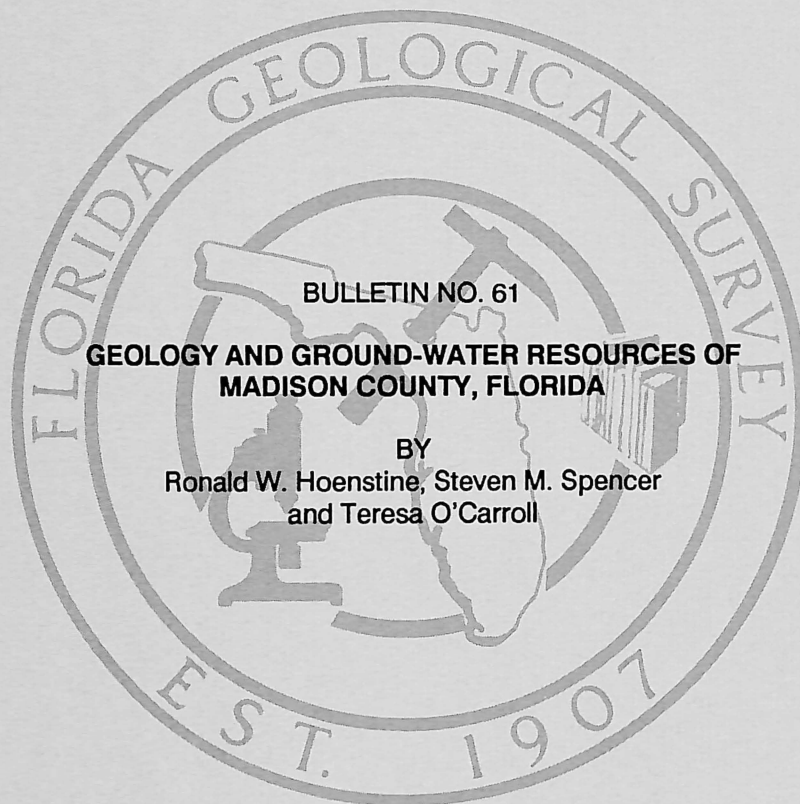


STATE OF FLORIDA
DEPARTMENT OF NATURAL RESOURCES
Tom Gardner, *Executive Director*

DIVISION OF RESOURCE MANAGEMENT
Jeremy A. Craft, *Director*

FLORIDA GEOLOGICAL SURVEY
Walter Schmidt, *State Geologist and Chief*



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SUWANNEE RIVER WATER MANAGEMENT DISTRICT

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BULLETIN NO. 61

**GEOLOGY AND GROUND-WATER RESOURCES OF
MADISON COUNTY, FLORIDA**

BY
Ronald W. Hoenstine, Steven M. Spencer
and Teresa O'Carroll

Published for the
FLORIDA GEOLOGICAL SURVEY
in cooperation with the
SUWANNEE RIVER WATER MANAGEMENT DISTRICT

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1990

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LETTER OF TRANSMITTAL



Florida Geological Survey
Tallahassee

June, 1990

Governor Bob Martinez, Chairman
Florida Department of Natural Resources
Tallahassee, Florida 32301

Dear Governor Martinez:

The Florida Geological Survey, Division of Resource Management, Department of Natural Resources, is publishing as Bulletin No. 61, "*Geology and Ground-water Resources of Madison County, Florida*," prepared by Ronald W. Hoenstine and Steven M. Spencer (Florida Geological Survey) and Teresa O'Carroll (formerly of the Suwannee River Water Management District).

Madison County is projected to experience population and industrial growth within the near future. This report fulfills a need for information on the stratigraphy of the area, which is the foundation for ground-water resources investigations. Information on the mineral deposits is also presented, along with data which will be helpful to county and state planners and other officials, as well as the private sector. This information will assist these groups in developing and implementing long range plans for effectively managing this growth in a manner that protects the environment while accommodating growth.

Respectfully,

Walter Schmidt, Ph.D.
State Geologist and Chief
Florida Geological Survey

Printed for the
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Tallahassee
1990

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Appreciation is due Cindy Collier for typing the manuscript and to Melissa Doyle, Jim Jones and Ted Kiper for drafting the figures. Thanks to Jo Borden and Jerry McClune (Madison County Road Department) for their cooperation in this county-wide study.

GEOLOGY AND GROUND-WATER RESOURCES OF MADISON COUNTY, FLORIDA

By

Ronald W. Hoenstine, P.G.#57, Steven M. Spencer, P.G.#319
and Teresa O'Carroll, P.G.#711

INTRODUCTION

PURPOSE AND DATABASE

The purpose of this study was to conduct a detailed geologic investigation of Madison County in order to provide information in the form of basic data and its interpretation to governmental agencies and the private sector concerning the county's stratigraphy, mineral resources, ground water and environment. This information will provide valuable assistance in all areas of land use concerns, including zoning, mineral potential and the identification of environmental factors affecting landfills and areas of ground-water recharge.

This study was based on information from 7 cores drilled by the Florida Geological Survey, in addition to 18 cores drilled through a cooperative hydrogeologic study with the Suwannee River Water Management District (SRWMD), as well as cuttings from a number of water and oil exploration wells from Madison and surrounding counties, stored at the Florida Geological Survey's sample repository. An augering program was undertaken to supplement areas with inadequate data. Additionally, outcrops were mapped and described. The Florida Geological Survey encoded computerized format for recording geologic well cutting and core data was utilized for this study (Appendix 1).

LOCATION

Madison County is located in the northeastern part of the Florida panhandle (Figure 1). The county is bordered to the north by the State of Georgia, to the east by Hamilton and Suwannee Counties, to the south by Lafayette and Taylor Counties, and to

the west by Jefferson County. The Aucilla River forms part of the western boundary while the Withlacoochee and Suwannee Rivers comprise the eastern boundary of Madison County (Figure 1).

In addition to being the county seat, the city of Madison is the largest city in the county. Madison County, which encompasses an area of 703 square miles, is located approximately 35 miles south of Valdosta, Georgia, 110 miles west of Jacksonville, Florida, and 55 miles east of Tallahassee, Florida.

PREVIOUS INVESTIGATIONS

There have been a number of publications addressing a wide range of topics including topography, general geology, paleontology, ground-water and soil surveys of the regional area encompassing Madison County. Those geologic reports that are most applicable and comprehensive include: Cooke (1945), Applin (1951), Puri and Vernon (1964), White (1970), and Colton, (1978). Knapp (1978) described the occurrences and lithology of near-surface sediments of Madison County as well as surrounding areas. Ceryak et al. (1983) addressed the geology and hydrogeology of the upper Suwannee River Basin in which the study area included the southeastern part of Madison County. Crane (1986) reported on the hydrogeology of the lower Suwannee River Basin which included the southeastern part of Madison County. The United States Soil Conservation Service (in press) has conducted a soil survey in Madison County.

MAPS

Maps used for field work in this study include the

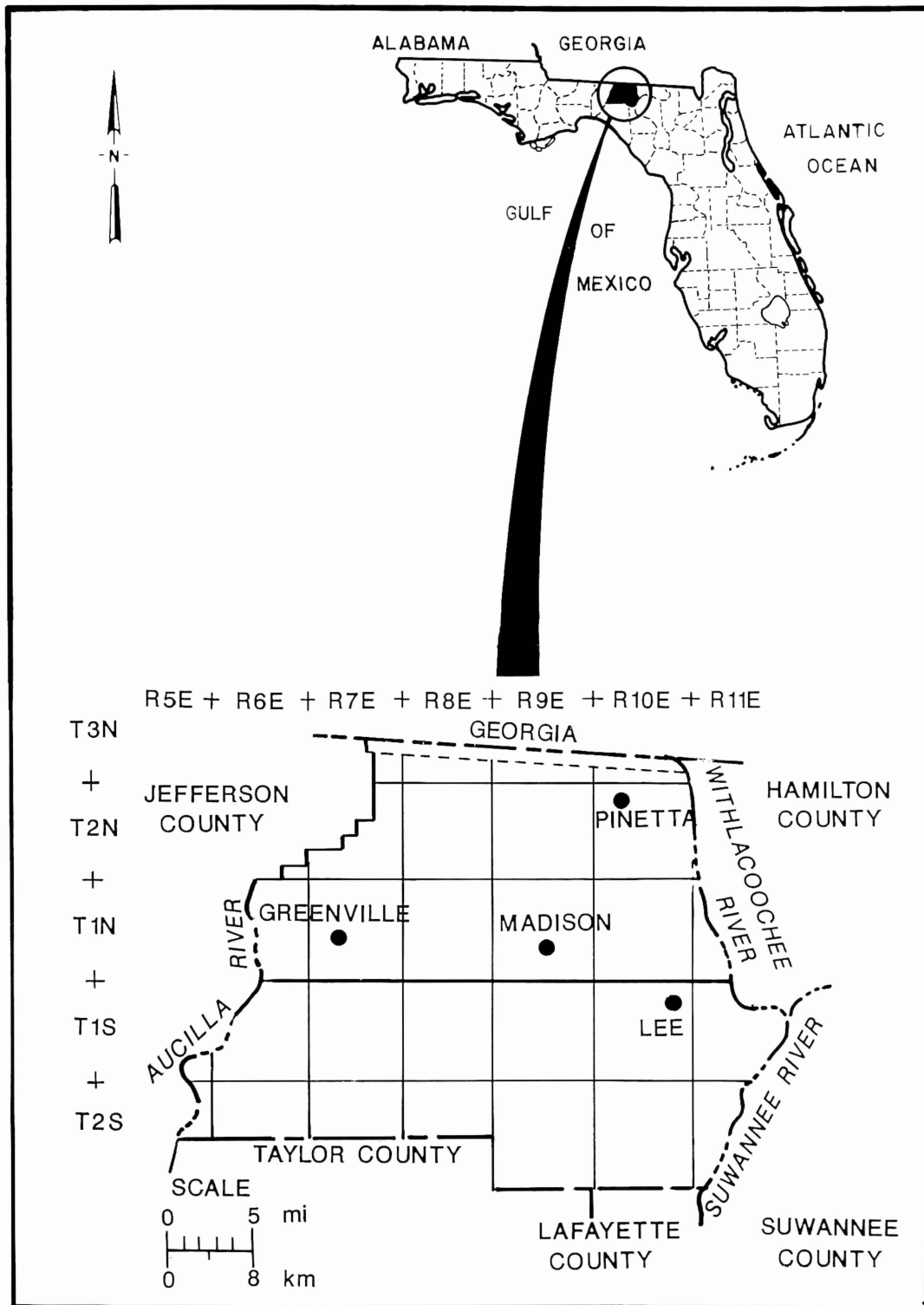


Figure 1. Location of Madison County.

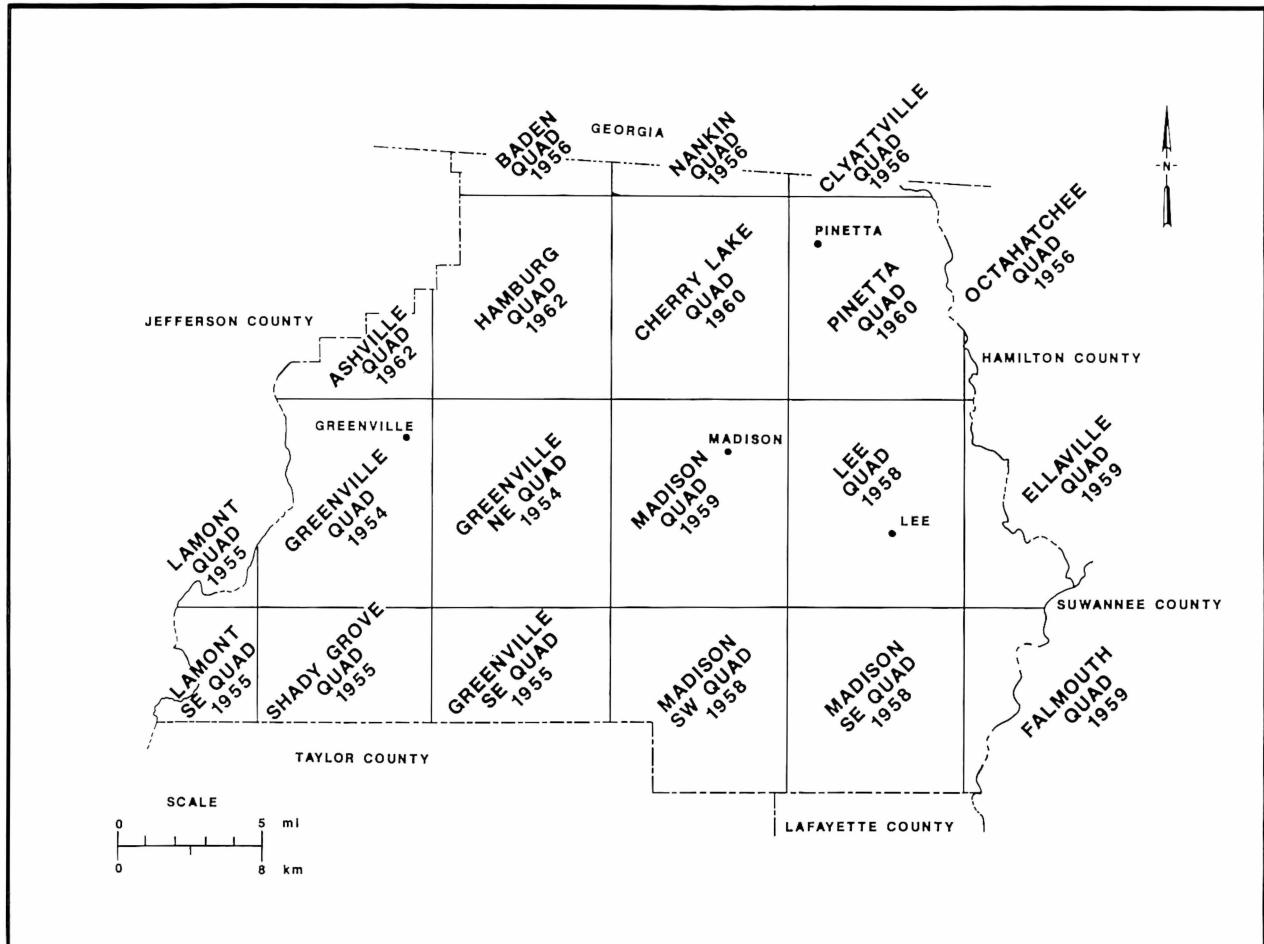


Figure 2. Index to 7.5 minute topographic quadrangle maps.

United States Geological Survey (USGS) 7.5 minute (1:24,000) topographic quadrangles. The index to these published topographic quadrangle maps is shown in Figure 2. Other maps utilized in this study include the general highway map of Madison County and Mark Hurd Aerial Photos Inc. (1976) which cover the same area as the USGS 7.5 minute topographic quadrangles.

TRANSPORTATION

Madison County is served by the Seaboard Coastline and the Georgia Southern and Florida railway systems. The nearest commercial airport is located in Valdosta, Georgia. Numerous highways cross the county with U.S. Highway 221, State Roads 53, 145 and County Roads 146, 150 and 255 representing the major north-south routes while Interstate 10 and U.S. Highway 90 serve as the major east-west routes (Figure 3). In addition, there are many secondary roads, which make the majority of the county accessible.

CLIMATE

Madison County's average annual precipitation is 52.5 inches. The wet season generally occurs from June through September and the dry season occurs October through November. The average annual temperature is 64° Fahrenheit with the winter season (December through February) averaging 46° Fahrenheit and the summer season (June through August) averaging 83° Fahrenheit (Fernald, 1981).

POPULATION AND DEVELOPMENT

Madison County was established as the fourteenth county in Florida on December 26, 1827. The county was named for James Madison, the fourth President of the United States.

As originally surveyed, Madison County, in addition to its present configuration, included the area encompassing Taylor, Lafayette and Dixie Coun-

ties. In December 1856, Madison County was divided and two additional new counties (Taylor and Lafayette) were created. In 1921, Dixie County was created from the southern part of Lafayette County.

The population of Madison County in 1987 was 15,858, up 8.72 percent from a 1980 population of 13,841 (Office of the Governor, 1987). The projected population for the year 2000 is 16,400.

The major industries in Madison County include farming and timber (pulpwood). Agricultural crops include peaches, vegetables, corn, soybeans and tobacco. There are approximately 60,000 acres of improved pastureland used for raising cattle, calves and hogs. In addition, poultry is raised extensively in several areas of the county.

METRIC CONVERSION FACTORS

In order to prevent the awkward duplication of English and metric units in the text of reports, the Florida Geological Survey has adopted the practice of inserting a table of conversion factors. For the use of those readers who may prefer to use metric units rather than English units, the conversion factors for terms used in this report are given in Table 1.

Table 1. Metric conversion factors.

MULTIPLY	BY	TO OBTAIN
acres	0.4047	hectares
acres	4047.0	sq. meters
cubic yards	0.7646	cu. meters
cubic feet/sec.	448.8	gallons/min.
feet	0.3048	meters
inches	2.540	centimeters
inches	0.0254	meters
miles	1.609	kilometers
sq. miles	2.590	sq. kilometers
Fahrenheit (F)	5/9 (F-32)	Centigrade

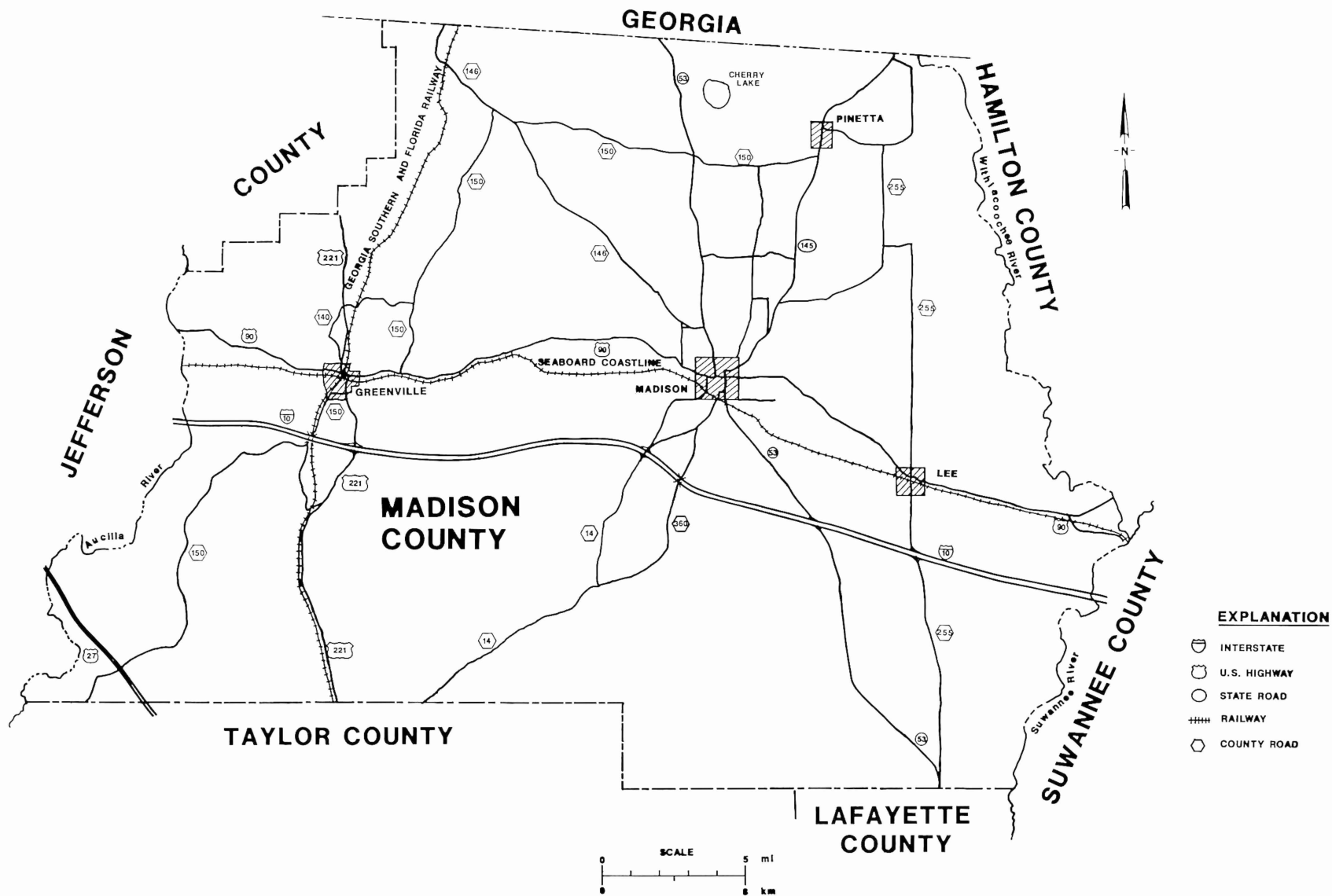


Figure 3. Major transportation routes in Madison County.

GEOLOGY GEOMORPHOLOGY

WELL AND OUTCROP NUMBERING SYSTEM

The locality and well numbering system used in this report is the rectangular system of section, township and range for identification (Figure 4). The number consists of five parts. These are: 1) a prefix of three letters designating L for locality or W for well and the county abbreviation; 2) the well accession number; 3) the section; 4) the quarter/quarter location within the section; 5) the township; and 6) the range.

The basic rectangle is the township, which is 6 miles on a side. It is consecutively identified by tiers both north and south of the Florida base line, an east-west line that passes through Tallahassee, starting with Township 1 North and 1 South. Townships are also consecutively numbered both east and west of the principal meridian, a north-south line that passes through Tallahassee as Range 1 East or West. In recording the township and range numbers, the "T" is left off the township numbers, and the "R" is left off the range numbers. Each township is divided into 36 square miles called sections, and are numbered 1 through 36 as shown in Figure 4.

The sections are divided into quarters which are labeled "a" through "d" as shown on Figure 4. Each of these quarter sections is divided into quarters and these quarter/quarter squares are labeled "a" through "d" in the same manner.

The location of the well WMd-13214 as shown in Figure 4 would be in the center of the northwest quarter of the northwest quarter of section 12, Township 2 North, Range 9 East, Madison County.

The exception to the system mentioned above will be those localities or wells occurring north of the Watson Line near the Georgia-Florida state line. This region was originally surveyed and settled as a part of Georgia. In 1887, this region officially became part of Florida but continued to use the Georgia survey system. Therefore, localities and wells from this area will be listed by the Georgia survey system section number only.

Florida has been divided into a number of geomorphic regions by various investigators. The following is a brief list of regional names in current usage as well as others which have gained serious consideration at one time or another.

Cooke (1939) proposed a geomorphic division of Florida based on such parameters as location and elevation. This classification divides Florida into five natural topographic regions: Coastal Lowlands, Western Highlands, Marianna Lowlands, Tallahassee Hills, and the Central Highlands. This classification is still frequently mentioned in the literature.

A genetic classification, based on geological origin, was proposed by Vernon (1951). This proposal, which comprised fewer geomorphic divisions, consisted of the following: the Delta Plain Highlands, Tertiary Highlands, Terraced Coastal Lowlands, and River Valley Lowlands. In addition, Vernon subdivided these major divisions into smaller units and applied local names to them. In this genetic classification Vernon placed Cooke's "Tallahassee Hills" region in his Tertiary Highlands, combined the Central Highlands and Western Highlands into his Delta Plain Highlands division and renamed Cooke's "Coastal Lowlands" and "Marianna Lowlands" to Terraced Coastal Lowlands and River Valley Lowlands, respectively.

In this system, based on geological origin, the Highlands are comprised of sediments deposited at higher elevations in a widespread, aggradational delta plain or are associated with Tertiary land masses rising above the plain. In contrast, sediments occurring in the Lowlands were formed either by deposition and erosion along coastlines by marine processes or by deposition and stream erosion along stream valleys.

Later, White, Puri and Vernon (Puri and Vernon, 1964) proposed a classification dividing Florida into six primary geomorphic provinces: Coastal Lowlands, Intermediate Coastal Lowlands, Gulf Coastal Lowlands, Central Highlands, Northern Highlands, and the Marianna Lowlands. These

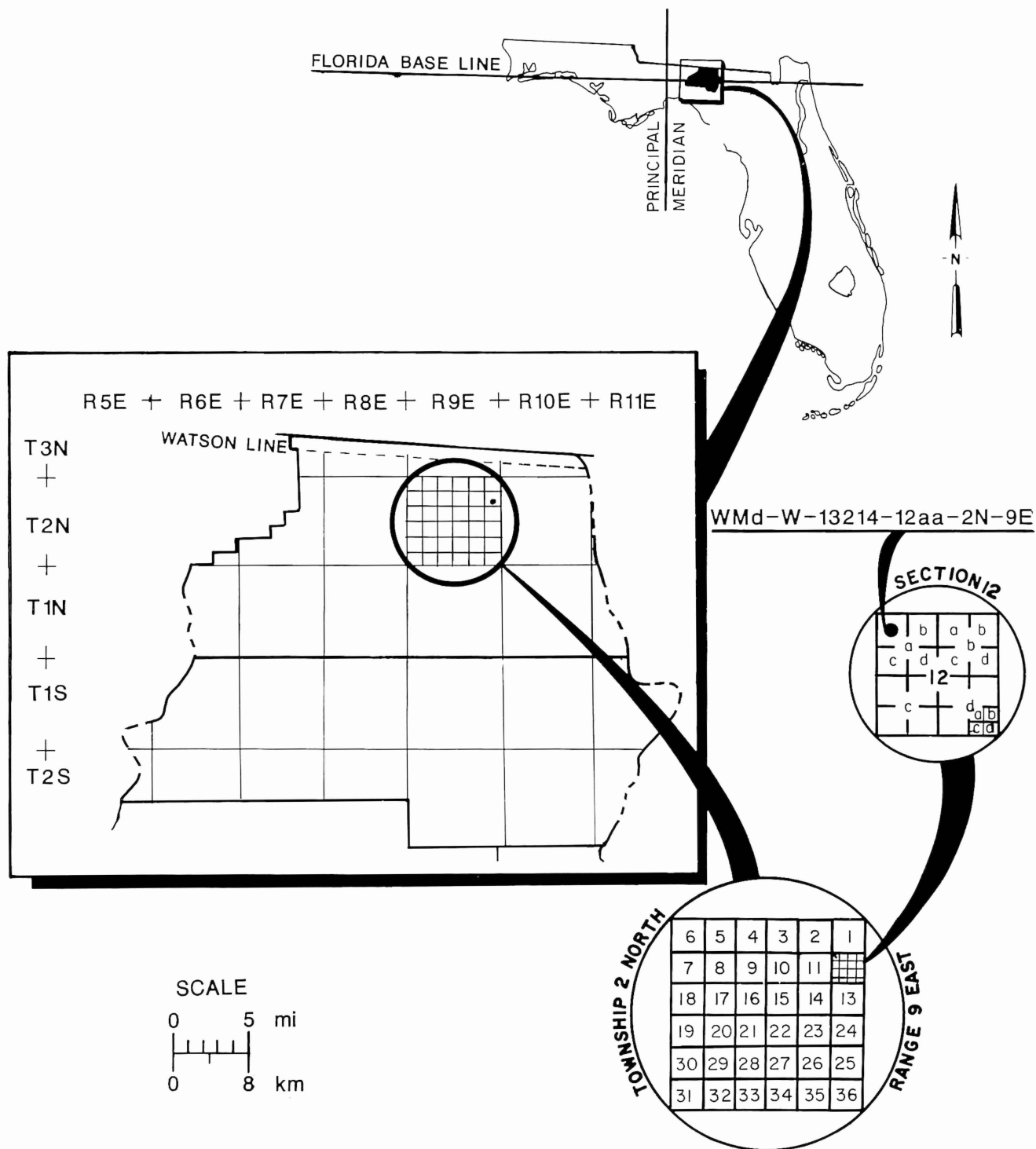


Figure 4. Locality and well numbering system used in this report.

provinces were further divided into secondary and tertiary units.

Subdivisions were proposed by White, Puri and Vernon (Puri and Vernon, 1964) for Vernon's Terraced Coastal Lowlands. Intended to be more descriptive of this general landform, these divisions are: Coastal Lowlands, Intermediate Coastal Lowlands, and Gulf Coastal Lowlands.

More recently, White (1970) divided the Florida peninsula into three distinct geomorphic zones: Northern (Proximal) Zone, Central (Mid-peninsular) Zone, and the Southern (Distal) Zone. In this classification, the Northern Zone, which includes Madison County, is generally a highland area extending from the Trail Ridge westward to the Apalachicola River Valley.

For the purposes of this study, the following geomorphic provinces of Vernon (1951) and of White, Puri and Vernon (Puri and Vernon, 1964) and Cooke (1939) are recognized in Madison County: Northern Highlands, Gulf Coastal Lowlands, and Aucilla, Withlacoochee, and Suwannee River Valley Lowlands (Figure 5). A discussion of these geomorphic regions which occur in the Eastern Gulf Coastal Plain follows.

NORTHERN HIGHLANDS Tallahassee Hills

The Tallahassee Hills is a subunit of the Northern Highlands. As defined by Puri and Vernon (1964), it includes the area between the Georgia State line on the north and the northern boundary of the coastal terraces as defined by the Cody Escarpment on the south - a width of nearly 25 miles - and between the Withlacoochee River on the east and the Apalachicola River on the west - a length of 100 miles. In Madison County, this geomorphic province includes the area southward from the Florida-Georgia border to the Gulf Coastal Lowlands (Figure 5).

Weathering has played a key role in shaping the topography of this geomorphic division in Madison County. Stream erosion and sub-surface dissolution have changed what is believed to have been a

once relatively featureless Pliocene prodelta to a land area characterized by undulating hills and ridges (Hendry and Sproul, 1966). These topographic highs attain maximum elevations in excess of 220 feet above mean sea level (MSL) in the area west of Cherry Lake and in an area to the north of the Watson line (sections 30 and 169 of Township 3N and Range 9E, respectively).

In general, the high areas are capped by a veneer of undifferentiated sands. These sediments are underlain by a mixture of reddish and yellowish-orange, clayey, quartz sands and sandy clays belonging to the Miccosukee Formation.

Madison County has numerous small lakes and ponds (Figure 6). Of special prominence is Cherry Lake, approximately 500 acres. This relatively large lake is representative of a karst feature that is common in Madison County. Occurring as a result of subsidence due to the dissolution of the underlying limestone and the subsequent collapse of overlying sediments, these karst lakes are numerous in the central and north-central part of the county (Figure 6).

The southern limit of the Tallahassee Hills in Madison County is marked by the Cody Scarp, a prominent escarpment named and described by Puri and Vernon (1964) as the most persistent topographic break in Florida (Figure 5). Although easily observed to the west in Jefferson County, the trend of the Cody Scarp in Madison County is irregular and difficult to observe in the field. However, north-to-south and west-to-east surface elevation profiles generated by the authors using USGS topographic quadrangles show a distinct break at the 100 feet MSL contour (Figure 7). The 100 feet MSL elevation, used by Crane (1986) and Cooke (1939) as defining the crest of the Cody Scarp in this area, is also used in this report and as such represents the southern limit of the Tallahassee Hills in Madison County.

GULF COASTAL LOWLANDS

Occupying less than 30 percent of the county, the Gulf Coastal Lowlands in Madison County lie in

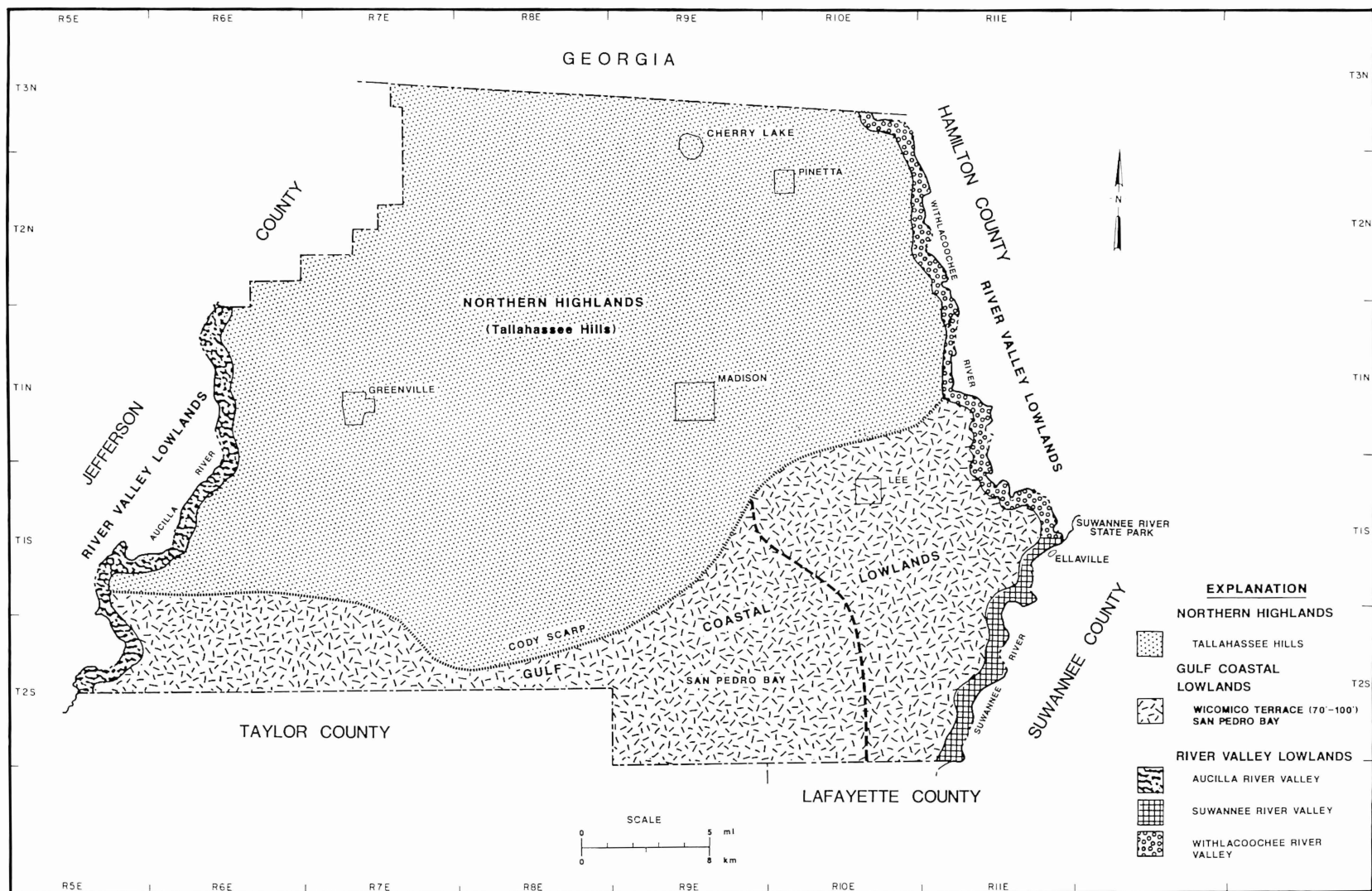


Figure 5. Geomorphic subdivisions in Madison County.

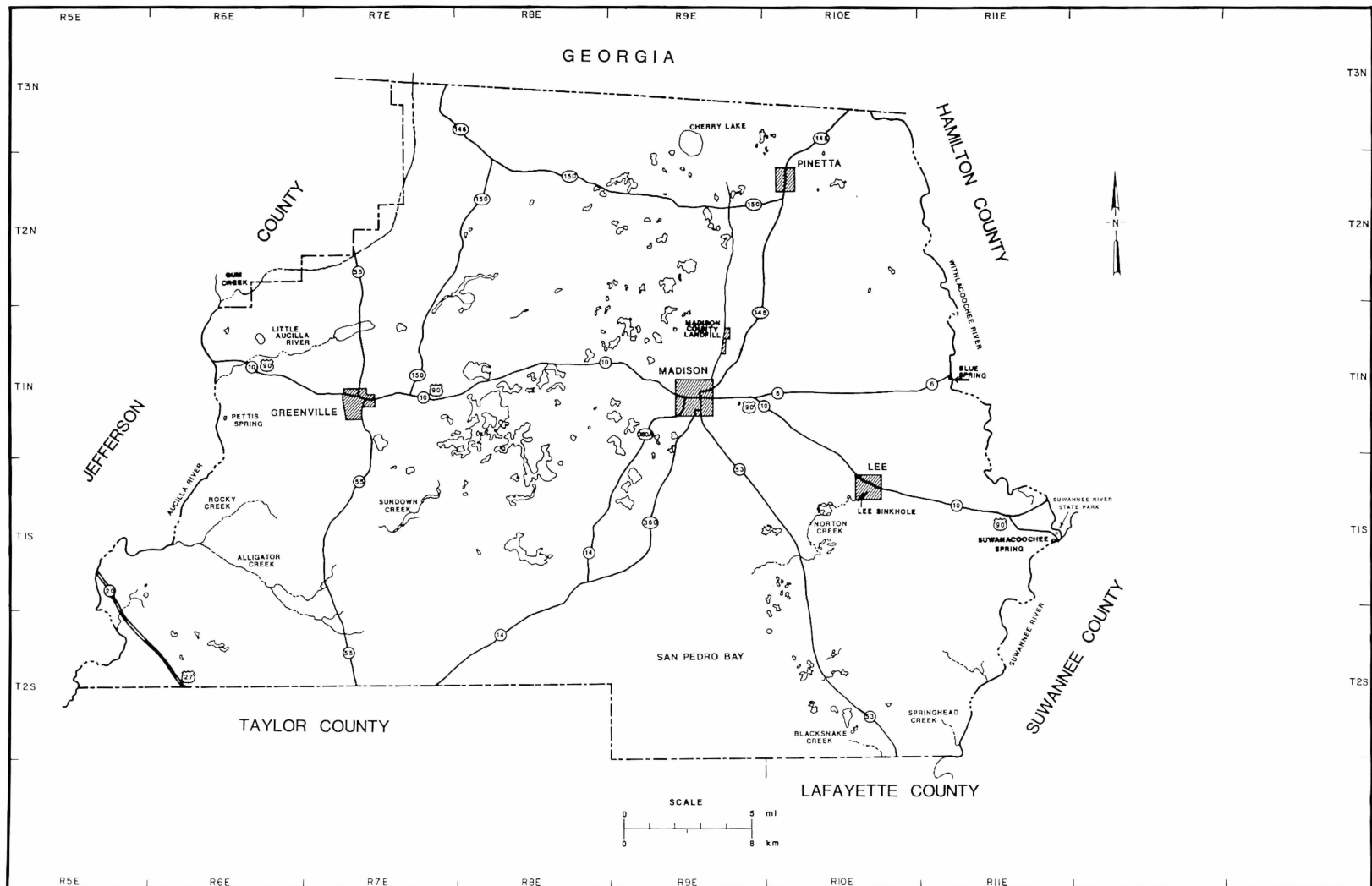


Figure 6. Significant surface water features.

an area bounded to the north by the Cody Scarp, to the south by the Taylor and Lafayette County line, to the west by the Aucilla River and to the east by the Suwannee and Withlacoochee Rivers (Figure 5). As shown by the topographic profiles (Figure 7), the northern boundary generally coincides with the 100 feet contour (Cooke, 1939 and Crane, 1986).

Cooke (1931) initially recognized seven interglacial marine terraces throughout Florida. Vernon (1942, 1951) cited evidence for four interglacial marine terraces and a deltaic plain. Cooke (1945) added an additional terrace to his original seven marine terraces. MacNeil (1950) proposed four interglacial marine terraces. More recently, Puri and Vernon (1964) proposed an additional terrace for a total of five marine terraces. Healy (1975) recognized four terraces based on elevation as being present in Madison County. The higher elevations present in the Northern Highlands Region of neighboring Jefferson County are highly dissected remnants of a Pliocene prodelta (Yon, 1966), an interpretation that is in this report extended to the Northern Highlands Region of Madison County.

Wicomico Terrace

One marine terrace proposed by Cooke (1945) is recognized by the authors in Madison County. This is the Pleistocene Epoch Wicomico Terrace occurring at the 70 to 100 feet MSL elevation range which coincides with the Gulf Coastal Lowlands in Madison County (Figure 5). In Madison County, the upper range of the Wicomico Terrace coincides with the top of the Cody Scarp. This escarpment, which represents a former shoreline of the Wicomico Sea, has a general elevation of 90 to 100 feet MSL. Initial terrace elevations of 100 feet to 105 feet MSL have experienced over time a general reduction in elevation in Madison County. This reduction, which is much more pronounced to the west in Jefferson County, is the result of erosion and karst processes. In Jefferson County, Yon (1966) identified this terrace as coinciding with the top of

the Cody Scarp, whose base occurs at 40 to 45 feet MSL. The westward extension of this scarp into Leon County shows an increase in elevation to approximately 100 feet elevation.

The Wicomico Terrace deposits of Madison County includes all of the area between the Cody Scarp and the Taylor and Lafayette County lines. Consisting of sands, silty sands and clays, these deposits form a relatively thin veneer overlying a limestone shelf upon which they were deposited. In general, much of this area, which includes a broad low area known as the San Pedro Bay, has poor surface drainage and is dotted with swamps in such areas as the Aucilla and Suwannee River floodplains.

San Pedro Bay (Figure 5), which occupies much of southern Madison County, extends into Taylor and Lafayette Counties. This geomorphic feature has elevations varying from 80 to 90 feet MSL. In general, its surface includes a veneer of organic sands underlain by a clay bed of varying thickness which in turn overlies the Suwannee Limestone. The low permeability clay acts as a confining bed to the Floridan aquifer system below, inhibiting the downward percolation of water causing a perched water table at the land surface.

River Valley Lowlands

The River Valley Lowlands occur in the form of narrow strips of land paralleling both sides of the Suwannee, the Withlacoochee and Aucilla Rivers (Figure 5). Numerous tributaries, in the form of small streams and creeks originating in the adjoining Tallahassee Hills, flow into these rivers (Figure 6). Although extending into the Northern Highlands, these river valley lowlands are placed in the Gulf Coastal Lowland province on the basis of their lowest elevations (Ceryak et al., 1983).

Suwannee River Valley Lowlands

With headwaters in the Okefenokee Swamp in southeastern Georgia, the Suwannee River flows southward to the Gulf of Mexico along a winding

Florida Geological Survey

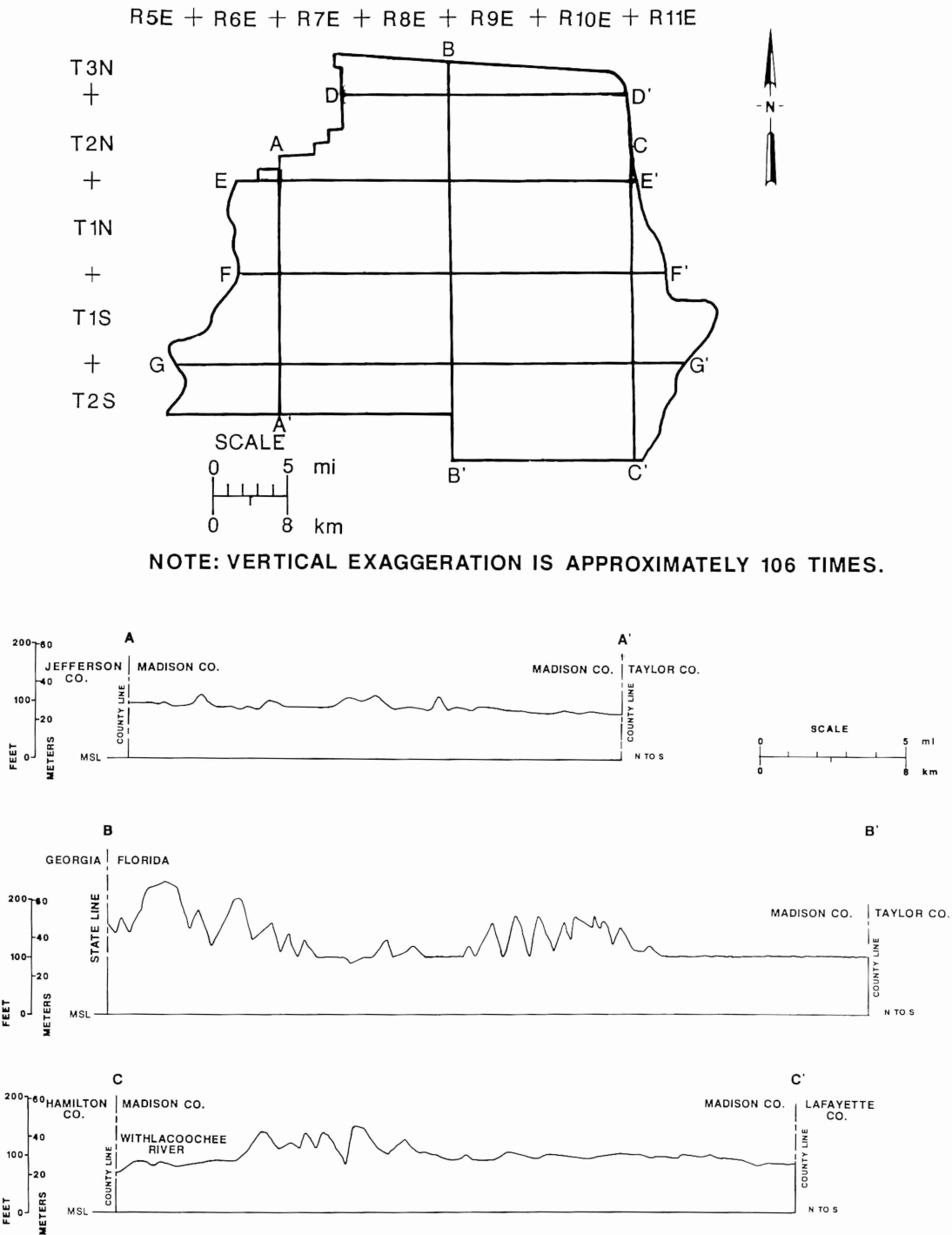


Figure 7a. North-south and west-east topographic profiles.

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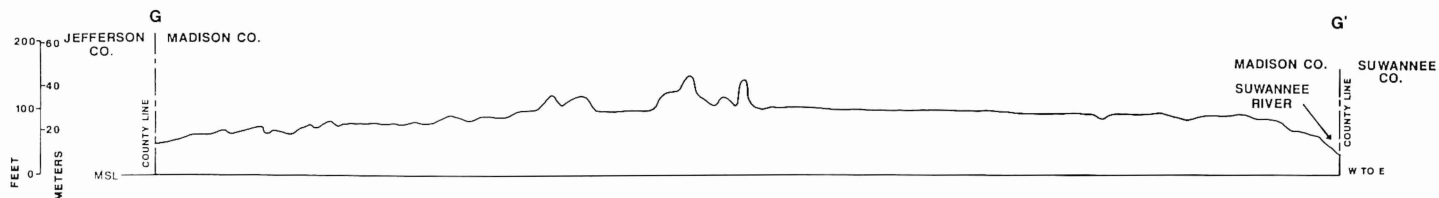
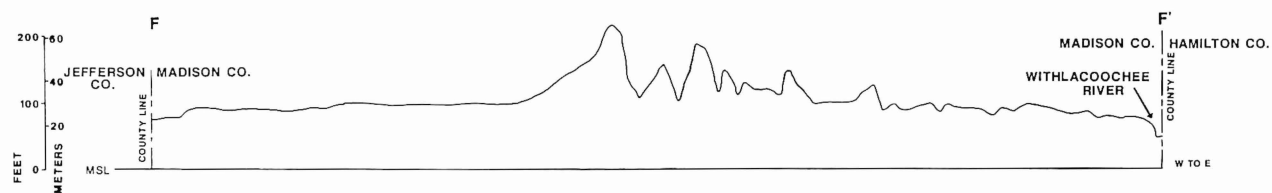
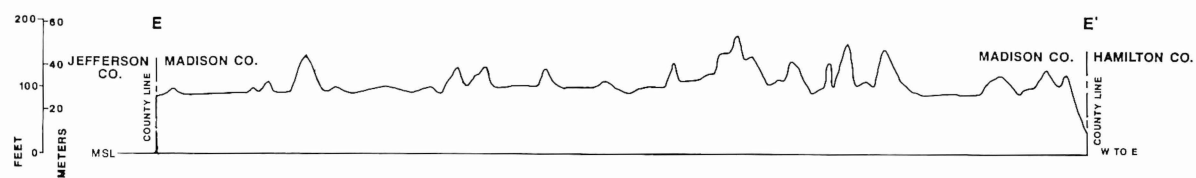
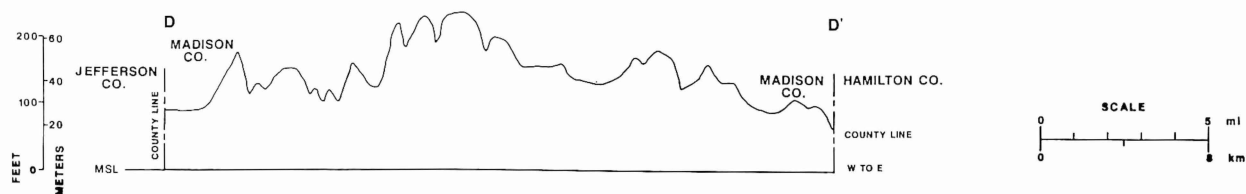


Figure 7b.

path that forms partial boundaries for Madison, Hamilton, Suwannee, Lafayette, Gilchrist, Dixie and Levy Counties. The river lowlands, which encompass the largest area of any river valley lowland in the county, extend from south Georgia to the Gulf of Mexico. In Madison County, these lowlands extend from Ellaville to the south-eastern corner of the county where the western border of Suwannee and the northeastern corner of Lafayette Counties intersect (Figure 5). The Suwannee River is joined by the Withlacoochee River at Ellaville.

The carbonate sediments cropping out on both sides of the Suwannee River at Ellaville are part of the Oligocene Series Suwannee Limestone deposited approximately 30 million years ago. The lithology of these sediments at this site varies from a moderately indurated dolomitic limestone to a poorly indurated (case hardened) limestone. Dolomite occurs in the area and to the north and south of the confluence of the Suwannee and Withlacoochee Rivers. A close examination of the Suwannee Limestone at Ellaville reveals the presence of fossil shells, molds, and numerous foraminifera and some echinoids exhibiting various degrees of preservation.

Natural levees, which formed during periods of past floods, can be observed along the river. Levees are formed during periods of flooding, when the river overflows its banks, causing an abrupt decrease in both water velocity and turbulence. This, in turn, causes the deposition of the coarser particles of the suspended sediments forming ridges or levees which generally parallel the river's banks. These features can be readily observed on the eastern side of the river just north of its confluence with the Withlacoochee River in the Suwannee River State Park.

Withlacoochee River Valley Lowlands

Originating in south-central Georgia, the meandering Withlacoochee River flows southward to the Suwannee River State Park at Ellaville where it merges with the Suwannee River. The river forms a natural boundary separating Madison and Hamil-

ton Counties (Figure 5). Figure 8 is a photograph of the Withlacoochee River at high water stage during the flood of 1986.

The lowlands on either side of the river are characterized by swampy conditions, with elevations generally less than 80 feet MSL and extensive areas below 60 feet MSL. These elevations are in stark contrast to the much higher elevations of 90 to 150 feet MSL associated with the nearby Northern Highlands Region through which the Withlacoochee River flows.

Aucilla River Valley Lowlands

The smallest river in Madison County is the Aucilla River. The headwaters of this river, which is located in south Georgia, flow southward into Jefferson County to a point approximately 1.5 miles north of State Road 90. There, it continues southward forming a meandering boundary between Jefferson and Madison Counties. Continuing further southward to the Gulf of Mexico, the river also forms a partial boundary separating Jefferson and Taylor Counties.

The USGS estimated the area drained by the Aucilla River to be about 750 square miles in Florida, almost half of which is in Madison County (Yon, 1966). Within this drainage area are a number of minor tributaries including the Little Aucilla River, Gum Creek, Rocky Creek and Alligator Creek (Figure 6).

During periods of high rainfall the river overflows the channel contributing significantly to the swampy conditions present over a large part of the valley. However, the Aucilla River quickly responds to rainfall and during periods of little or no rainfall the river is almost dry.

The river cuts into Hawthorn and Miccosukee siliciclastic sediments during the first several miles of its transit through Madison County. This lithology changes to calcareous sediments further south in the Coastal Lowlands Region as the river cuts into the Oligocene Series Suwannee Limestone.

Although much wider along the northern part of the river's course, with an average width of one mile,



Figure 8. Photograph of Withlacoochee River from State Road 6 at Blue Springs during high water stage in 1986. Photograph by authors.

the River Valley Lowlands narrows significantly to the south. The origin of this wide valley and narrow river channel may be attributed to dissolution of the underlying limestone and subsequent collapse of the overlying sediments (Yon, 1966).

Springs

Several springs, of which only one (Blue Spring) is of significant size, are present in Madison County (Figure 6). Blue Spring is a first magnitude spring as it discharges more than 100 cubic feet of water per second. The other springs are much smaller and less accessible.

Blue Spring

Blue Spring is located on the west bank of the Withlacoochee River about 10 miles east of the city of Madison just off of State Road 6 (section 17dc, Township 1N, Range 11E, Figure 6). A popular site for swimming, snorkeling and scuba diving, Blue Spring attracts many visitors from surrounding counties in both Florida and Georgia. This spring has had added importance in the past as a significant source of potable water for early inhabitants of the area.

The main spring pool is an irregular circle with a diameter of 75 feet. A cavern is present at an approximate depth of 30 feet below the water surface. A thin veneer of sand overlying Suwannee Limestone sediments cover the pool bottom. A 20-foot cliff consisting of Suwannee Limestone capped by a thin veneer of sand is present on the south bank.

The spring discharge flows northeastward into the Withlacoochee River through a run approximately 100-feet long. Measurements of this discharge have been conducted for a number of years. These measurements, taken by the USGS (Rosenau et al., 1977), show that the spring flow is highly variable, ranging from a minimum measured flow of 75 cubic feet per second (ft^3/sec) on March 16, 1932, to a maximum measured flow of 141 ft^3/sec . on November 15, 1960.

Suwanacoochee Spring

Suwanacoochee Spring is located on the west side of the Withlacoochee and north side of the Suwannee Rivers about 14 miles southeast of the city of Madison in the Suwannee River State Park (Figure 6). Although visible during low river flow, this small spring is inundated by the river during periods of high river stands.

The spring pool, which measures 20 feet in diameter, is ringed by dolomitized Suwannee Limestone sediments. A concrete wall constructed on the east end of the pool separates the spring from the river except during periods of high water and flooding.

Discharge takes place from a single vent on the west side of the pool from beneath a limestone ledge. A minimum measured discharge of 18.3 ft^3/sec was recorded by the USGS (Rosenau, et al., 1977) on March 16, 1932 and a maximum measured discharge of 51.6 ft^3/sec was recorded on March 8, 1973. The minimum discharge at this spring coincided with the date of minimum discharge recorded at Blue Spring.

Other Springs

Two other springs have been reported in the county. One of these, Cherry Lake Spring, was reported to be 3.5 miles west of the town of Pinetta, however, it could not be located for this study.

The other spring, Pettis Spring, was observed to be flowing from a three-inch pipe in 1946 at a site five miles west of Greenville on the east side of the Aucilla River (section 27a, Township 1N, Range 6E) (Yon, 1966). This pipe has since been capped and could not be located for this study.

Lakes

A number of lakes and ponds are present in Madison County that range in size from less than one acre to hundreds of acres. Some of these lakes are seasonal, disappearing during periods of

prolonged dry weather, while others contain water year-round.

A few lakes occur in the Coastal Lowlands, however, this region is flat and poorly drained and these lakes are primarily confined to a small area in the San Pedro Bay. In contrast, a number of ponds and small lakes occur in the Northern Highlands Region, an area of rolling uplands having porous carbonates and/or cavities underlying the surface sediments. The resultant karst topography is characterized by the formation of many closed surface depressions (dolines) that extend northward into Georgia and eastward and westward into parts of Hamilton and Jefferson Counties, respectively. The natural drainage is into these closed depressions, which are drained by seepage into the underlying limestone aquifer.

Figure 6 depicts a number of areas where significant surface water features occur. One of the most prominent concentrations occurs in an area south and southwest of Cherry Lake. Additional concentrations occur near Lee, and the area between Greenville and the city of Madison. These features can be attributed to local karstic conditions, including the close proximity of limestone to land surface and the presence of permeable overlying sediments.

Cherry Lake

Cherry Lake is by far the largest lake in Madison County with an area totaling more than 500 acres and a water surface elevation of 154 feet MSL. This prominent feature occupies an irregular, circular basin approximately one mile in diameter in north-central Madison County.

The surrounding topography is characterized by high elevations of more than 200 feet MSL to the north, west and southwest and lower elevations ranging from 150 to 160 feet MSL on the southeast.

A number of small ponds and depressions are located around the lake. These karstic features are especially numerous in this area as compared to other parts of the county.

STRATIGRAPHY

Introduction

Madison County is part of a transitional geologic area that lies between the thick, lower Tertiary (Paleogene) and Cretaceous carbonate sediments characteristic of the Florida peninsula and the age-equivalent, predominantly siliciclastic sediments of western Florida. The area is underlain by thick limestone deposits of the Oligocene and Eocene Epochs, which in turn are covered by younger limestones, dolomites, sands and clays (Figure 9). In Madison County, a total of 66 sets of well cuttings and 25 cores were examined (Figure 10, Table 2). Unless otherwise noted, structure contour maps and isopachs used in this report are based on cores due to their widespread coverage. Sediments range in age from Paleozoic to Holocene.

Paleozoic Erathem

To date, the deepest penetration of subsurface sediments in the county is to a depth of 10,049 feet below mean sea level (MSL) in the Amoco Production Company, Gilman Paper 22-2, No. 1, oil test well (Permit-1033, WMd-15017). Four other oil test wells have been drilled in Madison County (Table 2). Of the five oil test wells only three have penetrated Paleozoic sediments; they are the Gilman Paper 22-2 (WMd-15017), the Gibson No. 2 (WMd-1596), and No. 4 (WMd-1598). The Gibson No. 2 well penetrated a Paleozoic black shale at a depth of 4,521 feet below MSL and the Gibson No. 4 penetrated Paleozoic quartzitic sandstone and shale at 3,992 feet below MSL (Applin, 1951).

At a depth of 4,521 feet below MSL the Gibson No. 2 well, core No. 2 (WMd-1596) encountered dark gray shale containing the trilobite *Colpocoryphe exsul* considered to be Middle Ordovician (Pojeta et al., 1976). The undifferentiated Paleozoic sediments of the Gilman Paper 22-2 well (WMd-15017) consisted of shales, siltstones and sandstones. At this site, the top of the Paleozoic sediments are recognized on the electric log at 4,700 feet below MSL and continue to a total depth

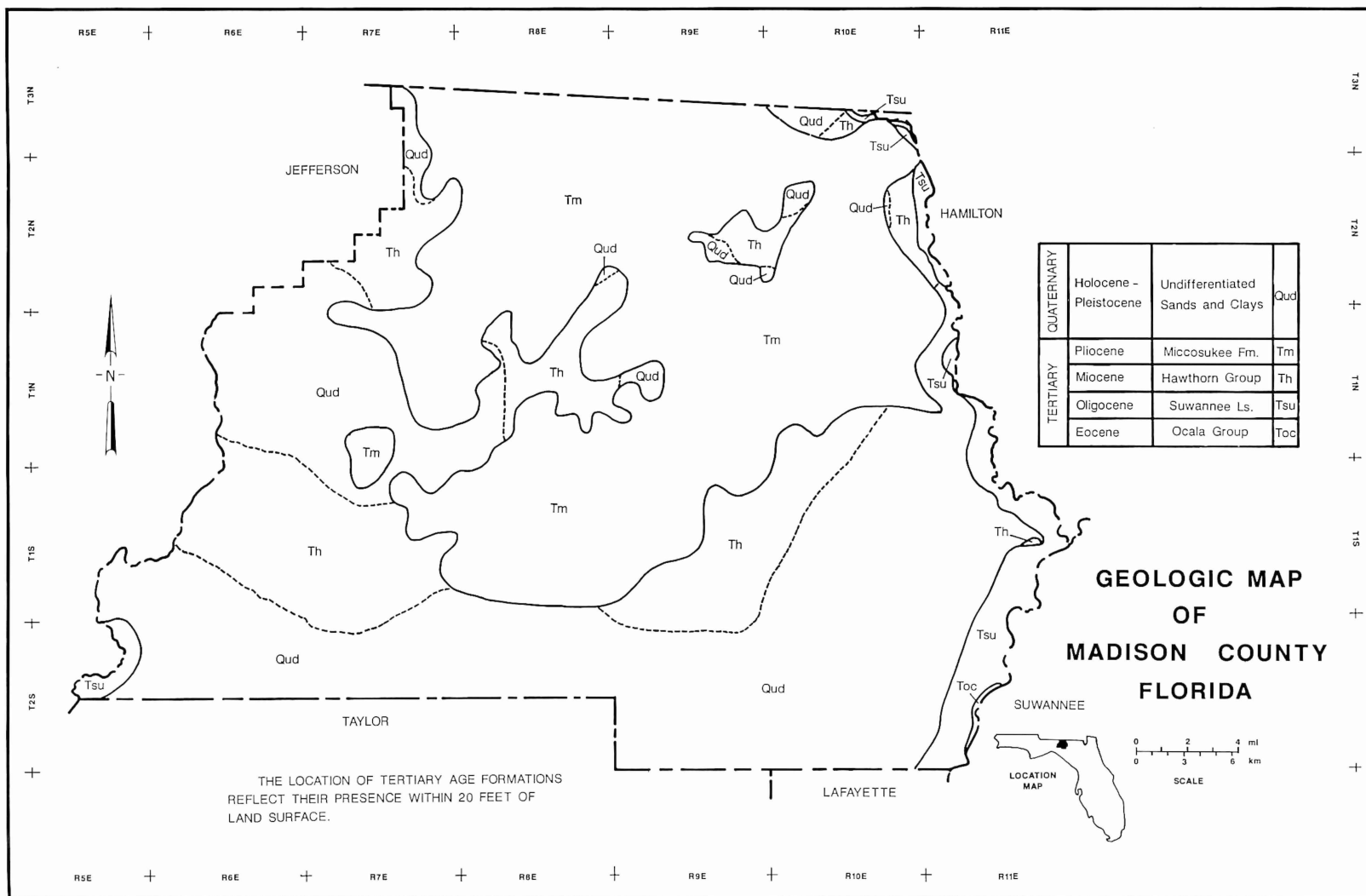
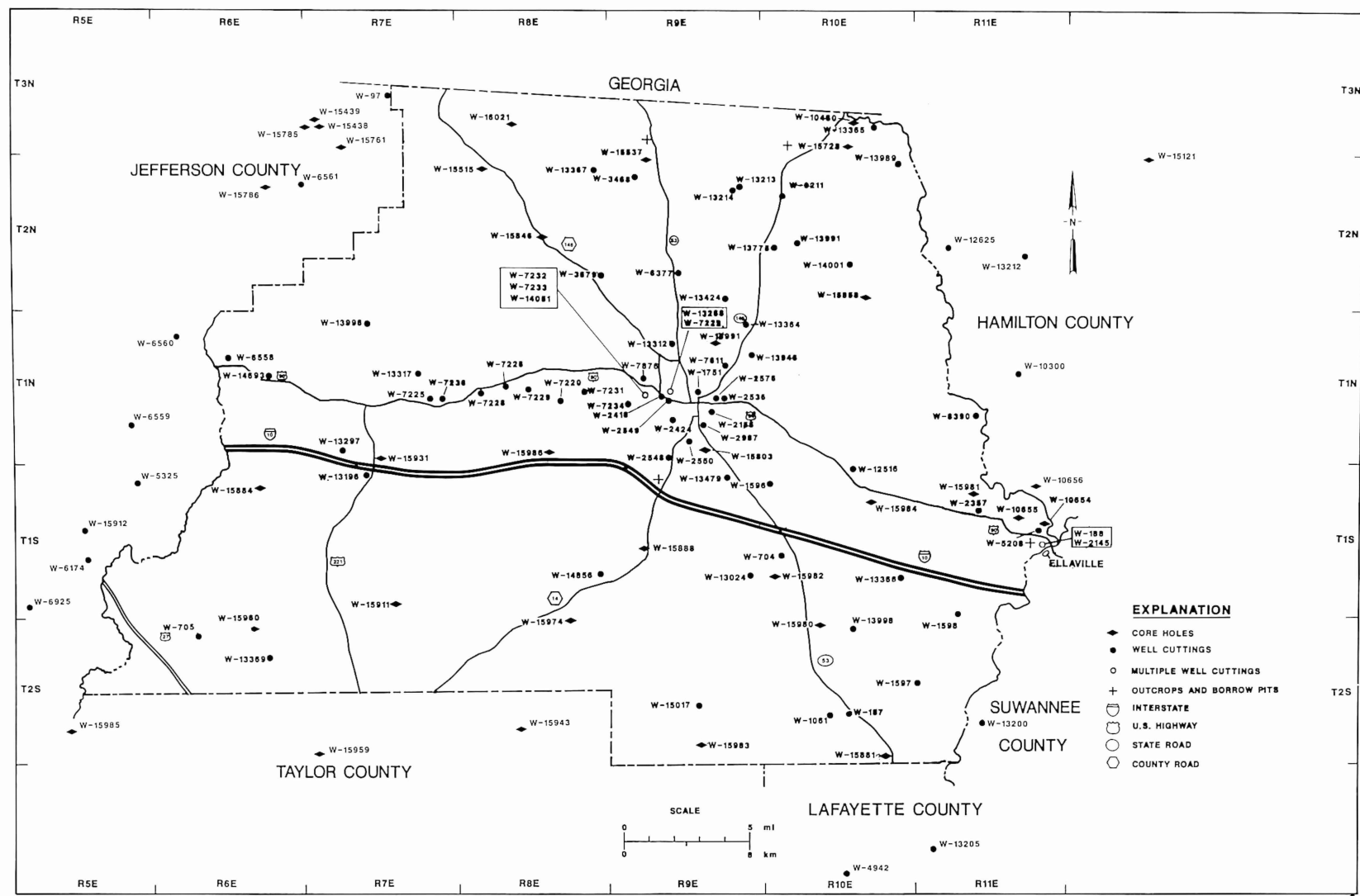


Figure 9. Geologic map of Madison County.



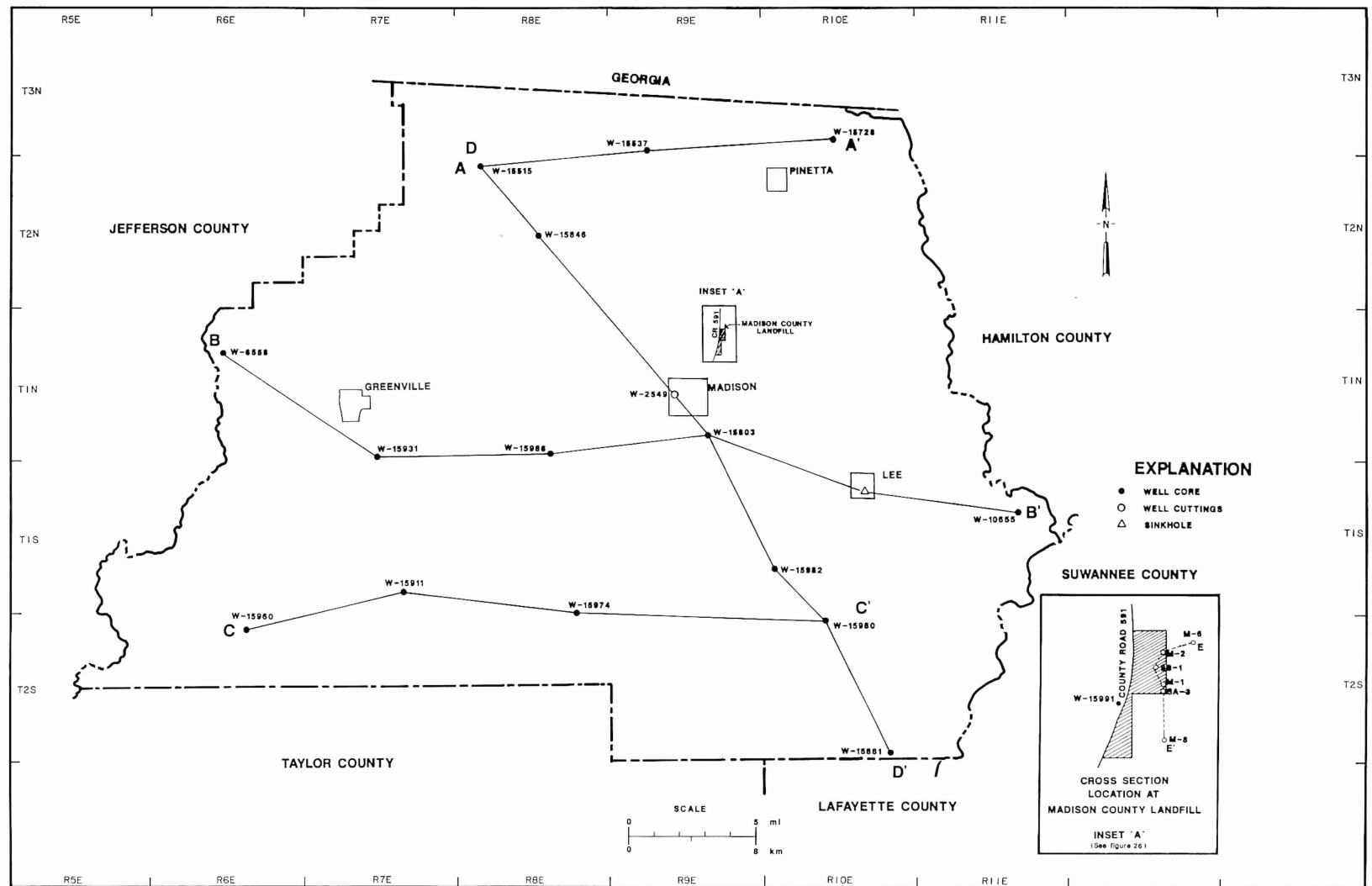


Figure 11. Index map of geologic cross sections.

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Florida Geological Survey

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WELL NO.	TOWNSHIP/RANGE/SEC	Latitude				Longitude				ELEV	UD	MCSK	HTRN	SMRK	SWNN	OCA	AP	TD
7233	T. 1N R. 9E S.20 BD	N D 30 M 28 S 24 W D 83 M 26 S 42					100					20			44			50
7234	T. 1N R. 9E S.19 AD	N D 30 M 28 S 7 W D 83 M 27 S 24					140				20	41						46
7236	T. 1N R. 7E S.24 DA	N D 30 M 28 S 20 W D 83 M 34 S 52					95				20	35						43
7611	T. 1N R. 9E S.14 B	N D 30 M 29 S 24 W D 83 M 23 S 27					150				0	20			110			202
7876	T. 1N R. 9E S.17	N D 30 M 28 S 58 W D 83 M 26 S 46					110				0	10			100			54
8390	T. 1N R.11E S.28 CB	N D 30 M 27 S 31 W D 83 M 13 S 26					66	0							20	120		170
10480	c T. 3N R.10E S.206B	N D 30 M 37 S 39 W D 83 M 18 S 17					99	0						23	48	199		208
10654	c T. 1S R.11E S.13 BC	N D 30 M 23 S 46 W D 83 M 10 S 43					57								0	37		70
10655	c T. 1S R.11E S.14 CA	N D 30 M 23 S 58 W D 83 M 11 S 46					60								0	28		41
12516	T. 1S R.10E S. 3 DB	N D 30 M 25 S 44 W D 83 M 18 S 23					90	0				7			85			90
13024	T. 1S R. 9E S.25 CA	N D 30 M 22 S 9 W D 83 M 22 S 32					97	0	10	20	60			70				145
13196	T. 1S R. 7E S. 4 BC	N D 30 M 25 S 45 W D 83 M 37 S 57					110		0	10				70				90
13213	T. 2N R. 9E S.12 AA	N D 30 M 35 S 31 W D 83 M 22 S 53					160	0			35			90				102
13214	T. 2N R. 9E S.12 AA	N D 30 M 35 S 29 W D 83 M 22 S 53					160	0	5	30	70			80				115
13268	T. 1N R. 9E S.21	N D 30 M 28 S 30 W D 83 M 25 S 44					94	0	10					60				105
13297	T. 1N R. 7E S.32	N D 30 M 26 S 38 W D 83 M 38 S 53					90	0						110				130
13312	T. 1N R. 9E S. 9	N D 30 M 30 S 7 W D 83 M 25 S 37					130	0	5	10								110
13317	T. 1N R. 7E S.14	N D 30 M 29 S 13 W D 83 M 35 S 48					100		0	80				110				130
13364	T. 1N R. 9E S. 1	N D 30 M 30 S 47 W D 83 M 22 S 40					120		0	30								155
13365	T. 3N R.10E S.205BB	N D 30 M 37 S 29 W D 83 M 17 S 27					99	0	5	15				40				75
13366	T. 1S R.10E S.25	N D 30 M 21 S 59 W D 83 M 16 S 28					84	0					130	150				165
13367	T. 2N R. 8E S. 1 DA	N D 30 M 36 S 9 W D 83 M 28 S 43					210?	0	5	60								148
13369	T. 2S R. 6E S.11	N D 30 M 19 S 26 W D 83 M 41 S 53					75	0			90			110				120
13424	T. 2N R. 9E S.35 AD	N D 30 M 31 S 39 W D 83 M 23 S 27					115	0	5	15				90				115
13479	T. 1S R. 9E S. 2 AD	N D 30 M 25 S 34 W D 83 M 23 S 25					110	0					50	70				100
13775	T. 2N R.10E S.19	N D 30 M 33 S 22 W D 83 M 21 S 29					90	0						30				80
13946	T. 1N R. 9E S.12 CD	N D 30 M 29 S 43 W D 83 M 22 S 23					120		0	50				90				160
13989	T. 2N R.10E S. 1	N D 30 M 36 S 14 W D 83 M 16 S 28					100	0			5	35		45				115
13991	T. 2N R.10E S.20	N D 30 M 33 S 31 W D 83 M 20 S 35					145		0	5		50		55				140
13996	T. 1N R. 7E S. 4	N D 30 M 30 S 55 W D 83 M 37 S 50					105	0	8	70			120					155
13998	T. 2S R.10E S. 3	N D 30 M 20 S 25 W D 83 M 18 S 35					90	0			8			20				35
14001	T. 2N R.10E S.27	N D 30 M 32 S 45 W D 83 M 18 S 28					150	0	6	18	65		70					118
14051	T. 1N R. 9E S.20 BC	N D 30 M 28 S 24 W D 83 M 26 S 42					150		0	10			60					165
14693	T. 1N R. 6E S.14	N D 30 M 29 S 10 W D 83 M 41 S 48					84	0			10							180
14856	T. 1S R. 8E S.25	N D 30 M 22 S 16 W D 83 M 28 S 34					110		0	60								90

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AP- Avon Park Formation.				TD- Total Depth.								
WELL NO.	TOWNSHIP/RANGE/SEC	Latitude	Longitude	ELEV	UD	MCSK	HTRN	SMRK	SWNN	OCA	AP	TD
15017	* T. 2S R. 9E S.22	N D 30 M 17 S 37 W D 83 M 24 S 40		100								10149
15515	c T. 2N R. 8E S. 5 CA	N D 30 M 36 S 18 W D 83 M 33 S 10		160	0	5	49		72	299		315
15537	c T. 2N R. 9E S. 5 BA	N D 30 M 36 S 38 W D 83 M 26 S 28		185	0	3	29	109	129	293		322
15728	c T. 3N R.10E S.33 AD	N D 30 M 36 S 50 W D 83 M 18 S 33		130	0	7	12	82	87			287
15803	c T. 1N R. 9E S.34 DB	N D 30 M 26 S 30 W D 83 M 24 S 19		161	0	4	39	79	86			100
15846	c T. 2N R. 8E S.22 BA	N D 30 M 33 S 48 W D 83 M 30 S 48		135		0	30		51			99
15858	c T. 2N R.10E S.35 BA	N D 30 M 31 S 38 W D 83 M 17 S 53		165	0	8	63	93	99			110
15881	c T. 2S R.10E S.35 BD	N D 30 M 15 S 49 W D 83 M 17 S 11		82	0				24	40		45
15884	c T. 1S R. 6E S. 2 CC	N D 30 M 25 S 21 W D 83 M 42 S 13		102	0		15		60			73
15888	c T. 1S R. 9E S.20 DA	N D 30 M 23 S 6 W D 83 M 26 S 49		162	0	5	27	72	82			89
15911	c T. 1S R. 7E S.34	N D 30 M 21 S 14 W D 83 M 36 S 51		95	0		2		83			94
15931	c T. 1N R. 7E S.33 CD	N D 30 M 26 S 20 W D 83 M 37 S 21		100	0	5	58		100			102
15960	c T. 2S R. 6E S. 3 BD	N D 30 M 20 S 26 W D 83 M 42 S 31		75	0				73			97
15974	c T. 2S R. 8E S. 2 AB	N D 30 M 20 S 37 W D 83 M 29 S 47		103	0		17		82			95
15980	c T. 2S R.10E S. 4 CB	N D 30 M 20 S 20 W D 83 M 19 S 45		90	0		22		33			52
15981	c T. 1S R.11E S. 9	N D 30 M 24 S 48 W D 83 M 13 S 33		75	0					25		62
15982	c T. 1S R.10E S.30 DA	N D 30 M 22 S 4 W D 83 M 21 S 33		95	0				36			45
15983	c T. 2S R. 9E S.34 AB	N D 30 M 16 S 14 W D 83 M 24 S 33		99	0				32			62
15984	c T. 1S R.10E S.11 DA	N D 30 M 24 S 35 W D 83 M 17 S 40		80	0							57
15986	c T. 1N R. 8E S.34 DB	N D 30 M 26 S 30 W D 83 M 30 S 34		125	0	2	32		98			101
15991	c T. 1N R. 9E S.11 DA	N D 30 M 30 S 8 W D 83 M 23 S 52		120	0		50		103			125
16021	c T. 3N R. 8E S.28 AD	N D 30 M 37 S 44 W D 83 M 31 S 57		155		0	29		90			121
Hamilton County												
10300	T. 1N R.11E S.14	N D 30 M 29 S 15 W D 83 M 11 S 28		90	0		5	35	45			80
10656	c T. 1S R.11E S.11 BB	N D 30 M 25 S 5 W D 83 M 11 S 7		68	0				21	44		62
12625	T. 2N R.11E S.20 BC	N D 30 M 33 S 25 W D 83 M 14 S 44		110			0		50			80
13212	T. 2N R.11E S.27	N D 30 M 32 S 40 W D 83 M 12 S 25		160	0				50			165
15121	c T. 2N R.12E S.03 BA	N D 30 M 37 S 5 W D 83 M 6 S 55		150	0		11	149				175
Jefferson County												
97	T. 3N R. 7E S.181	N D 30 M 38 S 53 W D 83 M 36 S 48		118	0				75			120
5325	T. 1S R. 5E S. 1 AD	N D 30 M 25 S 33 W D 83 M 47 S 8		87		0			77	104		151
6174	T. 1S R. 5E S.22 BC	N D 30 M 23 S 5 W D 83 M 48 S 50		68		0	28		75			80
6559	c T. 1N R. 5E S.25 CA	N D 30 M 27 S 35 W D 83 M 47 S 10		80		0			85			112

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WELL NO.	TOWNSHIP/RANGE/SEC	Latitude	Longitude	ELEV	UD	MCSK	HTRN	SMRK	SWNN	OCA	AP	TD	
6560	T. 1N R. 6E S. 8 DD	N D 30 M 29 S 38	W D 83 M 44 S 21	82		0						180	
6561	c T. 2N R. 6E S. 1 DD	N D 30 M 35 S 46	W D 83 M 40 S 35	184		0	36	82				103	
6925	c T. 1S R. 5E S.32 AC	N D 30 M 21 S 14	W D 83 M 51 S 18	134		0	35	45	50			69	
15438	c T. 3N R. 7E S.30 AD	N D 30 M 37 S 52	W D 83 M 39 S 39	158	0	10	60		120			240	
15439	c T. 3N R. 7E S.30 AD	N D 30 M 37 S 52	W D 83 M 39 S 40	157		0	40	100	105			150	
15761	c T. 3N R. 7E S.32	N D 30 M 37 S 31	W D 83 M 39 S 10	135	0	1	54					125	
15785	c T. 3N R. 7E S.30	N D 30 M 37 S 52	W D 83 M 39 S 40	157	0	2	65	108	120			128	
15786	c T. 2N R. 6E S.11 A	N D 30 M 35 S 44	W D 83 M 41 S 56	145	0	5	65		79			82	
15912	c T. 1S R. 5E S.22	N D 30 M 23 S 42	W D 83 M 48 S 45	70	0	4	24		34			70	
Lafayette													
4942	T. 3S R.10E S.27 C	N D 30 M 11 S 27	W D 83 M 18 S 45	86	0				32	45	145	175	
13205	T. 3S R.11E S.19 DA	N D 30 M 12 S 35	W D 83 M 18 S 40	75	0					27		28	
Suwannee													
13200	T. 2S R.11E S.28 CB	N D 30 M 17 S 3	W D 83 M 13 S 0	55	0				18			24	
Taylor													
15943	c T. 2S R. 8E S.28	N D 30 M 17 S 40	W D 83 M 32 S 9	92	0				30			59	
15959	c T. 2S R. 7E S.31	N D 30 M 16 S 2	W D 83 M 39 S 48	70	0				46			55	
15985	c T. 2S R. 5E S.28	N D 30 M 0 S 0	W D 83 M 0 S 0	40	0			24				35	

of 10,049 feet below MSL. The Paleozoic section in this well is about 5,350 feet thick.

MESOZOIC ERATHEM Triassic System

To date, Jurassic sediments have not been identified in Madison County. However, several diabase intrusions penetrated Paleozoic sediments in WMd-1596, WMd-1598 and WMd-15017. In WMd-1596 and WMd-1598 intrusions were encountered at 4,482 feet below MSL and 3,971 feet below MSL respectively. These intrusions, which have thicknesses of 39 and 16 feet, respectively, were tentatively identified as Triassic diabase (Arthur, 1988). In WMd-15017, three intervals of altered diabase were encountered at depths of 5,350, 5,700 and 9,100 feet below MSL with respective thicknesses of 120, 400 and 100 feet.

Cretaceous System

In the geological transitional area encompassing Madison County the Cretaceous sediments are variable in character ranging from siliciclastics to carbonates. Unnamed sequences of shales and sandstones, some of which are calcareous, dominate the Lower Cretaceous section. The Upper Cretaceous sediments consist of, in ascending order, the Atkinson Formation, unnamed shales and marls, and the Lawson Formation (Braunstein et al., 1988).

A description of Upper Cretaceous sediments from the Gibson No. 2 well in Madison County by Chen (1965) is on file at the Florida Geological Survey. Chen described Upper Cretaceous sediments in the Gibson No. 2 well (WMd-1596) from 2,163 to 2,403 feet below MSL as light grayish-brown, cherty, fossiliferous limestone, containing *Inoceramus* sp. prisms. In the interval from 2,028 to 2,163 feet below MSL, the Lawson Formation is described as a light grayish-brown to dark brown, well cemented, cherty and recrystallized fossiliferous limestone. Chen (1965) in a regional study placed the top of the Cretaceous sediments,

which dip to the west, at approximately 2,000 to 2,100 feet below MSL in the Madison County area.

CENOZOIC ERATHEM Tertiary System Paleocene Series Cedar Keys Formation

The Cedar Keys Formation was first named by Cole (1944) for the upper Lower Paleocene, cream to tan colored, hard limestones containing the foraminifera *Borelis gunteri* and *Borelis floridanus*. Cole further states that although these two foraminifera are found in the upper part of the formation the lower part is nearly devoid of fossils.

Distribution

Cole's (1944) original description states that the Cedar Keys Formation covers an area which encompasses the northeastern panhandle and the Florida peninsula. Five oil test wells in Madison County penetrated this formation at depths ranging from 1,213 to 1,672 feet below MSL (WMd-1598 and WMd-1596 respectively). These wells (WMd-1596 and WMd-1598) are located in the central and southeastern parts of the county respectively (Figure 10).

General Lithology

The Cedar Keys contains three lithologic units (Winston, 1978). The lower unit is a cream to tan, pelloidal, skeletal dolomite with euhedral dolomite rhombs near the base. The middle unit is a dolomitic limestone with occurrences of anhydrite. The upper unit is predominantly a gray, chalky, anhedral dolomite.

Thickness

The Cedar Keys Formation increases in thickness from less than 300 feet in northern Florida to as much as 2,000 feet in southern Florida in Collier

and Lee Counties (Chen, 1965). In Madison County this unit ranges from approximately 200 to 300 feet in thickness (Chen, 1965).

Stratigraphic Relations

The Cedar Keys Formation unconformably overlies the Upper Cretaceous Lawson Formation. It unconformably underlies the Early to Middle Eocene age Oldsmar Limestone.

Eocene Series Oldsmar Limestone

Applin and Applin (1944) originally applied the name Oldsmar Limestone to the carbonate rocks deposited during the Early to Middle Eocene Epoch. The Applins defined this formation on the basis of the abundance of the foraminifera *Helicostegina gyralis* and further stated that the base of this formation rests upon the Cedar Keys Formation.

Distribution

The original description by Applin and Applin (1944) stated that the Oldsmar is present in both the peninsula and northeastern Florida panhandle. In Madison County, a total of five oil test wells penetrated these sediments at depths ranging from 793 to 1,137 feet below MSL (Chen, 1965).

General Lithology

The lower section of the Oldsmar Limestone in the eastern Florida panhandle is a fine grain, skeletal carbonate. This lithology changes upward to a chalky white to tan or cream colored carbonate (Chen, 1965).

Thickness

In general, the Oldsmar Limestone is thicker than the underlying Cedar Keys Formation. In Madison

County, thicknesses range from 200 to more than 500 feet (Chen, 1965).

Stratigraphic Relations

The Oldsmar Limestone unconformably overlies the Lower Eocene Cedar Keys Formation. The Avon Park Formation (Miller, 1986), which combines the previously defined Lake City Limestone (Applin and Applin, 1944) and the Avon Park Limestone (Applin and Applin, 1944), unconformably (?) overlies the Oldsmar Limestone.

Avon Park Formation

The Lake City Limestone was proposed by Applin and Applin (1944) for limestone sediments of early Middle Eocene age present in north Florida. The Avon Park Formation was named by Applin and Applin (1944) for the late Middle Eocene limestone recognized in a Florida Geological Survey well (WPk-668) drilled at the Avon Park Bombing Range in Polk County, Florida. The Florida Geological Survey well WPk-668 was designated as the type well. Crane (1986) informally combined the Avon Park Limestone, the Lake City Limestone, and the Oldsmar Limestone into two lithofacies, a dolomite lithofacies and the undifferentiated carbonate lithofacies. Miller (1986) combined the lithologically similar Lake City Limestone and the Avon Park Limestone of Applin and Applin (1944) into a single unit, the Avon Park Formation.

Distribution

The Avon Park Formation is the oldest stratigraphic unit to crop out in Florida. Exposures of this unit are limited to areas in Levy and Citrus Counties. The Avon Park Formation forms the lower part of the potable Floridan aquifer system in Madison County. This unit, which occurs in the subsurface throughout Madison County can be observed in cuttings from relatively deep wells. These include well WMd-2549 (section 21 bc,

Township 1N, Range 9E) and WMd-1596 (section 6, Township 1S, Range 10E). The Avon Park in WMd-2549 is present at 286 feet below MSL. In well WMd-1596 the top of the Avon Park is at 303 feet below MSL.

General Lithology

In Madison County, the Avon Park Formation is a moderately to well indurated limestone or dolomite. It frequently occurs as a very pale orange to white to light olive-gray, moderately porous, fossiliferous, gypsiferous, and fragmental limestone. The dolomite occurs as a brown to grayish brown, moderately to well indurated, fossiliferous, microcrystalline to very fine grained carbonate. The Avon Park has been reported to include characteristic peat flecks in regions to the west in Jefferson County and to the southeast in the Florida peninsula (Yon, 1966). However, no organic material was observed in the Avon Park Formation in Madison County.

Thickness

Only two wells completely penetrated the Avon Park Formation. These two wells WMd-1596 and WMd-1598 had thicknesses of 220 feet and 80 feet, respectively.

Stratigraphic Relations

The Avon Park Formation unconformably (?) overlies the Oldsmar Limestone. It also unconformably underlies the Ocala Group.

Ocala Group

Dall and Harris (1892) proposed the term Ocala Limestone for exposed carbonate sediments present near the vicinity of Ocala. Puri (1957) raised the Ocala Limestone to the rank of group. He further subdivided the Ocala Group into three formations which are, from oldest to youngest: the

Inglis Formation, the Williston Formation, and the Crystal River Formation. These formations are not differentiated in this study due to limited outcrops and subsurface data and are referred to in the cross sections (Figure 11, cross section locations) as the Ocala Group Undifferentiated (Figures 12, 13, and 15). Puri (1957) gives an excellent historical review of the Ocala Group.

Distribution

The Ocala Group, which was deposited during the Late Eocene Epoch, represents the oldest sediments exposed in Madison County. These limestones, which form an integral part of the Floridan aquifer system in Madison County, occur at varying depths throughout the county (Figures 12, 13, 14 and 15). This observation is based on limited data as outcrops of the Ocala are limited to the extreme southeastern part of Madison County along the Suwannee River. Several wells in the county penetrated these calcareous sediments at depths ranging from 50 feet above MSL (WMd-15981) to 139 feet below MSL (WMd-15515) (Figure 16). Out of 66 sets of well cuttings and 25 cores in Madison County used in this study only 21 were deep enough to encounter the Ocala Group limestone. Of these 21 wells, seven from Madison County are cores (WMd-15515, WMd-15537, WMd-10480, WMd-15981, WMd-15881, WMd-10654, WMd-10655) the first three of which are located along an east-west line across the northern third of the county. Two cores (WMd-10655 and WMd-15981) are located near the confluence of the Withlacoochee and Suwannee Rivers near Ellaville (Figure 10).

General Lithology

The Ocala Group is generally a pale orange to white, poorly to moderately indurated, moderately to highly porous, micro-fossiliferous, partially dolomitized, partially recrystallized limestone. Several cores including WMd-15515 and WMd-15537 have sediments comprised primarily of dolomite. The occurrence of the distinctive foraminifera genus *Lepidocyclina* is common to

Figure 12. Geologic cross section A-A'.

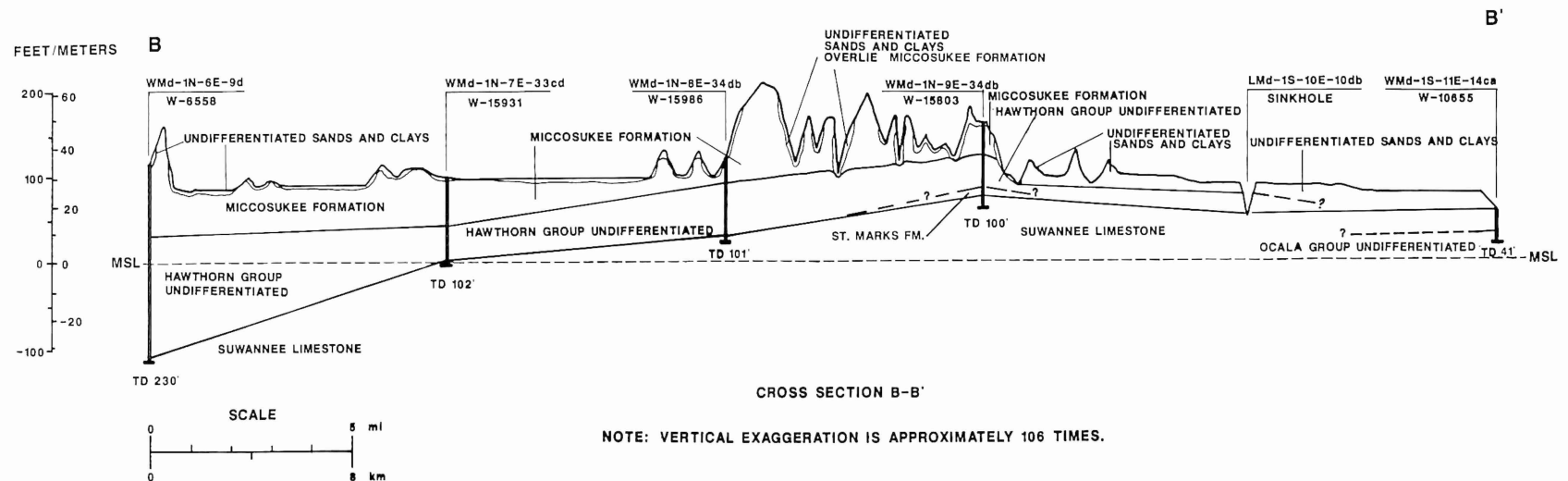
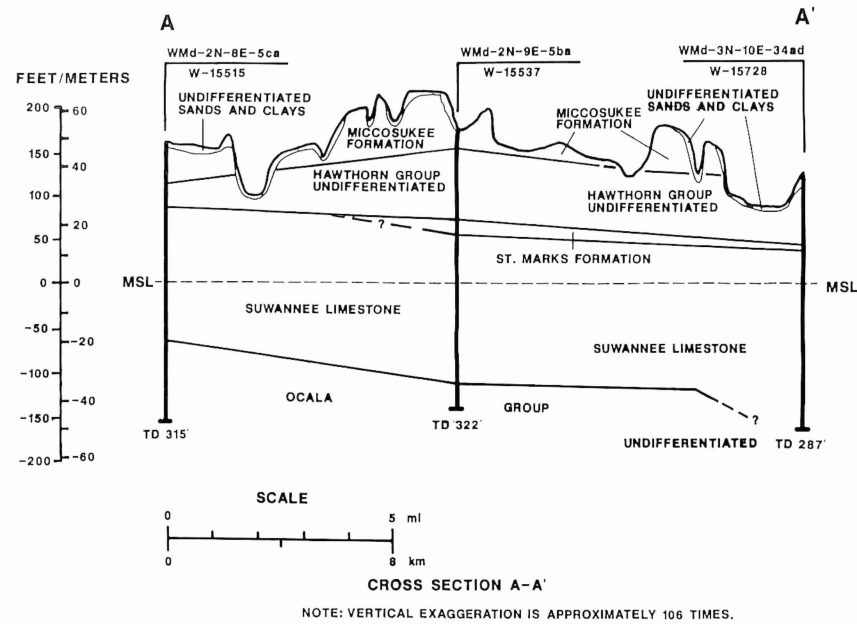


Figure 13. Geologic cross section B-B'.

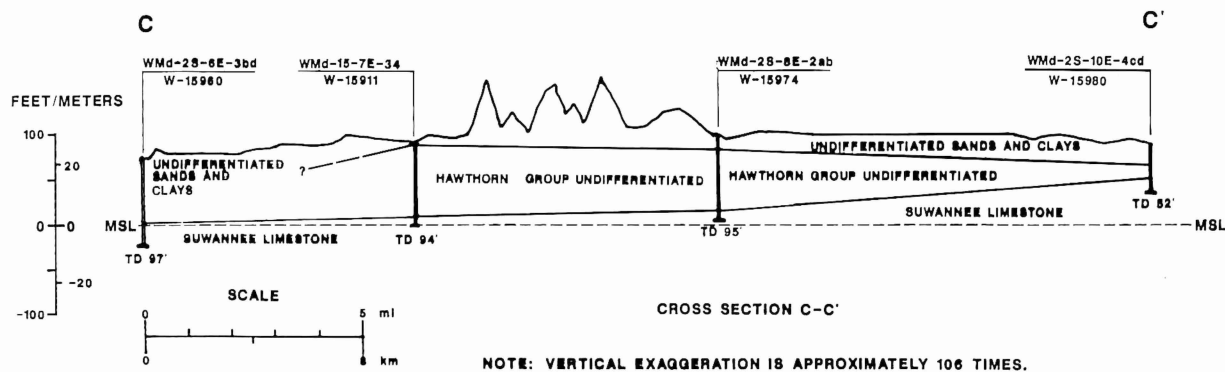


Figure 14. Geologic cross section C-C'.

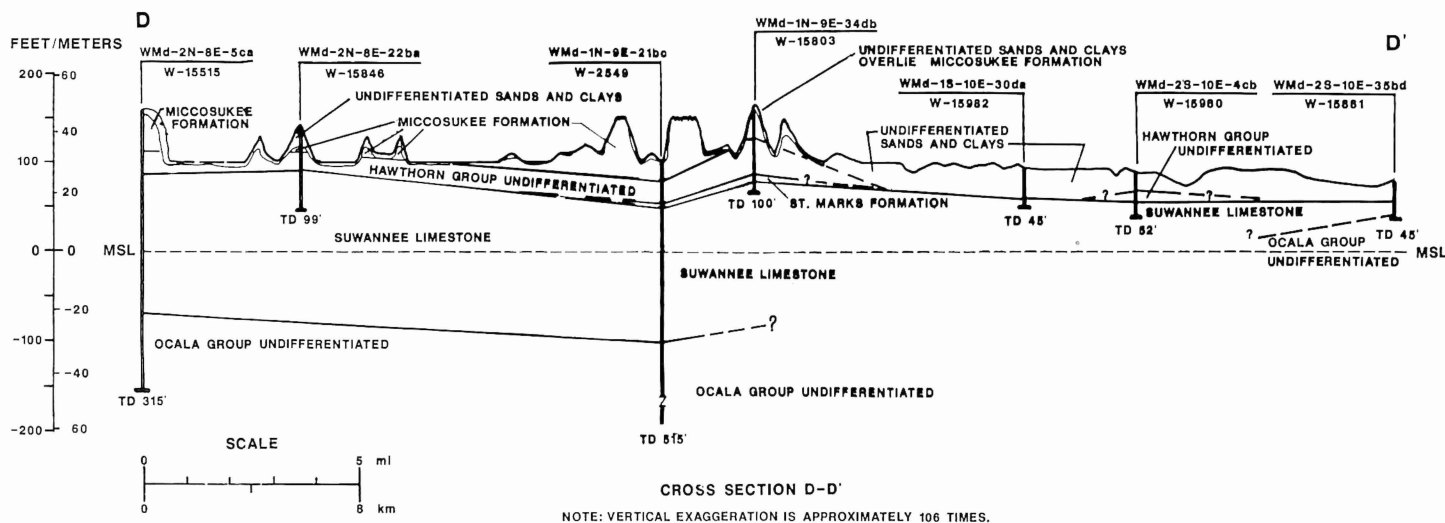


Figure 15. Geologic cross section D-D'.

Florida Geological Survey

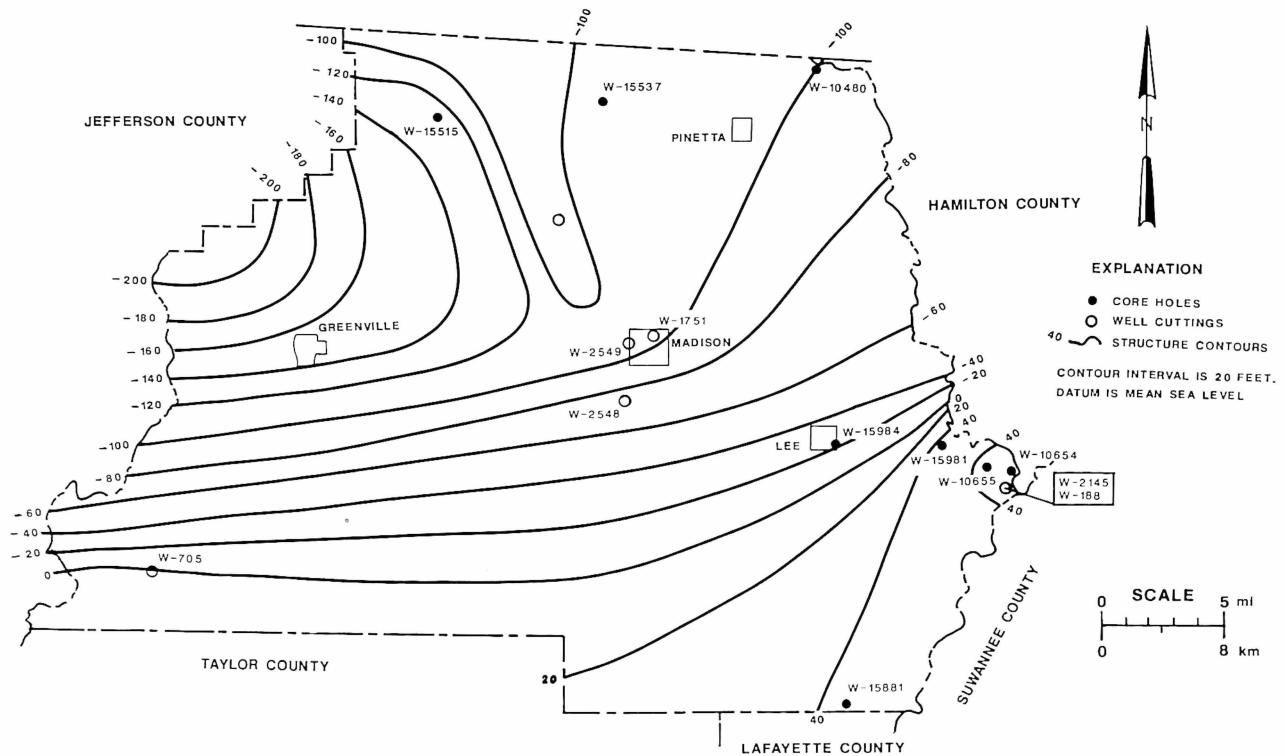


Figure 16. Generalized structure contour map of the top of the Ocala Group.

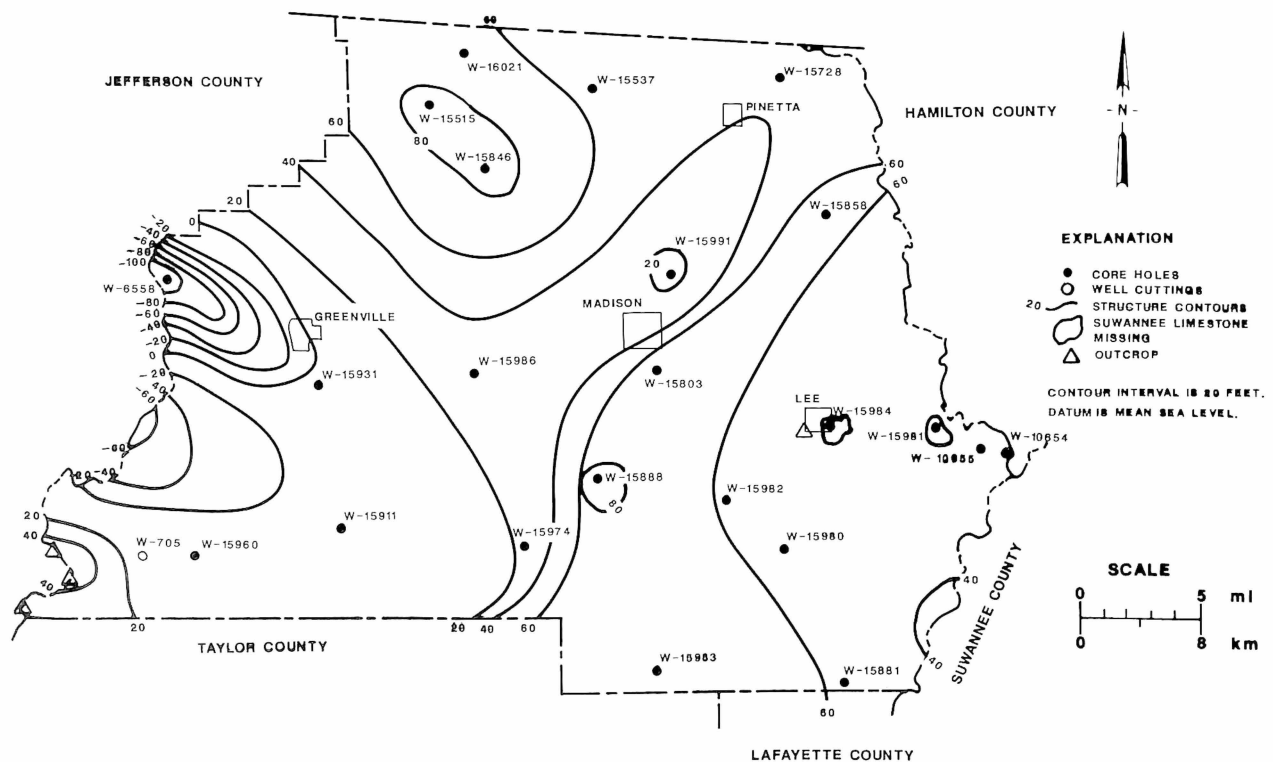


Figure 17. Structure contour map of the top of the Suwannee Limestone.

abundant and is often used as an aid in distinguishing this formation from the overlying younger Suwannee Limestone.

Thickness

A determination of unit thickness is difficult because none of the cores penetrated a complete Ocala sequence. However, approximations can be made based on several deep wells in Madison County (WMD-1596, WMD-1598 and WMD-2549) that penetrated complete Ocala intervals. In WMD-1596, located near the city of Madison (section 06, Township 1S, Range 10E), a maximum thickness of 210 feet was encountered in the interval from 93 to 224 feet below MSL. A minimum thickness of 80 feet was encountered in the interval from 42 to 122 feet below MSL in WMD-1598 (section 5db, Township 2S, Range 11E).

Stratigraphic Relations

The Ocala Group unconformably overlies the Middle Eocene Avon Park Formation. It unconformably underlies the Oligocene Suwannee Limestone.

Geologic Outcrops

Outcrops of the Ocala are limited in Madison County to a reach of the Suwannee River south of Ellaville. Here, in the extreme southeastern part of the county, Ocala Group limestones can be observed along the banks of the river during periods of low water levels. South of the Madison-Lafayette County boundary, exposures of Ocala can be viewed in the inactive Dowling Park Quarry owned by Anderson Mining Corporation (section 2, Township 3S, Range 11E).

Oligocene Series Suwannee Limestone

Cooke and Mansfield (1936) named the tan

limestone exposed along the Suwannee River from Ellaville eastward to a point near White Springs in Hamilton County, the Suwannee Limestone. An historical review of the stratigraphic nomenclature of the Suwannee Limestone is given by Puri and Vernon (1964), Colton (1978) and Crane (1986).

Distribution

The Suwannee Limestone is continuous throughout most of Madison County. One exception is a narrow strip in the southeastern part of the county near and along the Suwannee River where the older Ocala Group is at or near the surface.

The majority of cores examined for this study penetrated the Suwannee Limestone. This formation was encountered at various depths ranging from the surface along the banks of the Suwannee River at Ellaville (approximately 35 feet above MSL) to as deep as 109 feet below MSL in core WMD-6558 (section 9d, Township 1N, Range 6E). Figure 17 is a structure contour map drawn on top of the Suwannee Limestone.

General Lithology

The Suwannee Limestone is of marine origin and consists of a partially recrystallized limestone (calcarenite). It is very pale orange, finely crystalline, moderately to well indurated, with moderate to good porosity and is very fossiliferous. Chemical analysis of this formation in Jefferson County indicates a composition that is nearly 97 percent calcium carbonate (CaCO_3) (Yon, 1966). In various locations, such as along the Suwannee River at Ellaville, the top of the formation is silicified at the land surface and near surface. In addition, chert was encountered in well cutting samples and cores.

Well cutting samples and cores of the Suwannee Limestone show that dolomite $\text{CaMg}(\text{CO}_3)_2$ can occur throughout the complete section. In general, the dolomite occurs as a light orange to gray intergranular well indurated, microcrystalline

to very fine grained sediment. These dolomitic beds can often be delineated by electric and gamma logs as well as being identified in cores and well cuttings.

Thickness

In this report, the formation's thickness is approximated because most of the information available is from wells that terminate in the Suwannee. Thicknesses ranged from a maximum observed thickness of 227 feet in core WMd-15515 (section 5ca, Township 2N, Range 8E) to being absent in some wells in the eastern part of the county (WMd-15984 and WMd-15981).

Stratigraphic Relations

The Suwannee Limestone unconformably overlies the Ocala Group (Figures 12, 13, and 15). The Suwannee Limestone is unconformably overlain by the Hawthorn Group sediments or St. Marks Formation. Where the above units are absent, the Suwannee underlies younger undifferentiated sand and clay (Figures 13 and 15).

Geologic Outcrops

Outcrops of limestone and dolomitic limestone belonging to the Suwannee Limestone are present along the banks of the Suwannee River at Ellaville. These outcrops, which are fairly continuous eastward to near White Springs, are readily accessible via canoe during low to moderate river levels.

The outcrop on the east bank of the Suwannee River directly under the old U.S. 90 Highway bridge approximately 0.1 mile north of the new bridge near Ellaville is considered typical of the section. A description of this section is as follows:

Described by Steve Spencer (1987).

LSu section 24da, Township 1S, Range 11E (directly under the old US 90 Highway bridge approximately 0.1 mile north of the new bridge).

Unit	Description	Thickness Feet
A	Suwannee Limestone (Oligocene). Limestone. Very pale orange to white, moderately to well indurated, microcrystalline to coarse grained, fossiliferous (foraminifera), calcilutute matrix.....	4
B	Limestone. Very pale orange to white, moderately to well indurated, dolomitic, bedded, highly weathered, recrystallized, fossiliferous (foraminifera and mollusks).....	4
C	Dolomite. Brown, moderately to well indurated, moldic, massive, dolomitic cement.....	8
D	Undifferentiated Sands and Clays. Quartz sand, gray to orange-red, poorly indurated, medium grained (fine to coarse range), iron staining, organics present as rootlets, unfossiliferous.....	19

Miocene Series St. Marks Formation

Lithologic units assigned to the Early Miocene have undergone various revisions since L. C. Johnson (1888) first applied the name Tampa to deposits that are stratigraphically equivalent to calcareous sediments occurring in Madison County. An extensive historical treatment of the St. Marks stratigraphic nomenclature is summarized by Puri (1953) and Schmidt and Clark (1980).

Distribution

In contrast to the nearly continuous underlying

Suwannee Limestone, the St. Marks sediments are discontinuous in occurrence due to nondeposition or erosion in Madison County (Figures 12, 13 and 15). In general, the St. Marks Formation has widest occurrences in the northern part of the county as well as an area near the city of Madison. This formation was encountered at depths ranging from 69 feet above MSL to 46 feet below MSL.

General Lithology

The sediments, which form the St. Marks Formation, are white to very pale orange, sandy, silty, clayey, recrystallized limestone. The St. Marks is poorly to well indurated, has low to medium porosity, contains various species of foraminifera including *Sorites* sp., *Archaias floridanus* and molluscan molds and casts.

Thickness

The cross sections in Figures 12, 13 and 15 show thickness variability of the St. Marks throughout the study area. Formation thickness varies from being thin to absent in the central part of the county. A maximum core thickness of 20 feet in WMd-15537 (section 5ba, Township 2N, Range 9E) was observed in north-central Madison County in an area west of Cherry Lake. No exposures of St. Marks were observed in Madison County.

Stratigraphic Relations

The St. Marks Formation unconformably overlies the Suwannee Limestone in Madison County. Younger Miocene sediments belonging to the Hawthorn Group unconformably overlie the St. Marks Formation.

Hawthorn Group

Historically, the Hawthorn Formation has been a catch-all for Miocene sediments in peninsular

Florida, Georgia, and parts of South Carolina (Abbott and Andrews, 1979). This extremely complicated unit, which consists generally of clay, carbonate (primarily dolomite), and clayey, quartzitic, phosphatic sand, was named by Dall and Harris (1892) after the town of Hawthorne, Florida.

Huddlestun (1982) informally proposed raising this formational unit in Georgia to group level. He further expanded this group concept by informally recognizing the Parachucla Formation, Marks Head Formation, and its equivalent the Torreya Formation with its type section in Liberty County, Florida, and the Coosawhatchie Formation as comprising the Hawthorn Group along with their respective ages of deposition (Huddlestun, 1981). Later, Huddlestun (1988) formally raised the Hawthorn to group level in Georgia. Scott (1988) has formally extended the Hawthorn Group concept into Florida and recognized its component formations.

An extensive historical review of the term Hawthorn is given by Hoenstine (1984) and Scott (1983, 1988). Scott (1988) recognized only the Torreya Formation of the Hawthorn Group as being present in Madison County. The Hawthorn Group was not differentiated in Madison County for this study and is referred to in the cross sections as Hawthorn Group Undifferentiated (Figures 12, 13, 14 and 15).

Distribution

Hawthorn Group sediments are present throughout most of Madison County. Exceptions occur along the southern portion of the Withlacoochee River in Madison County and the extreme southwestern and the southeastern portions of Madison County along the Suwannee River, where the Hawthorn is absent. Figures 12, 13, 14 and 15 show the general distribution of these Miocene Series sediments. These sediments were encountered at depths ranging from surface occurrences to 35 feet above MSL in WMd-13996 (section 4, Township 1N, Range 7E).

The occurrence of Hawthorn clays in southeastern Madison County greatly influences surface conditions. In this area, Hawthorn clays

underlie a broad low area known as San Pedro Bay. These relatively thick clays, which range in thickness from 10 feet to 30 feet, inhibit the downward percolation of water resulting in extensive swampy conditions throughout the area (Copeland, in preparation).

General Lithology

Hawthorn sediments throughout Madison County are extremely variable ranging from phosphatic dolomites and clayey sands to dolomitic, silty clays. In general, these sediments consist of pale olive to moderate yellow, sandy, phosphatic clays and sands. Phosphate grains are a common constituent of the Hawthorn Group and aid in its identification. Phosphate, which may comprise up to eight percent of the sediment sample, is generally disseminated throughout sandy clays and very fine to medium, clayey, quartz sands and carbonates. The phosphate grains are present in variable amounts that commonly range from less than one percent to eight percent of the sample, with average values of approximately three percent (visual estimate).

Thickness

The Hawthorn is thin to absent in a broad area of south Madison County and a smaller portion in extreme southwestern Madison County. In contrast, thick deposits of Hawthorn Group sediments are present in the northeastern portion of Madison County as well as eastern and south-central parts of the county (Figure 18). A maximum thickness of 142 feet of Hawthorn sediments was observed in core WMd-6558 (section 9d, Township 1N, Range 6E) near State Road 90. This anomalous thick section may be related to karst activity.

Stratigraphic Relations

The Hawthorn Group sediments in Madison County lie unconformably upon either the Suwannee Limestone or the St. Marks Formation. They are in turn unconformably overlain by the Miccosukee Formation or, where the Miccosukee is

absent such as in southeast Madison County, by Pleistocene to Holocene undifferentiated sands.

The Hawthorn-Miccosukee contact is usually lithologically identifiable. The heterogeneous nature of water well cuttings can present a problem in distinguishing between the sands and clays of these respective units. However, the presence of phosphate can serve as a guide in identifying the Hawthorn sediments.

Geologic Outcrops

Surface outcrops of Hawthorn sediments occur on the eastern side of the county along the northern portion of the Withlacoochee River. These sediments are visible except during periods of high water levels. An accessible outcrop occurs 100 yards to the south of State Road 90 approximately 1.5 miles west of the Suwannee River at an elevation of 60 feet MSL, as measured from the USGS 7.5 minute Ellaville Topographic Quadrangle (Figure 19). The description of this outcrop is as follows:

Described by Ron Hoenstine and Steve Spencer (1987).

LMD section 23aa, Township 1S, Range 11E (1.5 miles west of bridge, south side of State Road 90).

<u>Unit</u>	<u>Description</u>	<u>Thickness Feet</u>
A	Hawthorn Undifferentiated (Miocene). Quartz sand, gray to yellowish to orange-red, poorly indurated, fine grained (silt to fine range) phosphorite grains, clay matrix, iron staining, well mottled, organics present as rootlets, unfossiliferous.....	1.3
B	Undifferentiated Sands and Clays. Quartz sand, brownish orange, poorly indurated, fine grained (silt to fine range), faintly mottled, unfossiliferous micaceous, organics present as rootlets, radational base.....	1.3

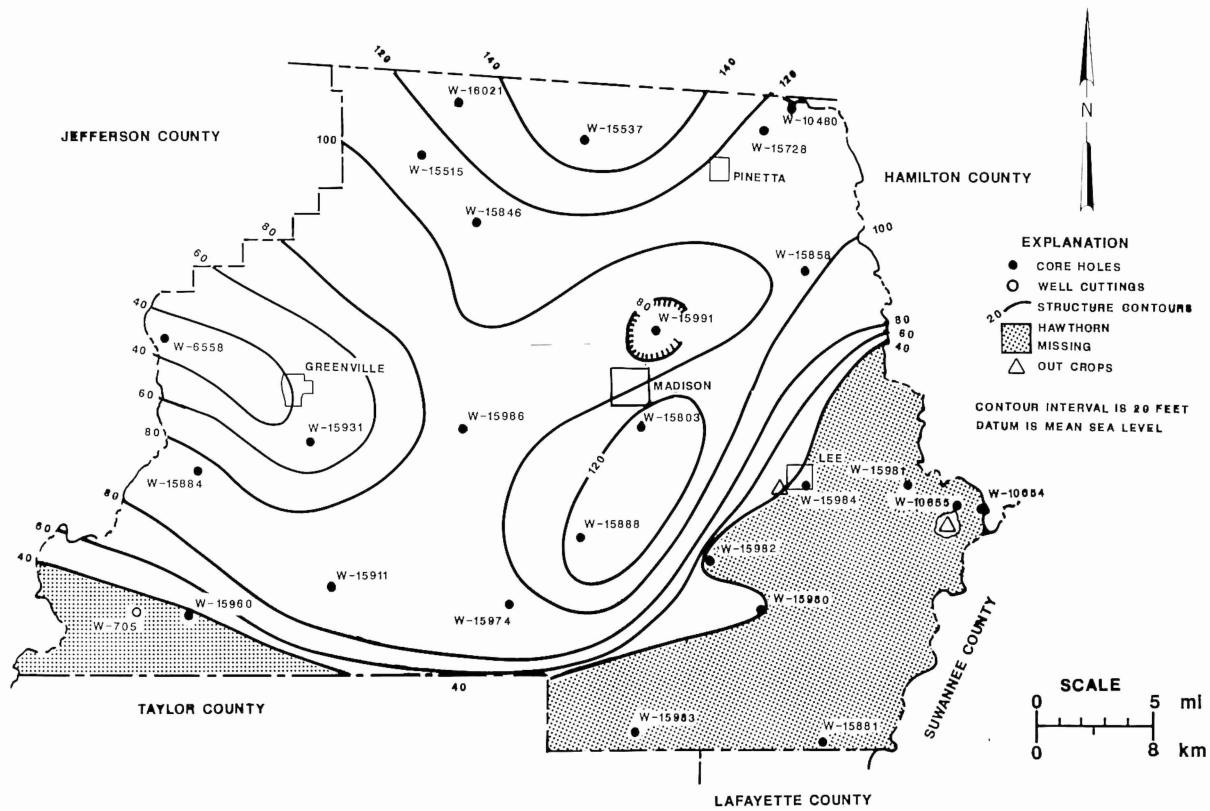


Figure 18. Isopach map of the Hawthorn Group.

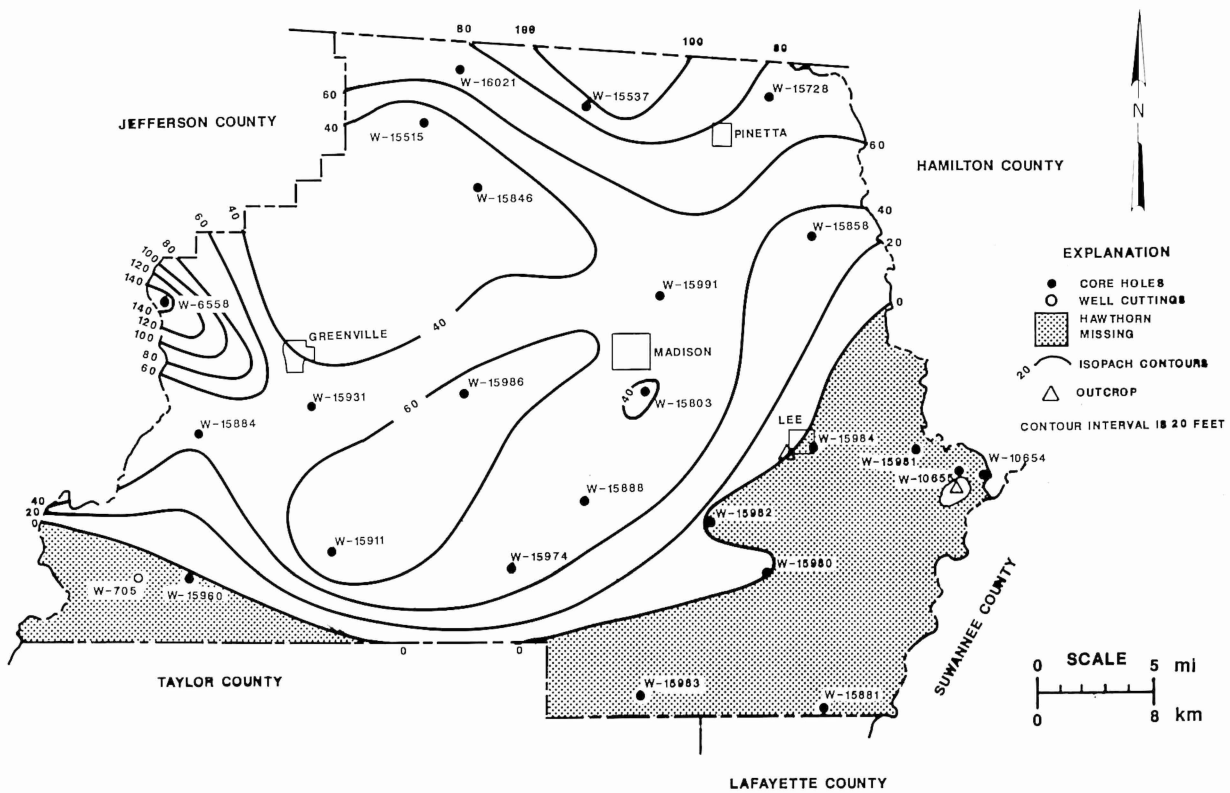


Figure 19. Structure contour map of the top of the Hawthorn Group.



Figure 20. Photograph of high water stage at a sinkhole in Lee, Florida. Photograph by the authors.

In a sinkhole near Lee, Florida, behind the Methodist Church, (section 10db, Township 1S, Range 10E, Figure 13) the Hawthorn Group occurs as a white to yellowish-brown, well indurated, finely crystalline, clayey limestone with low porosity. This Hawthorn outcrop has limited exposure due to slumpage and becomes inaccessible during periods of high water. This occurred in February of 1986 when the Hawthorn was covered by more than 10 feet of water (Figure 20).

Pliocene Series Miccosukee Formation

Prominent throughout the county is the varicolored (red to reddish-orange to gray) heterogenous complex of sediments referred to as the Miccosukee Formation. These siliciclastics have experienced a number of changes in stratigraphic nomenclature over the years and have been included in the Lafayette Formation (Matson and Clapp, 1909), the Alum Bluff Formation (Seldars, 1917) the Hawthorn Formation (Cooke and Mossom, 1929), the "Unnamed Coarse Clastics" (Puri and Vernon, 1964), and the Citronelle Formation (Doering, 1960). In addition, the period of deposition assigned to these sediments by various investigators over the years has ranged from the Oligocene to the Plio-Pleistocene. More recently, these sediments, which extend from Madison County westward into Jefferson, Leon and Gadsden counties and northward into Georgia, have been formally named the Miccosukee Formation by Hendry and Yon (1967). A comprehensive treatment of these sediments is given by Hendry and Sproul (1966) and Yon (1966).

Distribution

The Miccosukee Formation is widespread in Madison County, being generally present at the surface and in the subsurface in all areas except the river valley lowlands and the southern and extreme eastern parts of the county. These sediments are very distinctive in color and can be observed in

numerous roadcuts throughout the northern part of the county.

The type locality of this formation is located at a roadcut on the east side of U.S. Highway 19, about 3.1 miles south of the Georgia-Florida state line in neighboring Jefferson County (Yon, 1966; Hendry and Yon, 1967). The sequence of sediments in this section illustrates rapid depositional changes, including channel cut and fill features of a pro-deltaic environment. Puri and Vernon (1964) postulated that the siliciclastic sediments from Tallahassee eastward were once part of a large delta.

General Lithology

The Miccosukee Formation is an aggregate of lenticular clayey sands and clay beds which individually can be traced laterally for only short distances. These sediments are fine to coarse grained, poorly to moderately sorted, poorly to moderately indurated, reddish-orange sands to gray sandy clays (Figure 21). Cross-bedded sands frequently contain cross-bedded laminae of white to light gray clay. Yon (1966) described these sands as being widespread and generally the most persistent lithologic constituent of this unit.

Miccosukee sediments in Madison County are very heterogeneous in character with changes in lithology observed to occur over relatively short distances. Outcrops, one of which measures more than 35 feet in height (section 6bb, Township 1S, Range 9E), are extremely weathered (Figure 10). The weathering process has frequently destroyed bedding that may have been present and imparted a massive appearance to many of the exposed sediments.

Thickness

As shown on the geologic cross sections (Figures 12, 13, and 15) the Miccosukee is variable in thickness. In core WMd-15515 (section 5ca, Township 2N, Range 8E) 44 feet of Miccosukee clayey sands and clay beds were penetrated (Figure 22). The top of these sediments in the core



Figure 21. Photograph of Miccosukee Formation section at railroad cut near Pinetta. Abandoned railroad cut is 2 miles north of Pinetta, 200 feet past end of dirt road, west side of road. Note pen for scale.

occurs at 155 feet MSL. A maximum core thickness of 78 feet was observed in a core (WMd-6558, section 9d, Township 1N, Range 6E) located in western Madison County. In general, the top of the Miccosukee Formation coincides with surface elevations in the area north of the Cody Scarp in Madison County. Exceptions to this include core WMd-15858, (section 35, Township 2N, Range 10E) and water well WMd-13366 (section 25, Township 1S, Range 10E) in which 55 and 50 feet of Miccosukee sediments respectively were encountered. The top of the Miccosukee sediments in WMd-15858 occurs at an elevation of 157 feet MSL suggesting that this area is an erosional remnant.

Figure 22 is an isopach of the Miccosukee showing maximum thicknesses based on core data, occurring in the west-central part of the county. A thickening also occurs in an area southeast of the town of Pinetta in the northeastern part of the county.

Stratigraphic Relations

The Miccosukee Formation is underlain by the Hawthorn Group. The contact between these units may not always be readily discernible due to frequent similarities in gross appearances; however, the absence of phosphate grains can be used as a guide in identifying the Miccosukee (Yon, 1966). Chronostratigraphic control has thus far been insufficient in determining the conformable or unconformable relationship of these two units.

The overlying stratigraphic relationship is more easily determined as undifferentiated sands and clays overlie the Miccosukee Formation. In places, these sands and clays have developed from weathering of the underlying parent Miccosukee Formation.

Geologic Outcrops

The Miccosukee Formation crops out primarily in an area bounded on the south by I-10 just east of the city of Madison and bounded on the east by State Road 145 and continues to the north into

Georgia and to the west into Gadsden County. A maximum observed vertical thickness of 36 feet of Miccosukee sediments are exposed in a borrow pit southwest of the city of Madison in the northwest corner of the intersection of I-10 and State Road 14 (Figure 10). This represents one of the thickest vertical exposures of the Miccosukee Formation in Florida. A description of this outcrop is as follows:

Described by Ron Hoenstine and Steve Spencer (1987).

Lmd section 6bb, Township 1S, Range 9E.

<u>Unit</u>	<u>Description</u>	<u>Thickness Feet</u>
A	Miccosukee Formation. Quartz sand, white to reddish-orange, poor to moderately indurated, clay-silt matrix, fine grained (fine to medium range), laminae of reddish-orange oxidized sands alternating with white sand laminae, all of which dip to the north at approximately 30 degrees to the vertical, frequent clay nodules present.....	11.0
B	Quartz sand: Reddish-orange to gray, poorly indurated, highly oxidized, mottled, fine grained (fine to medium range), clay matrix.....	22.0
C	Quartz sand: Reddish-orange, poorly indurated, fine grained (very fine to fine range), silt-clay matrix, homogeneous.....	2.5
D	Undifferentiated Sands and Clays. Quartz sand, gray to brownish-tan, unconsolidated, fine grained (fine to medium range), organics present in the form of rootlets.....	0.5

These were the only Miccosukee sediments, other than cross-bedded laminae, observed to dip in Madison County. This bedding, which dips north at an angle of 30 degrees, may be attributed to karst collapse.

Other significant exposures occur along U. S. 90 just east of Greenville and along State Road 146 in the northwestern part of the county. The area around Cherry Lake, which has some of the highest surface elevations in the county, has a number of exposures including a six-foot exposure on the east side of the intersection of State Road 253 and State Road 53 (section 4aa, Township 2N, Range 9E, Figure 9).

A description of the outcrop near Pinetta which measures 12.5 feet is as follows:

Described by Ron Hoenstine and Steve Spencer (1987). Lmd section 31ab, Township 3N, Range 10E: 2 miles north of Pinetta, 200 feet past end of paved road on the west side in abandoned railroad bed (Figure 10).

<u>Unit</u>	<u>Description</u>	<u>Thickness Feet</u>
A	Miccosukee Formation. Quartz sand, reddish-yellow to red, poorly to moderately indurated, medium grained (fine to coarse range), silt-clay matrix, iron stained, mottled, root fragments.....	10.0
B	Quartz sand: Light reddish-orange, unconsolidated to poorly indurated, fine grained (fine to medium range), clay matrix, slightly mottled, root fragments.....	2.5
C	Undifferentiated Sands and Clays. Quartz sand, light gray to reddish brown unconsolidated, fine grained (fine to medium range), silt-clay matrix, organics present in the form of rootlets.....	0.5

Quaternary System Pleistocene and Holocene Deposits

Distribution

Surficial sediments deposited during the Pleistocene Epoch form much of the land surface in the south and southeastern parts of Madison County. Less widespread Holocene sediments are confined primarily to the present stream valleys. These sediments, which include soils developed on top of the Miccosukee Formation, consist of clays, silts and sands. These Pleistocene and Holocene deposits are referred to in this report and cross sections as Undifferentiated Sands and Clays (UDSC).

General Lithology

The Undifferentiated Sands and Clays occurring in the Gulf Coastal Lowlands are predominantly fine to medium quartz sands, silts and clays. In addition, significant accumulations of organic material are present in the low-lying areas of southern Madison County.

In contrast, the Holocene sediments present in the river valleys represent reworked quartz sands derived from older Pleistocene Series sediments as well as the Pliocene Miccosukee Formation and the Miocene Hawthorn Group.

Thickness

Figures 12, 13, 14, and 15 illustrate the variable thickness of these sediments. Thicknesses range from a thin veneer in northwest Madison County to more than 70 feet in the southwestern part of the county below the Cody Scarp (Figure 23).

Stratigraphic Relations

Sediments of Pleistocene and Holocene age overlie the Miccosukee Formation over most of Madison County. Exceptions occur in the area south of the Cody Scarp where these deposits

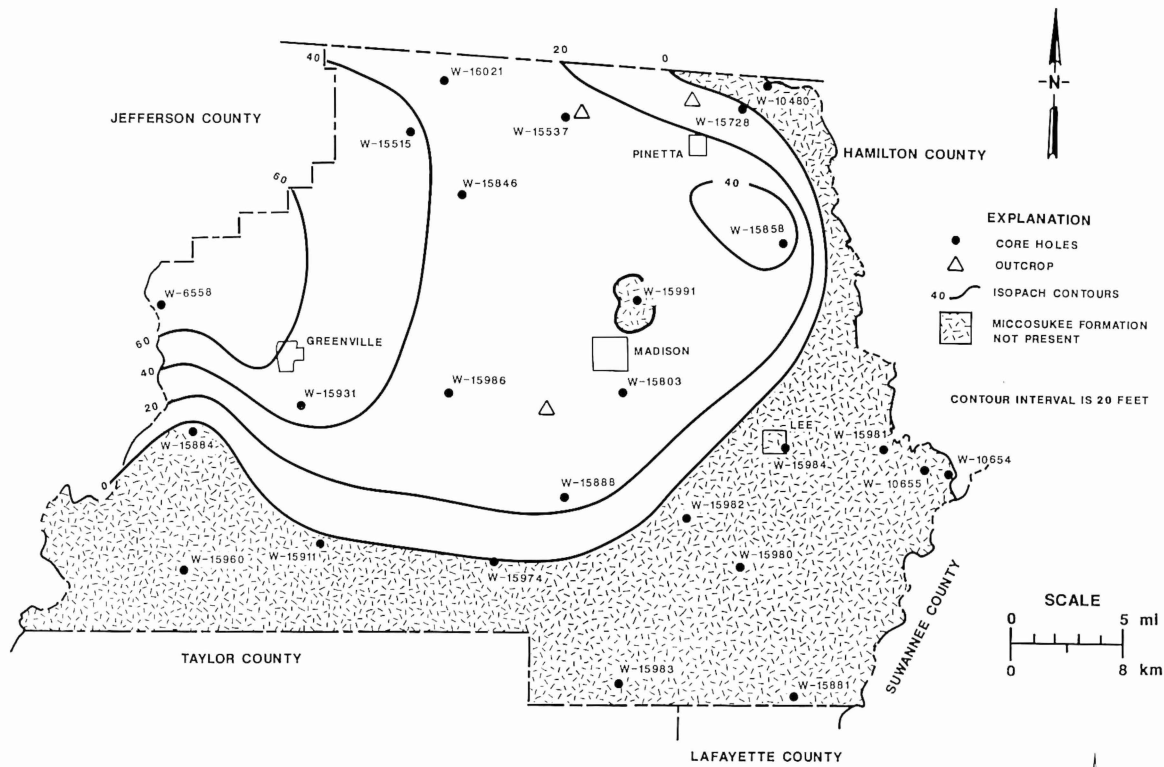


Figure 22. Isopach map of the Miccosukee Formation.

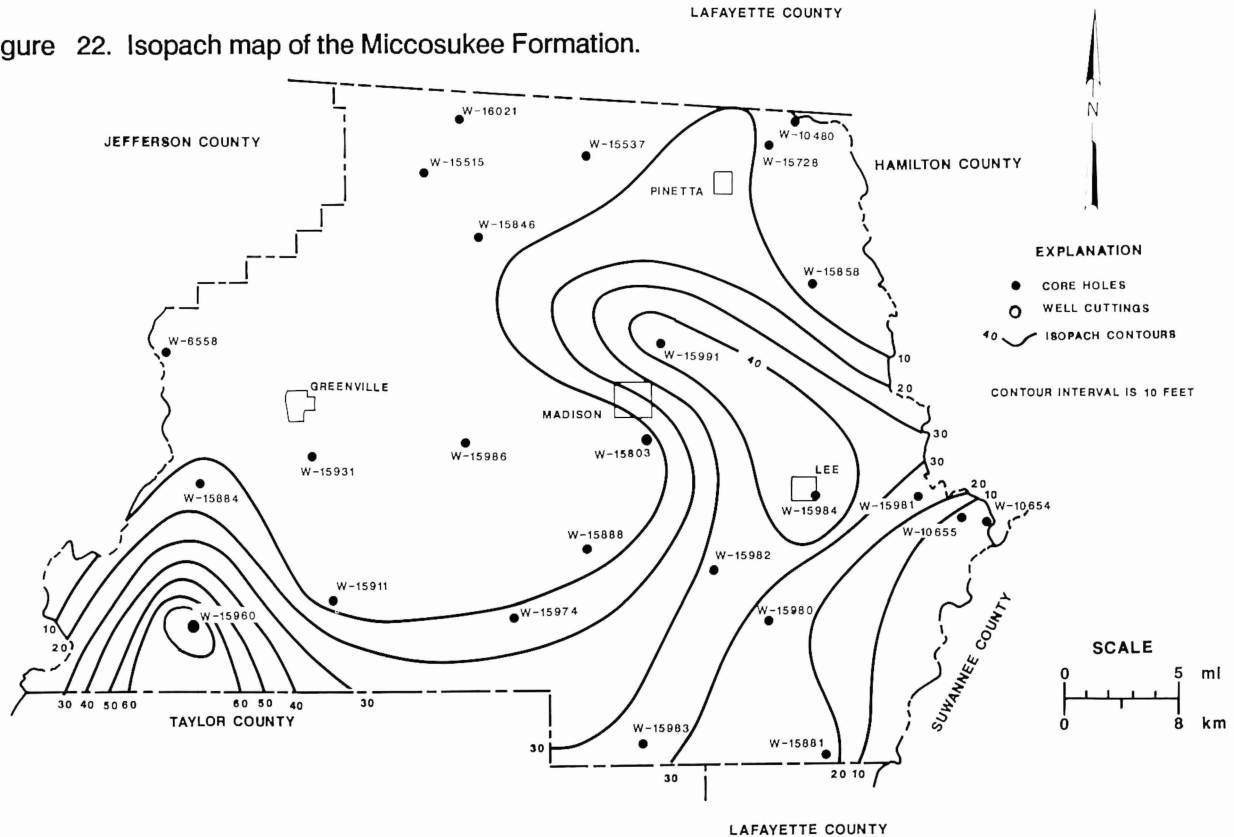


Figure 23. Isopach map of the Undifferentiated Sands and Clays.

unconformably overlies the Hawthorn Group, and a narrow band paralleling the river in extreme southeastern Madison County where they unconformably overlies the Ocala Group limestone.

GEOLOGIC HISTORY

Sediments observed underlying Madison County range in age from Paleozoic to Recent. A major unconformity, which separates the Paleozoic and Mesozoic sediments, is present in WMd-1596 (section 6, Township 1S, Range 10E) in Madison County (Puri and Vernon, 1964). The Mesozoic sediments, which measure approximately 2,800 feet in thickness in WMd-15017, consist of diabase intrusions, sandstones, marine shales, and chalky limestone (Arthur, 1988). Although the environment of deposition was predominantly nearshore marine throughout the Mesozoic, red beds present in the Lower Cretaceous in Madison County may be products of a terrestrial environment.

From the end of the Cretaceous until the Early Miocene, Madison County was an area of predominantly marine carbonate deposition. During this period of time the Paleocene Series Cedar Keys Formation, the Eocene Series Oldsmar Limestone, Avon Park Formation, Ocala Group, the Oligocene Series Suwannee Limestone and the Early Miocene Series St. Marks Formation were deposited.

The depositional environment changed during the Early Miocene resulting in deposition of the siliciclastic and carbonate sediments of the Hawthorn Group. In much of the study area, this unit overlies the Suwannee Limestone. This period of sedimentation was followed by another change in the depositional environment resulting in the deposition of widespread sands, silts and clays belonging to the Miccosukee Formation. Yon (1966) has attributed these deposits to a delta complex, which encompassed many square miles of Madison, Jefferson, Leon and Gadsden Counties and extended into southern Georgia directly north of these counties. Huddleston (1988) concluded that the environment of deposition of the Mic-

cosukee Formation was coastal marine based on occurrences of burrows and bioturbated sediments. The change in the depositional environment from shallow marine during Hawthorn time to a prodeltaic and deltaic sedimentation associated with the Miccosukee deposits appears to have been gradational (Yon, 1966).

It was noted that the Hawthorn Group and younger Miccosukee Formation had anomalously thick deposits along the Jefferson-Madison County boundary in west-central Madison County. This thickening may be attributed to karst activity which influenced subsequent sediment deposition during the Miocene and Pliocene.

The next major change occurred during the Pleistocene, when seas covered much of Madison County forming terraces and other associated features of the Gulf Coastal Lowlands. During this time, erosion may have removed additional St. Marks sediments in the southern part of the county leaving the majority of St. Marks sediments in the northeastern and east-central parts of the county. It was during this time that the present drainage system of rivers and associated tributaries probably developed.

Sea level has fluctuated generally below present mean sea level during the last several thousand years of the Holocene Epoch (Stapor and Tanner, 1977). Sediment deposition in Madison County during this period of time has been restricted to alluvium along the streams and organic deposits in the low areas.

STRUCTURE

The structure maps and the following interpretive discussion are based on cores within Madison County. Additional core and water well data in the areas contiguous to southern, western and eastern Madison County were also utilized. In addition, Yon (1966) is used in interpreting the structure on the western side of the county. An exception occurs in discussing the Ocala Group as only well cuttings were available for these sediments.

Only the oil test wells and one water well (WMd-

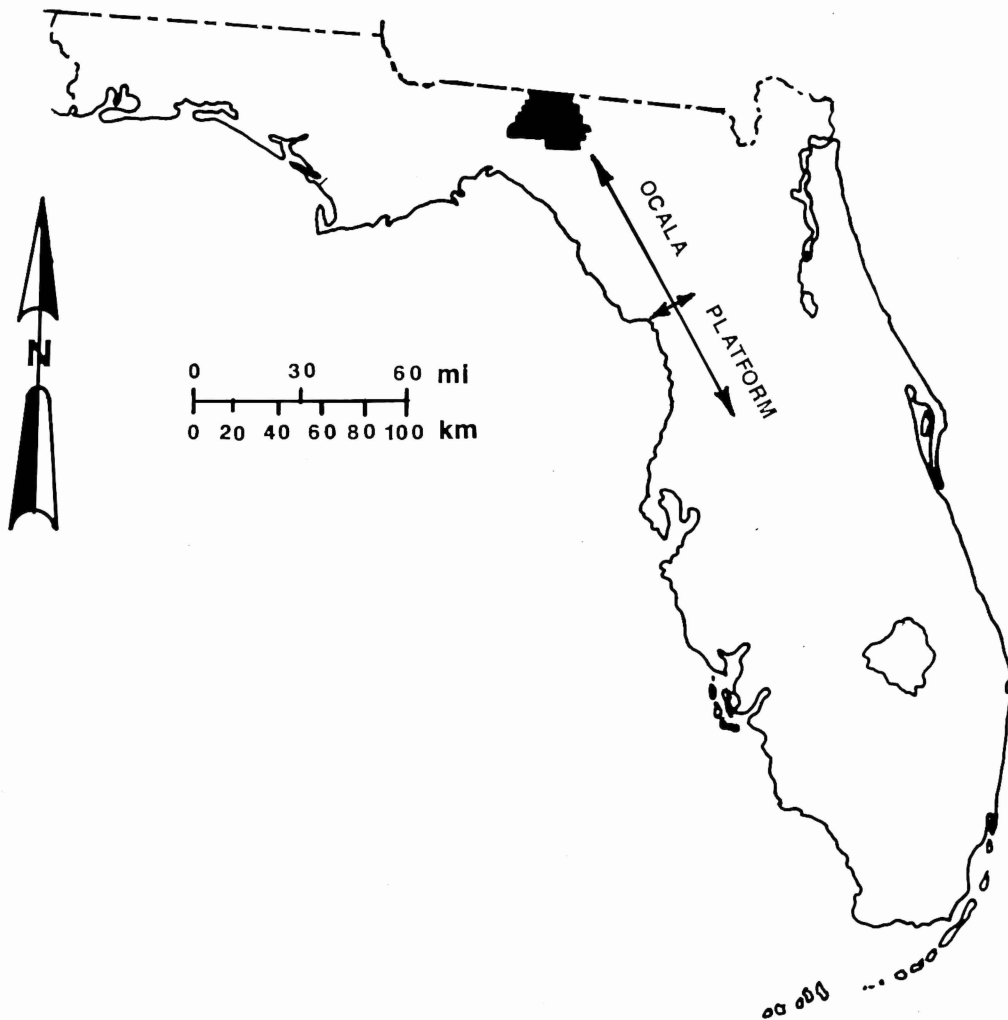


Figure 24. Location of the Ocala Platform (modified from Puri and Vernon, 1964).

2549) encountered sediments older than the Eocene Series Ocala Group (Table 2). The oldest sediments penetrated by stratigraphic cores belong to the Ocala Group. Structure contour maps were drawn utilizing data derived from cores and water well cuttings listed in Table 2.

A structure contour map drawn on top of the Ocala is shown in Figure 16. This structure map shows highest elevations occurring in the southeastern corner of the county with the general attitude of the sediments dipping to the north-northwest. The higher elevations in the southeastern part of the county occur on the northwest flank of the Ocala Uplift (Vernon, 1951), "blister dome" (Winston, 1978) or Ocala platform (Scott, 1988) as it is commonly referred to today (Figure 24). Although surface outcrops occur in extreme southeast Madison County along the Suwannee River, the maximum elevation of Ocala sediments encountered in wells is 50.5 feet MSL (WMd-15981, section 9, Township 1S, Range 11E).

Structure contours drawn on top of the Suwannee Limestone are shown in Figure 17. This map shows the top of the Suwannee Limestone having three definitive highs and two less prominent low areas. The highs occur in the northwestern, western and south-central parts of the county. The low areas may represent karst features. One of these is located on the western side of the county and extends into Jefferson County. Another negative area occurs in the northeastern part of the county near the Madison County landfill.

The top of the Suwannee has a very irregular surface. This undulatory surface is karstic and may be attributed to dissolution of the carbonate sediments.

Structure contours drawn on top of the Hawthorn Group are shown in Figure 19. In general, highest elevations occur in the extreme northern part of the county and in an area just south of the city of Madison. Typically, lower elevations are present in the western part of the county. The Hawthorn is missing in southeastern and extreme southwestern Madison County. The Hawthorn oc-

curs at a maximum observed elevation of 156 feet MSL in core WMd-15537 (section 5ba, Township 2N, Range 9E) in the northern part of the county just west of Cherry Lake. An observed minimum elevation of 33 feet MSL occurs in western Madison County in core WMd-6558 (section 9d, Township 1N, Range 6E). The Hawthorn Group has a general south-southeast dip.

Figure 19 shows a high in northern Madison County and a less prominent high located in an area just south of the city of Madison. A distinct linear depression is present near the western boundary of Madison County. This depression and the irregularity of the Hawthorn top may be attributed to a number of factors, including sediment deposition over limestone with post-depositional karstic development.

The Miccosukee Formation either crops out or is within a few feet of the surface over the majority of its area of occurrence. Therefore, a structure contour map drawn on top of this formation would closely parallel a topographic map.

ECONOMIC GEOLOGY

INTRODUCTION

The following discussion provides information on the general occurrence of economic minerals in Madison County, types of tests performed and analyses of samples collected. The information presented is not intended to be an exhaustive investigation leading to immediate mineral resource development. However, where data are favorable may indicate that certain areas might warrant further investigation. The Mineral Resources Map (Figure 25) is designed to present an overview of the major mineral commodities present in an area. Factors such as thickness of overburden, quality and volume of the deposit could affect the mining of the mineral commodity at any specific site. The resources discussed are sand, clay, peat, phosphate, limestone and petroleum.

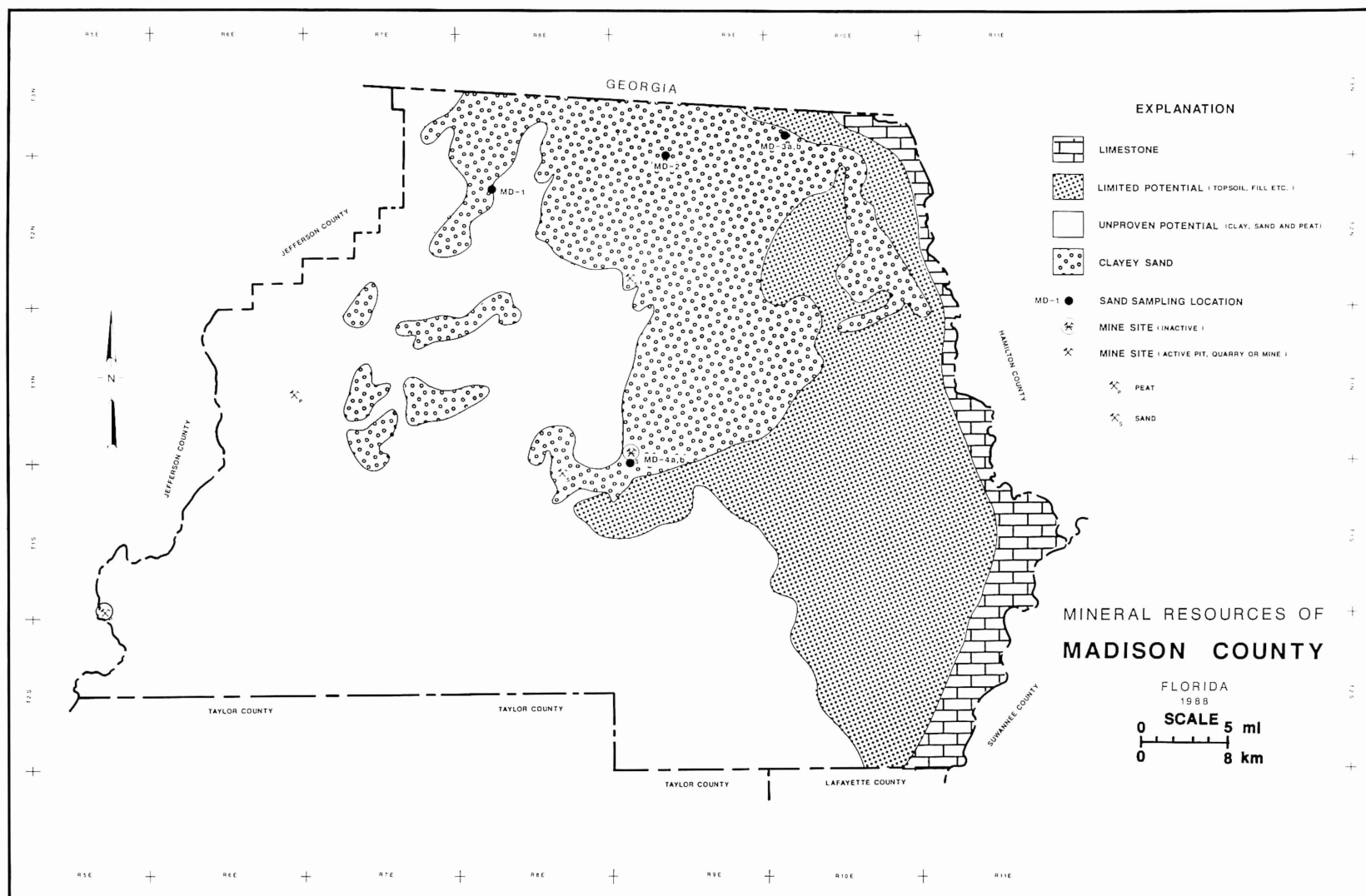


Figure 25. Mineral resources map (reproduced from Florida Geological Survey Map Series 121, 1988).

Sand

Much of Florida is covered by quartz sand or clayey sands which, through time, have been reworked and shifted by fluctuating sea levels and fluvial systems. Sea level stands formed terraces and associated features such as dunes and sand bars. Streams eroded sediments from higher elevations and deposited in low areas.

In the Northern Highlands, the clayey sands of the Miccosukee Formation cover extensive areas of Madison County. The sediments from the Miccosukee Formation in Madison County consist of clayey to very clayey, silty, iron stained, reddish-orange to yellowish-orange, poor to moderately indurated, fine to coarse grained quartz sand, with mottling and fine laminae occurring throughout. Sediments of the Gulf Coastal Lowlands are fine grained, clayey, and contain organic material. The River Valley Lowland sediments consist primarily of alluvial sand and abundant organic material.

Currently the sands and clayey sands of the Miccosukee Formation are being used by the Madison County Road Department. The road department maintains two borrow pits (Figure 25), one in the Cherry Lake region (section 31bb, Township 2N, Range 9E), the other just southwest of the city of Madison (section 2ca, Township 1S, Range 8E). Approximately 2,000 cubic yards of clayey sand are obtained from these pits annually (Madison County Road Department - personal communication, 1986). Transportation of material from these pits is entirely by truck. Presently, no commercial sands are mined in Madison County.

In Madison County, these clayey sands are used for stabilization along roadways, as a base material for athletic fields such as tennis and basketball courts and as a filler for baseball infields. Currently, this material is of small economic value and the potential for commercial mining activity is minimal for the foreseeable future. Table 3 gives sand analyses for selected locations in Madison County. Analyses suggest that these sands may be suitable for concrete.

Clay

To date, in Madison County, there have been no commercial clay mining operations. However, the county road department extracts very clayey sand from its borrow pits for use in stabilizing roadway and athletic fields (Figure 25). This material has minimal commercial value.

Clays in Madison County occur primarily in two units, the Miccosukee Formation and the Hawthorn Group. The clays in the Miccosukee Formation are extremely variable, occurring as thin stringers or lenses with little lateral continuity. This type of occurrence precludes their use as a mineable commodity. In contrast, the Hawthorn clays are thicker, but their sporadic occurrences place serious limitations on their commercial utilization.

Peat

Conditions for accumulation of potentially mineable organic deposits (peat) exist in regions of Madison County (Figure 25). Peat, a product of partial decomposition of organic materials such as sedges, mosses, and other plants, forms when the rate of accumulation exceeds decomposition (Bond et al., 1986). The process of peat formation requires wetland areas of low topographic relief and reducing environments. The highest potential for mining deposits occurs in southern Madison County in areas such as the San Pedro Bay where swamps and forests dominate (Davis, 1946). Other areas where conditions for accumulations of peat are favorable occur along the Aucilla River Valley Lowlands. Analyses conducted by the United States Geological Survey and University of Florida on samples taken five miles east of the town of Greenville and samples obtained from peat accumulations in southwestern Madison County (section 35cc, Township 1S, Range 5E) are presented in Table 4.

Two companies have mined peat in Madison County, Anderson Organics, Inc. (section 35cc, Township 1S, Range 5E) off State Road 27 and the Pasco Products Company located west of Greenville (section 24bb, Township 1N, Range 6E) off

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Table 3. Screen Analysis of Sand in Madison County, Florida.

Deposits			Laboratory Test Data Screen Analysis Sieve No. and Cumulative Weight Percent Retained						
Sample No.	Location	Method of Sampling	4	8	16	30	50	100	Fineness Modulus*
Md-1	Section 8ba T2N, R8E	Channel	----	----	0.058	4.694	33.078	99.999	1.39
Md-2	Section 4aa T2N, R9E	Spot	----	----	0.313	4.948	31.039	100.000	1.36
Md-3a	Section 3lab T3N, R10E	Channel	----	0.068	1.514	24.277	86.134	99.999	2.12
Md-3b	Section 3lab T3N, R10E	Channel	----	0.252	4.123	29.745	82.784	100.000	2.17
Md-4a	Section 6bb T1S, R9E	Channel	----	----	0.018	0.774	30.125	100.000	1.31
Md-4b	Section 6bb T1S, R9E	Channel	----	----	0.307	4.579	27.380	100.000	1.32

*Fineness Modulus: a means of evaluating sand and gravel deposits which consist of sieving samples through a standardized set of sieves, adding the cumulative weight percentages of the individual screens, dividing by 100, and comparing the resultant fineness modulus number to various specification requirements (Bates and Jackson, 1980).

The fineness modulus is an index to the fineness or coarseness of an aggregate, but gives no indication of the grading. The higher the fineness modulus the coarser the aggregate (American Society for Testing and Materials, 1987).

The method of sieve analysis presented here follows that outlined in ASTM, 1987, v. 402, section C136-84a. The reader is also referred to the Florida DOT Manual of Florida sampling and testing methods for aggregates, FDOT, designation FM 1-T 027.

Florida Geological Survey

Table 4. Selected Peat Analyses.

Location (Sec, T,R)	Moisture % loss		Ash	Moisture Free Analysis (%)				BTU
	Airdrying	Overdrying		Volatiles	C	N	S	
20, 1N, 8E*	63.9	9.2	3.9	63.7	32.5	--	2.9	10,048
Location (Sec, T,R)	pH		Soluble Salts	Ca	Mg	P	NO ₃	
35cc,1S,5E**	4.6	246	3	2	0.2	39		

* (after Harper, 1910)

** (Anderson Organics, personal communication, 1986)

Table 5. Selected Well Data Showing Granular Phosphate.
(Visual Estimates)

Well No.	Location (Sec, T, R)	Surface Elevation (feet MSL)	Depth of Sample (feet)	Phosphate (highest est. percent)
2424	28aa, 1N, 9E	167	70-80	3
2987	27, 1N, 9E	129	30-40	3
3679	25d, 2N, 8E	98	40-45	3
7226	17dd, 1N, 8E	98	38-41	1
7234	19ad, 1N, 9E	140	41-45	1
7876	17, 1N, 9E	16	60-70	8
13213	12aa, 2N, 9E	160	60-80	3
13364	1, 1N, 9E	120	60-70	1
13424	35ad, 2N, 9E	115	70-80	2
13946	12ad, 1N, 9E	120	50-60	2
15515c*	5ca, 2N, 8E	160	46-54	3
15537c*	5ba, 2N, 9E	185	34-79	4

* c indicates core

State Road 90 (Figure 25). Although no longer in operation, Anderson Organics maintained a 35 acre site and mined to an average depth of eight feet. A high fiber peat was extracted, shredded and stock-piled for shipping. In 1985, approximately 70,000 cubic yards of material were mined and shipped by Anderson Organics in bulk by truck to processing plants in Adell and Cressant, Texas (Anderson Organics - personal communication, 1986). Another company, Pasco Products currently maintains a 10 acre site. At this site, peat is mined and top soil is extracted as a commercial by-product. Pasco Products processes and markets its product on site.

The future potential for continued commercial mineable peat deposits is considered good. In addition, the marketability and transport of this commodity is further enhanced by the county's existing road system.

Phosphate

In 1986, Florida produced almost 80 percent of the total United States phosphate and nearly 25 percent of the world phosphate production (Florida Phosphate Council, 1987). In recent years, approximately 90 percent of the mined phosphate has been used in the production of agricultural fertilizer (Florida Phosphate Council, 1987).

Table 5 shows those cores and cuttings where granular phosphate was observed. These data indicate that the phosphate, although sporadic, is more abundant in northern Madison County. Col-loidal phosphate, which is embedded in the clay matrix of the Hawthorn sediments, tends to be of a limited nature and varies from one area to another. The analyses shown in Table 5 indicates that the future potential of economically mineable phosphorites are low.

Limestone

Limestone is a term applied to a sedimentary rock comprised of predominantly calcium carbonate (CaCO_3). Impurities such as clay, sand,

iron oxide, magnesium carbonate and others may be found in limestone. Commerical quality limestone used in the manufacture of lime must attain a purity greater than 97 percent total calcium carbonates, whereas road base material requires 70 percent or greater total carbonates (Schmidt et al., 1979).

Limestone sediments mined in Florida range in age from Middle Eocene to Pleistocene. There are no limestone quarry operations in Madison County. Although the road department obtains limestone from outside the county on an "as needed" basis, the potential does exist for economic deposits of this commodity in a band along the eastern side of the county (Figure 25). The potential in this region is enhanced by a thin overburden of sands and clays that range in thickness from a few feet to tens-of-feet. Limestone suitable as an economic commodity from this part of Madison County would include the Suwannee Limestone and the Ocala Group.

Petroleum

A total of five oil test wells have been drilled in Madison County (Table 2). The maximum depth penetrated occurred in test well WMd-15017 (section 22, Township 2S, Range 9E) which terminated in quartz sand at a depth of 10,149 feet. This well was plugged and abandoned as a dry hole. None of the test wells encountered any oil. Present data suggests that the potential for oil in Madison County is minimal.

LANDFILL SITE Waste Disposal

The potential contamination of Madison County's domestic water supply is a topic of continuing concern. In this county, a vast array of chemicals are used by a large agricultural community. These chemicals are present in the form of pesticides, herbicides and fertilizers for row crops and livestock operations. Added to this are chemical wastes generated by local industry as well as common household wastes including cleaning

agents, paint thinner and medicines. Although precautions in the form of warnings as to waste disposition and inspections of waste are taken, some of these contaminants inevitably end up at the landfill site.

Disposal of these wastes currently takes place at the Madison County landfill site located off County Road 591 (Figure 11). Currently, wastes totaling more than 40 tons per day are being dumped at this disposal site, which occupies an area in excess of 80 acres. It has been in continual operation since 1970 as the county's sole waste disposal site. Here, a variety of waste products are dumped into unlined cell excavations, which average 50 feet in length, 30 feet in width and 16 to 20 feet in depth. When filled to capacity, these cells are capped with soil.

Background data originally available for the evaluation of the Madison County site consisted of a number of shallow soil probe samples measuring 80 inches in length taken by the United States Soil Conservation Service (SCS). Descriptions of these soils were incorporated into a soil map by the SCS. The soil map and accompanying descriptions formed the bulk of information utilized in the evaluation of this local county owned parcel for a waste disposal site.

Recently, wells to the southeast of this landfill showed signs of contamination. Subsequently, several holes were drilled on the landfill site to depths ranging from 50 to 90 feet in order to determine the geology of the underlying sediments and structure. In addition, a core (WMd-15991) was drilled to a depth of 125 feet below land surface along County Road 591 just west of the landfill (Figure 11). Data from this preliminary investigation suggests that this site is located over an old sinkhole (Hoenstine et al., 1987). As cross section E-E' (Figure 26) shows, porous and permeable Hawthorn sands, silty sands and discontinuous clay beds directly overlie the Suwannee Limestone which forms the top of the Floridan aquifer system at this site. There appears to be no intervening confining layer at well M-2 and contaminants from a variety of waste products have potential access to the underlying aquifer.

In this situation, a geologic site investigation

conducted prior to site selection would have, in all probability, pointed out the potential geologic hazards associated with this site. Such a study would have either located a more suitable site or determined the need for plastic liners.

Landfills represent the most popular method of disposal as they can accommodate a variety of wastes at relatively low operating costs. However, this method of disposal has inherent risks including the potential contamination of the underlying Floridan aquifer system by the downward percolation of contaminants. For this reason, a suitable natural site should have an impermeable clay underlying the area to prevent ground-water contamination.

The county is seeking a new landfill site since the old one is near capacity. A number of potential sites have been investigated, however, to date no location has been found to have a satisfactory underlying continuous impermeable clay layer. This clay, if present, would probably be part of the Hawthorn Group and, except for the San Pedro Bay area, the Hawthorn clays are, in general, sporadic in occurrence throughout Madison County. It appears likely that a new landfill site will have to utilize plastic liners, plus other leachate treatment technology.

HYDROGEOLOGY

Three distinct aquifer systems have been identified in Madison County through core analysis and well construction. The three aquifers present are the Floridan aquifer system, an intermediate aquifer system and a surficial (perched water table) aquifer system. Table 6 correlates the geologic formations with the various aquifer systems. The three aquifer systems can be differentiated by water chemistry, stratigraphic position, lithology and hydraulic heads.

The Floridan aquifer system, which exists under confined, semi-confined and unconfined conditions, is the major source of ground water in Madison County. Figure 27 represents the general hydrogeologic conditions of the Floridan aquifer system in the study area.

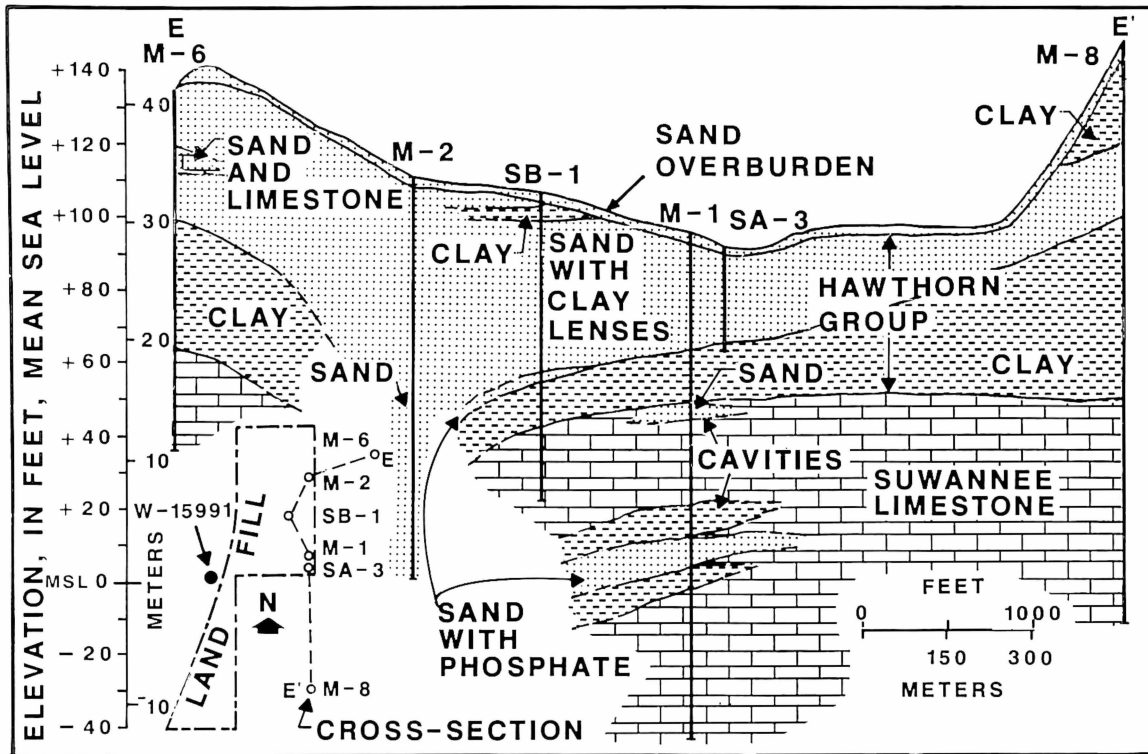


Figure 26. Geologic cross section E-E' (Landfill site) (modified from Kirkner and Associates, 1986; Hoenstine et al., 1987).

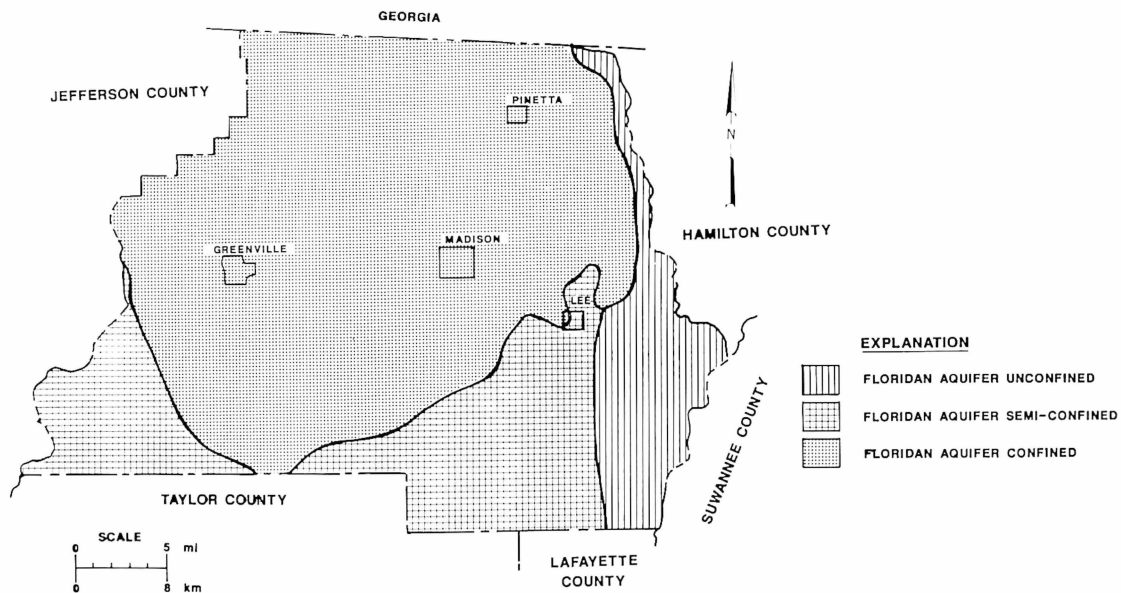


Figure 27. General Hydrogeologic conditions of the Floridan aquifer system in Madison County (after SRWMD).

Florida Geological Survey

System	Series	Geologic Time (M.Y.)	Eastern Panhandle FLORIDA	
			Geologic Formation	Hydrostratigraphic Unit
Quaternary	Holocene	0.01	Undifferentiated terrace marine and fluvial deposits (Undifferentiated Sands and Clays this report)	Surficial aquifer system
	Pleistocene	1.8		
Tertiary	Pliocene	5.0	Miccosukee Formation	intermediate aquifer system or intermediate confining unit
	Miocene	22.5	Hawthorn Group Undifferentiated St. Marks Formation	
	Oligocene	37.5	Suwannee Limestone	Floridan aquifer system
	Eocene	54.0	Ocala Group Avon Park Formation Oldsmar Limestone	
	Paleocene	65.0	Cedar Keys Limestone	sub-Floridan confining unit
Cretaceous and Older		141.0	Undifferentiated	

Table 7 was derived from data obtained through the Suwannee River Water Management District (SRWMD) Permitting Program. Within the study area, the town of Greenville and the city of Madison have municipal public supply well systems. There are an additional 60 private community and non-community public supply well systems in Madison County (SRWMD data). Withdrawals for irrigation use are seasonally distributed, but for the purpose of permitting, are calculated as average daily withdrawals for an entire year. Most irrigation actually takes place during the spring and early summer months. A maximum volume of 102.3 million gallons per day (mgd) is the value obtained when estimating peak irrigation requirements during these periods. Presently, industrial use is minimal. Other uses (Table 7) include withdrawals for aesthetic, nursery, recreational and power production purposes.

The only known wells completed into the intermediate aquifer system are ground-water quality monitoring wells constructed by the Suwannee River Water Management District as part of the district-wide Water Quality Assurance Network. Other private or public withdrawals from the intermediate aquifer system have not been identified.

Few wells are completed into the surficial aquifer system. Private wells tapping the surficial aquifer system are primarily used for livestock and low

demand domestic purposes. However, numerous surface water diversions for agricultural uses are made from the ubiquitous private ponds which are hydraulically connected to the surficial aquifer system.

SURFICIAL AQUIFER SYSTEM

An unconfined, surficial aquifer system covers a large portion of Madison County. In the Tallahassee Hills, the surficial aquifer system consists of Pliocene and younger siliciclastic sediments. These surficial sediments are underlain by low permeability units of the Hawthorn Group. South of the Cody Scarp, in the San Pedro Bay, the surficial aquifer system consists of Pleistocene Series sands and clayey sands overlying Hawthorn Group clays of varying thickness.

The San Pedro Bay surficial aquifer system and related aquiclude are laterally continuous and extend from Madison County southward into Taylor and Lafayette Counties. In the study area, the sands of the surficial aquifer system generally range in thickness from 10 to 40 feet (Figure 23). The thickness of the basal clay, which acts as a semi-confining aquiclude, generally ranges from 10 to 30 feet (Copeland, in preparation). Auger samples obtained throughout the San Pedro Bay indicate

Table 7. Permitted Ground-water Withdrawals in Madison County, Florida
(SRWMD Data, 1986)

Type of Use	Water Use in Million Gallons/Day (mgd)	Water Consumed (mgd)
Public Supply	1.23	1.05
Industrial	0.15	0.14
Private Domestic	0.024	0.021
Agricultural Livestock	0.37	0.33
Agricultural Irrigation	13.81	13.68
Other	0.65	0.65
Total	16.23	15.87

that, in numerous locations, dissolution of the underlying limestone has occurred, resulting in anomalous thicknesses of the surficial sands and/or basal clays.

The topography of the Tallahassee Hills has been shaped by weathering and karst activity. It is characterized by high hills surrounding closed basins. The closed basins are the result of subsidence due to the dissolution of the underlying limestone and the subsequent collapse of overlying sediments. In and around the basins, the St. Marks Formation, Hawthorn Group, Miccosukee Formation and marine terrace deposits have thinned, or have been breached (Price, 1984). Natural drainage is into these closed basins resulting in the formation of numerous isolated surface water bodies. Generally, the surficial sands underlying these basins vary from 5 to 20 feet in thickness (drillers logs, SRWMD). The surficial aquifer system occurs within these sands. It is supported by low permeability beds of the underlying formations which act as an aquitard.

At the higher elevations of the surrounding hills all of the geologic units are generally intact. Frequently, the surficial sands at these elevations are unsaturated. Rainfall percolates downward through these sands until reaching the relatively impermeable underlying sediments. Ground water within the sands then flows laterally into the closed basins where it recharges the surficial aquifer system and its hydraulically connected lakes, ponds and swamps.

Water levels within the surficial aquifer system of both regions (Tallahassee Hills and San Pedro Bay) are at or within a few feet of land surface. The water table is a subdued replica of the topography and coincides with the water levels of local lakes, ponds and swamps. Water level fluctuations and recharge to the surficial aquifer system are directly dependent on rainfall, runoff and evapotranspiration. Mean annual rainfall for the study area is 52 inches per year, while water lost to evapotranspiration is approximately 42 inches per year (Fisk, 1977). To date, an accurate measure of water level fluctuations within the surficial aquifer system and subsequent correlation with rainfall records has not

been possible. This is primarily due to the lack of existing wells completed into the surficial aquifer system.

Discharge from the surficial aquifer system has both downward and lateral components. The downward movement of water is an important source of recharge to the underlying Floridan aquifer system. The surficial aquifer system also discharges laterally into the topographically lower areas of the River Valley Lowlands.

Ground water in the surficial aquifer system typically shows high sodium, chloride, potassium, and nitrate values (unpublished SRWMD data, 1987). This suggests the possibility that these high values may be derived from marine aerosols (salts in ocean derived precipitation) indicating that ground water in the surficial aquifer system is essentially rainwater (Ceryak et al., 1983). High nitrate values are typically the result of human agricultural and domestic activities.

INTERMEDIATE AQUIFER SYSTEM

An intermediate aquifer system exists in Madison County within the Tallahassee Hills. This aquifer system is extremely variable and discontinuous both laterally and vertically. It has been identified in the clayey sands of the Miccosukee Formation and the sands and carbonates of the Hawthorn Group. Locally, clays within the Miccosukee Formation or the Hawthorn Group act as confining units.

The intermediate aquifer system, which is artesian, is recharged from the overlying surficial aquifer system where the confining beds are discontinuous or leaky. Discharge from the intermediate aquifer system is vertically downward, into the Floridan aquifer system. Again, this occurs where the confining beds separating the two aquifers are breached or are relatively permeable.

The quality of water in the intermediate aquifer system is diminished relative to the underlying Floridan aquifer due to the presence of higher concentrations of dissolved minerals. Potentially a source of potable supply, wells completed into this

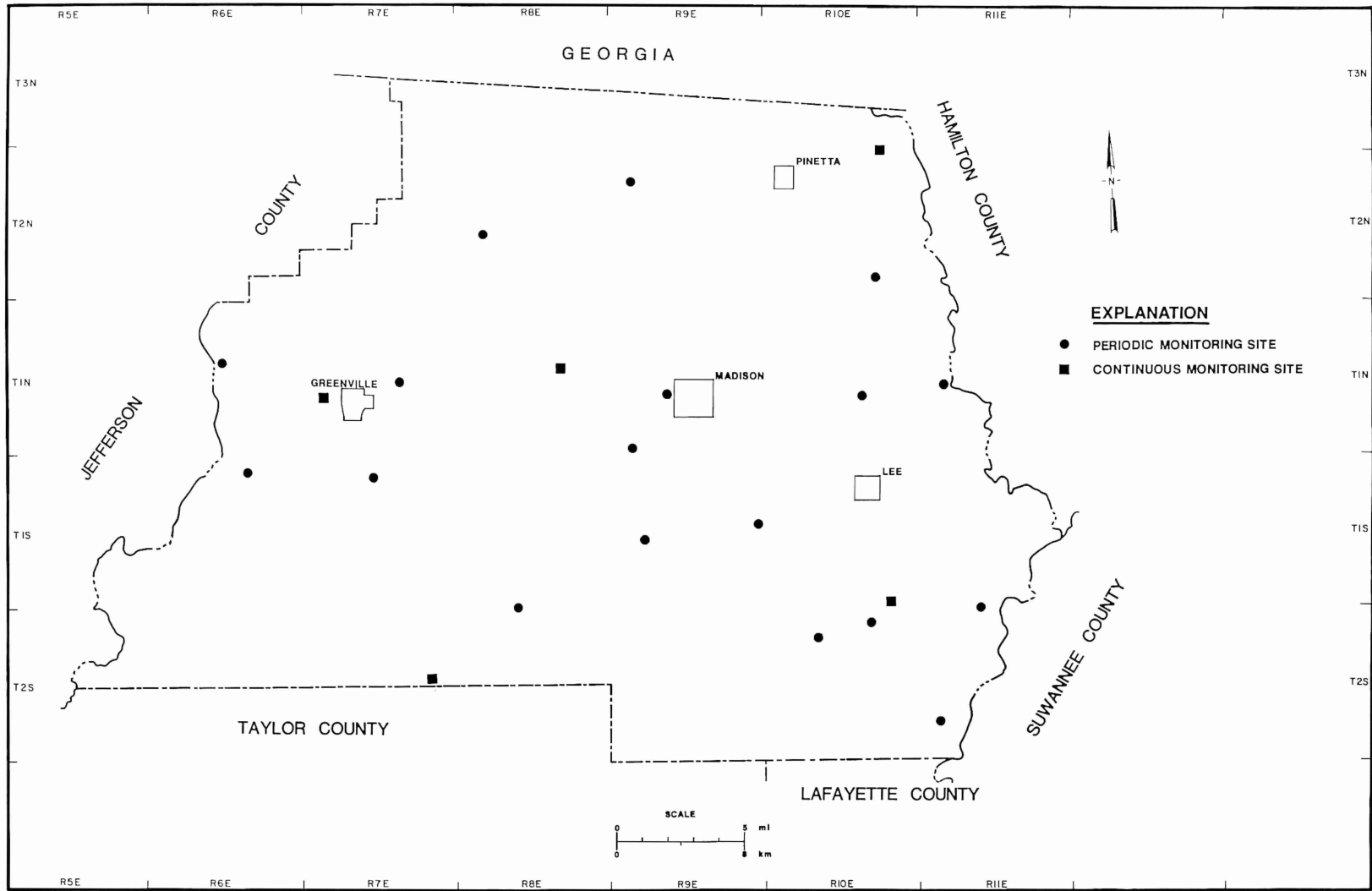


Figure 28. Floridan aquifer system potentiometric network (1950-1989) (data from SRWMD).

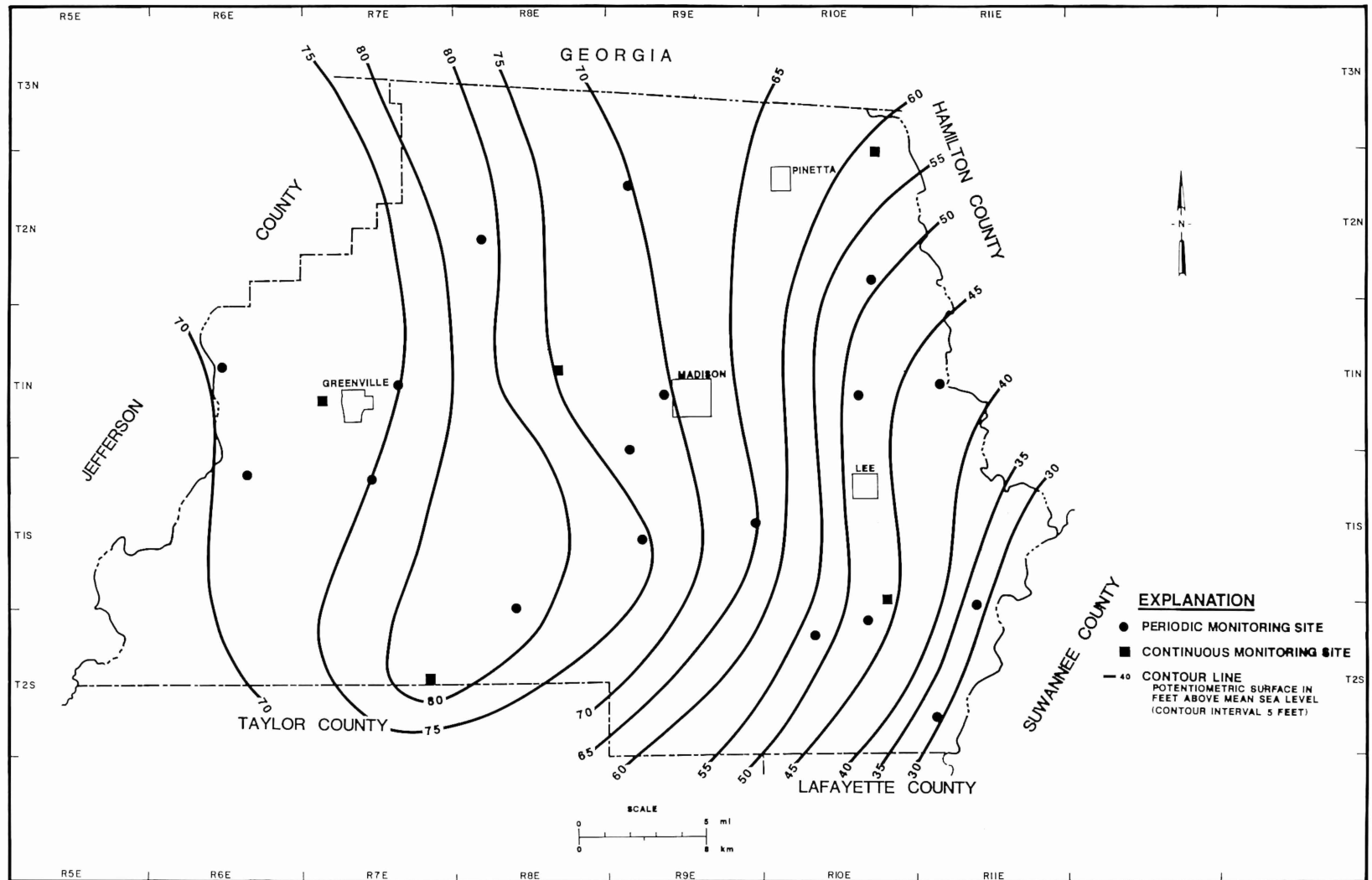


Figure 29. Potentiometric surface of the Floridan aquifer system November 1981 - low water period (data from SRWMD).

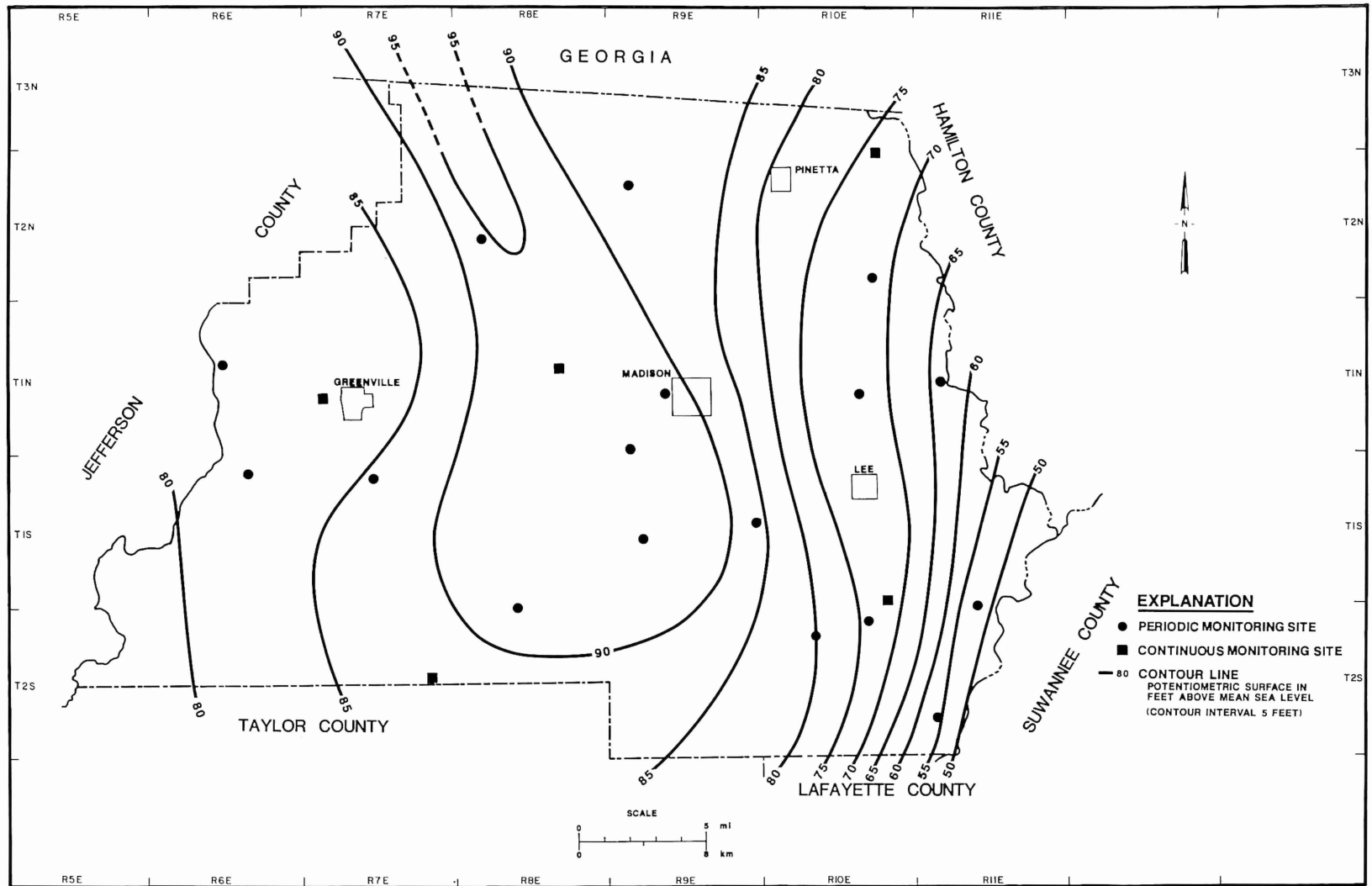


Figure 30. Potentiometric surface of the Floridan aquifer system April 1984 - high water period (data from SRWMD).

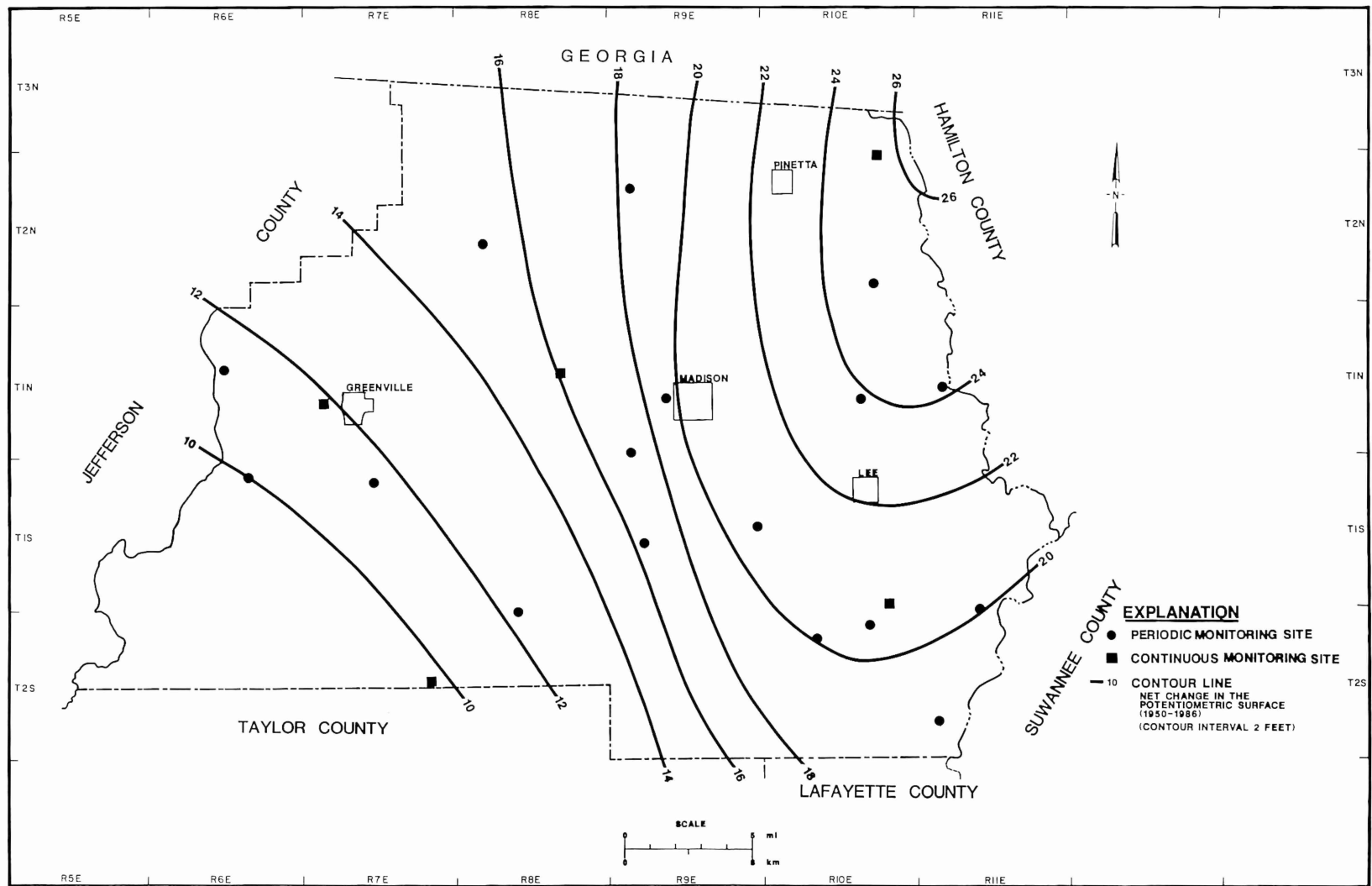


Figure 31. Net fluctuation in the potentiometric surface of the Floridan aquifer system, 1950-1989 (data from SRWMD).

aquifer system have historically been difficult to develop for production due to the abundance of fine sediments.

FLORIDAN AQUIFER SYSTEM

The Floridan aquifer system is the principle ground-water source for much of the State of Florida. This carbonate aquifer, which underlies all of Florida, is referred to as the "Floridan aquifer system" in Alabama, Florida, Georgia and South Carolina (Miller, 1986). The stratigraphic units comprising the potable water-bearing portion of the Floridan aquifer system are, from oldest to youngest: the Avon Park Formation and Ocala Group (Eocene), the Suwannee Limestone (Oligocene), and the St. Marks Formation (Miocene).

In the study area, the top of the Floridan aquifer system corresponds to the top of either the Suwannee Limestone (Figure 17) or to the top of the St. Marks Formation where present. However, in southeastern Madison County, where both the St. Marks Formation and the Suwannee Limestone are missing, the Ocala Group forms the top of the Floridan aquifer system. The base of potable water, which occurs within the Avon Park Formation in this area, is estimated to be present at approximately 1,250 feet below land surface based on a chloride concentration of less than 500 milligrams per liter (Klein, 1975).

In the Tallahassee Hills, the Floridan aquifer system is confined under artesian pressure by the relatively impermeable beds of the Hawthorn Group. Under these conditions, the surface of the water table is no longer free to rise. However, the water level in wells penetrating the aquifer will rise above the top of the saturated carbonates. The level to which water will rise in cased wells is defined as the potentiometric surface of the aquifer.

In San Pedro Bay, the Floridan aquifer system is semi-confined by overlying clays of low permeability (unpublished SRWMD data, 1986). The hydraulic gradient between the potentiometric surfaces of the Floridan aquifer system and the San

Pedro Bay surficial aquifer system is generally less than five feet.

In the River Valley Lowlands, the Floridan aquifer system is unconfined. The top of the limestone crops out or is overlain by a veneer of permeable sands. The saturated zone of the aquifer is at atmospheric pressure and water levels can fluctuate from below the top of the limestone up into the overlying sands.

A potentiometric network was established by SRWMD for the study area to monitor short and long term ground-water trends. The network consists of 23 wells completed into the Floridan aquifer system (Figure 28). Figures 29 and 30 show the potentiometric surface of the Floridan aquifer system in Madison County during the periods of November 1981 and April 1984, representing conditions when water levels were generally at their highest and lowest, respectively. Continued monitoring of the well network has shown that the configuration of the potentiometric surface remains relatively constant.

Figure 31 shows net fluctuation in the potentiometric surface based on the maximum and minimum ground-water levels recorded in the Floridan aquifer system at each well location. Total fluctuations within the aquifer range from 10 feet to 26 feet. The greatest range of fluctuation occurs along the Withlacoochee River Valley Lowlands. In this region, ground-water levels quickly respond to rainfall, which readily percolates downward and recharges the Floridan aquifer system. In addition, large quantities of rainfall can cause river stages in the Withlacoochee River to rise rapidly. An increase in a river's water stage to a level that is higher than the potentiometric surface of the unconfined aquifer will be quickly followed by an increase in the potentiometric surface immediately adjacent to the river, which recharges the aquifer (Copeland, in preparation).

Where the Floridan aquifer system is confined or semi-confined, ground-water level fluctuations occur at a slower rate and to a lesser extent. Downward percolation of precipitation is retarded. Therefore, while ground-water levels in the unconfined Floridan aquifer system may be declining in

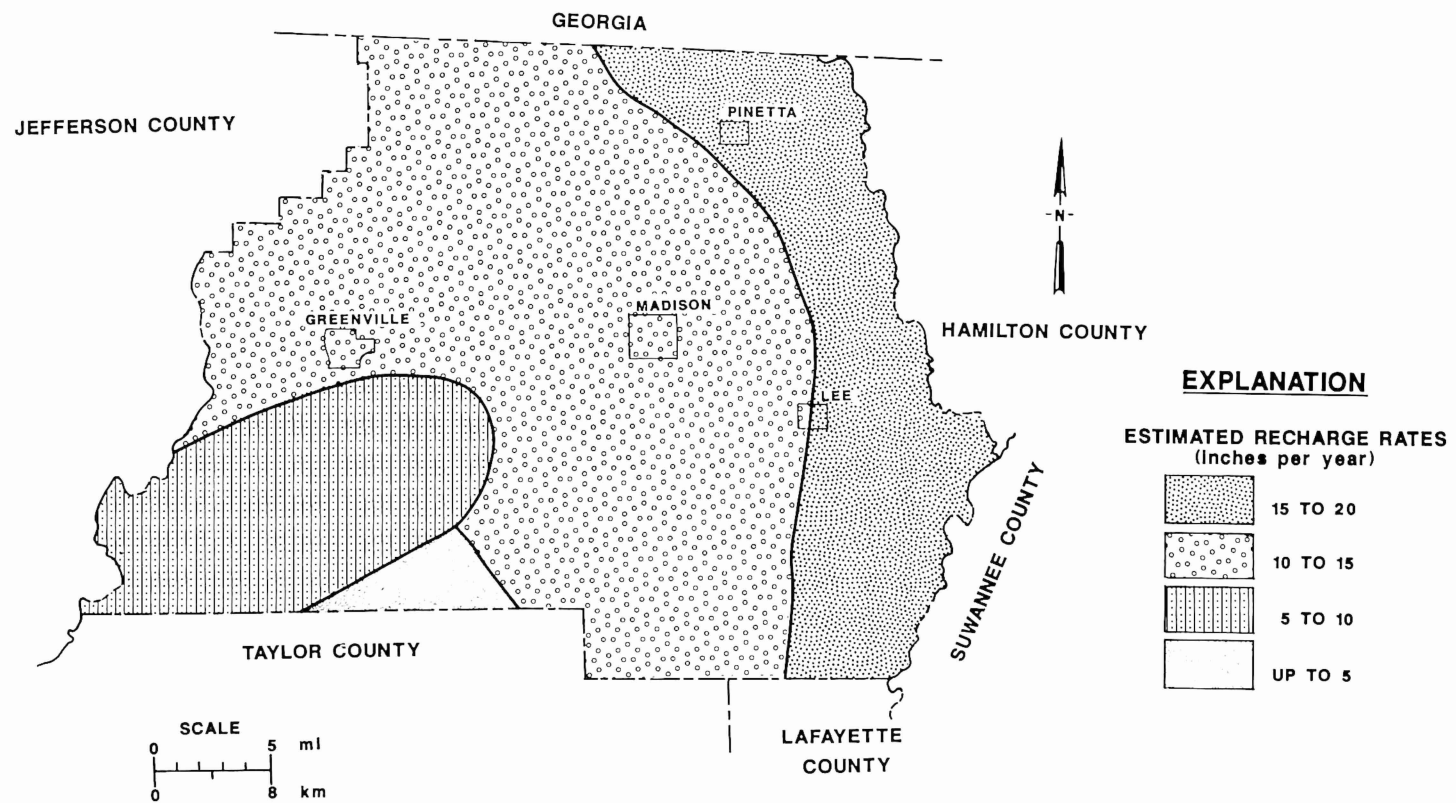


Figure 32. Distribution of recharge to the Floridan aquifer system in the Suwannee River Water Management District (Fisk, 1984b).

direct response to lower rainfall conditions, ground-water levels in the adjacent confined Floridan aquifer system may be stable or even increasing due to the retarded release of continued storage and subsequent downward recharge from the surficial aquifer system.

Recharge to the Floridan aquifer system is generalized in Figure 32. In the study area, the highest rate of recharge, 15 to 20 inches per year, occurs in the River Valley Lowlands, reflecting the direct interaction between ground water and rainfall. Recharge to the Floridan aquifer system in the Tallahassee Hills and the San Pedro Bay occurs at a lower rate than in the adjacent area where the Floridan aquifer system is unconfined. In these areas, recharge is estimated to be 10 to 15 inches per year.

The configuration of the potentiometric surface of the Floridan aquifer system in Madison County

shown in Figures 29 and 30 (SRWMD data, 1986) correlates favorably with the regional mapping of the potentiometric surface of the Floridan aquifer system in south-central Georgia and north-central Florida (Figure 33, SRWMD data, 1986). A potentiometric high in the Valdosta area is principally located within the boundaries of the Withlacoochee River Basin. This potentiometric high is created by a high rate of recharge that primarily occurs as flow from the Withlacoochee River and other streams that enter the Floridan aquifer system via sinkholes and solution cavities (Ceryak et al., 1983). This potentiometric high acts as a pressure head that moves ground water southward across the state line into Madison County. Ground water within the Floridan aquifer system flows from this potentiometric high toward the River Valley Lowlands and Northern Highlands of Madison County.

Most potable supply wells in Madison County are

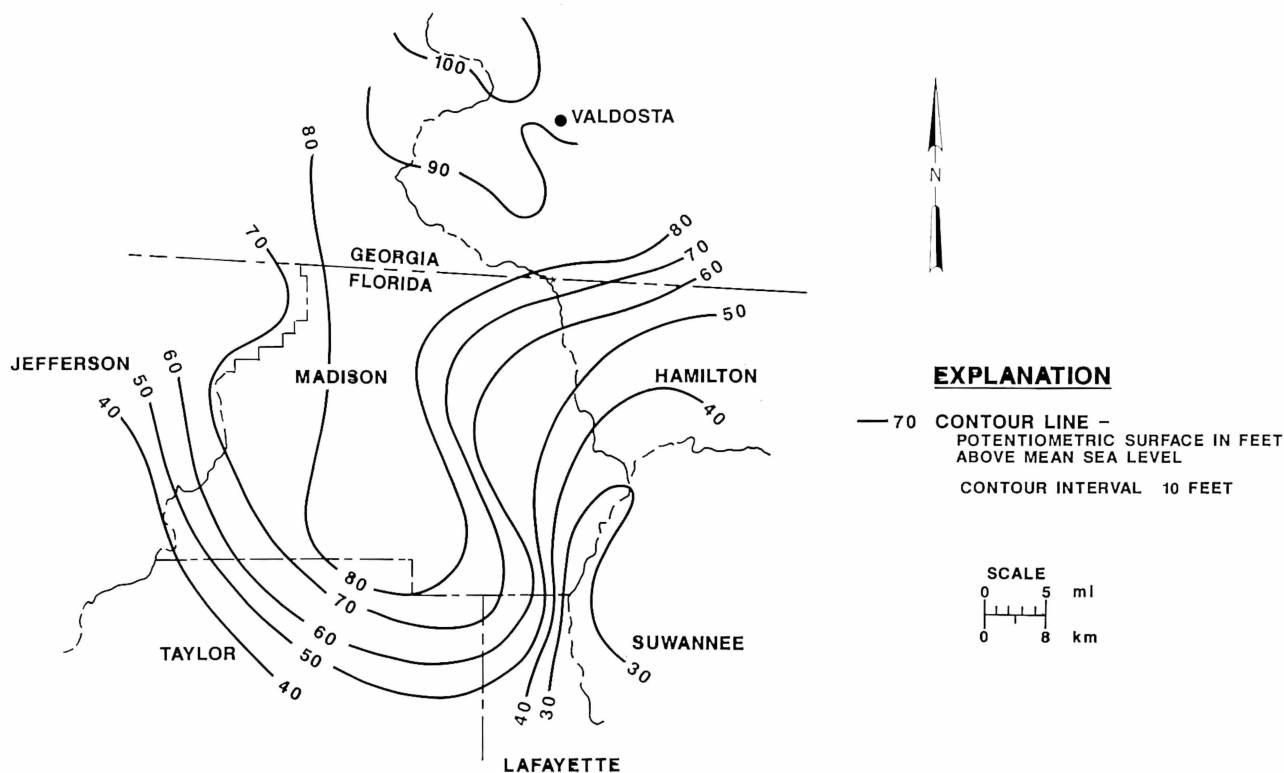


Figure 33. Potentiometric surface of the principal artesian - Floridan aquifer system in south-central Georgia and north-central Florida (data from SRWMD).

completed into the upper 100 feet of the Floridan aquifer system. Ground water from this upper zone is generally of good quality and is within the limits recommended by the United States Environmental Protection Agency for drinking water standards. In Madison County, the major dissolved constituents are calcium and bicarbonate, which are typically characterized by high values for specific conductance, calcium, alkalinity, magnesium, pH and sulfate. These high values are due to the dissolution of limestone by ground water. The concentrations up to the point of saturation for the above parameters, increase proportionally with the length of time that ground water is in contact with sediments or rocks. Comparatively, artesian water from the Floridan aquifer system displays higher concentrations than the non-artesian Floridan aquifer system. The exception is calcium. Higher values of calcium in non-artesian ground waters are related to more rapid percolation downward of acidic rainwaters, contributing to more rapid dissolution of the limestone (Ceryak et al., 1983). A higher nitrate value relates to the downward leaching of man-induced nitrates through the permeable sediments overlying the unconfined aquifer.

Excessive iron, tannic acid, and unpleasant taste and odor caused by various iron-and sulfur-reducing bacteria are the major causes of ground-water complaints within the study area. Iron, which is an abundant mineral in the earth's crust, is found in most water. The presence of iron in water is objectionable because of its taste, staining capacity and encrusting property. The source of iron in the Floridan aquifer system is surface water that recharges the aquifer. Iron is introduced into the Floridan aquifer system through the numerous sinkholes, lakes and adjacent rivers.

Tannic acid imparts an undesirable brown color to ground water. This discoloration is the result of natural organic processes that occur when the surface water of rivers, ponds, and swamps come into contact with organic debris. Although tannic acid is not a health hazard, it is aesthetically undesirable. Like iron, tannic acid enters ground water through recharge of the aquifer by surface water.

Iron and sulfur-reducing bacteria are a common

problem in Madison County. However, they are considered a nuisance problem and not a health hazard. These bacteria thrive on the dissolved iron and sulfate in ground water. Sulfur-reducing bacteria utilize sulfates and sulfide and transform them into hydrogen sulfide. Hydrogen sulfide, which imparts an offensive "rotten egg" odor to the ground water, is very corrosive. Iron-reducing bacteria produce acids that cause blocking or corrosion of pipes. They also impart an unpleasant taste and discoloration to the water. Iron and sulfur-reducing bacteria are introduced into the Floridan aquifer system in the same manner as iron and tannic acid. In addition, they can be introduced by contaminated well drilling and pumping equipment. Iron and sulfur-reducing bacteria are virtually impossible to eliminate once they have been introduced into a well.

SUMMARY

Private and public potable water supplies in Madison County are obtained entirely from ground-water sources. There are three aquifer systems present - a surficial, an intermediate, and the Floridan aquifer system, which can be differentiated by water chemistry, stratigraphic position, lithology, and hydraulic heads.

The Floridan aquifer system is the principal water-bearing unit in Madison County. It includes all of the Middle Eocene to Oligocene age sediments and part of the Lower Miocene carbonates. This system exists under unconfined, semi-confined, and confined conditions. Hawthorn Group clays form the overlying unit in areas where the Floridan aquifer system exists under confined conditions.

The intermediate aquifer system is present in northern Madison County. This artesian aquifer system occurs within discontinuous units of both the Miccosukee Formation and Hawthorn Group. To date, minimal data are available on the water-bearing properties of this system. Clays within the Miccosukee Formation or the Hawthorn Group act as confining units.

The surficial aquifer system occurs within the undifferentiated sands and clays overlying the Miccosukee Formation or the Hawthorn Group clays. Ground-water levels within the surficial aquifer system are at or within a few feet of land surface and respond directly to precipitation and evapotranspiration. Ground water in the surficial aquifer system has high sodium, chloride, potassium, and nitrate values.

Ground-water fluctuations within the unconfined Floridan aquifer system respond rapidly to precipitation. Over 20 feet of fluctuation has been recorded in these areas. The response time is

slower and the total fluctuation is less in areas where the Floridan aquifer system is confined or semi-confined.

Ground-water quality in the surficial aquifer system and in the unconfined portions of the Floridan aquifer system is highly susceptible to degradation from various land uses, storage, and waste disposal practices. Where the Floridan aquifer system is confined or semi-confined, degradation of the water quality in the overlying surficial aquifer system can subsequently diminish the ground-water quality of the Floridan aquifer system via the numerous hydrologic connections.

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APPENDIX I

SELECTED CORE DESCRIPTIONS

W-15515

W-15537

Florida Geological Survey

LITHOLOGIC WELL LOG PRINTOUT

SOURCE - FGS

WELL NUMBER: W- 15515

COUNTY - MADISON

TOTAL DEPTH: 00287 FT.

LOCATION: T.02N R.08E S.05 C

SAMPLES - NONE

LAT = N 30D 36M 18

LON = W 83D 33M 10

COMPLETION DATE - 02/22/84

ELEVATION - 160 FT

OTHER TYPES OF LOGS AVAILABLE - NONE

OWNER/DRILLER: HOWARD (JUSTIN HODGES)

WORKED BY: RON HOENSTINE, FEB, 1984, CRYSTAL RIVER FM SHOWS ATYPICAL DOLOMITIZATION

0.0- 5.0 UNDIFFERENTIATED SAND AND CLAY
5.0- 49.0 MICCOSUKEE FM.
49.0- 72.0 HAWTHORN GROUP
72.0- 299.0 SUWANNEE LIMESTONE
299.0- 315.0 OCALA GROUP

0 - 0.1 NO SAMPLES

0.1- 1 SAND; GRAYISH ORANGE; 25% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ROUNDED; MEDIUM SPHERICITY; UNCONSOLIDATED;
ACCESSORY MINERALS: HEAVY MINERALS-01%, PHOSPHATIC SAND-01%, CLAY-02%;
OTHER FEATURES: PARTINGS;
UNIFORM IN APPEARANCE

1 - 5 SAND; MODERATE YELLOWISH BROWN; 26% POROSITY, INTERCRYSTALLINE, INTERGRANULAR;
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM;
ROUNDNESS: SUB-ANGULAR TO ROUNDED; MEDIUM SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: HEAVY MINERALS-01%, CLAY-03%;
OTHER FEATURES: PARTINGS;

5 - 6.5 SAND; LIGHT BROWN; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN SIZE: FINE; RANGE: FINE TO COARSE;
ROUNDNESS: SUB-ANGULAR TO ROUNDED; MEDIUM SPHERICITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: SILT-15%, CLAY-05%, IRON STAIN-01%;
FOSSILS: NO FOSSILS;

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- 6.5- 8 SAND; MODERATE REDDISH BROWN TO GREENISH GRAY; 18% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ROUNDED; MEDIUM SPHERICITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: STREAKED, MOTTLED,
ACCESSORY MINERALS: SILT-10%, CLAY-25%, IRON STAIN-01%;
IRREGULAR CLAY LENSES INTERBEDDED WITH SAND AND SILT
- 8 - 11.5 SAND; LIGHT BROWN TO VERY LIGHT GRAY; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; MEDIUM SPHERICITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-05%, IRON STAIN-01%;
OTHER FEATURES: PARTINGS;
- 11.5- 17 CLAY; LIGHT OLIVE GRAY; 12% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: IRON STAIN-01%, QUARTZ SAND-03%, PHOSPHATIC SAND-01%;
- 17 - 17.3 SAND; DARK YELLOWISH ORANGE; 17% POROSITY, INTERCRYSTALLINE, INTERGRANULAR;
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM;
ROUNDNESS: SUB-ANGULAR TO ROUNDED; MEDIUM SPHERICITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-05%, SILT-10%, PHOSPHATIC SAND-01%;
OTHER FEATURES: PARTINGS;
- 17.3- 18.5 CLAY; YELLOWISH GRAY TO LIGHT BROWN; 13% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE,
INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: SILT-10%, PHOSPHATIC SAND-01%;
DISTINCT LITHOLOGIC BREAK
- 18.5- 20 SAND; VERY LIGHT GRAY TO WHITE; 22% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; MEDIUM SPHERICITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: PHOSPHATIC SAND-01%, IRON STAIN-01%, CLAY-03%, SILT-05%;

Florida Geological Survey

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- 20 - 20.9 SILT; LIGHT OLIVE GRAY TO DARK YELLOWISH ORANGE; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-03%, QUARTZ SAND-08%, IRON STAIN-01%, PHOSPHATIC SAND-02%;
OTHER FEATURES: PARTINGS;
MOTTLING AND IRREGULAR STREAKING PRESENT
- 20.9- 22.3 CLAY; LIGHT OLIVE GRAY TO LIGHT BROWN; 11% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, LOW PERMEABILITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: SILT-10%, IRON STAIN-01%, PHOSPHATIC SAND-01%, QUARTZ SAND-01%;
- 22.3- 23.5 SILT; DARK YELLOWISH ORANGE TO GRAYISH ORANGE; 17% POROSITY, INTERCRYSTALLINE, INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-01%, PHOSPHATIC SAND-01%;
- 23.5- 25.5 SILT; YELLOWISH GRAY; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-10%, PHOSPHATIC SAND-01%, QUARTZ SAND-15%;
OTHER FEATURES: PARTINGS;
ISOLATED PATCHES OF ORGANICS
- 25.5- 28.5 CLAY; GRAYISH GREEN; 11% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MASSIVE,
ACCESSORY MINERALS: PHOSPHATIC SAND-01%;
OTHER FEATURES: PARTINGS;
TYPICAL GRAYISH GREEN HAWTHORN CLAY, ORGANICS PRESENT
- 28.5- 33 NO SAMPLES
- 33 - 37 CLAY; LIGHT GRAYISH GREEN TO WHITE; 11% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED, STREAKED,
ACCESSORY MINERALS: PYRITE-01%, IRON STAIN-01%;
ORGANIC INCLUSIONS
- 37 - 40 CLAY; WHITE TO LIGHT OLIVE; 12% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
PREDOMINANTLY KAOLIN

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- 40 - 42 CLAY; GRAYISH ORANGE TO VERY LIGHT ORANGE; 11% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
- 42 - 42.5 CLAY; VERY LIGHT ORANGE TO YELLOWISH GRAY; 11% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MASSIVE,
ACCESSORY MINERALS: QUARTZ SAND-01%, PHOSPHATIC SAND-01%;
- 42.5- 44.3 CLAY; WHITE; 13% POROSITY, INTERCRYSTALLINE, INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: PHOSPHATIC SAND-01%;
FOSSILS: PLANT REMAINS;
- 44.3- 46 CLAY; LIGHT OLIVE GRAY; 12% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
MASSIVE OLIVE CLAY WITH KAOLIN AND PEAT INCLUSIONS
- 46 - 49 CLAY; GRAYISH BROWN TO LIGHT OLIVE GRAY; 11% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: PHOSPHATIC SAND-03%, QUARTZ SAND-01%;
OTHER FEATURES: CALCAREOUS;
- 49 - 50 CLAY; WHITE; 14% POROSITY, INTERCRYSTALLINE, INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: PHOSPHATIC SAND-01%, IRON STAIN-01%, QUARTZ SAND-01%;
OTHER FEATURES: CALCAREOUS;
- 50 - 54 SILT; GRAYISH ORANGE; 17% POROSITY, INTERGRANULAR, INTERCRYSTALLINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-05%, CLAY-10%, PHOSPHATIC SAND-03%;
LEACHED PHOSPHATE PRESENT
- 54 - 54.5 CALCILUTITE; WHITE; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC;
ACCESSORY MINERALS: QUARTZ SAND-01%, PHOSPHATIC SAND-01%, CLAY-05%;
FAIRLY UNIFORM TEXTURE
- 54.5- 61 CLAY; LIGHT OLIVE; 10% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MASSIVE,
OTHER FEATURES: CALCAREOUS;

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- 61 - 62.5 CALCILUTITE; VERY LIGHT ORANGE TO LIGHT OLIVE; 20% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-01%, CLAY-10%;
DOMINANTLY MICRITE WITH GREEN OLIVE CLAY INCLUSIONS

- 62.5- 71 CHERT; WHITE TO LIGHT GRAY; 07% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE; GOOD INDURATION;
CEMENT TYPE(S): SILICIC CEMENT;
ACCESSORY MINERALS: CALCILUTITE-05%;
CHERT NODULES WITH MICRITE COATING

- 71 - 72 CALCILUTITE; WHITE; 21% POROSITY, PIN POINT VUGS, INTERGRANULAR, INTERCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-03%, PHOSPHATIC SAND-01%, CLAY-05%;

- 72 - 72.5 LIMESTONE; WHITE TO VERY LIGHT ORANGE; 18% POROSITY,
GRAIN TYPE: CALCILUTITE; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX;
ACCESSORY MINERALS: CLAY-08%, CHERT-02%;

- 72.5- 77 LIMESTONE; WHITE; 22% POROSITY, PIN POINT VUGS, VUGULAR, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-01%, PHOSPHATIC SAND-01%;
OTHER FEATURES: CHALKY;

- 77 - 82 CALCARENITE; WHITE; 25% POROSITY, MOLDIC, INTERGRANULAR, VUGULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 90% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: COARSE; RANGE: MEDIUM TO VERY COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: PYRITE-01%, QUARTZ SAND-01%;
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS;

- 82 - 87 LIMESTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY; 20% POROSITY, PIN POINT VUGS, INTERCRYSTALLINE, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: GRANULE; RANGE: GRANULE TO GRAVEL; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX;
ACCESSORY MINERALS: CLAY-10%;
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS;

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- 87 - 92 LIMESTONE; WHITE; 19% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN TYPE: CALCILUTITE; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: LITHOGRAPHIC; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-01%;
OTHER FEATURES: SUCROSIC;

- 92 - 92.5 LIMESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE PINK; 1 % POROSITY, INTERCRYSTALLINE,
PIN POINT VUGS;
GRAIN TYPE: CALCILUTITE, CRYSTALS; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: CLAY-03%;
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS, FOSSIL MOLDS;

- 92.5- 97 CALCARENITE; VERY LIGHT ORANGE; 22% POROSITY, PIN POINT VUGS, INTERGRANULAR, MOLDIC;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM;
ACCESSORY MINERALS: CLAY-02%;
FOSSILS: BENTHIC FORAMINIFERA, MOLLUSKS, FOSSIL FRAGMENTS, FOSSIL MOLDS;

- 97 - 103 NO SAMPLES

- 103 - 106 CALCARENITE; VERY LIGHT ORANGE; 24% POROSITY, PIN POINT VUGS, VUGULAR, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 90% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX;
ACCESSORY MINERALS: CLAY-15%;
FOSSILS: BENTHIC FORAMINIFERA, CONES, MOLLUSKS, FOSSIL FRAGMENTS, FOSSIL MOLDS;

- 106 - 107 CALCARENITE; VERY LIGHT ORANGE; 22% POROSITY, PIN POINT VUGS, INTERGRANULAR,
INTERCRYSTALLINE;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: PYRITE-01%;
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA, FOSSIL MOLDS;
UNIFORM TEXTURE

- 107 - 113 CALCARENITE; VERY LIGHT ORANGE; 26% POROSITY, VUGULAR, PIN POINT VUGS, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 90% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: CLAY-04%;
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA, FOSSIL MOLDS;
RECRYSTALLIZED COQUINA

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- 113 - 114 CALCILUTITE; VERY LIGHT ORANGE; 21% POROSITY, PIN POINT VUGS, INTERGRANULAR;
MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: FOSSIL MOLDS;

- 114 - 114.5 CHERT; PINKISH GRAY; 08% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE; GOOD INDURATION;
CEMENT TYPE(S): SILICIC CEMENT;
ACCESSORY MINERALS: CALCILUTITE-05%;

- 114.5- 115 AS ABOVE

- 115 - 116 LIMESTONE; VERY LIGHT ORANGE; 22% POROSITY, INTERCRYSTALLINE, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: LITHOGRAPHIC; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: SUCROSIC;
FOSSILS: FOSSIL MOLDS;

- 116 - 117 CALCARENITE; VERY LIGHT ORANGE; 26% POROSITY, PIN POINT VUGS, INTERGRANULAR, VUGULAR;
GRAIN TYPE: BIOGENIC, CALCILUTITE, CRYSTALS; 90% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: BENTHIC FORAMINIFERA, MOLLUSKS, FOSSIL FRAGMENTS, FOSSIL MOLDS, CONES;
COQUINA

- 117 - 118 CALCILUTITE; VERY LIGHT ORANGE; 22% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS, FOSSIL MOLDS;

- 118 - 141.5 CALCARENITE; VERY LIGHT ORANGE; 24% POROSITY, PIN POINT VUGS, INTERGRANULAR,
INTERCRYSTALLINE;
GRAIN TYPE: CRYSTALS, CALCILUTITE, BIOGENIC; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: SUCROSIC;
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS, FOSSIL MOLDS;
RECRYSTALIZED

- 141.5- 150 CALCILUTITE; WHITE; 23% POROSITY, INTERCRYSTALLINE, INTERGRANULAR, PIN POINT VUGS;
MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-01%;
FOSSILS: FOSSIL MOLDS;
MICRITIC LIMESTONE DISPLAYING UNIFORM TEXTURE

- 150 - 160 AS ABOVE

- 160 - 170 AS ABOVE

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- 170 - 177 DOLOMITE; VERY LIGHT ORANGE; 09% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: CRYPTOCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: MICA-01%;
OTHER FEATURES: CALCAREOUS;
- 177 - 179 DOLOMITE; GRAYISH BROWN TO DARK YELLOWISH BROWN; 08% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: CRYPTOCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
HIGHLY INDURATED TIGHT DOLOMITE
- 179 - 182 CALCARENITE; VERY LIGHT ORANGE; 24% POROSITY, PIN POINT VUGS, VUGULAR, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL MOLDS, FOSSIL FRAGMENTS;
RECRYSTALLIZED LIMESTONE, UNIFORM TEXTURE
- 182 - 184.5 DOLOMITE; LIGHT OLIVE GRAY TO BROWNISH GRAY; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: CRYPTOCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: SPECKLED;
SILT INCLUSIONS PRESENT(193') INTERVAL
- 184.5- 196 DOLOMITE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN; 08% POROSITY, LOW PERMEABILITY, INTERGRANULAR, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: CALCITE-01%;
OTHER FEATURES: SPECKLED, SUCROSIC, CALCAREOUS;
FOSSILS: FOSSIL MOLDS, MOLLUSKS;
TIGHT IMPERMEABLE DOLOMITE
- 196 - 204 DOLOMITE; GRAYISH ORANGE; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: CLAY-01%;
OTHER FEATURES: SUCROSIC;
FINE UNIFORM TEXTURED TIGHT DOLOMITE

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- 204 - 205 DOLOMITE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN; 09% POROSITY, LOW PERMEABILITY, INTERGRANULAR, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: SUCROSIC, SPECKLED;
FOSSILS: FOSSIL MOLDS, MOLLUSKS;
- 205 - 206.5 DOLOMITE; GRAYISH ORANGE; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: CLAY-01%;
SIMILIAR TO THE (204') INTERVAL
- 206.5- 207 DOLOMITE; GRAYISH ORANGE; 10% POROSITY, LOW PERMEABILITY, INTERGRANULAR, INTERCRYSTALLINE;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: SUCROSIC;
- 207 - 209 DOLOMITE; LIGHT GRAYISH RED; 08% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, INTERGRANULAR; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: CRYPTOCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: CLAY-01%;
OTHER FEATURES: SUCROSIC;
FOSSILS: MOLLUSKS, FOSSIL MOLDS, FOSSIL FRAGMENTS;
BORINGS AND BURROWS PRESENT
- 209 - 219 NO SAMPLES
- 219 - 220 DOLOMITE; MODERATE GRAY TO LIGHT GRAY; 08% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: SUCROSIC;
FOSSILS: FOSSIL MOLDS, MOLLUSKS;
CLAY INCLUSIONS IN CAVITIES

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- 220 - 222 DOLOMITE; LIGHT GRAY TO YELLOWISH GRAY; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: CLAY-01%, QUARTZ SAND-01%, MICA-01%;
OTHER FEATURES: SUCROSIC;
FOSSILS: FOSSIL MOLDS, MOLLUSKS;
- 222 - 224 NO SAMPLES
- 224 - 225 NUMEROUS ALTERED MICROFOSSILS
- 225 - 226 AS ABOVE
- 226 - 227 DOLOMITE; LIGHT GRAY TO YELLOWISH GRAY; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: CALCAREOUS, SUCROSIC;
- 227 - 229 DOLOMITE; LIGHT GRAY; 11% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
FOSSILS: BENTHIC FORAMINIFERA, MOLLUSKS, FOSSIL MOLDS, FOSSIL FRAGMENTS;
- 229 - 243 DOLOMITE; GRAYISH BROWN; 10% POROSITY, LOW PERMEABILITY, PIN POINT VUGS;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: PHOSPHATIC SAND-01%;
OTHER FEATURES: SUCROSIC, SPECKLED;
FOSSILS: BENTHIC FORAMINIFERA, MOLLUSKS, FOSSIL MOLDS, FOSSIL FRAGMENTS;
NUMEROUS ALTERED MICROFOSSILS
- 243 - 250 DOLOMITE; YELLOWISH GRAY; 11% POROSITY, LOW PERMEABILITY, PIN POINT VUGS;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: SUCROSIC;
FOSSILS: MOLLUSKS;
- 250 - 251 DOLOMITE; YELLOWISH GRAY; 12% POROSITY, LOW PERMEABILITY, PIN POINT VUGS, VUGULAR; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: CALCAREOUS, SUCROSIC;
FOSSILS: FOSSIL MOLDS, MOLLUSKS, BENTHIC FORAMINIFERA;
HIGHLY ALTERED COQUINA DISPLAYING PROMINENT MOLDS

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- 251 - 260 AS ABOVE
- 260 - 267 CALCARENITE; YELLOWISH GRAY; 22% POROSITY, MOLDIC, INTERGRANULAR, PIN POINT VUGS;
GRAIN TYPE: CALCILUTITE, BIOGENIC, CRYSTALS; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: GRANULE; RANGE: COARSE TO GRANULE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT;
ACCESSORY MINERALS: DOLOMITE-15%;
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS, FOSSIL MOLDS, ALGAE;
RECRYSTALIZED COQUINA - PREDOMINANTLY BIVALVES
- 267 - 268 DOLOMITE; GRAYISH ORANGE; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: PHOSPHATIC SAND-01%, HEAVY MINERALS-01%;
OTHER FEATURES: SUCROSIC;
UNIFORM TEXTURE
- 268 - 270 DOLOMITE; YELLOWISH GRAY; 10% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: MICA-01%;
OTHER FEATURES: SUCROSIC;
FOSSILS: FOSSIL MOLDS, MOLLUSKS, FOSSIL MOLDS, FOSSIL FRAGMENTS;
DOLOMITIZED COQUINA
- 270 - 287.5 DOLOMITE; YELLOWISH GRAY; 09% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: CRYPTOCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
FOSSILS: MOLLUSKS;
LEPIDOCYCLINA SP PRESENT
- 287.5- 299 DOLOMITE; YELLOWISH GRAY; 08% POROSITY, LOW PERMEABILITY, INTERCRYSTALLINE;
50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
FOSSILS: FOSSIL MOLDS, FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA;
- 299 - 315 LIMESTONE; YELLOWISH GRAY; 19% POROSITY, INTERCRYSTALLINE, INTERGRANULAR;
GRAIN TYPE: CRYSTALS, CALCILUTITE; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT;
OTHER FEATURES: DOLOMITIC, SUCROSIC;
FOSSILS: FOSSIL MOLDS;
PROBABLE TOP OF OCALA
- 315 TOTAL DEPTH

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LITHOLOGIC WELL LOG PRINTOUT

SOURCE - FGS

WELL NUMBER: W- 15537

COUNTY - MADISON

TOTAL DEPTH: 322 FT.

LOCATION: T.02N R.09E S.05 B

SAMPLES - NONE

LAT = N 30D 36M 38

LON = W 83D 26M 28

COMPLETION DATE - 04/10/84

ELEVATION - 185 FT

OTHER TYPES OF LOGS AVAILABLE - ELECTRIC, GAMMA, NEUTRON

OWNER/DRILLER: BURNETT FBG CORE HOLE (JUSTIN HODGES)

WORKED BY: STEVEN M. SPENCER MAY 15, 1984 GOOD CORE SAMPLES

- 0.0- 3.0 UNDIFFERENTIATED SAND AND CLAY
3.0- 29.3 MICCOSUKEE FM.
29.3- 109.0 HAWTHORN GROUP
109.0- 129.0 ST. MARKS FM.
129.0- 293.2 SUWANNEE LIMESTONE
293.2- 322.0 OCALA GROUP
- 0 - 2 NO SAMPLES
- 2 - 3 SAND; YELLOWISH GRAY TO YELLOWISH GRAY; 30% POROSITY, INTERGRANULAR;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; MEDIUM SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-10%, SILT-01%, PLANT REMAINS-01%;
- 3 - 4 SAND; MODERATE ORANGE PINK TO VERY LIGHT ORANGE; 15% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; MEDIUM SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-15%, HEAVY MINERALS-01%, IRON STAIN-01%;
INTERVAL 3-4' IS TRANSITION FROM TOPSOIL INTO MICCOSUKEE FM.
- 4 - 11.7 SAND; GRAYISH ORANGE PINK TO MODERATE ORANGE PINK; 15% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM;
ROUNDNESS: ANGULAR TO SUB-ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-15%, IRON STAIN-01%, HEAVY MINERALS-01%;
DISTINCT PURPLES AND PINK COLORS. THIN CLAY LAMINAE COMMON. GRADES ABRUPTLY INTO COARSER CLAYEY SANDS.

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- 11.7- 13.7 SAND; LIGHT YELLOWISH ORANGE TO DARK YELLOWISH ORANGE; 18% POROSITY, INTERGRANULAR;
GRAIN SIZE: COARSE; RANGE: MEDIUM TO COARSE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; MEDIUM SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-10%, HEAVY MINERALS-01%;
- 13.7- 15 SAND; GRAYISH ORANGE TO DARK GRAYISH RED; 15% POROSITY, INTERGRANULAR;
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM;
ROUNDNESS: ANGULAR TO SUB-ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-10%, HEAVY MINERALS-01%, IRON STAIN-01%;
CLAY LAMINAE COMMON.
- 15 - 16 SAND; LIGHT YELLOWISH ORANGE TO DARK YELLOWISH ORANGE; 18% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO FINE;
ROUNDNESS: ANGULAR TO SUB-ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: CLAY-10%;
CLAY LAMINAE COMMON. BECOMES UNCONSOLIDATED AT BOTTOM.
- 16 - 17.5 SAND; VERY LIGHT ORANGE TO LIGHT YELLOWISH ORANGE; 20% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; LOW SPHERICITY; UNCONSOLIDATED;
ACCESSORY MINERALS: CLAY-03%, HEAVY MINERALS-01%;
CLAY LENSES ARE FEW.
- 17.5- 19.2 SAND; VERY LIGHT ORANGE TO LIGHT YELLOWISH ORANGE; 20% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-07%, HEAVY MINERALS-01%;
GRADATIONALLY BECOMING MORE CLAYEY AND DARKER AT BOTTOM.
- 19.2- 19.9 CLAY BLEBS COMMON.
- 19.9- 21 CLAY; LIGHT YELLOWISH ORANGE TO MODERATE BROWN; LOW PERMEABILITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: LAMINATED, BEDDED, INTERBEDDED,
ACCESSORY MINERALS: QUARTZ SAND-25%, LIMONITE-05%, IRON STAIN-01%;
INTERBEDDED SAND AND LIMONITIC SAND COARSE TO FINE SIZE.

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- 21 - 28.7 SAND; DARK YELLOWISH ORANGE TO LIGHT YELLOWISH ORANGE; 15% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-07%, HEAVY MINERALS-01%;
SAND INTERBEDDED WITH CLAY LENSES AT 27.5' CLAY CONTENT INCREASING TOWARD BOTTOM.
- 28.7- 29.3 CLAY; GRAYISH ORANGE TO LIGHT YELLOWISH ORANGE; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-35%, HEAVY MINERALS-03%, MICA-01%;
- 29.3- 29.9 SAND LENSES COMMON WITH HEAVY MINERALS WITHIN.
- 29.9- 31.5 SAND; GRAYISH YELLOW TO DARK YELLOWISH ORANGE; 10% POROSITY, INTERGRANULAR;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: INTERBEDDED,
ACCESSORY MINERALS: CLAY-20%, HEAVY MINERALS-03%, MICA-01%;
CLAY LENS AT 29.5 & 30.5, SAND BECOMES BETTER CEMENTED BELOW 30.5'
- 31.5- 34 CLAY; LIGHT YELLOWISH ORANGE TO DARK YELLOWISH ORANGE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED, LAMINATED,
ACCESSORY MINERALS: QUARTZ SAND-35%, PHOSPHATIC SAND-03%, MICA-01%, HEAVY MINERALS-01%;
VERY SANDY IRON STAINED CLAY BECOMING MASSIVE AT 34', PHOSPHATE. GRAINS (MEDIUM TO FINE)
BLEACHED WHITE, TRACE TO 2 OR 3%, BEGINNING AT 32.5'. KAOLINITE BLEBS THROUGHOUT.
- 34 - 36.5 CLAY; GRAYISH YELLOW TO LIGHT GRAYISH GREEN; LOW PERMEABILITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MASSIVE,
ACCESSORY MINERALS: PHOSPHATIC SAND-03%, QUARTZ SAND-03%, IRON STAIN-01%, MICA-01%;
WAXY GRAY IRON STAINED CLAY WITH BLEACHED, FINE SIZE PHOSPHORITE SAND CONTENT INCREASES
AT 36.5'
- 36.5- 47 CLAY; VERY LIGHT ORANGE TO LIGHT YELLOWISH ORANGE; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-40%, PHOSPHATIC SAND-04%, HEAVY MINERALS-01%,
IRON STAIN-01%;
VERY SANDY WITH TRACE MICAS. GRADES INTO GRAYISH MASSIVE CLAY AT ABOUT 47'. 46.5-47.5
BLEACHED PHOSPHORITE PEBBLES IN UNCONSOLIDATED SAND AND CLAY.
- 47 - 49.2 CLAY; LIGHT GRAYISH GREEN TO LIGHT GREENISH YELLOW; LOW PERMEABILITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC SAND-03%, MICA-01%, IRON STAIN-01%;
BLEACHED PHOSPHORITE THROUGHOUT, VERY FINE SIZE. ABRUPT LITHO CHANGE AT 49.2' FROM WAXY
CLAY TO CLAYEY SAND. TRACE HEAVIES.

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- 49.2- 55.7 SAND; VERY LIGHT ORANGE TO GRAYISH YELLOW; 15% POROSITY, INTERGRANULAR;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-20%, PHOSPHATIC SAND-04%, IRON STAIN-01%, MICA-01%;
THIN CLAY LENSES COMMON. GRADES INTO A MASSIVE CLAY. 2 INCHES THICK, MEDIUM TO COARSE SIZE
PHOSPHORITE SEAM AT 53.2'. TRACE HEAVIES.
- 55.7- 58 CLAY; LIGHT OLIVE GRAY TO VERY LIGHT ORANGE; LOW PERMEABILITY; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MOTTLED,
ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC SAND-04%;
GRADES INTO FINE SAND BELOW. WAXEY.
- 58 - 58.7 SAND; VERY LIGHT ORANGE TO GRAYISH YELLOW; 15% POROSITY, INTERGRANULAR;
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: SUB-ANGULAR TO ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-10%, PHOSPHATIC SAND-04%, HEAVY MINERALS-01%;
- 58.7- 59.7 CLAY; LIGHT OLIVE GRAY TO LIGHT OLIVE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
SEDIMENTARY STRUCTURES: MASSIVE,
ACCESSORY MINERALS: PHOSPHATIC SAND-05%, QUARTZ SAND-04%, HEAVY MINERALS-01%;
WAXEY CLAY WITH BLEACHED PHOSPHORITE THROUGHOUT.
- 59.7- 60.7 SAND; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY; 07% POROSITY, INTERGRANULAR;
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE;
ROUNDNESS: ANGULAR TO SUB-ANGULAR; LOW SPHERICITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: CLAY-12%, HEAVY MINERALS-01%, PHOSPHATIC SAND-01%;
- 60.7- 64 CLAY; WHITE TO VERY LIGHT ORANGE; LOW PERMEABILITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-15%, HEAVY MINERALS-01%;
DARK MATERIAL THROUGHOUT TRACE AMOUNTS.
- 64 - 79 CLAY; WHITE TO YELLOWISH GRAY; LOW PERMEABILITY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
ACCESSORY MINERALS: QUARTZ SAND-15%, HEAVY MINERALS-01%;
CLAY INDURATION IS POOR TO UNCONSOLIDATED. SOME OF CORE MATERIAL LOST DURING DRILLING DUE
TO NATURE OF CLAY. UNCONSOLIDATED.
- 79 - 90.5 CLAY; WHITE TO VERY LIGHT ORANGE; GOOD INDURATION;
CEMENT TYPE(S): CLAY MATRIX, SILICIC CEMENT;
ACCESSORY MINERALS: QUARTZ SAND-05%, HEAVY MINERALS-01%, PHOSPHATIC SAND-01%;
PO4 INDICATES DEFINITE PHOSPHATE CONTENT IN ROCK. CAVITY AT 84' -84.5, CAVITY FILLING
MATERIAL i.e.,SAND AND CLAY,FROM 83-84.5 AND 88-89. ABRUPT TRANSITION AT 90.5 INTO CLAY
CLAST ZONE.

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- 90.5- 104 CLAY; LIGHT GREENISH GRAY TO YELLOWISH GRAY; INTERGRANULAR; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX;
CLASTS OF HARD CLAY AS FLOAT IN CLAY MATRIX. PO4 INDICATES PHOSPHATE IN OR ON WAXEY CLASTS
AND IN MATRIX MATERIAL.
- 104 - 109 CLAY; LIGHT GREENISH GRAY TO YELLOWISH GRAY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX;
ACCESSORY MINERALS: DOLOMITE-%;
FEW DOLOMITE NODULES. ABRUPT TRANSITION INTO INDURATED ZONE BELOW
- 109 - 111 DOLOMITE; YELLOWISH GRAY TO VERY LIGHT ORANGE; INTERGRANULAR,
INTERCRYSTALLINE; 10-50% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; MODERATE INDURATION;
CEMENT TYPE(S): CLAY MATRIX, DOLOMITE CEMENT;
ACCESSORY MINERALS: CLAY-07%, QUARTZ SAND-05%;
QUARTZ SAND IN THE DOLOMITE. CLAY CONTENT DECREASING AT BOTTOM. TRACE ORGANICS.
- 111 - 115 LIMESTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY; 05% POROSITY, INTERGRANULAR,
INTERCRYSTALLINE;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC;
MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX;
ACCESSORY MINERALS: DOLOMITE-10%, QUARTZ SAND-05%, CLAY-05%;
FOSSILS: FOSSIL FRAGMENTS;
- 115 - 115.5 DOLOMITE,CLAY AND QUARTZ SAND CONTENT VARIABLE AND DECREASING WITH DEPTH.
LOST CIRCULATION AT 115'.
- 115.5- 120 LIMESTONE; VERY LIGHT ORANGE TO WHITE; 05% POROSITY, INTERGRANULAR, INTERCRYSTALLINE,
MOLDIC;
GRAIN TYPE: CALCILUTITE, BIOGENIC, CRYSTALS;
GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
ACCESSORY MINERALS: QUARTZ SAND-03%;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS;
- 120 - 126 LIMESTONE; VERY LIGHT ORANGE TO WHITE; 08% POROSITY, INTERGRANULAR, INTERCRYSTALLINE,
MOLDIC;
GRAIN TYPE: CALCILUTITE, BIOGENIC, CRYSTALS;
GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT, DOLOMITE CEMENT;
ACCESSORY MINERALS: DOLOMITE-25%, QUARTZ SAND-02%;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS;
CAVITY 122-123. COMPOSITION VARIABLE CALCILUTITE TO CALCARINITE. GRADING INTO MORE
BIOGENIC AND DOLOMITIC MATERIAL.

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- 126 - 129 LIMESTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY; 08% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC;
GRAIN TYPE: CALCILUTITE, BIOGENIC, CRYSTALS;
GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT;
ACCESSORY MINERALS: DOLOMITE-30%, QUARTZ SAND-02%;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS;
CAVITY AT 126-129. BIOGENIC MATERIAL IN CRACKS. MINOR OR TRACE QUARTZ SAND EMBEDDED IN LIMESTONE.
- 129 - 139 CALCARENITE; VERY LIGHT ORANGE; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN TYPE: SKELETAL, BIOGENIC, CRYSTALS; 95% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
ACCESSORY MINERALS: QUARTZ SAND-01%, IRON STAIN-01%;
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS, MILIOLIDS, CONES;
WACKESTONE TO GRAINSTONE.
- 139 - 141 CALCARENITE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN; 10% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SILICIC CEMENT;
ACCESSORY MINERALS: CHERT-30%, IRON STAIN-01%;
WACKESTONE TO GRIANSTONE. 2-4 INCH CHERT LENSES PRESENT.
- 141 - 146 CALCARENITE; VERY LIGHT ORANGE TO WHITE; 16% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN TYPE: SKELETAL, BIOGENIC, CRYSTALS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS, FOSSIL FRAGMENTS;
ALLOCHEMS BECOME SMALLER IN SIZE.
- 146 - 154 CALCARENITE; VERY LIGHT ORANGE; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN TYPE: SKELETAL, BIOGENIC, CRYSTALS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS, FOSSIL FRAGMENTS;
GRADES FROM FINER GRAIN TO COARSE THEN GRADING TO FINER AT BASE.
- 154 - 160 CALCILUTITE; WHITE TO VERY LIGHT ORANGE; 05% POROSITY, INTERGRANULAR, LOW PERMEABILITY, INTERCRYSTALLINE;
GRAIN TYPE: CALCILUTITE, BIOGENIC, CRYSTALS;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: CHALKY;
FOSSILS: FOSSIL FRAGMENTS;
VERY TIGHT, GRADING INTO RECRYSTALLIZED LIMESTONE. 3' CAVITY AT 16

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- 160 - 170 LIMESTONE; WHITE TO VERY LIGHT ORANGE; 10% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, PIN POINT VUGS;
GRAIN TYPE: SKELETAL, BIOGENIC, CRYSTALS;
GOOD INDURATION;
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX;
OTHER FEATURES: HIGH RECRYSTALLIZATION;
FOSSILS: FOSSIL FRAGMENTS, MILIOLIDS;
ALLOCHEMS IN SPAR AS FLOAT. BIOGENIC INFILLING IN SOME VOIDS, GRADATIONAL INTO CALCILUTITE.
- 170 - 171 CALCILUTITE; VERY LIGHT ORANGE TO WHITE; 12% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, PIN POINT VUGS;
GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC;
GRAIN SIZE: MICROCRYSTALLINE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
FOSSILS: SPICULES, FOSSIL MOLDS, MOLLUSKS;
- 171 - 171.7 LIMESTONE; VERY LIGHT ORANGE TO WHITE; 10% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN TYPE: SKELETAL, CALCILUTITE;
RANGE: MICROCRYSTALLINE TO COARSE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
ACCESSORY MINERALS: IRON STAIN-01%;
COMPOSITION VARIABLE, GRADES FROM HIGHLY RECRYSTALLIZED TO SKELETAL CALCARENITE.
- 171.7- 180 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC;
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE; 90% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
FOSSILS: BENTHIC FORAMINIFERA, CONES, MOLLUSKS, FOSSIL FRAGMENTS, FOSSIL MOLDS;
PREDOMINANTLY PACKSTONE TO GRAINSTONE. SMALL ZONES OF TIGHT, RECRYSTALLIZED LIMESTONE THROUGHOUT. GOOD PERMEABILITY.
- 180 - 190 AS ABOVE
- 190 - 200 AS ABOVE
- 200 - 208.3 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 18% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC;
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
SLIGHTLY FINER GRAINED AND BETTER INDURATED. TRANSITION SHARP AT BASE TO A MICRITE.

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- 208.3- 210 CALCILUTITE; WHITE; INTERGRANULAR, LOW PERMEABILITY;
GRAIN TYPE: CALCILUTITE;
POOR INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
ACCESSORY MINERALS: CLAY-05%;
OTHER FEATURES: CHALKY, PLASTIC;
SOFT AND PLASTIC WHEN FRESH (WET). CLAY BLEBS.
- 210 - 213 LIMESTONE; WHITE TO VERY LIGHT ORANGE; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC;
GRAIN TYPE: BIOGENIC, SKELETAL, CRYSTALS; 40% ALLOCHEMICAL CONSTITUENTS;
GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
- 213 - 217 CALCARENITE; WHITE; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, MOLDIC;
GRAIN TYPE: SKELETAL, BIOGENIC, CALCILUTITE; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
- 217 - 225 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 17% POROSITY, INTERGRANULAR, PIN POINT VUGS;
GRAIN TYPE: BIOGENIC, CALCILUTITE; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: FINE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
PELLOIDAL TEXTURES COMMON.
- 225 - 233 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 18% POROSITY, INTERGRANULAR, INTERCRYSTALLINE;
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE; 80% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO VERY COARSE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
PELLOIDAL TEXTURE THROUGHOUT. TRANSITIONAL INTO CALCIRUDITE.
- 233 - 236 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 22% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, PIN POINT VUGS;
95% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: COARSE; RANGE: FINE TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
VERY COARSE CALCIRUDITE TEXTURE BECOMING FINER GRAINED AT BOTTOM, PELLOIDAL STRUCTURES COMMON.
- 236 - 240 CALCARENITE; WHITE; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, PIN POINT VUGS;
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; MODERATE INDURATION;
SIMILAR TO ABOVE SAMPLES.

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- 240 - 242 LIMESTONE; LIGHT GRAY TO YELLOWISH GRAY; 08% POROSITY, INTERCRYSTALLINE, PIN POINT VUGS;
GRAIN TYPE: SKELETAL, BIOGENIC;
GRAIN SIZE: COARSE; RANGE: MEDIUM TO COARSE; GOOD INDURATION;
CEMENT TYPE(S): SILICIC CEMENT;
ACCESSORY MINERALS: CHERT-35%;
SILICA ENRICHED LIMESTONE. SILICA CEMENT VARIES 20-80% i.e. CHERTY LIMESTONE. LITHO TYPE
ENDS AT CAVITY 242'.
- 242 - 247 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 20% POROSITY, INTERGRANULAR, VUGULAR;
GRAIN TYPE: SKELETAL, BIOGENIC, CALCILUTITE; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
GRAINSTONE TO PACKSTONE
- 247 - 251 LIMESTONE; MODERATE BROWN TO WHITE; 12% POROSITY, INTERGRANULAR, INTERCRYSTALLINE,
PIN POINT VUGS;
GRAIN TYPE: SKELETAL, BIOGENIC, CRYSTALS;
GOOD INDURATION;
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
RECRYSTALLIZATION VARIABLE LOW TO HIGH.
- 251 - 256.8 CALCARENITE; VERY LIGHT ORANGE TO WHITE; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE,
VUGULAR;
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE; 90% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: COARSE; RANGE: FINE TO GRANULE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: LOW RECRYSTALLIZATION;
FOSSILIFEROUS WITH LARGE VUGS. RARE TURRITELLA, MOLLUSKS COMMON.
- 256.8- 260 CALCARENITE; VERY LIGHT ORANGE TO WHITE; 12% POROSITY, INTERGRANULAR, INTERCRYSTALLINE,
PIN POINT VUGS;
GRAIN TYPE: BIOGENIC, CRYSTALS, SKELETAL;
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
- 260 - 261 CALCILUTITE; WHITE; 10% POROSITY, INTERGRANULAR;
GRAIN TYPE: CALCILUTITE, SKELETAL; 10% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: CHALKY;
GRADES FROM CALCARENITE TO MICRITIC LIMESTONE. PLASTIC WHEN WET.
- 261 - 266 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE,
PIN POINT VUGS;
GRAIN TYPE: BIOGENIC, CALCILUTITE, CRYSTALS; 65% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;

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- 266 - 267 CALCILUTITE; WHITE TO VERY LIGHT ORANGE; 10% POROSITY, INTERGRANULAR, PIN POINT VUGS;
GRAIN TYPE: CALCILUTITE, BIOGENIC;
GRAIN SIZE: MICROCRYSTALLINE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: MEDIUM RECRYSTALLIZATION;
- 267 - 267.4 DOLOMITE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN; 07% POROSITY, INTERCRYSTALLINE,
INTERGRANULAR, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO VERY FINE; MODERATE INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: QUARTZ-02%;
OTHER FEATURES: HIGH RECRYSTALLIZATION;
DOLOMITIC SILT-INDURATED. QUARTZ FILLING SOME VUGS.
- 267.4- 270 DOLOMITE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN; 20% POROSITY, INTERCRYSTALLINE,
INTERGRANULAR, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: CALCITE-02%;
OTHER FEATURES: SUCROSIC, HIGH RECRYSTALLIZATION;
- 270 - 271.3 DOLOMITE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE; 17% POROSITY, INTERCRYSTALLINE,
INTERGRANULAR, PIN POINT VUGS; 10-50% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT;
ACCESSORY MINERALS: SPAR-05%, CALCITE-03%;
OTHER FEATURES: SUCROSIC;
NUMEROUS FINE FRACTURES HEALED WITH SPARY CALCITE. DOLOSILT AT BOTTOM BUT INDURATED.
- 271.3- 272.6 DOLOMITE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE; 15% POROSITY, INTERCRYSTALLINE,
INTERGRANULAR, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
OTHER FEATURES: SUCROSIC, HIGH RECRYSTALLIZATION;
VERY SUCROSIC AND WELL INDURATED.
- 272.6- 273.1 DOLOMITE; GRAYISH ORANGE TO LIGHT OLIVE GRAY; 13% POROSITY, INTERCRYSTALLINE,
INTERGRANULAR, PIN POINT VUGS; 10-50% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
SEDIMENTARY STRUCTURES: LAMINATED,
OTHER FEATURES: SUCROSIC, MEDIUM RECRYSTALLIZATION;

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- 273.1- 277 DOLOMITE; GRAYISH ORANGE TO MODERATE YELLOWISH BROWN; 20% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, VUGULAR; 10-50% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO VERY FINE; MODERATE INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
SEDIMENTARY STRUCTURES: LAMINATED,
ACCESSORY MINERALS: CALCITE-02%, PYRITE-01%;
OTHER FEATURES: SUCROSIC, MEDIUM RECRYSTALLIZATION;
TURRITELLIDS THROUGHOUT. INDURATION IS VARIABLE-POOR TO GOOD. BIOGENIC IN APPEARANCE.
- 277 - 278 DOLOMITE; VERY LIGHT ORANGE TO WHITE; 08% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, PIN POINT VUGS; 0-10% ALTERED; ANHEDRAL;
GRAIN SIZE: CRYPTOCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE;
MODERATE INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT, CLAY MATRIX;
ACCESSORY MINERALS: CALCITE-25%;
OTHER FEATURES: CHALKY;
TRANSITIONAL FROM DOLOMITE TO LIMESTONE. CALCILUTITIC AT BASE.
- 278 - 278.2 CLAY; GREENISH GRAY TO GREENISH GRAY; POOR INDURATION;
CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX;
ACCESSORY MINERALS: CALCITE-15%;
- 278.2- 282.3 CALCARENITE; WHITE; 12% POROSITY, INTERGRANULAR, PIN POINT VUGS;
GRAIN TYPE: CALCILUTITE, BIOGENIC; 65% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: LOW RECRYSTALLIZATION;
- 282.3- 286.5 DOLOMITE; GRAYISH BROWN TO YELLOWISH GRAY; 15% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, VUGULAR; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: MICROCRYSTALLINE; RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX;
ACCESSORY MINERALS: CALCITE-10%;
GRADATIONAL FROM 285-BASE AND 286.3-286.5 BEING VERY BIOGENIC WITH TURRITELLIDS AND POSSIBLE LEPIDOCYCLINA FRAGMENTS. RECRYSTALLIZATION VARIES HIGH UPHOLE TO LOW DOWNHOLE.
- 286.5- 293.2 CALCARENITE; WHITE; 22% POROSITY, INTERGRANULAR, INTERCRYSTALLINE, VUGULAR;
GRAIN TYPE: SKELETAL, BIOGENIC; 85% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: FINE TO VERY COARSE; GOOD INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT;
RARE TURRITELLIDS AND LEPIDOCYCLINA.
- 293.2- 301.2 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 30% POROSITY, INTERGRANULAR, MOLDIC, VUGULAR;
GRAIN TYPE: SKELETAL, BIOGENIC; 95% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL; POOR INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: COQUINA;
VERY FOSSILIFEROUS. LEPIDOCYCLINA, CONES AND NUMEROUS BRYOZOANS. RICH IN MOLLUSKS.

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- 301.2- 301.7 CALCARENITE; LIGHT GRAY TO VERY LIGHT ORANGE; 15% POROSITY, INTERGRANULAR, PIN POINT VUGS;
GRAIN TYPE: SKELETAL, BIOGENIC;
GRAIN SIZE: COARSE; RANGE: COARSE TO VERY COARSE; GOOD INDURATION;
CEMENT TYPE(S): SILICIC CEMENT;
ACCESSORY MINERALS: CHERT-35%;
LEPIDOCYCLINA AND OPERCULINOIDES COMMON. CHERTIFICATION HAS SET IN. DARK ORGANIC LIKE BLEBS COMMON.
- 301.7- 306 CALCARENITE; LIGHT GRAY TO VERY LIGHT ORANGE; 25% POROSITY, INTERGRANULAR, MOLDIC, VUGULAR;
GRAIN TYPE: SKELETAL, BIOGENIC; 95% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO VERY COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: COQUINA;
SIMILAR TO 293.2 TO 301.2.
- 306 - 317 CALCARENITE; LIGHT GRAY TO VERY LIGHT ORANGE; 18% POROSITY, INTERGRANULAR,
INTERCRYSTALLINE;
GRAIN TYPE: BIOGENIC, SKELETAL, CRYSTALS; 70% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
OTHER FEATURES: LOW RECRYSTALLIZATION;
VERY LITTLE SKELETAL DEBRIS AT TOP, BECOMES INCREASINGLY SKELETAL (i.e. LEPIDOCYCLINA AND OPERCULINOIDES) WITH DEPTH.
- 317 - 321 DOLOMITE; DARK YELLOWISH BROWN TO GRAYISH ORANGE; 15% POROSITY, INTERGRANULAR,
INTERCRYSTALLINE, PIN POINT VUGS; 50-90% ALTERED; SUBHEDRAL;
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION;
CEMENT TYPE(S): DOLOMITE CEMENT;
ACCESSORY MINERALS: SPAR-02%;
OTHER FEATURES: SUCROSIC;
- 321 - 322 CALCARENITE; WHITE TO VERY LIGHT ORANGE; 17% POROSITY, INTERGRANULAR;
GRAIN TYPE: SKELETAL, BIOGENIC, CALCILUTITE; 65% ALLOCHEMICAL CONSTITUENTS;
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO VERY COARSE; MODERATE INDURATION;
CEMENT TYPE(S): CALCILUTITE MATRIX;
SIMILAR TO 306 TO 317'.
- 322 TOTAL DEPTH

APPENDIX II
POTENTIOMETRIC NETWORK

Florida Geological Survey

MADISON COUNTY POTENTIOMETRIC NETWORK Floridan aquifer system

Township Range Section	Aquifer Condition	Latitude	Longitude	Land Surface Datum (feet, MSL)	Casing Depth (feet)	Total Depth (feet)
01S 09E 06	Confined	302603	832714	193	*	193
01N 07E 19	Confined	302824	834009	96	*	*
01S 09E 20	Confined	302312	832609	135	*	*
01N 07E 22	Confined	302834	833614	99	124	*
01S 09E 13	Confined	302356	832215	85	72	95
02S 10E 02	Confined	302024	831801	63	49	94
02S 10E 08	Unconfined	301918	832005	93	*	92
02S 11E 30	Unconfined	301649	831514	71	*	71
02N 10E 35	Confined	303212	831743	163	*	164
01S 10E 35	Confined	302104	831625	47	78	87
01N 09E 21	Confined	302822	832555	307	322	101
02N 08E 20	Confined	303332	833302	131	140	125
02N 10E 02	Confined	303626	831720	160	282	95
01N 11E 17	Unconfined	302847	831446	151	*	*
01N 10E 22	Confined	302806	831809	115	157	119
02S 07E 13	Unconfined	301817	833510	94	58	94
01S 08E 33	Confined	302100	823147	130	135	123
01N 08E 14	Confined	302914	833009	114	133	115
02N 09E 07	Confined	303515	832712	85	125	144
01N 06E 16	Confined	302928	834319	106	128	107
01S 06E 02	Unconfined	302532	834208	88	57	88
02S 11E 04	Unconfined	302037	831326	63	*	64
01S 07E 04	Confined	302531	833724	90	110	120

*Information unknown.

APPENDIX III
WATER QUALITY NETWORK

Florida Geological Survey

Madison County Water Quality Network

Township Range Section	Latitude	Longitude	Land Surface Datum (feet, MSL)	Casing Depth (feet)	Total Depth (feet)
<u>Floridan Aquifer System</u>					
01N 07E 33	302613	833713	100	90	110
01N 08E 34	302610	833056	125	83	103
01N 09E 34	302651	822408	165	91	121
02N 08E 22	303400	833053	140	61	81
02N 10E 35	302128	831741	164	105	125
01S 06E 02	302523	834203	90	50	75
01S 07E 34	302132	833617	95	70	90
01S 09E 20	302259	832637	160	75	113
01S 10E 11	302432	831735	80	58	78
01S 11E 29	302222	832111	95	41	61
01S 11E 29	302217	831400	75	49	69
02S 06E 03	302018	834228	75	84	104
02S 08E 02	302049	832935	103	80	100
02S 09E 34	301604	832408	99	47	67
02S 10E 35	302038	831831	90	33	53
02S 10E 35	301553	831702	82	27	37
02S 10E 35	301554	831702	82	27	37
01N 06E 01	303035	834031	91	174	198
01N 06E 16	303938	834319	107	*	128
01N 07E 16	302853	833707	147	*	*
01N 07E 19	302832	834008	92	*	*
01N 07E 19	302814	833944	108	*	*
01N 07E 20	302817	833916	111	*	*
01N 07E 20	302811	833912	115	*	*
01N 07E 21	302834	833803	100	*	*
01N 07E 21	302812	833949	144	*	*
01N 07E 21	302806	833805	107	*	*
01N 07E 22	302819	833635	105	60	70
01N 07E 22	302834	833614	109	99	124
01N 07E 22	302812	833613	117	128	140
01N 07E 22	302812	833713	144	*	*
01N 07E 22	302837	833617	102	98	108
01N 07E 22	302816	833636	102	*	*
01N 07E 22	302800	833516	116	*	*
01N 07E 28	302709	833728	111	67	91
01N 07E 29	302731	833854	92	*	*
01N 07E 29	302724	833915	97	*	*
01N 08E 33	302649	832519	140	*	*
01N 09E 12	303004	832259	145	*	140
01N 09E 23	302816	832338	172	142	178
01N 09E 32	302635	832646	130	*	*
01N 09E 33	302649	832519	140	*	*
01N 09E 34	302648	832410	150	90	120
01N 10E 22	302806	831809	116	*	*
*Information Unknown					

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Township Range Section	Latitude	Longitude	Land Surface Datum (feet, MSL)	Casing Depth (feet)	Total Depth (feet)
02N 06E 11	303543	834155	155	*	*
02N 07E 16	303419	833814	107	*	37
02N 09E 07	303513	832712	143	85	125
03N 09E 34	303719	832447	170	175	175
01S 05E 17	302404	835125	75	192	193
01S 06E 02	302532	834208	87	*	57
01S 07E 04	302528	835758	102	92	115
01S 07E 36	302115	833502	145	80	*
01S 08E 01	302534	832834	189	*	*
01S 08E 16	302349	833136	133	80	117
01S 08E 20	302251	833248	170	*	*
01S 08E 24	302328	832853	160	*	84
01S 08E 25	302156	832820	117	80	*
01S 08E 32	302120	833259	127	*	80
01S 08E 33	302100	833147	122	129	135
01S 09E 04	302605	832509	128	*	*
01S 09E 06	302603	832714	193	*	*
01S 09E 13	302356	832215	94	72	85
01S 09E 17	302419	832630	110	*	100
01S 09E 33	302124	832605	101	*	105
01S 10E 40	302523	831945	98	92	110
01S 10E 32	302133	832028	94	*	*
01S 10E 35	302100	831725	87	47	78
01S 11E 01	302558	831023	78	36	109
01S 11E 06	302518	831501	75	52	66
01S 11E 16	302415	831341	81	*	99
01S 11E 17	302356	831411	83	*	*
01S 11E 24	302305	831008	67	65	161
01S 11E 25	302203	831034	72	87	100
01S 11E 25	302138	831042	69	69	84
02S 05E 12	301957	834711	60	*	*
02S 05E 23	301809	834805	46	*	*
02S 05E 26	301712	834724	47	*	*
02S 05E 28	301712	834927	41	*	*
02S 06E 04	302014	834340	80	93	97
02S 06E 08	301946	832244	115	86	94
02S 06E 20	301734	834449	50	65	*
02S 06E 22	301759	834311	74	*	*
02S 06E 25	301710	834054	66	*	*
02S 06E 28	301640	834328	54	*	*
02S 06E 29	301712	834459	50	26	32
02S 07E 02	302027	834459	50	26	32
02S 07E 02	302027	833556	137	*	73
02S 07E 30	302032	833556	137	*	73
02S 07E 30	302009	833716	118	70	78
02S 07E 05	302032	833852	91	*	135
02S 07E 13	301817	833510	91	*	36
*Information Unknown					

Florida Geological Survey

Township Range Section	Latitude	Longitude	Land Surface Datum (feet, MSL)	Casing Depth (feet)	Total Depth (feet)
02S 07E 20	301720	833835	82	*	19
02S 07E 28	301721	833854	82	*	*
02S 07E 28	301649	833746	87	*	50
02S 07E 30	301640	833938	74	*	*
02S 08E 05	302041	833217	105	*	*
02S 08E 05	302015	833411	99	*	90
02S 10E 02	302024	831801	92	*	*
02S 10E 08	301918	832005	93	*	*
02S 10E 16	301827	831943	92	*	50
02S 11E 11	301959	831150	61	139	152
02S 11E 26	301720	831153	75	*	*
02S 11E 29	301717	831459	65	*	55
02S 11E 30	301649	831514	71	*	*
<u>Intermediate Aquifer</u>					
01N 07E 33	302613	833714	100	40	60
01N 08E 34	302670	833053	125	30	50
02S 06E 03	302017	834228	75	25	35
<u>Surficial Aquifer System</u>					
01S 06E 02	302524	834204	102	3	13
01S 07E 34	302131	833617	95	2	12
02S 06E 03	302016	834228	75	3	13
02S 08E 02	302049	832933	103	2	12

*Information Unknown

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FLORIDA GEOLOGICAL SURVEY**

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