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FLORIDA GEOLOGICAL SURVEY
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REPORT OF INVESTIGATIONS NO. 21

THE ARTESIAN WATER OF THE RUSKIN AREA OF HILLSBOROUGH COUNTY, FLORIDA

By
HARRY M. PEEK
U. S. Geological Survey

Prepared by the
UNITED STATES GEOLOGICAL SURVEY
in cooperation with the
FLORIDA GEOLOGICAL SURVEY
and the
BOARD OF COUNTY COMMISSIONERS OF HILLSBOROUGH COUNTY

TALLAHASSEE, FLORIDA
1959

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LETTER OF TRANSMITTAL

Florida Geological Survey

Tallahassee

September 9, 1959

MR. ERNEST MITTS, *Director*
FLORIDA STATE BOARD OF CONSERVATION
TALLAHASSEE, FLORIDA

DEAR MR. MITTS:

The Florida Geological Survey will publish as their Report of Investigations No. 21 a comprehensive study of THE ARTESIAN WATER OF THE RUSKIN AREA OF HILLSBOROUGH COUNTY. This study was made by Mr. Harry M. Peek, Geologist with the U. S. Geological Survey, in cooperation the Florida Geological Survey and with the Board of County Commissioners of Hillsborough County.

The area in the vicinity of Ruskin is used extensively for truck farming. During drought periods, considerable difficulty has been experienced through the accumulation of salts in low places, the salts having been derived from water used for irrigation. This study provides data that will be helpful in evaluating the problem of salt accumulation in soils and will provide the necessary help for a wise and conservative utilization of our water resources in that area.

Respectfully yours,

ROBERT O. VERNON, *Director*

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By
HARRY M. PEEK

ABSTRACT

The Ruskin area of Florida, as defined in this report, comprises about 200 square miles in southwestern Hillsborough County. The area has a subtropical climate and an average rainfall of more than 50 inches, so that it is well suited to livestock farming and growing of winter vegetables. As in much of the State, however, truck crops and pasture require irrigation during periods of relatively light rainfall; thus, large quantities of water are withdrawn through many hundreds of wells during the growing season.

The surface formations in the Ruskin area consist predominantly of deposits of sand, limestone, and shells, of Pleistocene and Pliocene age, which range in thickness from a few feet to about 60 feet. These deposits are underlain by the Hawthorn formation, of middle Miocene age, which is exposed at a few places. The Hawthorn consists of calcareous clay or marl interbedded with limestone and sand and ranges in thickness from less than 10 feet in the northern part of the area to more than 150 feet in the southern part. The Tampa formation,[1] of early Miocene age, underlies the Hawthorn formation and ranges in thickness from 50 feet in the northern part of the area to about 200 feet in the southern part. Its upper surface ranges in elevation from about sea level in the northern part of the area to about 250 feet below sea level in the southern part. The Tampa is the youngest of the limestone formations of Tertiary age, which have a total thickness of several thousand feet in southwestern Hillsborough County. The other limestone formations penetrated by water wells in the area are the Suwannee limestone, of Oligocene age, and the Ocala group and Avon Park limestone, of Eocene age.

[1]The stratigraphic nomenclature used in this report conforms to that of the Florida Geological Survey. It conforms also to that of the U. S. Geological Survey, with the following exceptions: the Tampa limestone is herein referred to as the Tampa formation and the Ocala limestone is referred to as the Ocala group.

The Hawthorn and younger formations are the source of some domestic and other small water supplies, but the large quantities of water required for irrigation and industrial use are obtained from the underlying limestone formations.

The Suwannee limestone and Tampa formation are the principal sources of artesian water in the area, although the older limestones yield water to a few wells. The water in these formations occurs in permeable zones that are separated by relatively impermeable beds of considerable thickness. The water is replenished by rainfall in western Polk County and eastern Hillsborough County, and it is confined under pressure by the relatively impermeable strata within the formations and by the overlying Hawthorn formation. The artesian aquifer has a transmissibility coefficient of about 115,000 gpd per foot and a storage coefficient of about 0.0006.

Significant fluctuations of artesian-pressure head result from daily and seasonal variations in withdrawal of water from wells. During periods of heaviest withdrawal, the piezometric surface is lowered about four to five feet throughout the area and more than eight feet at some places. The artesian pressure head declined progressively in the coastal area during a period of extensive agricultural development from 1950 to 1952. Since 1952, however, seasonal fluctuations have decreased in magnitude and a slight progressive rise in artesian head has occurred locally, as a result of a decrease in withdrawals. Records of water levels in wells not affected by local variations in discharge indicate that, regionally, the artesian head declined progressively in 1955-56.

INTRODUCTION

Along much of the coast of Florida, salt water is present in part or all of the principal water-bearing formations. Thus, the problem in many coastal areas is to find supplies of fresh water that are adequate to meet increased demands and are economically feasible to develop. The problem in other areas is to protect present supplies from contamination by salt water encroaching from the sea or from formations that lie beneath the fresh-water supply. Encroachment from either source may be induced by excessive lowering of the fresh-water head.

During recent years, expansion of agriculture in the Ruskin area of southwestern Hillsborough County has greatly increased the use of artesian water for irrigation which has lowered the artesian head in the area. The detection of relatively salty water in some wells has suggested that salt water may be encroaching from Tampa Bay. Recognizing this possibility, the Board of County Commissioners of Hillsborough County requested the U. S. Geological Survey and the Florida Geological Survey to make a study of the ground-water resources in the Ruskin area. Accordingly, the Federal Geological Survey began an investigation in October 1950, in cooperation with the above agencies.

Most of the fieldwork of the investigation was done by the author prior to June 1953, under the immediate supervision of H. H. Cooper, Jr., then District Engineer of the Federal Survey, in Tallahassee. Completion of the fieldwork and preparation of the report were under the immediate supervision of M. I. Rorabaugh, present District Engineer of the U. S. Geological Survey. The entire investigation was made under the general supervision of A. N. Sayre, Chief of the Ground Water Branch, U. S. Geological Survey.

PURPOSE AND SCOPE OF THE INVESTIGATION

The purpose of the investigation was to make a detailed study of the geology and ground-water resources of southwestern Hillsborough County, with the primary objective of determining whether the artesian water had been contaminated by salt water from Tampa Bay or from other sources. The investigation, therefore, consisted of several phases, as described below:

1. An inventory of about 650 selected wells, to obtain pertinent information related to the occurrence and use of ground water in the area.
2. Collection of data on water levels, to determine trends and magnitude of water-level fluctuations, and for use in constructing maps showing the altitude to which water will rise in artesian wells.
3. Collection of water samples from selected wells, for chemical analysis.
4. Determination of the chloride content of water from wells, to ascertain the location and extent of areas in which the artesian water has been contaminated.
5. Periodic determination of the chloride content of water from selected wells, to understand the relation between the chlorinity of the water and the artesian pressure head.
6. A study of geologic conditions as related to the occurrence and movement of ground water.
7. Exploration of selected wells with a deep-well current meter,

to determine the depth, thickness, and relative productivity of the principal water-bearing zones.

8. Resistivity surveys and determination of the chloride content of water samples collected at several different depths in selected wells, to determine the relative chlorinity of the water in the principal water-bearing zones.

9. Studies to determine the water-transmitting and water-storing capacities of the different formations.

PREVIOUS INVESTIGATIONS

No detailed study of the geology and ground-water resources of southwestern Hillsborough County has been made previously. However, the Florida Geological Survey and the U. S. Geological Survey have published several reports that include brief discussions of the geology and the occurrence of ground water in Hillsborough County.

One of the earlier reports (Matson and Sanford, 1913, p. 320, 323; pl. 5) contains a generalized map of the Pleistocene terraces, logs of wells, descriptions of formations exposed at the land surface, and a brief discussion of the ground water of Hillsborough County. A report by Sellards and Gunter (1913, p. 258-262, fig. 16) includes a summary of the geology and ground-water resources of the county and contains a map showing the area of artesian flow.

The geology and ground water of Hillsborough County are described in a report by Stringfield (1936, p. 127, 128, 152). This report includes maps of the Florida Peninsula showing the area of artesian flow, the height above sea level to which water will rise in wells that penetrate the principal artesian aquifer, and the areas in which water with a chloride content of more than 100 parts per million (ppm) is present at moderate depths. Water-level measurements and other data from several wells in the county also are included.

A report by Parker and Cooke (1944, pl. 3) contains a map showing the general configuration of the Pleistocene terraces in southern Florida, including Hillsborough County. Reports by MacNeil (1949, p. 105, pl. 19), Cooke (1945, p. 11-13, 245-312), and Parker (Parker and others, 1955, p. 89-124, pl. 10) discuss the Pleistocene terraces of Florida and contain maps showing the configuration of the terraces and shorelines in Hillsborough County.

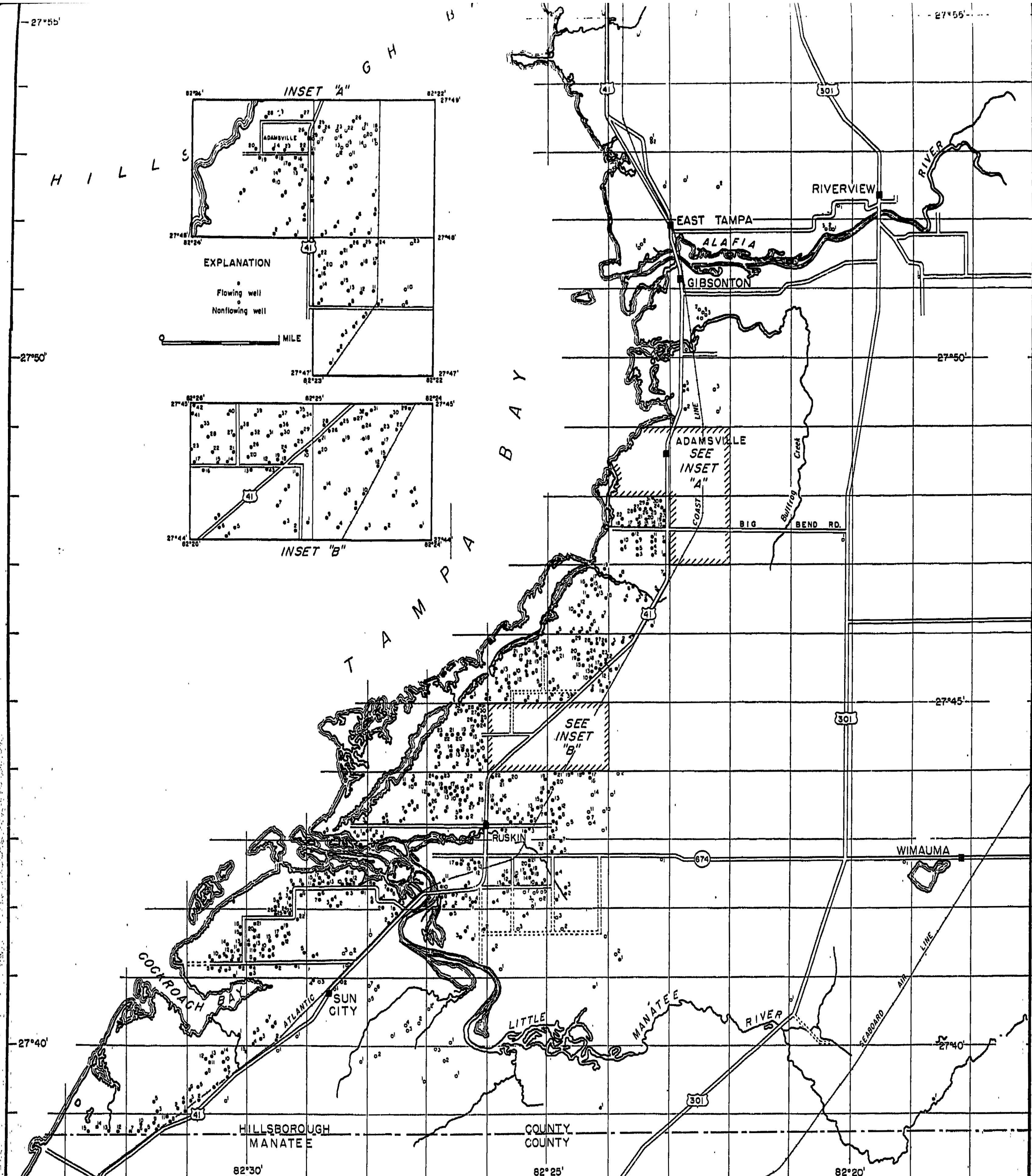

Plate 1. Map of the Ruskin area showing location of wells.

The formations penetrated by wells and those exposed at the surface are described in some detail in a report on the geology of Florida by Cooke (1945, p. 34, 42, 47, 125, 208, 222, 290, 305). A report by Vernon (1951, figs. 11, 33, pl. 2) contains maps showing the subsurface features of some of the formations underlying Hillsborough County.

Chemical analyses of water from several wells and springs in Hillsborough County are included in a report by Collins and Howard (1928, p. 216-217) and one by Black and Brown (1951, p. 64).

ACKNOWLEDGMENTS

Appreciation is expressed to the many well owners in the Ruskin area who contributed information and otherwise aided the investigation. Special acknowledgment is made to the well drillers who collected rock cuttings and furnished much valuable information. These include H. J. Tucker, Howard Morrill, and E. E. Boyette, of Ruskin; and May Bros. of Tampa.

WELL-NUMBERING SYSTEM

The well-numbering system used in this report is based on latitude and longitude. The Ruskin area, which lies between 27° and 28° north latitude and 82° and 83° west longitude (fig. 1), has been divided into quadrangles by a grid of 1-minute parallels of latitude and 1-minute meridians of longitude, as shown on plate 1. The wells have been assigned numbers according to their location within this grid. Each well number consists of three parts: the first part is the latitude, in minutes, of the south side of the 1-minute quadrangle in which the well is located; the second part is the longitude, in minutes, of the east side of the same 1-minute quadrangle; and the third part is the number of the well within the quadrangle. For example, the number 43-25-4 designates the fourth well in the quadrangle bounded by latitude 43′ on the south and longitude 25′ on the east. The degree of latitude and longitude are not included as a part of the well number, as they are the same for all wells used in this report. Well locations are shown on the map, plate 1. Complete well descriptions, locations, and other data are published in Florida Geological Survey Information Circular No. 22 and may be obtained for one dollar per copy.

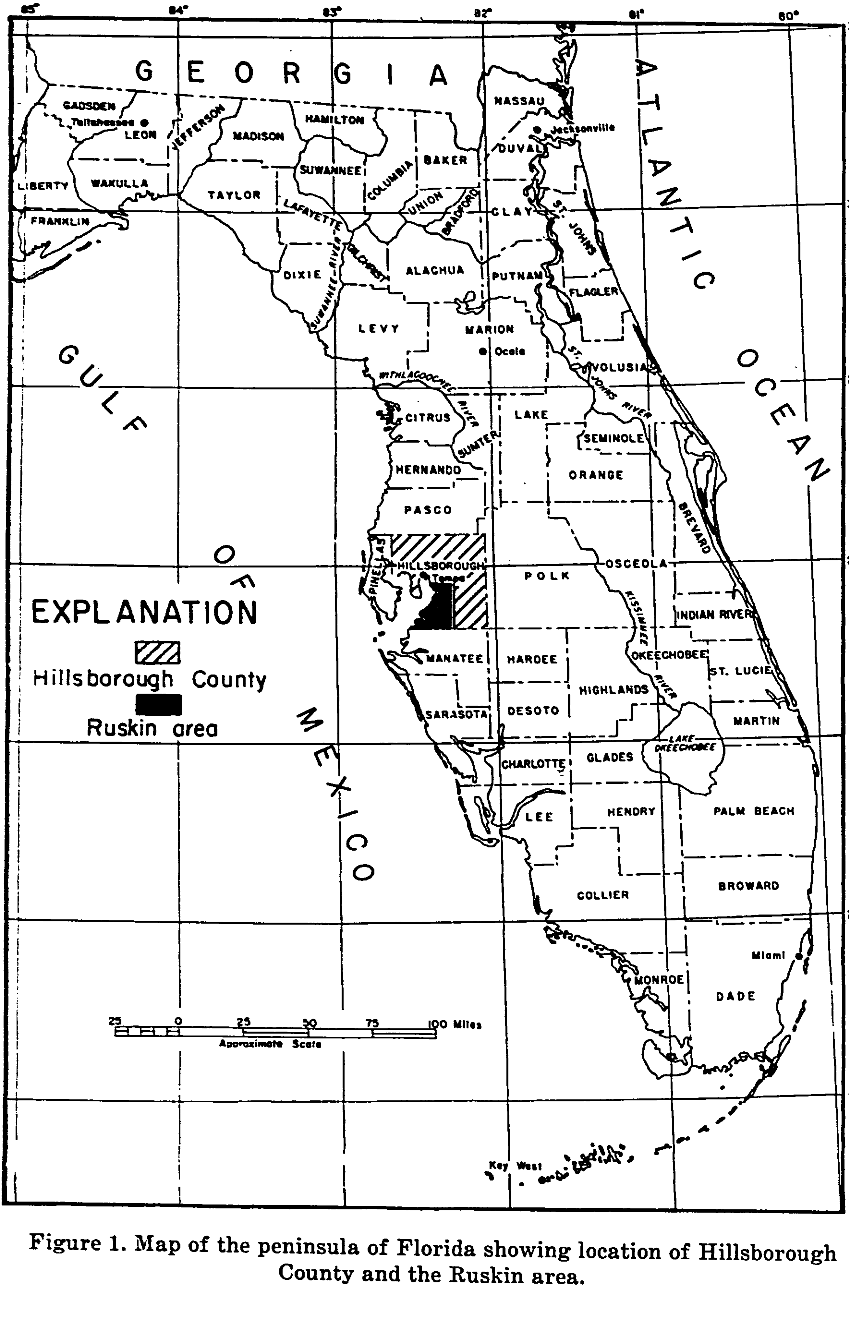

Figure 1. Map of the peninsula of Florida showing location of Hillsborough County and the Ruskin area.

GEOGRAPHY

The Ruskin area, as defined for this report, comprises about 200 square miles in southwestern Hillsborough County (fig. 1). It is bounded on the south by Manatee County and extends northward to the 27°56′ parallel of north latitude. From Tampa Bay, which forms the western boundary, the area extends eastward to the 82°17′ meridian of west longitude.

CLIMATE

The Ruskin area has a subtropical climate, with a mean temperature of about 72° F, according to the U. S. Weather Bureau. The mean monthly temperatures at Tampa range from 61.5° F in January to 82° F in August, as shown in figure 2. For comparison, the figure shows the average maximum and minimum monthly temperatures during 1956.

The records of the U. S. Weather Bureau show (fig. 2) that the average yearly precipitation at Tampa during the period from 1891 through 1955 was 49.94 inches; the range was from 32.25 inches in 1908 to 67.19 inches in 1912. The average monthly rainfall ranged from 1.04 inches in November to 8.11 inches in July, and more than 70 percent of the annual precipitation occurred between June 1 and September 30.

PHYSIOGRAPHY

The Ruskin area is in the Terraced Coastal Lowlands of Vernon (1951, p. 16), a subdivision of the Coastal Plain province. The topographic forms consist mostly of marine terraces and associated features that were developed during the Pleistocene time, when the sea at several times stood above or below its present level. The topography may be divided generally into units—a relatively flat coastal area and a hilly upland area. The coastal area is about three to six miles wide and extends inland from Tampa Bay to an escarpment that represents the shoreline of the Pamlico sea of late Pleistocene time. The coastal area slopes gently toward the bay from the base of the escarpment, which is about 25 feet above sea level. Most of the coastal area is between 5 and 15 feet above sea level, but it contains a few low hills and ridges having altitudes of 30 feet or more. The hilly upland area extends eastward from the Pamlico escarpment, gradually increasing in altitude to more than 100 feet in the vicinity of Wimauma. Most

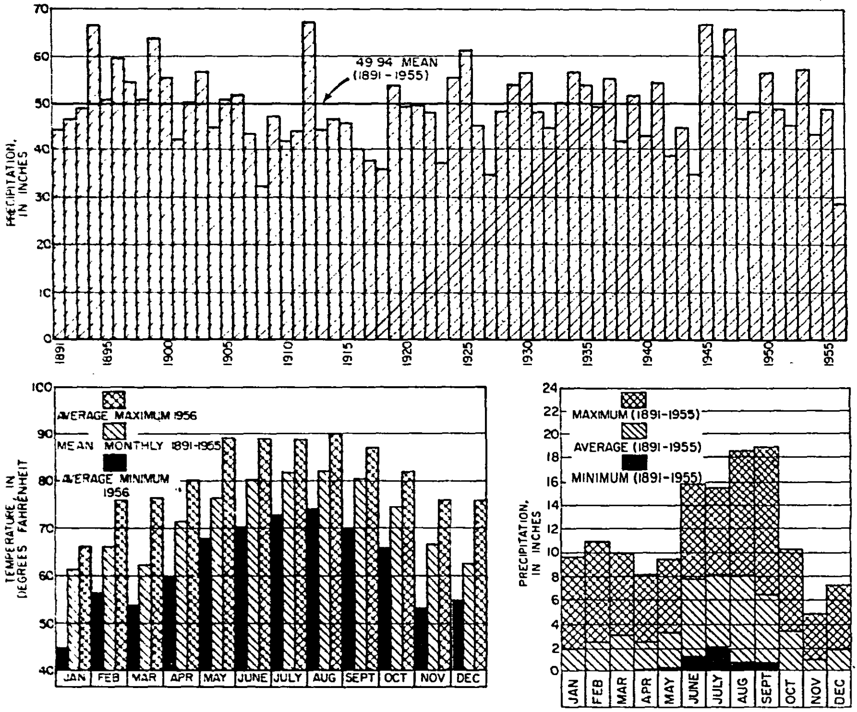

Figure 2. Precipitation and temperature at Tampa.

of the upland area consists of low rolling hills having relatively flat summits, at altitudes of 50 to 90 feet. The marine terraces and associated features have been modified to some extent by stream dissection. Numerous ponds, depressions, and swamps occur in the poorly drained parts of the area.

The history of the Pleistocene epoch and the marine terraces and deposits associated with the fluctuations of sea level in Florida are discussed in detail in reports by Cooke (1945, p. 11-13, 245-312), Vernon (1951, p. 15-42, 208-215), and Parker (Parker and others, 1955, p. 89-124). The rise and fall of the sea is attributed to the advance and retreat of the great continental ice sheets, the sea level rising during interglacial periods and falling during glacial periods. When the sea remained relatively stationary for long periods, shoreline features and marine plains were developed. The remnants of five marine terraces of Pleistocene age and the general configuration of four shorelines have been mapped in the Ruskin area (Cooke, 1945, figs. 43-47; Parker and others, 1955, pl. 10), as listed in the following table:

TABLE 1. Pleistocene Terraces and Shorelines of the Ruskin Area

Terrace	Altitude of shoreline (feet above msl)
Sunderland	170[1]
Wicomico	100
Penholoway	70
Talbot	42
Pamlico	25

[1]Sunderland shoreline not present in Ruskin area.

Figure 3 shows the general boundaries of the Pleistocene terraces in the Ruskin area, as determined from aerial photographs, topographic maps, and field observation. The highest and oldest surface lies above the Wicomico shoreline and represents the remnants of the Sunderland terrace (Cooke, 1945, p. 278-279). The sea was about 170 feet above the present level when the Sunderland was formed, and practically all of south Florida was submerged.

During Wicomico time, the sea stood about 100 feet above the present level and all the Ruskin area was submerged except the Sunderland terrace and associated islands. The shoreline of the Wicomico sea is marked by an escarpment that is well preserved in many places.

The Penholoway terrace was formed when the sea stood at an altitude of about 70 feet. The general configuration of the shoreline can be distinguished on aerial photographs, on topographic maps, and in the field (fig. 3).

The shoreline of the Talbot sea, which stood at an altitude of about 42 feet, is poorly defined throughout most of the area, and in many places the shoreline escarpment coincides with the escarpment of the Pamlico terrace.

The Pamlico terrace is the youngest Pleistocene terrace that has been recognized in the Tampa Bay area. It was formed when the sea was about 25 to 30 feet above the present level. The shoreline of the Pamlico sea is marked by an escarpment which is well preserved throughout most of the area. The base of the escarpment is generally about 25 feet above sea level.

Surface drainage in the Ruskin area is principally through the Little Manatee River, the Alafia River, and Bullfrog Creek, all of which flow into Tampa Bay. Much of the coastal area is drained by small streams that extend inland from Tampa Bay for relatively

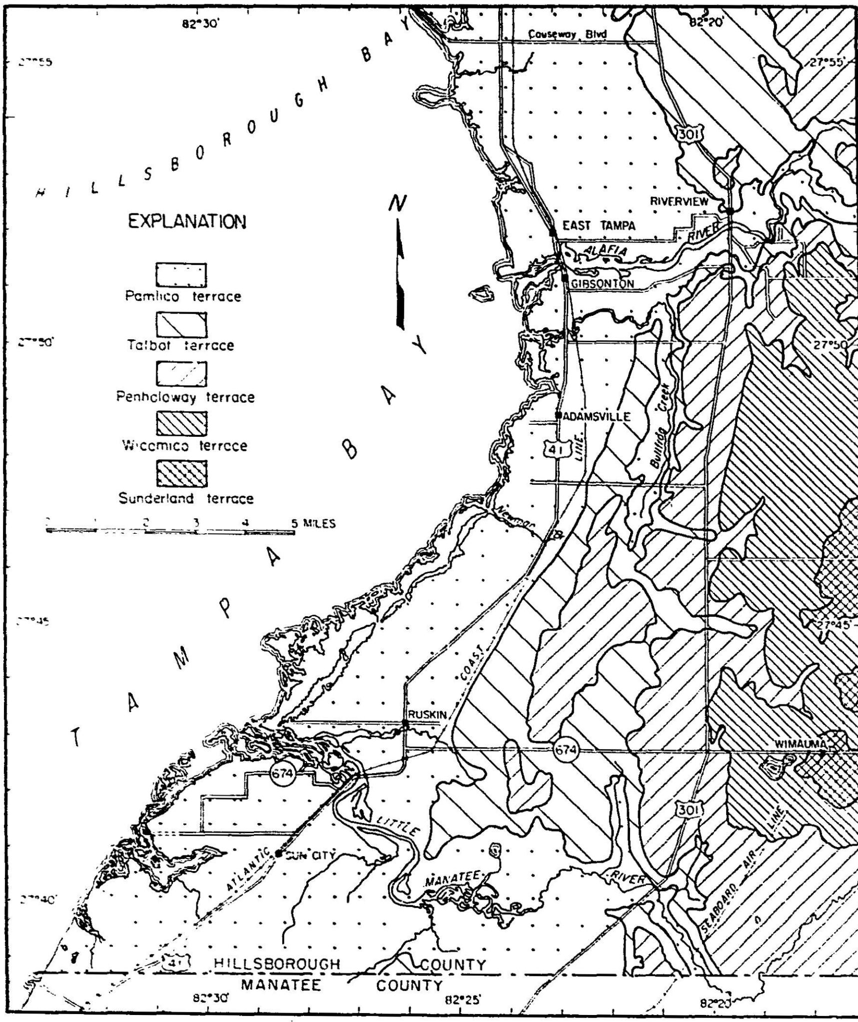

Figure 3. Map of the Ruskin area showing the Pleistocene terraces.

short distances. Canals have been dug throughout most of the area to supplement the natural drainage.

CULTURE

The principal towns in the Ruskin area are East Tampa, Gibsonton, Riverview, Ruskin, Sun City, and Wimauma (pl. 1). U. S. Highway 41 passes through all towns along the coast and connects them with Tampa to the north and Bradenton to the south. U. S. Highway 301 provides a north-south route through the eastern part of the area. State Highway 674 and several other paved roads connect the U. S. Highways. The Atlantic Coastline Railroad provides transportation in the coastal area and the Seaboard Air Line Railroad serves Wimauma and the eastern part of the area.

GEOLOGY

The surface formations over most of the Ruskin area consist of undifferentiated deposits of Pleistocene age, although beds as old as Miocene are exposed at some places. The geologic formations penetrated by water wells are listed and briefly described in table 2, and geologic cross sections are shown in figure 4. The subsurface formations are described on the basis of rock cuttings, electric logs, and drillers' logs of wells in and adjacent to the Ruskin area. Those penetrated by water wells in the area are the only formations discussed in this report.

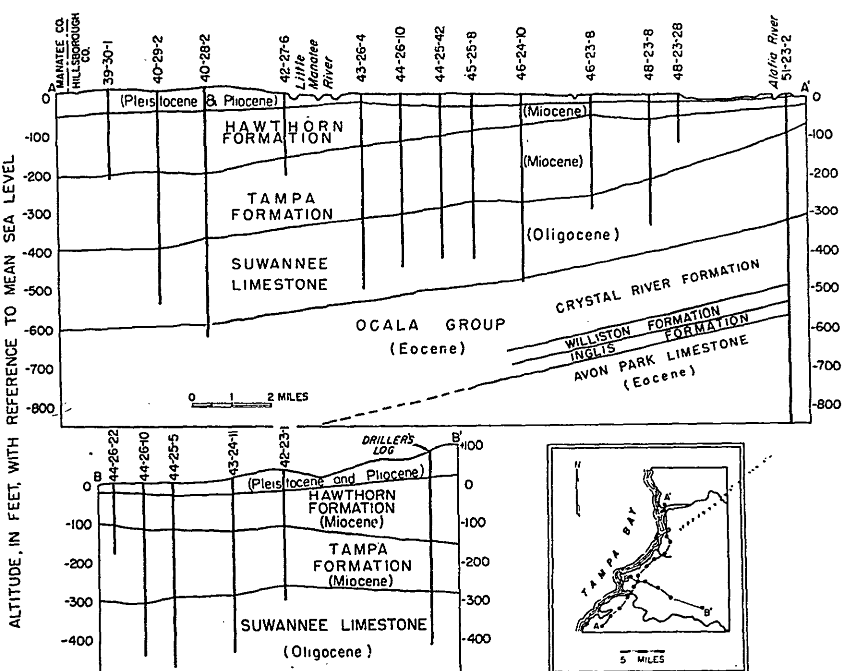

Figure 4. Geologic cross sections showing the formations penetrated by water wells in the Ruskin area.

TABLE 2. Geologic Formations Penetrated by Water Wells in the Ruskin Area

Age	Formation	Characteristics	Thickness (feet)
Pleistocene	Pamlico sand	Sand, shells, limestone, and calcareous clay.	0- 60
	Older Terrace deposits	Sand, silt, and some clay.	
Late Miocene and Pliocene	Undifferentiated deposits	Sand and gravel of quartz and phosphate, clay, and bone fragments.	0- 20?
		Sand, shells, gravel of quartz and phosphate, and lignite.	0- 25?
Miocene	Hawthorn formation	Clay and marl, gray, greenish gray to blue-gray, sandy, phosphatic, interbedded with sandy limestone, sand, silt and shells. Serves as a confining layer for the water in the underlying limestones but is the source of small water supplies.	10-150
	Tampa formation	Limestone, creamy white, gray, and tan, fairly hard, porous to dense, sandy, fossiliferous, silicified in part. A very productive source of artesian water.	50-200
Oligocene	Suwannee limestone	Limestone, creamy white to tan, fairly soft, granular, porous, fossiliferous, crystalline and dolomitic in part. Probably a more productive source of water than the Tampa, but water is somewhat more mineralized.	200-225
Eocene	Ocala group	Limestone, white, cream and tan, soft, granular, chalky, fossiliferous, coquinoid in part. Penetrated by only a few wells in the Ruskin area but may be a very productive source of artesian water. The water is probably highly mineralized in the coastal area.	250±
	Avon Park limestone	Limestone, white to tan, soft, somewhat chalky, granular, foraminiferal; dolomite, tan to dark brown hard crystalline, lignitic in part, very porous. A very productive source of artesian water but tapped by very few wells. Water is salty in the coastal area.	600-700

EOCENE SERIES

The Eocene limestones have a combined thickness of about 5,000 feet in the Tampa Bay area, but only the upper part of this limestone section is tapped by water wells.

AVON PARK LIMESTONE

The upper part of the late middle Eocene limestone in Florida was named the Avon Park limestone by Applin and Applin (1944, p. 1680, 1686). It is the oldest formation exposed at the surface (with outcrops in Citrus and Levy counties) and is also the oldest formation penetrated by water wells in southwestern Hillsborough County.

The upper part of the Avon Park consists predominantly of white to tan, soft, chalky, granular limestone containing many foraminifers and other fossils. The lower part is principally a tan to dark brown, hard, crystalline dolomite containing carbonaceous material but very few fossils.

The Avon Park limestone is probably about 600 to 700 feet thick in the Ruskin area. The top of the formation ranges in depth from about 575 feet below sea level in the northern part of the area to about 900 feet in the southern part.

The formation is very permeable, owing to the extensive development of solution channels, and is a productive source of artesian water. However, relatively few wells in the area penetrate the Avon Park, because it contains highly mineralized water in much of the coastal zone and sufficient quantities of water of better quality can be obtained from the younger formations at shallower depths.

OCALA GROUP

Until recent years, all the limestone deposits of late Eocene age in peninsular Florida were considered as a single formation, the Ocala limestone. As shown in table 3, Cooke (1945, p. 53-62) and Applin and Applin (1944, p. 1683) referred all late Eocene limestones to the Ocala; however, Applin and Applin recognized upper and lower members of the formation, on the basis of lithologic and faunal differences. After completion of his studies in Citrus and Levy counties, Vernon (1951, p. 111-171) separated the late Eocene limestones into two formations—the Ocala limestone, restricted to the upper part, and the Moodys Branch formation. He also divided the Moodys Branch formation into two members—the Williston member, to include the upper part, and the Inglis member, to include the lower part. Puri (1953, p. 130) changed the name of the Ocala limestone (as restricted by Vernon) to the Crystal River formation, and gave formational rank to the Williston and Inglis members of Vernon's Moodys Branch formation. The Crystal River, Williston and Inglis formations, as described by Puri, are now referred to as the Ocala group by the Florida Geological Survey.

TABLE 3. Stratigraphic Nomenclature of the Upper Eocene in Florida

<table>
<tr><th colspan="3">U. S. Geological Survey</th><th colspan="4">Florida Geological Survey</th></tr>
<tr><th>Cooke (1945)</th><th colspan="2">Applin (1944)</th><th colspan="2">Vernon (1951)</th><th colspan="2">Puri (1953)</th></tr>
<tr><td rowspan="3">Ocala limestone</td><td rowspan="3">Ocala limestone</td><td>Upper member</td><td colspan="2">Ocala limestone (restricted)</td><td rowspan="3">Ocala group</td><td>Crystal River formation</td></tr>
<tr><td rowspan="2">Lower member</td><td rowspan="2">Moodys Branch formation</td><td>Williston member</td><td>Williston formation</td></tr>
<tr><td>Inglis member</td><td>Inglis formation</td></tr>
</table>

The Ocala group lies unconformably on the Avon Park limestone in southwestern Hillsborough County and is probably about 250 feet thick. The top of the formation ranges in depth from about 300 feet below sea level in the northern part of the area to about 600 feet in the southern part. The upper part of the Ocala is a creamy white to tan, soft, somewhat granular, chalky, coquinoid limestone, composed of the remains of foraminifers, mollusks, echinoids, and other fossils which are loosely cemented in a fine, granular, chalky matrix. The lower part of the Ocala is more granular and less chalky than the upper part and contains fewer foraminifers.

The Ocala is penetrated by relatively few wells in the Ruskin area, although it may be a productive source of water. In the coastal area, the water in the Ocala has a considerably higher mineral content than the water in the younger limestones.

OLIGOCENE SERIES

SUWANNEE LIMESTONE

The Suwannee limestone, as defined in this report, includes all deposits of Oligocene age in the Ruskin area. The Suwannee is differentiated from the underlying Eocene formations and the overlying Miocene formations on the basis of lithology and fauna and is separated from these formations by unconformities.

The upper part of the Suwannee is generally a creamy white to tan, soft, granular, fossiliferous limestone, but at some places it contains beds that are crystalline, dolomitic, and partly silicified. The lower part of the formation is generally a tan to brown, soft to hard, granular to dense limestone that is harder, more crystalline and dolomitic, and less fossiliferous than the upper part. The formation contains abundant remains of mollusks, echinoids, and foraminifers. Specimens of the foraminifer *Rotalia mexicana* are fairly abundant throughout the formation. The occurrence of *Dictyoconus cookei* and *Coskinolina floridana* is generally restricted to the lower part of the Suwannee.

The top of the Suwannee limestone in the Ruskin area ranges in depth from about 75 feet below sea level in the northern part of the area to about 400 feet in the southwestern part. The formation has a fairly uniform thickness of about 200 to 225 feet. The contours on the map in figure 5 show the configuration and approximate altitude of the top of the formation.

The Suwannee limestone is probably the most productive source of artesian water generally tapped in the Ruskin area. In the coastal area, however, the water in the Suwannee is somewhat more mineralized than the water in the overlying Tampa formation.

MIOCENE SERIES

The deposits of Miocene age in the Ruskin area are herein referred to the Tampa formation of early Miocene age (Cooke, 1945, p. 1070) and the Hawthorn formation of middle Miocene age. Both formations are of marine origin, but they represent different depositional environments and are separated by unconformities.

TAMPA FORMATION

The Tampa formation lies unconformably on the Suwannee limestone of Oligocene age and consists of white, gray, and tan hard, dense, sandy limestone. It is crystalline and dolomitic in

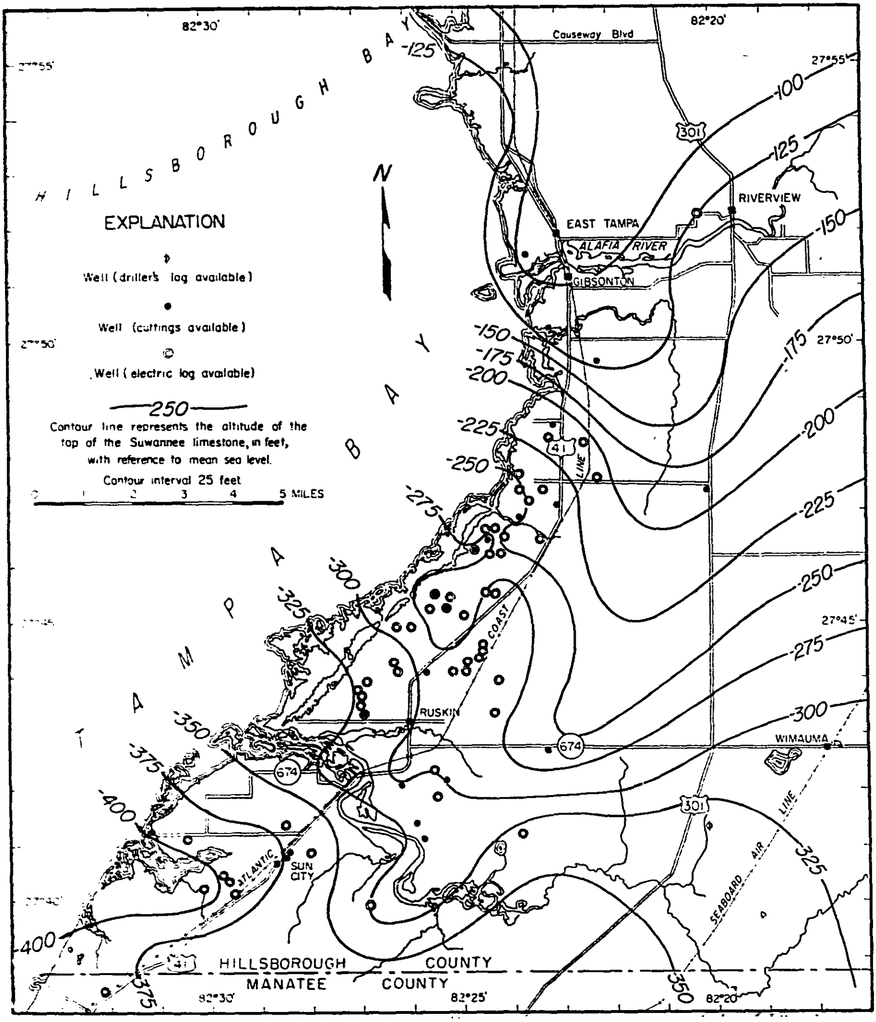

Figure 5. Map of the Ruskin area showing the configuration and altitude of the top of the Suwannee limestone.

part and contains silicified layers. The formation is generally fossiliferous, containing echinoid plates and spines, tests of ostracods and foraminifers, and many molds and casts of mollusks. Specimens of the foraminifers *Archaias* and *Sorites* are fairly abundant throughout most of the Tampa.

The top of the Tampa formation ranges in depth from a little below sea level in the northern part of the Ruskin area to about

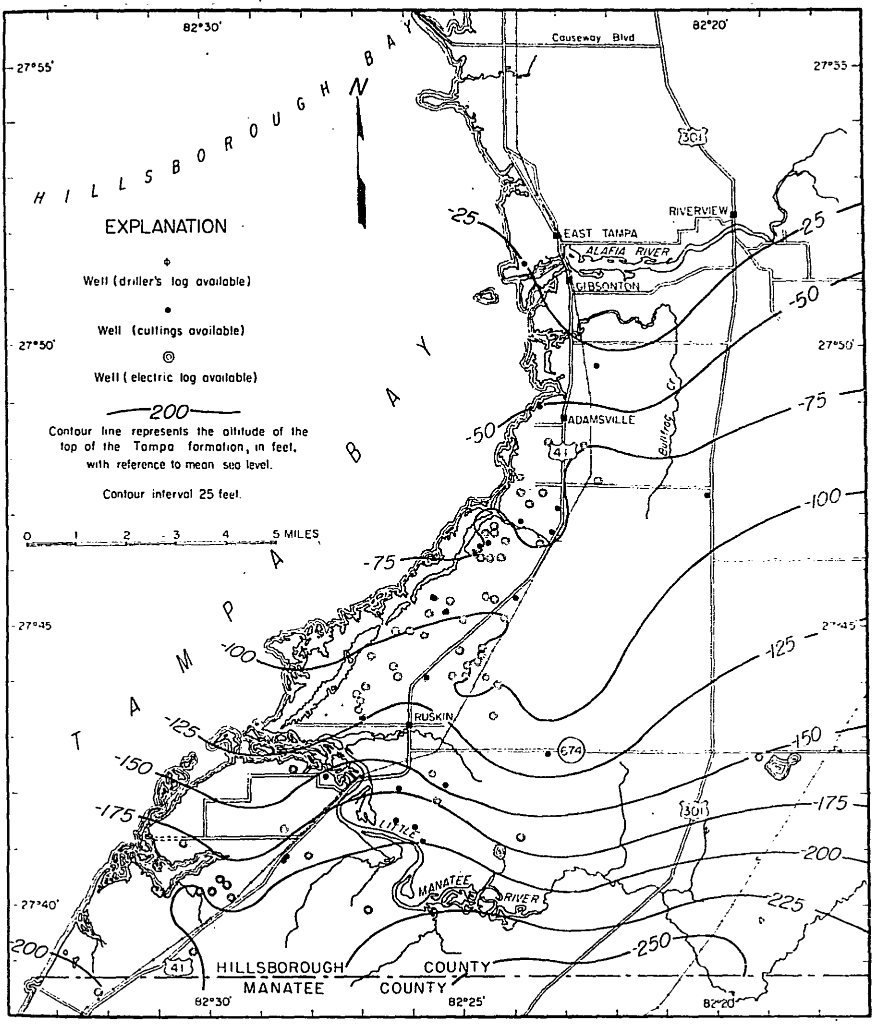

Figure 6. Map of the Ruskin area showing the configuration and altitude of the top of the Tampa formation.

250 feet below sea level in the southern part. The contours on the map in figure 6 show the configuration and approximate altitude of the top of the formation in the area. The thickness of the Tampa is about 50 feet near the northern boundary of the area and increases southward, in the direction of dip, to about 200 feet (fig. 4). The average thickness is about 175 feet in the area south of Big Bend Road (pl. 1).

The Tampa formation is a productive source of artesian water in the Ruskin area. Most of the water is obtained from relatively thin zones that have a high permeability, owing to the many interconnecting cavities formed by solution of the limestone.

HAWTHORN FORMATION

The Hawthorn formation, as defined in this report, includes all marine deposits of middle Miocene age. It was deposited in shallow water and consists predominantly of gray, blue-gray and gray-green, sandy, calcareous, phosphoritic clay interbedded with thin layers of gray, white, and tan sandy phosphoritic limestone, and thin beds of sand and shells. The limestone layers are dolomitic, silicified, and fossiliferous in part. The altitude of the top of the Hawthorn ranges from about 25 feet above sea level to about 50 feet below sea level, and the upper part of the formation is exposed at several places in the area. The thickness increases from north to south in the direction of dip, ranging from less than 10 feet in the northern part of the area to more than 150 feet in the southern part (fig. 4).

The thin beds of sand and limestone yield artesian water to some wells in the area, but the Hawthorn is not generally a very productive source of water. Because of the thickness and low permeability of the clay beds, the Hawthorn serves as a confining layer for the water in the underlying limestones.

PLIOCENE AND PLEISTOCENE SERIES

The Hawthorn formation is overlain at some places by about 5 to 10 feet of sediments that consist of shells, sand, carbonaceous material, and gravel of phosphorite and quartz. At other places it is overlain by several feet of sediments consisting predominantly of sand but containing some clay, gravel of quartz and phosphate, bone fragments, and shark teeth. The age of these sediments has not been determined, but it is probably late Miocene or Pliocene.

Pleistocene sediments of the higher terraces consist mostly of undifferentiated sands that range in thickness from about 10 feet to 60 feet. The surface of the Pamlico terrace is underlain by sand, sandy clay, and shells. The beds of limestone and shells, which pinch out near the Pamlico shoreline and are generally less than 20 feet above sea level, were apparently deposited during late Pleistocene time. However, these beds were referred by Cooke (1945, p. 222-223) to the Caloosahatchee marl of Pliocene age.

The Pleistocene deposits beneath the Pamlico surface range in thickness from about 10 feet to 50 feet, except where they have been completely eroded by streams. The Pleistocene deposits are the source of a few domestic water supplies in the area.

GROUND WATER

PRINCIPLES OF OCCURRENCE

Practically all the water of the earth moves through the vast circulatory system known as the hydrologic cycle. Water condenses from the moisture in the atmosphere and falls as rain or snow, moves over or beneath the land surface to the oceans, and is returned to the atmosphere. Actually, the cycle may be modified or completed at any time after the water condenses from the atmosphere, as evaporation may begin even before the water reaches the earth and continue throughout the entire cycle. Great quantities of water are returned to the atmosphere by evaporation from vegetal surfaces (transpiration).

Much of the water that falls on the land surface as rain or snow runs off into streams, lakes, or other bodies of surface water, and a part eventually reaches the oceans. Some water is returned to the atmosphere by evaporation directly from land and water surfaces, and a part of it is absorbed by the soil or surficial rocks and becomes subsurface water. The amount of water than sinks directly into the ground from each rainfall depends on many factors, such as the slope of the land surface, vegetal cover, intensity of the rainfall, and previous moisture content and character of the surface material.

Subsurface water may be divided into two general classes—suspended water and ground water. Suspended water is the water in the zone of aeration—the zone in which the interstices of the soil or rocks are not completely filled with water. Ground water is the water in the zone in which all the interstices are completely filled with water under greater than atmospheric pressure. This saturated zone is the reservoir that yields water to all springs and wells.

The water in the zone of saturation may occur as (1) unconfined ground water (under nonartesian conditions), or (2) confined ground water (under artesian conditions). Where the ground water is not confined—its upper surface is under atmospheric pressure and is free to rise and fall—it is said to be under nonartesian conditions. Its upper surface is called the water table. Where the water is confined in a permeable bed that is overlain and underlain by relatively impermeable beds, its upper surface is not free to rise and fall and it is said to be under artesian conditions. The term "artesian" is applied to ground water that is confined under sufficient pressure to cause it to rise above the top of the permeable bed that contains it, but not necessarily above the land surface.

An aquifer is a formation, group of formations, or part of a formation, in the zone of saturation, that is permeable enough to transmit usable quantities of water. Recharge is the process of replenishment of the water in an aquifer, and areas in which it occurs are known as recharge areas. Generally, unconfined aquifers may receive direct recharge from precipitation throughout their lateral extent, whereas artesian aquifers may receive such recharge only where their confining beds are absent or relatively permeable.

The piezometric surface of an aquifer is an imaginary surface to which water from an artesian aquifer will rise in tightly cased wells that penetrate the aquifer. Where the piezometric surface is above the land surface, artesian wells will flow under natural pressure.

GROUND WATER IN FLORIDA

Ground water occurs in Florida under both nonartesian and artesian conditions. Nonartesian conditions are generally restricted to the shallow deposits of sand, gravel, shells, and limestone which form many aquifers of relatively small areal extent. These deposits are the source of many domestic water supplies throughout the State and also of public and industrial supplies in areas where the deeper formations contain salty water. The water in the unconfined aquifers is generally replenished by local rainfall.

ARTESIAN WATER

Most of Florida is underlain by a thick section of permeable limestone formations of Eocene, Oligocene, and Miocene age. These formations compose an extensive artesian aquifer from which most of the large ground-water supplies of the State are obtained. Stringfield (1936, p. 125-132, 146) described the aquifer and mapped the piezometric surface in 1933 and 1934. The name "Floridan aquifer" was introduced by Parker (Parker and others, 1955, p. 188-189) to include "parts or all of the middle Eocene (Avon Park and Lake City limestones), upper Eocene (Ocala limestone), Oligocene (Suwannee limestone), and Miocene (Tampa limestone, and permeable parts of the Hawthorn formation that are in hydrologic contact with the rest of the aquifer)," The artesian water is confined by relatively impermeable layers in the limestone formations and by the overlying clay beds of Miocene age which extend over most of the State. The water in the artesian aquifer is replenished chiefly by rainfall in areas where the confining beds are absent, are breached by sinkholes, or are sufficiently permeable to permit the passage of water from the land surface into the limestone.

PIEZOMETRIC SURFACE

The configuration of the piezometric surface in peninsular Florida is shown by the contour lines in figure 7. These lines represent the height, in feet above sea level, to which water will rise in wells that penetrate the Floridan aquifer. They indicate the areas in which recharge occurs; and, through inference, the general direction of water movement in the Floridan aquifer may be deduced. In areas of recharge, the piezometric surface is relatively high. The water moves away from these areas in the direction of steepest gradient, at right angles to the contour lines, toward areas of discharge, where the piezometric surface is relatively low. In central Florida the piezometric surface forms an elongated dome which is centered in northern Polk County. The presence of this dome indicates that the lake region of Polk County is the center of a relatively large area of recharge which probably extends into adjacent counties (Stringfield, 1936, p. 148). The water enters the limestone formations in this area through the numerous sinkholes and at places where the confining bed is either absent or slightly permeable.

GROUND WATER IN THE RUSKIN AREA

In the Ruskin area the water in the Pleistocene sands and other permeable beds that lie above the Hawthorn formation is generally unconfined and is replenished by local rainfall. A few small domestic water supplies are obtained from these formations, but most domestic and larger supplies are obtained from the permeable beds of the Hawthorn formation or the underlying limestones.

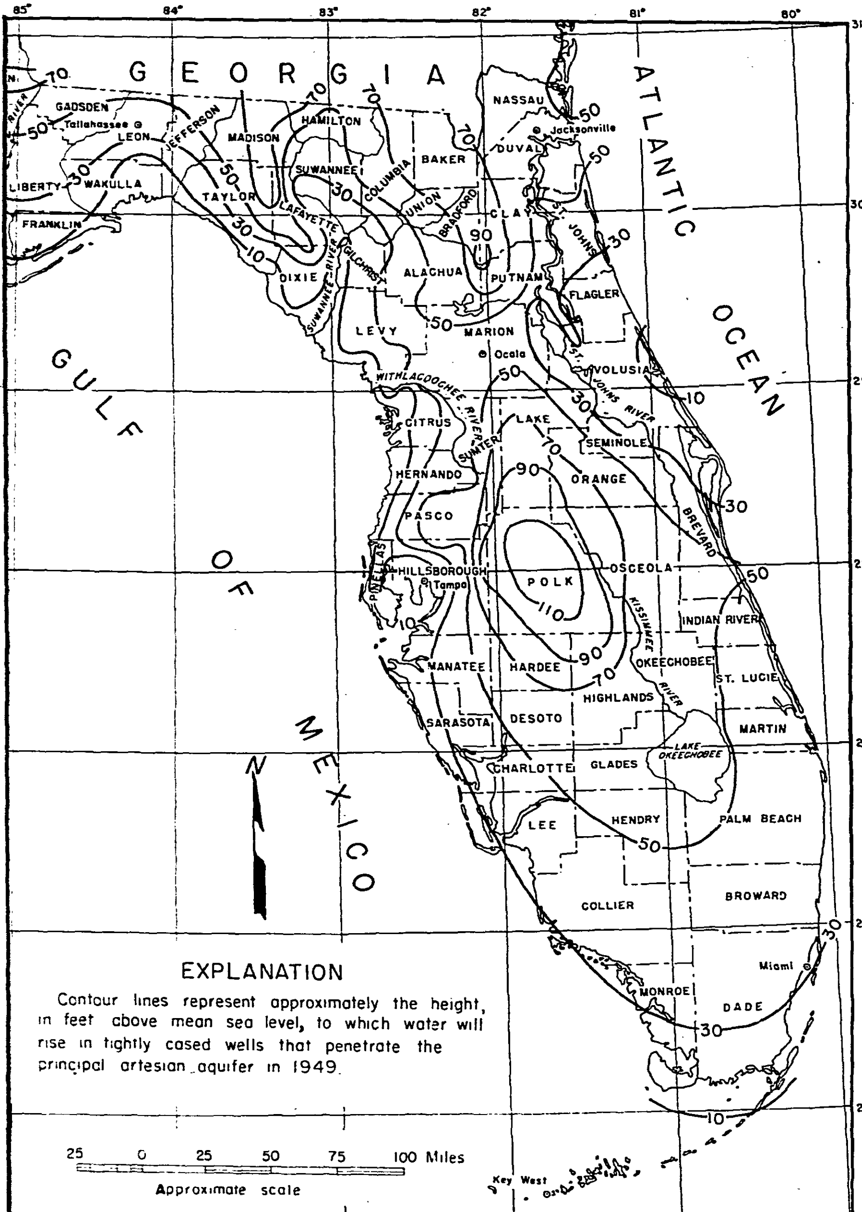

Figure 7. Map of peninsular Florida showing the piezometric surface of the Floridan aquifer in 1949.

ARTESIAN WATER

In the Ruskin area, as in most of the State, the Floridan aquifer is the principal artesian aquifer. The water in this aquifer is replenished chiefly by infiltration of rainfall in the recharge area centered in northern Polk County. From there it moves southwestward into the Ruskin area, as suggested by the configuration of the contours in figure 7.

The Avon Park limestone and the Ocala group of Eocene age, which are productive sources of water in much of peninsular Florida, are probably capable of yielding large quantities of water in the Ruskin area. These formations are penetrated by very few wells in the area, however, as the Suwannee limestone and Tampa formation are sufficiently productive to supply most wells.

The water in the Suwannee limestone and Tampa formation occurs in permeable zones separated by relatively impermeable layers which retard vertical movement of the water and serve locally as confining beds.

The Hawthorn formation consists predominantly of clay and serves as a confining bed for the water in the Floridan aquifer. Thin beds of sand and limestone within the formation contain artesian water that is the source of many domestic supplies and some small irrigation supplies. The artesian pressure head in the Hawthorn is considerably less than the head in the Floridan aquifer; thus, the Hawthorn probably receives some recharge by upward percolation of water from the Floridan aquifer.

Current-Meter Exploration: In order to determine the depth, thickness, and relative productivity of the different water-bearing zones in the limestone formations, explorations were made in several selected wells with a deep-well current meter, a device for measuring the velocity of flow of water through a well bore. The results of the current-meter traverses are shown graphically in figures 8 through 26, which also include well-construction data, electric logs, and resistivity and chloride content of the water. The velocity of the water is expressed in revolutions per minute (rpm) of the current meter. Actual flow rates, which are a function of velocity and cross-sectional area, cannot be computed accurately, as the diameter of the uncased part of the wells is not uniform.

A summary of the information obtained from the current-meter explorations (figs. 8-26) is given in table 4.

Fluctuations of Artesian Pressure Head: Fluctuations of artesian pressure head range from a fraction of a foot to several feet and are caused by one or more of several factors. The larger

TABLE 4. Summary of Results of the Current-Meter Explorations

Well number	Rate of flow (gpm)	Depth of principal producing zones (feet below msl)
40-30-1	250	200 to 245 245 to 355 355 to 360 420 to 445
43-26-4	100	320 to 325 365 to 395 420 to 480
43-26-7	300	245 to 285 315 to 325 355 to 365
43-26-12	300	125 to 150 235 to 250 325 to 350
43-26-26	300	100 to 120 200 to 270 310 to 410
44-24-15	50	280 to 290
44-25-42	350	120 to 160 295 to 335 355 to 370
44-26-10	200	100 to 285 305 to 320 345 to 370
44-26-31	350	395 to 420+
45-24-13	350	70 to 190 395 to 404
45-24-17	300	220 to 260 295 to 310 340 to 345
45-24-23	125	155 to 170 255 to 265 365 to 380
45-25-20	200	90 to 105 170 to 265
45-26-2	125	110 to 140 295 to 305
45-26-3	250	170 to 195 265 to 275 355 to 385 410 to 420
46-24-7	350	195 to 495
46-24-8	350	85 to 105 235 to 275 395 to 415
46-24-12	150	70 to 80 195 to 237+
46-24-17	250	170 to 190 295 to 333
47-23-8	125	150 to 160 255 to 275
48-23-15	150	175 to 190 215 to 240 265 to 280

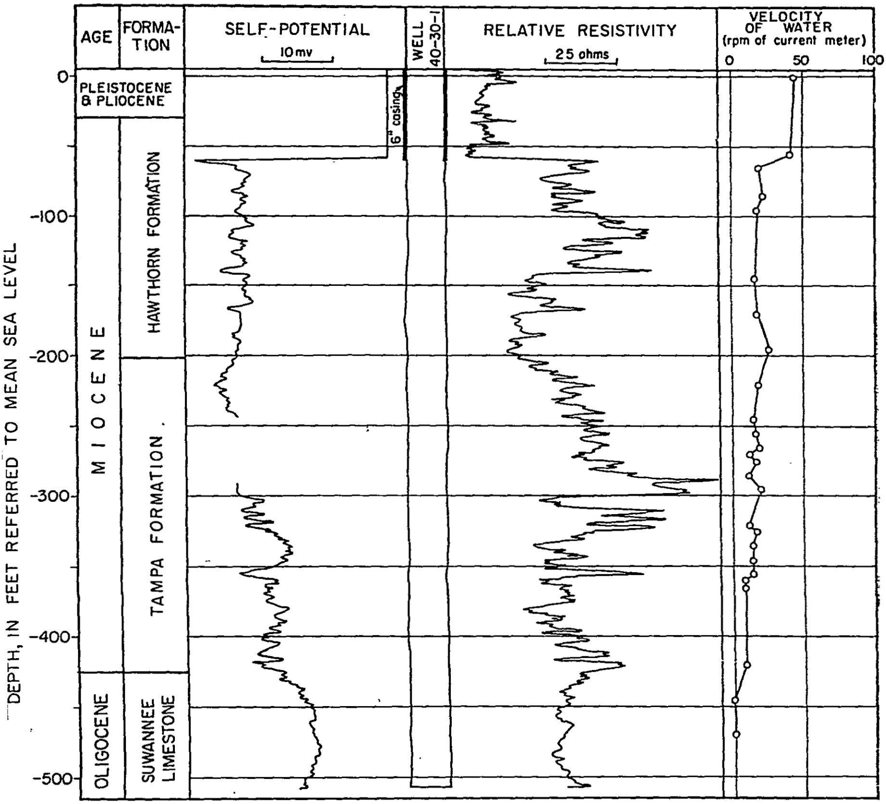

Figure 8. Graph showing well-exploration data for well 40-30-1.

fluctuations generally result from daily and seasonal changes in withdrawal of water from wells or from variations in recharge from rainfall. Minor fluctuations are caused by tides, atmospheric-pressure changes, winds, earthquakes, and passing trains. The minor fluctuations of water levels and their causes are discussed in detail in a paper by Parker and Stringfield (1950).

Records from continuous recording gages on two wells and periodic water-level measurements in about 20 wells provide information on the fluctuations of artesian pressure head in the Ruskin area during a period of about 6 years. Hydrographs prepared from the records of the continuous recording gages on wells 42-19-1 and 44-25-39 are shown in figure 27. Hydrographs of 16 wells in which water levels were measured periodically are shown in figures 28-33. Water-level measurements in other wells are listed in table 6 and in Information Circular No. 22.

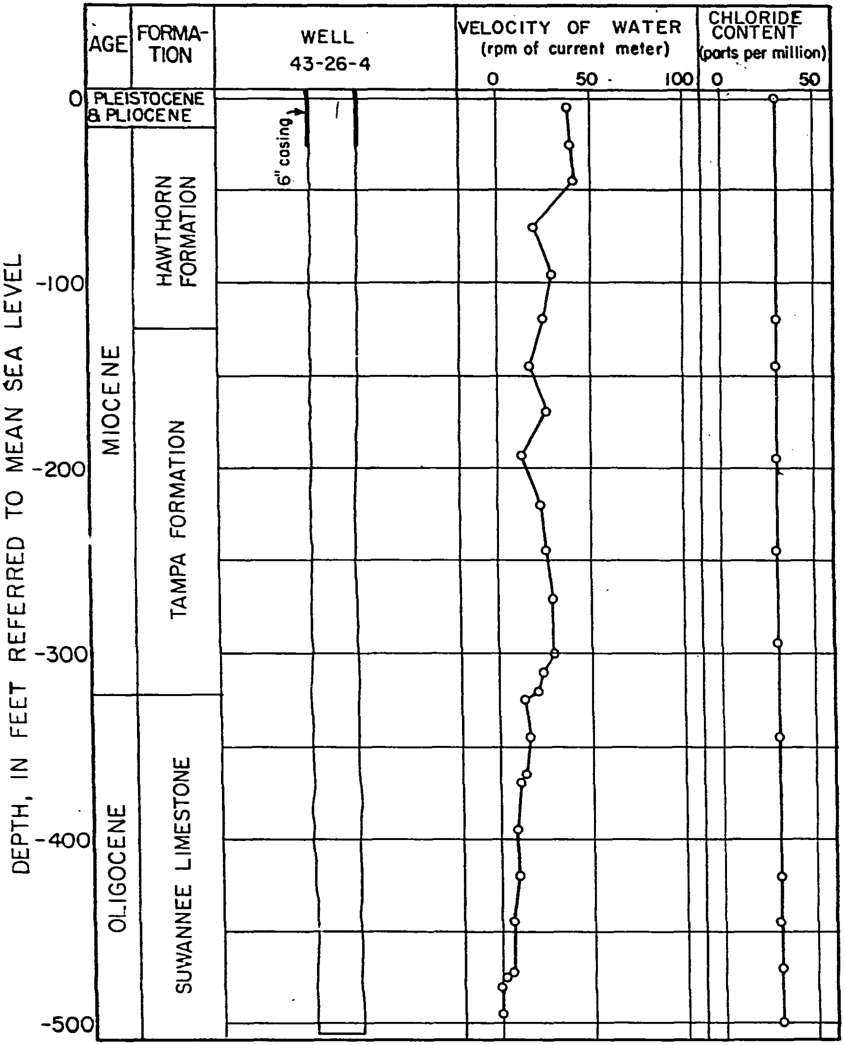

Figure 9. Graph showing well-exploration data for well 43-26-4.

The hydrograph of well 42-19-1 (fig. 27) shows the seasonal fluctuations and regional trend of the artesian pressure head from August 1951 to December 1956. The seasonal use of water is indicated by the declines in head during periods of least rainfall, when large quantities of water were being used for irrigation. The rises in head, corresponding to periods of greater rainfall, are due primarily to a decrease in discharge but at times may

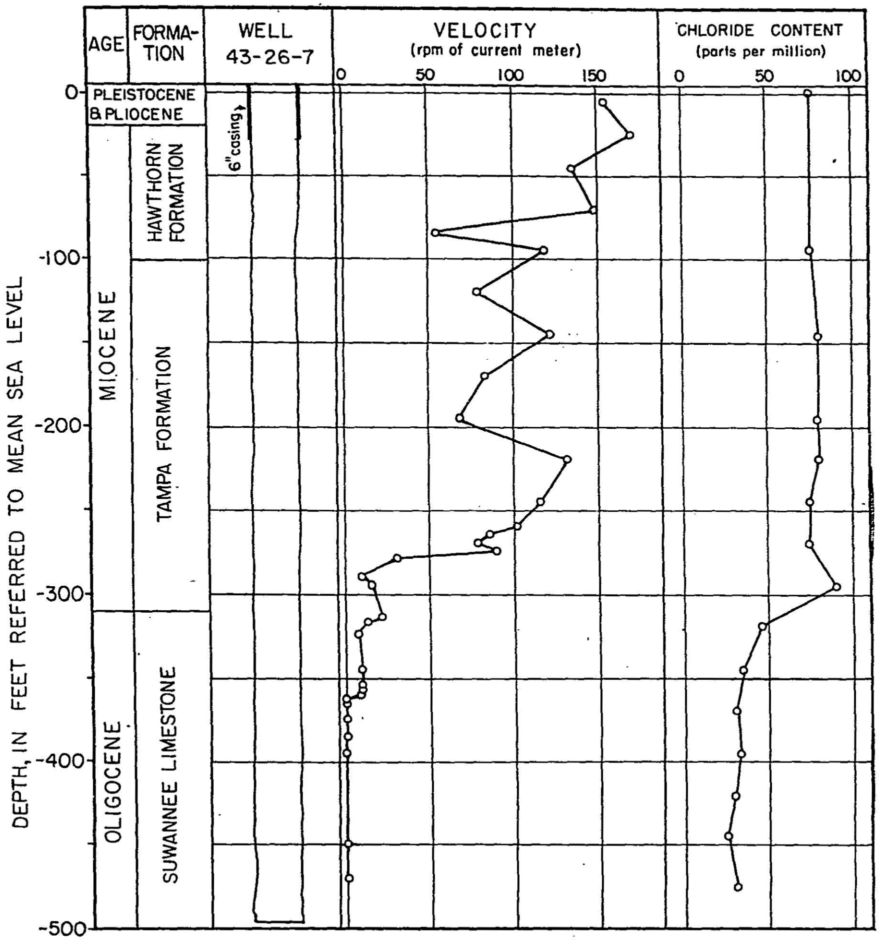

Figure 10. Graph showing well-exploration data for well 43-26-7.

indicate an increase in recharge. The hydrograph indicates that the magnitude of seasonal fluctuations has increased from about four feet in 1952 to about eight feet in 1956. The lowest recorded water level in this well was 29.6 feet, in April 1956. The progressive increase in the magnitude of seasonal fluctuations and the general downward trend of the artesian pressure head throughout the period of record reflect the regional increase in both seasonal and perennial use of water.

The hydrograph of well 44-25-39 (fig. 27) shows the effects of seasonal differences in local withdrawals. The slight downward

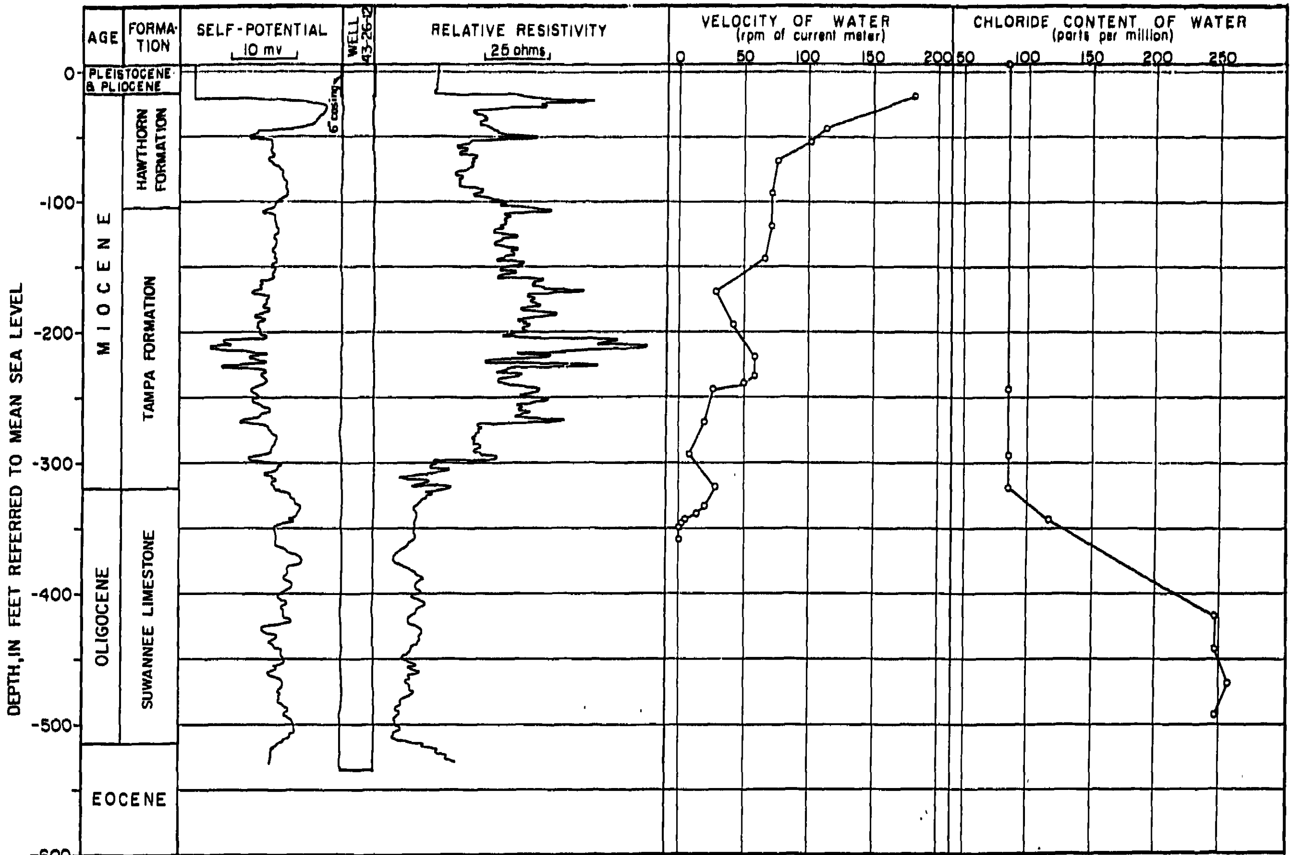

Figure 11. Graph showing well-exploration data for well 43-26-12.

trend of the artesian pressure head from 1950 to 1952 probably reflects the increased use of water resulting from expansion of agriculture during this period. The hydrograph indicates that local use of water has been relatively stable since 1952.

The hydrographs in figures 28-33 also show seasonal fluctuations due to local discharge. Some hydrographs indicate that discharge has remained relatively stable since about 1952, whereas others show a general upward trend of the artesian pressure head since 1953, thus indicating a decrease in local use of water.

Although the principal fluctuations of artesian head in the Ruskin area are caused by changes in the rate of withdrawal of water from wells, observable changes are caused by earthquakes, atmospheric-pressure changes, and other factors.

Earthquake waves passing through the earth's crust cause a relatively rapid expansion and contraction of artesian aquifers, which results in fluctuations of the artesian pressure head. The magnitude of these fluctuations in a particular well may range from a few hundredths of a foot to several feet, according to the intensity of the earthquake and the distance of the epicenter from

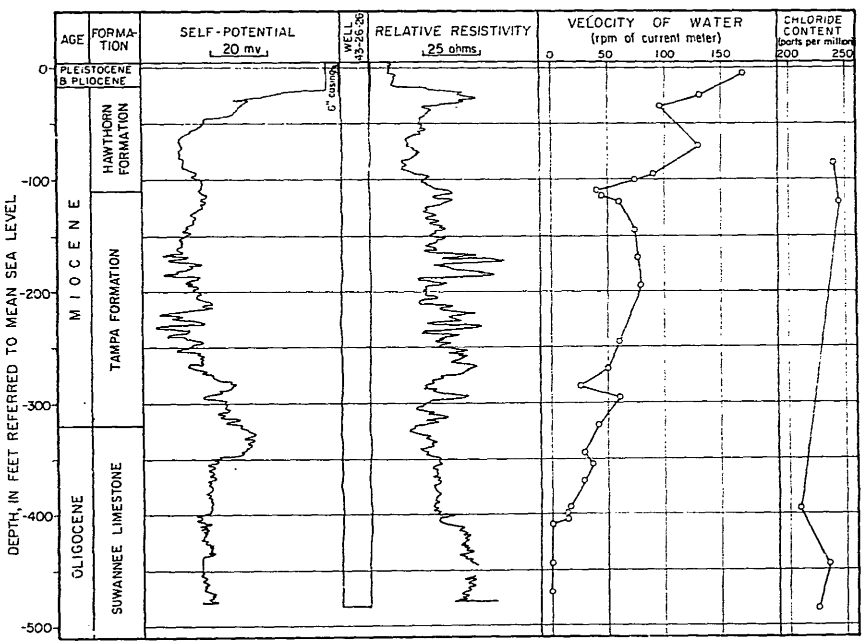

Figure 12. Graph showing well-exploration data for well 43-26-26.

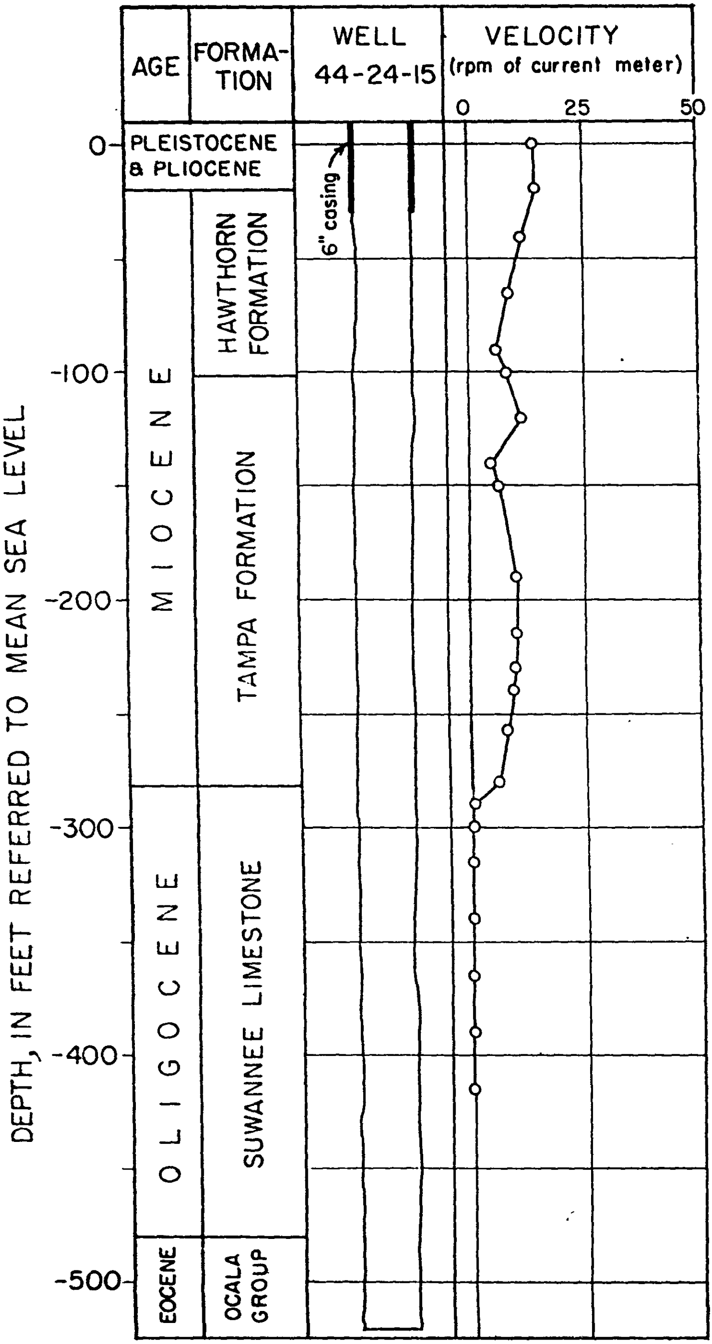

Figure 13. Graph showing well-exploration data for well 44-24-15.

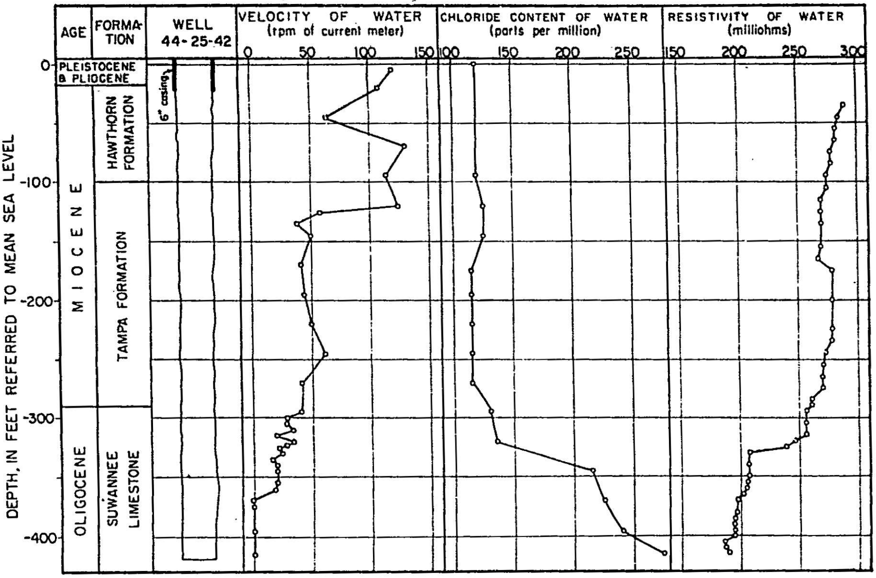

Figure 14. Graph showing well-exploration data for well 44-25-42.

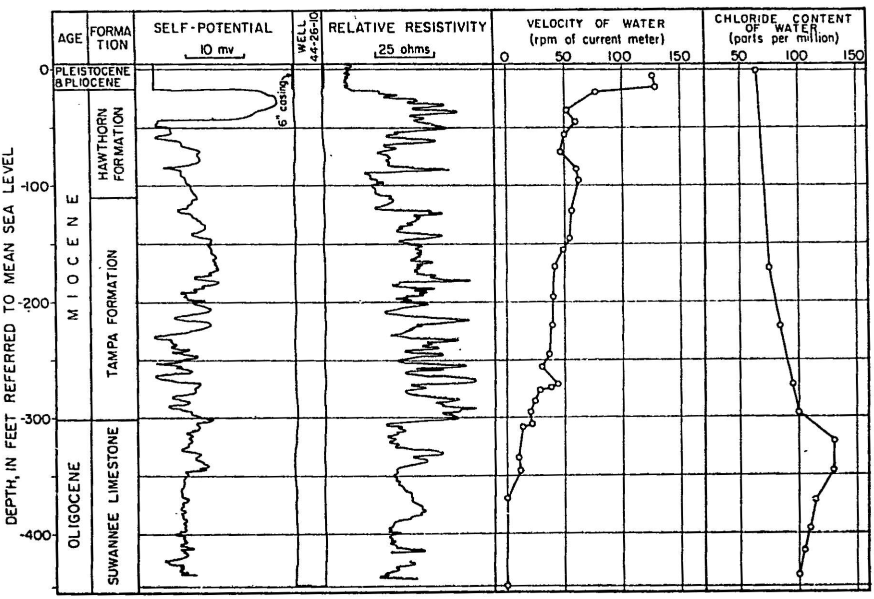

Figure 15. Graph showing well-exploration data for well 44-26-10.

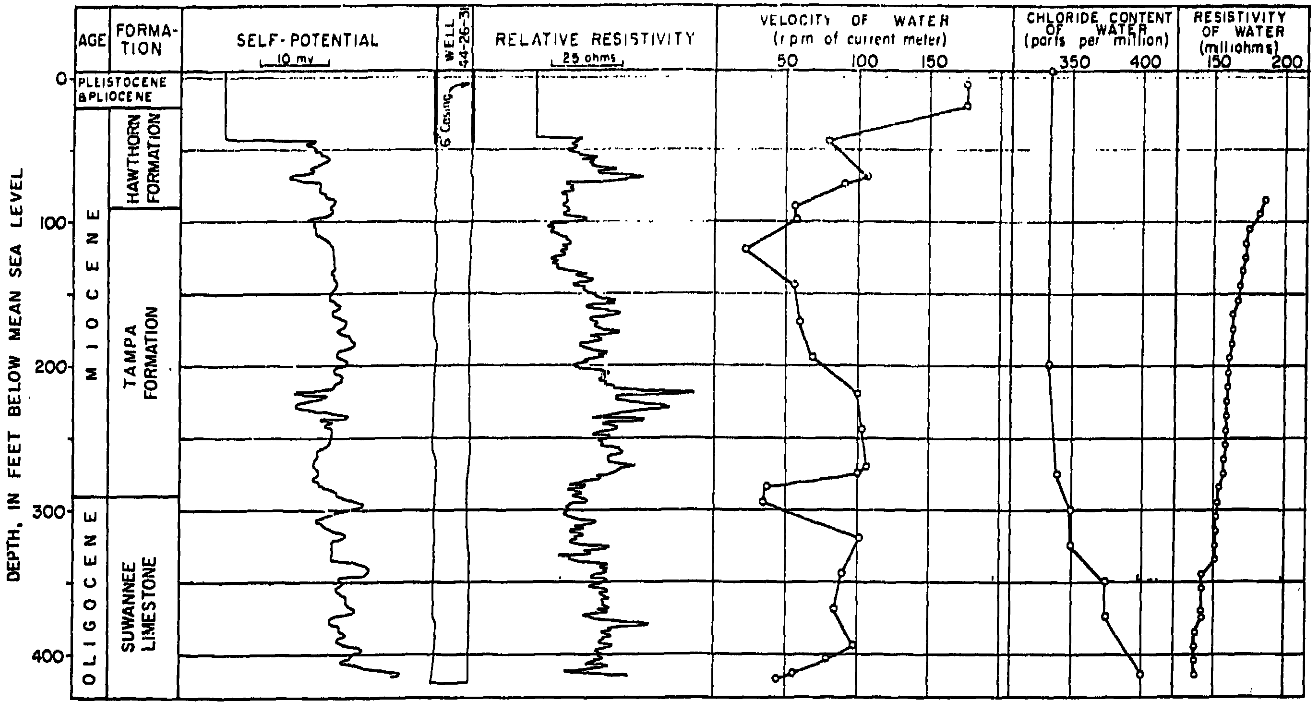

Figure 16. Graph showing well-exploration data for well 44-26-31.

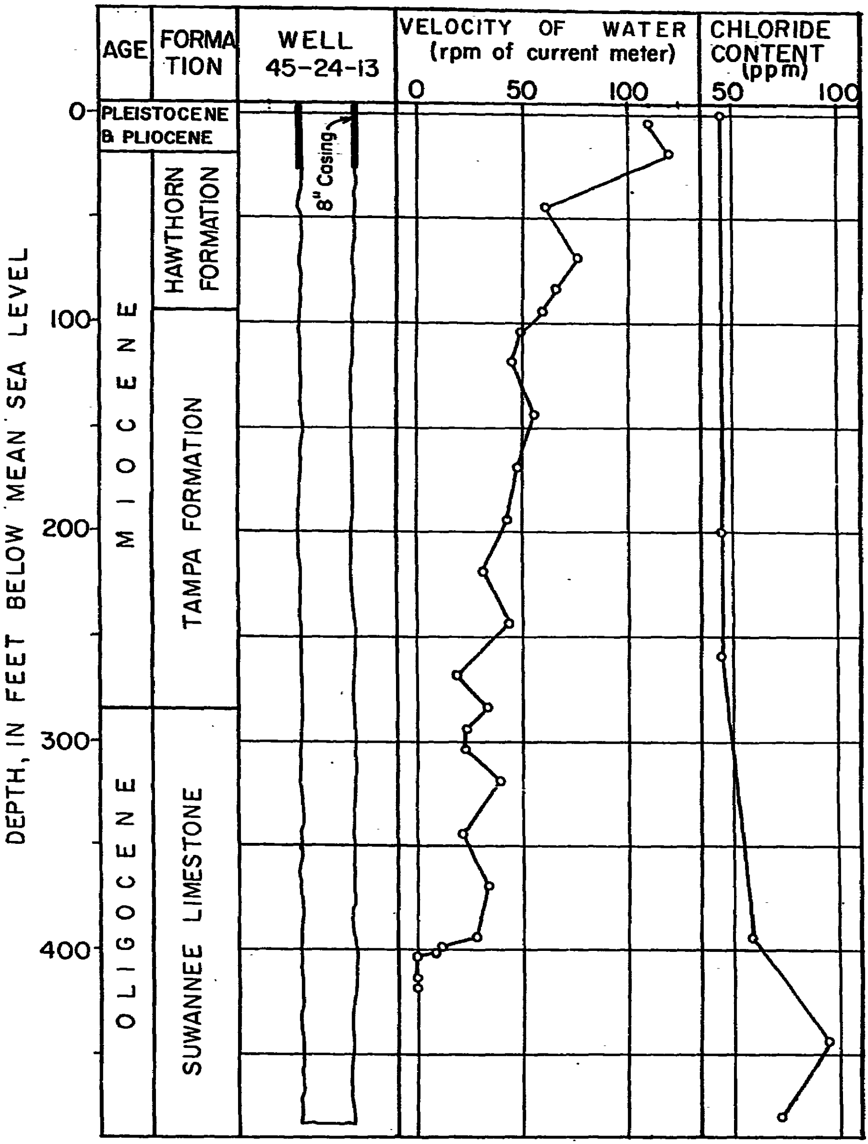

Figure 17. Graph showing well-exploration data for well 45-24-13.

the well. The effects of earthquakes on water levels in wells 42-19-1 and 44-25-39 are shown on the hydrographs in figure 34, which were traced from the charts of continuous recording gages. An earthquake in southern California, which occurred on July 21, 1952, had a magnitude of 7.5 (based on a comparative scale that ranges from a minimum intensity of 1 to a maximum intensity of 10) and caused maximum water-level fluctuations of 0.85 foot in well 42-19-1 and 0.46 foot in well 44-25-39. An earthquake of 8.5 intensity near the east coast of Kamchatka, in Siberia, on November 4, 1952, caused maximum water-level fluctuations of 0.86 foot in well 42-19-1 and 1.24 feet in well 44-25-39.

Daily changes in atmospheric pressure cause minor fluctuations of artesian pressure head which are observable in most wells, but these changes may be masked or modified by fluctuation due to tides, local pumping, or other factors. The effects of atmospheric-pressure changes on the water level in well 44-25-39 may be seen on the hydrographs in figure 34, even though these fluctuations are probably modified somewhat by effects of ocean tides and local discharge. The effects of changes in atmospheric pressure on the water level in well 42-19-1, which is not affected by local pumping or ocean tides, are shown also in figure 34. The

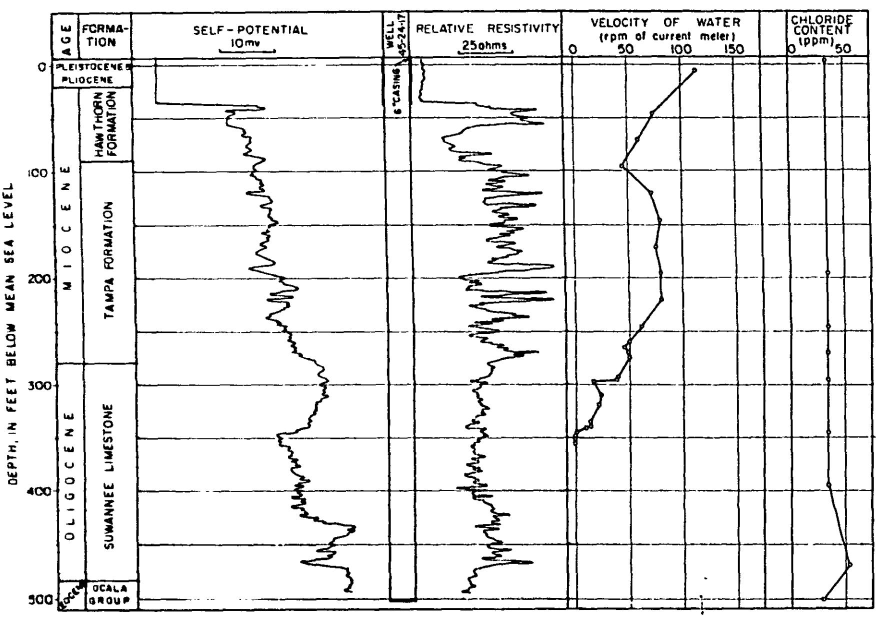

Figure 18. Graph showing well-exploration data for well 45-24-17.

periods of low atmospheric pressure in the early morning and late afternoon are represented by high water levels. The highest atmospheric pressures occur about noon and midnight and are represented by the lowest water levels. The magnitude of the fluctuations caused by changes in atmospheric pressure is generally

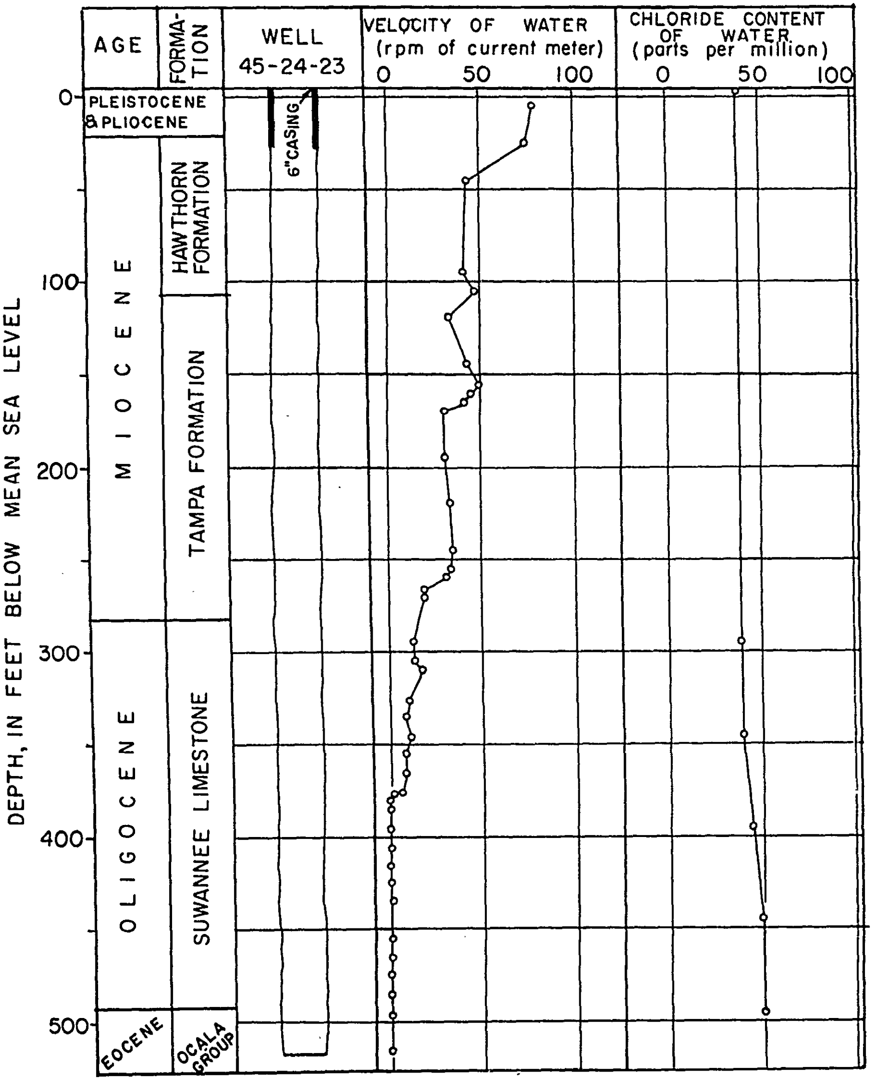

Figure 19. Graph showing well-exploration data for well 45-24-23.

less than 0.1 foot but may be considerably greater during a hurricane, when extremely low pressure may cause water levels to rise several tenths of a foot.

Piezometric Surface: The contours on the map in figure 35 show the configuration of the piezometric surface of the Floridan aquifer in October 1952. The piezometric surface at that time was more than 45 feet above mean sea level (msl) in the southeastern part of the area and from there sloped northwestward to sea level in the vicinity of East Tampa, indicating a general movement of the artesian water from southeast to northwest. In the eastern part of the area, where interference by discharging wells is negligible, the gradient of the piezometric surface is about three to five feet per mile. The depressions in the piezometric surface along the coast reveal the areas in which water was being discharged from the aquifer. The deepest depressions, and hence the areas of greatest discharge, are indicated by the closed contours north of Ruskin and northwest of Sun City.

The depressions in the piezometric surface are probably the result of discharge from wells. However, as most of the wells are cased to depths of less than 50 feet, the depressions may reflect, in addition, losses of artesian pressure head caused by upward leakage of water from the Floridan aquifer into the shallow formations through unused wells. The relatively large depression indicated by the contours north of Adamsville is probably the result of perennial withdrawal of large quantities of water for industrial use and also some natural discharge from springs and seeps.

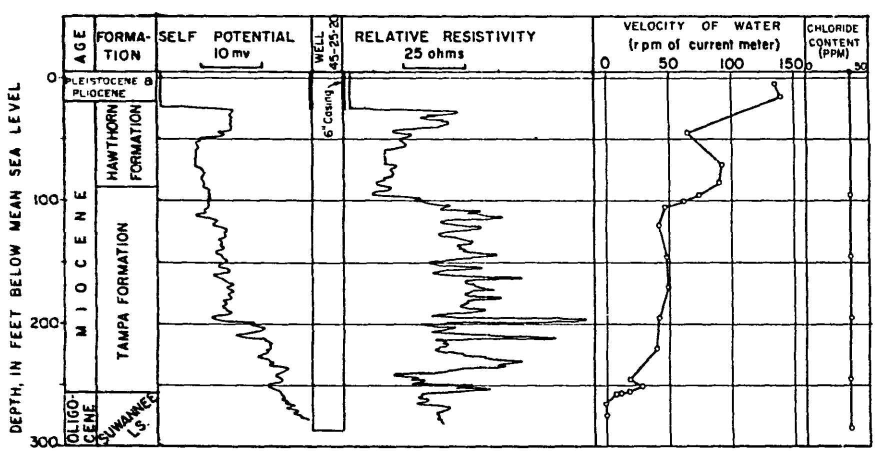

Figure 20. Graph showing well-exploration data for well 45-25-20.

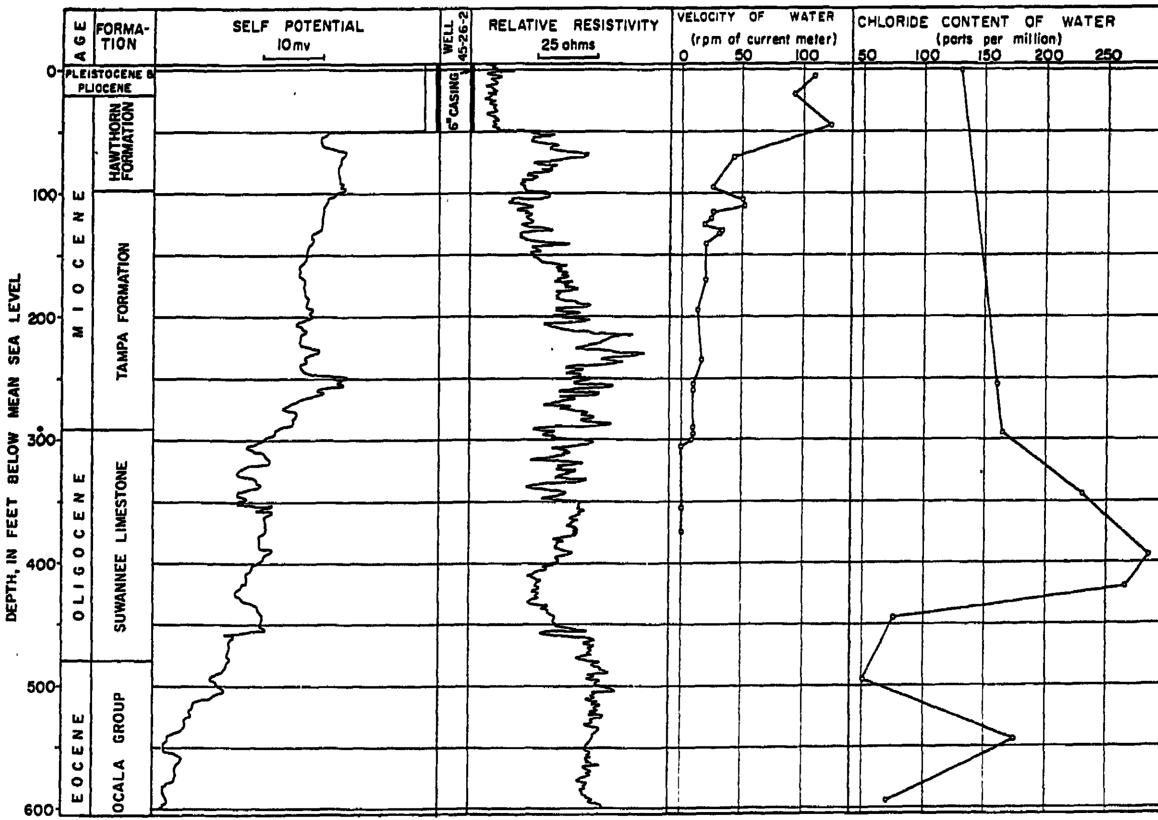

Figure 21. Graph showing well-exploration data for well 45-26-2.

The contours on the map in figure 36 represent the piezometric surface in May 1953, during an extended period of dry weather when large quantities of ground water were being withdrawn for irrigation. The altitude of the piezometric surface ranged from more than 40 feet above msl in the southeastern part of the area to sea level in the vicinity of East Tampa. A comparison of figures 35 and 36 shows that the piezometric surface was generally about 5 feet lower in May than in October

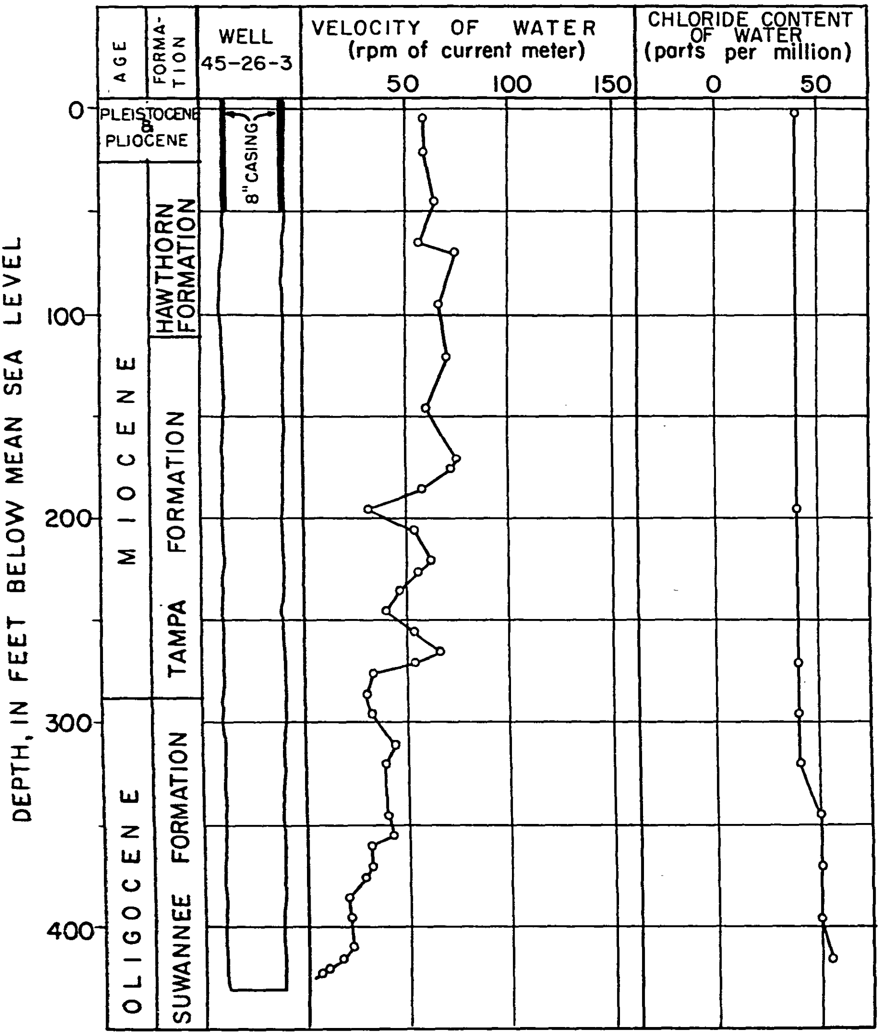

Figure 22. Graph showing well-exploration data for well 45-26-3.

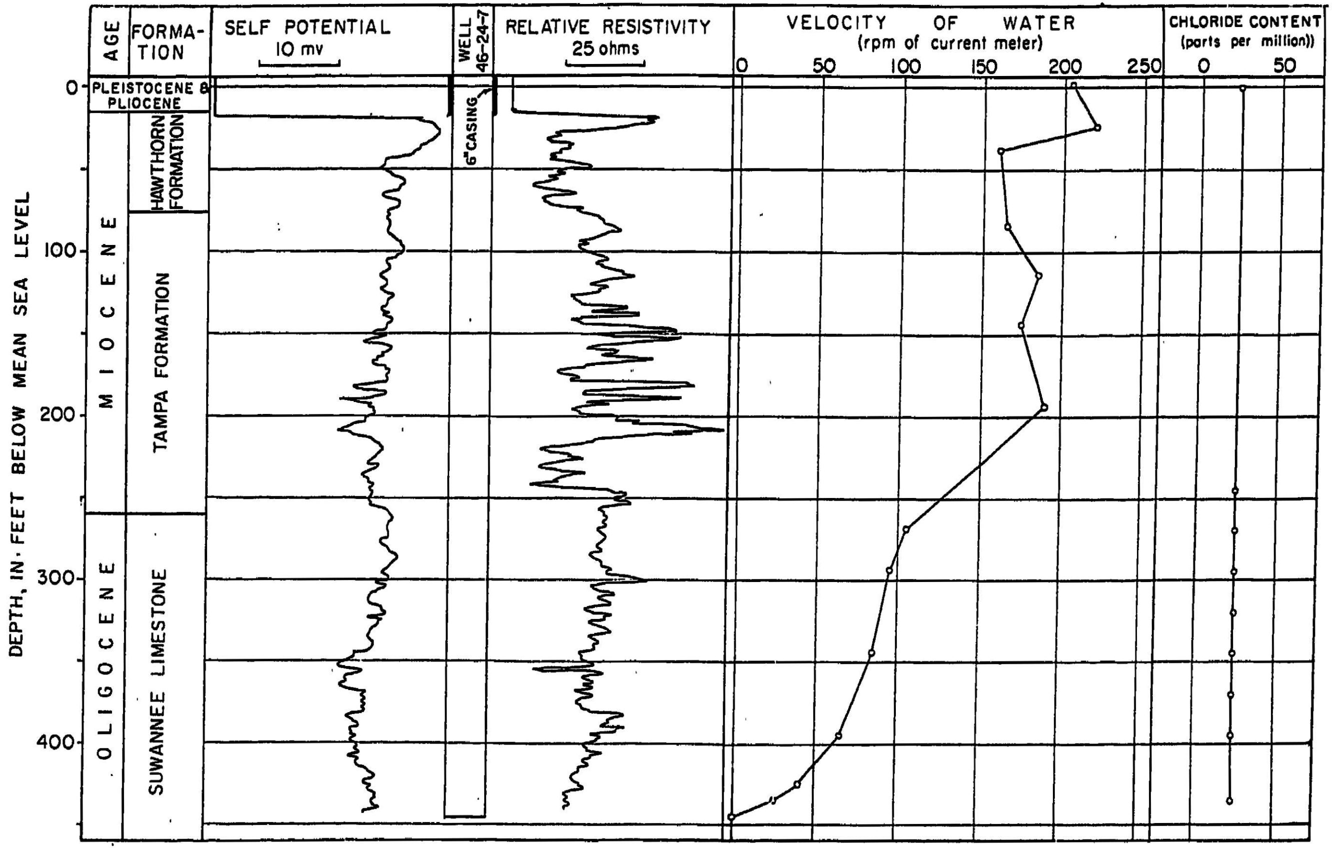

Figure 23. Graph showing well-exploration data for well 46-24-7.

as a result of the combined drawdown of several hundred irrigation wells.

Depth of Water Levels Below Land Surface: The area of artesian flow and the approximate depth to water below the land surface in wells that penetrate the Floridan aquifer, based on the piezometric surface in May 1953, are shown in figure 37. The area of flow includes a zone about one to three miles wide along the coast, south of the Alafia River, and extends completely across the Ruskin area along the valley of the Little Manatee River. It includes also a narrow zone along the Alafia River in the vicinity of Riverview. The depth to water below the land surface is

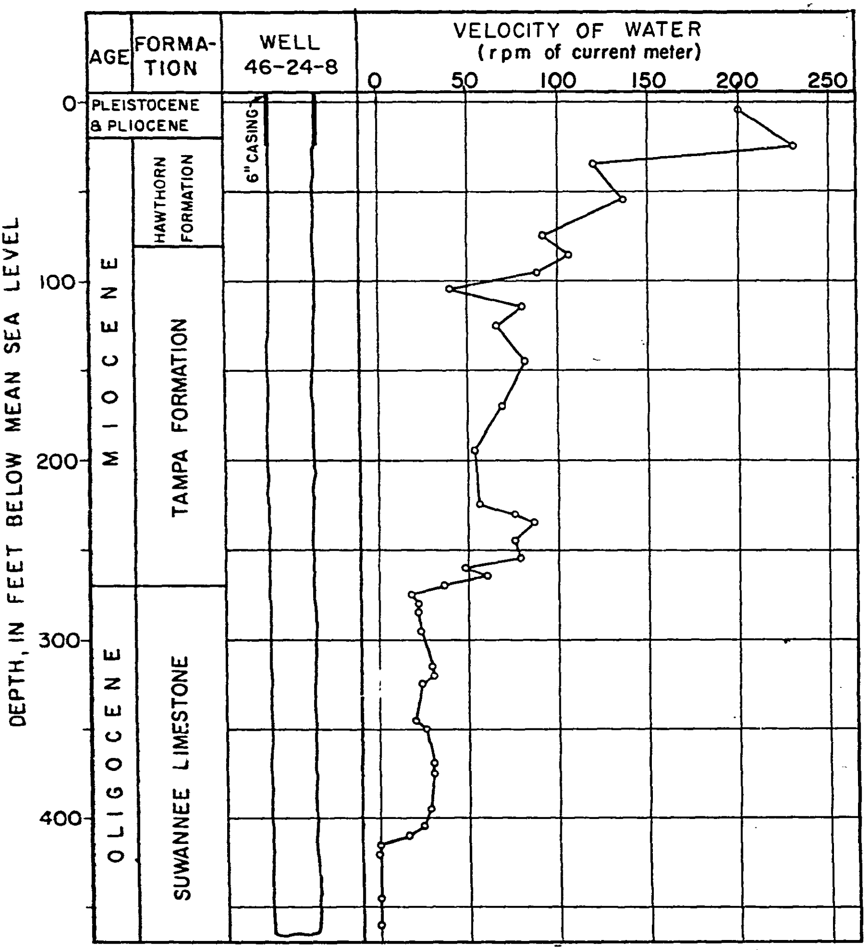

Figure 24. Graph showing well-exploration data for well 46-24-8.

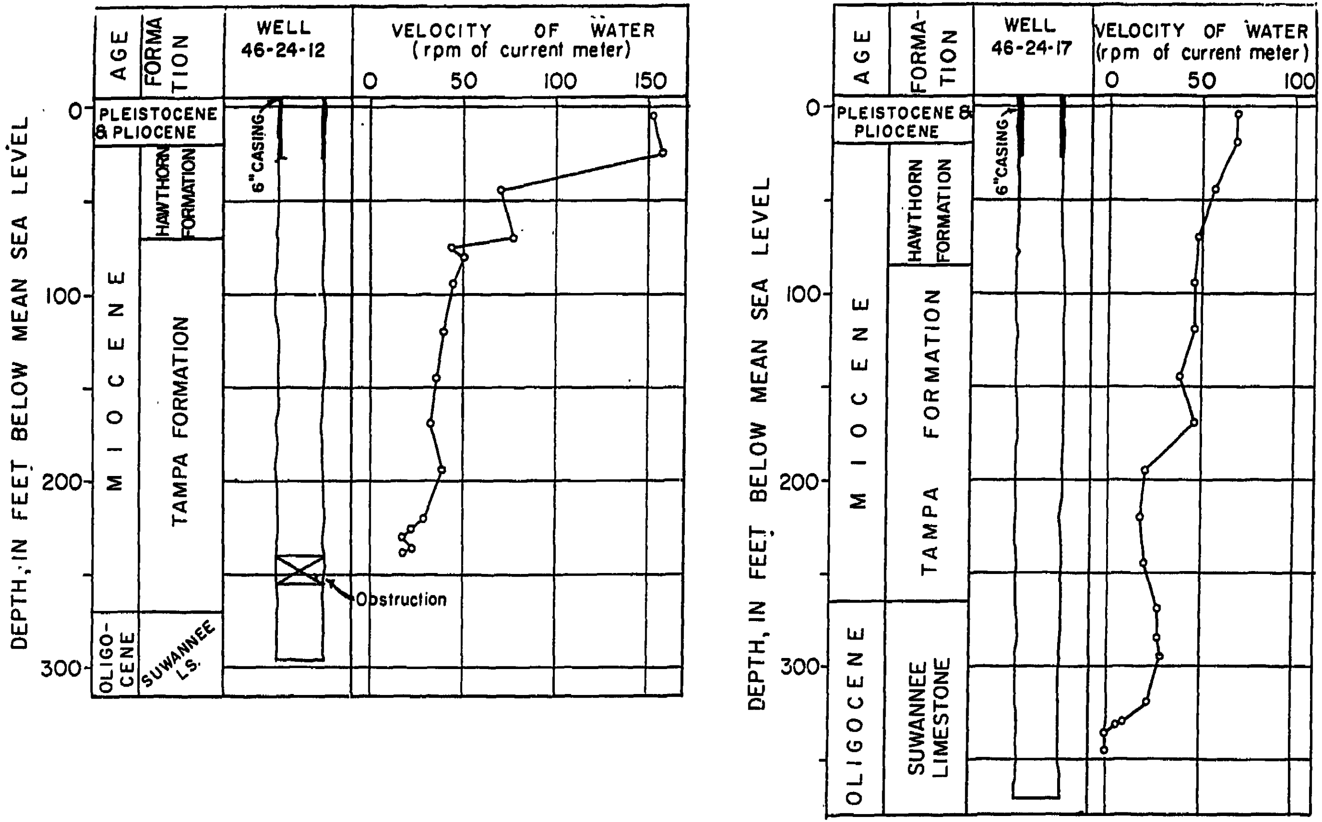

Figure 25. Graphs showing well-exploration data for wells 46-24-12 and 46-24-17.

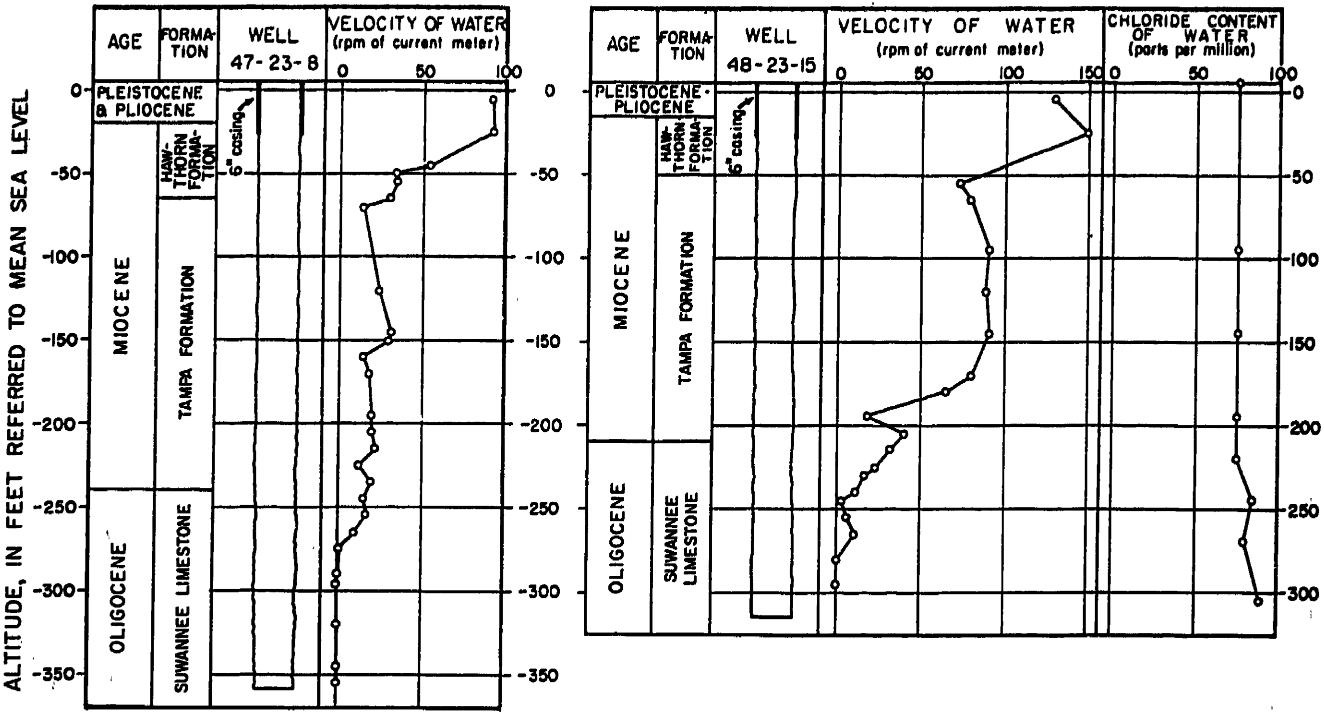

Figure 26. Graphs showing well-exploration data for wells 47-23-8 and 48-23-15.

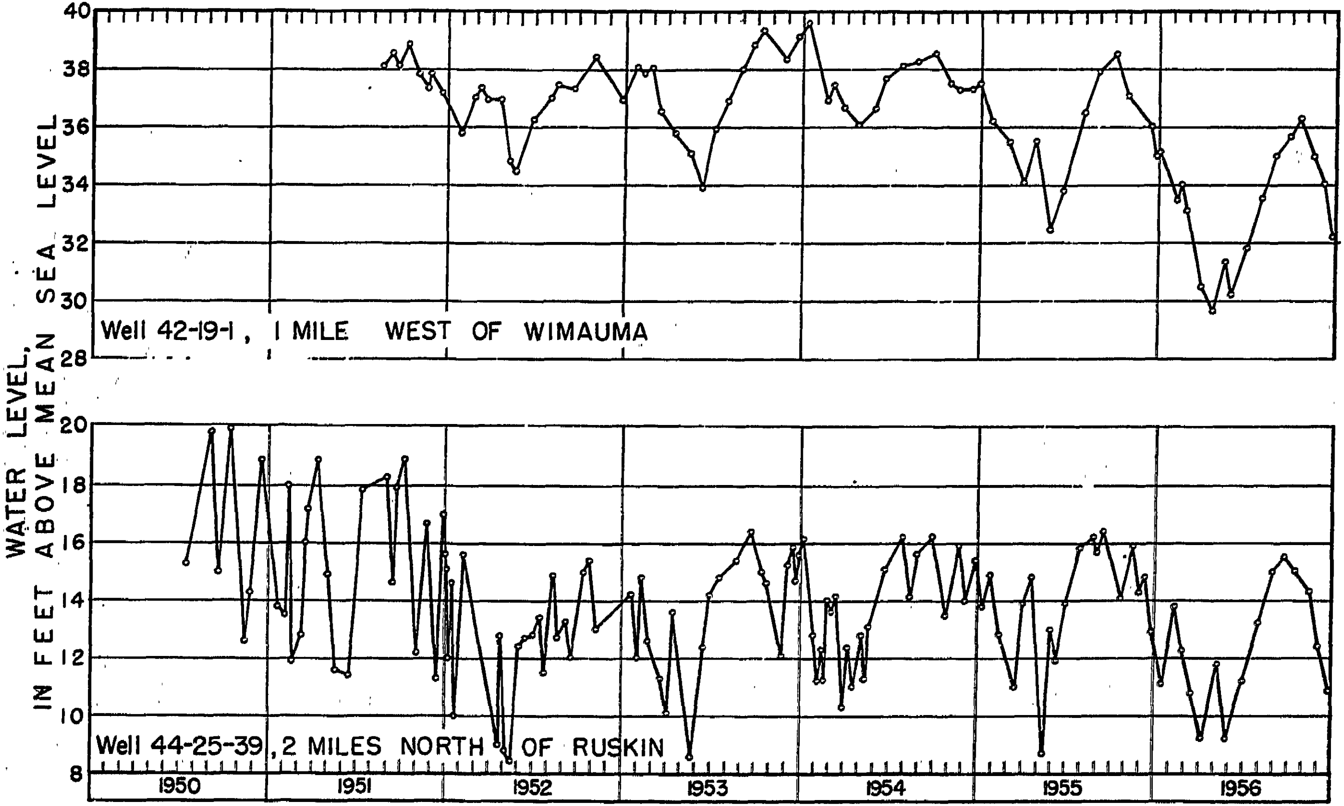

Figure 27. Hydrographs of wells 42-19-1 and 44-25-39.

greatest in the east-central part of the area, where it is 50 feet or more. Throughout most of the area, however, it is less than 25 feet.

Wells: About 650 wells were inventoried during this investigation, and the information obtained is given in Information Circular No. 22. As shown in plate 1, most of the wells are in a zone about three to five miles wide along the coast, and most of them flow, at least intermittently. They range in depth from 60 to more than 700 feet, but most of them are between 300 and

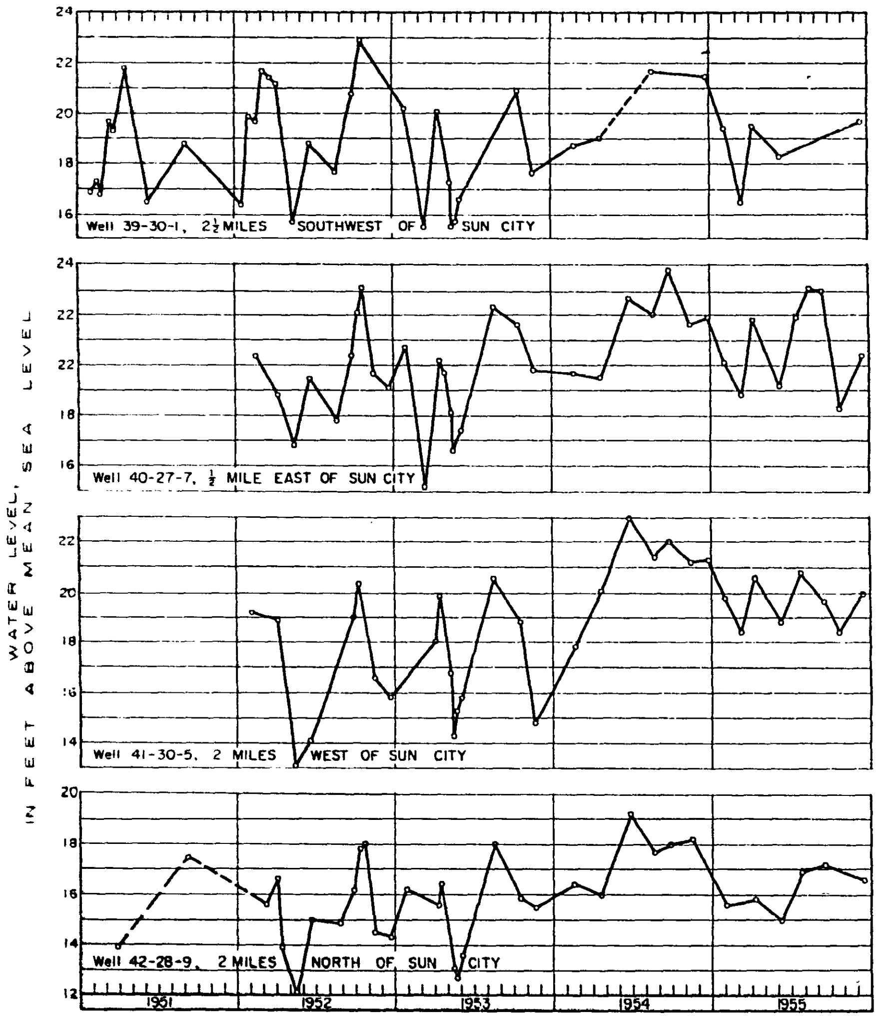

Figure 28. Hydrographs of wells 39-30-1, 40-27-7, 41-30-5, and 42-28-9.

500 feet deep. They range in diameter from 2 inches to 18 inches, but most of them are 6 to 8 inches in diameter. Surface casings are generally seated in the Hawthorn formation, at depths of 20 to 75 feet, although some wells contain as much as 200 feet of surface casing. In addition to the surface casing,

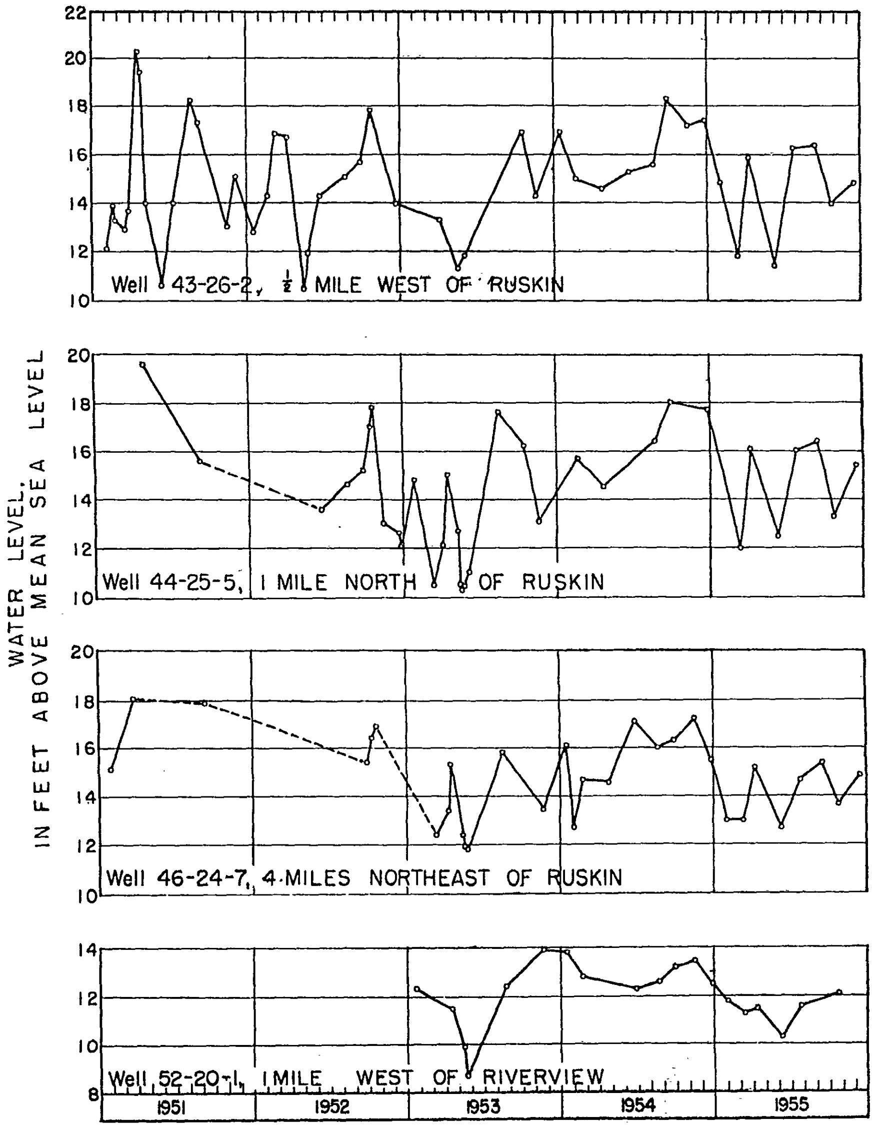

Figure 29. Hydrographs of wells 43-26-2, 44-25-5, 46-24-7, and 52-20-1.

many wells are equipped with an inner casing extending to greater depth to shut off caving sands.

The yields of the wells differ because of difference in the permeability and thickness of the aquifer penetrated, the artesian pressure head, and the size of the well bore. The irrigation wells six inches or more in diameter, in the area of perennial artesian flow, generally yield about 100 to 400 gpm.

Temperature: Measurements of the temperature of artesian water from several hundred wells are given in Information Circular No. 22 and a few are included in table 5. The temperature of the water from the Hawthorn formation is generally between 74° and 76°F, and that from the Tampa formation is generally between 76° and 77.5°F, depending upon the depth to the principal producing zones. The temperature of the water from wells that penetrate the Suwannee limestone and older formations is generally about 78° to 79°F, but it ranges from about 77.5° to 82°F, according to the depth and proportionate yield of the various producing zones in these formations.

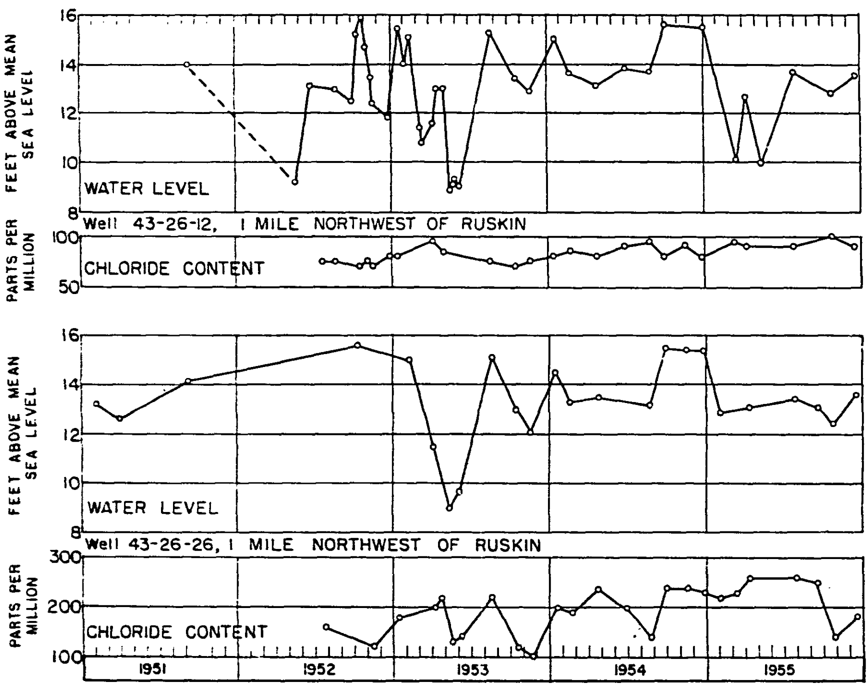

Figure 30. Hydrographs of and chloride content of water from wells 43-26-12 and 43-26-26.

QUANTITATIVE STUDIES

The withdrawal of water from an artesian aquifer creates a depression in the piezometric surface in the vicinity of the point of withdrawal. This depression generally has the approximate form of an inverted cone and is referred to as the cone of depression. The distance the piezometric surface is lowered at any given point within this cone is known as the drawdown at

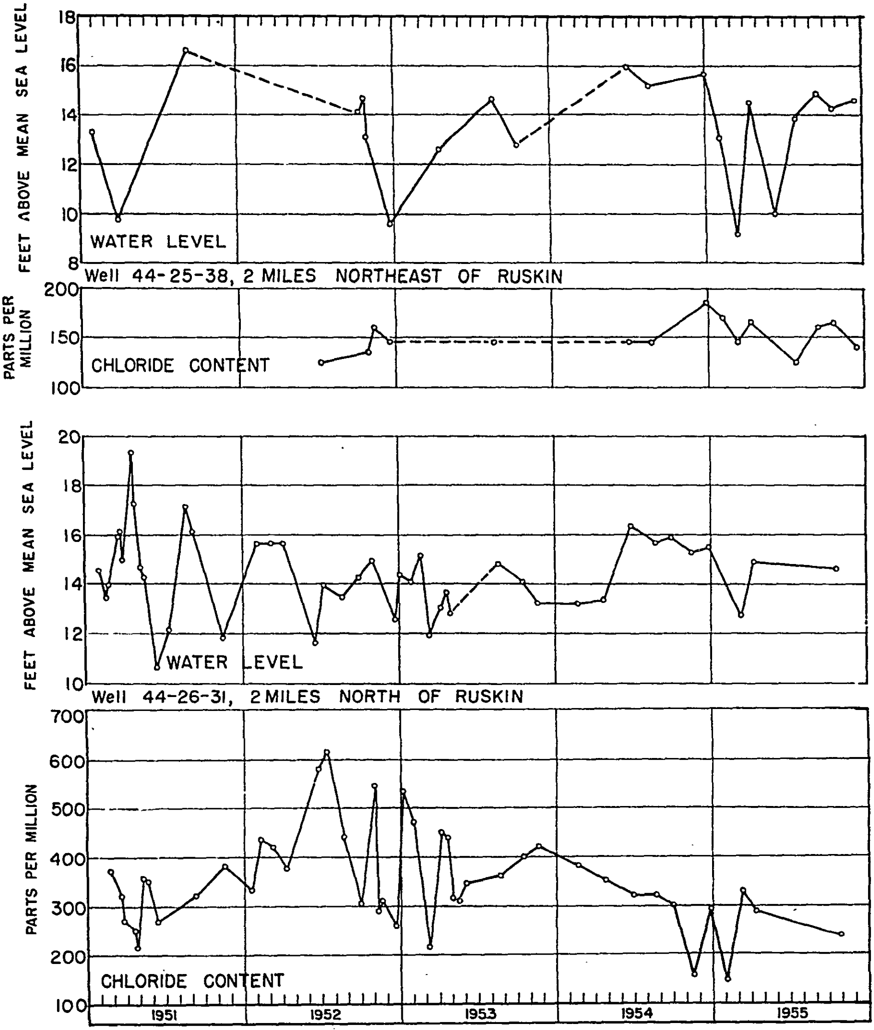

Figure 31. Hydrographs of and chloride content of water from wells 44-25-38 and 44-26-31.

that point. The size, shape, and rate of growth of the cone of depression depends on several factors, including (1) the rate of pumping, (2) the water-transmitting and storage capacities of the aquifer, (3) the increase in recharge resulting from the lowering of the piezometric surface, and (4) the decrease in natural discharge due to the lowering of the piezometric surface. The perennial yield of the artesian aquifer in the Ruskin area is limited by the extent to which the piezometric surface can be lowered without impairing the quality of the water or making the cost of obtaining the water prohibitive.

The principal hydraulic properties of an aquifer are its capacities to transmit and store water, for all aquifers serve as

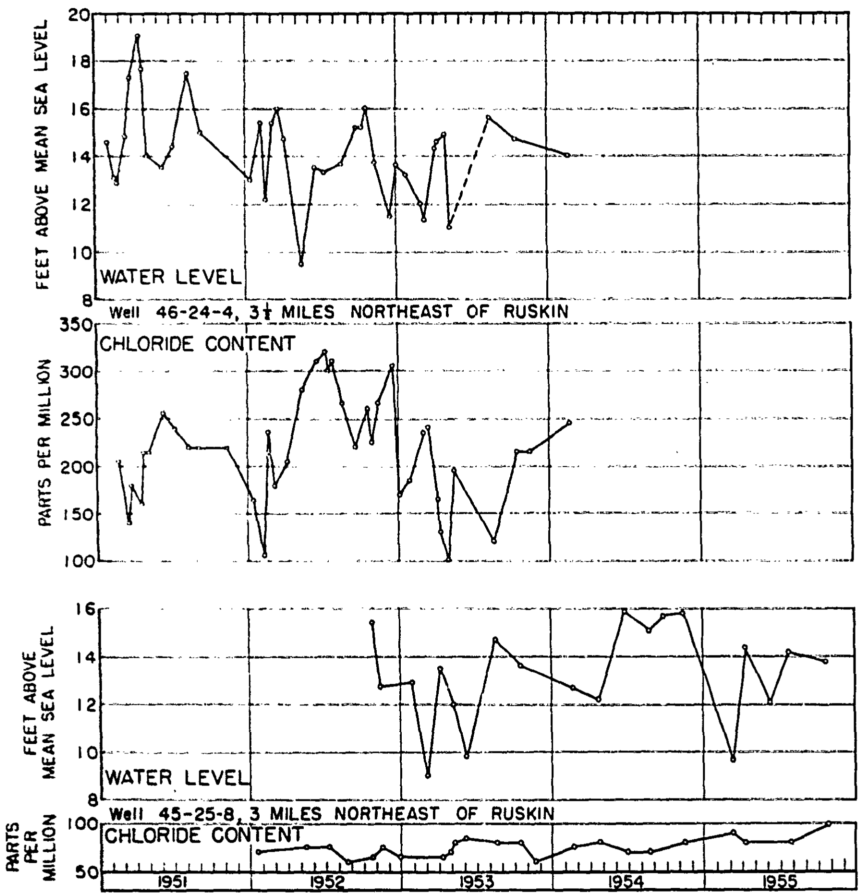

Figure 32. Hydrographs of and chloride content of water from wells 45-25-8 and 46-24-4.

both conduits and reservoirs. An artesian aquifer functions primarily as a conduit, transmitting water from places of recharge to places of discharge; however, it is capable of storing water, by expansion, or releasing water, by compression.

The coefficient of transmissibility is a measure of the capacity of an aquifer to transmit water. In units commonly used by the U. S. Geological Survey, it is the quantity of water, in gallons per day (gpd), that will flow through a vertical section of the aquifer one foot wide and extending the full saturated height, under a unit hydraulic gradient, at the prevailing temperature of the water. The coefficient of storage is a measure of the capacity of an aquifer to store water, and is defined as the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in head normal to that surface.

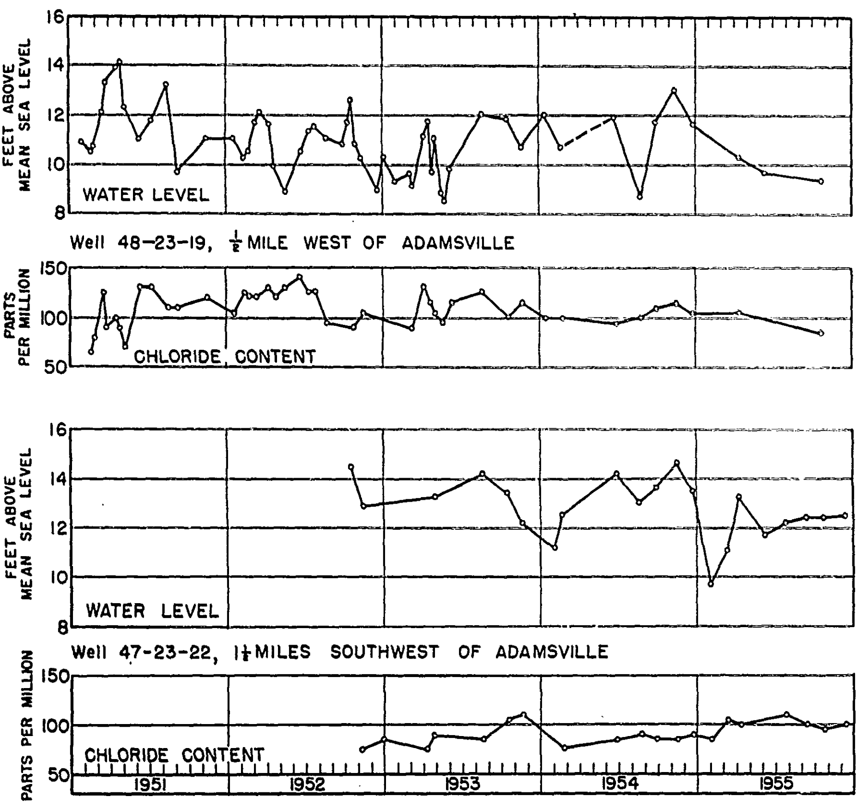

Figure 33. Hydrographs of and chloride content of water from wells 47-23-22 and 48-23-19.

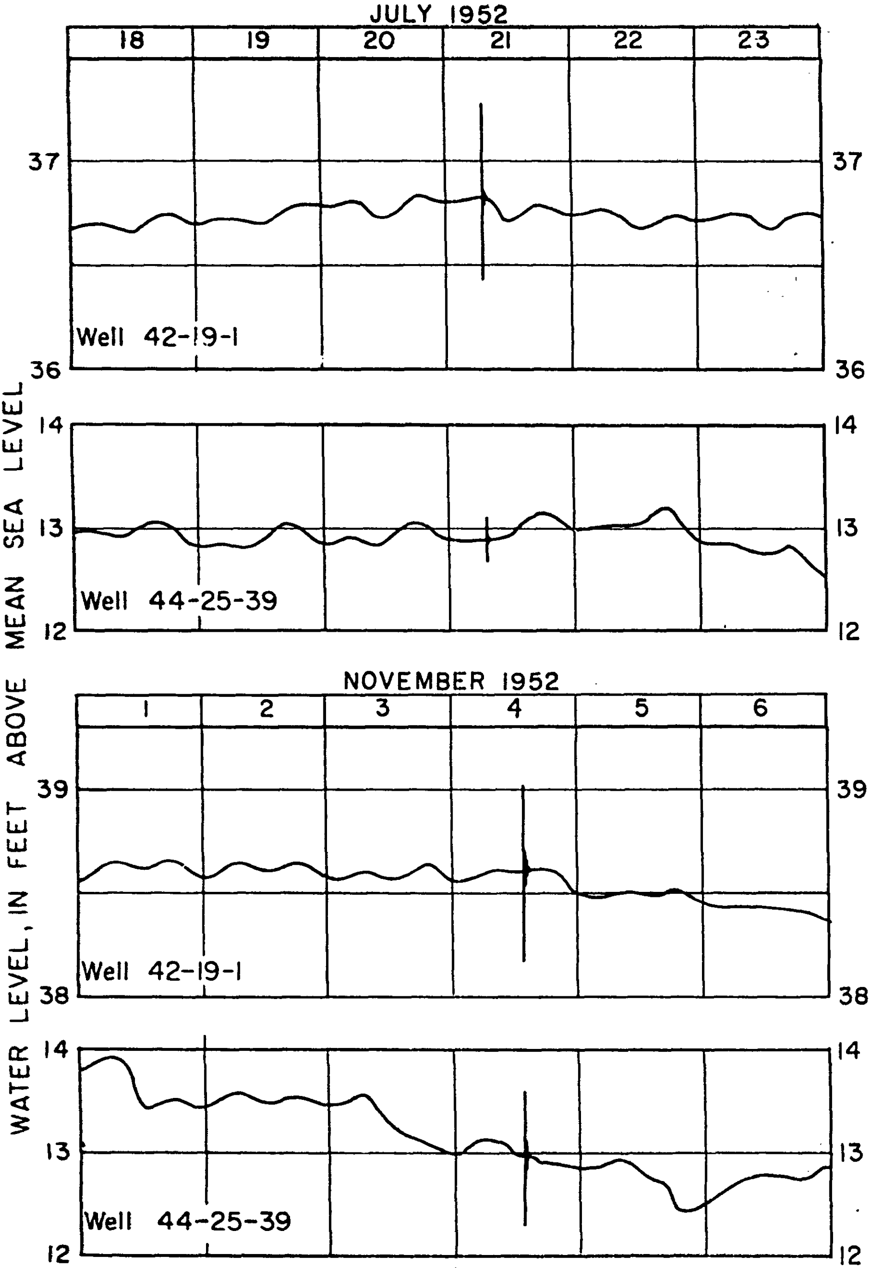

Figure 34. Effects of earthquakes and atmospheric-pressure changes on the water levels in wells 42-19-1 and 44-25-39.

In order to determine the transmissibility and storage coefficients of the Floridan aquifer in the Ruskin area, a pumping test was made in August 1955. Well 40-27-6, one-half mile east of Sun City, was pumped at the rate of 650 gpm for a period of 31 hours, beginning at 9:15 a.m. on August 18 and ending at 4:12 p.m. on August 19. Throughout the period of pumping, water-level measurements were made periodically in well 40-27-7, which

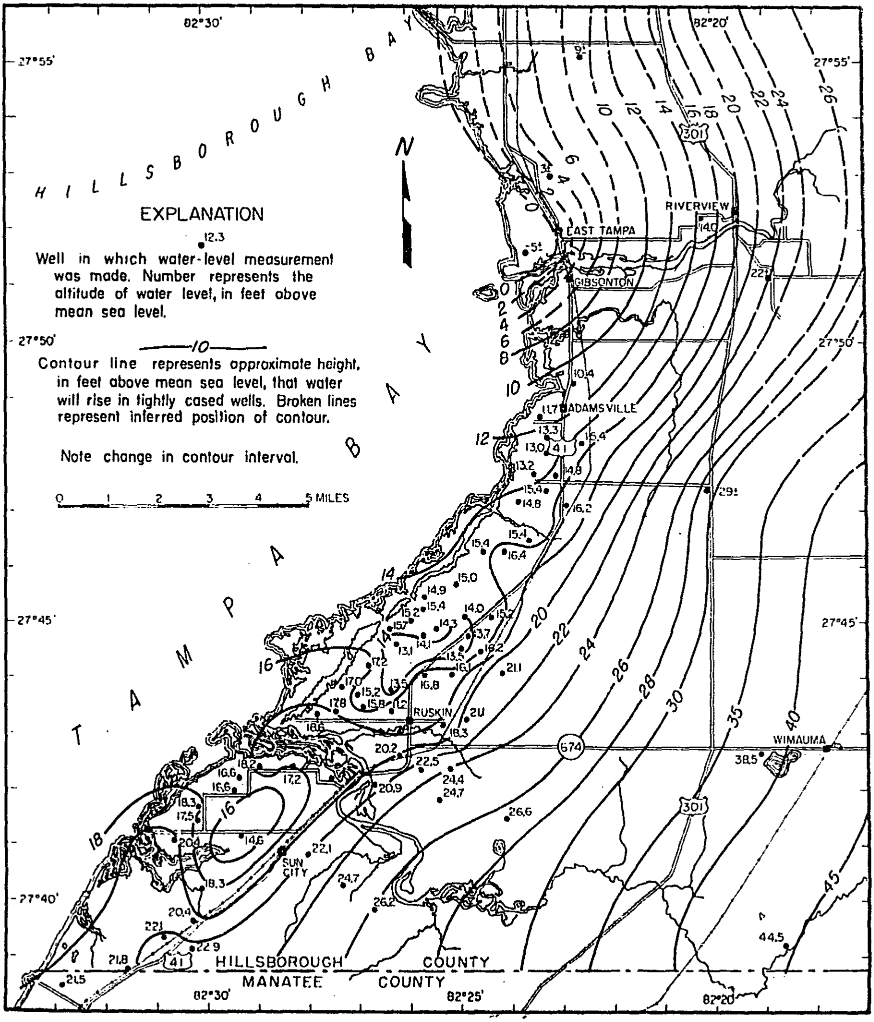

Figure 35. Map of the Ruskin area showing the piezometric surface of the Floridan aquifer in October 1952.

is 0.12 mile northwest of the pumped well, to determine the rate and magnitude of drawdown. The coefficients obtained are not necessarily correct for all parts of the area, but they are considered to be representative.

The Theis graphical method, as described by Wenzel (1942, p. 87-89), was used to compute the transmissibility and storage coefficients from the drawdown produced in well 40-27-7. This

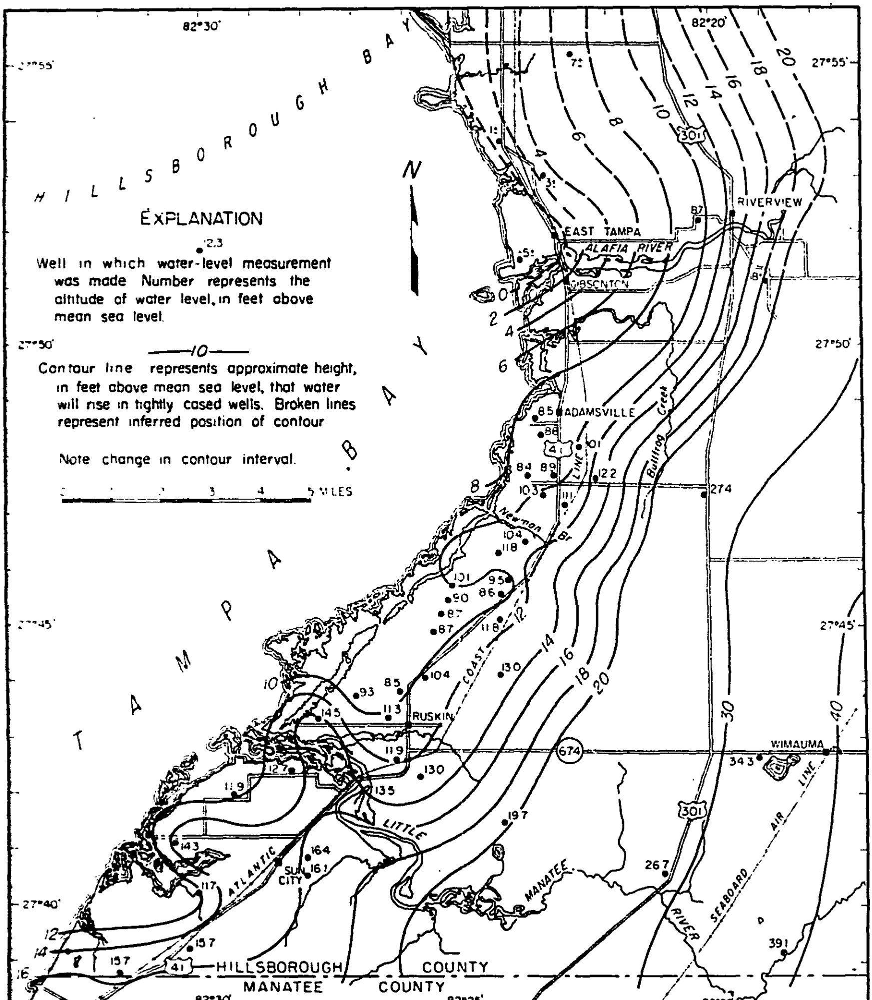

Figure 36. Map of the Ruskin area showing the piezometric surface of the Floridan aquifer in May 1953.

method relates the drawdown in the vicinity of a pumping well to the rate and duration of discharge and is based on several simplifying assumptions which include the following: (1) the aquifer has an indefinite areal extent, (2) the aquifer is homogeneous and transmits water with equal facility in all directions, (3) the discharge well obtains water from the full thickness of the aquifer, (4) the coefficient of transmissibility is

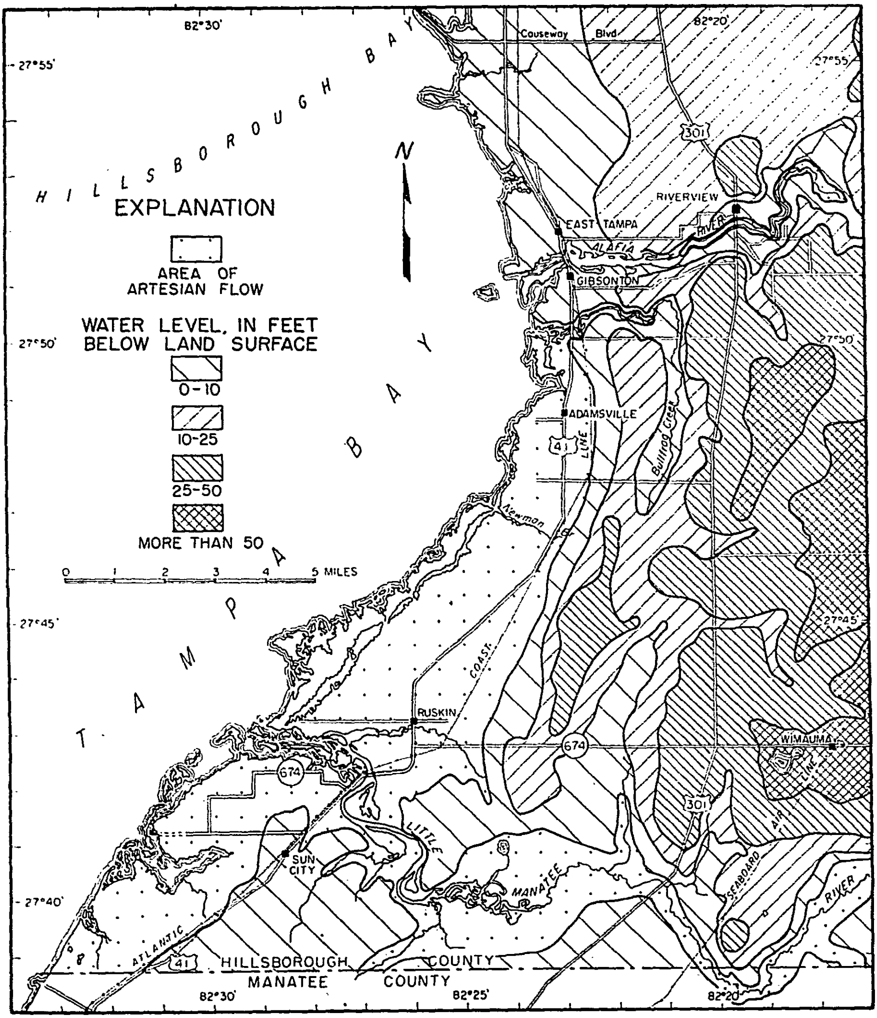

Figure 37. Map of the Ruskin area showing area of artesian flow and depth of water level below land surface.

constant at all places and at all times, (5) the discharge well has an infinitesimal diameter, and (6) water taken from storage by the decline in water level is discharged instantaneously with the decline in head.

The observed data for well 40-27-7 matched against the type curve, as shown in figure 38, yielded the following figures:

Where $W(u) = 1.0$, $s = 0.65$
and where $u = 0.1$, $t/r^2 = 1.0 \times 10^{-7}$

These figures inserted in the formulas $T = \frac{114.6\ QW(u)}{s}$ and $S = \frac{uTt}{1.87\ r^2}$ give a transmissibility coefficient of 114,600 gpd/ft and a storage coefficient of .0006.

QUALITY OF WATER

The water that falls on the earth's surface as rain or snow is practically free of mineral matter except for very small quantities of atmospheric gases and dust. Therefore, the mineral constituents and the degree of mineralization of ground water depends generally

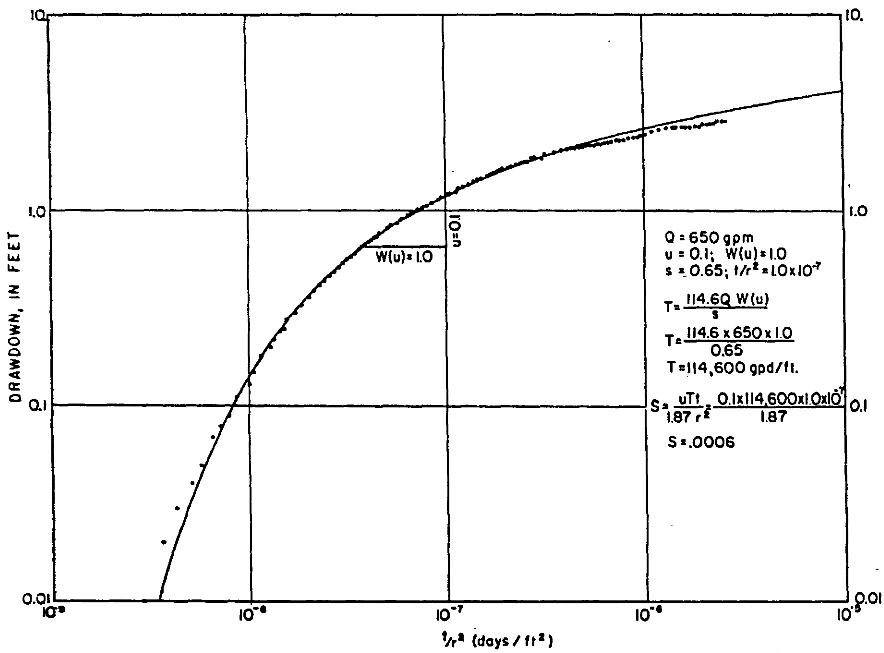

Figure 38. Logarithmic plot of drawdown in well 40-27-7 versus t/r^2.

upon the composition and solubility of the soil and rocks through which the water passes. In some places, mineralization of ground water may result from the mixing of relatively fresh water with highly mineralized, residual sea water within the water-bearing formations.

Chemical analyses of water samples from 29 selected wells in the Ruskin area (fig. 39) were made by the Quality of Water

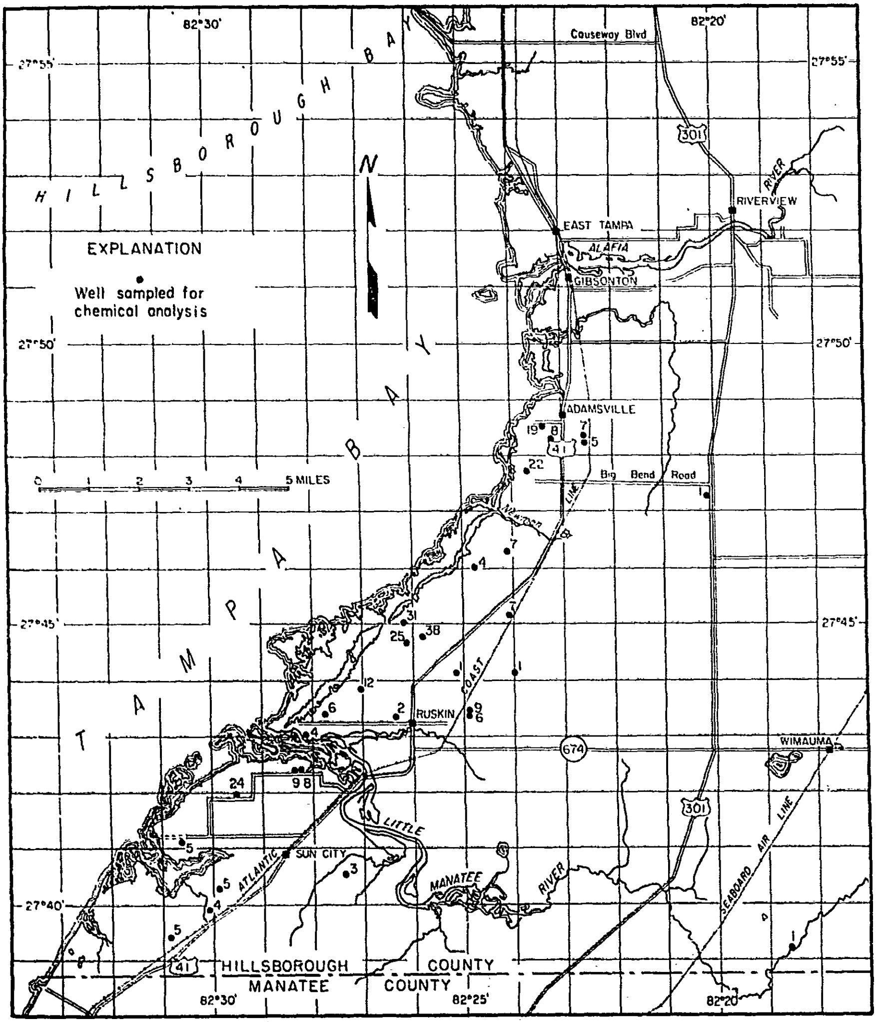

Figure 39 Map of the Ruskin area showing wells sampled for chemical analysis.

Branch of the U. S. Geological Survey. The results of these analyses are shown in table 5 and are discussed briefly below. The concentrations of mineral constituents are given in parts per million (ppm)—1 ppm is approximately equivalent to 8.34 pounds per million gallons of water. The specific conductance is expressed in micromhos at 25°C, and the hydrogen-ion content in standard pH units. The concentration limits given for the ions, unless otherwise stated, are taken from standards for drinking water prescribed by the U. S. Public Health Service (1946).

Calcium (Ca) is dissolved principally from limestone, which is predominantly calcium carbonate, by water containing carbon dioxide. Calcium is a principal cause of hardness in water. As indicated by the analyses, the water from the Floridan aquifer in the Ruskin area has a calcium content ranging from 81 to 275 ppm.

Magnesium (Mg) is dissolved principally from dolomite or dolomitic limestone and, like calcium, is a major cause of hardness in water. As magnesium is one of the principal mineral constituents of sea water, ground water that has been contaminated by sea water usually has a relatively high magnesium content. The water from the Floridan aquifer in the Ruskin area has a magnesium content ranging from 33 to 109 ppm. (See table 5.)

Sodium (Na) and potassium (K) are dissolved in small amounts from many types of rocks, but they constitute only a small to moderate part of the total mineral content of fresh ground water. The sodium content of water that has been contaminated by sea water is generally high, as sea water is principally a solution of sodium chloride. Water from the Floridan aquifer in southwestern Hillsborough County contained 7 to more than 100 ppm of sodium and potassium.

Bicarbonate (HCO_3) in ground water results from the solution of limestone and other carbonate rocks. Hardness caused by calcium and magnesium equivalent to the carbonate and bicarbonate is known as carbonate hardness in water. The bicarbonate content of water from the Floridan aquifer is relatively high, ranging from about 150 to more than 225 ppm.

Sulfate (SO_4) in ground water may be due to the oxidation of sulfide minerals or the solution of sulfate salts in the formations. Large quantities of sulfates in water may impart a bitter taste and have a laxative effect. Sulfates of calcium and magnesium cause boiler scale. The concentration limit of sulfate in drinking and culinary water is considered to be about 250 ppm. The sulfate content of water from the Floridan aquifer in southwestern

TABLE 5. Chemical Analyses of Artesian Water from Wells in the Ruskin Area
(Analyses by U. S. Geological Survey; chemical constituents in parts per million)

Well No.	Date Sampled	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Flouride (F)	Nitrate (NO_3)	Dissolved solids	Hardness ($CaCO_3$)	Specific conductance (micromhos at 25°C)	pH	Temperature (°F)
39-18-1	4-4-55	----	------	81	33	6.7	158	192	16	----	----	480	338	696	8.1	82
39-30-5	4-8-55	----	------	110	50	8.3	178	300	28	----	----	692	480	950	7.8	78.3
40-27-3	4-7-55	----	------	104	48	13	182	275	35	----	----	656	457	894	7.7	78.2
40-29-4	4-8-55	----	------	101	43	16	188	260	28	----	----	634	429	876	7.9	77
40-29-5	4-8-55	----	------	84	39	25	200	215	25	----	----	554	370	806	7.9	76
40-29-24	4-7-55	----	------	90	44	12	194	232	22	----	----	594	406	827	7.9	77
41-30-5	4-7-55	----	------	110	50	17	182	320	24	----	----	706	480	943	7.9	77
42-28-8	4-7-55	----	------	97	43	14	190	255	21	----	----	606	419	846	7.9	77
42-28-9	4-7-55	----	------	117	52	12	188	332	23	----	----	718	506	987	7.9	78.5
43-24-6	4-14-55	----	------	105	46	9.9	190	272	24	----	----	632	451	885	7.9	78.1
43-24-9	4-14-55	----	------	83	38	10	198	185	22	----	----	536	363	745	8.0	76
43-26-2	4-7-55	----	------	115	51	11	180	330	21	----	----	702	496	950	7.8	78
43-26-12	3-9-53	21	0.10	234	96	74	170	678	202	0.7	0.9	1,560	978	1,920	7.5	79
43-27-6	4-14-55	----	------	135	59	10	182	405	22	----	----	854	580	1,090	7.9	78
43-28-4	4-14-55	----	------	104	53	12	190	305	22	----	----	674	478	938	7.9	77
44-24-1	7-27-55	----	------	81	36	21	210	165	26	----	----	484	350	686	7.3	76.5
44-25-1	4-8-55	----	------	95	43	7.4	192	232	22	----	----	590	414	825	7.9	77
44-25-38	4-8-55	----	------	177	75	43	172	475	148	----	----	1,230	750	1,590	7.6	79
44-26-25	7-27-55	----	------	135	55	18	186	388	25	----	----	800	563	1,010	7.4	77.5
44-26-31	3-5-53	17	.69	199	81	89	168	582	190	.9	.8	1,350	830	1,780	7.3	80

Table 5 (Continued)

Well No.	Date sampled	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium and potassium (Na and K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness ($CaCO_3$)	Specific conductance (micromhos at 25°C)	pH	Temperature (°F)
45-24-7	7-27-55	----	------	105	47	16	156	312	25	----	----	653	456	870	8.0	78
46-24-4	3-6-53	18	.6	276	109	108	162	821	270	1.2	.6	1,840	1,140	2,300	7.4	----
46-24-7	3-10-53	19	.14	122	52	16	178	364	19	.4	.2	750	518	956	7.4	----
47-20-1	3-6-53	23	0.06	87	38	14	228	188	14	0.6	0.7	531	373	718	7.4	----
47-23-22	4-8-55	----	------	162	69	36	170	475	94	----	----	1,100	688	1,420	7.8	77.5
48-22-5	7-27-55	----	------	161	60	15	198	455	28	----	----	909	648	1,110	7.4	76
48-22-7	7-27-55	----	------	177	68	16	181	525	26	----	----	1,010	721	1,220	7.8	77
48-23-8	7-27-55	----	------	206	79	76	176	610	157	----	----	1,340	839	1,720	7.4	79.5
48-23-19	3-6-53	21	.28	170	65	52	172	510	88	.4	.4	1,080	693	1,370	7.3	77

Hillsborough County is relatively high, ranging from about 165 to more than 800 ppm. Throughout the coastal area, the sulfate content is more than 250 ppm (fig. 40).

Chloride (Cl) in small quantities is dissolved from most soils and rocks and is found in large quantities in ground water that has been contaminated by sea water. Chloride salts do not generally decrease the potability of water except when present in

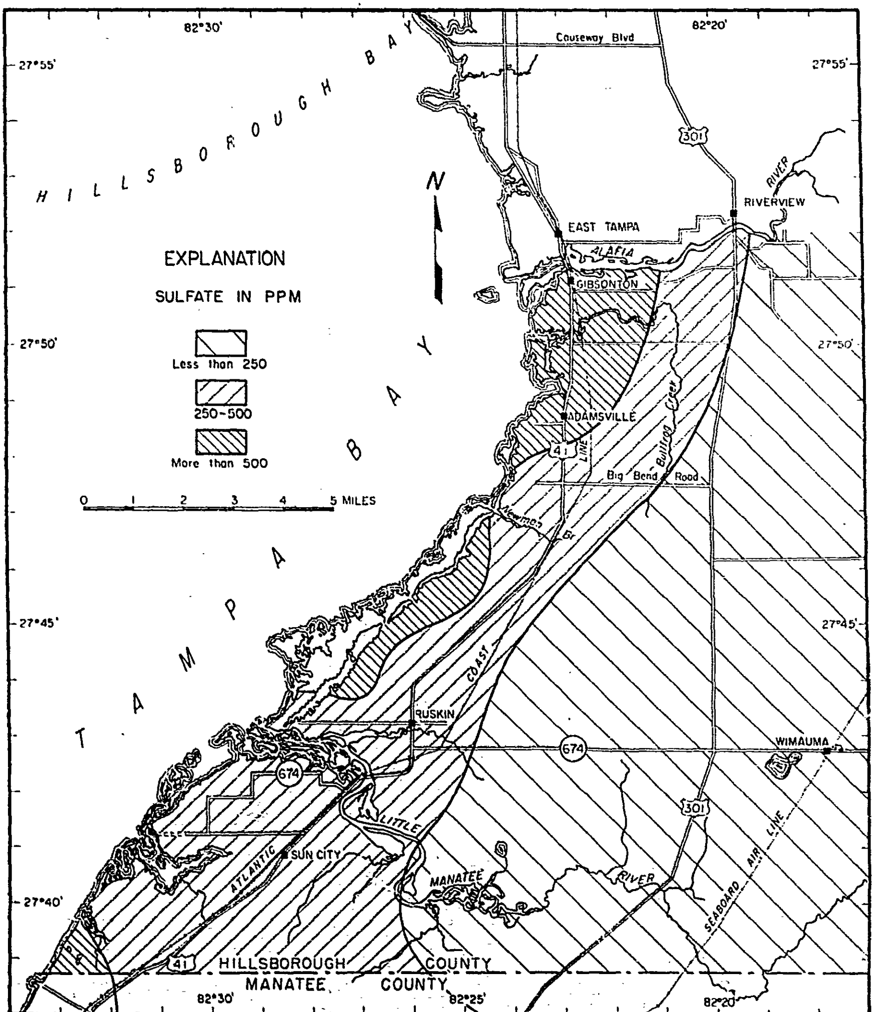

Figure 40. Map of the Ruskin area showing the sulfate content of water from the Floridan aquifer.

quantities sufficient to cause a salty taste. The chloride content of water from the Floridan aquifer in the Ruskin area ranges from about 15 ppm to more than 1,000 ppm. The chloride content of water from the Tampa formation is shown in figure 41, and that from the Suwannee and older formations is shown in figure 42. The chloride content of the artesian water is discussed in more detail under the heading "Salt-Water Contamination."

Iron (Fe) occurs in almost all rocks, but the quantity of iron

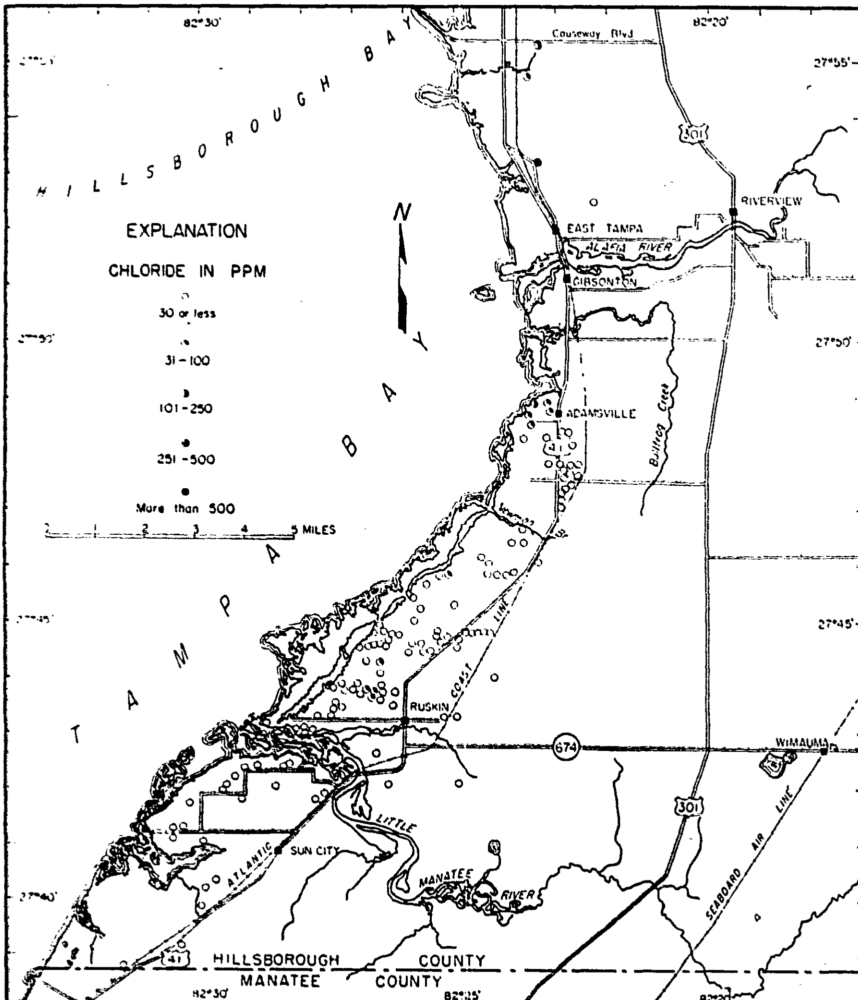

Figure 41. Map of the Ruskin area showing the chloride content of water from the Tampa formation.

dissolved by ground water is relatively small in comparison with the quantity of more soluble minerals. Water containing more than about 0.3 ppm of iron causes stains on fixtures, utensils, and clothing; and water containing 0.5 to 1.0 ppm has an objectionable taste. Iron can generally be removed from water by aeration and filtration. The iron content of water from six wells in the Ruskin area ranged from 0.06 to 0.69 ppm (table 5).

Fluoride (F) is present in minor amounts in most ground

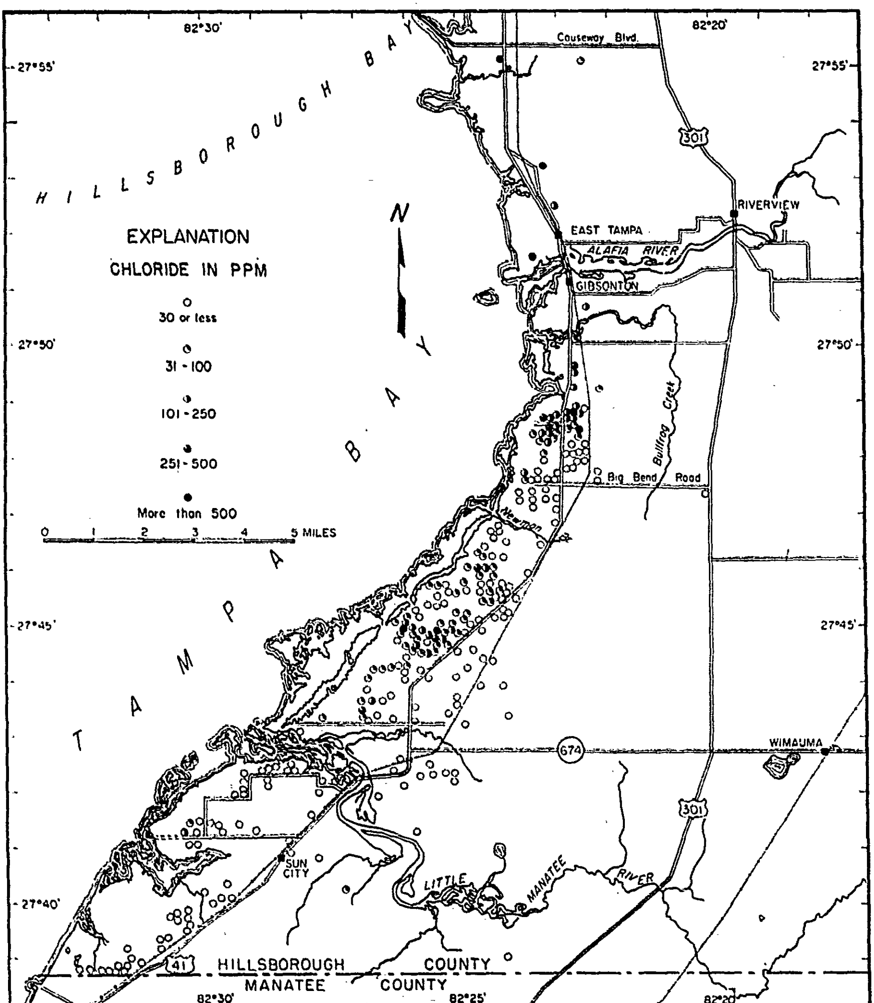

Figure 42. Map of the Ruskin area showing the chloride content of water from the Suwannee limestone and older formations.

water. Water containing fluoride in excess of 1.5 ppm may cause mottling of children's teeth during their formation (Cox and Ast, 1951, p. 641-648). In concentrations of 1.5 ppm or less, fluoride is recognized as being beneficial to dental health through reducing tooth decay and is added to many public water supplies for this reason. As shown in table 5, the fluoride content of water from six wells that penetrate the Floridan aquifer ranged from 0.4 ppm to 1.2 ppm.

The dissolved-solids content of ground water represents the approximate amount of mineral matter in solution. Water containing less than 500 ppm of dissolved solids is generally of good chemical quality, according to the U. S. Public Health Service drinking-water standards, and water containing as much as 1,000 ppm may be used for public supplies if a less mineralized water is not available. The concentration of dissolved solids in water from the Floridan aquifer in the Ruskin area ranges from slightly less than 500 ppm to more than 1,800 ppm. (See fig. 43 and table 5.)

The hardness of water is due principally to the salts of calcium and magnesium. The most noticeable effects of hardness are the formation of curds and the lack of suds when soap is added to the water, and the formation of a scale in vessels in which the water is heated. Water having a hardness of 60 ppm or less is generally satisfactory for most purposes. Water having a hardness between 60 and 120 ppm requires treatment for many industrial uses. Water having a hardness of more than 200 ppm is commonly softened for domestic and some other uses, although many private and some public supplies having a hardness of more than 500 ppm are not treated. The hardness of water from the Floridan aquifer in the Ruskin area ranges from about 350 ppm in the eastern part to more than 1,100 ppm near the coast (fig. 44).

The specific conductance of water is a measure of its capacity to conduct an electric current and depends upon the concentration and ionization of the minerals in solution. It indicates in a general way the relative mineralization of the water. As shown in table 5, the specific conductance of water from the Floridan aquifer in the Ruskin area ranged from 686 to 2,300 micromhos.

Hydrogen sulfide (H_2S) is a gas that gives water an objectionable odor and may cause corrosion of plumbing. Water containing it is often referred to as "sulfur water." Aeration is generally the most practical method of treatment. No analyses were made of the hydrogen sulfide content of water from the Floridan aquifer in the Ruskin area, but the odor of the gas is detectable in water from most wells.

The pH of a water indicates the instantaneous concentration of hydrogen ions. Water that has a pH of 7.0 is said to be neutral. Water having a pH of less than 7.0 is acidic and may be corrosive; water having a pH greater than 7.0 is alkaline and not generally corrosive. The water from the Floridan aquifer in the Ruskin area is slightly alkaline, the pH ranging from 7.3 to 8.1.

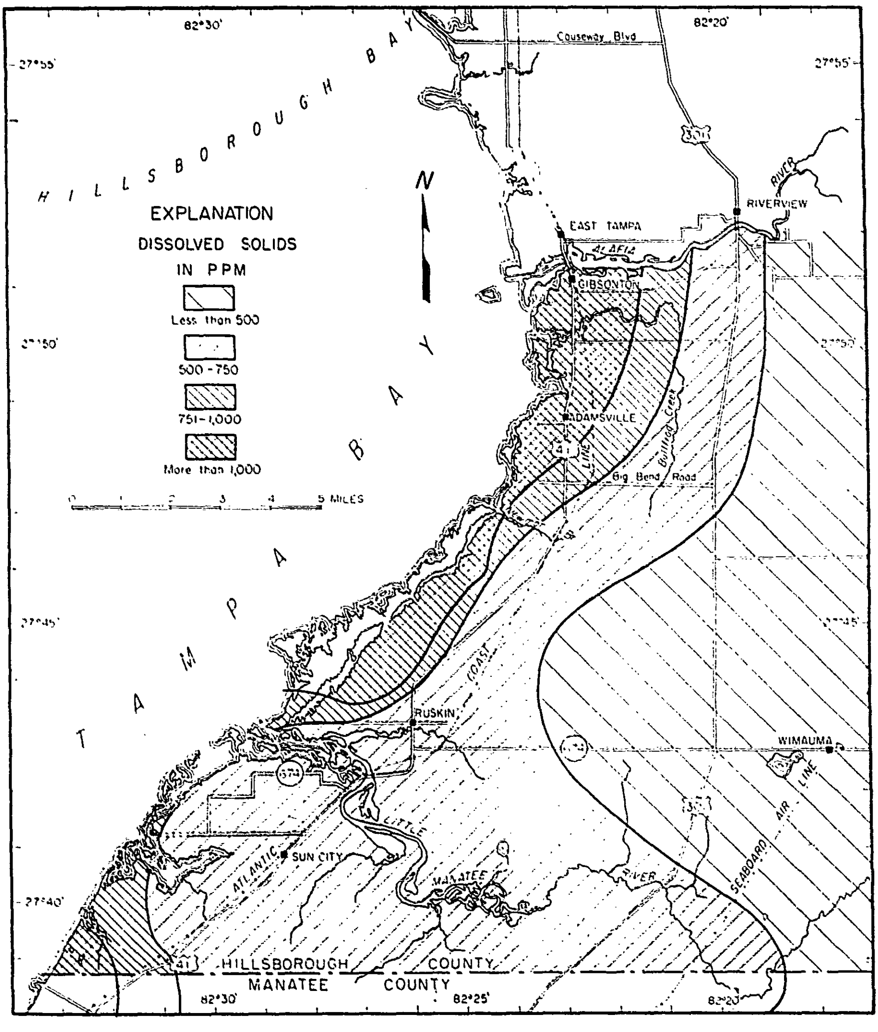

Figure 43. Map of the Ruskin area showing the dissolved-solids content of water from the Floridan aquifer.

SALT-WATER CONTAMINATION

In coastal areas underlain by permeable water-bearing formations that are hydraulically connected to the sea, the depth to salt water is directly related to the height of the fresh ground water above sea level. The density of fresh water is slightly less than that of sea water, so that fresh water floats on sea water in

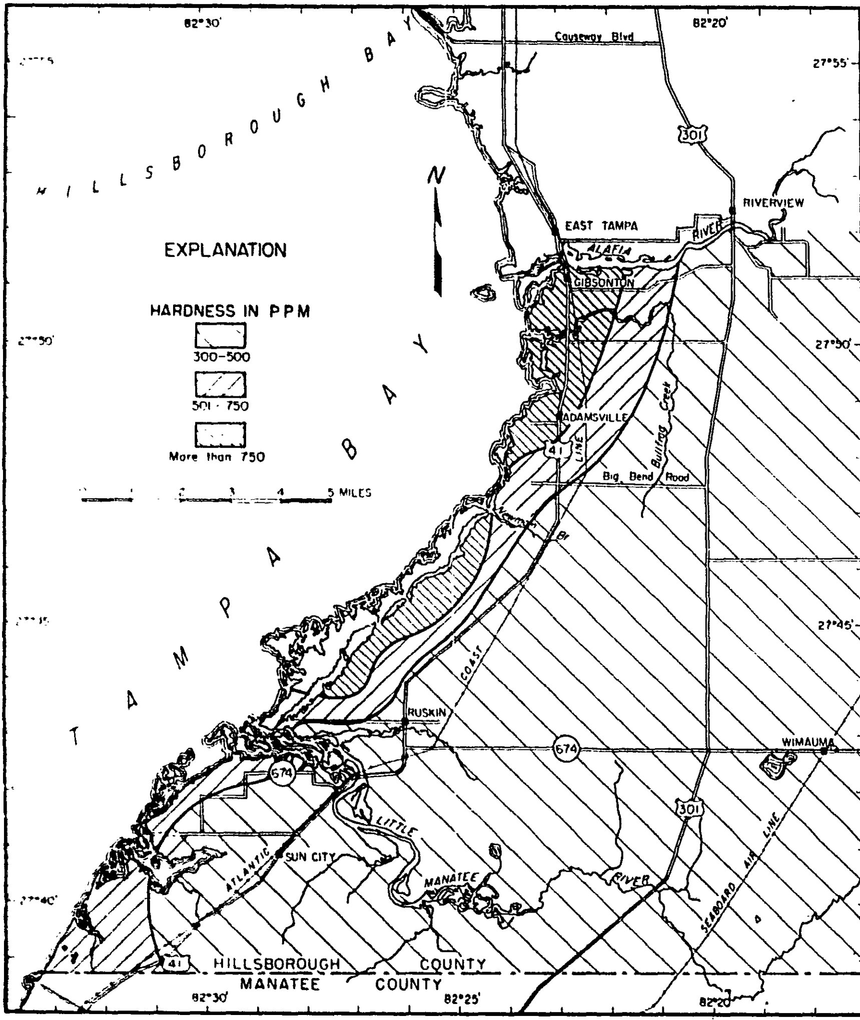

Figure 44. Map of the Ruskin area showing the hardness of water from the Floridan aquifer.

much the same way that ice floats on water. The specific gravity of sea water is generally about 1.025, whereas that of fresh water, for practical purposes, is 1.000. Thus, with these specific gravities a column of sea water 40 feet high will exactly balance a column of fresh water 41 feet high. This principle was first applied to the hydrology of coastal areas by Badon Ghyben and Alexander Herzberg (Brown, 1925, p. 16) who found that for each foot of fresh water above sea level there was approximately 40 feet of fresh water below sea level. Although the 40-to-1 ratio is strictly applicable only under a condition of static equilibrium, it applies approximately in coastal aquifers, except in areas very close to the shore.

Salty water is present in the Floridan aquifer at relatively shallow depths throughout most of the coastal area of Florida. At some places, the lowering of the artesian head by withdrawal of large quantities of water from wells has caused the encroachment of sea water into the aquifer. In most of the area, however, the artesian pressure head is sufficiently high to prevent encroachment of water directly from the sea; thus, the widespread salty water probably represents residual sea water that entered the aquifer prior to Recent time.

The Floridan aquifer was partly filled with sea water several times during the interglacial stages of the Pleistocene epoch, when the sea rose above the present level. Since the last recession of the sea, the circulation of fresh water through the aquifer has been gradually diluting and flushing out the salty water. In much of the coastal area, however, a part or all of the water-bearing formations still contain water that is too salty for most uses, although it is considerably less salty than sea water. Excessive lowering of the head may reverse the flushing action and cause lateral migration of sea water into the aquifer. It may also cause an upward migration of the salty water from the lower zones of the aquifer into the upper part, except where such migration is retarded by relatively impermeable strata.

RELATIVE SALINITY OF THE ARTESIAN WATER

The dissolved mineral constituents of sea water consist predominantly of chloride salts; thus, an abnormally high chloride content of ground water is generally a reliable indicator of salt-water contamination. Water samples from about 400 wells were analyzed in order to determine the chloride content of the water from the Floridan aquifer in the Ruskin area. The results of these analyses are included in table 5 and are shown by symbols in figures 41 and 42.

The chloride content of the water from the Floridan aquifer is about 10 ppm in western Polk County and about 15 ppm in eastern Hillsborough County. It increases gradually toward Tampa Bay, in the direction in which the water is moving. Throughout most of the Ruskin area, the chloride content of water from the Floridan aquifer is about 20 to 30 ppm, but in some parts of the coastal area it ranges from 31 to more than 500 ppm.

The chloride content of water from the Tampa formation is shown in figure 41. Most of the wells that yield water of relatively high chloride content are in a narrow zone that extends along the coast from the vicinity of Adamsville to the northern boundary of the area. The chloride content of water from these wells ranges from less than 50 to more than 500 ppm. A few wells south of Adamsville yield water from the Tampa containing about 35 to 40 ppm of chloride. The relatively high chloride content of the water from these wells may represent contamination from nearby wells that penetrate the deeper formations.

Figure 42 shows the chloride content of water from wells that penetrate the Suwannee limestone, the Ocala group, and the Avon Park limestone. Most of the wells that yield water of relatively high chloride content are in a zone about a mile wide that extends along the coast from the Little Manatee River to the northern boundary of the area. Wells that penetrate the Suwannee limestone in this zone yield water having a chloride content ranging from about 30 ppm to more than 800 ppm, and wells that penetrate the Ocala group and Avon Park limestone yield water having a chloride content of more than 1,000 ppm. A few wells south of the Little Manatee River yield water whose chloride content is 35 to 65 ppm.

In order to determine the relative salinity of the water from the different producing zones in the aquifer, water samples were collected at several depths in selected wells with a deep-well sampler and measurements of the electrical resistivity of the water at different depths were made in several wells. The chloride content of water samples collected in wells is shown graphically in figures 9-12, 14-18, 20-23, 26, and 45-47. The results of resistivity measurements also are included in figures 14, 16, and 45.

As indicated by these graphs, the salty water enters the wells from the deep producing zones and is diluted by fresher water from other producing zones as it moves up the well bore. For example, the analyses of samples collected in well 44-25-42 (fig. 14) show that the chloride content of the water from the Suwannee

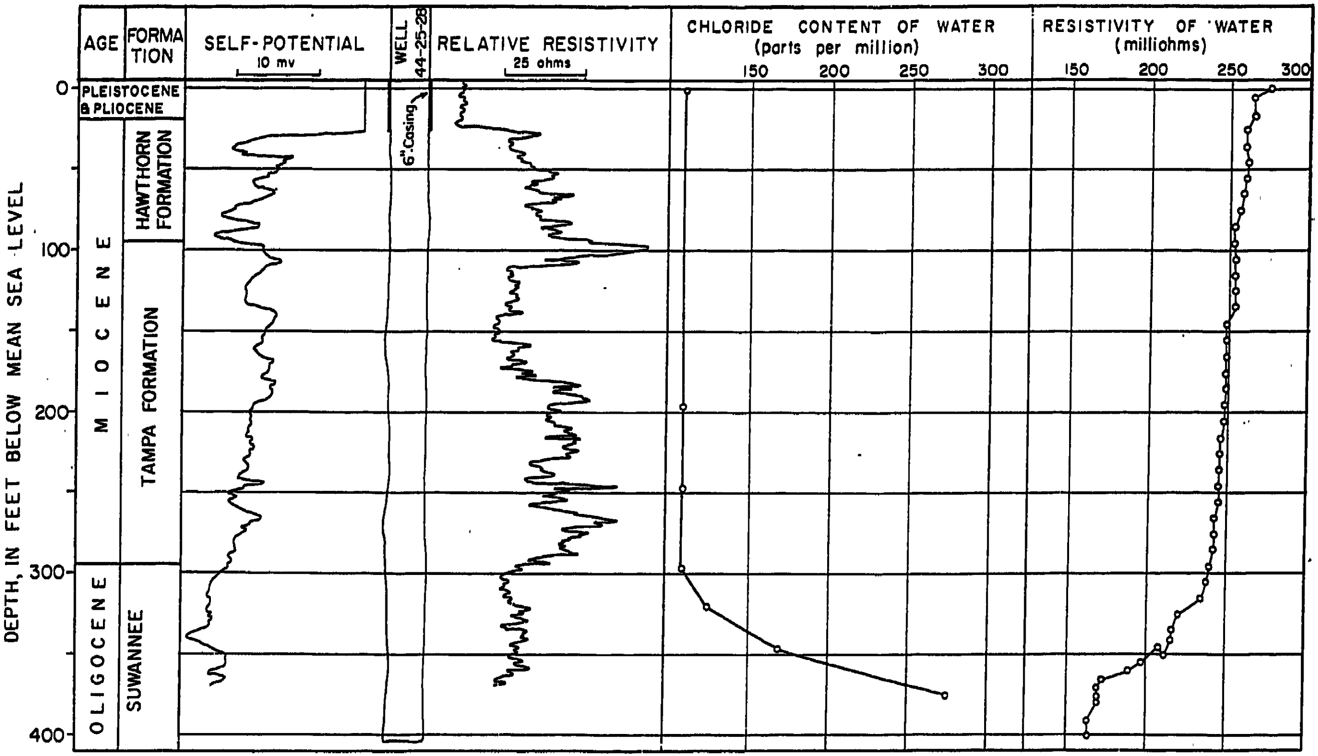

Figure 45. Graph showing well-exploration data for well 44-25-28.

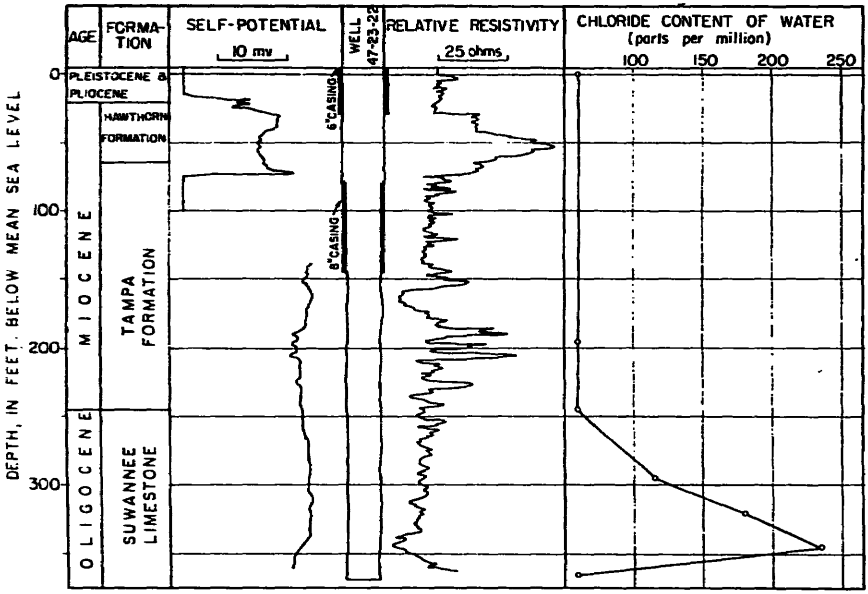

Figure 46. Graph showing well-exploration data for well 47-23-22.

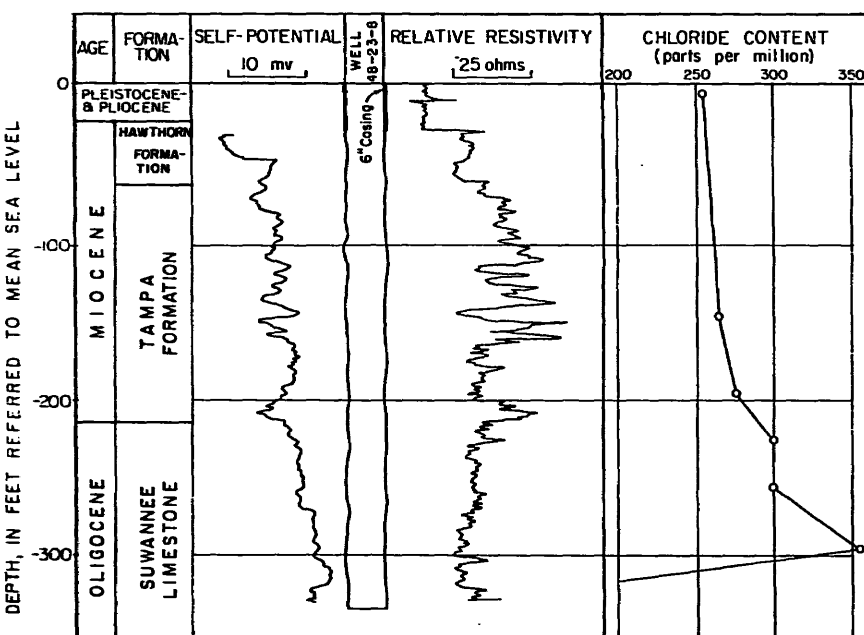

Figure 47. Graph showing well-exploration data for well 48-23-8.

limestone was 225 ppm at a depth of 370 feet and 135 ppm at a depth of 320 feet. The sharp increase in the resistivity from about 207 milliohms at 330 feet to about 256 milliohms at 315 feet indicates that most of the fresh water entered the well in this interval.

Periodic analysis of water samples shows that the chloride content of the water varies with changes in artesian pressure head. A decrease in head is generally accompanied by an increase in chloride content, and vice versa. This relationship indicates that the lowering of the head causes a vertical movement of salty water from the deeper formations. It may also reflect variations in the proportion of the total yield of the well that is obtained from each formation or producing zone. During periods of heavy withdrawal, the artesian head of the Tampa formation may be slightly less in some places than the head of the Suwannee limestone or deeper formations. This difference in head would increase the proportional yield of the deeper formations and increase the chloride content of the water obtained.

SOURCES OF CONTAMINATION

As indicated by the contours in figures 35 and 36, the mean artesian head along the coast ranges from about sea level in the area north of the Alafia River to about 18 feet above sea level near the Manatee County line. If the 40-to-1 ratio applies, the depth below sea level to salt water in the aquifer would be nearly zero at East Tampa and more than 600 feet south of the Little Manatee River. In the area south of Adamsville, the mean artesian head is sufficiently high to prevent encroachment of water from the sea into the Suwannee limestone (see fig. 4); thus, the occurrence of relatively salty water in the Suwannee or in the Tampa formation probably represents residual sea water that entered the formations during Pleistocene time.

Studies of current-meter traverses show that the Floridan aquifer contains permeable zones separated by relatively impermeable beds of considerable thickness. The permeable zones tapped by most wells in the area are generally less than 450 feet below sea level. The relatively impermeable beds beneath the principal water-bearing zones retard or prevent upward migration of salty water from the deeper formations.

The salinity of the water in the Suwannee limestone and Tampa formation in the area north of Adamsville is probably due in part to residual Pleistocene sea water and in part to encroachment of water from Tampa Bay during recent years.

The Tampa formation is at or near the land surface in the northern Tampa Bay area, and in 1955 large quantities of artesian water were being discharged from the formation through springs and seeps. The northern part of Tampa Bay is apparently the center of a large area of natural discharge which has existed for many thousands of years. The withdrawal of large quantities of water from wells during recent years has lowered the piezometric surface to sea level at some places, permitting salt water from Tampa Bay to enter the upper part of the aquifer.

The withdrawal of large quantities of salt water at East Tampa, through wells that penetrate the Avon Park limestone, has created a cone of depression which extends below sea level in the vicinity of the pumped wells but is relatively small in areal extent. The limited extent of this cone is probably due to the salvage of natural discharge and the induction of recharge from Tampa Bay. The quantity of water discharged from the wells is apparently near equilibrium with the recharge from Tampa Bay and the intercepted natural discharge, so that the artesian head is relatively stable; however, salt water is steadily encroaching.

SUMMARY AND CONCLUSIONS

The investigation of the ground-water resources of the Ruskin area of Hillsborough County involved collecting and evaluating data from about 650 wells. The principal results of the study are summarized below:

1. The Ruskin area is underlain by a thick section of Tertiary limestones whose upper surface ranges in depth from about sea level in the northern part of the area to about 250 feet below sea level in the southern part. The limestone formations penetrated by water wells include the Avon Park limestone and Ocala group of Eocene age, the Suwannee limestone of Oligocene age, and the Tampa formation of early Miocene age. The Tampa is overlain by the Hawthorn formation of middle Miocene age which consists of sandy, calcareous clay and thin beds of limestone and sand.

2. The Suwannee limestone and Tampa formation are the principal sources of artesian water in the area, although the deeper limestones yield water to a few wells. The water in these formations occurs in permeable zones which are generally separated by relatively impermeable layers of considerable thickness. The water is replenished by rainfall in western Polk County and eastern Hillsborough County and is confined under pressure by the relatively impermeable strata within the formations and by

the overlying Hawthorn formation. The beds of limestone and sand in the Hawthorn are the source of many domestic water supplies.

3. Water-level records show that significant fluctuations of artesian pressure head result from the daily and seasonal variations in withdrawal of water from wells. During periods of heaviest withdrawal, the piezometric surface is lowered about 4 feet throughout the area and more than 8 feet at some places. The artesian pressure head declined progressively in the coastal area during a period of extensive agricultural development from 1950 to 1952. Since 1952 the seasonal fluctuations in the coastal area have decreased in magnitude and a slight progressive increase in artesian pressure head has occurred locally as a result of a decrease in withdrawals. In wells not affected by local use of water the artesian pressure head declined progressively in 1955-56.

4. Analysis of data collected during a pumping test indicates that the artesian aquifer has a transmissibility coefficient of about 115,000 gpd/ft and a storage coefficient of 0.0006.

5. Chemical analyses show that the mineral content of the water in the Suwannee limestone and Tampa formation is lowest in the eastern part of the area and progressively higher toward Tampa Bay, in the direction in which the water is moving. Concentrations of dissolved solids range from less than 500 ppm in the eastern part of the area to more than 1,800 at some places along the coast, and the hardness ranges from about 350 ppm to more than 1,000 ppm. The water in the Suwannee limestone is somewhat more mineralized than the water in the Tampa, and that in the Eocene formations probably is much more mineralized than the water in the Suwannee limestone, particularly in the coastal area.

6. The chloride content of the artesian water is about 20 to 30 ppm throughout most of the area. In a narrow zone along the coast north of the Little Manatee River, many wells yield water having a considerably higher chloride content, indicating that the artesian water has been contaminated to some extent by salty water.

In the area south of Adamsville, salt-water contamination is apparently due to residual sea water that entered the aquifer during Pleistocene time, as the mean artesian head along the coast is sufficiently high to prevent encroachment of water from Tampa Bay into the Suwannee limestone and Tampa formation. The circulation of fresh water through the aquifer has flushed most of the sea water from these formations, although some water from the

Suwannee limestone has a chloride content of several hundred ppm. The water in the Tampa formation generally contains about 30 ppm of chloride or less.

Contamination in the vicinity of Adamsville and northward is probably due to both residual Pleistocene sea water and encroachment of water from Tampa Bay during recent decades. The northern part of Tampa Bay is the approximate center of an area of natural discharge that has existed for many thousands of years. The withdrawal of water through wells in recent decades has lowered the artesian head to sea level at some places, permitting water from Tampa Bay to enter the upper part of the Floridan aquifer. Some wells that penetrate the Eocene limestones yield water as salty as sea water.

Periodic analysis of water from selected wells shows that the chloride content varies with significant changes in artesian pressure head. The chloride content generally increases as the artesian head declines, and vice versa. This relationship may reflect variations in the proportion of the total yield of the well that is obtained from each formation or producing zone, or it may indicate that a decline in artesian pressure head results in upward encroachment of salty water from the deeper formations. The relatively impermeable strata in the aquifer probably retard or prevent an upward movement of the salty water throughout most of the area, as only a few wells have yielded water that has shown a progressive increase in chloride content and the contaminated zone has not expanded during the period of record. An appreciable lowering of the artesian pressure head in the coastal area, however, would eventually result in lateral encroachment. It might result also in vertical encroachment in areas where the impermeable strata are breached or absent.

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TABLE 6. Measurements of Water Levels in Wells in the Ruskin Area
(All measurements shown in feet above or below (—) measuring point)

Well Number	Date	Water level	Date	Water level	Date	Water level	Date	Water level
38-31-5	8-22-52	4.2	12-23-52	8.2	8-17-53	12.6		
	9-29-52	8.6	5-18-53	5.8	9-14-54	12.0		
39-18-1	9- 7-51	10.6	5-18-53	4.9	4- 4-55	8.0		
	7- 2-52	9.0	9-30-54	11.1				
39-31-5	2- 1-51	11.8	3-28-51	10.7	5-13-52	8.6		
40-20-1	2-19-51	—23.5	3-26-51	—24.2	6-11-51	—25.75	3- 4-53	—23.9
	2-26-51	—24.5	4-17-51	—23.0	7-11-51	—24.34	4-14-53	—25.7
	3-16-51	—25.3	5- 4-51	—22.7	9- 8-51	—22.30	5-21-53	—26.75
40-24-1	2-19-51	20.1	3-16-51	22.9	4-27-51	22.5	9- 7-51	25.9
	2-26-51	24.9	3-26-51	24.0	6-11-51	20.6	5-16-52	18.9
40-27-4	5-13-52	—8.75	10-10-52	1.8	8-17-53	0.7	6- 8-55	—3.13
40-28-2	11-26-51	—6.15	12- 3-51	—8.27	12-14-51	—10.50	9-29-52	—11.25
40-30-1	3-28-51	8.1	5-13-52	8.8	5-18-53	5.6		
	9- 7-51	7.0	10-13-52	13.2				

Table 6. (Continued)
(All measurements shown in feet above or below (—) measuring point)

Well Number	Date	Water level	Date	Water level	Date	Water level	Date	Water level
41-24-1	9- 7-51	—11.52	6-23-52	—14.65	5-18-53	—19.2		
	5-16-52	—18.7	10-10-52	—12.3				
41-29-23	3-28-51	0.7	10-22-52	6.5	1-30-53	1.4	10-15-53	1.2
	5-13-52	—4.57	11-18-52	0.3	5-21-53	1.0	11-20-53	3.2
	10-10-52	5.7	12-22-53	1.3	8-17-53	7.0	6- 8-55	4.62
41-30-6	2-19-51	9.3	3-16-51	9.9	4-17-51	14.6	9- 7-51	12.2
	2-26-51	8.3	3-26-51	12.7	6-11-51	9.9	10-10-52	13.7
41-30-13	9- 7-51	7.4	5-13-52	2.5	10-10-52	9.2	10-22-52	10.3
42-25-13	2- 1-51	3.0	10-10-52	6.8	9-27-55	5.7		
	9- 6-51	4.6	6- 8-55	2.45				
42-26-12	9- 6-51	10.1	10-13-52	11.2	5-18-53	2.9		
	5-14-52	1.78	5-14-53	3.5				
43-24-6	2- 1-51	3.9	6-23-52	4.6	10-22-52	7.6	7-27-55	6.1
	3-26-51	4.2	8-25-52	2.5	1-30-53	5.5		
	9- 6-51	4.6	9-29-52	5.7	9-30-54	8.0		
	5-13-52	—2.15	10-10-52	7.0	6- 8-55	1.05		

Table 6. (Continued)
(All measurements shown in feet above or below (—) measuring point)

Well Number	Date	Water level	Date	Water level	Date	Water level	Date	Water level
43-24-17	2- 1-51 2-19-51	0.8 1.3	2-26-51 3-26-51	—4.1 1.9	4-17-51 4-25-51	6.9 6.3	5- 4-51 6-11-51	0.1 —1.6
43-25-3	9- 6-51	8.5	5-14-52	—0.5	10-10-52	9.2	10-22-52	9.7
43-25-18	2- 1-51	4.4	3-28-51	3.9	9- 6-51	6.8	5-13-52	—0.2
43-27-4	2- 1-52	9.9	9- 6-51	10.0	5-15-52	5.4	10- 9-52	11.1
43-27-6	2-19-51 2-26-51 3-16-51	9.9 9.9 11.8	3-26-51 4-17-51 4-24-51	12.2 14.3 13.2	6-11-51 9- 6-51 10-13-52	9.1 8.8 12.1	5-15-53 5-21-53	8.0 8.5
43-27-11	2- 1-51 3-27-51	11.9 12.5	9- 6-51 5-15-52	10.7 7.9	10-13-52	13.2		
44-24-1	9- 6-51 10-13-52	4.1 3.7	5-15-53 8-17-52	—4.4 3.4	10-15-53	1.95		
44-24-17	2- 1-51	4.4	3-27-51	1.7	9- 6-51	8.4	10-13-52	5.8

Table 6. (Continued)
(All measurements shown in feet above or below (—) measuring point)

Well Number	Date	Water level	Date	Water level	Date	Water level	Date	Water level
44-24-20	2- 1-51 3-27-51	4.9 2.8	9- 6-51 5-14-52	9.9 —0.15	10-13-52 10-22-52	5.6 6.6		
44-25-1	2- 1-51 3-27-51 9- 6-51	5.6 4.5 9.0	4- 2-52 7-25-52 8-22-52	10.1 3.95 6.2	9-29-52 10- 9-52 10-22-52	6.1 8.5 9.2	1-30-53 11-20-53	6.5 4.1
44-25-9	2- 1-51	5.7	3-27-51	3.9	9- 6-51	9.1	5-15-52	0.85
44-26-9	3-26-51	11.6	9- 6-51	12.0	5-15-52	6.9	10- 9-52	12.0
45-23-3	1-31-51	4.2	3-26-51	7.6	9- 5-51	6.6	5-21-53	—1.1
45-24-6	1-31-51	5.2	5-15-52	0.3	10- 9-52	6.4	10-21-52	7.5
45-25-10	9- 7-51	8.5	10- 9-52	9.7	10-21-52	10.3	12-22-52	6.1
45-25-15	1-31-51	7.7	3-26-51	9.0	9- 5-51	7.2	5-15-53	2.0
45-25-18	1-31-51 3-26-51	9.6 11.4	9- 5-51 5-15-52	8.5 4.15	10- 9-52 5-21-53	10.1 5.2		

Table 6. (Continued)
(All measurements shown in feet above or below (—) measuring point)

Well Number	Date	Water level	Date	Water level	Date	Water level	Date	Water level
46-23-2	1-31-51	3.2	9- 5-51	6.5	9-30-54	5.3		
	3-26-51	6.8	10-10-52	5.1				
46-24-9	9- 5-51	10.0	10- 9-52	10.4	10-22-52	10.6	11-19-53	5.5
46-24-12	1-31-51	10.2	3-26-51	11.1	9- 5-51	11.5	10- 9-52	11.0
46-24-15	9- 5-51	11.1	5-15-52	3.25	8-25-52	8.5		
	4- 2-52	10.0	6-23-52	8.3	9-29-52	9.0		
47-20-1	6-11-51	—36.65	8-23-54	—29.20	2- 1-55	—30.75	6- 8-55	—33.0
	11-20-53	—29.15	9-30-54	—28.65	3-10-55	—32.50	7-27-55	—30.45
	6-28-54	—29.40	12-28-54	—29.30	4- 8-55	—31.72	10-25-55	—30.50
47-22-2	1-31-51	2.3	9- 5-51	7.1	5-21-53	—1.65		
	3-26-51	4.3	10-10-52	7.0				
47-22-6	5-15-53	—7.5	8-17-53	—5.85	4- 8-55	—6.60		
	5-21-53	—9.1	2-25-54	—6.45	6- 8-55	—6.55		
47-22-12	3-26-51	5.4	4-27-51	6.7	6-11-51	3.0		
	4-17-51	7.5	5- 4-51	2.3	9- 5-51	5.6		

Table 6, (Continued)
(All measurements shown in feet above or below (- -) measuring point)

Well Number	Date	Water level	Date	Water level	Date	Water level	Date	Water level
47-22-18	2-19-51	0.6	2-26-51	2.1	3-16-51	3.8	3-26-51	5.1
47-23-19	9- 5-51	6-7	10-10-52	5.4	5-21-53	—0.5		
	5-14-52	0.2	10-21-52	5.6				
47-23-21	1-31-51	3.9	9- 5-51	6.6	4-14-53	5.5		
	3-27-51	6.8	10-10-52	5.7	5-21-53	0.9		
47-23-31	1-31-51	3.9	3-27-51	6.8	9- 5-51	6.1	5-14-52	1.25
48-22-5	3-27-51	3.7	10-10-52	2.8	11-20-52	0.25	9-30-54	1.80
	9- 5-51	4.2	5-21-53	—2.5	2-25-54	0.70	7-27-55	1.30
	5-14-52	—1.7	8-17-53	2.2	6-28-54	0.90		
	6-23-52	1.1	10-14-53	2.0	8-24-54	1.1		
48-23-10	1-31-51	4.2	9- 5-51	3.6	2- 6-53	5.7		
	3-27-51	6.6	5-14-52	2.24	5-21-53	2.3		
49-22-1	2-19-51	0.1	3-22-51	0.8	5- 4-51	0.4	9- 5-51	1.37
	2-26-51	0.0	4-17-51	1.4	6-11-51	—0.8		
	3-16-51	0.3	4-27-51	1.3	8-13-51	1.30		

TABLE 7. Logs of Selected Wells in the Ruskin Area

Well 40-28-2

(Florida Geol. Survey No. W-2323)

Lithology	Depth Below Land Surface
Pleistocene and Pliocene	
Sand, white, quartz, fine to medium, subrounded to well-rounded, carbonaceous.	0- 10
Sand, brown, quartz, fine to coarse, subrounded to well-rounded, carbonaceous.	10- 20
Sand, brown, quartz, carbonaceous, fine to medium.	20- 35
Sand, as above; peat; wood; amber.	35- 40
Sand, as above; abundant shells and fragments; carbonaceous material; gray silty clay.	40- 50
Shell fragments and sand; quartz pebbles and black phosphate pebbles, rounded and frosted.	50- 60
Hawthorn formation	
Clay, gray, sandy, calcareous, phosphatic; quartz and phosphate pebbles, as above; a few shell fragments.	60- 70
Clay, gray-white, chalky, phosphatic, sandy in part.	70- 90
Clay, as above, with some gray impure limestone.	90-100
Clay, as above.	100-110
No sample.	110-120
Clay, white, chalky, sandy in part, phosphatic.	120-125
No sample.	125-130
Clay, white, chalky, sandy; gray-white sandy limestone, with a few mollusk molds and casts.	130-140
Clay, greenish gray calcareous, sandy, phosphatic.	140-145
No sample.	145-150
Clay, as above but very sandy; much chert.	150-155
No sample.	155-160
Clay, gray-white calcareous, sandy, phosphatic; gray-white sandy limestone; some chert.	160-165
Clay, greenish gray, calcareous, sandy, phosphatic; some chert.	165-170
Limestone, gray-white, impure, porous.	170-175
No sample.	175-180
Clay and limestone, with some chert.	180-185
No sample.	185-210
Clay, gray-white, sandy, phosphatic; some chert.	210-215
Tampa formation	
Limestone, white to cream, hard to soft, very sandy; some chert. *Archaias* sp. and *Sorites* sp.	215-220
Limestone, creamy white, gray, and tan, soft to hard, granular, porous, granular to dense, sandy, fossiliferous; crystalline calcite. *Archaias* sp. and *Sorites* sp.	220-230
Limestone, as above.	230-250

Table 7. (Continued)

Lithology	Depth Below Land Surface
No sample.	250-270
Limestone, white to tan, granular to dense, sandy; some chert.	270-275
Limestone, buff and tan, soft to hard, dense to granular, sandy; crystalline calcite in solution cavities.	275-285
No sample.	285-300
Limestone, buff and tan, soft to hard, dense to granular, fossiliferous; contains numerous fragments of gastropod molds and casts.	300-305
No sample.	305-310
Limestone, white to brown, soft to hard, chalky, porous, sandy in part, fossiliferous.	310-315
No sample.	315-325
Limestone, as above; also dark brown, hard, porous.	325-330
Limestone, as above, and some chert.	330-340
No sample.	340-345
Limestone, as above, *Archaias* sp.	345-350
Limestone, as above.	350-360
Limestone, as above, but no chert.	360-370
No sample.	370-380
Limestone, white, tan, and brown, granular to dense, porous, dolomitic in part, fossiliferous; crystalline calcite and some chert.	380-385
No sample.	385-400
Suwannee limestone	
Limestone, creamy white to white, soft, granular to chalky, porous, fossiliferous, calcitic.	400-410
Limestone, as above. *Rotalia mexicana* and other foraminifers.	410-420
Limestone, creamy white, soft, granular, calcitic, porous, chalky matrix, fossiliferous, abundant molds, casts, spines, and foraminifers. *Rotalia mexicana.*	420-425
No sample.	425-430
Limestone, as above.	430-460
No sample.	460-470
Limestone, buff and tan to white, fairly soft, porous, chalky; brown crystalline dolomite; some chert. *Rotalia mexicana, Dictyoconus cookei* and other foraminifers present.	470-475
No sample.	475-480
Limestone, as above.	480-485
No sample.	485-490
Limestone, white to tan, granular, porous, dolomitic in part, fossiliferous. Abundant *Dictyoconus cookei, Coskinolina floridana* and *Rotalia mexicana.*	490-500
Limestone, as above, and brown shaly, carbonaceous clay.	500-510
Limestone, as above.	510-520
Limestone, white, soft, granular, porous, fossiliferous; hard brown crystalline dolomite; *Dictyoconus cookei* and other foraminifers poorly preserved.	520-525

Table 7. (Continued)

Lithology	Depth Below Land Surface
No sample.	525-530
Dolomite, brown, hard, crystalline.	530-535
Dolomite, as above, with some soft granular porous fossiliferous limestone. *Dictyoconus cookei* and *Coskinolina floridana.*	535-550
No sample.	550-560
Limestone, white, granular, soft to hard, porous to dense; small amount of fossiliferous dolomite. *Dictyoconus cookei* and *Coskinolina floridana.*	560-565
No sample.	565-575
Limestone, as above, but dolomite not present.	575-580
No sample.	580-600
Limestone, white, finely granular, soft, porous, fossiliferous; abundant foraminifers, echinoid spines.	600-605
No sample.	605-615
Ocala group	
Limestone, white, chalky, soft, finely granular, porous, fossiliferous. *Lepidocyclina ocalana, L. floridana, Nummulites* sp., *Gypsina globula*, and other foraminifers.	615-642

Well 42-23-1

(Florida Geol. Survey No. W-2675)

Pleistocene and Pliocene	
Soil and sand.	0- 5
Sand, brown stained, quartz, fine to coarse.	5- 40
Clay, gray, calcareous, very sandy with phosphate; frosted gray and brown, quartz grains and pebbles; fish teeth; pyrite.	40- 45
Clay, gray, very sandy, calcareous, phosphatic; coarse to fine sand; frosted rounded quartz pebbles.	45- 55
Hawthorn formation	
Clay, gray-white, calcareous, chalky, sandy, phosphatic.	55- 70
Clay, as above, with some gray, sandy, impure limestone.	70- 85
Clay, as above; limestone, white, hard, sandy, fossiliferous, phosphatic.	85- 90
No sample.	90- 95
Clay, as above, with some impure limestone.	95-115
No sample.	115-125
Clay, gray-green to white, waxy to chalky, calcareous, sandy in part; impure limestone with a few mollusk fragments; phosphate and some chalcedony.	125-135

Table 7. (Continued)

Lithology	Depth Below Land Surface
Tampa formation	
Clay, olive green to gray, calcareous, sandy; gray, sandy limestone; some crystalline calcite; chert and phosphate.	135-145
Limestone, gray-white, fairly hard, sandy, dolomitic in part; chert; a few mollusk fragments and foraminifers, *Archaias* and *Sorites*.	145-165
No sample.	165-170
Limestone, gray-white, fairly hard, sandy, porous in part, fossiliferous, dolomitic in part; chert and pyrite. *Archaias* and *Sorites*.	170-180
No sample.	180-185
Limestone, as above.	185-195
No sample.	195-205
Limestone, as above.	205-215
No sample.	215-225
Limestone, gray-white, tan and brown, hard, dense, dolomitic and crystalline in part, sandy, porous in part, fossiliferous; crystalline calcite and chert; mollusks and foraminifers. *Archaias*.	225-235
No sample.	235-240
Limestone, as above.	240-250
No sample.	250-255
Limestone, gray-white to brown, fairly soft to hard, granular to dense, porous, dolomitic in part, sandy in part; crystalline calcite and pyrite; mollusk molds and casts, foraminifers. *Archaias*.	255-275
No sample.	275-300
Suwannee limestone	
Limestone, white to buff, soft, granular to somewhat chalky, very porous, fossiliferous; chert; echinoid spines and plates, mollusk molds and casts, many small foraminifers. *Rotalia mexicana*.	300-310
No sample.	310-320
Limestone, as above.	320-345
No sample.	345-350
Limestone, as above, but more chalky and less porous.	350-360
No sample.	360-365
Limestone, as above.	365-375

Well 42-25-3

(Florida Geol. Survey No. W-2796)

Lithology	Depth Below Land Surface
Pleistocene and Pliocene	
Sand, white, fine to coarse.	0- 10
Sand, brown, fine to coarse, carbonaceous, shells.	10- 20

Table 7. (Continued)

Lithology	Depth Below Land Surface
Sand, quartz and phosphate, fine to coarse.	20- 23
Hawthorn formation	
Clay, gray-white, calcareous, chalky, phosphatic; few mollusk molds and casts.	23- 25
Clay, white, chalky, sandy, calcareous, phosphatic; gray-white impure sandy limestone; pyrite.	25- 35
No sample.	35- 45
Clay, gray-white, calcareous, sandy, phosphatic; gray impure sandy fossiliferous limestone; pyrite; chert; mollusk molds and casts.	45- 50
No sample.	50- 60
Clay, white to gray, chalky, sandy; chert and phosphate.	60- 70
No sample.	70- 75
Clay, greenish gray, sticky, sandy, calcareous; phosphate grains and pebbles; gray impure sandy limestone, oolitic in part, phosphatic.	75- 85
No sample.	85- 90
Clay, gray-white, chalky; phosphatic sand and pebbles; gray hard impure limestone; phosphatic sand.	90-100
No sample.	100-110
Clay, gray-white, calcareous, very sandy; white to buff sandy limestone; phosphate and pyrite.	110-120
No sample.	120-140
Clay, as above; gray to buff, hard, dense sandy limestone; phosphate; chalcedony; dolomite.	140-150
Clay, gray-green, calcareous, very sandy, phosphatic.	150-153
Tampa formation	
Limestone, white, chalky, soft, fossiliferous, fairly porous. *Archaias.*	153-155
No sample.	155-165
Limestone, gray-white, fairly hard, sandy, fossiliferous; chert.	165-170
No sample.	170-175
Limestone, gray-white, hard, porous to dense, crystalline, sandy; chert; mollusk fragments. Abundant *Archaias* and *Sorites.*	175-185
No sample.	185-190
Limestone, gray to tan, hard, porous to dense, dolomitic in part, sandy in part; gray and tan chert; crystalline calcite; mollusks and foraminifers. *Sorites.*	190-200
No sample.	200-210
Limestone, gray-white to brown, granular, sandy, porous to dense, hard, dolomitic, and crystalline in part, fossiliferous; chert. *Archaias.*	210-245
No sample.	245-255

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, as above.	255-275
Limestone, gray-white to dark brown, soft to hard, granular, porous to dense, fossiliferous, dolomitic, slightly sandy; crystalline calcite, chert; mollusks and foraminifers.	275-285
No sample.	285-290
Limestone, as above but no chert.	290-300
Limestone, gray-white to brown, fairly soft to hard, granular, porous to dense, fossiliferous, dolomitic in part, slightly sandy; gray and brown chert; crystalline calcite.	300-305
No sample.	305-310
Limestone, white and buff, fairly soft, granular, porous in part, fossiliferous; crystalline calcite; chert; *Sorites*.	310-315
No sample.	315-320
Limestone, as above, but dolomitic in part.	320-330
No sample.	330-340
Suwannee limestone	
Limestone, white, soft, granular to chalky, porous, fossiliferous; crystalline calcite; mollusks, echinoid spines, foraminifers.	340-345
No sample.	345-365
Limestone, creamy white, soft, granular, porous, finely crystalline in part; crystalline calcite. *Rotalia mexicana*.	365-375
No sample.	375-380
Limestone, as above.	380-390
No sample.	390-415
Limestone, creamy white to buff, soft, granular to chalky, porous; fossils abundant but poorly preserved. *Rotalia mexicana, Dictyoconus cookei*.	415-425
No sample.	425-435
Limestone, gray-tan, fairly hard, granular with a chalky matrix, not very porous, fossiliferous as above.	435-445
No sample.	445-460
Limestone, gray-tan, soft, granular, porous, fossiliferous; crystalline in part. *Rotalia mexicana, Dictyoconus cookei*.	460-470
No sample.	470-480
Limestone, white, soft, granular, fossiliferous; dolomite, tan and brown, hard, crystalline; chert. *Rotalia mexicana, Dictyoconus cookei, Coskinolina floridana*.	480-490
Limestone, gray-tan, fairly hard, granular, impure, dolomitic in part, fairly porous; chert. *Rotalia mexicana, Dictyoconus cookei, Coskinolina floridana, Gypsina globula*. Top of Ocala group apparently in this interval.	490-500
Ocala group	
Limestone, gray-white to tan, granular, fairly porous, fossilferous, dolomitic in part; chert; crystalline calcite. *Gypsina globula* abundant.	500-510

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, gray-white to buff, fairly soft, granular to chalky, porous, fossiliferous; chert and crystalline calcite. *Gypsina globula*, *Nummulites* sp., *Operculinoides* sp., *Heterostegina ocalana*.	510-520
Limestone, predominantly a coquina of mollusk fragments and poorly preserved foraminifers in a finely granular to chalky matrix. *Nummulites* sp., *Gypsina globula*, *Lepidocyclina ocalana*.	520-550

Well 45-25-8

(Florida Geol. Survey No. W-2546)

No sample.	0- 30
Hawthorn formation	
Clay, white, chalky, sandy, calcareous, phosphatic.	30- 35
Limestone, gray-white, dense, sandy with chert; pyrite; phosphate.	35- 40
Clay, light green, waxy, sandy, calcareous, phosphatic; some chert.	40- 50
As above.	50- 65
Clay, as above; limestone, white, dense, sandy; some chert and a few mollusk fragments.	65- 85
As above.	85- 95
Tampa formation	
Limestone, gray-white, hard, dense, sandy, fossiliferous; crystalline calcite in solution cavities; dolomite, gray-tan, hard, dense, crystalline.	95-100
No sample.	100-110
Limestone, white and gray, hard, sandy; chert fragments; mollusk molds and casts.	110-120
Limestone, white and gray, granular, porous, chalky, sandy in part; chert; mollusk molds and casts. *Archaias* and other foraminifers.	120-130
Limestone, as above but more porous. *Sorites*, abundant *Archaias*.	130-140
No sample.	140-150
Limestone, white, gray, and tan, fairly hard, dense to porous, sandy in part, fossiliferous; chert.	150-160
No sample.	160-170
Limestone, white to tan, fairly hard, dense, sandy in part; chert; pyrite and crystalline calcite.	170-180
No sample.	180-200
Limestone, as above, but dolomitic in part.	200-210
No sample.	210-240
Limestone, white to tan, fairly hard, dense to granular, porous; contains a few foraminifers.	240-250
No sample.	250-270

Table 7. (Continued)

Lithology	Depth Below Land Surface
Suwannee limestone	
Limestone, white, chalky, granular, porous; abundant small foraminifers and echinoid fragments.	270-275
Limestone, creamy white to tan, soft, granular, porous, fossiliferous.	275-285
No sample.	285-315
Limestone, as above.	315-325
No sample.	325-340
Limestone, as above. *Rotalia mexicana* and *Dictyoconus cookei.*	340-350
As above.	350-365
No sample.	365-415
Limestone, buff and tan, soft, granular, porous, fossiliferous. *Dictyoconus cookei.*	415-425

Well 42-27-6

(Florida Geol. Survey No. W-2674)

Pleistocene and Pliocene	
Sand and shells.	0- 38
Hawthorn formation	
Clay, gray, calcareous, sandy, phosphatic.	38- 45
No sample.	45-140
Clay, gray, sandy, calcareous, waxy in part; phosphate grains and pebbles; chert.	140-165
Tampa formation	
Limestone, white, gray, buff and tan, fairly soft, granular, fossiliferous; chert; *Sorites.*	165-170
Limestone, gray-white to buff, soft, granular, porous, sandy; chert; crystalline calcite in solution cavities; mollusk fragments, small foraminifers. *Sorites.*	170-175
No sample.	175-210

Well 43-26-4

(Florida Geol. Survey No. W-2414)

Pleistocene and Pliocene	
Sand.	0- 5
Sand and shells.	5- 15
Sand, shells, clay, gray, calcareous, sandy, phosphatic.	15- 20

Table 7. (Continued)

Lithology	Depth Below Land Surface
Hawthorn formation	
Clay, gray, sandy, calcareous, phosphatic.	20- 40
Clay, gray-green, white, calcareous, sandy, phosphate grains and pebbles; large quartz grains.	40- 50
Clay, gray-white, calcareous, sandy, phosphatic; white to tan, impure, sandy limestone; chert.	50- 60
Clay, as above, with pyrite fragments.	60- 80
Clay, as above, with some impure limestone and chert.	80- 85
Clay, blue-gray, calcareous, sandy; phosphate and chert.	85-100
Clay, white to blue-gray, chalky, sandy; phosphate and chert.	100-110
Clay, white to green, chalky, shaly, sandy, calcareous; phosphate and chert.	110-115
Clay, green, calcareous, very sandy; phosphate and chert.	115-125
Clay, green, calcareous, shaly, slightly sandy; phosphate and chert.	125-130
No sample.	130-135
Tampa formation	
Limestone, white to tan, fairly hard, granular to dense, porous, sandy in part, fossiliferous; chert; mollusks and foraminifers. *Archaias* and *Sorites*.	135-140
Limestone, white to dark gray, hard, very sandy, crystalline calcite in solution cavities; chert; few mollusk molds and casts. *Archaias* and *Sorites*.	140-170
Limestone, white, chalky, granular, slightly sandy in part, porous; crystalline calcite in cavities; mollusk fragments. *Archaias* and *Sorites*.	170-180
No sample.	180-190
Limestone, as above.	190-195
Limestone, gray-white, granular to tan, hard, dense, sandy; crystalline calcite; chert. *Archaias* and *Sorites*.	195-220
Limestone, tan to dark gray, very hard, dense, slightly sandy in part, dolomitic; chert.	220-235
Limestone, gray-white, fairly hard, sandy, chalky; crystalline calcite in solution cavities; mollusk molds and casts.	235-240
No sample.	240-250
Limestone, white, gray, and tan, hard, dense, sandy; chert and crystalline calcite.	250-265
No sample.	265-275
Limestone, as above.	275-280
Limestone, white, soft, granular, chalky, sandy; crystalline calcite; mollusk molds and echinoid spines.	280-290
Limestone, buff, fairly soft, granular, slightly sandy, crystalline in part; chert and calcite.	290-295
No sample.	295-300

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, gray-white, tan, and brown, hard, dense, dolomitic, slightly sandy.	300-305
Limestone, gray-white, tan, soft to hard, granular to dense, dolomitic in part; chert and calcite; mollusk fragments.	305-315
No sample.	315-325
Suwannee limestone	
Limestone, creamy white, buff, and tan, soft, granular, porous fossiliferous; chert and calcite.	325-345
Limestone, as above, somewhat harder. *Rotalia mexicana.*	345-355
Limestone, white, soft, granular, somewhat chalky, fairly porous; mollusks, echinoids and foraminifers. *Rotalia mexicana.*	355-435
Limestone, white to tan, soft, granular, somewhat chalky, not very porous, fossiliferous; crystalline calcite. *Rotalia mexicana* and *Dictyoconus cookei.*	435-455
Limestone, white to tan, soft to hard, granular to dense, fossiliferous. *Rotalia mexicana, Dictyoconus cookei, Coskinolina floridana.*	455-465
Limestone, tan, gray, and brown, soft to hard, granular to dense, crystalline in part, fossilferous. *Dictyoconus cookei,* and *Coskinolina floridana.*	465-475
Limestone, gray-brown, fairly soft, granular, crystalline in part, fossiliferous. *Dictyoconus cookei* and *Coskinolina floridana.*	475-510

Well 46-23-5

(Florida Geol. Survey No. W-2668)

Lithology	Depth Below Land Surface
Pleistocene and Pliocene	
No sample.	0- 20
Sand, gray-brown, fine to coarse, rounded, carbonaceous.	20- 27
Hawthorn formation	
Clay, gray, waxy, sandy in part, calcareous, phosphatic.	27- 30
Clay, gray, calcareous, sandy, phosphatic.	30- 40
Clay, as above; limestone, gray-white, sandy, chalky, impure; chert and phosphate.	40- 70
Clay, gray-green, waxy, calcareous, sandy in part; chert and phosphate.	70- 80
Tampa formation	
Limestone, dark gray to brown, hard, sandy, silicified in part, dolomitic in part.	80-100
Limestone, gray-white, fairly hard, sandy, porous, fossiliferous; dolomite, brown, crystalline; chert. *Archaias* and *Sorites.*	100-120

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, white, soft, chalky, slightly sandy, granular porous; gray-brown hard, dense, splintery, sandy limestone; brown crystalline dolomite. *Archaias* and *Sorites*.	120-130
Limestone, gray-white, sandy, hard, porous to dense; dolomite, as above; chert and a few poorly preserved fossils.	130-140
Limestone, gray-white to tan, fairly soft, chalky; hard dense, porous in part, sandy, fossiliferous limestone; dolomite, as above, and some chert. *Sorites* and other foraminifers.	140-150
Limestone, gray to tan, hard, sandy; gray-brown hard, crystalline dolomite; chert.	150-170
Limestone, gray-white, tan, fairly hard, sandy, dolomitic, fossiliferous; chert. *Sorites*.	170-180
Limestone, white, gray and brown, hard, sandy; gray-brown hard crystalline dolomite, porous in part.	180-200
Limestone, gray-white, tan, brown, hard, dense, sandy in part, dolomitic in part; chert; few poorly preserved fossils.	200-220
Limestone, white, soft, granular, porous, fossiliferous; dolomite, gray-brown; echinoid spines. *Archaias*.	220-230
Limestone, as above, also gray-brown, sandy, dolomitic. *Sorites*.	230-250
Limestone, creamy white, buff, and tan, soft, granular, fossiliferous.	250-260

Well 46-23-8

(Florida Geol. Survey No. W-2671)

No sample.	0- 30
Hawthorn formation	
Clay, gray-white, calcareous, sandy; phosphate grains and pebbles, interbedded with gray hard sandy, fossiliferous limestone.	30- 55
Tampa formation	
Limestone, gray to white, fairly soft to hard, granular, porous to dense, sandy; brown dolomite; chert; mollusk fragments and foraminifers. *Sorites*.	55- 70
Limestone, gray-brown, hard, dense, sandy, dolomitic in part, porous in part, fossiliferous; chert. *Sorites*.	70-100
Limestone, white, soft, granular, having chalky matrix, porous, fossiliferous; much chert. *Sorites, Archaias*.	100-110
Limestone, gray, white, tan, fairly soft, porous, sandy; chert; mollusks, echinoids, foraminifers.	110-120
No sample.	120-130
Limestone, gray-white, tan, hard, dense, sandy to soft, chalky, porous; chert; mollusks, milliolids. *Sorites*.	130-140

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, gray-white, tan, fairly hard, dense, porous in part, sandy in part, dolomitic in part; chert. *Archaias*.	140-150
No sample.	150-160
Limestone, as above.	160-170
Limestone, gray-brown, hard, sandy, dolomitic, fossiliferous; chert; mollusks and echinoid spines.	170-180
Limestone, white, soft, chalky; brown hard dolomite containing much sand.	180-190
No sample.	190-200
Limestone, gray-brown, hard to soft, dense, chalky, fossiliferous in part; chert.	200-205
No sample.	205-210
Limestone, gray-white and tan, fairly soft, granular, sandy in part, dolomitic in part; chert; fossils poorly preserved.	210-220
No sample.	220-230
Limestone, gray-brown, hard, dense, crystalline in part, chalky and porous in part, dolomitic in part, fossiliferous.	230-255
No sample.	255-260
Suwannee limestone	
Limestone, creamy white, soft, granular, porous, fossiliferous; echinoid spines and plates, mollusk fragments, abundant foraminifers. *Rotalia mexicana*.	260-300

Well 46-24-10

(Florida Geol. Survey No. W-2321)

Lithology	Depth Below Land Surface
No sample.	0-180
Tampa formation	
Limestone, white, chalky, sandy, porous; brown hard dense, dolomitic, fossiliferous limestone; chert; mollusks and foraminifers. *Archaias* and *Sorites*.	180-200
No sample.	200-210
Limestone, white, buff, and tan, chalky, granular, porous; hard dense, very sandy limestone.	210-230
No sample.	230-240
Limestone, white, tan, and brown, soft to hard, granular, porous to dense, fossiliferous; chert; abundant small foraminifers. *Archaias*.	240-245
As above, with pyrite fragments.	245-265
No sample.	265-285
Suwannee limestone	
Limestone, creamy white to buff, soft, granular, porous, foraminiferal; mollusks, echinoids, milliolids, and other small foraminifers abundant but poorly preserved.	285-300

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, as above, crystalline in part, somewhat chalky; *Rotalia mexicana.*	300-365
No sample.	365-375
Limestone, as above.	375-380
No sample.	380-390
Limestone, gray-white to tan, fairly soft, granular; limestone, fairly hard, dense, crystalline, porous in part, fossiliferous; some chert. *Rotalia mexicana, Dictyoconus cookei,* and *Coskinolina floridana.*	390-400
Limestone, as above, but no chert.	400-410
Limestone, as above, with pyrite and chalcedony.	410-420
Limestone, creamy white, soft, granular, porous, fossiliferous, with some carbonaceous material. *Rotalia mexicana, Dictyoconus cookei, Coskinolina floridana.*	420-435
Limestone, gray-brown, hard, dense, crystalline in part, fossiliferous; abundant milliolids, poorly preserved.	435-450
Limestone, gray-brown, fairly soft to hard, granular, porous to dense, crystalline in part; mollusks and foraminifers.	450-460
No sample.	460-470
Limestone, as above. *Coskinolina floridana* and *Dictyoconus cookei;* white, buff and tan soft granular fossiliferous limestone. *Gypsina globula.* Top of Ocala group in this interval.	470-480

Well 47-23-1

(Florida Geol. Survey No. W-2670)

Pleistocene and Pliocene	
Sand and shells.	0- 25
Hawthorn formation:	
Clay, gray, sandy, calcareous, phosphatic; sandy hard phosphatic limestone; a few mollusk molds and casts.	25- 30
No sample.	30- 50
Clay, greenish gray, waxy, calcareous, sandy, phosphatic.	50- 60
Clay, gray-white, chalky.	60- 65
Tampa formation:	
Limestone, gray-white to tan, fairly hard, dense, sandy; chert, pyrite, and a few fragments of mollusk molds and casts.	65- 70
Limestone, gray-white, very sandy, fairly hard, with very fine black phosphate grains; chert. *Sorites* sp. and other fossils.	70- 80
Limestone, white to buff, soft, chalky to granular, porous, sandy in part, some chert, fossiliferous. Specimens of *Archaias* and *Sorites* fairly abundant.	80- 90

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, as above.	90-100
Limestone, gray-white, fairly soft, granular, porous in part; very sandy, hard limestone, dense in part; chert; fossiliferous, as above, including specimens of *Archaias* and *Sorites*.	100-110
Limestone, gray to white, soft to hard, dense to porous; sandy, dolomitic in part; chert; fossiliferous, as above.	110-120
Limestone, gray to tan, fairly hard, dense, sandy; mollusk molds and casts and foraminifers.	120-130
Limestone, as above.	130-140
No sample.	140-150
Limestone, gray to tan and brown, hard, dense, sandy, dolomitic in part.	150-165
Limestone, as above, but more dolomitic; a few fossil molds and casts.	165-175
Limestone, gray, white, and tan, fairly hard, dense to granular, porous, dolomitic in part; some poorly preserved foraminifers and other fossils.	180-200
Limestone, white to tan, soft, granular to chalky, porous; milliolids, echinoid plates and spines abundant.	200-220
Limestone, gray to tan, fairly hard, dense to granular and porous, fossiliferous as above.	220-230
Suwannee limestone	
Limestone, creamy white, soft, granular, porous; small amount of chert; foraminifers abundant but poorly preserved.	230-250
Limestone, creamy white, soft, granular, porous, chalky, fossiliferous. *Rotalia mexicana* fairly abundant.	250-290
No sample.	290-330
Limestone, gray-tan, fairly soft, granular, porous, fossiliferous. *Dictyoconus cookei, Coskinolina floridana*.	330-340

Well 51-23-2

(Florida Geol. Survey No. W-2411)

Lithology	Depth Below Land Surface
Pleistocene and Pliocene	
Sand, quartz, medium to coarse, carbonaceous material, shell fragments.	0- 5
Hawthorn formation	
Clay, gray to brownish, sandy, calcareous; phosphate grains and pebbles.	5- 20
Clay, gray, sandy, calcareous; gray-white hard sandy, argillaceous limestone; chert and phosphate grains and pebbles.	20- 38

Table 7. (Continued)

Lithology	Depth Below Land Surface
Tampa formation	
Limestone, white, fairly soft, chalky, sandy; chert and calcite.	38- 45
Limestone, white, soft, chalky, slightly sandy; chert and calcite; few foraminifers. *Sorites.*	45- 50
Limestone, as above, with mollusk fragments.	50- 55
Limestone, as above, with very little sand; chert and calcite. *Sorites* and *Archaias.*	55- 60
Limestone, gray-white to tan, fairly hard, sandy; calcite; mollusk molds and casts. *Sorites, Archaias* and other foraminifers.	60- 80
Limestone, gray-white to tan, hard, dense, sandy; abundant mollusk fragments. *Sorites.*	80- 85
Limestone, gray-white, fairly soft, slightly sandy; gray and tan, hard dense impure limestone. *Archaias.*	85- 90
Limestone, as above, with some chert and a few fossils.	90- 95
Limestone, gray-white to tan, hard, dense, impure; very little sand; chert.	95-100
Suwannee limestone	
Limestone, creamy white to buff, soft, granular, porous, crystalline in part, having a chalky matrix; chert; mollusks, abundant echinoid spines. *Rotalia mexicana* and other foraminifers.	100-145
Limestone, creamy white to buff, soft, granular, porous, crystalline in part, fossiliferous; foraminifers abundant but poorly preserved.	145-160
Limestone, as above, with chert fragments.	160-175
Limestone, creamy white to buff, soft, granular, porous, crystalline in part; abundant mollusk fragments, echinoid spines, and foraminifers.	175-210
Limestone, gray-white to tan, soft, granular, porous, crystalline in part, fossiliferous; few poorly preserved *Dictyoconus cookei.*	210-215
Limestone, as above, with some chert. *Dictyoconus cookei* and *Coskinolina floridana.*	215-220
Limestone, as above, but no chert.	220-225
Limestone, gray, white, and tan, soft to hard, granular to dense, fossiliferous; mollusks, echinoids, foraminifers. *Dictyoconus cookei* and *Coskinolina floridana.*	225-260
Limestone, as above, with some chert; no *Dictyoconus* or *Coskinolina* noted.	260-270
No sample.	270-275
Limestone, gray-white to tan, fairly soft, granular, porous, fossiliferous; chert.	275-290
Limestone, white, buff, and tan, granular, chalky to dense, fossiliferous, granular cemented with calcite paste; porosity probably low; some crystalline calcite and chert.	290-300

Table 7. (Continued)

Lithology	Depth Below Land Surface
Limestone, buff and tan, granular, with a chalky calcite matrix; dolomitic in part, fossiliferous.	300-325
Limestone, as above. *Rotalia mexicana, Dictyoconus cookei,* and *Coskinolina floridana.*	325-330
Ocala group	
Limestone, creamy white, buff and tan, soft, granular, porous, foraminiferal with a chalky matrix. *Gypsina globula, Lepidocyclina floridanus, L. ocalana.*	330-400
Limestone, buff and tan, coquinoid, with fine granular matrix, porous. *Gypsina globula, Lepidocyclina, Camerina.*	400-450
Limestone, creamy white to tan, coquinoid, with a chalky matrix; foraminifers include *Gypsina globula, Lepidocyclina ocalana, Operculinoides* sp., *Heterostegina ocalana.*	450-500
Limestone, creamy white to buff, soft, granular, porous, crystalline in part, fossiliferous; a few larger foraminifers and mollusks. *Gypsina globula, Operculinoides* sp., *Nummulites* sp.	500-520
Limestone, creamy white to buff, granular, fossiliferous; chert and limonite; foraminifers poorly preserved.	520-535
Limestone, creamy white to buff, soft, chalky, granular, fossiliferous, echinoid spines. *Operculinoides* sp., *Nummulites* sp.	535-555
Limestone, white, buff, and gray, soft, granular, fossiliferous; abundant echinoid spines.	555-570
Limestone, creamy white to buff, soft, very fine, granular, less fossiliferous than above.	570-575
Avon Park limestone	
Limestone, white, buff, and tan, soft, granular, chalky; limestone, hard, dense, crystalline, fossiliferous. *Dictyoconus cookei.*	575-585
Limestone, white, buff, and tan, soft, granular, chalky, fossiliferous. *Dictyoconus cookei.*	585-610
No sample.	610-670
Dolomite, brown, hard, crystalline, lignitic, and limonitic; white to brown granular to dense limestone; crystalline calcite in abundant solution cavities.	670-730
No sample.	730-765
Dolomite, as above; tan to brown dolomitic crystalline limestone.	765-775
No sample.	775-785
Dolomite and limestone, as above.	785-795
No sample.	795-805
Dolomite, medium to dark brown, hard, crystalline, porous; brown hard crystalline dolomitic limestone; crystalline calcite in solution cavities.	805-850