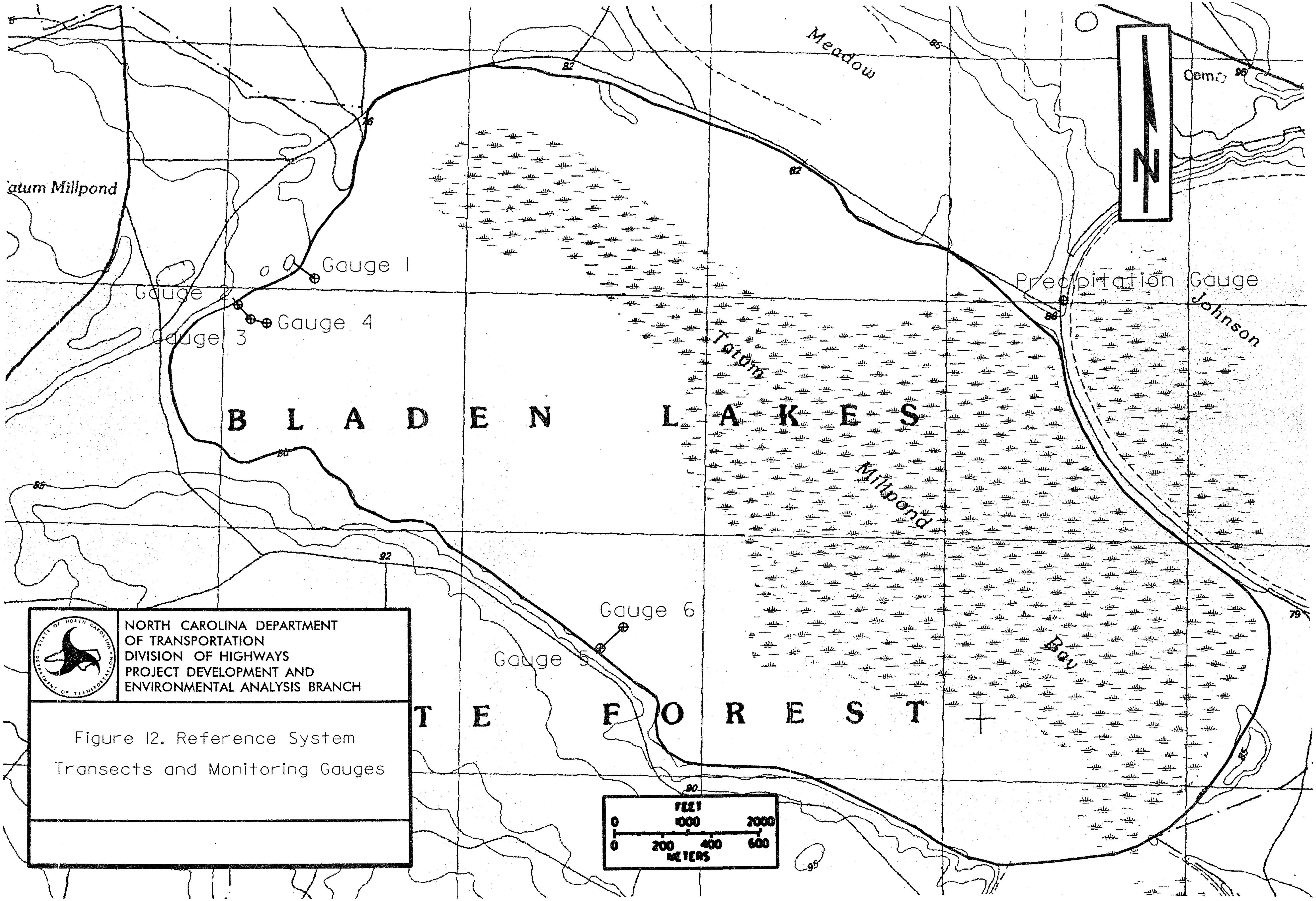

Figure 12. Reference System Transects and Monitoring Gauges

cutting and maintaining access trails. Thus, much of the far interior of the bay remains beyond the reasonable range of study. However, given the bowl-shaped characteristics of the landform, it is reasonable to assume that the hydrology and hydric soil characteristics of the bay (i.e. organic matter content, hydroperiod, etc.) will increase toward the interior.

The growing season for Bladen County is defined as April 2 to October 31, a period of 213 days (NRCS 1990). This is somewhat shorter than the growing season identified by the NRCS in adjacent Robeson County. In order to provide consistent comparisons between both sites, the Robeson County growing season of March 25 to November 4 (225 days) was used to define the growing season for Tatum Millpond Bay.

Water table data collected to date are presented in Appendix B. In general, the data clearly indicate that soil saturation occurs for sufficient duration to meet wetland jurisdictional criteria (Table 14).

Table 14. Longest hydroperiod exhibited by each monitoring gauge at Tatum Millpond Bay.

	2000		2001	
Gauge	**Days**	**% GS**	**Days**	**% GS**
1	113	50.2	136+	60.4+
2	97	43.1	50	22.2
3	80	35.6	34	15.1
4	86	38.2	53	23.6
5	113	50.2	136+	60.4+
6	225	100.0	136+	60.4+

Note: + - Gauge exhibited wetland hydrology on the last date of available data (August 7, 2001) and likely would have continued for additional days

All monitoring gauges at Tatum Millpond Bay exhibit jurisdictional wetland hydrology in both years, and most gauges indicate very wet conditions, in excess of the 12.5 percent threshold established by the U.S. Army Corps of Engineers. As expected, variability occurs between soil types. The Croatan muck exhibits the longest hydroperiods (Gauges 1 and 6), while the Lynn Haven sand exhibits the shortest hydroperiod (Gauges 2 and 3). Torhunta soils were intermediate. The driest recorded site occurred at Gauge 3 which exhibited a maximum hydroperiod of 34 days in 2001. Gauge 6 was by far the wettest site observed, and in fact, the water table at this location did not drop below 12 inches for the entire 16-month monitoring period. These data indicate hydroperiods much longer than those observed at nearly all of Juniper Bay (Table 9). Only Gauge 17 at Juniper Bay exhibited a hydroperiod similar to that recorded at Tatum Millpond Bay. Hydrographs of both sites clearly indicate the more extreme water table fluctuations which occur at Juniper Bay due to the rapid drainage of water by the ditch network. While water table variability does occur at Tatum Millpond Bay, the fluctuations are much more gradual since most water is lost from the site via evapotranspiration. Groundwater data will continue to be collected at the reference site throughout the duration of the mitigation monitoring period (five years) to observe trends and note variability associated with climatic conditions.

Natural Communities

Plant communities were studied along the established sampling transects to document the species composition of the reference system. Wildlife species observed were also noted. Plant communities were best fit to the NCNHP classification scheme based on the species observed. Evidence of past selected timber harvesting (e.g. residual stumps) suggests that canopy composition may have been altered in some locations. NC Forest Service records indicate timber harvesting within Tatum Millpond Bay up to 1954. Therefore, predictions were made as to likely community classification in some cases where canopy dominants did not clearly match identified types. Reference communities were identified to approximate steady state, climax community structure as described in the Classification of the Natural Communities of North Carolina (Schafale and Weakley, 1990), to provide goals for the wetland mitigation activities.

Species Observed

In general, the observed vegetation did not fit precisely into defined community types. However, trends in dominance and structure were apparent which suggest prior community structure. Community types observed along transects were correlated to NRCS soils mapping and to monitoring gauge data. In general, all of the communities sampled exhibited a very dense shrub layer with an open to moderately closed canopy of trees. Canopy trees were typically not extremely tall or large in diameter. Swales and hummocks were present along most transects.

Transect 1

Transect 1 occurs along the south side of Tatum Millpond Bay. The dominant soil type in this area is Croatan muck, grading into Torhunta along the margins. Monitoring gauges 5 and 6 are located along this transect, with gauge 6 located in the interior. Gauge 6 exhibited the longest hydroperiod of any gauge at the reference site. Dominant species of the canopy along this transect include red maple (*Acer rubrum*) and swamp tupelo (*Nyssa sylvatica* var. *biflora*). Swamp red bay (*Persea borbonia*), sweetbay (*Magnolia virginiana*), laurel-leaved greenbrier (*Smilax laurifolia*), fetterbush (*Lyonia lucida*), pepperbush (*Clethra alnifolia*), and maleberry (*Lyonia ligustrina*) dominate the midstory and shrub layer. Some Atlantic white cedar (*Chamaecyparis thyoides*) is present, particularly near the perimeter of the bay, but it lacks dominance throughout the majority of the stand. Similarly, the stand lacks significant occurrence of bays in the canopy, but these species are present in the midstory. Evidence of past timber harvesting suggests that certain species such as Atlantic white cedar and bald cypress (*Taxodium distichum*) may have been selectively removed. In addition, the forest shows evidence of numerous windthrows associated with recent hurricanes. A complete list of the species observed along Transect 1 is included in Table 1 of Appendix E.

Wildlife observed in this community include ruby throated hummingbird (*Archilochus colubris*), hooded warbler (*Wilsonia citrina*), Carolina wren (*Thryothorus ludovicianus*), bluejay (*Cyanocitta cristata*), white-eyed vireo (*Vireo griseus*), chickadee (*Parus carolinensis*), red bellied woodpecker (*Melanerpes carolinus*), and pickerel frog (*Rana palustris*).

Transect 2

Transect 2 occurs along the west side of Tatum Millpond Bay. The dominant soil type in this area is Lynn Haven, grading into Torhunta toward the interior. Monitoring gauges included on this transect are 2, 3, and 4. These gauges exhibited somewhat drier hydroperiods than other gauges in the reference system. The dominant canopy species observed in this community are loblolly pine (*Pinus taeda*) and loblolly bay (*Gordonia lasianthus*). Red maple (*Acer rubrum*), fetterbush (*Lyonia lucida*), inkberry (*Ilex coriacea*), and laurel-leaved greenbrier (*Smilax laurifolia*) are the dominant shrubs present. This community exhibited a distinct two-level structure with an open, relatively sparse overstory, and a very thick shrub layer. The intermediate level midstory was poorly developed. The forest lacks dominance of pond pine (*Pinus serotina*), though scattered individuals may occur. Past silvicultural activity in Tatum Millpond Bay may have resulted in a shift in dominance on site from pond pine to loblolly pine. In addition, the abundance of hardwood and shrub species indicates long fire exclusion. A complete list of species observed along Transect 2 is included in Table 2 of Appendix E.

Wildlife observed in this community include black bear (*Ursus americanus*), rufous-sided towhee (*Pipilo erythrophthalamus*), and southern toad (*Bufo terrestris*).

Transect 3

Transect 3 occurs along the west side of Tatum Millpond Bay. The dominant soil type in this area is Croatan muck, grading into Torhunta along the margins of the bay. Monitoring gauge 1 is located along this transect. The dominant canopy species observed along Transect 3 are loblolly bay (*Gordonia lasianthus*) and Atlantic white cedar (*Chamaecyparis thyoides*). The well developed midstory and shrub layer are comprised primarily of red maple (*Acer rubrum*), sweet bay (*Magnolia virginiana*), fetterbush (*Lyonia lucida*), inkberry (*Ilex coriacea*), and laurel-leaved greenbrier (*Smilax laurifolia*). A variety of other shrubs are also present. A complete list of species observed along Transect 3 is included in Table 3 of Appendix E.

Natural Community Classification

Based on the vegetative assemblages observed along the sampling transects, three natural communities have been identified at Tatum Millpond Bay which fit the classification scheme of the North Carolina Natural Heritage Program (NCNHP). These communities are Peatland Atlantic White Cedar Forest, Bay Forest, and Pond Pine Woodland. In addition, NCNHP records identify two other community types at Tatum Millpond Bay: Low Pocosin and High Pocosin. However, the mapped locations of these communities occur in the wettest central portions of the bay where soil and hydrologic conditions do not correlate well with the probable conditions of Juniper Bay. Also, the peat deposits described by NCNHP for these pocosin communities are deeper than those observed at Juniper Bay. As a result, these two community types have not been included in this study.

Although the forests observed along the sampling transects showed some evidence of past disturbance, the presence of residual dominants, appropriate associate species, and overall stand structure provide sufficient evidence to suggest prior community composition in relation to NCNHP types. Thus, the Peatland Atlantic White Cedar Forest, Bay Forest, and Pond Pine Woodland communities were identified as reference communities for Juniper Bay. The following community descriptions are from the NCNHP.

Peatland Atlantic White Cedar Forest

Peatland Atlantic White Cedar Forests occur in broad peatlands, Carolina bays, or other depressions with peat deposits and without flowing or seepage water. Organic soils supporting these communities may be either shallow or deep. Sites are typically intermittently to seasonally saturated.

The canopy is dominated by Atlantic white cedar (*Chamaecyparis thyoides*), with or without associated wetland trees such as pond pine (*Pinus serotina*), loblolly pine (*Pinus taeda*), red maple (*Acer rubrum*), swamp tupelo (*Nyssa biflora*), and bald cypress (*Taxodium distichum*). The understory is comprised of loblolly bay (*Gordonia lasianthus*), sweetbay (*Magnolia virginiana*), swamp red bay (*Persea palustris*), fetterbush (*Lyonia lucida*), titi (*Cyrilla racemiflora*), gallberry (*Ilex glabra*), maleberry (*Lyonia ligustrina*), blue huckleberry (*Gaylussacia frondosa*), and inkberry (*Ilex coriacea*). Herbs are typically sparse but may include partridgeberry (*Mitchella repens*), netted chainfern (*Woodwardia areolata*), and sphagnum moss (*Sphagnum* spp.).

The occurrence and distribution of this community type is determined by fire history, though hydrology and nutrient status may also be important factors. These forests typically occur as even-aged stands, often with a dense canopy, that establish after removal of the previous vegetation by a crown fire or other large disturbance. Such disturbance is necessary to eliminate sufficient numbers of competing trees and shrubs. As the even-aged stands mature, dead wood accumulates, making the community susceptible to severe fires. In the long absence of fires, these forests are believed to succeed to Bay Forest, Pond Pine Woodland, or Nonriverine Swamp Forest. However, more frequent fires can lead to the formation of Low Pocosin or High Pocosin communities.

This community type is prominent in the Carolina bays of the Bladen Lakes area. It is usually found in association with Nonriverine Swamp Forest, Pond Pine Woodland, or other pocosin communities. With fire control and fragmentation of large peatlands, fires suitable for creating patches of Peatland Atlantic White Cedar Forest have become extremely rare. With the loss of natural fire regime and with widespread logging and drainage, these communities, which were once abundant, have become very rare.

<u>Bay Forest</u>

Bay Forests occur on the outer parts of domed peatlands and in peat-filled Carolina bays. Soils are shallow organic soils or nutrient poor mineral soils with organic surface layers. Sites are typically seasonally flooded or saturated.

The vegetation of Bay Forests is dominated by combinations of loblolly bay (*Gordonia lasianthus*), sweetbay (*Magnolia virginiana*), and swamp red bay (*Persea palustris*). Associate species include pond pine (*Pinus serotina*), swamp tupelo (*Nyssa biflora*), red maple (*Acer rubrum*), loblolly pine (*Pinus taeda*), and Atlantic white cedar (*Chamaecyparis thyoides*). The moderately dense shrub layer is typically comprised of fetterbush (*Lyonia lucida*), titi (*Cyrilla racemiflora*), maleberry (*Lyonia ligustrina*), inkberry (*Ilex coriacea*), and dahoon (*Ilex cassine*).

Like other peatland communities, Bay Forests are wet and nutrient poor, though less so than Low Pocosins or High Pocosins. These communities are usually considered a late successional community replacing Peatland Atlantic White Cedar Forest or Pond Pine Woodland after long absence of fire. Severe fires may revert this community type to the other two, though more moderate fires likely do not. Bay Forests usually grade into Pond Pine Woodland, Nonriverine Swamp Forest, Peatland Atlantic White Cedar Forest, or High Pocosin.

<u>Pond Pine Woodland</u>

Pond Pine Woodlands occur on the outer parts of domed peatlands and peat filled Carolina bays. Soils are usually shallow Histosols or oligotrophic mineral soils with organic surface layers. Sites are typically temporarily flooded or saturated. The water table drops to the underlying mineral soil during the dry season, allowing plants access to subsurface nutrients.

The canopy is open to nearly closed and is dominated by pond pine (*Pinus serotina*), sometimes codominant with loblolly bay (*Gordonia lasianthus*). Associate species include sweetbay (*Magnolia virginiana*), red maple (*Acer rubrum*), loblolly pine (*Pinus taeda*), swamp red bay (*Persea palustris*), and Atlantic white cedar (*Chamaecyparis thyoides*). Shrub layer is tall and dense, comprised of titi (*Cyrilla racemiflora*), fetterbush (*Lyonia lucida*), maleberry (*Lyonia ligustrina*), inkberry (*Ilex coriacea*), gallberry (*Ilex glabra*), blue huckleberry (*Gaylussacia frondosa*), pepperbush (*Clethra alnifolia*), swamp red bay (*Persea palustris*), and laurel-leaved greenbrier (*Smilax laurifolia*). Herbs are usually nearly absent, although occasional Virginia chainfern (*Woodwardia virginica*), netted chainfern (*Woodwardia areolata*), and sphagnum (*Sphagnum* sp.) mats may be present.

Pond Pine Woodlands are wet and nutrient poor, though less so than pocosin communities. Sites are susceptible to fire during dry periods, and because water levels are lower, fires may occur more frequently than in wetter peatland communities. The high fuel loads can make fires intense, though recovery of the shrubs is generally rapid.

Target Vegetative Communities

Overall, the species composition is similar for all of the communities observed, particularly in the shrub layer. Community distinctions are primarily based on the relative dominance of a particular species at a particular site (i.e. loblolly bay, Atlantic white cedar, pond pine). Broad transitional zones appear to occur between the identified communities where dominance by a particular species or assemblage is not pronounced. Species in the shrub layer are somewhat ubiquitous throughout the described Carolina bay communities, especially fetterbush, laurel-leaved greenbrier, maleberry, and inkberry. Furthermore, past disturbance may be an important factor in affecting the dominance observed. The NCNHP acknowledges that the causative environmental factors which result in these communities are presently poorly understood.

All of these factors tend to suggest that precise demarcation of abrupt community boundaries would be difficult to achieve at Juniper Bay. Communities will likely occur as broad gradients which differ primarily in the relative dominance of a few species (e.g. Atlantic white cedar, loblolly bay, pond pine). Based on these observations, a hybrid Peatland Atlantic White Cedar Forest/Bay Forest community is proposed for the organic soil portions of Juniper Bay. The species composition of these two community types is very similar and only the relative dominance of Atlantic white cedar versus loblolly bay and sweet bay dictates type. Similarly, a hybrid Pond Pine Woodland/Bay Forest is proposed for the mineral soil portions of Juniper Bay. Because all of the target species are hydrophytic, it is not considered to be critical to establish a rigid compositional structure.

Mitigation Plan

The goal of the Juniper Bay mitigation project is to re-establish a stable wetland system that will restore natural processes, structure, and species composition to mitigate for wetland functions and values that will be impacted by highway construction activities in the Lumber River Basin. The proposed activities will restore wetland hydrology to soils defined as hydric but currently lacking wetland hydrology, and will improve or "lift" wetland functions provided by the site. The objective is to recreate to the greatest extent possible the predicted conditions which existed on site prior to human disturbance. Predictions of predisturbance conditions are based on study of a reference system, hydrology monitoring and modeling, extensive soils investigations, and published literature. Given the characteristics of the site and its history of disturbance, the mitigation plan will foucs on:

1) Elimination of the drainage ditch network
2) Soil surface resculpting to eliminate field crowns and promote microtopography
3) Revegetation of the site with wetland forest vegetation.

Wetland Hydrology Restoration

Hydrologic restoration of Juniper Bay will focus on systematic plugging and backfilling of the ditch network which exists across the site. Precautions must be taken not to flood the site too extensively before planted seedlings become established. Therefore, ditch plugging and backfilling may occur in two phases. Lateral ditches may be blocked initially while primary collector ditches remain open until planted seedlings are sufficiently established that full flooding of the site can occur.

All interior ditches on the site will eventually be plugged with a soil plug. Each ditch plug will consist of a core of clay-based, low permeability material and be sufficiently wide and deep to form an imbedded overlap in the existing banks and ditch bed. It is important that ditch plugs form an effective barrier to the preferential flow of groundwater in former ditch channels. Ditches will receive systematic impervious plugs at bends, junctions, and intervals determined by total slope over ditch length.

Backfilling of ditches will occur where sufficient soil material is available. Where they occur, crowned fields will be leveled and this material used to fill in ditches. However, exact quantaties of soil need for ditch backfilling have not yet been calculated and it is possible that insufficient soil exists in some portions of the site. In particular, subsidence may have occurred within the organic soil portion of the site, such that excavation of sufficient soil to backfill ditches would result in unacceptable alterations to surface elevations. In such cases, it may be preferable to simply block ditches, rendering them ineffective, and leave the remaining channels open as linear depressions. Such open water depressions could serve important habitat functions for amphibians, birds, and other wildlife, by providing local aquatic resources within a broader wetland system. Regardless, given the very low slope across the site (0.10 percent) and the tendency of depressional features to drain inward, it is highly unlikely that the proposed ditch plugs will experience sufficient stress to cause failure. Exact quantaties of soil needed for ditch filling and the final grade alterations proposed for construction will be determined during the design phase of this project.

It is likely that portions or all of the perimeter ditch will remain unaltered. Blocking the perimeter ditch would result in raising the groundwater table laterally on both sides of the ditch. Because this ditch forms the property boundary in many locations, plugging and backfilling will not be possible to avoid hydrologic trespass on adjacent properties.

DRAINMOD predicts that these activities will restore wetland hydrology to the majority of the hydric soils present on the site. Based on the most conservative scenario, approximately 568 acres of agricultural land will be restored to wetland hydrology. DRAINMOD simulations indicate that leaving the perimeter in place will reduce the potential restorable wetland area by approximately 131 acres. The majority of the affected area will be the Spodosol soil type and the Pond Pine Woodland community.

Hydric Soil Remediation

The hydric soil restoration proposed at Juniper Bay is primarily passive. Restoration of wetland hydrology will recreate the conditions necessary to re-establish hydric soil properties over time. Increasing the site's hydroperiod will increase the duration of anaerobic conditions which will in turn reduce the oxidation of organics, allow the recovery of soil organic matter to equilibrium, and recreate reduced conditions in mineral soils.

Some reshaping of the soil surface is proposed in places where field crowns have been formed to elevate the central portions of fields. These crowns will be leveled and the soil material used to backfill ditches or spread evenly across the surface. In addition, deep ripping (1-2 feet) will be implemented across the site to disrupt any subsurface plow pans and to create surface microtopography.

Wetland Vegetation Restoration / Planting Plan

Target species were determined from observations at the reference system, Tatum Millpond Bay, and from community descriptions defined by NCNHP. Two natural community types are proposed for establishment: Peatland Atlantic White Cedar Forest/Bay Forest and Pond Pine Woodland/Bay Forest (Figure 13). These communities are differentiated primarily by soil type, topographic elevation, and projected hydroperiod, with the Peatland Atlantic White Cedar Forest community occupying the wetter portions of the site and Pond Pine Woodland occurring in the remainder of the bay.

The Peatland Atlantic White Cedar Forest/Bay Forest community is proposed primarily for portions of the site with organic soils, though a small area of this community type is also proposed for the northeast corner of the bay. These communities will occupy the most poorly drained parts of the bay at the lowest elevations in the central portion of the site. 281.7 acres of this community are projected following the completion of restoration activities, though 5.5 acres of this total are not projected to ultimately meet hydrology because of their proximity to the perimeter ditch encircling the site..

The Pond Pine Woodland/Bay Forest community is proposed for the remainder of the mitigation site which exhibits sandy soils. These occupy slightly higher elevations within the bay around the lower central portions. 416.4 acres of this community are proposed for planting, though 125.3 acres of this total are not projected to ultimately meet wetland hydrology.

Ecological descriptions of the proposed communities are provided in the Reference System section of the mitigation plan. Significant similarities exist between the two proposed community types as described by NCNHP (1990), and differences in the two types are primarily determined by the relative dominance of particular species. Therefore, it is likely that the ultimate boundaries between the proposed communities will be subtle and indistinct. The following species are proposed for planting in each community:

<u>Peatland Atlantic White Cedar Forest/Bay Forest</u>

Atlantic white cedar	*Chamaecyparis thyoides*	OBL
Loblolly bay	*Gordonia lasianthus*	FACW
Swamp tupelo	*Nyssa sylvatica* var. *biflora*	OBL
Bald cypress	*Taxodium distichum*	OBL
Sweetbay	*Magnolia virginiana*	FACW+
Pond pine	*Pinus serotina*	FACW+
Swamp red bay	*Persea palustris*	FACW

<u>Pond Pine Woodland/Bay Forest</u>

Pond pine	*Pinus serotina*	FACW+
Loblolly bay	*Gordonia lasianthus*	FACW
Sweetbay	*Magnolia virginiana*	FACW+
Atlantic white cedar	*Chamaecyparis thyoides*	OBL
Loblolly pine	*Pinus taeda*	FAC
Swamp red bay	*Persea palustris*	FACW

Planting of seedlings should occur between December 1 and March 31 when trees are dormant. 680 stems/acre of the appropriate species mix will be planted in each designated community on approximately 8 ft. by 8 ft. centers. The proposed planting plan assumes the availability of high quality planting stock at the time of planting of the species proposed. If quality seedlings of a particular species are not available at the time of planting, that species will be eliminated and an appropriate substitute found. The COE Compensatory Hardwood Mitigation Guidelines (1993) were utilized in developing the planting plan. Planting of characteristic wetland species will establish the third parameter of jurisdictional wetland status and speed the recovery of the system to equilibrium structure and functioning. Plantings will also promote habitat for typical forested wetland wildlife.

Longleaf pine plantations on south side of the property will be removed and replanted with species typical of Pond Pine Woodland/Bay Forest community. Although the longleaf pines in this area are already well established, their survival is questionable once wetland hydrology has been restablished. No stands of this type were observed in any portion of the reference system, therefore their presence is not considered to be representative of predisturbance conditions.

Opportunistic species, which typically dominate disturbed forests, have been excluded from initial community restoration efforts. However, some opportunistic species such as sweet gum, red maple, American sycamore, and black willow may ultimately become established. To the degree that species diversity is not jeopardized, these species should be considered important components of the proposed steady state forest communities.

Target Wetland Functions

Carolina bays identified as Depression wetlands according to hydrogeomorphic (HGM) classification system developed by Brinson (1993). Mitigation will restore the suite of wetland functions characteristic of forested depressions. The site presently exhibits no wetland functions because it lacks the necessary hydrology and vegetation. The site currently functions as a source of water runoff and discharge, sediment loss, nutrient loss, marginal wildlife habitat, and potential chemical contamination. The proposed wetland restoration activities are expected to return most of the site to near natural wetland conditions and thereby restore natural wetland functions. Following is a discussion of benefits, in terms of wetland functions, expected to be realized through the implementation of this mitigation plan.

<u>Surface/Subsurface Water Storage</u>

Juniper Bay does not naturally receive surface water inputs from overbank flooding of stream channels. However, precipitation inputs and groundwater inflow will be significantly contained once the ditch network is eliminated. Removal of the ditch network discharge will greatly increase surface and subsurface water storage capacity on site and increase the retention of water. Residence time of incoming precipitation will be greatly increased, with evapotranspiration as the primary source of water loss during growing season. Channel discharge to Big Indian Swamp will be significantly decreased. Juniper Bay represents a 1.41 square mile watershed in which most precipitation will be retained on-site.

Nutrient Storage/Transformation

Nutrient storage and transformation potential at Juniper Bay is related to water inputs and storage capacity. The site does not receive significant inputs of nutrients from surrounding watershed via overbank flooding of channels or receive runoff from upland areas. However, atmospheric inputs of nutrients will be significantly detained once the ditch network is eliminated. Nutrient losses from the site will be reduced via peat storage, vegetation storage, and microbial biochemical transformation/assimilation.

Sediment Retention

Carolina bays such as Juniper Bay do not naturally perform significant sediment retention functions within watersheds. Juniper Bay does not normally experience sediment deposition from upland runoff. Sediment loss in the watershed is transported by flowing channels and deposited downstream at sites of overbank flooding. Juniper Bay does not receive such sediment laden floodwaters.

However, in its current condition as a drained agricultural system, Juniper Bay loses sediment and is a source of turbidity for downstream waters. Once the ditch system is eliminated, on site sediments will be fully retained. Water outputs from the site will be almost exclusively through evapotranspiration and groundwater discharge. Surface water, if present, will be standing or of extremely low velocity. There will be virtually no opportunity for surface transport of sediment off site.

Groundwater Recharge

Juniper Bay offers good opportunity as a site for groundwater recharge. After the ditch network is removed, precipitation inputs will be retained on site for long duration. Significant quantities of available water will be lost to evapotranspiration during the growing season, but the majority of the remainder will infiltrate to subsurface groundwater.

Carbon Storage

Juniper Bay provides the opportunity for significant carbon storage on site. It is probable that the existing peat soils in the bay are currently experiencing some subsidence due to oxidation of organic matter. This oxidation represents a loss of carbon from the system. Re-establishing the site's natural wetland hydrology will likely result in peat recovery and carbon accumulation over time, adding to soil carbon and rebuilding the soil profile.

Wildlife Habitat

Juniper Bay currently supports agricultural fields used for row crop production. The wildlife species associated with such conditions are typically common in the Coastal Plain of North Carolina. Through the proposed mitigation activities, the site will be restored to an assemblage of forested wetland communities which will provide habitat characteristic of undisturbed, large Carolina bays. The forested wetlands will provide improved horizontal zonation, vertical structure, and plant species diversity. The site will also have improved microtopography and associated pool/hummock formation to provide breeding sites for amphibians. The proximity of the site to extensive forests and gamelands to the north will provide a large, contiguous forested area.

Monitoring Plan and Success Criteria

Following completion of the proposed restoration activities, the Juniper Bay site will be monitored to document the trend toward successful establishment of the proposed wetland communities. Monitoring of the site will occur for five years following completion of the final phase of implementation, assuming the stated success criteria are met by the end of the fifth year. If success criteria are not met, remedial actions will be considered in coordination with the regulatory review agencies and additional monitoring initiated. Monitoring activities are proposed for both hydrology and vegetation. The monitoring plan consists of an evaluation of jurisdictional wetland criteria, along with comparison to reference wetland conditions. This monitoring plan was developed in accordance with the U.S. Army Corps of Engineers Compensatory Hardwood Mitigation Guidelines (1993).

Monitoring will entail analysis of two primary wetland parameters: hydrology and vegetation. Relic hydric soils currently exist at the site and monitoring is not considered to be necessary to verify hydric soil requirements for a jurisdictional determination. The monitoring program will be implemented to document system development and progress toward achieving mitigation goals and objectives. Vegetative data will be correlated with the appropriate hydrologic data from the groundwater monitoring gauges to determine if objectives are being met. If, after the completion of five growing seasons, jurisdictional status has not been achieved where desired, or the desired vegetation has not been established, NCDOT will consult with the regulatory review agencies and implement appropriate corrective measures.

Hydrology

After restoration activities have been implemented, automated groundwater monitoring gauges will be installed across the site to monitor site hydrology. Monitoring gauges will be installed in representative locations in each proposed community type and will be installed in accordance with USACE guidelines (USACE 1993). Hydrologic restoration will be considered successful if the soil is ponded, flooded, or saturated within 12 inches of the surface for at least 12.5% of the growing season during years with normal precipitation. This hydroperiod translates to saturation for a minimum of 28 consecutive days during the growing season, extending from March 25 to November 4. Six ground water monitoring gauges will also be maintained in the reference system at Tatum Millpond Bay for comparative purposes (though not for success determination) to help evaluate wetland hydrology and natural hydrologic variation during periods of atypical precipitation. Hydrologic monitoring will continue for five years following completion of site construction.

Precipitation data will be obtained from the closest NOAA gauge station in Lumberton, NC. In addition, a precipitation gauge will be installed on site for comparative purposes. Normal precipitation will be defined as within the 30th and 70th percentiles, as defined by the climatic record. A "normal" year, based on NRCS climatological data for Robeson County, must receive an annual rainfall of between 43.8 and 51.5 inches.

In years not exhibiting normal precipitation, groundwater data from the mitigation site will be compared to observations at the reference system. Under such conditions, the hydroperiod of the mitigation site must exceed 75 percent of the hydroperiod exhibited by the reference gauges located within the same approximate soil type and landscape position.

Vegetation

Success criteria have been established to verify that mitigation areas support a species composition necessary for a jurisdictional determination. Monitoring procedures for vegetation are designed in accordance with EPA guidelines enumerated in Mitigation Site Type (MiST) documentation (1990) and COE Compensatory Hardwood Mitigation Guidelines (1993).

After planting has been completed, the site will be inspected to verify that proper planting methods were used, including proper plant spacing, density, and species composition. Assuming successful planting, 0.05 acre vegetative plots (50 ft. by 50 ft.) will be established in representative locations across the site. Plot locations will be placed in proximity of water table monitoring gauge points where possible to help correlate data between vegetation and hydrology parameters. For each plot, species composition and density will be reported. Quantitative sampling of vegetation will be performed during each growing season (June to November) for five years or until vegetative success criteria are met. In addition, permanent photography stations will be established at selected vantage points to provide a visual record of vegetation development over time.

During the first year after planting, the site will receive cursory visual observation on a periodic basis to ascertain the degree of overtopping of planted trees by nuisance species. If site assessments indicate excessive competition from non-target species, remedial actions in the form of competition control will be evaluated and implemented.

Vegetative success will be determined by the survival of target species within the sample plots. The required minimum survival rates are as follows:

320 stems/acre of target species at end of third year
290 stems/acre at end of year 4
260 stems/acre at end of year 5

Included in the required survival criteria are planted seedlings and natural recruitment of the same species. At least six different representative tree species should be present on the entire site. If the vegetative success criteria are not met, the cause of failure will be determined and appropriate corrective action will be taken. Supplemental plantings or remedial actions will be taken if necessary if plots do not exhibit the minimum tree densities.

Report Submittal

An "as built" report will be generated after completion of planting that includes: a plan view of the site, final elevations, photographs, sample plot locations, monitoring gauge locations, and a description of initial species composition by community and sample plot locations. A discussion of the planting design, including species planted, species densities, and number of stems planted will be included. The report will be provided within 90 days of completion of planting and monitoring gauge installation.

Subsequently, reports will be submitted yearly to appropriate permitting agencies following each assessment. Submitted reports will include: sample plot data, gauge data (if applicable), and a discussion of problems and proposed solutions. The duration of wetland hydrology during the growing season will also be calculated at each monitoring gauge location and extrapolated to each restored or enhanced community. Survival and density of planted tree stock and natural recruitment will be reported and evaluated relative to the success criteria.

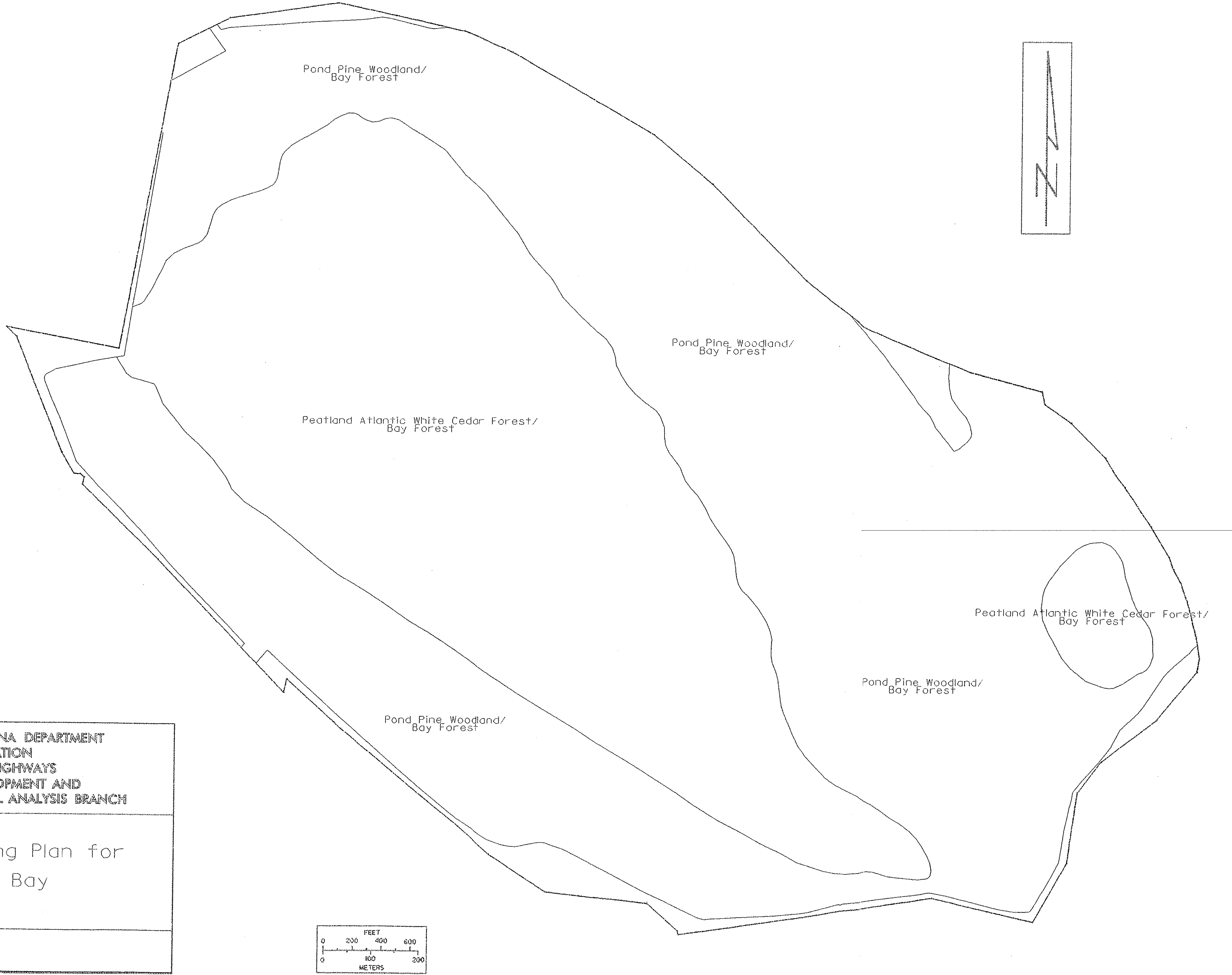

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Figure 13. Planting Plan for Juniper Bay

Juniper Bay Automated Monitoring Gauges

Gauge Number	Serial Number	Length (in.)	Elevation	Distance to Ditch (ft.)
JB01	S317529	40	-3.15	123.2
JB02	S3175C3	40	-4.29	85.7
JB03	S31755E	40	-4.65	133.4
JB04	S3174EA	40	-4.71	75.7
JB05	S31F8B0	40	-3.89	43.8
JB06	S317404	40	-4.36	34.1
JB07	S3175B8	40	-4.47	77.7
JB08	S3174B2	40	-4.83	128.4
JB09	S31762E	40	-5.45	65.1
JB10	S31742C	40	-5.86	118.0
JB11	S31738A	40	-5.53	105.9
JB12	S317352	40	-6.19	32.2
JB13	S3174A6	40	-3.97	69.0
JB14	S317659	40	-4.03	115.1
JB15	S317509	40	-4.52	57.2
JB16	S317466	40	-4.71	106.1
JB17	S3174B0	40	-6.66	105.9
JB18	S31751D	40	-4.22	94.1
JBSG1	S3539E2	80	-5.07	NA
JBSG2	S317465	40	-6.64	NA

Bladen Lakes Automated Monitoring Gauges

Gauge Number	Serial Number	Length (in.)
BL01	S31691D	40
BL02	S3167AB	40
BL03	S2EAD13	40
BL04	S3173F9	40
BL05	S317539	40
BL06	S31745F	40

Site Dispensation and Long Term Management

Ownership and management of the site will remain with NCDOT for the duration of all implementation and monitoring activities. Once mitigation activities are deemed successful, the property will be transferred to an appropriate recipient for long term management. NCDOT is in the process of soliciting conservation groups and natural resource agencies (public or private) for final dispensation of the property. However, until an acceptable agreement can be reached with an appropriate recipient of the property, ownership of the mitigation site will remain with NCDOT. Deed restrictions will be included upon transfer to any recipient to insure that the property remains as conservation land in perpetuity.

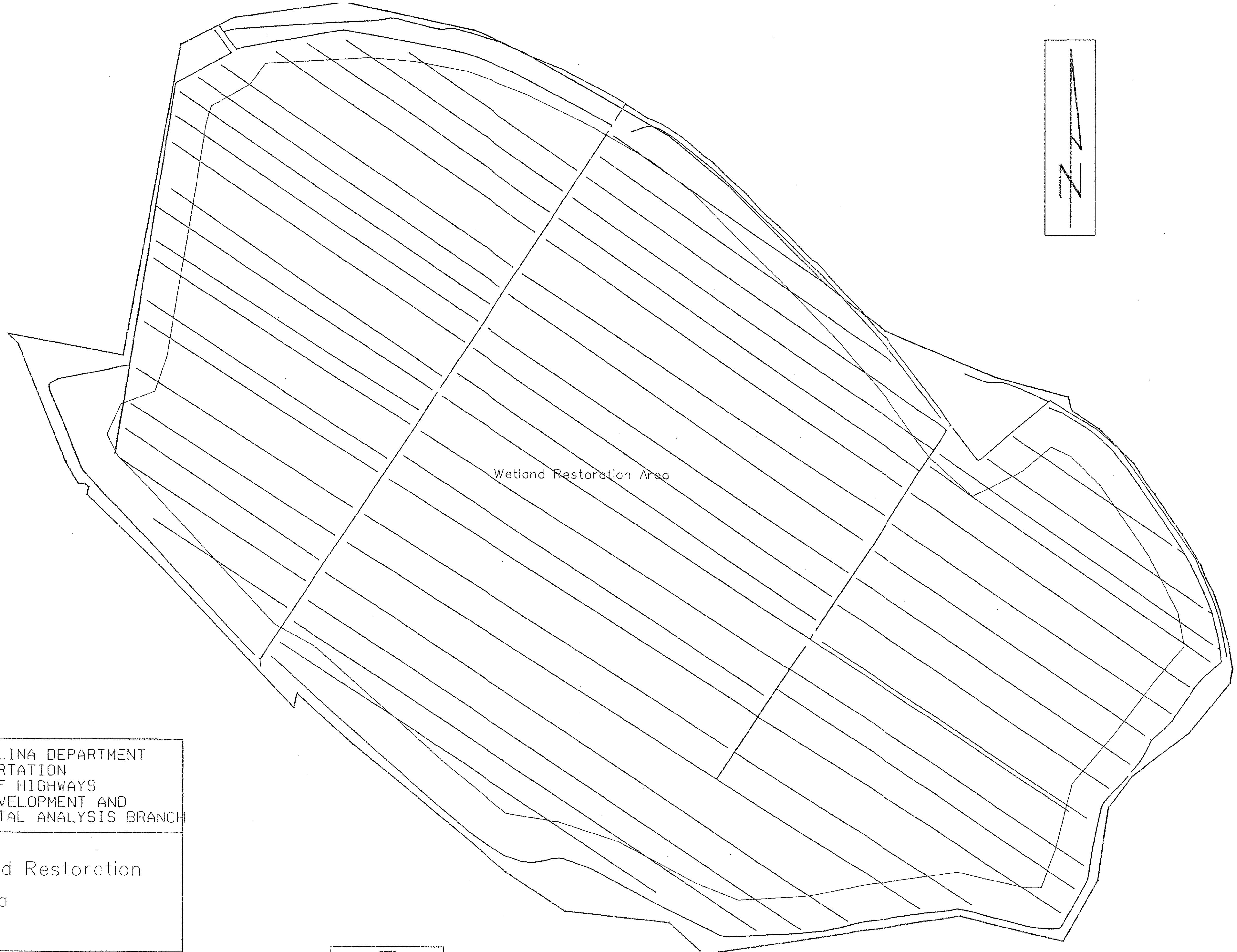
Research Project

In June 2000, NCDOT initiated a research project with North Carolina State University (NCSU) to study the long term development of the Juniper Bay mitigation site. This project, funded by NCDOT, will investigate the current condition of the soils, hydrology, and vegetation on the site and later study the development of these features over time once restoration activities have been completed. The project will also investigate a range of undisturbed Carolina bay systems to document the natural variability which exists between sites and the potential for using these sites to establish success criteria. The purpose of this project is to advance the science of wetland mitigation with respect to predicting the hydrologic, edaphic, and ecological processes which occur from restoration practices and the improvements in wetland functioning which can be expected from such activities.

Work is currently underway to document the existing conditions of Juniper Bay. This work will continue through the implementation of the restoration activities. Once mitigation activities are completed, NCSU will continue to study the post-implementation status of the site to record changes in hydrology, soil, vegetation, and wetland functioning which occur. Post-restoration studies are scheduled to continue for up to ten years following completion.

Wetland Mitigation Credit Determination

At present, approximately 98.4 percent of the Juniper Bay property is non-jurisdictional due to a extensive drainage. Only 11.4 acres out of 728.5 retains wetland hydrology. Therefore, most of the proposed mitigation will qualify as restoration. Portions of the site, however, are projected to remain drained following completion of mitigation activities because of the need to avoid hydrologic trespass issues (Figure 14). 160.8 acres of the site may not meet wetland criteria as a result. Table 15 lists the estimated wetland acreage by community type which will be restored or enhanced at the Juniper Bay mitigation site.



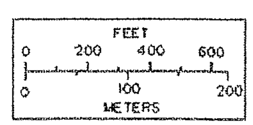


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Figure 14. Wetland Restoration Area

Table 15. Projected mitigation area at Juniper Bay.

Community Type	Restoration (Acres)	Enhancement (Acres)
Peatland Atlantic White Cedar Forest	264.8	11.8
Pond Pine Woodland	291.1	

The mitigation credit developed at the Juniper Bay property is proposed by NCDOT to be used to offset future wetland impacts in the Lumber River basin resulting from highway construction activities.

Summary

NCDOT proposes to restore Juniper Bay to provide compensatory wetland mitigation to offset impacts associated with highway construction projects. The proposed mitigation site is located in Robeson County in the Lumber River Basin.

Juniper Bay presently consists of a Carolina bay system which has been extensively ditched and drained for agricultural production. Recommended mitigation activities for Juniper Bay include systematically plugging and backfilling the ditch network, resculpting the soil surface to eliminate field crowns, and replanting the site with wetland tree species typical of Carolina bay forest communities. Expected results of these mitigation activities are greatly increased water storage capacity and water retention time on site, increased protection of on-site sediments, reduction in nutrient loss from the site, carbon and peat accumulation, and improved wildlife habitat. The proposed mitigation plan provides for the restoration of 568 acres of nonriverine wetlands, consisting of Peatland Atlantic White Cedar Forest, Bay Forest, and Pond Pine Woodland communities.

Following construction, the site will be monitored by way of groundwater monitoring gauges and vegetation plots to document trends toward success. After success criteria are met, NCDOT will dispense the site to an appropriate public or private conservation organization to be protected in perpetuity. On-going research activities with NCSU will study the long-term trends in the development of hydrology, soils, vegetation, and wildlife.

APPENDIX A
Soil Profile Descriptions

Soil Unit OC

Ap1 0 - 5 inches; very dark brown (10YR 2/2) sandy loam; medium granular structure, friable; appears to be ditch material spread over original ground surface.

Ap2 5-9 inches; black (10YR 2/1) mucky sandy loam; medium subangular blocky structure, very friable, breaking to coarse granular structure.

Oa 9-22 inches; very dark brown (7.5YR 2.5/2) sapric material; massive.

2A 22-31 inches; dark brown (7.5YR 3/3) mucky silt loam; coarse, angular blocky structure, friable.

2C1 31-48 inches; brown (7.5YR 5/3) silty clay; coarse, subangular blocky structure, friable, breaking to fine subangular blocky structure.

2C2 48-55+ inches; light yellowish brown (2.5Y 6/3) clay, coarse, subangular blocky structure.

Slope: 0%
Examination Method: backhoe pit
Date: July 26, 2001
Weather: Partly sunny
Investigators: Michael Wood, Annie Lynn Smith

Soil Unit OS

Ap1 0 - 6 inches; black (10YR 2/1) mucky sandy loam; fine granular structure, very friable, 95% of sand grains coated with organic stain.

A 6-16 inches; very dark brown (7.5YR 2.5/2) mucky silt loam; massive.

2A 16-20 inches; very dark brown (7.5YR 2.5/2) loamy sand; medium, subangular blocky structure, very friable.

2C1 20-29 inches; dark yellowish brown (10YR 4/4) loamy sand; coarse, subangular blocky structure, friable.

2C2 29-40+ inches; yellowish brown (10YR 5/4) loamy sand, single grain.

Slope: 0%
Examination Method: backhoe pit
Date: July 26, 2001
Weather: Partly sunny
Investigators: Michael Wood, Annie Lynn Smith

Soil Unit SS

Ap	0 - 8 inches; black (5YR 2.5/1) loamy sand; medium granular structure, very friable, 85% of sand grains coated with organic stain, few nodules present.
AE	8-13 inches; very dark brown (7.5YR 2.5/3) loamy sand; medium subangular blocky structure, friable.
E1	13-21 inches; brown (7.5YR 4/4) loamy sand; medium subangular blocky structure, very friable.
E2	21-37 inches; yellowish brown (10YR 5/6) sand; single grain.
EBh	37-46 inches; light olive brown (2.5Y 5/3) sand; single grain.
Bh	46-50+ inches; black (5YR 2.5/1) sandy loam; cemented, massive.

Slope: 0%
Examination Method: backhoe pit
Date: July 26, 2001
Weather: Partly sunny
Investigators: Michael Wood, Annie Lynn Smith

Soil Unit OC

Ap1 0 - 6 inches; black (10YR 2/1) mucky sandy loam; medium granular structure, friable.

AE 6-12 inches; very dark gray (7.5YR 3/1) sandy loam; medium subangular blocky structure, friable.

Bhs 12-21 inches; black (7.5YR 2.5/1) sandy loam; weakly cemented, breaking to medium angular blocky structure.

E' 21-32 inches; light yellowish brown (2.5Y 6/3) sandy loam; medium subangular blocky structure, friable.

2A 32-38+ inches; black (2.5Y 2.5/1) sandy clay; coarse, subangular blocky structure, firm.

Slope: 0%
Examination Method: backhoe pit
Date: July 26, 2001
Weather: Partly sunny
Investigators: Michael Wood, Annie Lynn Smith

Soil Unit SC2

A1 0-1 inches; pale brown (10YR 6/3) loamy sand; fine granular structure, very friable; 30% of sand grains coated with organic stain; appears to be fill material spread over original ground surface.

C 1-4 inches; light olive brown (2.5Y 5/4) loamy sand; fine granular structure, very friable; appears to be fill material spread over original ground surface.

2A 4-12 inches; black (10YR 2/1) mucky fine sandy loam; fine granular structure, friable.

2AE 12-18 inches; black (10YR 2/1) loamy sand with many gray (10YR 5/1) sand streaks (uncoated); medium subangular blocky structure, friable.

2Bt 18-24 inches; dark grayish brown (2.5Y 4/2) sandy loam with many distinct gray (2.5Y 5/1) sand streaks (uncoated); medium subangular blocky structure, friable.

3C 24-40 inches; gray (2.5Y 6/1) sandy clay loam; coarse, subangular blocky structure, firm.

Slope: 0%
Examination Method: backhoe pit
Date: July 26, 2001
Weather: Partly sunny
Investigators: Michael Wood, Annie Lynn Smith

APPENDIX B
Groundwater Monitoring Gauge Data

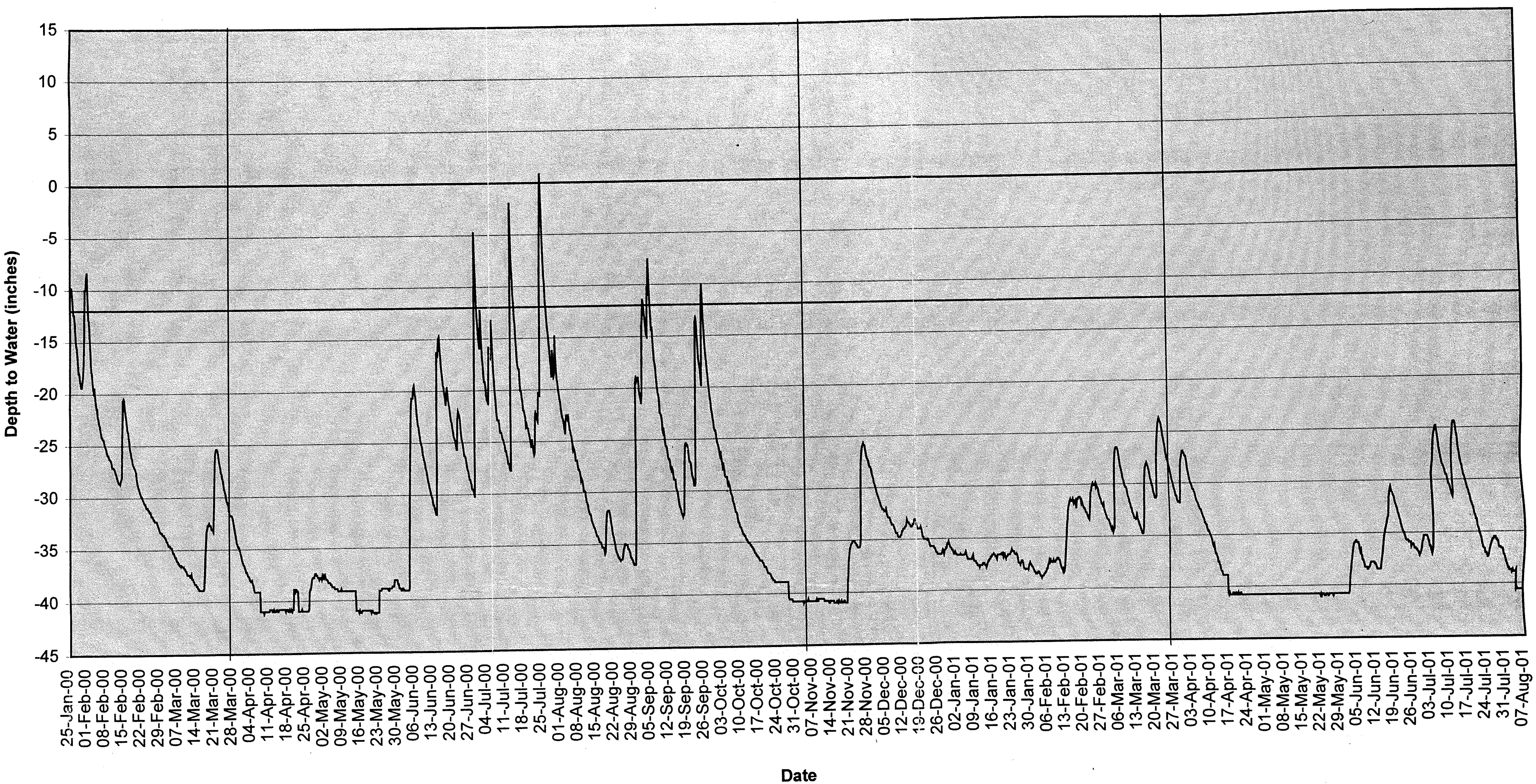
Juniper Bay Automated Monitoring Gauges

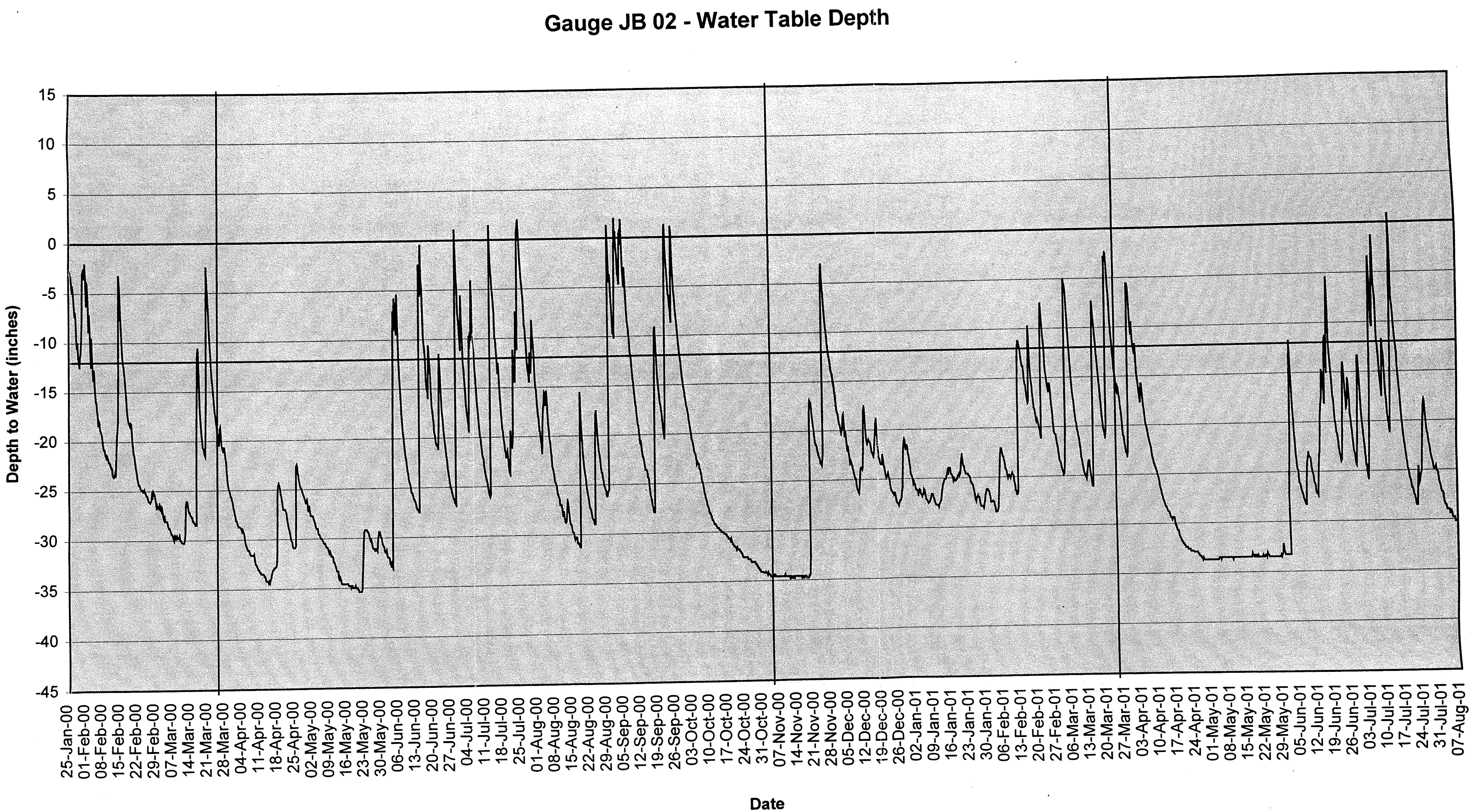
Gauge Number	Serial Number	Length (in.)	Elevation	Distance to Ditch (ft.)
JB01	S317529	40	-3.15	123.2
JB02	S3175C3	40	-4.29	85.7
JB03	S31755E	40	-4.65	133.4
JB04	S3174EA	40	-4.71	75.7
JB05	S31F8B0	40	-3.89	43.8
JB06	S317404	40	-4.36	34.1
JB07	S3175B8	40	-4.47	77.7
JB08	S3174B2	40	-4.83	128.4
JB09	S31762E	40	-5.45	65.1
JB10	S31742C	40	-5.86	118.0
JB11	S31738A	40	-5.53	105.9
JB12	S317352	40	-6.19	32.2
JB13	S3174A6	40	-3.97	69.0
JB14	S317659	40	-4.03	115.1
JB15	S317509	40	-4.52	57.2
JB16	S317466	40	-4.71	106.1
JB17	S3174B0	40	-6.66	105.9
JB18	S31751D	40	-4.22	94.1
JBSG1	S3539E2	80	-5.07	NA
JBSG2	S317465	40	-6.64	NA

Bladen Lakes Automated Monitoring Gauges

Gauge Number	Serial Number	Length (in.)
BL01	S31691D	40
BL02	S3167AB	40
BL03	S2EAD13	40
BL04	S3173F9	40
BL05	S317539	40
BL06	S31745F	40

Gauge JB 01 - Water Table Depth





Gauge JB 02 - Water Table Depth
Depth to Water (inches)
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0
-5
-10
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-40
-45
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01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
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14-Mar-00
21-Mar-00
28-Mar-00
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11-Apr-00
18-Apr-00
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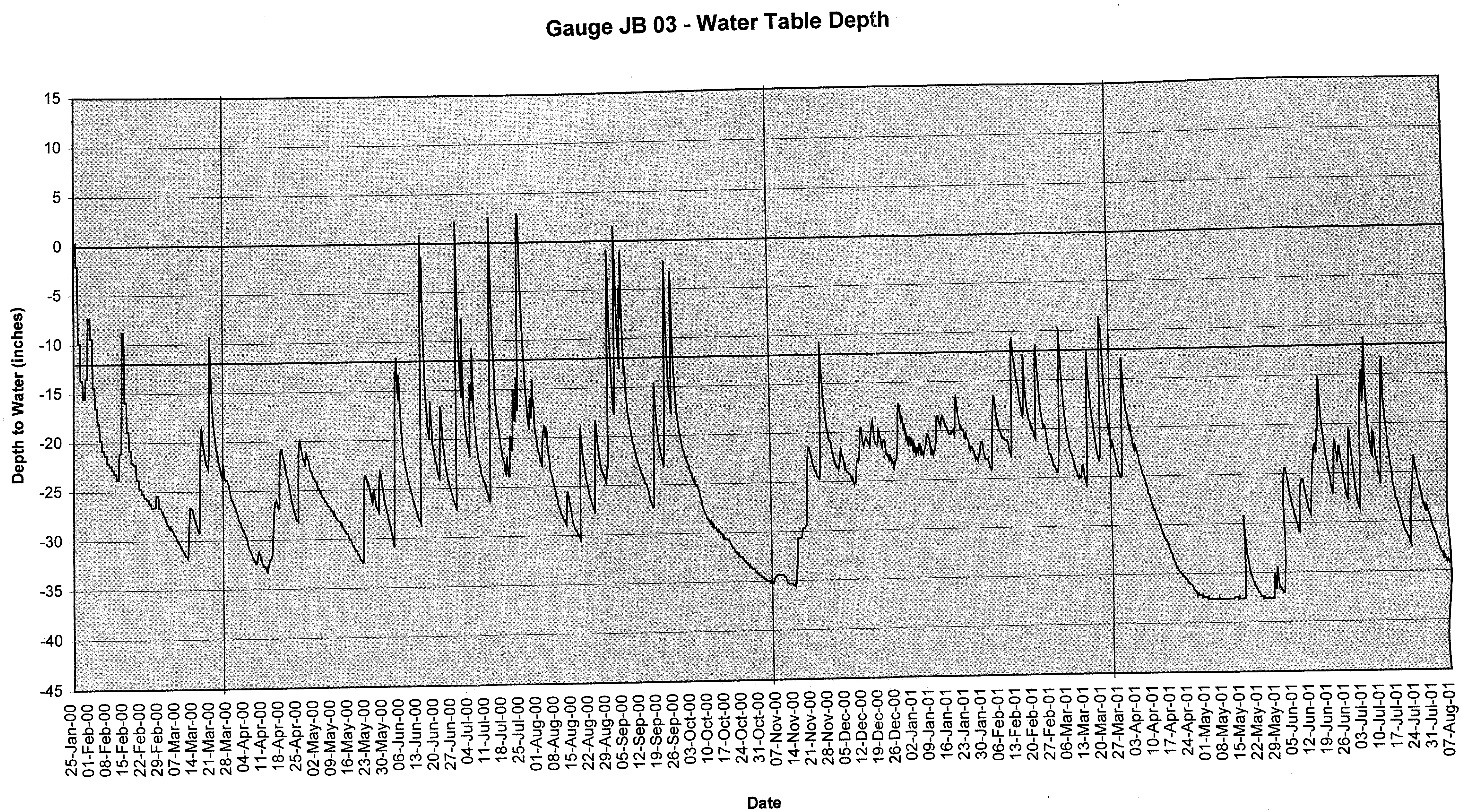
Date


Gauge JB 03 - Water Table Depth
Depth to Water (inches)
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-25
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-40
-45
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01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
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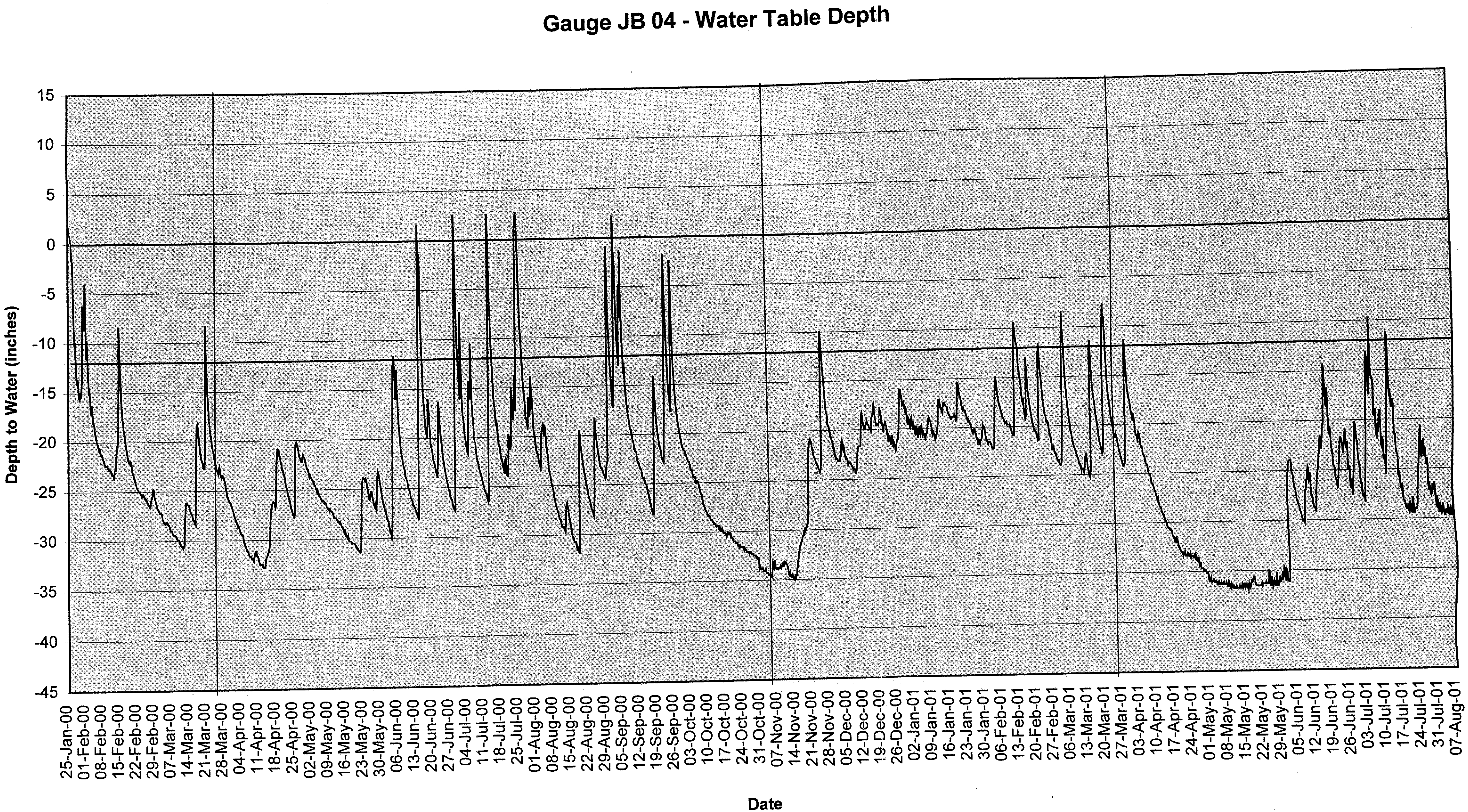
Gauge JB 04 - Water Table Depth
Depth to Water (inches)
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-5
-10
-15
-20
-25
-30
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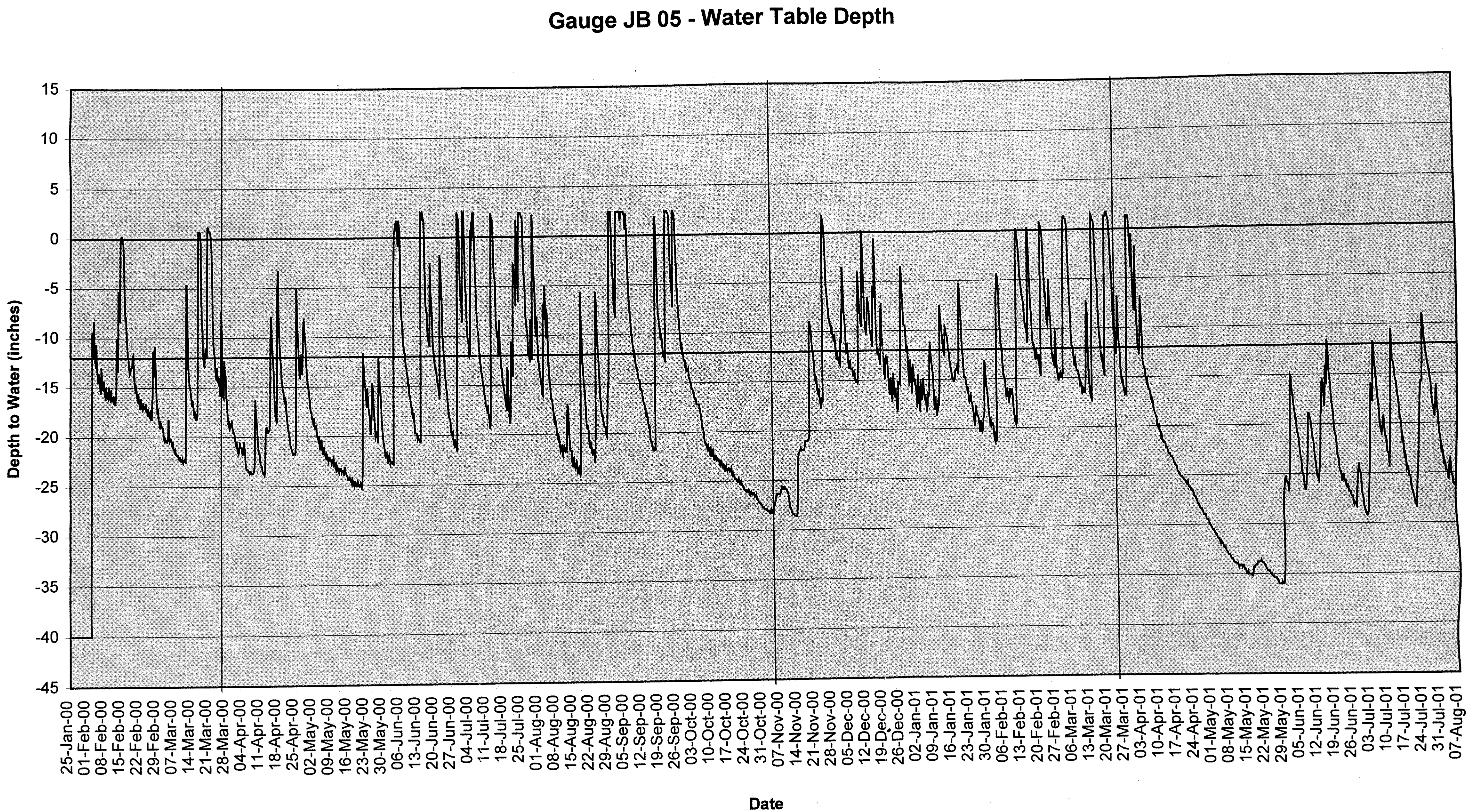
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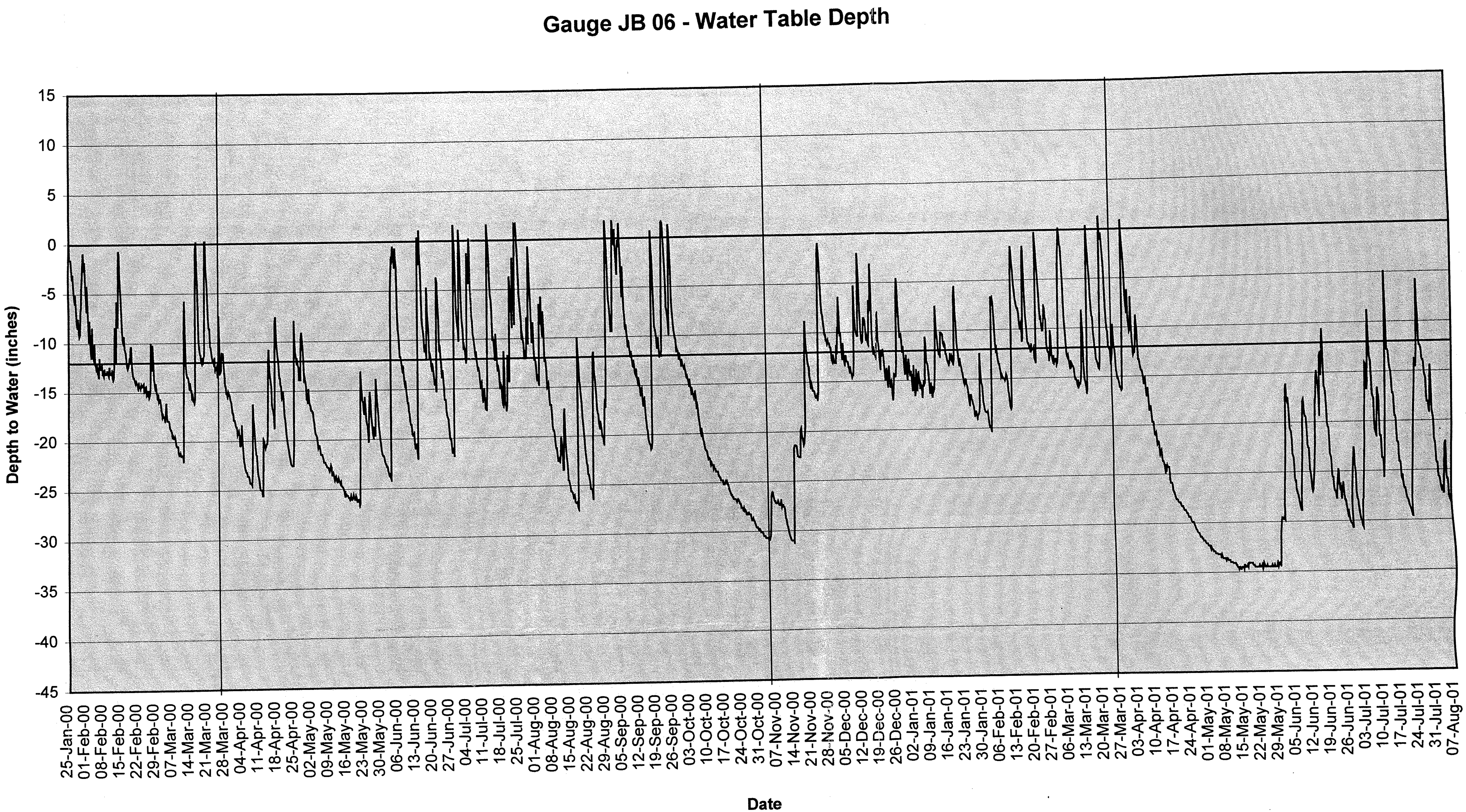
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
26-Jun-01
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01
Date



Gauge JB 06 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Date
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
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26-Jun-01
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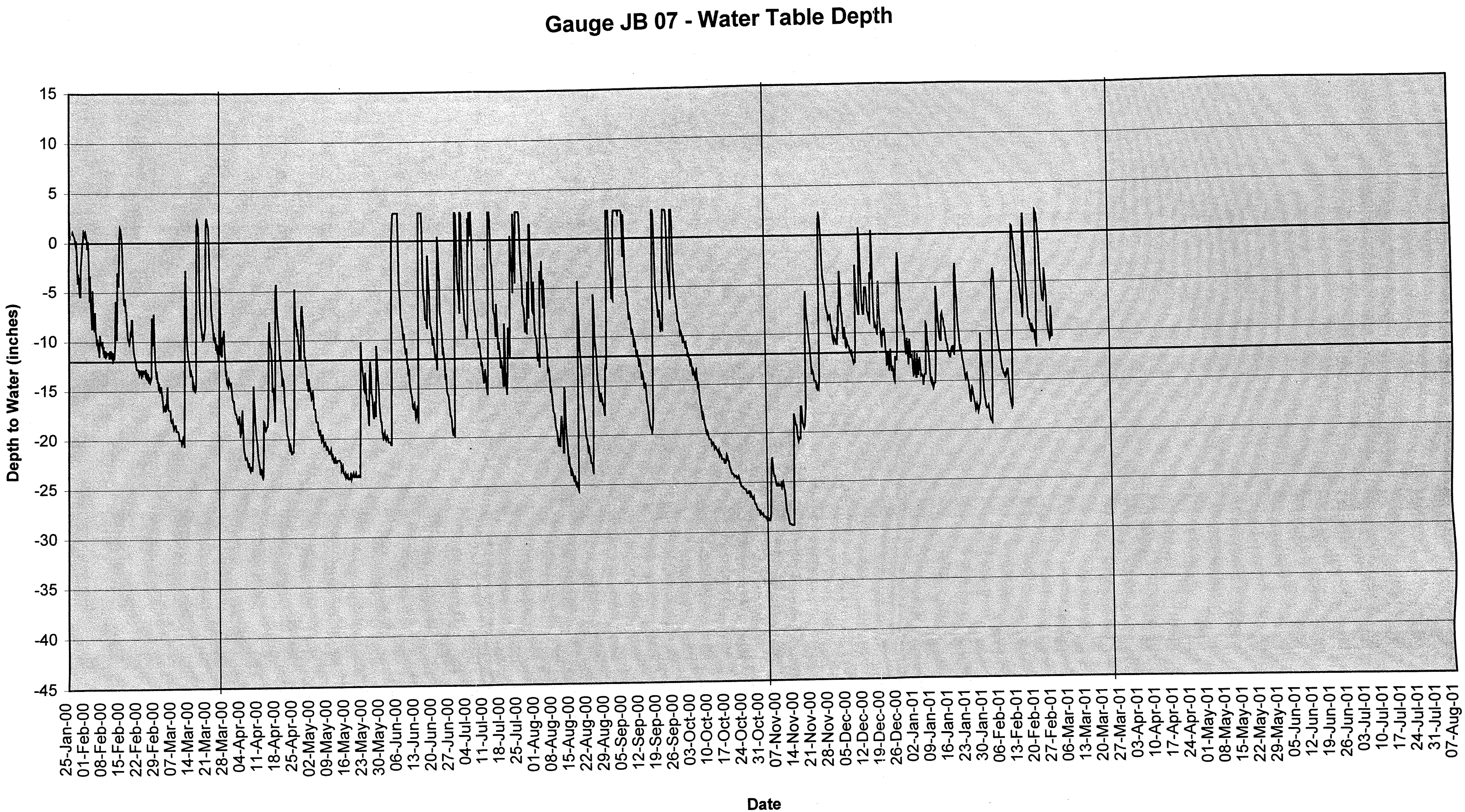
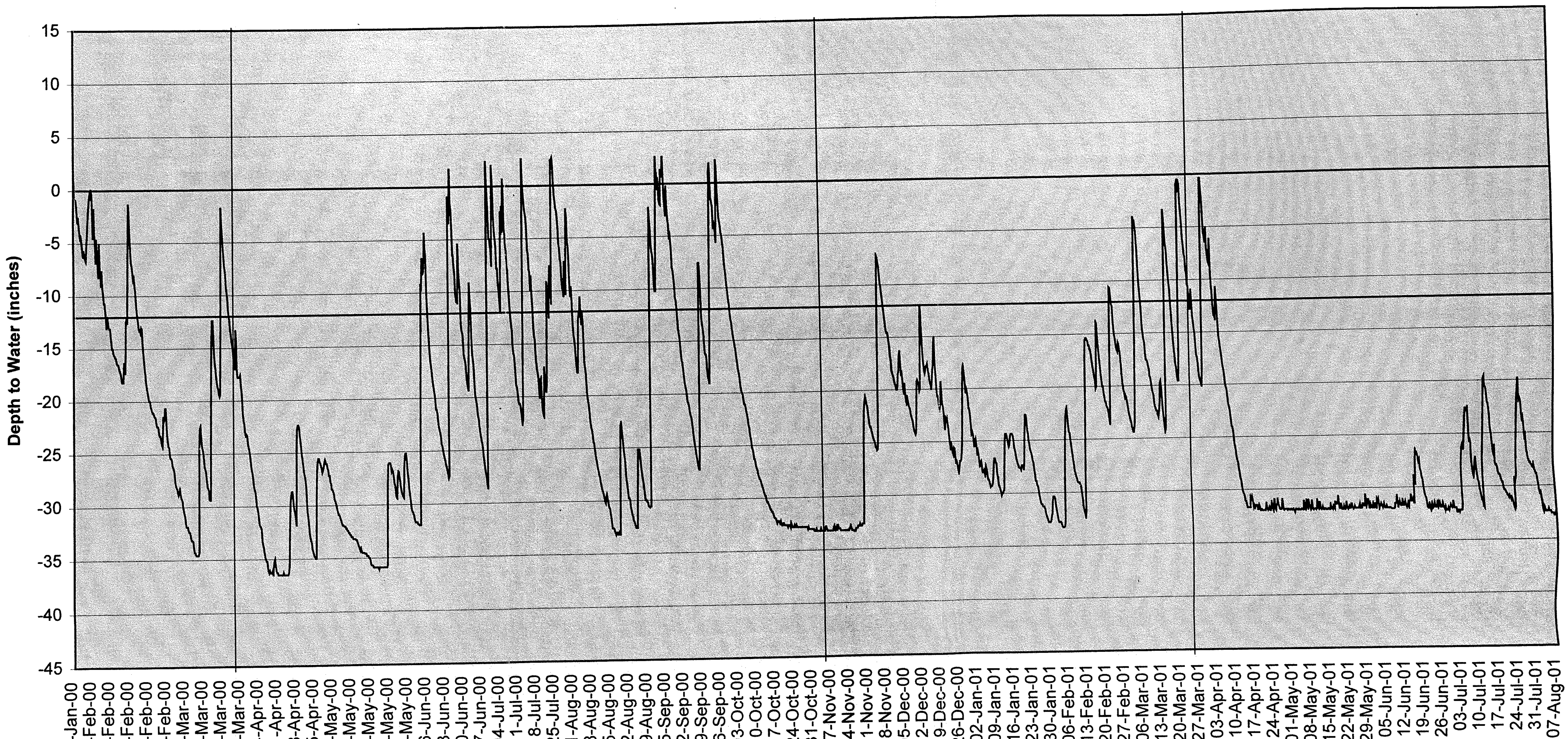
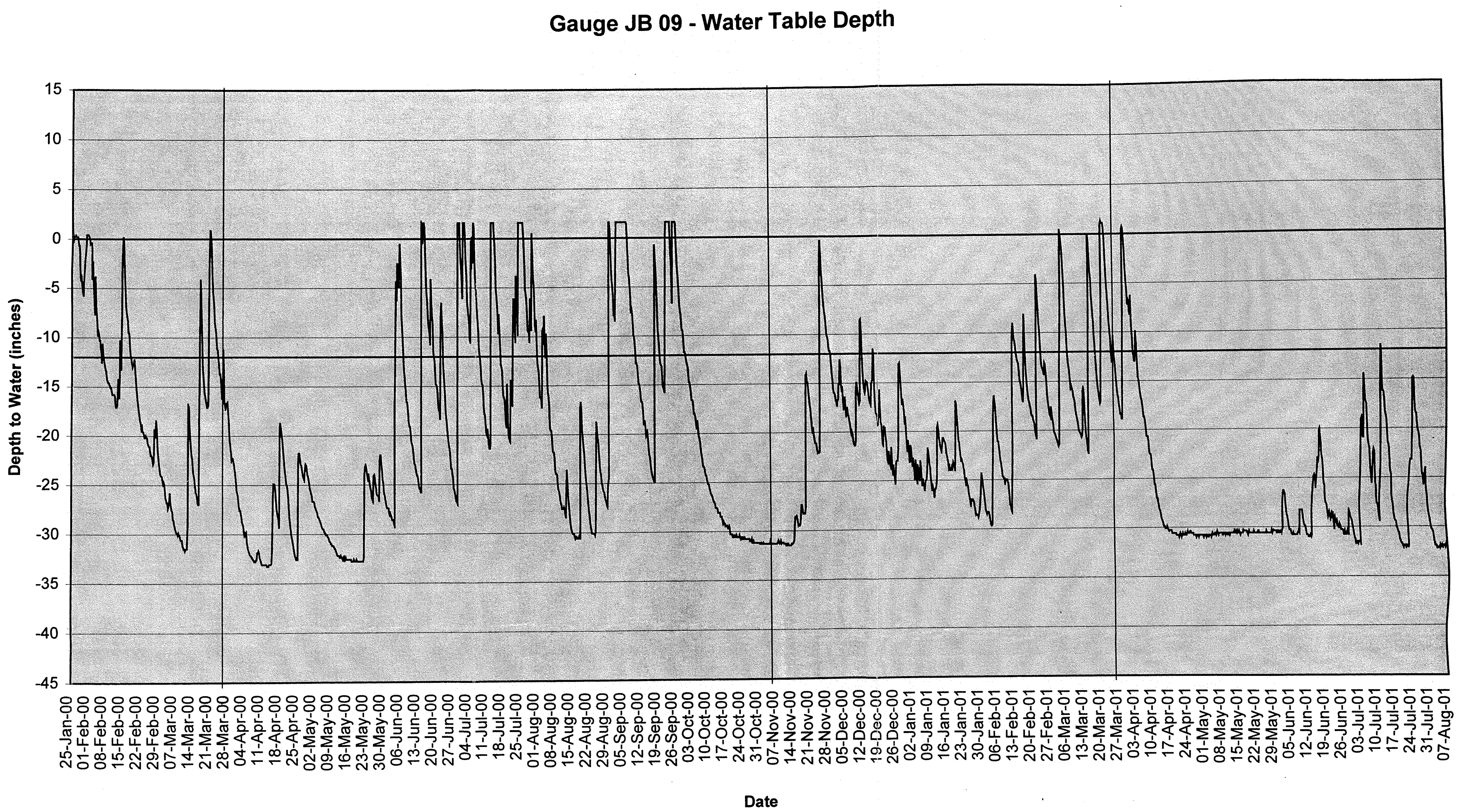
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01


Gauge JB 07 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
26-Jun-01
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01
Date

Gauge JB 08 - Water Table Depth




Gauge JB 09 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
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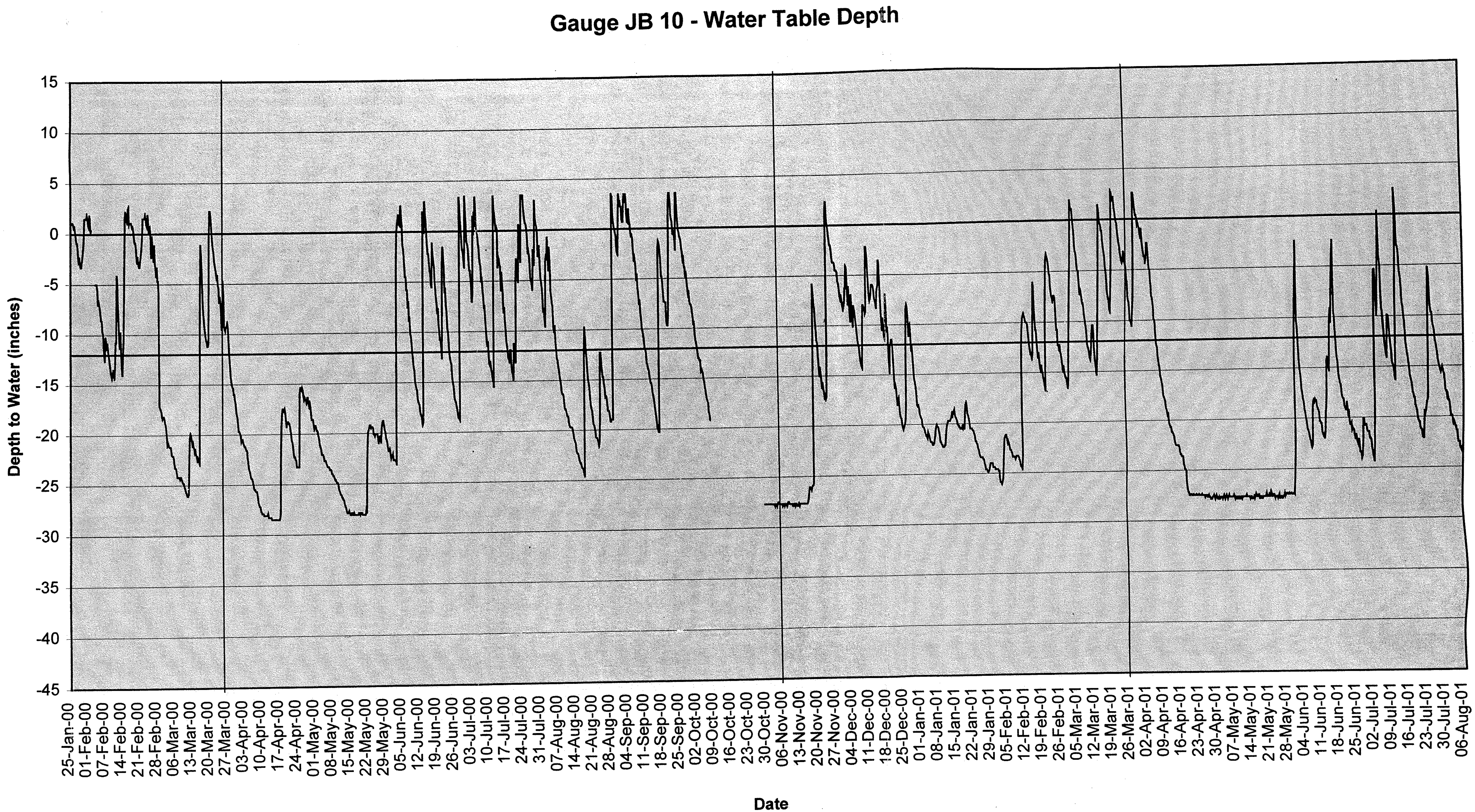
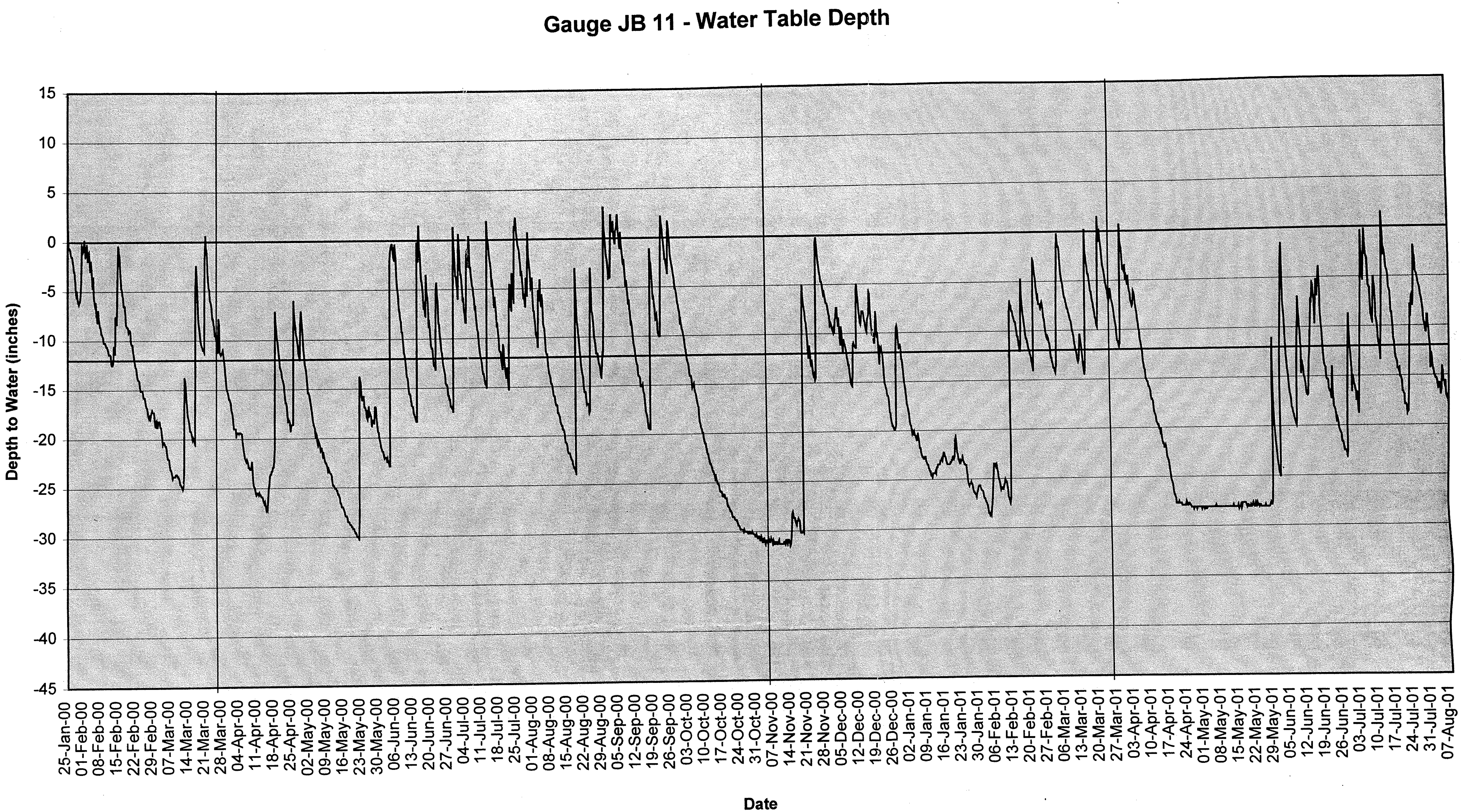
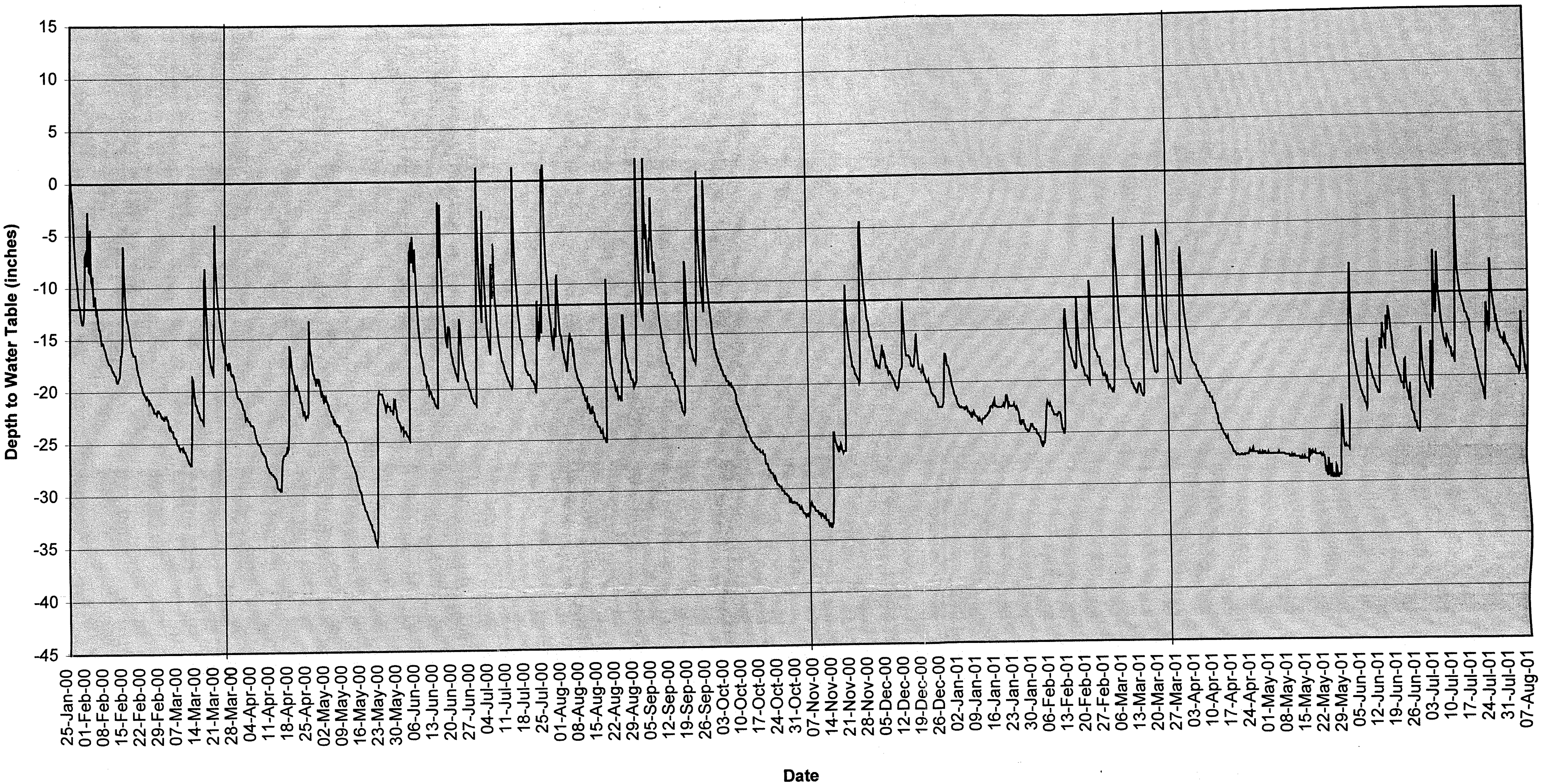
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01
Date

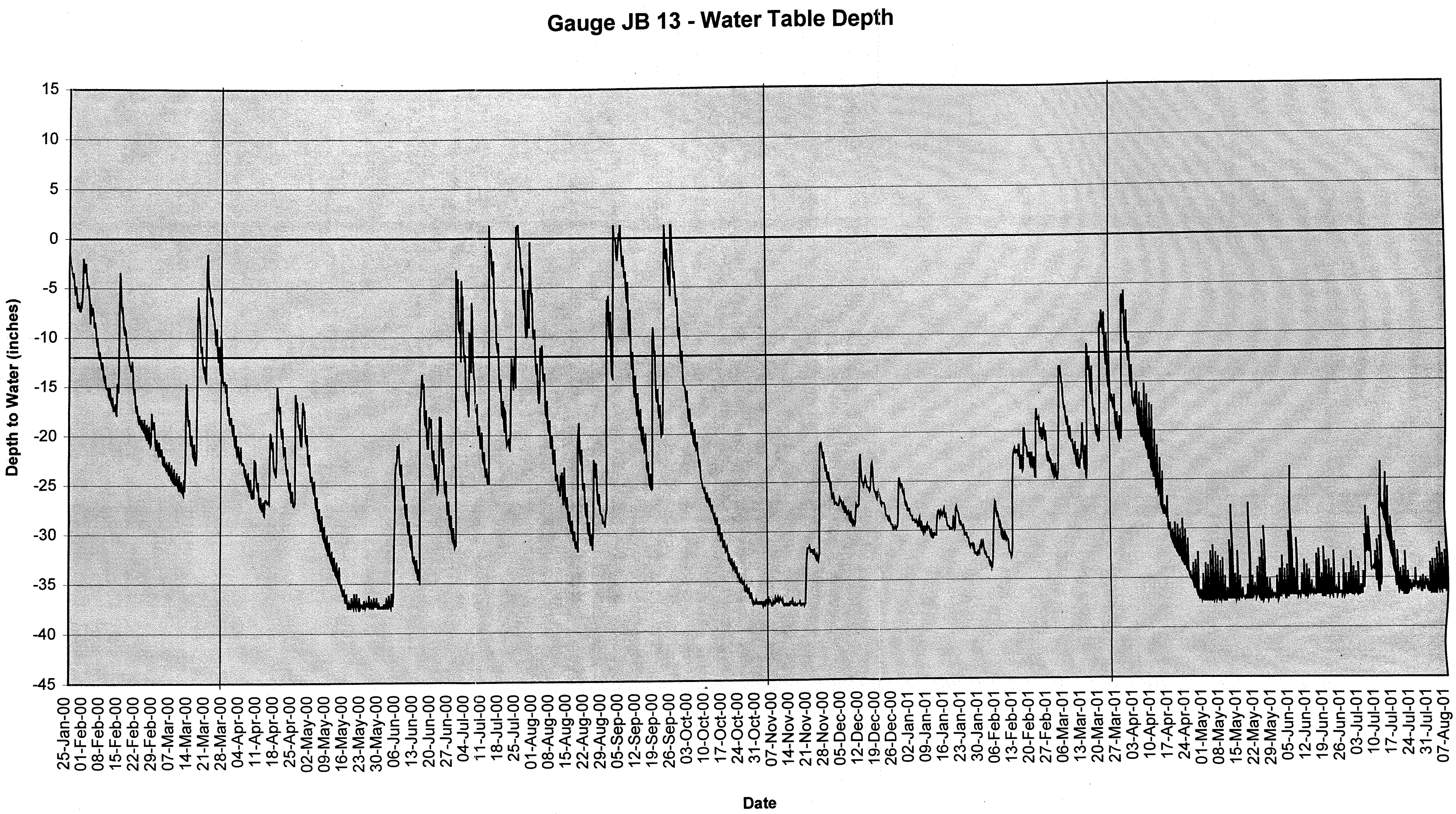


Gauge JB 10 - Water Table Depth
Depth to Water (inches)
Date


Gauge JB 11 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Date
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
26-Jun-01
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01

Gauge JB 12 - Water Table Depth




Gauge JB 13 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Date
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
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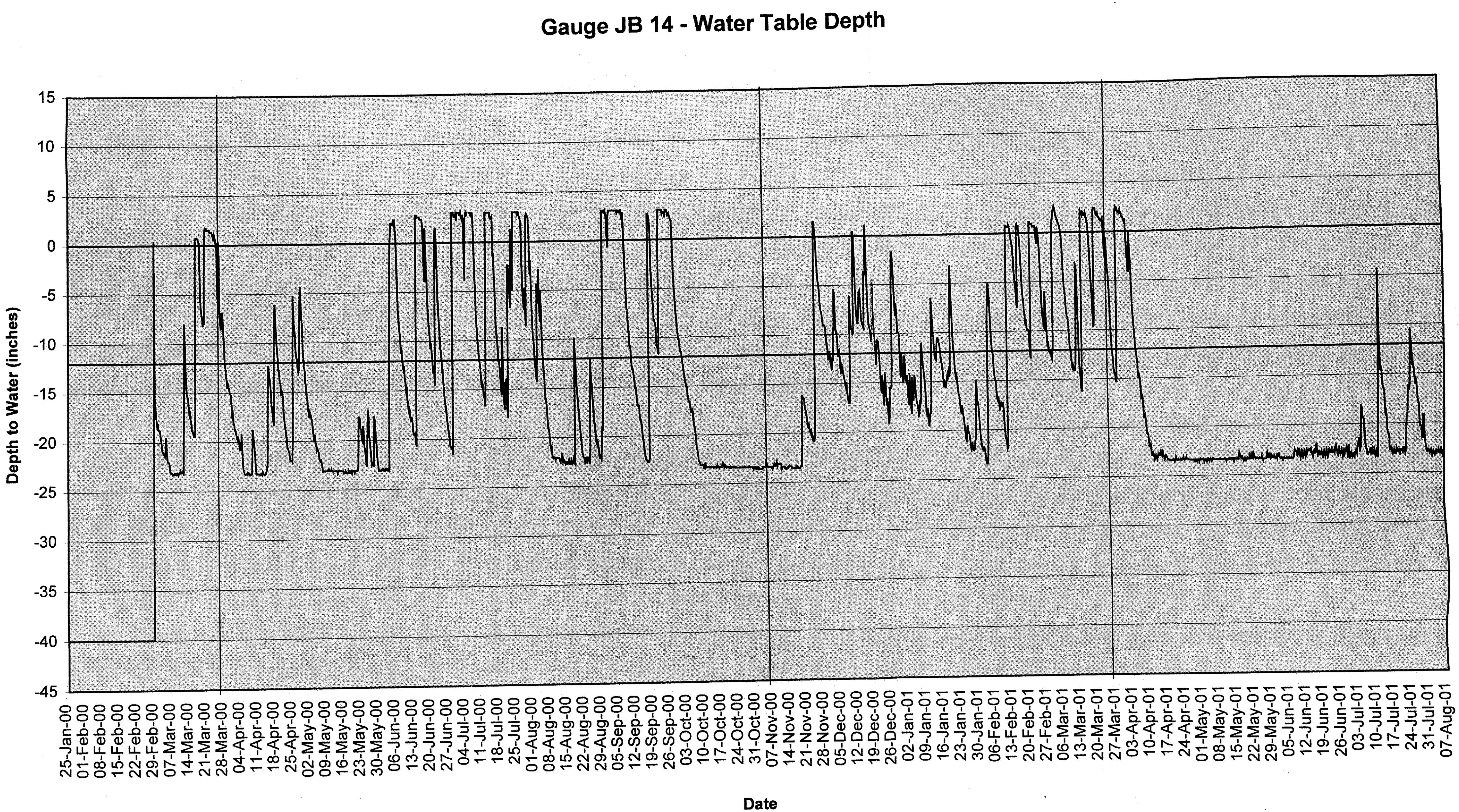
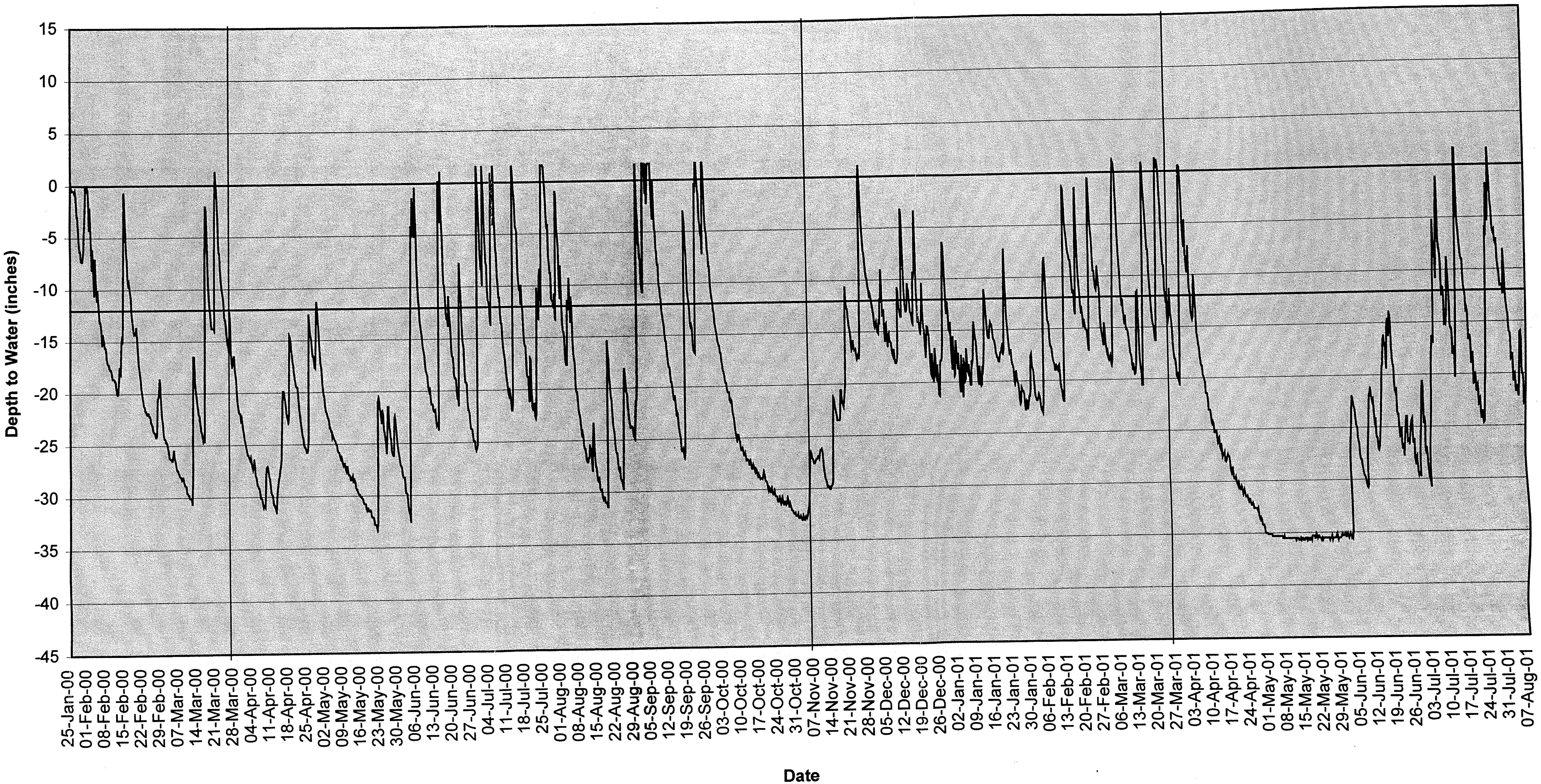
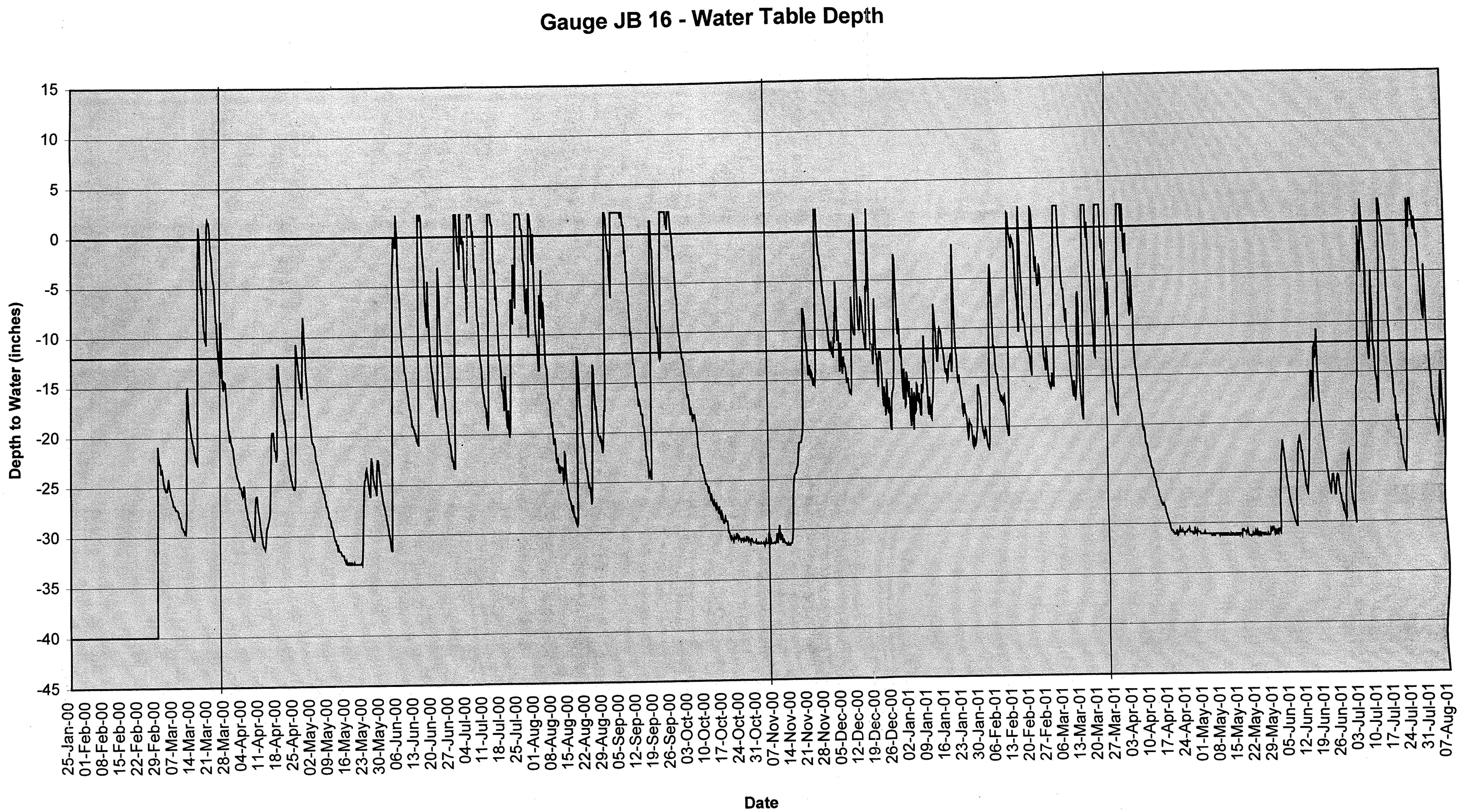
24-Jul-01
31-Jul-01
07-Aug-01

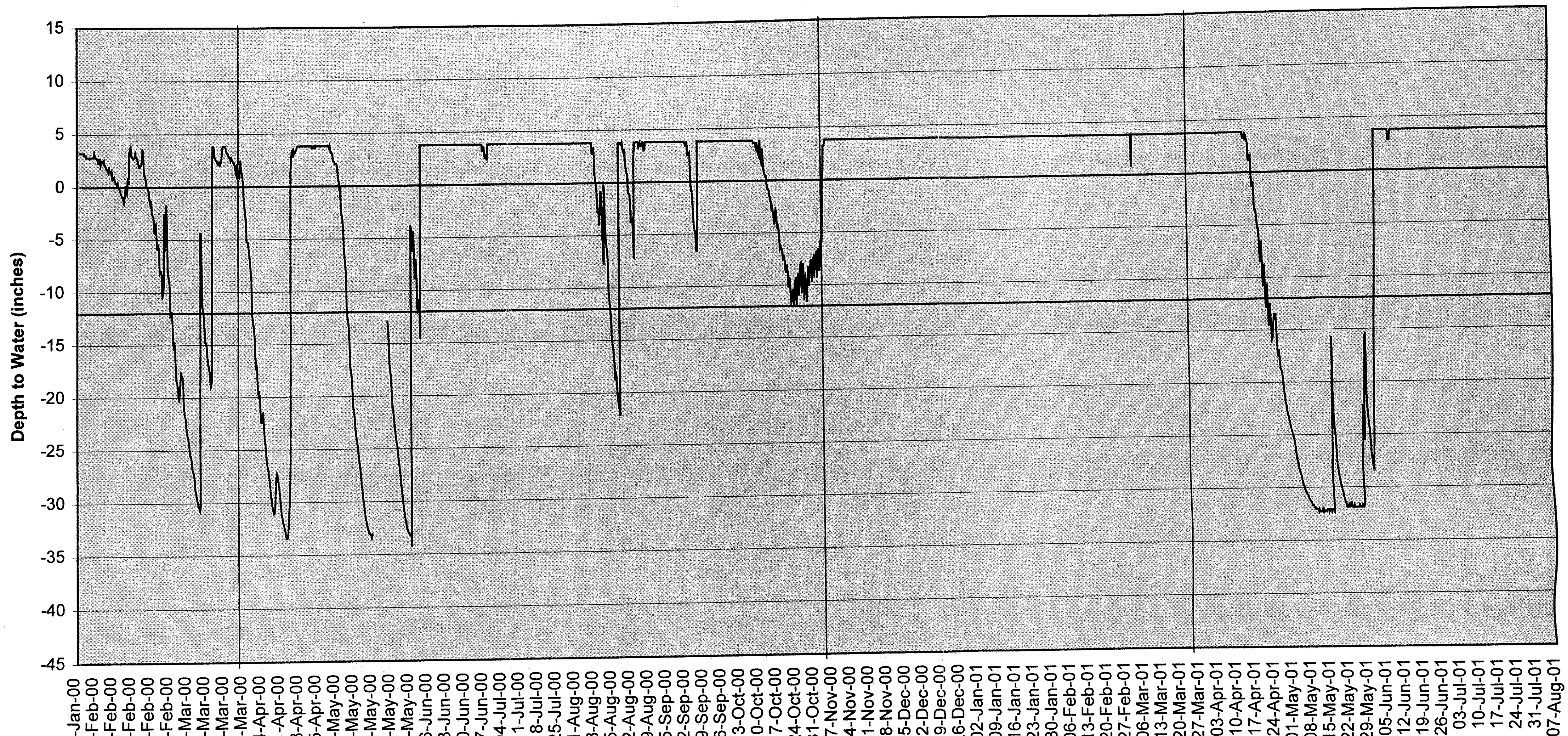

Gauge JB 14 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Date
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
26-Jun-01
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01

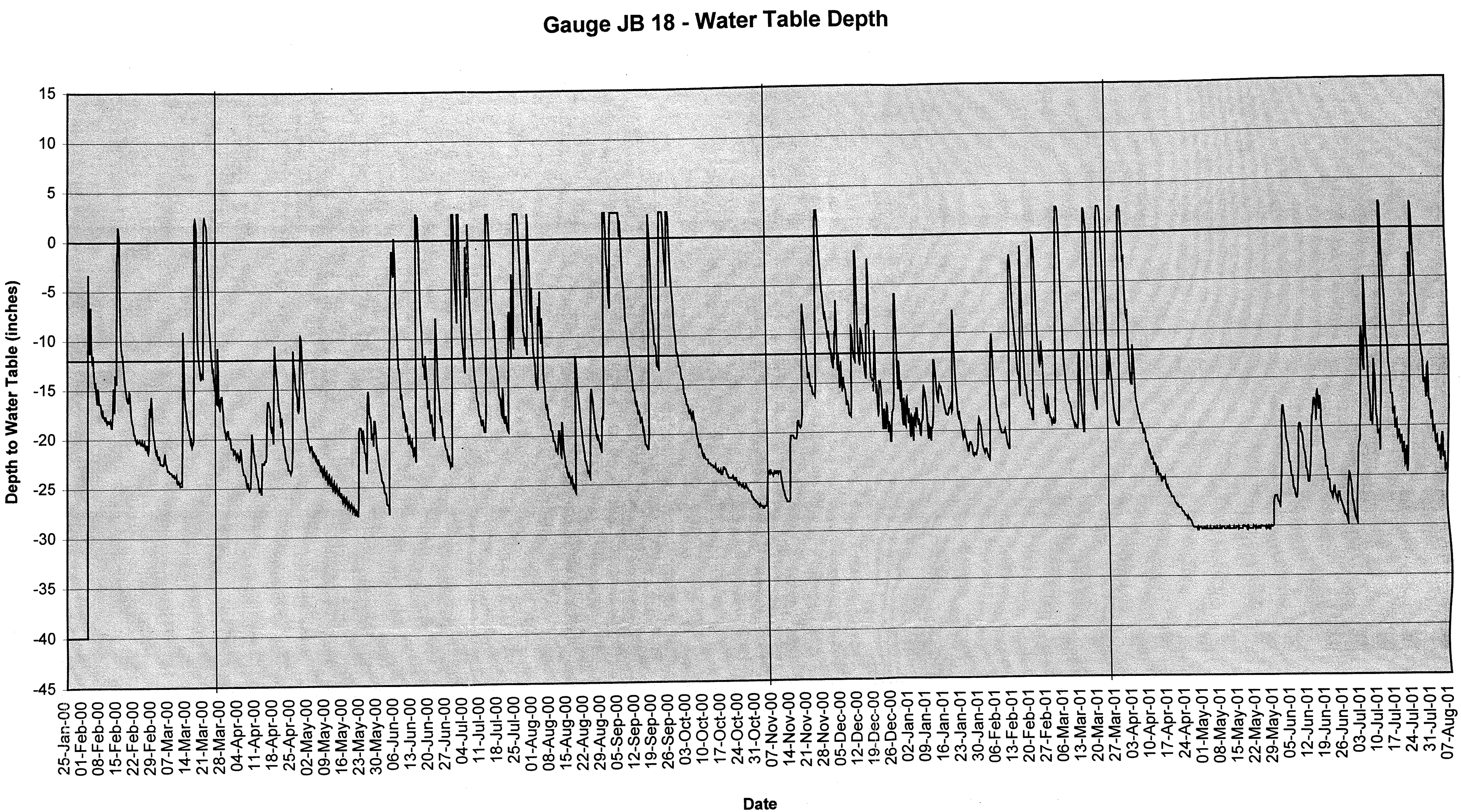
Gauge JB 15 - Water Table Depth




Gauge JB 16 - Water Table Depth
Depth to Water (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
26-Jun-01
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01
Date

Gauge JB 17 - Water Table Depth




Gauge JB 18 - Water Table Depth
Depth to Water Table (inches)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Date
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
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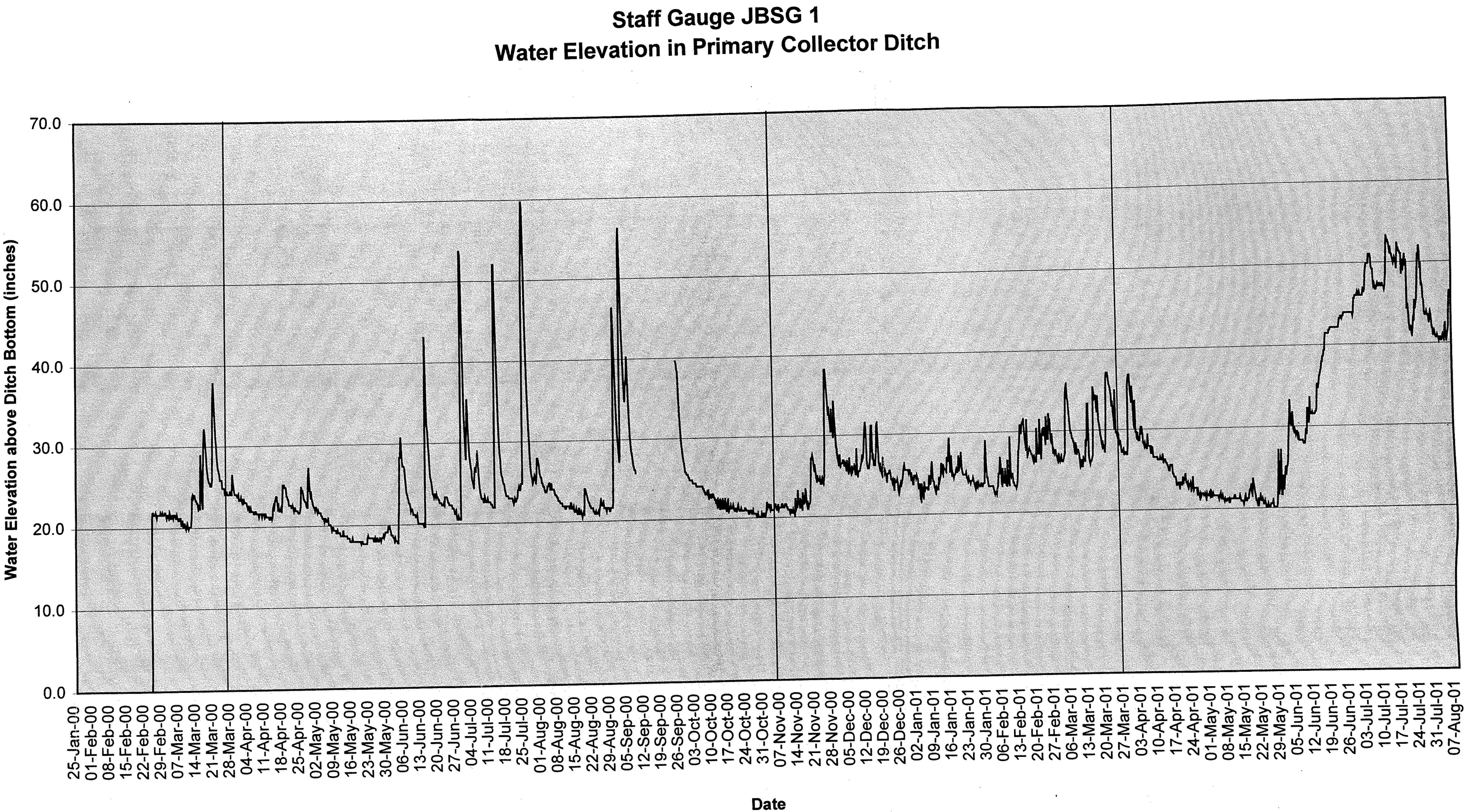
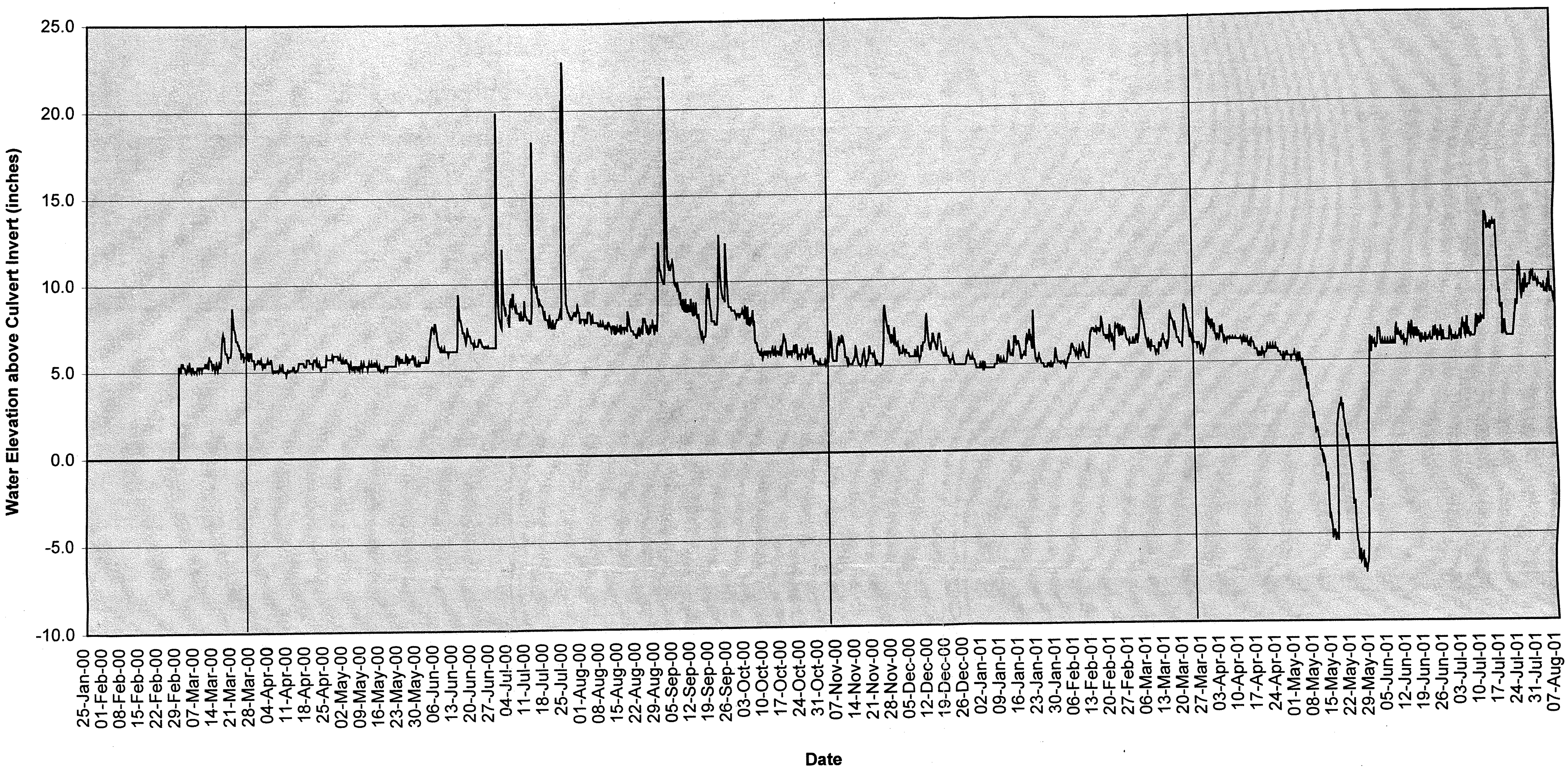
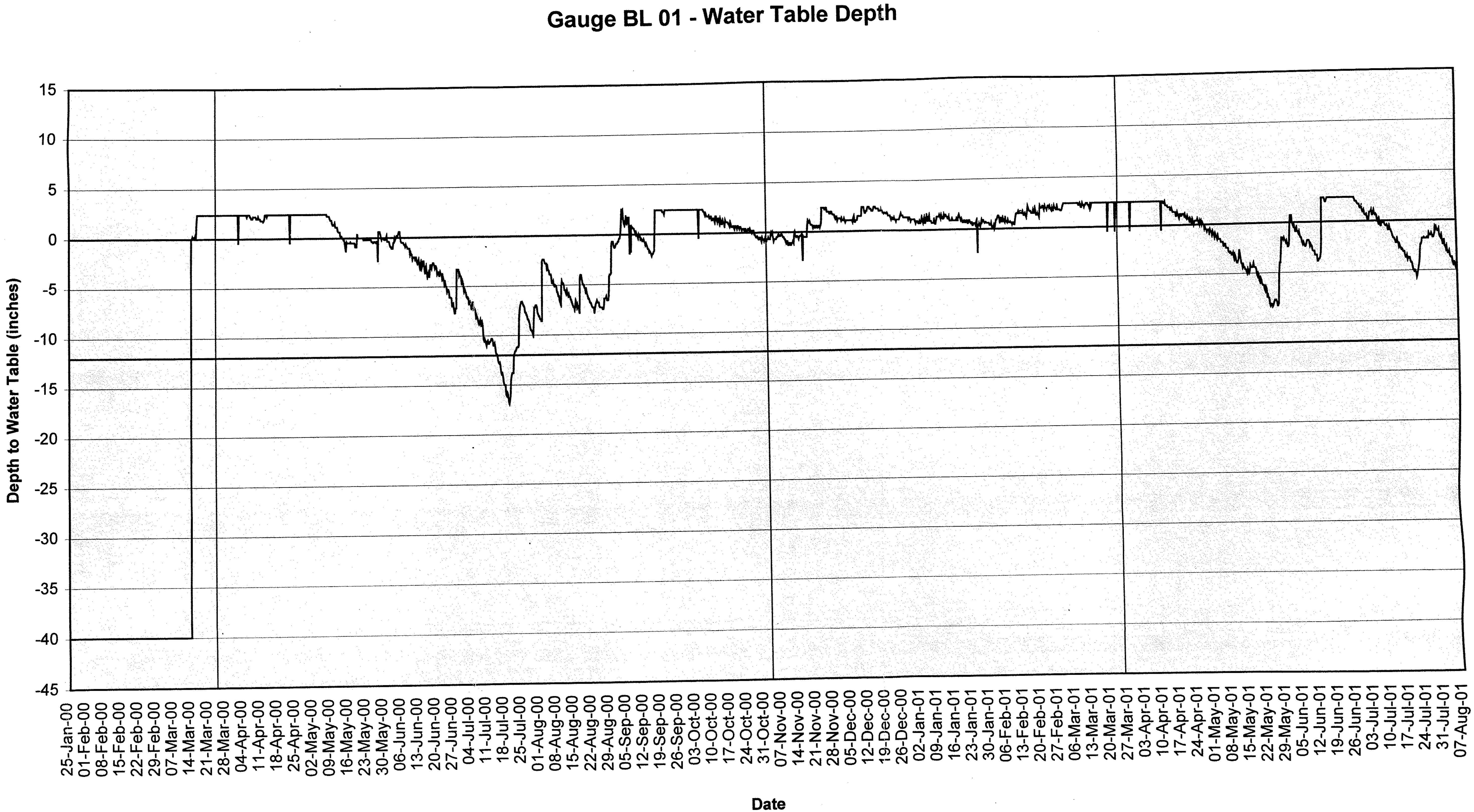
31-Jul-01
07-Aug-01


Staff Gauge JBSG 1
Water Elevation in Primary Collector Ditch
Water Elevation above Ditch Bottom (inches)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
12-Jun-01
19-Jun-01
26-Jun-01
03-Jul-01
10-Jul-01
17-Jul-01
24-Jul-01
31-Jul-01
07-Aug-01
Date

Staff Gauge JBSG 2
Water Elevation in Interior Collector Ditch



JBSG2all
JBSG2 Chart2


Gauge BL 01 - Water Table Depth
Depth to Water Table (inches)
Date
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
07-Mar-00
14-Mar-00
21-Mar-00
28-Mar-00
04-Apr-00
11-Apr-00
18-Apr-00
25-Apr-00
02-May-00
09-May-00
16-May-00
23-May-00
30-May-00
06-Jun-00
13-Jun-00
20-Jun-00
27-Jun-00
04-Jul-00
11-Jul-00
18-Jul-00
25-Jul-00
01-Aug-00
08-Aug-00
15-Aug-00
22-Aug-00
29-Aug-00
05-Sep-00
12-Sep-00
19-Sep-00
26-Sep-00
03-Oct-00
10-Oct-00
17-Oct-00
24-Oct-00
31-Oct-00
07-Nov-00
14-Nov-00
21-Nov-00
28-Nov-00
05-Dec-00
12-Dec-00
19-Dec-00
26-Dec-00
02-Jan-01
09-Jan-01
16-Jan-01
23-Jan-01
30-Jan-01
06-Feb-01
13-Feb-01
20-Feb-01
27-Feb-01
06-Mar-01
13-Mar-01
20-Mar-01
27-Mar-01
03-Apr-01
10-Apr-01
17-Apr-01
24-Apr-01
01-May-01
08-May-01
15-May-01
22-May-01
29-May-01
05-Jun-01
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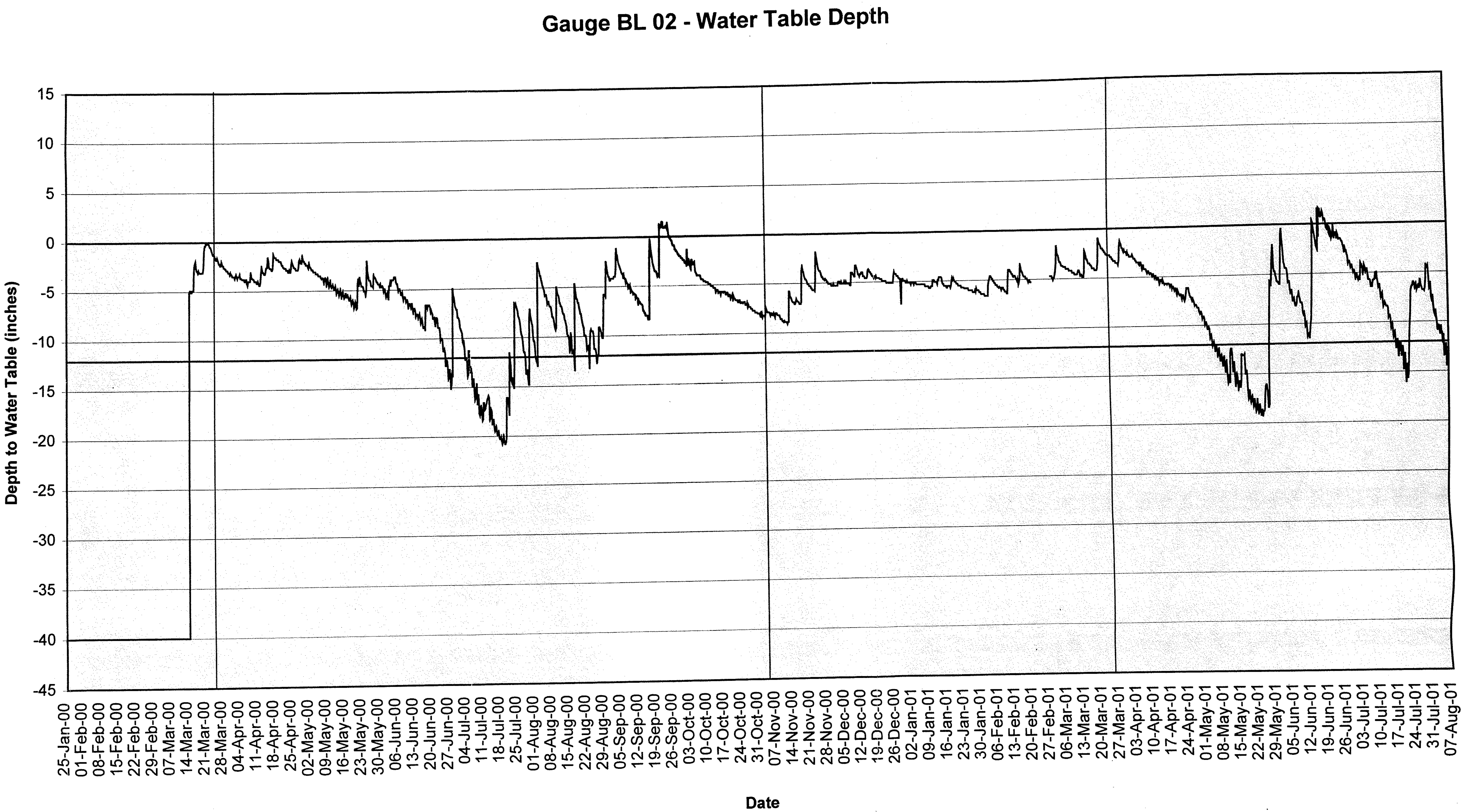
31-Jul-01
07-Aug-01



Gauge BL 02 - Water Table Depth
Depth to Water Table (inches)
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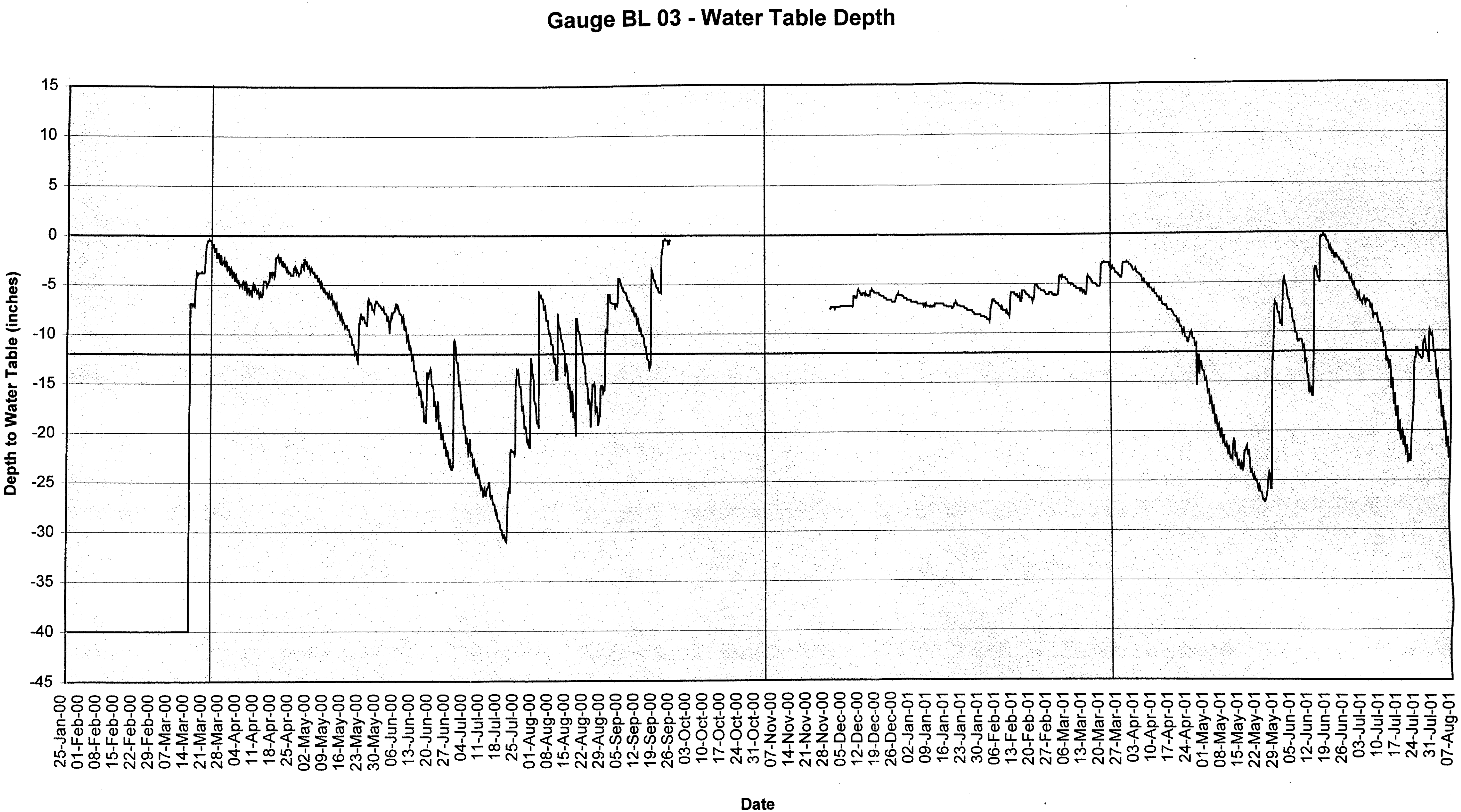
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Date


Gauge BL 03 - Water Table Depth
Depth to Water Table (inches)
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-15
-20
-25
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-35
-40
-45
25-Jan-00
01-Feb-00
08-Feb-00
15-Feb-00
22-Feb-00
29-Feb-00
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04-Apr-00
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18-Apr-00
25-Apr-00
02-May-00
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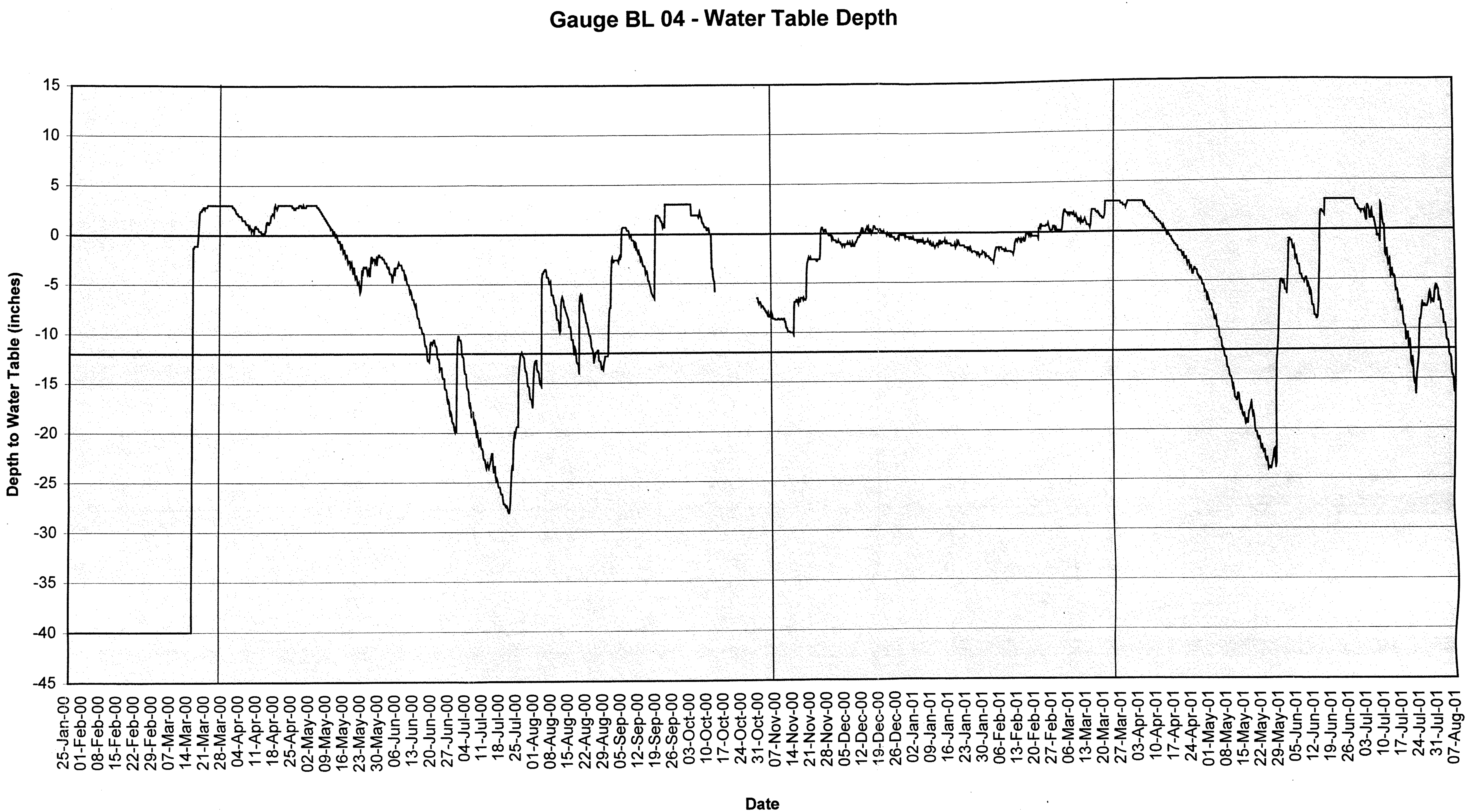
07-Aug-01



Gauge BL 04 - Water Table Depth
Depth to Water Table (inches)
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Date
25-Jan-00
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08-Feb-00
15-Feb-00
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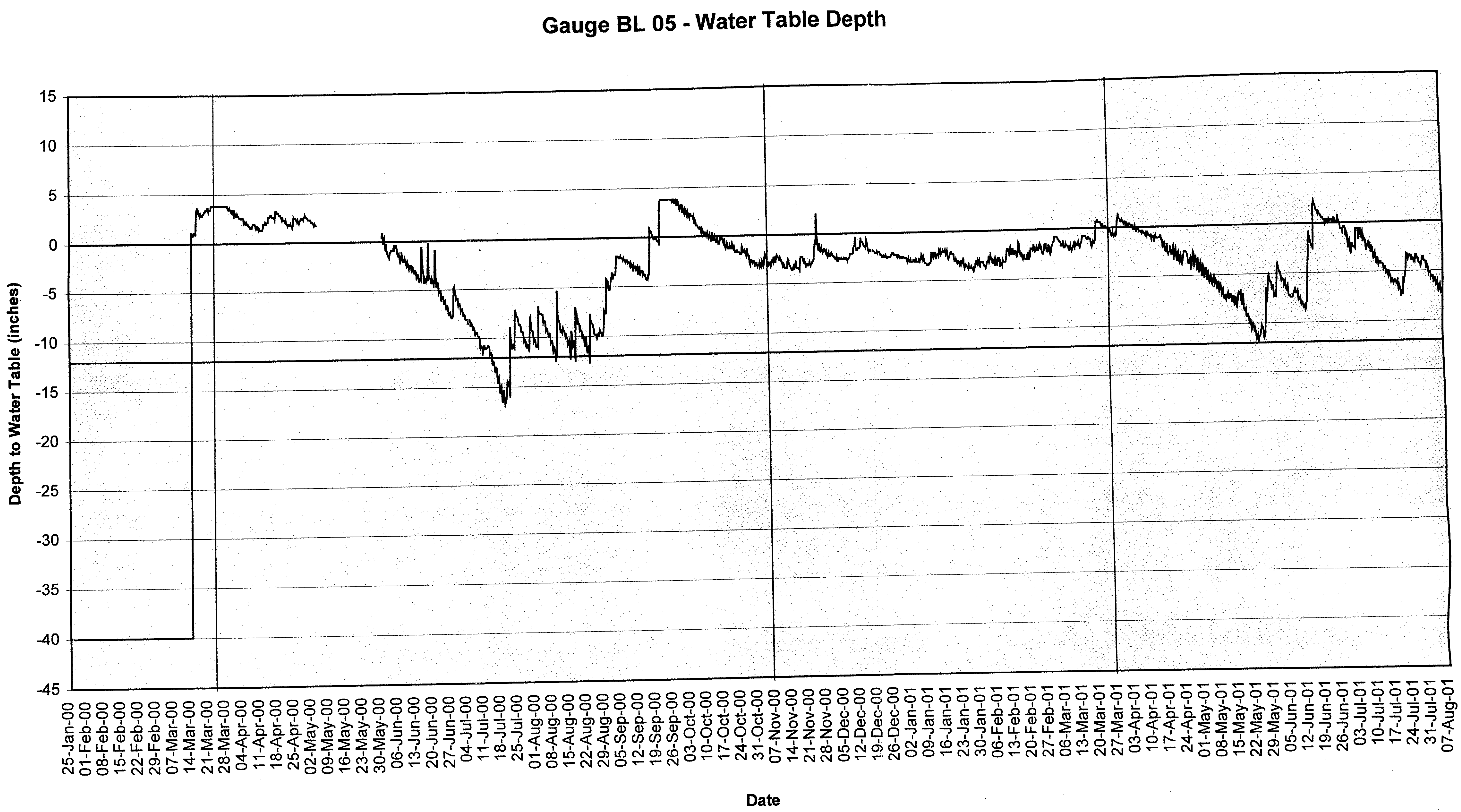
31-Jul-01
07-Aug-01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Depth to Water Table (inches)
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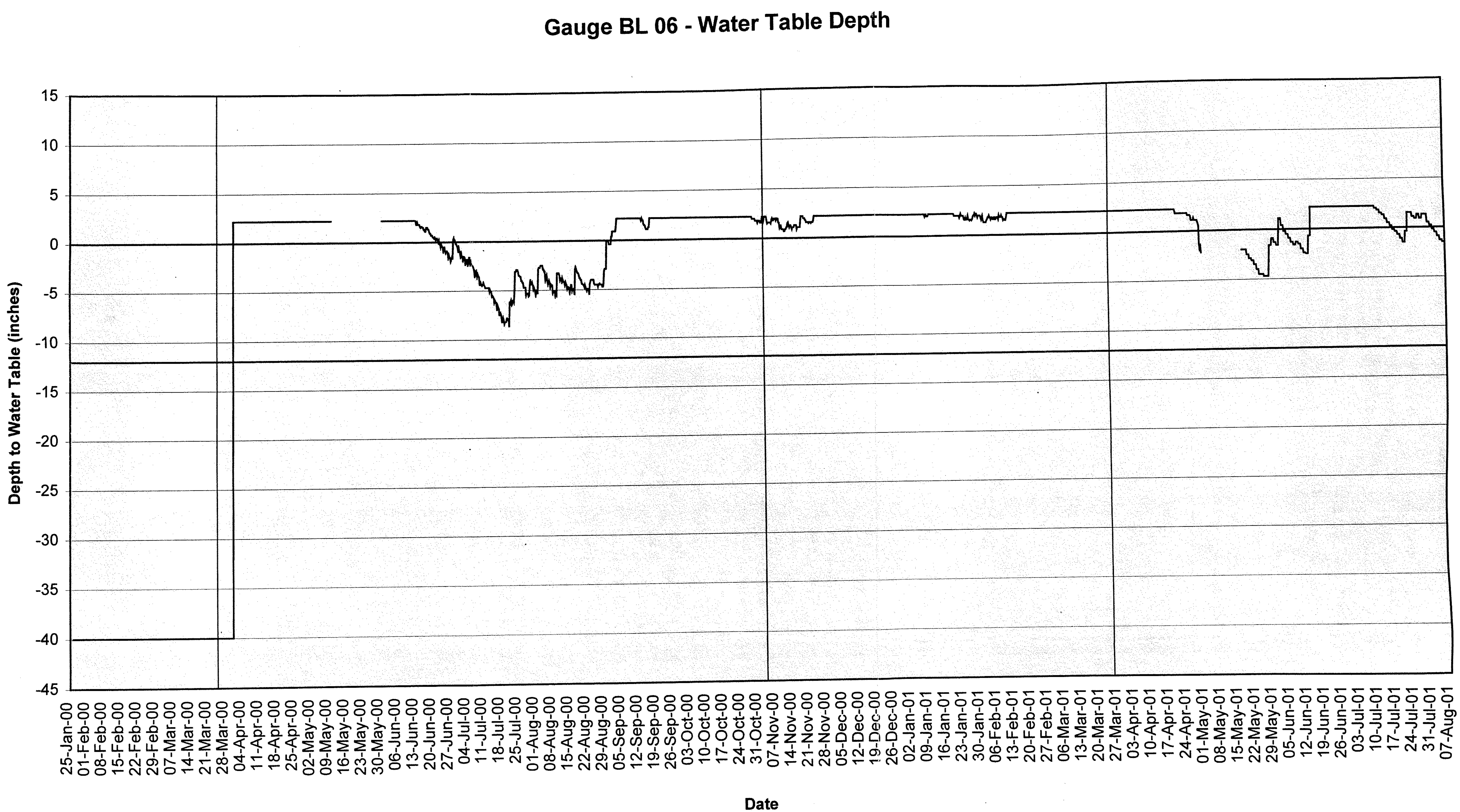
Gauge BL 06 - Water Table Depth
Depth to Water Table (inches)
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07-Aug-01

APPENDIX C
Climatological Data for Robeson County

Monthly/Annual Climate Data - Sum of Daily Precipitation from 1971 to 2001

LUMBERTON, NC (UCAN: 14194,COOP: 315177)

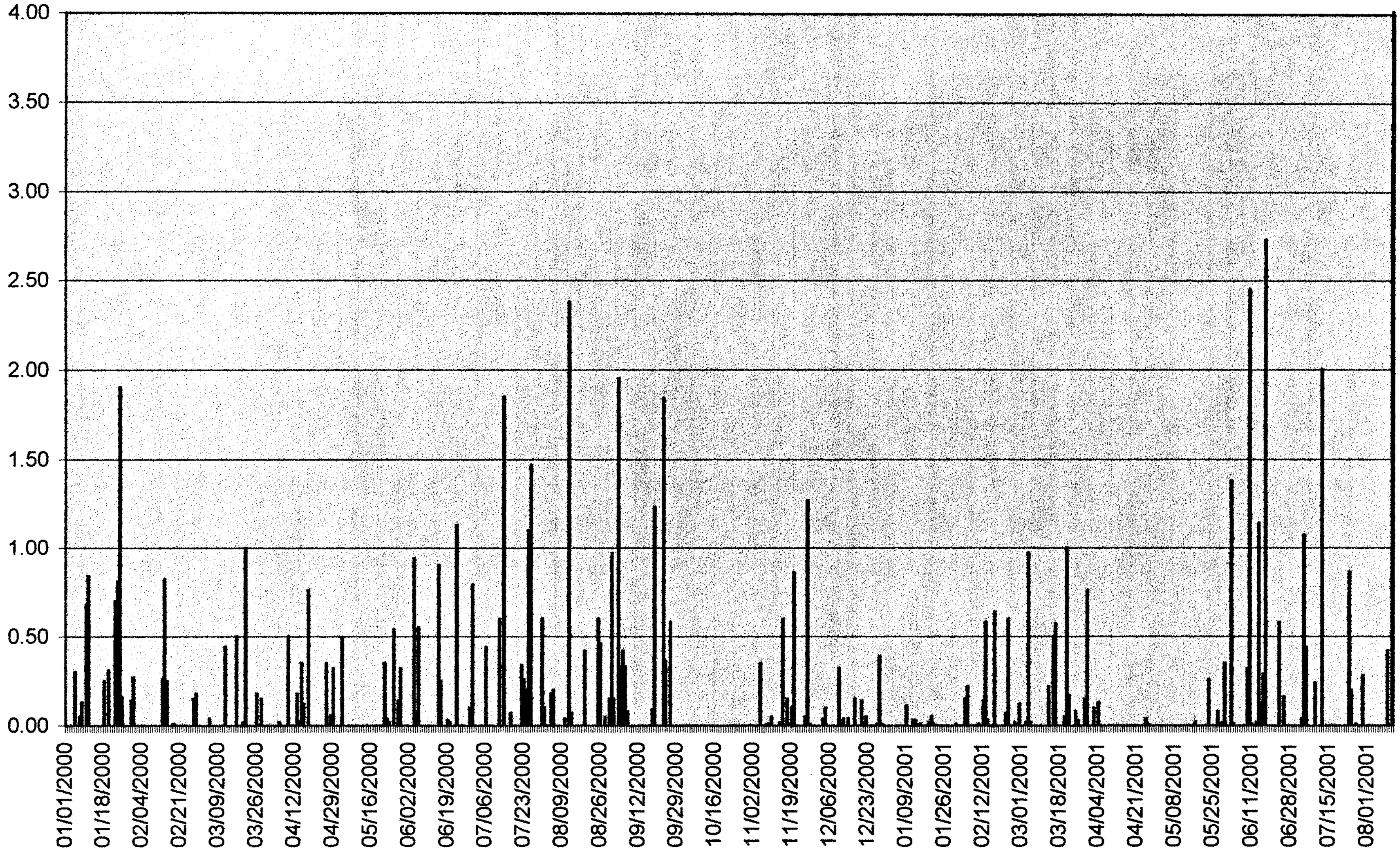
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1971	4.52	4.42	9.37	2.50	4.58	4.80	4.92	5.44	2.97	8.93	1.19	1.45	55.09
1972	4.58	4.07	2.38	1.55	3.52	4.60	5.44	3.78	2.86	2.46	4.53	3.14	42.91
1973	3.71	5.13	6.35	6.74	3.37	4.54	5.20	4.85	1.42	0.58	0.67	6.28	48.84
1974	3.53	4.13	2.54	2.04	7.92	5.10	5.74	10.46	4.84	0.90	1.61	4.41	53.22
1975	4.62	4.71	6.36	2.64	6.03	4.18	11.04	2.42	6.89	2.06	1.96	4.94	57.85
1976	3.19	1.13	3.09	0.11	4.66	5.23	3.46	4.40	2.48	4.49	3.30	5.15	40.69
1977	3.56	1.47	6.40	0.98	8.51	4.17	1.25	7.71	5.94	3.80	1.42	5.60	50.81
1978	5.25	0.71	3.04	4.10	5.87	7.11	5.92	3.45	2.36	0.70	5.83	2.54	46.88
1979	3.96	4.12	4.94	2.32	3.86	4.42	5.67	1.71	11.76	1.10	4.78	1.71	50.35
1980	4.19	2.30	8.36	2.16	6.49	3.56	2.54	1.37	3.23	5.40	1.80	2.38	43.78
1981	0.86	1.96	2.34	0.40	5.91	3.02	9.23	7.67	0.85	2.32	0.76	5.18	40.50
1982	6.01	5.72	1.61	5.00	3.31	5.02	7.29	1.84	2.95	5.68	2.38	4.67	51.48
1983	3.44	6.75	9.11	5.38	2.28	3.30	4.70	3.77	3.97	2.22	3.64	6.83	55.39
1984	1.94	5.96	5.58	3.09	3.78	4.11	6.43	3.53	5.32	2.16	0.66	1.29	43.85
1985	4.43	4.69	0.85	0.79	2.63	6.36	8.76	6.14	0.26	2.86	4.61	0.70	43.08
1986	1.46	2.28	2.52	1.22	2.36	2.70	3.28	8.73	1.54	3.38	3.99	2.82	36.28
1987	7.19	4.18	4.42	2.19	0.92	5.46	2.57	4.71	3.42	0.38	2.89	3.42	41.75
1988	1.95	1.52	2.29	2.25	3.83	4.36	6.32	6.23	7.01	1.52	1.54	0.14	38.96
1989	2.45	3.01	5.42	5.79	3.48	5.77	5.26	3.66	4.59	3.63	3.42	3.50	49.98
1990	1.26	0.62	1.84	--	--	--	--	--	--	--	--	--	3.72
1991	--	--	--	--	--	--	--	--	--	--	--	--	
1992	3.12	2.21	2.17	2.18	4.50	2.64	1.74	11.08	3.72	3.63	5.92	3.15	46.06
1993	6.81	2.18	3.21	4.53	1.30	2.12	4.69	5.12	5.51	4.03	2.26	2.89	44.65
1994	5.31	1.83	4.33	2.18	3.00	11.90	6.57	7.59	5.12	5.12	2.84	3.60	59.39
1995	6.72	5.73	2.76	0.90	3.04	10.34	5.60	4.75	3.16	6.36	3.00	1.39	53.75
1996	3.75	2.25	5.34	3.64	4.10	4.24	5.21	4.47	9.88	6.05	2.32	3.00	54.25
1997	3.31	3.63	3.95	3.75	1.71	2.45	11.18	1.50	4.85	3.01	3.57	5.20	48.11
1998	7.18	7.04	7.90	4.95	4.12	2.20	3.13	7.53	3.77	1.23	1.70	5.29	56.04
1999	7.40	2.02	2.84	4.04	4.43	3.77	6.20	4.94	16.92	7.24	1.14	1.79	62.73
2000	6.54	1.67	2.33	2.69	1.90	4.77	6.93	5.62	7.36	0.00	3.49	1.30	44.60
2001	0.27	2.58	4.54	0.28	0.73	9.21	5.14	0.42	--	--	--	--	23.17
AVG	**4.08**	**3.33**	**4.27**	**2.77**	**3.87**	**4.88**	**5.57**	**5.00**	**4.82**	**3.26**	**2.76**	**3.35**	**47.96**

Monthly/Annual Climate Data - Average of Mean Temperature from 1971 to 2001

LUMBERTON, NC (UCAN: 14194,COOP: 315177)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1971	41.15	44.30	47.56	58.70	66.29	76.82	77.82	76.45	73.82	66.52	52.07	53.13	61.22
1972	48.31	42.53	52.13	58.90	65.18	71.17	77.13	76.65	72.02	59.90	50.80	47.55	60.19
1973	42.27	41.09	56.45	59.13	67.06	75.75	77.48	77.85	74.87	63.35	54.57	44.02	61.16
1974	53.11	44.80	55.48	60.68	69.44	73.55	77.03	77.02	70.98	57.52	51.15	44.73	61.29
1975	46.89	48.61	51.27	58.83	71.42	75.90	76.69	79.84	73.55	64.06	53.95	43.35	62.03
1976	39.60	51.03	57.21	61.98	66.18	72.78	78.10	75.05	69.00	55.69	45.72	40.71	59.42
1977	31.73	41.73	55.69	64.32	70.23	75.43	81.25	78.40	74.75	58.02	54.40	45.33	60.94
1978	36.77	36.61	49.84	61.77	68.16	75.98	78.21	79.02	72.68	58.76	53.44	44.23	59.62
1979	40.00	38.86	52.97	62.53	68.03	71.25	77.29	76.79	71.85	58.31	53.73	42.13	59.48
1980	41.56	36.24	46.58	59.98	68.16	73.62	79.19	78.55	76.30	57.58	48.95	41.89	59.05
1981	34.85	44.59	47.29	64.05	66.68	79.03	78.37	74.56	68.48	56.84	48.98	38.30	58.50
1982	35.97	46.64	52.65	58.20	70.18	75.00	78.27	76.52	69.90	58.82	53.13	49.79	60.42
1983	42.61	41.91	51.52	54.60	65.95	72.87	78.05	78.06	70.15	59.69	51.45	42.48	59.11
1984	38.81	47.50	50.11	57.80	67.85	74.97	76.77	76.40	68.50	65.98	47.55	49.68	60.16
1985	37.38	44.64	53.89	63.75	68.56	76.08	77.19	75.61	71.47	65.47	61.68	--	63.25
1986	38.37	47.00	51.34	61.63	68.65	77.18	81.66	76.42	71.88	63.21	55.55	43.52	61.37
1987	39.35	40.86	49.87	56.58	69.44	76.90	78.27	78.92	72.12	53.39	53.98	45.15	59.57
1988	36.66	42.38	50.32	58.55	66.18	72.60	77.60	78.81	69.29	54.00	50.67	39.43	58.04
1989	43.76	49.56	49.18	58.06	64.50	76.58	77.28	74.45	70.36	59.54	58.03	39.54	60.07
1990	49.58	53.33	55.00	--	--	--	--	--	--	--	--	--	52.64
1991	--	--	--	--	--	--	--	--	--	--	--	--	
1992	44.13	48.67	51.21	59.53	64.90	73.40	82.35	76.69	73.12	58.82	54.90	44.98	61.06
1993	46.40	43.09	50.00	57.30	69.79	77.38	83.69	78.08	74.80	62.27	53.97	42.89	61.64
1994	40.37	46.91	54.95	63.38	65.18	78.03	80.02	76.48	69.98	60.55	57.73	49.50	61.92
1995	44.13	41.95	55.16	62.88	70.42	75.27	80.26	78.98	71.32	65.06	49.10	40.48	61.25
1996	41.68	44.62	48.89	60.38	70.61	76.17	79.39	76.44	72.27	61.82	48.70	47.06	60.67
1997	43.45	48.55	58.68	57.35	65.39	73.03	80.52	76.68	73.12	62.73	49.87	45.08	61.20
1998	46.82	47.88	52.79	61.53	71.27	80.12	81.95	79.27	75.58	63.97	54.72	50.05	63.83
1999	48.02	47.55	49.24	63.72	67.85	75.05	80.76	81.16	71.02	61.74	57.47	45.24	62.40
2000	41.32	48.22	55.94	59.37	72.85	77.73	77.85	77.44	72.15	61.81	50.65	37.68	61.08
2001	41.73	48.73	50.05	62.28	69.56	76.95	77.47	80.50	--	--	--	--	63.41
AVG	**41.89**	**45.01**	**52.11**	**60.27**	**68.14**	**75.40**	**78.89**	**77.49**	**71.98**	**60.55**	**52.75**	**44.37**	**60.74**

LUMBERTON, NC (UCAN: 14194,COOP: 315177) SUM Precip (in)



APPENDIX D
Species Observed at Juniper Bay

Agricultural Fields

Acalypha sp.	Three seeded mercury
Agalinis purpurea	Gerardia
Amaranthus spinosus	Thorny amaranth
Cassia nictitans	Wild sensitive plant
Cassia obtusifolia	Sicklepod
Croton glandulosus	
Diodia teres	Buttonweed
Elusine indica	Goosegrass
Eupatorium capillifolium	Dog fennel
Geranium carolinianum	Geranium
Gnaphalium obtusifolium	Rabbit tobacco
Ipomea hederacea	Morning glory
Ipomea purpurea	Common morning glory
Oenothera biennis	Evening primrose
Polygonum cespitosum	Smartweed
Polygonum lapathifolium	Smartweed
Polygonum pensylvanicum	Smartweed
Sedum sp.	Stonecrop
Solidago puberula	Goldenrod
Solidago rugosa	Goldenrod
Sorghum halepense	Johnson grass
Stellaria sp.	Chickweed
Taraxacum officinale	Dandelion
Verbena brasiliensis	

Ditches

Acer rubrum	Red maple
Andropogon virginicus	Broomsedge
Aralia spinosa	Devil's walking stick
Aster sp.	Aster
Baccharis halimifolia	Sea myrtle
Clethra alnifolia	Sweet pepperbush
Erianthus giganteus	Plume grass
Gordonia lasianthus	Loblolly bay
Ilex glabra	Gallberry
Juncus effusus	Soft rush
Lemna sp.	Duckweed
Liquidambar styraciflua	Sweetgum
Lonicera japonica	Honeysuckle
Ludwigia sp.	
Lyonia lucida	Fetterbush
Magnolia virginiana	Sweetbay
Myrica cerifera	Wax myrtle
Panicum sp.	Panic grass
Persea borbonia	Red bay
Pinus taeda	Loblolly pine
Polygonum cespitosum	Smartweed
Polygonum lapathifolium	Smartweed
Polygonum pensylvanicum	Smartweed
Rhexia mariana	Meadow beauty
Rhus copallina	Winged sumac
Rubus sp.	Blackberry
Salix nigra	Black willow
Sassafras albidum	Sassafras
Scirpus cyperinus	Woolgrass
Solidago sp.	Goldenrod
Toxicodendron radicans	Poison ivy
Typha latifolia	Cattail
Vitis rotundifolia	Muscadine

Longleaf Pine Plantations

Agalinus purpurea	Gerardia
Andropogon virginicus	Broomsedge
Aster sp.	Aster
Baccharis halimifolia	Sea myrtle
Campsis radicans	Trumpet creeper
Cassia fasciculata	Partridge pea
Eupatorium capillifolium	Dog fennel
Gnaphalium obtusifolium	Rabbit tobacco
Pinus palustris	Longleaf pine
Pinus taeda	Loblolly pine
Prunus serotina	Black cherry
Rhus copallina	Winged sumac
Solidago sp.	Goldenrod

Emergent Wetland

Andropogon virginicus	Broomsedge
Baccharis halimifolia	Sea myrtle
Cyperus erythrorhizos	Red-root flat sedge
Cyperus strigosus	
Erianthus giganteus	Plume grass
Juncus canadensis	
Juncus effusus	Soft rush
Panicum sp.	Panic grass
Polygonum pensylvanicum	Smartweed
Scirpus cyperinus	Woolgrass
Sesbania exaltata	Rattle-bush
Solidago sp.	Goldenrod

Wildlife

Castor canadensis	Beaver
Odocoileus virginianus	White-tailed deer (tracks)
Ondatra zibethicus	Muskrat
Sylvilagus floridanus	Cottontail rabbit
Agelaius phoeniceus	Red-winged blackbird
Ardea herodias	Great blue heron
Botaurus lentiginosus	American bittern
Butorides striatus	Green heron
Cathartes aura	Turkey vulture
Charadrius vociferus	Killdeer
Circus cyaneus	Marsh hawk
Colinus virginianus	Bobwhite quail
Eudocimus albus	Ibis
Passerina cyanea	Indigo bunting
Quiscalus quiscula	Grackle
Sialia sialis	Bluebird
Sturnella magna	Eastern meadowlark
Zenaida macroura	Mourning dove
Chrysemys floridana	Florida cooter
Coluber constrictor	Black racer
Hyla cinerea	Green treefrog
Rana palustris	Pickerel frog

APPENDIX E
Species Observed at Tatum Millpond Bay

Table 1. Plant species observed on Transect 1 at Tatum Millpond Bay.

Stratum	**Common Name**	**Scientific Name**
Canopy	Swamp tupelo *	*Nyssa sylvatica* var. *biflora*
	Red maple *	*Acer rubrum*
	Bald cypress	*Taxodium distichum*
	Atlantic white cedar	*Chamaecyparis thyoides*
	Loblolly pine	*Pinus taeda*
Midstory	Red maple *	*Acer rubrum*
	Swamp red bay *	*Persea borbonia*
	Laurel-leaved greenbrier *	*Smilax laurifolia*
	Sweetbay *	*Magnolia virginiana*
	Atlantic white cedar	*Chamaecyparis thyoides*
	Loblolly bay	*Gordonia lasianthus*
Shrubs	Fetterbush *	*Lyonia lucida*
	Pepperbush *	*Clethra alnifolia*
	Maleberry *	*Lyonia ligustrina*
	Virginia willow	*Itea virginica*
	Sweetbay	*Magnolia virginiana*
	Doghobble	*Leucothoe axillaris*
	Inkberry	*Ilex coriacea*
	American holly	*Ilex opaca*
	Highbush blueberry	*Vaccinium corymbosum*
	Yellow jessimine	*Gelsimium sempervirens*
	Swamp azalea	*Rhododendron viscosum*
	Gallberry	*Ilex glabra*
	Leatherleaf	*Cassandra calyculata*
Herbs	Sphagnum moss *	*Sphagnum* sp.
	Virginia chain fern	*Woodwardia virginica*

Note: * - Dominant species in the particular stratum.

Table 2. Plant species observed on Transect 2 at Tatum Millpond Bay.

Stratum	Common Name	Scientific Name
Canopy	Loblolly pine *	*Pinus taeda*
	Loblolly bay *	*Gordonia lasianthus*
Midstory	Red maple *	*Acer rubrum*
	Laurel-leaved greenbrier *	*Smilax laurifolia*
	Sweetbay	*Magnolia virginiana*
Shrubs	Fetterbush *	*Lyonia lucida*
	Red maple *	*Acer rubrum*
	Inkberry *	*Ilex coriacea*
	Swamp azalea	*Rhododendron viscosum*
	Maleberry	*Lyonia ligustrina*
	Pepperbush	*Clethra alnifolia*
	Dangleberry	*Gaylussacia frondosa*
	Titi	*Cyrilla racemiflora*
	Chokeberry	*Aronia arbutifolia*
	Swamp red bay	*Persea borbonia*
Herbs	Cinnamon Fern	*Osmunda cinamomea*

Note: * - Dominant species in the particular stratum.

Table 3. Plant species observed on Transect 3 at Tatum Millpond Bay.

Stratum	Common Name	Scientific Name
Canopy	Loblolly bay *	*Gordonia lasianthus*
	Atlantic white cedar *	*Chamaecyparis thyoides*
	Swamp tupelo	*Nyssa sylvatica* var. *biflora*
Midstory	Red maple *	*Acer rubrum*
	Sweetbay *	*Magnolia virginiana*
	Loblolly bay *	*Gordonia lasianthus*
Shrubs	Fetterbush *	*Lyonia lucida*
	Laurel-leaved greenbrier *	*Smilax laurifolia*
	Inkberry *	*Ilex coriacea*
	Pepperbush	*Clethra alnifolia*
	Maleberry	*Lyonia ligustrina*
	Swamp red bay	*Persea borbonia*
	Highbush blueberry	*Vaccinium corymbosum*
	Titi	*Cyrilla racemiflora*
Herbs	Sphagnum moss	*Sphagnum* sp.

Note: * - Dominant species in the particular stratum.