

William L. Jackson



Larry Martin



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CUIS/General

Memorandum

To: Jerry Belson, Regional Director, Southeast Region

Through: William L. Jackson, Chief, Water Operations Branch, Water Resources Division

From: Larry Martin, Hydrologist, Water Operations Branch, Water Resources Division

Subject: Potential for groundwater pumping from the Floridan aquifer on the mainland to affect wetlands on Cumberland Island.

SUMMARY:

A rather lengthy letter was sent to the Southeast Regional Director from a Sydney T. Bacchus, Ph.D. Among other things, the letter alleges that groundwater pumping from the Floridan aquifer on the mainland in Georgia is the cause of perturbations to the hydrologic regime of wetlands on Cumberland Island.

Having reviewed several reports from the USGS and Georgia Geologic Survey, I could find no corroborating evidence for this claim. The artesian pressure in the Floridan aquifer at Cumberland Island has decreased since the first well was drilled on the island in 1887. However, since the artesian pressure is still 10-20 feet higher than land surface, it is physically impossible for water to leak downward from the surficial sand aquifer to the Floridan aquifer.

There are a number of possible causes for the perturbations (if there are any) to the hydrologic regime of wetlands on Cumberland Island. Possible causes include:

1. Drought
2. Changes in operation of drainage ditches
3. Naturally occurring geologic processes

Pumping groundwater from the Floridan aquifer on the mainland, or any other groundwater management activities involving the Floridan or deeper aquifers, will not affect the hydrologic regime of the surficial sand aquifer or wetlands on Cumberland Island. The surficial sand aquifer is underlain by a confining bed that effectively isolates it from deeper aquifers.

DISCUSSION:

Hydrogeology

There are many USGS reports describing various aspects of the local and regional hydrogeology of southeast Georgia and adjacent parts of South Carolina and Florida (Brown 1984, Leeth 1999, Randolph and Krause 1990). In general, these reports focus on the Floridan aquifer, the major groundwater resource in the area. The Floridan aquifer has been extensively developed for municipal and industrial water supplies in this area. The USGS reports generally ignore the small, near-surface aquifers because they are not areally extensive, and are not a source of large quantities of water. However, these reports clearly identify the Floridan aquifer as being confined. The confining units are a series of dense, impermeable beds of clay, marl, limestone, and dolomite.

Herndon (1991) investigated the hydrogeology of the near-surface units at Cumberland Island. She was generally only concerned with the aquifers down to about 100 feet below ground surface. (These are the sediments that are lumped together as the surficial aquifer in the USGS reports.) From the surface to 100 feet below ground surface, Herndon (1991) describes the hydrogeology (from land surface down) as consisting of a surficial sand aquifer, a confining layer, the Pliocene-Miocene aquifer, and another confining layer.

The surficial sand aquifer is about 20-60 feet thick and is mostly comprised of very-fine quartz sand. This sand is a barrier island facies deposited in a near shore environment that has been repeatedly reworked by water, wind, and waves. The sand overlies 5-40 feet of clay and sandy clay, representing back-bay sedimentation in a relatively quiet marsh-type environment. Commonly, the clay is interbedded with sand ranging from less than 1 to 10 feet thickness. The lithology indicates an estuarine back-barrier depositional environment interrupted by periods of high energy (Herndon, 1991). The Pliocene-Miocene aquifer consists of Miocene-age limestone and Pliocene-age sand. Herndon's study area was on the south end of the island where the Pliocene-Miocene aquifer ranged in thickness from 15-33 feet thick, starting at depths of 50-80 feet below land surface. The Pliocene-Miocene aquifer is confined above by about 30 feet of Pleistocene-age clay sediments and below by alternating layers of argillaceous dolomite and clay (Herndon, 1991). The presence of a thick clay layer above the Pliocene-Miocene aquifer limits interaction with the surficial sand aquifer. A graphic depiction of the hydrogeology of the shallow sediments on Cumberland Island is shown in Figure 1.

The near-surface hydrogeology of Cumberland Island is very similar to other barrier islands. The sequence of a surficial sand aquifer composed of reworked sand overlying a confining unit

composed of back-bay sediments overlying older sediments is typical of barrier islands all along the east coast (Pilkey and others, 1978).

Starting about 100 feet below land surface is a series of confining units and minor aquifers (see Figure 2). The confining units consist of dense, relatively impermeable beds of clay and marl (Brown, 1984). The aquifers are sand, limestone, or dolomite. These units are often lumped together as the upper confining unit in the USGS reports on regional hydrogeology. The upper confining unit is about 400 feet thick and separates the surficial aquifer from the Floridan aquifer. The confining units have low hydraulic conductivity that retards groundwater flow between aquifers. There is some leakage of water from one aquifer to another, but the rate of leakage is orders of magnitude less than the rate of flow within an aquifer.

The Floridan aquifer is a stratified sequence of limestone and dolomite layers about 1600 feet thick. The top of the aquifer is about 500 feet below sea level at Cumberland Island. The Floridan aquifer is the primary source of large amounts of water for municipal and industrial supplies. Large-scale groundwater pumping at Fernandina Beach, St. Marys, and Brunswick has resulted in a decrease in the artesian pressure in the aquifer. At Cumberland Island, the artesian pressure in the Floridan aquifer has decreased from about 60 feet above sea level to about 30 feet above sea level.

The relationship of the surficial aquifer on Cumberland Island to the deep Floridan aquifer and to the series of aquifers and confining beds in the context of the regional hydrogeology is shown in Figure 3.

Hydrology

The artesian pressure in the Floridan aquifer remains sufficient to produce flow from wells on Cumberland Island. The hydraulic gradient between the Floridan aquifer and shallow aquifers is upward. Leakage tends to be from the deep aquifer to the shallow aquifers. If there were fractures or faults creating an interconnection between the aquifers, the tendency would be for water to flow from the deep Floridan aquifer toward the surface. The shallow aquifers could not, and do not (under existing or past conditions), act as recharge sources for the deep Floridan aquifer.

If water were leaking from the deep Floridan aquifer upward into the shallower aquifers, the pressure would be reduced with each succeeding aquifer as the water moved upward in the geologic column. Water leaking into the surficial sand aquifer from below does not form a "mound" because the permeability of the sand is so large, and the volume of water so small, that the water can flow horizontally as easily as it does vertically. Even if the rate of upward leakage were reduced, it would not affect the elevation of the water table in the surficial sand aquifer. The water table elevation of the surficial sand aquifer is controlled by recharge, which is dependent on the amount and frequency of rainfall on the island.

Bacchus (2000) states with regard to the sinkhole-like depressions on Cumberland Island, “the apparent rim of the largest depression observed in the Wilderness Area [is] approximately 7 m (23 ft) in diameter.” However, it seems likely that a much larger surface expression would result if the sinkhole depressions were caused by aquifer dissolution and collapse of the rock matrix at a depth greater than 500 feet below ground surface. Fuller (1997) states that test drilling on Cumberland Island encountered a calcareous zone in all test wells at a depth of about 55 feet and having a thickness of about 20 feet. Dissolution of these shallow calcareous rocks could be the source of the small sinkhole depressions observed at Cumberland Island.

The surficial sand aquifer is recharged by precipitation. Brown (1984) estimated that recharge to the groundwater system from infiltration of precipitation averaged 6 inches per year. Flow between the surficial sand aquifer and deeper aquifers is restricted by the confining bed from about 30-60 feet below ground surface. Herndon (1991) constructed several nests of monitoring wells, each monitoring well in the nest being completed at a different depth and in a different aquifer. At Site 3, near Dungeness, there is one shallow monitoring well completed in the surficial sand aquifer and 3 monitoring wells ranging from 72-132 feet deep completed in aquifers below the confining bed. Water levels in all wells were measured on June 28, 1991. The water level in the shallow well was about 2½ feet higher than in the deeper wells, showing that the uppermost confining bed was sufficiently impermeable to allow a large difference in water levels between wells located only a few feet apart but completed on opposite sides of the confining bed. This relationship is shown in Figure 4.

In 2000, NPS use of potable water on the island was approximately 1.8 million gallons. This water is obtained from a deep well completed in the Floridan aquifer. Most of this water is recharged to the surficial sand aquifer after passing through septic tanks and leachfields. The amount of water used by private property owners on the island is not known. There are at least 23 deep wells completed in the Floridan aquifer on Cumberland Island. Unless the water taken from these wells is physically transported off the island, it ends up recharging the surficial sand aquifer.

The estimated groundwater recharge of six inches per year from infiltration of precipitation (Herndon, 1991) is equivalent to 104 million gallons per year per square mile. All of this recharge occurs to the surficial sand aquifer. The confining bed underlying the surficial sand aquifer limits groundwater flow from the surficial sand aquifer to deeper aquifers. The majority of the water that is recharged to the surficial sand aquifer is either consumed by evapotranspiration or discharges to the ocean.

Most of Georgia has been experiencing a drought during the past 4 years. Since recharge to the surficial sand aquifer is dependent on rainfall, we would expect lower than normal water levels in wetlands during droughts. An extended drought period will have a cumulative effect and we would expect to see more prolonged periods of lower water table conditions.

The topographic map for Cumberland Island South shows a drainage ditch constructed in the large wetland complex southeast of Plum Orchard. This is the only artificial drainage ditch shown on

topo maps of the island. Operation and maintenance of the ditch may cause changes in the hydroperiod of this wetland and adjacent wetlands. Replacement of a headgate, change in the elevation of an outflow control structure, or simply cleaning vegetation out of the ditch could result in more efficient drainage of water from the wetland, resulting in generally lower water levels in the wetland.

If you would care to solicit a second or third opinion on this subject, I suggest that you contact William H. McLemore, Georgia State Geologist, at (404)-656-3214 or Edward H. Martin, USGS Georgia District Chief, at (770)-903-9100. Either of these gentlemen, or someone on their staff, should be able to provide an opinion on this subject. Both of these agencies have conducted numerous scientific investigations regarding the hydrogeology and groundwater resources of coastal Georgia.

CONCLUSIONS:

The hydrogeology at Cumberland Island is not conducive to downward leakage from the shallow aquifers to the Floridan aquifer. There are many low-permeability confining units between the shallow aquifers and the Floridan aquifer that would impede the vertical movement of groundwater. There have been numerous hydrologic and geologic reports regarding the groundwater flow system in coastal Georgia. None of these previous reports identified faults, fractures, or sinkhole conduits that might act as vertical conduits for groundwater flow between the Floridan aquifer and shallow aquifers. The artesian pressure in the Floridan aquifer is higher than land surface on Cumberland Island. It is impossible for surface water to infiltrate from wetlands on the island downward to the Floridan aquifer because the hydraulic gradient is vertically upward.

ACTION ITEMS:

None. WRD staff are available to provide further assistance if requested by the park.

REFERENCES:

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Clarke, J.S., C.M. Hacke, and M.F. Peck, 1990, Geology and Ground-Water Resources of the Coastal Area of Georgia, Georgia Geologic Survey Bulletin No. 113, 106 pp.

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Leeth, David C., 1999, Hydrogeology of the Surficial Aquifer in the Vicinity of a Former Landfill, Naval Submarine Base Kings Bay, Camden County, Georgia, USGS Water-Resources Investigation Report 98-4246, 28 pp.

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Randolph, Robert B. and Richard E. Krause, 1990, Analysis of the Effects of Hypothetical Changes in Ground-Water Withdrawal from the Floridan Aquifer System in the Area of Glynn County, Georgia, USGS Water-Resources Investigation Report 90-4027, 32 pp.

Wilson, Stephen K., 1990, The Hydrochemistry of Southeastern Cumberland Island, Georgia, M.S. Thesis, Georgia State University, Department of Geology, also available as Research/Resources Management Report SER 91/04, U.S. National Park Service, Southeast Regional Office, 93 pp.

Attachments (4)

cc:

CUIS – Superintendent, Andy Ferguson
2380 – Kimball, Pettee, Flora
5010 – Rich Sussman, John Barrett, Jerry O'Neal

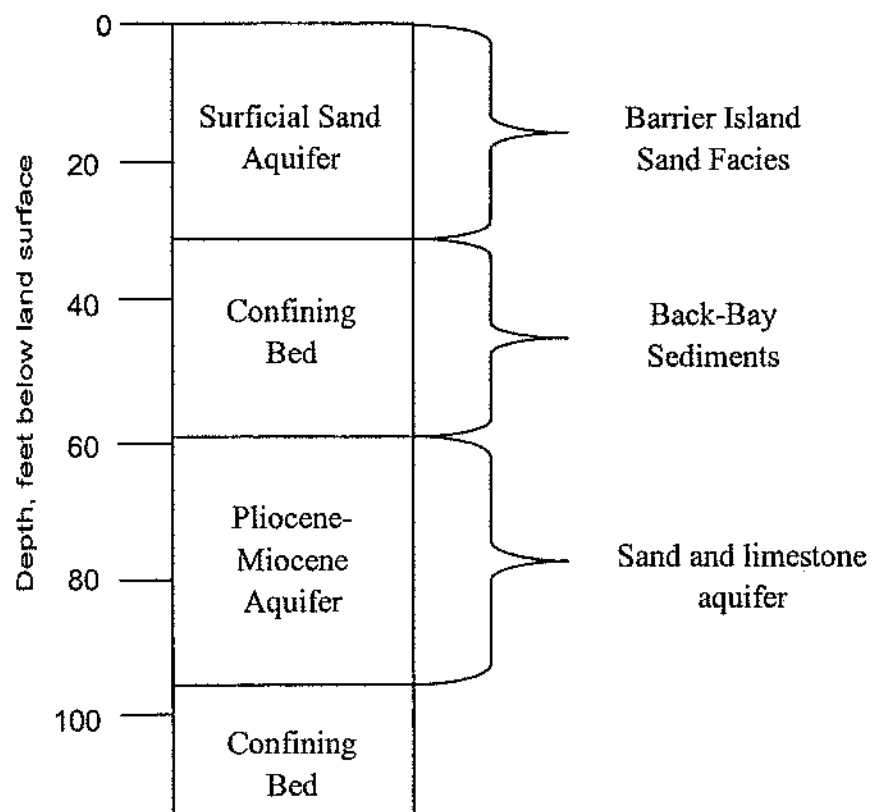


Figure 1. Hydrogeology of the near-surface sediments at Cumberland Island, from Wilson (1990)

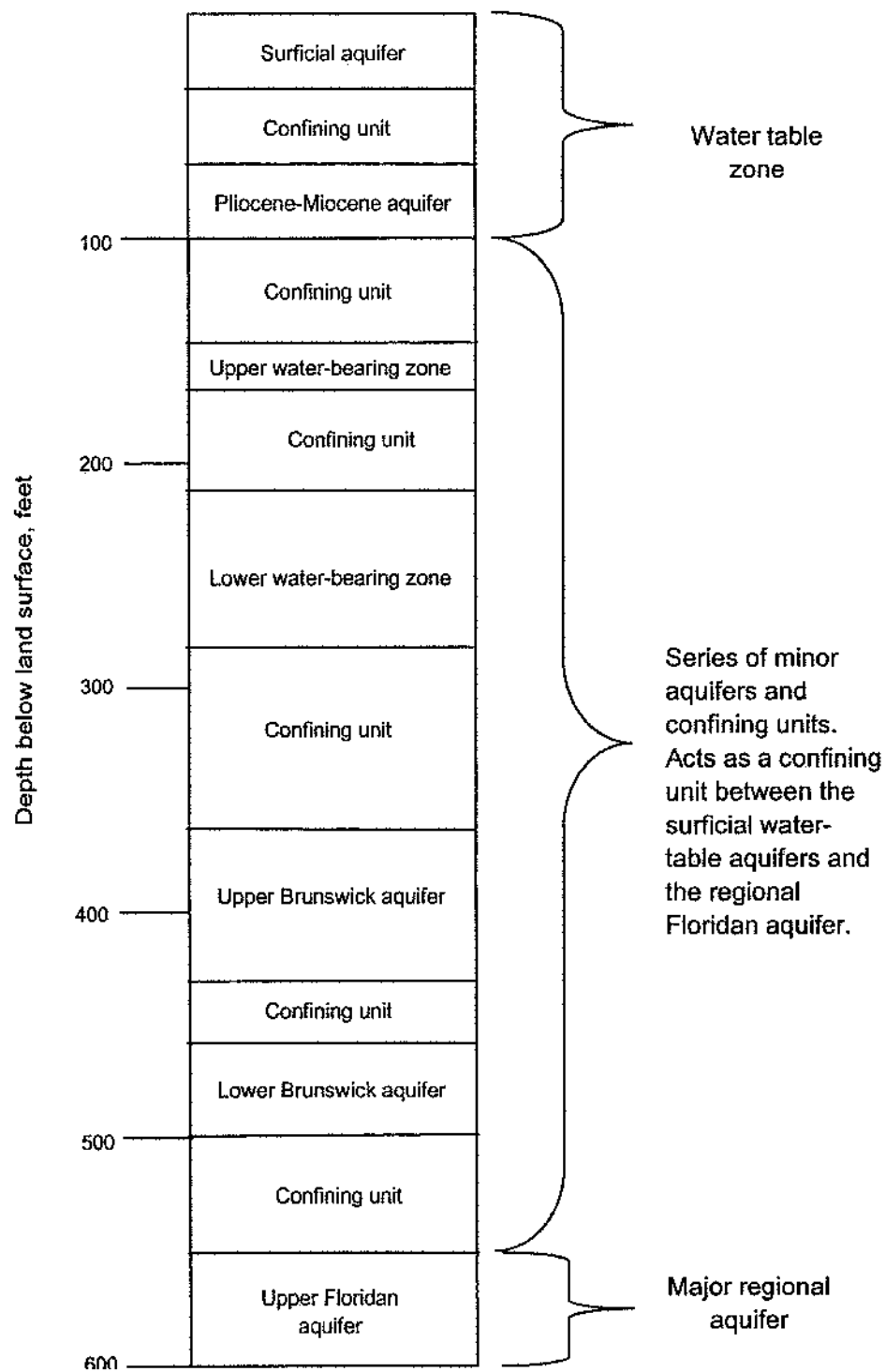


Figure 2. Generalized hydrogeology, Cumberland Island, Georgia (from Leeth, 1999 and Clarke and others, 1990)

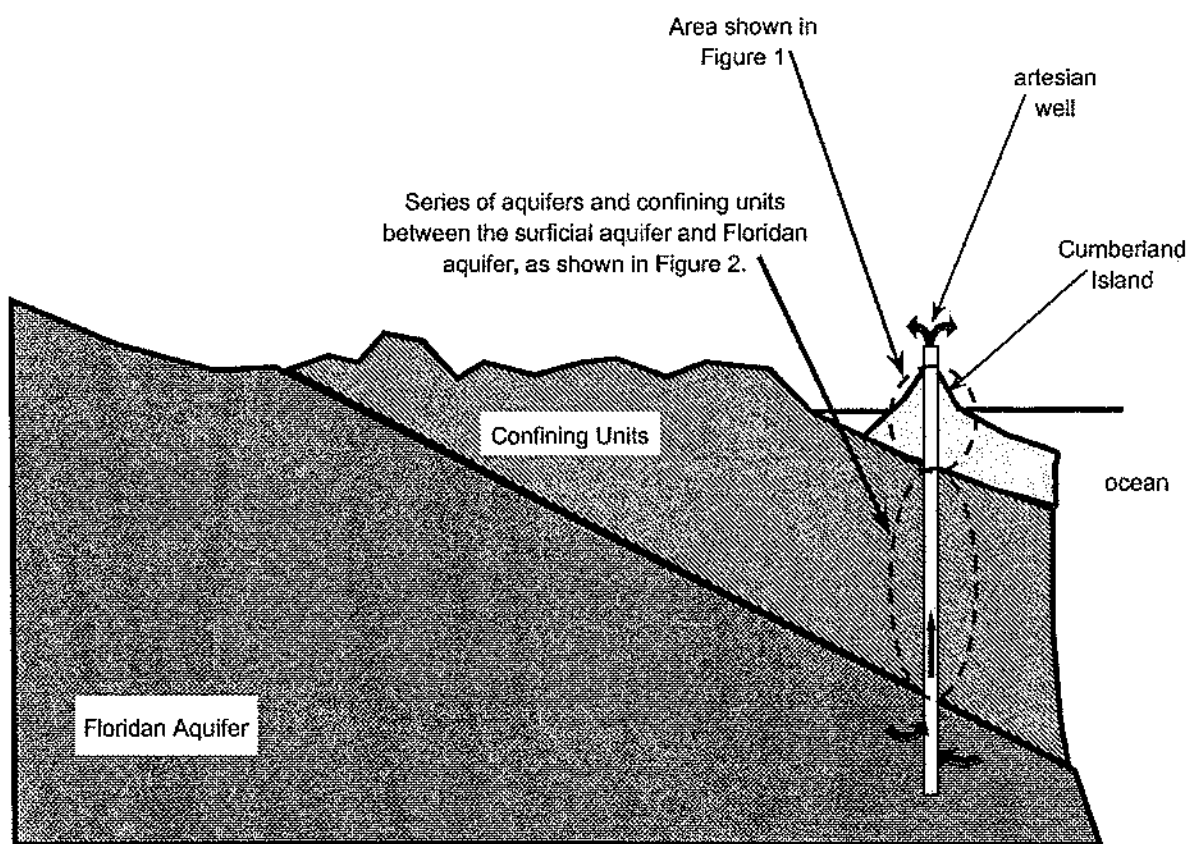


Figure 3. Regional hydrogeology of the Georgia coastal plain

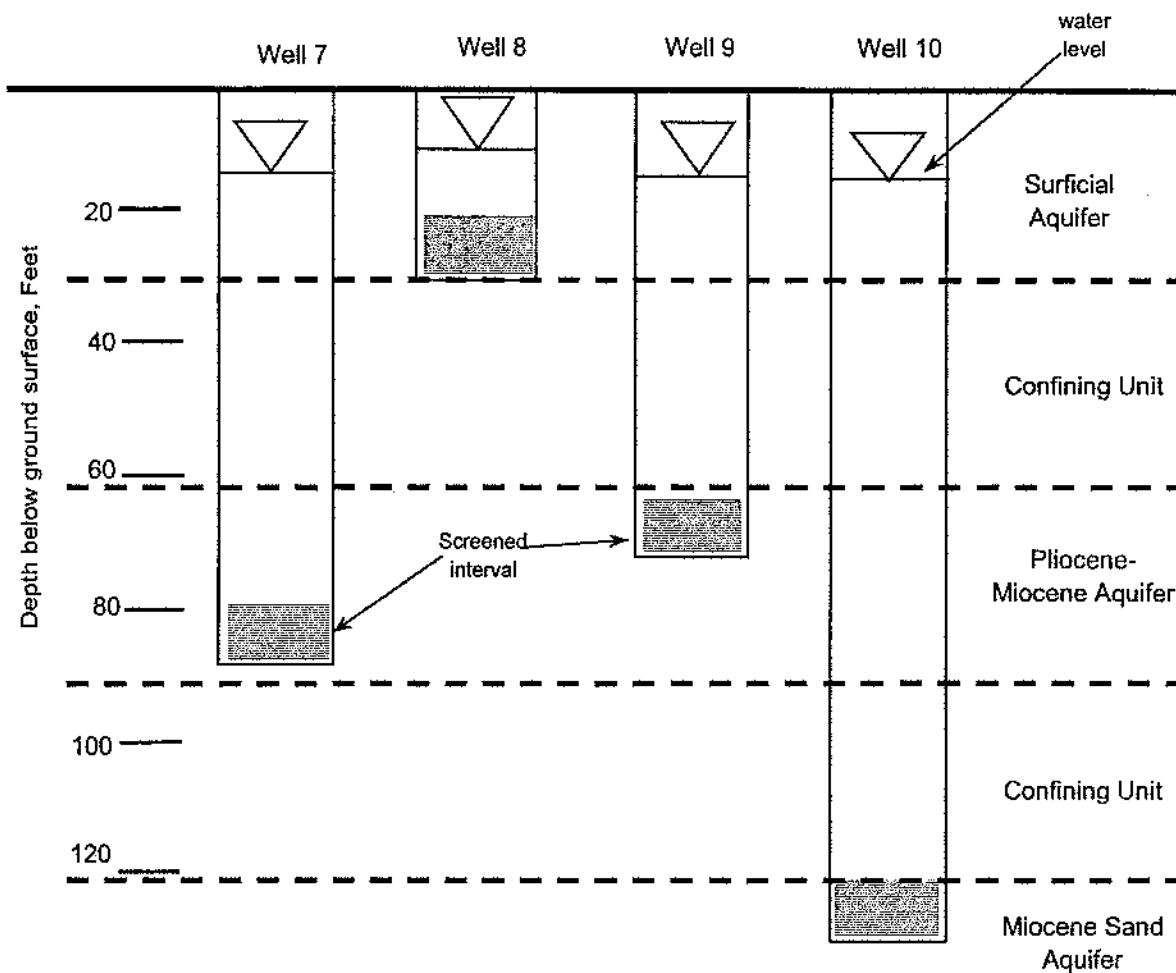


Figure 4. Depth to water in monitor wells at Site 3, 6/28/90
Near Dungeness, Cumberland Island