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INTERIM REPORT ON THE GROUND-WATER RESOURCES OF SEMINOLE COUNTY, FLORIDA

By

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and
Jack T. Barraclough

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ABSTRACT

Seminole County is in the east-central part of the Florida Peninsula. The county is underlain, beginning at a depth of 75 to 150 feet, by a series of limestone formations having a total thickness of several thousand feet. The upper part of the limestone section is composed of the Lake City limestone of early middle Eocene age, the Avon Park limestone of late middle Eocene age, and the Ocala group 1/ of late Eocene age. The limestone formations are overlain by the Hawthorn formation of middle Miocene age, and, where the Hawthorn is absent, by deposits of clay and sandy shell which are referred to in this report as deposits of late Miocene or Pliocene age. A blanket of Pleistocene and Recent sand underlies the surface of the county to a depth of 25 to 50 feet.

The section of limestone that includes the Ocala group and the Avon Park limestone is the most important source of ground water in the county. Water in this section is under artesian pressure in most of the county and will flow at the surface from wells penetrating the limestone in the lowland areas. The artesian water is derived principally from recharge that enters the limestones in Orange and Polk counties, although some may be derived from small recharge areas in Seminole County.

1/ The stratigraphic nomenclature used in this report conforms to the usage of the Florida Geological Survey. It also conforms to the usage of the U. S. Geological Survey with the exception of the Ocala group and its subdivisions.

Records of the seasonal fluctuations of artesian pressure show that the pressure head is lowered during the periods of heaviest withdrawal as much as 10 feet in the Oviedo area and 4 to 6 feet in the Sanford area. A comparison of measurements made in 1937 with ones made recently shows that, in areas where withdrawals have increased, the artesian pressure head has declined slightly, whereas, in areas where the withdrawals are unchanged or have decreased, the pressure head has remained about the same.

The chloride content of water from artesian wells in Seminole County ranges from less than 10 parts per million (ppm) in the recharge areas around the towns of Lake Mary and Geneva to more than 5,000 ppm in the area adjacent to Lake Harney. In the truck-farming areas, near Sanford and Oviedo, the chloride content ranges from about 25 ppm to slightly more than 1,500 ppm. A comparison of chloride analyses made in 1937 with those made recently shows that there has been little or no change in the chloride content of the artesian water in most of the county.

INTRODUCTION

Salt-water encroachment is undoubtedly the problem of most concern to users of ground water in Florida. This is a problem in many coastal areas where water levels are lowered excessively by heavy pumping. It is a problem also in some inland areas where the water-bearing formations contain salty water at relatively shallow depths. Among the coastal areas where wells have become contaminated with salt water are Pinellas County and the Miami area of Dade County. Inland areas where wells are likely to become contaminated with salt water include Seminole County and the southwestern part of Volusia County.

Much of the economy of Seminole County is based on the growing of winter vegetables. The most important farming areas are in the lowlands adjacent to Lake Monroe and Lake Jessup, where adequate supplies of water are available from the natural flow of artesian wells. In parts of the farming areas, wells yield relatively salty water. Also, locally the artesian pressure has declined as a result of the heavy withdrawal of water for irrigation and vegetable packing. This decline has resulted in a decrease in the area of artesian flow, and caused the use of pumps on wells that had previously produced an adequate supply of water by natural flow. It may lead also to contamination of the existing supplies with salty water from the formations that underlie the producing aquifer. Recognizing this possibility, the Board of County Commissioners of Seminole County requested the United States Geological Survey and the Florida Geological Survey to make an investigation of the ground-water resources of the county. In response to this request, an investigation was begun in October 1951 by the U. S. Geological Survey and the Florida Geological Survey in cooperation with the Board of County Commissioners of Seminole County and the City of Sanford.

The purpose of the investigation is to make a detailed study of the geology and ground-water resources of the county with special emphasis on the problems associated with declining water levels and salt-water contamination. This report reviews briefly the progress of the investigation through February 1954. The major phases of the investigation include the following:

(1) An inventory of wells to determine their number and distribution, their depths and diameters, their yields and artesian pressure, and other pertinent information.

(2) A study of artesian pressure to determine the seasonal fluctuations and progressive trends. This study will include mapping the height to which water will rise in wells in the county.

(3) A study of water quality based on chemical analysis of samples from selected wells.

(4) Collection of data on the use of water in order to arrive at an estimate of the total quantity of ground water being withdrawn.

(5) Studies to locate the water-bearing zones and to determine the water-transmitting and water-storing capacities of the artesian aquifer.

(6) Geologic studies to determine the thickness, character, and extent of the different geologic formations.

(7) A study of the shallow, nonartesian aquifer to determine the quantity and quality of water available from this source.

Previous Investigations

The geology and ground-water resources of Seminole County are described in several reports published by the Florida Geological Survey, the Florida Academy of Sciences, and the United States Geological Survey.

A report by Matson and Sanford (1913, p. 376-381) contains a brief discussion of the geology and ground-water resources of Orange County which, at that time, included the area that is now Seminole County. A report by Sellards and Gunter (1913, p. 113) contains information on the wells in Seminole County.

As part of a general investigation of the ground-water resources of the State, Stringfield (1934) made a brief investigation of the ground-water resources of Seminole County in the early thirties. The geology and ground water of Seminole County also is discussed by Stringfield (1936, p. 135-136, 162, 174, and 188) in a report on the artesian water in the Florida Peninsula. This report includes a map showing the area of artesian flow, a map showing the areas in which the artesian water contains more than 100 ppm of chloride, and the first published map of the piezometric surface of the principal artesian aquifer. A study of the artesian water supply and geology of Seminole County was made by Stubbs. His report (Stubbs, 1937, p. 24-36) includes two maps of the piezometric surface and a map showing the areas of artesian flow. Stubbs' report also contains a discussion of the different formations that underlie the county. As a part of his work in the county, Stubbs periodically measured the water levels in selected wells and analyzed the chloride content of water samples collected from selected wells. 2/

2/ Unpublished records of Sidney A. Stubbs and Irving Feinberg in the files of H. James Gut, Sanford, Fla.

A report by Unklesbay (1944), describing ground-water conditions in Orlando and vicinity, includes records of three wells and one spring in Seminole County. The geology of the State, including the formations in Seminole County, is described in a report by Cooke (1945, p. 225).

A report by Ferguson and others (1947, p. 149-154) contains descriptions of three of the largest springs in the county and chemical analyses of their waters. Chemical analyses of water from wells in Seminole County are contained in reports by Collins and Howard (1928, p. 228) and Black and Brown (1951, p. 104).

GEOGRAPHY

Seminole County is in the east-central part of the Florida Peninsula (see fig. 1). The area of the county is 321 square miles or 205,440 acres. The mean temperature in the area is about 72°F, according to the records of the United States Weather Bureau. The average annual rainfall is about 50.5 inches.

The topography of Seminole County may be divided into two types: a flat lowland, characteristic of the area adjacent to Lake Monroe in the vicinty of Sanford; and hilly uplands, characteristic of the area in the vicinity of Lake Mary.

The level lowland includes the area ranging from a few hundred feet to more than 2 miles wide adjacent to the Wekiva and St. Johns rivers, Lake Jessup, and Econlockhatchee Creek. Altitudes within this area range from about 7 feet above sea level near the St. Johns River to about 25 feet above sea level where the area merges into the hilly upland.

The hilly upland includes the remainder of the county. The surface features of this area include numerous sand hills, a few relatively level areas, and numerous lakes. Many of the lakes were probably formed by the collapse of the surface deposits into caverns formed by solution of the underlying limestone. Altitudes in this area range from about 25 feet, where the area adjoins the level lowlands, to about 100 feet in the vicinity of Altamonte Springs.

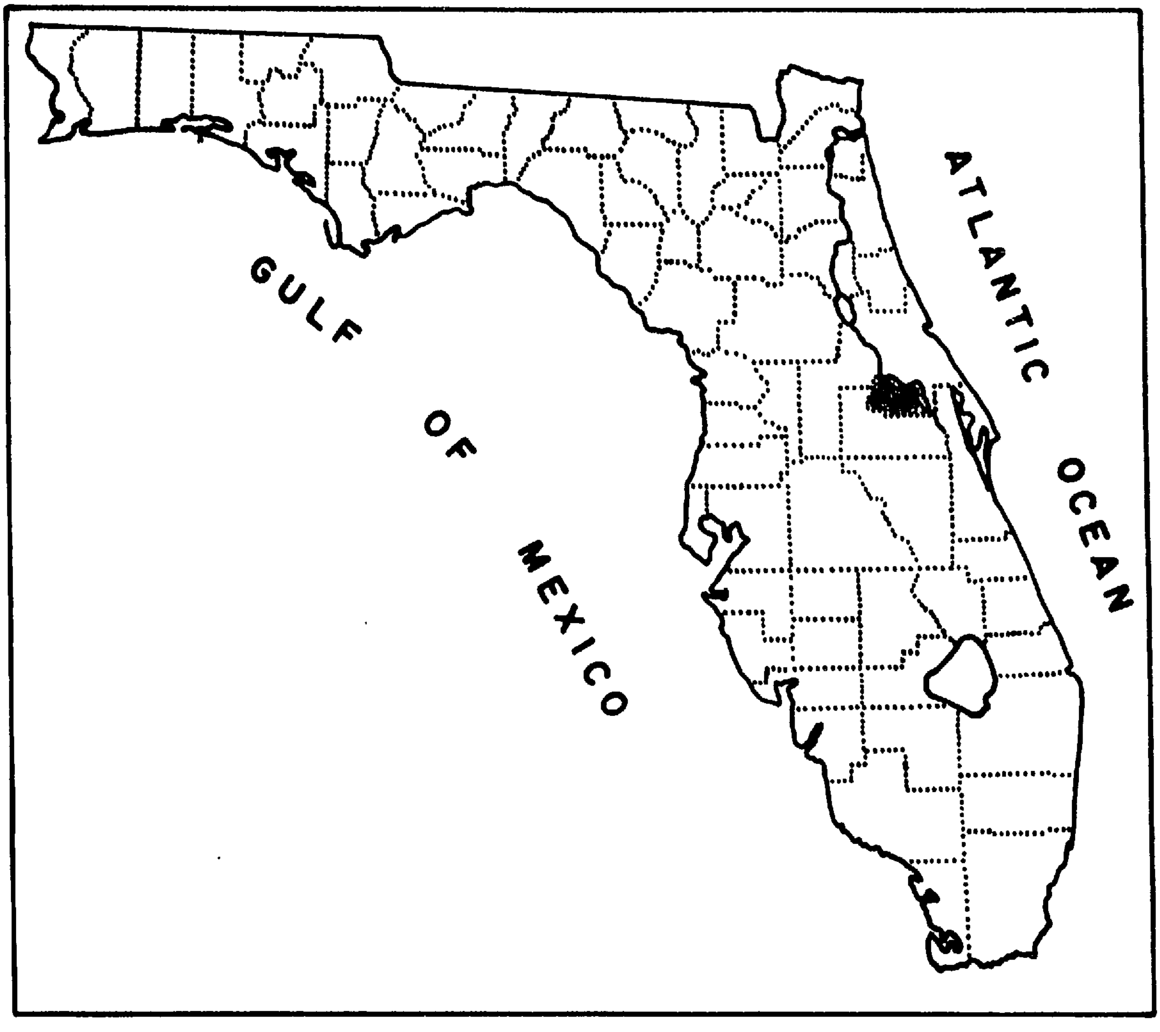

Figure 1. Map of Florida showing location of Seminole County.

The level lowlands and some small areas of the hilly uplands are drained by the St. Johns River and its tributaries, which include Lake Jessup, the Wekiva River, and Econlockhatchee Creek. The remainder of the hilly uplands are drained through lakes and sinkholes into the limestone aquifer.

According to the Florida State Marketing Bureau's annual fruit and vegetable report for the 1952-53 season (Scruggs and Scarborough, 1953) Seminole County, with a total of 8,575 acres under cultivation, ranked seventh among the counties of the State in the growing of vegetables. Thus, although Seminole is the fourth smallest county in the State, it ranks high in agricultural production. The county ranks second in the growing of celery, is tied with St. Johns County for second place in the production of cabbage, and ranks seventeenth in the production of citrus fruits, having 7,829 acres planted in groves. The county's large production of vegetables is due principally to the availability of adequate supplies of water from the natural flow of relatively shallow wells.

GEOLOGY

Only a few sets of the cuttings collected from wells drilled in the county during the current investigation have yet been studied. Therefore, only a generalized description of the subsurface geology will be included in this interim report.

A generalized cross section showing the formations penetrated by water wells is shown in figure 2. As may be seen from the figure the lowermost formation penetrated by water wells in Seminole County is the Lake City limestone of early middle Eocene age. However, only a few wells have been drilled into this formation because adequate supplies of water can generally

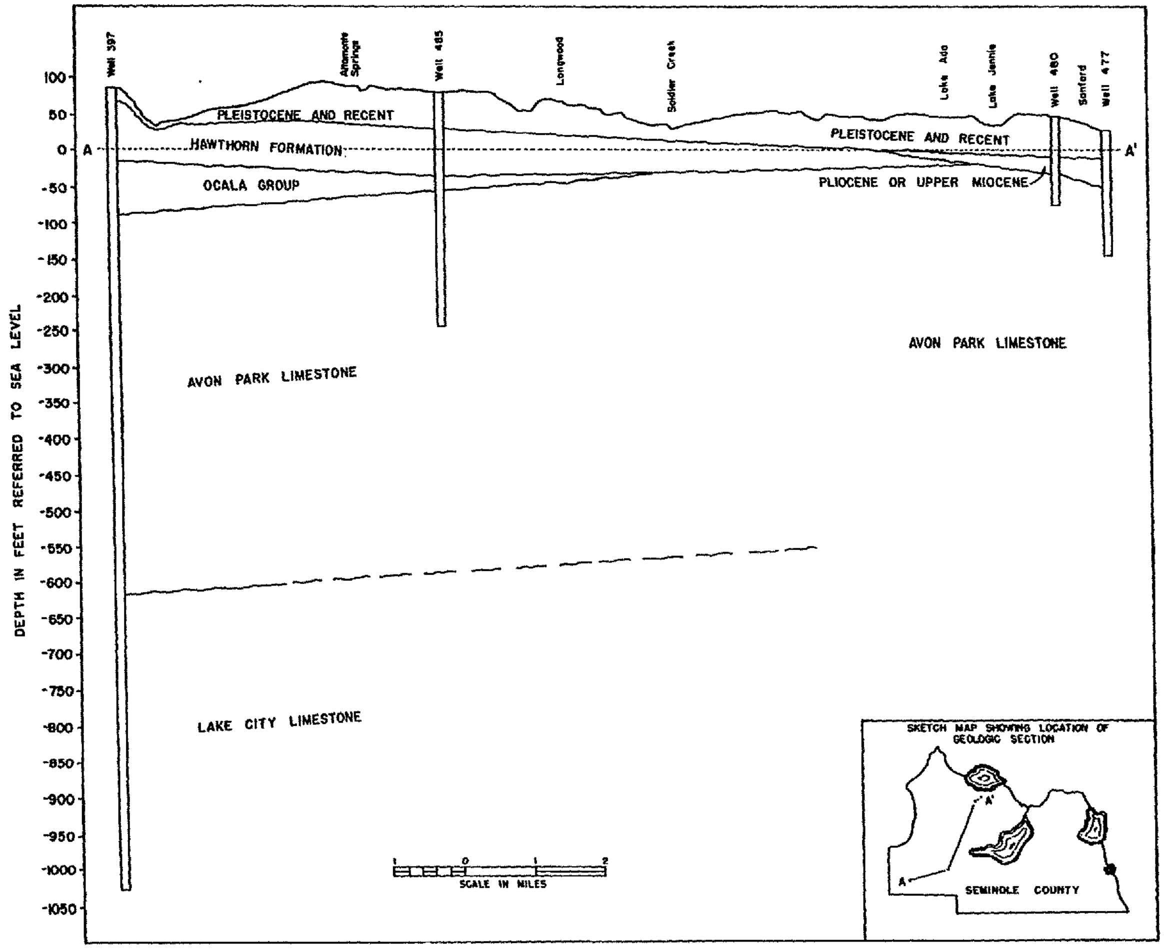

Figure 2. Generalized geologic section showing the formations penetrated by wells in Seminole County.

be obtained from the overlying formations. The Lake City limestone consists generally of alternating layers of dark-brown and chalky limestone. In some areas, it has been altered to dolomitic limestone and dolomite. The water from the Lake City is somewhat less mineralized than the water from the overlying formations in areas where these formations do not contain salty water. This may be due to the fact that the formation contains an appreciable percentage of dolomite or dolomitic limestone which is less soluble in water than pure limestone.

The principal source of ground water in the vicinity of Sanford is the Avon Park limestone of late middle Eocene age. It consists of chalky limestone ranging in color from white to buff. The formation has been irregularly dolomitized since deposition, although the original structures of the rock are commonly preserved. The Avon Park is the first limestone penetrated by wells in the north-central part of the county, and as it is a highly productive source of water, many of the wells in the north-central part of the county draw from it exclusively.

Prior to work in Levy and Citrus Counties by Vernon (1951, p. 156-171) all the deposits of late Eocene age in Florida were referred to the Ocala limestone (Cooke, 1945, p. 53-62). On the basis of differences in the fossil content and lithology of these deposits Vernon restricted the name Ocala limestone to the upper part and placed the lower part in the Moodys Branch formation. He further subdivided the Moodys Branch formation into the Williston member at the top and the Inglis member at the bottom. Recently, Puri (1953, p. 130) changed the name of the Ocala limestone (restricted) to Crystal River formation and raised the Williston and Inglis members of the

Moodys Branch to the rank of formations. These three formations, the Crystal River, Williston, and Inglis, are now collectively referred to as the Ocala group by the Florida Geological Survey.

The Ocala group unconformably overlies the Avon Park limestone in all except the north-central part of the county, where it is absent. The Ocala group is about 75 feet thick in the southern part of the county and thins toward the north. It consists of white to cream chalky limestone in the upper part and cream to buff fragmental limestone and dolomitic limestone in the lower part. It is highly fossiliferous and locally is composed almost entirely of foraminiferal shells. The Ocala group constitutes one of the most productive zones of the limestone aquifer, and hundreds of irrigation and domestic wells draw from it exclusively.

The Hawthorn formation of middle Miocene age consists of beds of blue to gray calcareous clay, alternating with beds of white to gray sandy limestone containing numerous grains of black to cream phosphate rock and fragments of chert. The beds of sandy limestone of the Hawthorn yield small quantities of water to a few wells. However, because the Hawthorn includes beds of clay, having low permeability, it serves as an effective confining bed for the artesian water in the underlying limestones.

The Hawthorn has been removed by erosion in the northern part of the county. Here, a deposit consisting of sticky blue clay in the upper part and sandy shell at the base overlies the Hawthorn formation where it is present and overlies the limestones of Eocene age where the Hawthorn is absent. Stubbs (1937, p. 30-31) and Cooke (1945, p. 225) thought that these deposits were of Pliocene age and placed them in the Caloosahatchee marl. Vernon (1951) in figures 13 and 33 placed these beds in the upper

Miocene in geologic sections and contoured beds. Recent studies in other parts of the State appear to confirm the age assigned to these deposits by Vernon. As no attempt has been made during the current investigation to determine the correct age of these deposits, they are referred to in this report as deposits of Pliocene or late Miocene age.

The bed of sandy shell in the lower part of these deposits yields small to moderate quantities of water to wells, and many wells draw only from this bed. Most wells, however, are open to this bed and the limestone beneath it and draw water from both sources. Pressure measurements and chemical analyses indicate that the pressure head and chemical character of the water in this bed are essentially the same as that of the water in the underlying limestones. In view of this, it appears probable that there is circulation of water between the bed of sandy shell and the limestones of Eocene age.

The county is underlain from the surface to as much as 25 to 50 feet by deposits of Pleistocene and Recent age. These deposits consist predominantly of sand except in the vicinity of lake basins and swamps, where they consist of sandy peat. In the area adjacent to the St. Johns River, in the eastern part of the county, these deposits contain some shelly sand and thin beds of clay. One notable feature of the Pleistocene and Recent deposits is the presence of a layer of sand, generally less than 2 feet thick, whose grains have been cemented together with iron oxide and other cementing agents. This layer, referred to locally as hardpan, underlies most of the level lowlands at a depth of 3 to 5 feet. Because this layer of hardpan retards the downward percolation of water and thereby tends to retain water in the soil, it makes possible the local practice of irrigating through drain tile buried about 3 feet beneath the surface. The Pleistocene and Recent deposits serve as the source of supply for a few driven wells equipped with screens. The water from these deposits is generally low in mineral content.

GROUND WATER

Ground water is the subsurface water that is in the zone of saturation, which is the zone in which all the pore spaces are completely filled with water under positive hydrostatic head. The water in the zone of saturation is derived from rain that falls on the earth's surface. Not all the rain falling on the surface reaches the zone of saturation, however. Part of it returns to the atmosphere by evaporation and by the transpiration of plants and part of it enters lakes, streams, and other open bodies of water and becomes surface water. Only the water in the zone of saturation--ground water--is available to supply wells and springs.

Water in the zone of saturation moves laterally under the influence of gravity toward places of discharge, such as wells, springs, surface streams, or the ocean. Ground water may occur under either water-table (nonartesian) conditions or artesian conditions. Where the ground water is unconfined and its surface is free to rise and fall, it is said to be under water-table conditions. The upper surface of unconfined ground water is called the water table. Where the water is confined, as where it completely fills a permeable bed that is overlain by a relatively impermeable bed, its surface is not free to rise and fall, and it is said to be under artesian conditions. Technically, the term "artesian" is applied to ground water that is confined under sufficient pressure to rise above the top of the permeable bed that contains it, but not necessarily to or above the land surface.

A formation in the zone of saturation that is permeable enough to yield water in a usable quantity to wells and springs is called an aquifer or water-bearing formation. Areas in which aquifers receive replenishment from infiltration are called recharge areas. Water-table aquifers are usually exposed at the land surface and receive recharge over most of their expanse, whereas artesian aquifers generally receive most of their recharge in areas where the confining beds are discontinuous or absent.

Water-Table Aquifer

Ground water in Seminole County occurs under both water-table and artesian conditions. The water in the blanket of surficial sands of Pleistocene and Recent age is under water-table conditions in all parts of the county except in a few small areas in which the sands are overlain by thin beds of peat or clay. Water from wells drawing from these sands is used mainly for domestic supplies, although a few such wells in the vicinity of Sanford are used to irrigate lawns and gardens. Wells that draw from the water-table aquifer generally are equipped with hand pumps, although a few, used for irrigating lawns and gardens, are equipped with electric pumps. The number of wells in the county drawing from sands of Pleistocene and Recent age probably does not exceed 400.

The water-table aquifer is replenished by rain falling on the county. In addition to this natural recharge, the aquifer probably receives recharge also in the truck-farming areas as a result of the slow percolation of irrigation water downward through the hardpan. Water is lost from the aquifer by natural discharge through springs and seeps into the lakes and streams, by downward percolation into the artesian aquifer in the nonflowing areas, and by withdrawal from wells. Water from the water-table aquifer generally contains about

50 ppm of dissolved solids in those areas in which the water in the aquifer has not been contaminated by relatively highly mineralized artesian water. In a few areas the water contains an excessive amount of iron, which stains clothes, porcelain fixtures, and kitchen utensils.

Artesian Aquifer

The principal source of water in Seminole County is an artesian aquifer, that forms a part of the principal artesian aquifer of the Florida Peninsula and adjacent area. The aquifer in Seminole County is composed of the beds of sand and shell in the lower part of the deposits of Pliocene or late Miocene age, and the limestone formations of middle and late Eocene age. It appears probable, also, that permeable beds near the bottom of the Hawthorn formation, at least in the southwestern part of the county, may be a part of the artesian aquifer. All these deposits will be referred to collectively in this report as the artesian aquifer. It should be pointed out, however, that the differences in static head, chloride content, and temperature of water at different depths in some parts of the county suggest that impermeable beds may be continuous over large areas, and that the Eocene limestones consist of several relatively thin aquifers rather than one thick aquifer.

The height to which water will rise in an artesian well is called the artesian pressure head. The head at any place in the artesian aquifer is controlled in part by the head in the recharge area, which is in turn determined by the amount of replenishment that reaches the aquifer from rainfall. Periodic measurements of the pressure head and the water levels in wells are an important part of a ground-water investigation.

In his investigation in the early thirties, Stringfield (1936, p. 195) made a series of water-level measurements in selected wells in the county.

In 1937, Stubbs resumed measurements in several of the wells measured by Stringfield and also began measurements in other selected wells. 3/ During

3/ Unpublished records of Sidney A. Stubbs and Irving Feinberg in the files of H. James Gut, Sanford, Fla.

the current investigation, measurements were resumed in many of the wells measured by Stringfield and Stubbs, in an attempt to determine whether there has been any progressive decline of artesian head. In addition, measurements are being made periodically in approximately 40 other wells in order to determine the seasonal fluctuation of the water level in different parts of the county.

The measurements made in 1937 were referred by Stubbs to mean sea level in order to determine the direction of movement of the artesian water and the location of recharge and discharge areas. Therefore, before the measurements being made currently can be compared to those made in 1937, the height of the wells above mean sea level must be determined. As the altitudes of only a few wells have been determined so far, it is not yet possible to arrive at any final conclusions regarding progressive changes in water levels. It can be stated, however, that the studies appear to show that in those areas in which the use of water has increased, water levels have declined, but probably no more than 5 feet. Where the use of water has remained about the same, there appears to have been little or no change.

Piezometric Surface of the Principal Artesian Aquifer in Florida

One of the most important parts of an investigation of ground water is the construction of maps representing the altitude of the water levels in wells. In the case of a water-table aquifer, such a map shows the altitude and configuration of the water table. A map showing the altitude to which the water levels in artesian wells will rise depicts an imaginary surface because the water in the aquifer is confined under pressure and will rise in wells to some height above the top of the aquifer. This imaginary surface is referred to as a "piezometric surface."

The piezometric surface of water in the principal artesian aquifer in Florida is shown by the contour lines in figure 3. This aquifer consists of several limestone formations of Eocene, Oligocene, and Miocene age that act more or less as a single hydrologic unit. Stringfield (1936, pl. 12) first mapped the piezometric surface and described the aquifer. The shape of the piezometric surface indicates the direction of movement of the artesian water and the areas in which the aquifer is replenished. Water enters the aquifer in those areas in which the piezometric surface is high and moves in a direction approximately perpendicular to the contour lines toward the areas in which the piezometric surface is low. One of the most notable features of the piezometric surface in Florida is the dome centered in Polk County, which indicates that considerable recharge enters the artesian aquifer in Polk County and the surrounding area.

In Polk County and also in the western part of Orange County water enters the artesian aquifer through numerous sinkholes, filled with permeable material, that penetrate the Hawthorn and younger formations. As shown by the contours on the map in figure 3, the artesian water flows northeastward from the recharge area in Polk and Orange counties into Seminole County and the adjacent area.

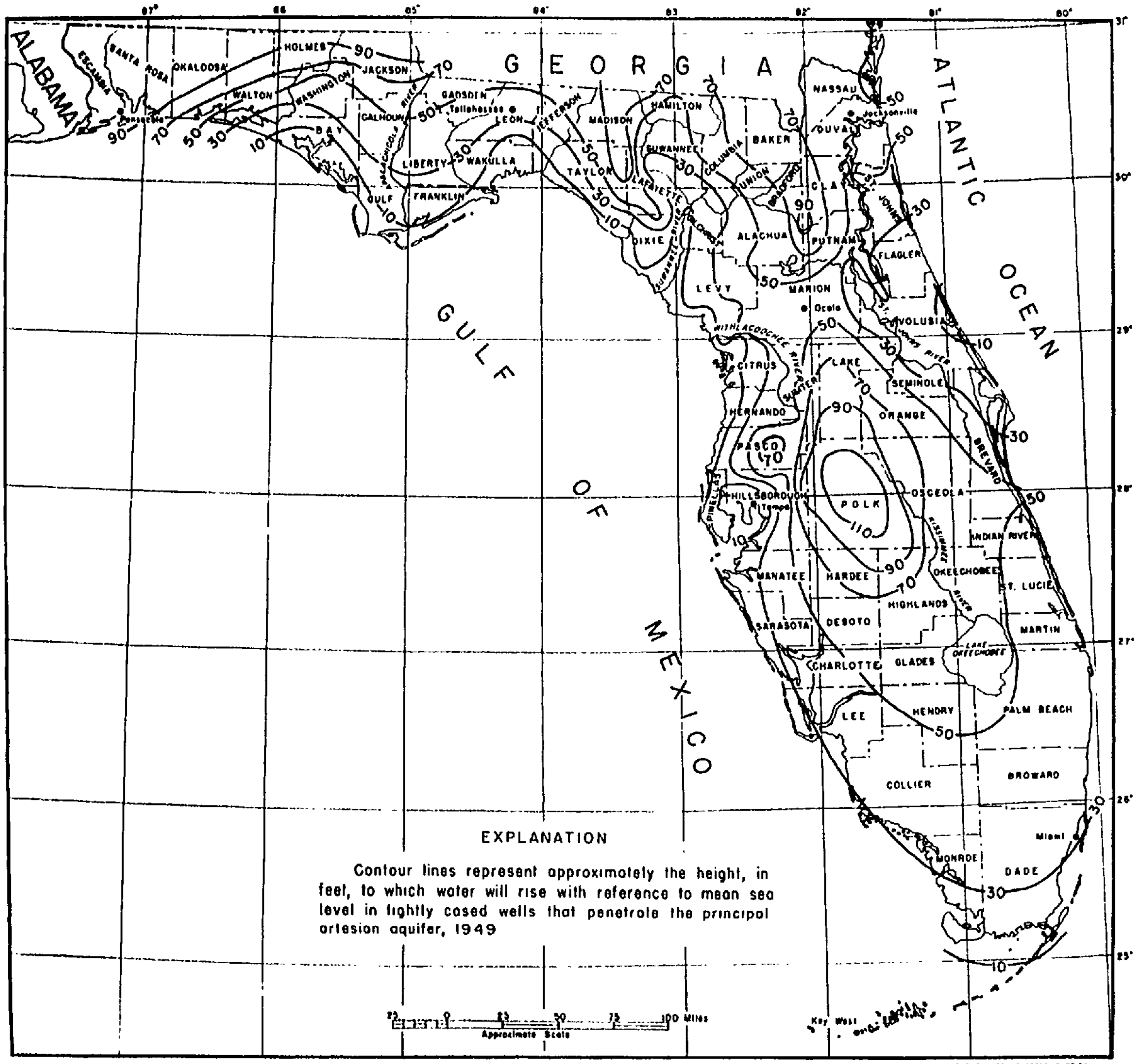

Figure 3. Map of Florida showing the piezometric surface of the principal artesian aquifer.

Although the location of the principal recharge areas for the artesian aquifer can be determined from the map, the map is not detailed enough to show the many small recharge areas that are known to exist. It does not reveal, for example, that the artesian aquifer receives recharge in at least two areas in Seminole County, which will be discussed in the following section.

Piezometric Surface in Seminole County

Although the altitudes of measuring points have not yet been determined on a sufficient number of wells to map the piezometric surface in Seminole County, previous work indicates that in general the flow of water in the artesian aquifer is to the northeast (Stubbs, 1937, p. 25-26, 34). Information obtained by Stringfield and Stubbs during their investigations indicates that in addition to the water entering the county from the recharge area centered in Polk County the artesian aquifer receives replenishment in the areas around the towns of Lake Mary and Geneva. The aquifer probably receives a small amount of replenishment in the Longwood-Altamonte Springs area also. Although the geologic conditions under which replenishment occurs have not yet been investigated, it appears probable that most of the replenishment is through sinkholes filled with permeable material.

The St. Johns River and associated lakes, Palm Springs, Sanlando Spring, Sheppard Springs, and parts of the Wekiva River are places of natural discharge of the artesian water in Seminole County. In fact, natural discharge from the artesian aquifer forms most of the base flow in the St. Johns River. The magnitude of the ground-water discharge into the St. Johns River and its tributaries is indicated by the fact that the combined discharge of the three springs referred to above is approximately 31 million gallons a day (Ferguson and others, 1947, p. 149-153). Wells are places of artificial discharge of the artesian water.

As a part of recent studies in the Sanford area by the Florida Geological Survey and by Robert M. Angas and Associates, altitudes were determined for 35 wells. As most of these wells are between Sanford and Lake Mary they provided adequate control for the construction of a map of the piezometric surface of the area (see figure 4). Owing to changing rates of replenishment and withdrawal, the piezometric surface is continuously rising and falling and changing in configuration. Therefore, figure 4, which was drawn from water-level measurements made in May, 1952, will only approximately represent the piezometric surface at other times. As may be seen from the figure, the flow of the artesian water is generally to the northeast. The curvature of the 40-foot contour line east of the town of Lake Mary shows the effect of the recharge in that area. The small cone of depression south of Lake Ada is a result of the pumping of approximately 1 million gallons of water a day from the municipal well field of the city of Sanford. The tendency of the contours to parallel the shore of Lake Monroe is probably a result of the discharge of artesian water into the lake.

Area of Artesian Flow

Wherever the piezometric surface stands higher than the land surface, artesian wells will flow. The areas of artesian flow in Seminole County are shown approximately in figure 5. As may be seen from the figure, the principal area of flow extends in an unbroken band along the Wekiva River to the St. Johns River and along the St. Johns to a point about 2 miles east of the outlet of Lake Jessup. From the St. Johns, the band extends down both sides of Lake Jessup into the farming area southwest of Oviedo. East of

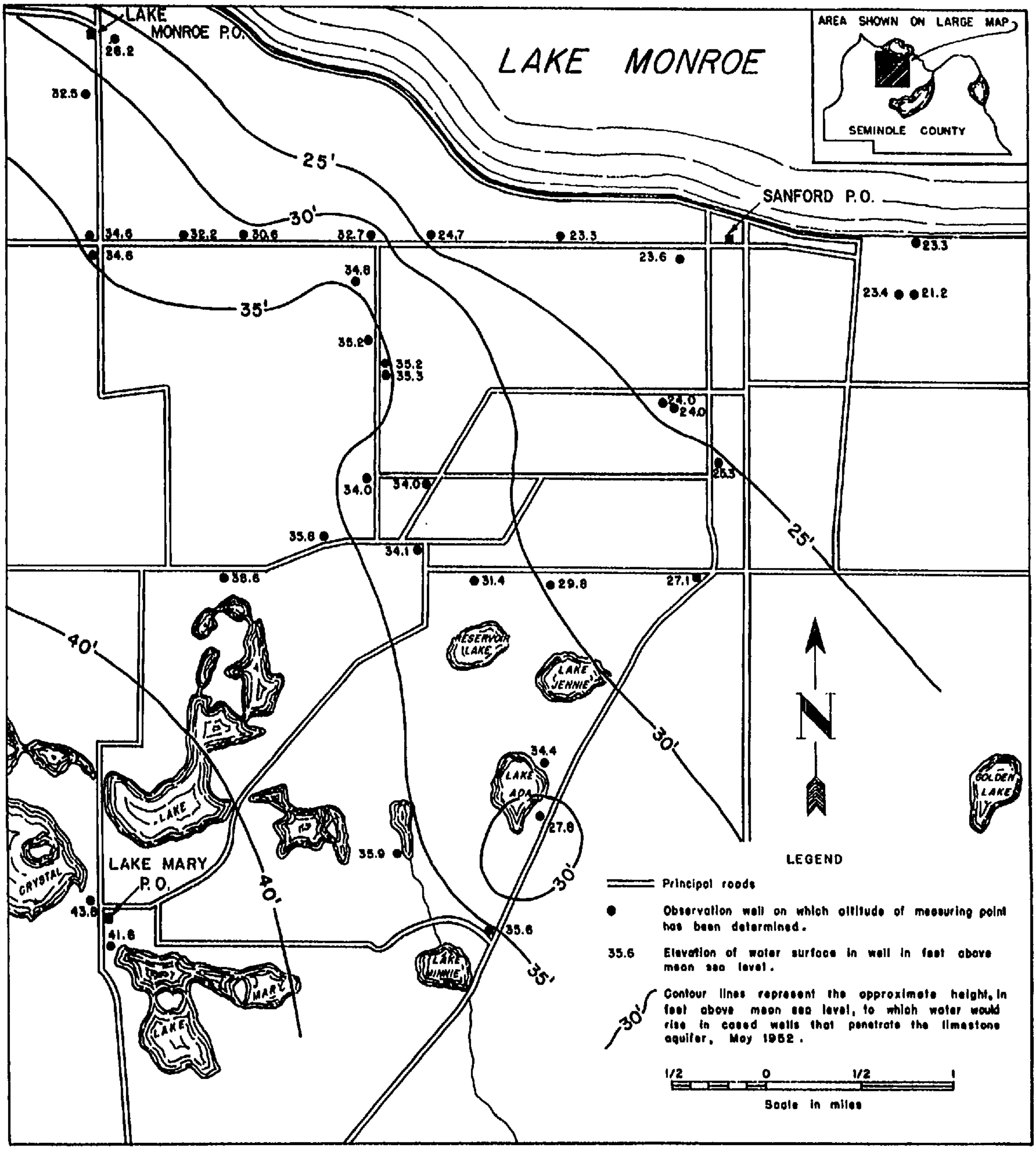

Figure 4. Map of the Sanford-Lake Mary area showing the piezometric surface.

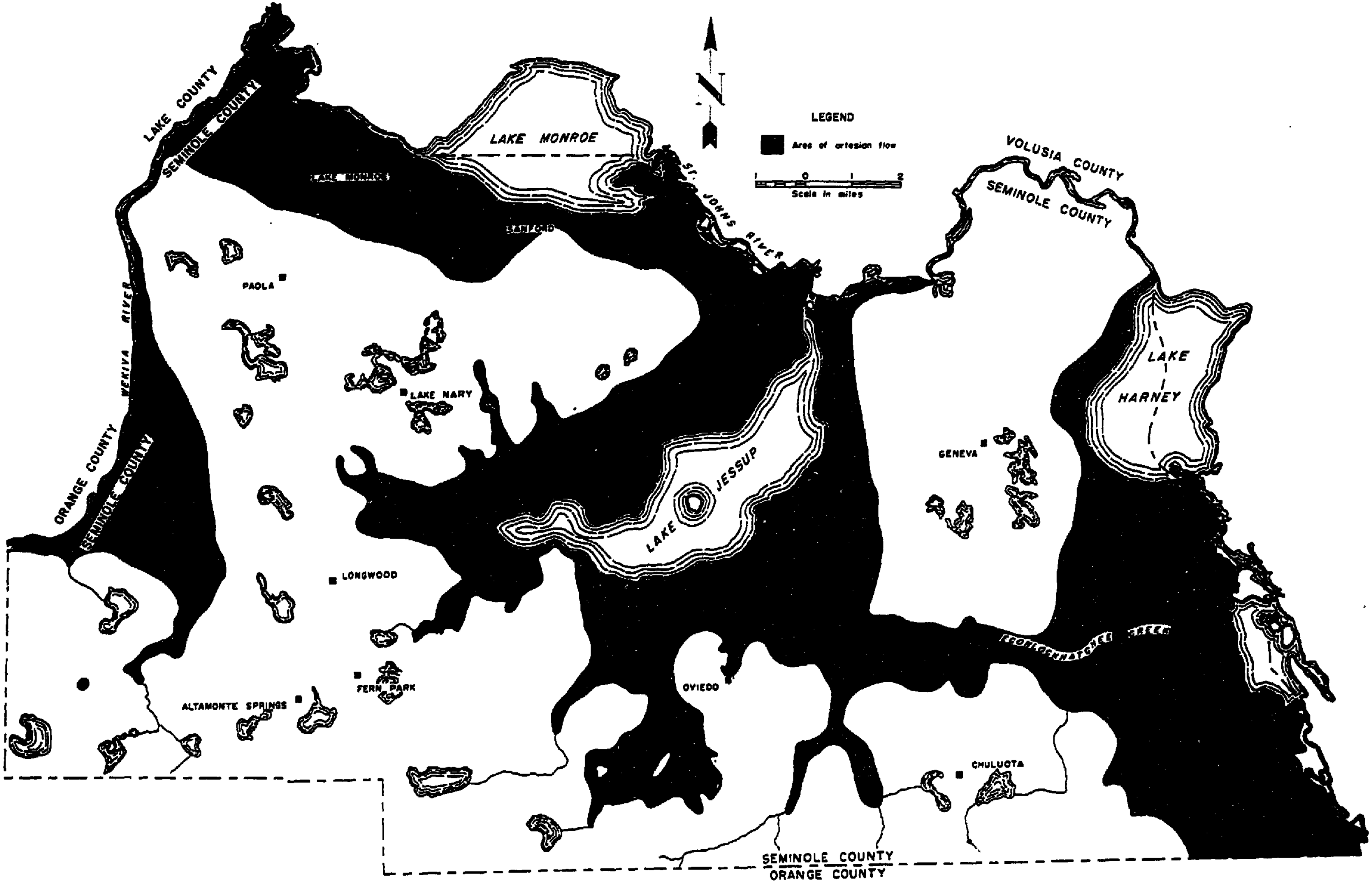

Figure 5. Map of Seminole County showing the approximate areas of artesian flow.

Oviedo the area of flow extends down the valley of the Econlockhatchee Creek into the level lowlands along the west side of the St. Johns River. The area of artesian flow is generally 1 to 2 miles wide. However, along the Wekiva River, in the area northwest of Paola, the area is only a few hundred feet wide. The area is narrow also in downtown Sanford and in a small area along the southwest shore of Lake Jessup. In addition to the principal area of artesian flow, there is a small area of flow in a dry lake basin near the Forest Lake Academy in the southwestern corner of the county.

The area of artesian flow was doubtless appreciably wider prior to the agricultural development in the county. In fact, in parts of the farming areas in the vicinity of Sanford, it was probably more than half a mile wider than it is at present. In most of the farming areas the boundary of the area of flow has receded out onto the level lowlands, where a decline in artesian pressure of 1 foot results in a decrease of several hundred feet in width.

A more detailed view of the area of artesian flow between Lake Monroe and Lake Jessup is shown in figure 6. The contours on the figure represent the height in feet above the land surface to which water would rise in artesian wells penetrating the top of the limestone aquifer in May, 1952. As may be seen from the figure, wells will flow at a height of more than 15 feet above the land surface in small areas both east and west of Sanford. In an area along the north shore of Lake Jessup wells will flow at a height of more than 20 feet. The water-level measurements used to draw figure 6 were made at a time when the use of water was relatively slight. Therefore, during times of heavy withdrawals, as during the peak of the winter growing season, the position of the lines will shift toward Lake Monroe and Lake Jessup. In fact, owing to continual changes in the rates of replenishment and withdrawals,

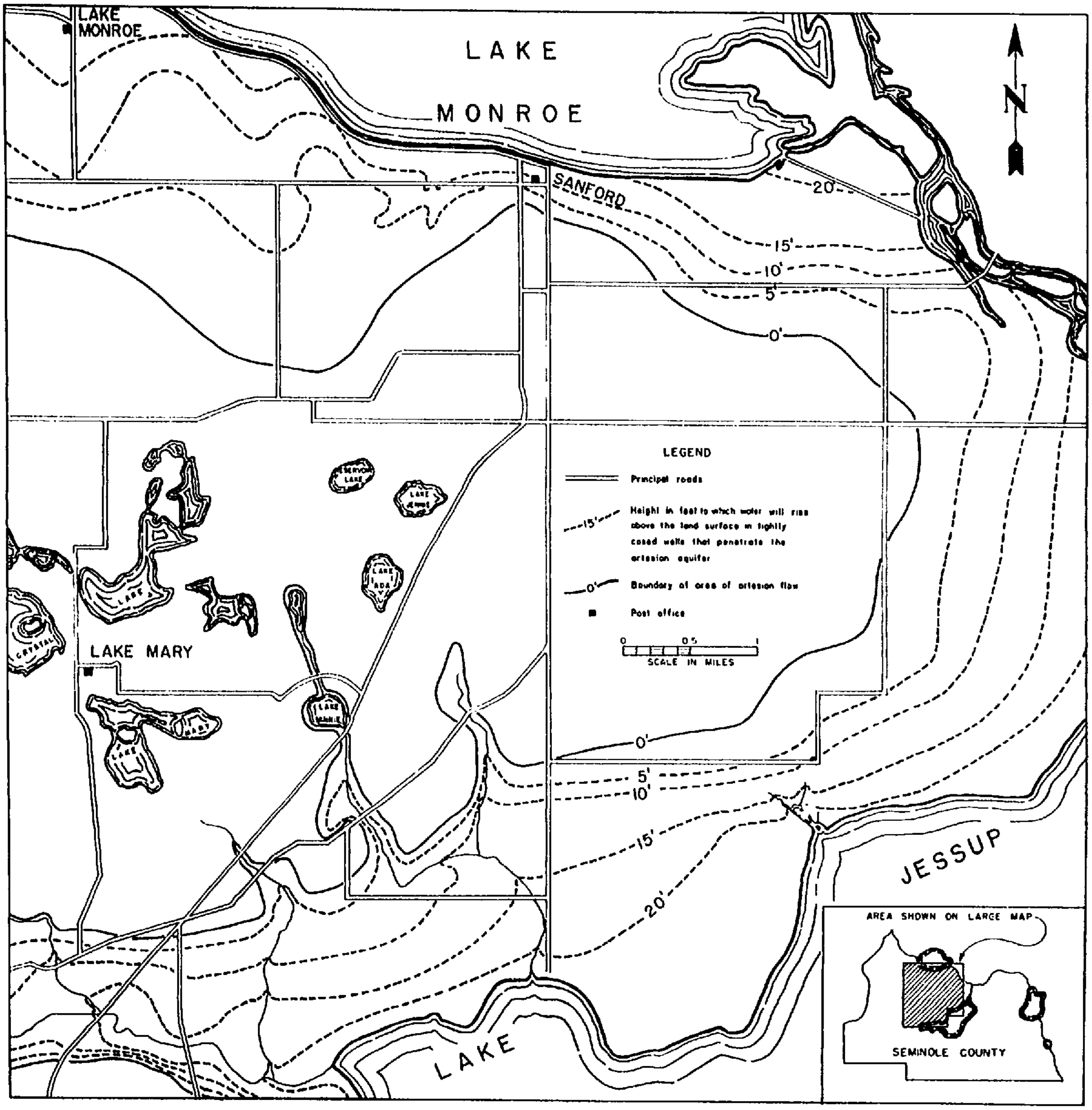

Figure 6. Map of the area between Lake Monroe and Lake Jessup showing the height above the land surface to which wells will flow.

the contours represent only the approximate conditions at any particular time.

Wells

One of the most important phases of any ground-water investigation is the collection of data on the location, distribution, and construction of wells, commonly referred to as the well inventory. Figure 7 shows the distribution of 732 wells that have been inventoried during the investigation. Of this total 34 draw water from the water-table aquifer and 698, of which 371 are flowing wells, draw from the artesian aquifer. The following table shows a breakdown of the wells according to the purpose for which the water is used.

Breakdown of the Inventoried Wells According to Use

Use of Well	Number
Irrigation	313
Domestic	259
Unused	75
Industrial	28
Stock	26
Other uses	31

A breakdown of the inventoried wells according to diameter is shown in the following table.

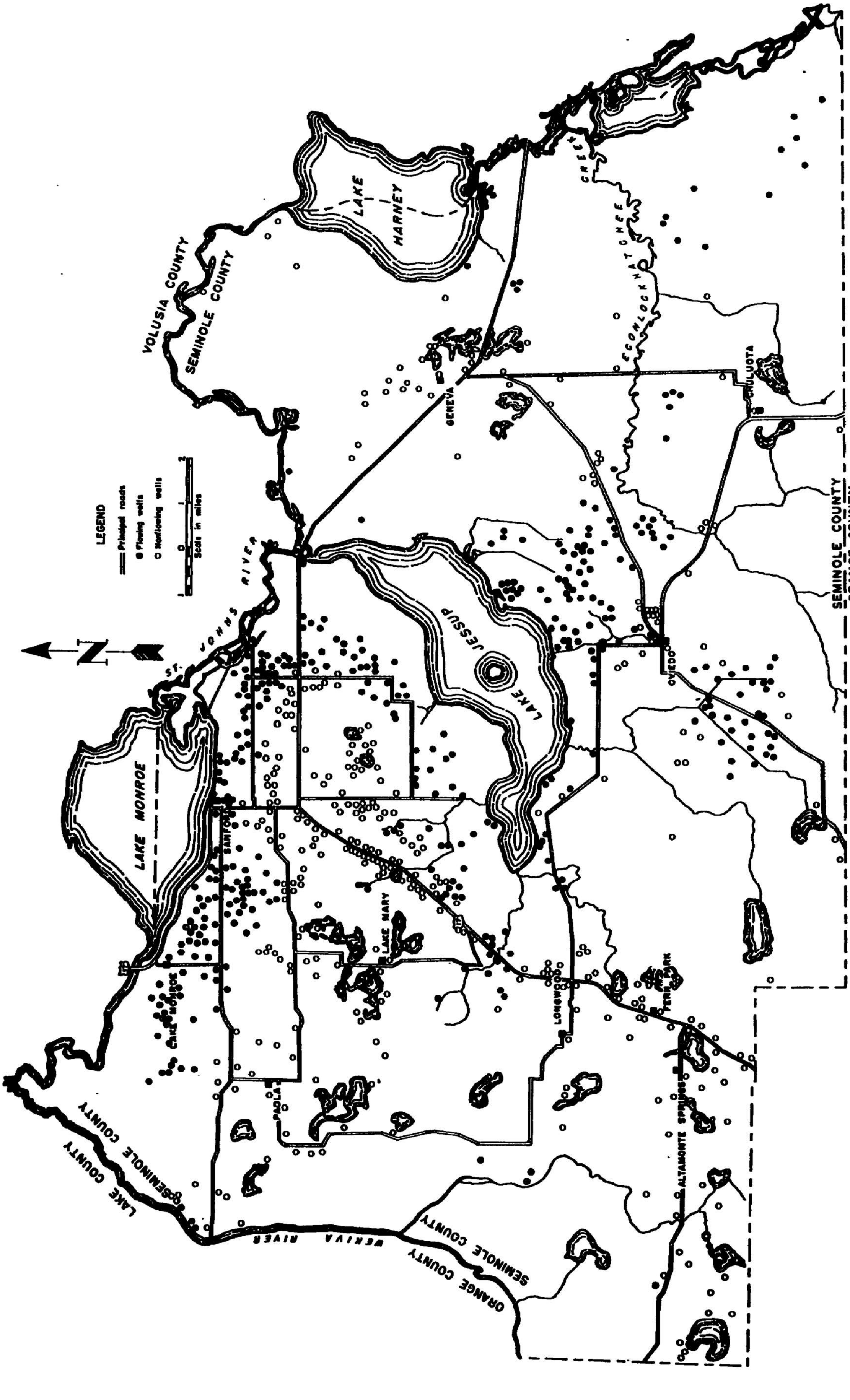

Figure 7. Map of Seminole County showing the distribution of wells that have been inventoried.

Diameter of Inventoried Wells

Well Diameter (inches)	Number of Wells	Percentage of Total
1 1/4	38	5.2
2	337	46.0
2 1/2	27	3.7
3	147	20.1
4	105	14.4
5	8	1.1
6	47	6.4
8	15	2.0
Over 8	8	1.1

The relative percentage of the wells of each diameter in the table would probably remain essentially unchanged if all the wells in the county were inventoried. As may be seen from the table, 46 percent of the inventoried wells are 2 inches in diameter. The final report on the investigation in the county will include all the data collected on the inventoried wells.

Artesian wells in the county range in depth from about 50 to 1,122 feet. However, more than 95 percent of the artesian wells are between 75 and 250 feet in depth. The total number of wells in the county that draw water from the artesian aquifer is estimated to be more than 4,000.

The more or less uniform transmissibility of the upper part of the artesian aquifer in large areas of the county has resulted in most small-diameter wells in the same area being finished with approximately the same length of open hole. As a result, the yield of flowing wells in any particular area depends primarily on the (1) diameter, (2) height of the static head above the well outlet, and (3) age and hence the extent of corrosion in the well.

The relation between the height of the static head above the well outlet and the yield in gallons per minute for 3-inch wells in two areas near Sanford is shown in figure 8. The points used in constructing the two graphs in figure 8 are shown as solid dots. Each graph was drawn as a wedge in order to indicate the range in yield that can be expected as a result of differences in the construction of individual wells and small differences in the water-transmitting capacity of the aquifer in each area.

The yield of a flowing well depends primarily upon the water-transmitting capacity of the formations penetrated by the well and the height of the static head. One of the best methods of comparing the yield of different wells is to compare the specific capacity--that is, the yield in gallons per minute for each foot of drawdown. In the case of flowing wells, such as those used to construct figure 8, the drawdown is equal to the height of the static head above the well outlet. Therefore, the specific capacity of wells in the northern part of Seminole County may be determined from figure 8 by dividing the yield of the wells in gallons per minute by the static head in feet. For wells in the area west of Sanford (see upper graph) this is found to be about 14 gpm. The specific capacity of wells in the area south and east of Sanford (see lower graph) is about 10 gpm, or only about two-thirds as much as in the area west of Sanford.

SALT-WATER CONTAMINATION

Salt water is present naturally in the artesian aquifer in many areas in Florida. Although the salty water may be derived from several sources, in Seminole County the relatively highly mineralized water present in both the water-table and artesian aquifers appears to be due principally to the flooding of salty water into the aquifer during Pleistocene time when the sea stood higher than at present. Since the last decline of sea level, fresh water

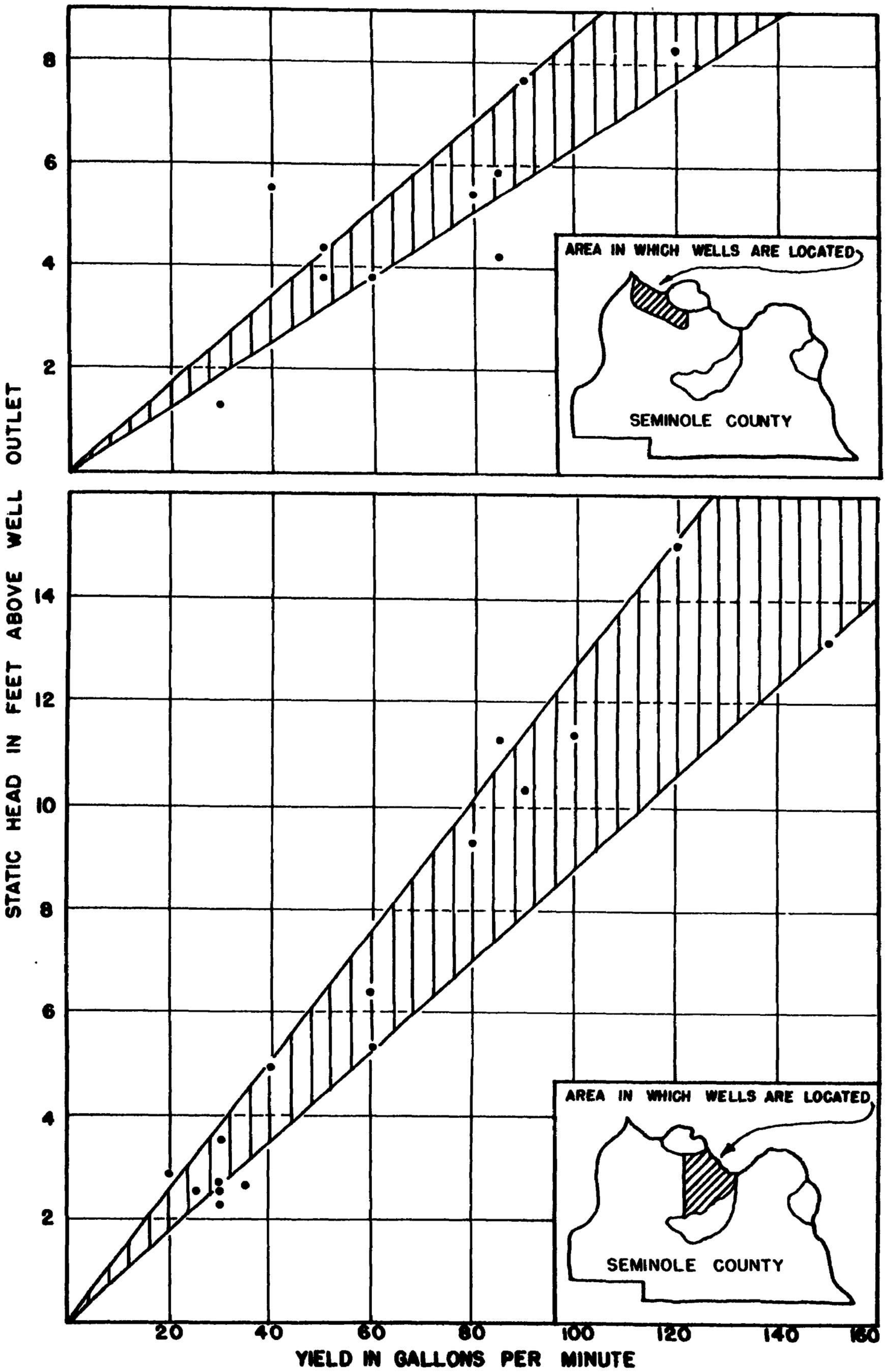

Figure 8. Graph showing the relation between the static head and the yield of flowing 3-inch artesian wells in two areas in the northern part of Seminole County.

entering the aquifer has been slowly diluting and flushing out the salty water. Water samples collected from wells of different depths in the northern and central parts of the county show that flushing has progressed further in the upper part of the artesian aquifer than in the lower part. Thus, the deeper wells in that area yield water with the highest salt content. One of the most important water problems facing the county is the danger that, as withdrawals from the upper part of the aquifer are increased, water from the lower zones will move upward and contaminate the producing zones.

The chloride content of ground water is generally a reliable index of contamination by salt water because about 91 percent of the dissolved-solids content of sea water consists of chloride salts. Thus, one of the most important phases of the investigation consists of analyzing the chloride content of water from wells. To date water samples from 637 wells have been analyzed and the results show that the chloride content of the water from the upper part of the artesian aquifer ranges from about 5 ppm to more than 5,000 ppm. The lowest chloride content, 4 ppm, was determined for samples from wells near Paola, near the southwest shore of Lake Jessup, and southeast of Lake Mary. The highest chloride content so far determined was one of 5,440 ppm for a sample of water from a well located along the south shore of Lake Harney. The generalized results of these analyses are shown by the shaded areas in figure 9. As may be seen from the figure, water from the artesian aquifer beneath most of the hilly upland areas has a chloride content of less than 25 ppm. The relatively low chloride content of the artesian water in this area is believed to be due to the fact that there is little

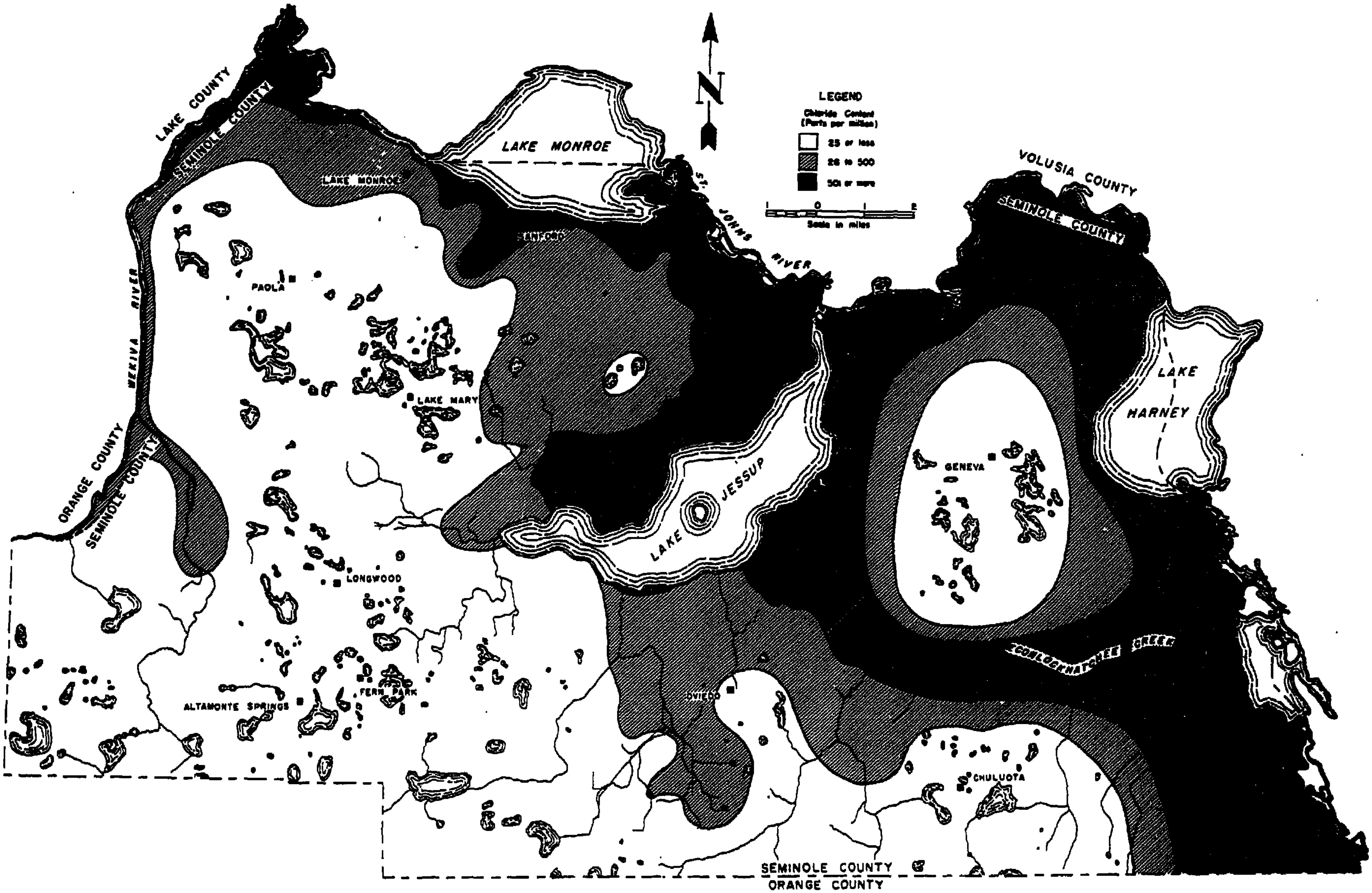

Figure 9. Map of Seminole County showing the chloride content of water from the upper part of the limestone aquifer.

surface runoff and the rainfall that is not returned to the atmosphere by evaporation and transpiration must percolate downward to recharge the artesian aquifer. The effect of this local recharge in flushing out the salty water can be seen by the difference in chloride content of the artesian water in the Geneva area, where it is fresh, and in the surrounding areas where it is salty.

The lowness of the chloride content of artesian water in local recharge areas was first noted by Stringfield (1936, pl. 16) in his investigation of the artesian water in the Florida peninsula. After making subsequent investigations in Seminole County and mapping 4/ the chloride content of the

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4/ Unpublished map in the files of the U. S. Geological Survey.

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artesian water in the county, he concluded that the lowness of the chloride content in the Geneva area was a result of flushing by local recharge. 5/

5/ Personal Communication.

The areas in which the artesian water contains more than 26 ppm of chloride include the northeastern half of the county, with the exception of the hilly area around Geneva, and a narrow belt along the valleys of the Wekiva and Little Wekiva Rivers. Within the heavily shaded parts of this area (see figure 9) the water would have a distinctly salty taste. In relatively large parts of this area the chloride content of the water exceeds 1,000 ppm and is unsuitable for many uses, including the irrigation of certain crops (Westgate, 1950, p. 116-123).

Analyses of water samples collected periodically at the times when the measurements of artesian pressure were made indicate that the chloride content of the artesian water varies with changes in artesian pressure. Decreases in artesian pressure are accompanied by increases in the chloride content, and vice versa, as shown in figures 10 and 11. Figure 10 includes data collected by Stubbs in 1937 and Feinberg in 1939, as well as data collected during the present investigation. This figure shows a change in chloride content of 25 to 50 ppm with each change in head of 1 foot in well 31, which is about 2 miles southwest of Sanford. The graph for this well also shows an increase in chloride content of about 100 ppm since 1937. This increase is probably a result of the increased withdrawal of water in the area in which the well is located.

Figure 11 shows the changes in chloride content of water from two wells near Oviedo. A comparison of the graph for well 167 with that for well 31, in figure 10, indicates that the chloride content of the water in the Oviedo area changes less in response to changes in pressure than that in the Sanford area. This may be due to the fact that the upper part of the aquifer in the Oviedo area is underlain by a relatively impermeable zone which retards the upward movement of salty water from the lower zones of the aquifer.

SUMMARY AND CONCLUSIONS

The following progress has been made on each of the phases of the investigation outlined in the introduction:

1. Information has been obtained on more than 700 wells in the well inventory. In addition, the location of approximately 1,000 other wells have been plotted on aerial photographs.

2. Periodic water-level measurements are being made in more than

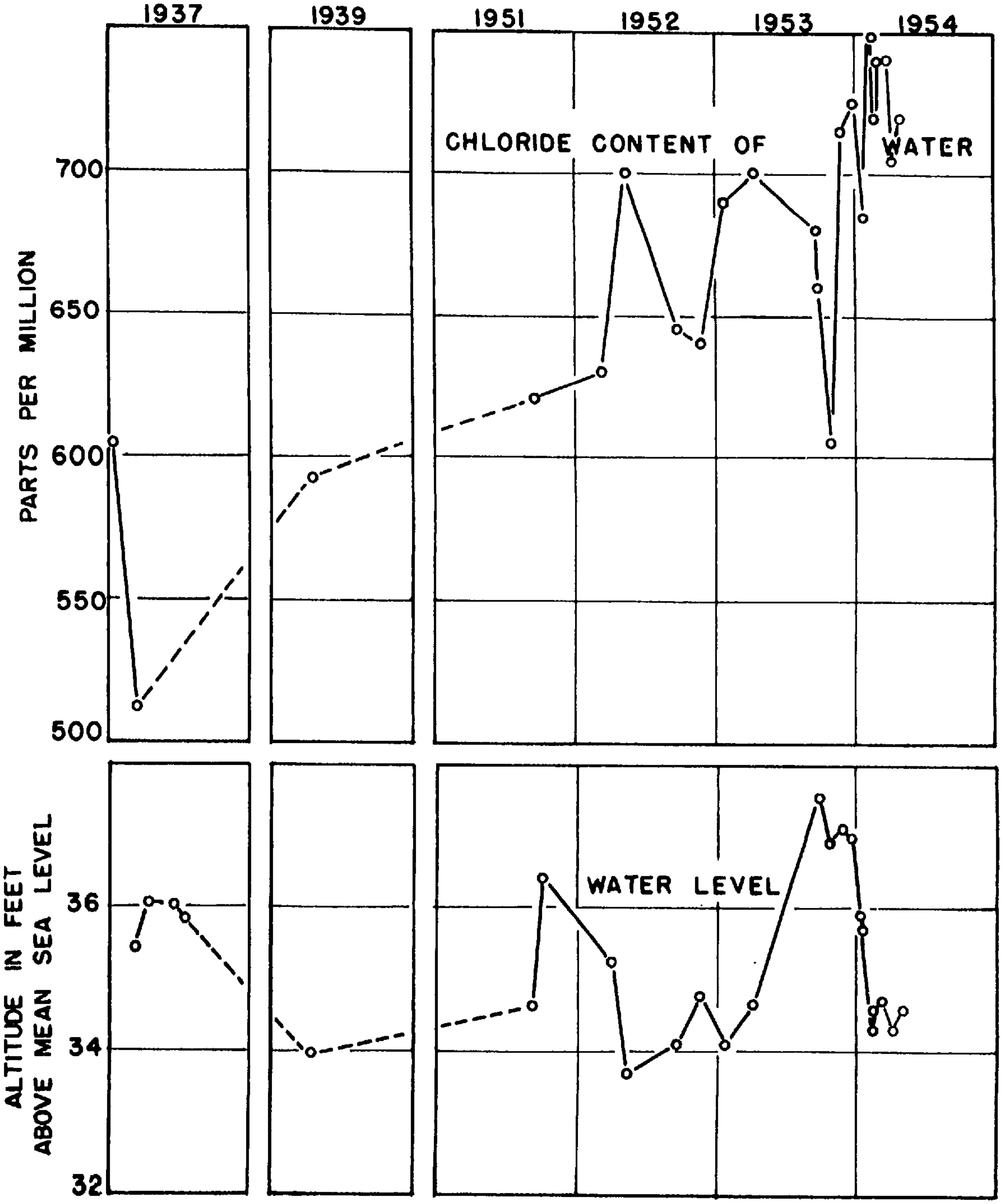

Figure 10. Graph showing the relation between the chloride content and the artesian pressure head in well 31, 2 miles southwest of Sanford.

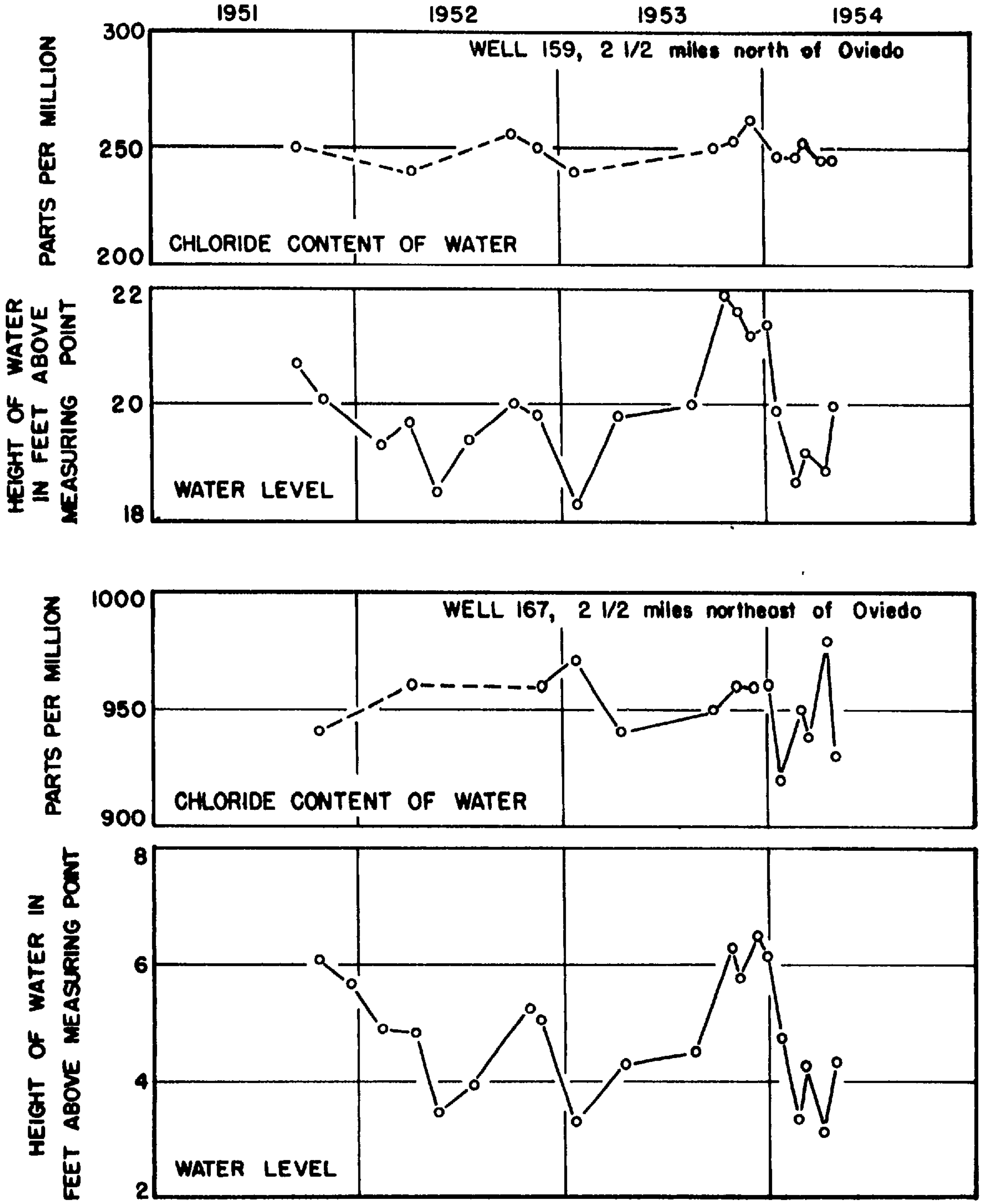

Figure 11. Graph showing the relation between the chloride content and artesian pressure head in two wells near Oviedo.

70 wells.

3. The chloride content of water samples from 637 wells has been determined during the investigation. Periodic chloride analyses have been made on samples from about 20 wells for a period of more than 2 years in order to determine the relation between changes in chloride content and changes in water levels.

4. Chemical analyses of water samples from about 100 wells have been made in order to determine the chemical content of the water in different parts of the county.

5. Rock cuttings from about 15 wells have been collected for use in preparing geologic structure maps.

6. Recording gages have been installed on two wells to determine progressive trends of water levels and rapid fluctuations that cannot be detected by means of periodic measurements.

As the investigation is incomplete at this time, available data are not adequate for final conclusions to be reached concerning the ground-water problems confronting the county. However, the results obtained so far may be summarized as follows:

1. The principal source of ground-water supply in Seminole County is a thick section of limestone that underlies the county at depths ranging from 75 to 150 feet. This limestone is overlain by a deposit consisting of 50 to 75 feet of relatively impermeable clay which confines the water in the limestone under pressure. Overlying the clay deposit is from 25 to 75 feet of sand and sandy peat. Small supplies of water are obtained in some parts of the county from screened wells penetrating these sand deposits.

2. Most of the ground water in Seminole County probably is derived from rain falling on the recharge areas in Polk and Orange counties, although there are important recharge areas in Seminole County also. The local areas of recharge are in the vicinity of the towns of Lake Mary and Geneva, and in the southern part of the county. Natural discharge of ground water in Seminole County is through large artesian springs such as Sanlando, and through springs and seeps in the bottom of Lake Jessup, and the St. Johns and Wekiva rivers.

3. Records of the seasonal fluctuations of artesian pressures show that they are lowered as much as 10 feet in parts of the Oviedo area during the periods of heaviest withdrawal. In the Sanford area the seasonal fluctuations are between 4 and 6 feet. A comparison of water-level measurements made in 1937 with measurements made during the present investigation shows that, where withdrawals have been increased, water levels have declined only slightly. In those areas in which there has been no increase in withdrawals, as for example in the western part of Sanford, the water levels appear to have remained relatively unchanged or to have risen slightly.

4. The chloride content of water from artesian wells in Seminole County ranges from less than 10 ppm near the recharge areas to more than 5,000 ppm in the area adjacent to Lake Harney. In the Sanford-Oviedo farming area, the chloride content ranges from about 25 ppm to slightly more than 1,500 ppm. A comparison of chloride analyses made in 1937 with those made during the current investigation shows that, in general, the chloride content of the artesian water has remained about the same. An exception to this is a small area southwest of Sanford where the chloride content appears to have increased

as much as 100 ppm. The seasonal variation in chloride content in response to fluctuations in artesian pressure in the farming areas near Sanford is from 50 to 150 ppm. In the farming areas near Oviedo the seasonal change is generally less than 50 ppm. Chloride analyses of water samples from wells of different depths also show that the chloride content increases with depth.

Future studies in Seminole County will include:

1. An inventory of additional wells in the more sparsely settled areas.

2. Determinations of the altitudes of measuring points on water-level observation wells for use in mapping the piezometric surface.

3. Pumping tests to determine the water-transmitting and water-storing capacity of the artesian aquifer.

4. The exploration of selected wells with a current meter to determine the position and thickness of the producing strata. Deep-well sampling equipment will be used also to determine the quality of water in each zone.

5. A study of well cuttings and electric logs to determine the position and thickness of the different geologic formations.

6. Collection of data on the use of ground water in order to arrive at an estimate of the annual withdrawal. This information will be used in conjunction with data on water levels and the water-transmitting and storing capacity of the aquifer to predict the effect on water levels of increased withdrawals.

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