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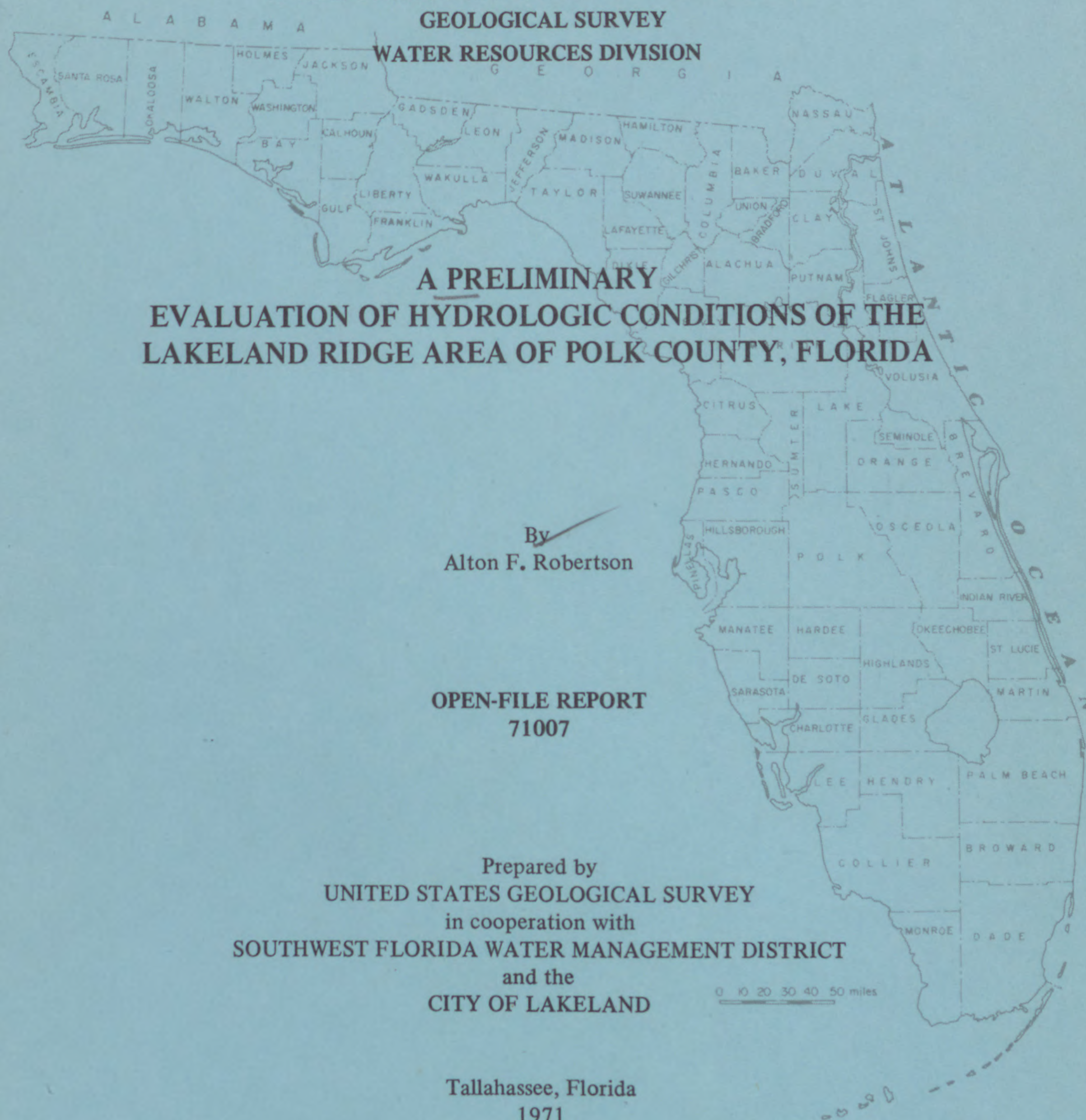

A PRELIMINARY EVALUATION OF HYDROLOGIC CONDITIONS OF THE LAKELAND RIDGE AREA OF POLK COUNTY, FLORIDA

By
Alton F. Robertson

OPEN-FILE REPORT
71007

Prepared by
UNITED STATES GEOLOGICAL SURVEY
in cooperation with
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
and the
CITY OF LAKELAND

Tallahassee, Florida
1971

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A PRELIMINARY

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OF POLK COUNTY, FLORIDA

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ABSTRACT

The Lakeland ridge area covers about 300 square miles in northwest Polk County. The rapid growth of this area has resulted in an increase in ground-water withdrawals such that in 1968 about 67.5 million gallons per day was pumped to satisfy the demands of municipal, irrigation, and industrial users.

Declines of water-levels of as much as 30 feet in the area cause pumps to lose suction and increase the hazard of upward migration of saline water. However, no widespread deterioration of water quality has been noted to date.

Considerable hydrologic data are available for the Lakeland ridge area. However, in order to give water managers a proper base for decisions that would allow for optimum utilization of the ground water resources, more detailed data are needed about the hydraulic characteristics of the aquifer, the quantity of ground-water withdrawals, and the quality of water at various depths in the Floridan aquifer.

INTRODUCTION

Central Florida is underlain by aquifers that contain large quantities of fresh water. Ground-water pumpage and the expected increase in pumpage are so great, however, that those involved in water management are concerned about the future of this supply. Declines in ground-water levels, as much as 30 feet near Lakeland, have required lowering of intakes of many pumps in the past two decades. As the water-levels decline, more power is required to pump the wells. Water-level declines may increase the hazard of deterioration of the water's quality by permitting upward movement of poor quality water from known saline sources at depth.

Agricultural and industrial operations throughout Polk County contribute greatly to the State's economy. The ridge area's attractiveness to tourists is another economically important feature that depends directly upon its water resources. The many demands for fresh water and the possible consequences of increased demands indicate a need for effective water management to obtain optimum use of the supply without detrimental effects.

The lakeland ridge area covers about 300 square miles in northwest Polk County. The location of the study area is shown on figure 1.

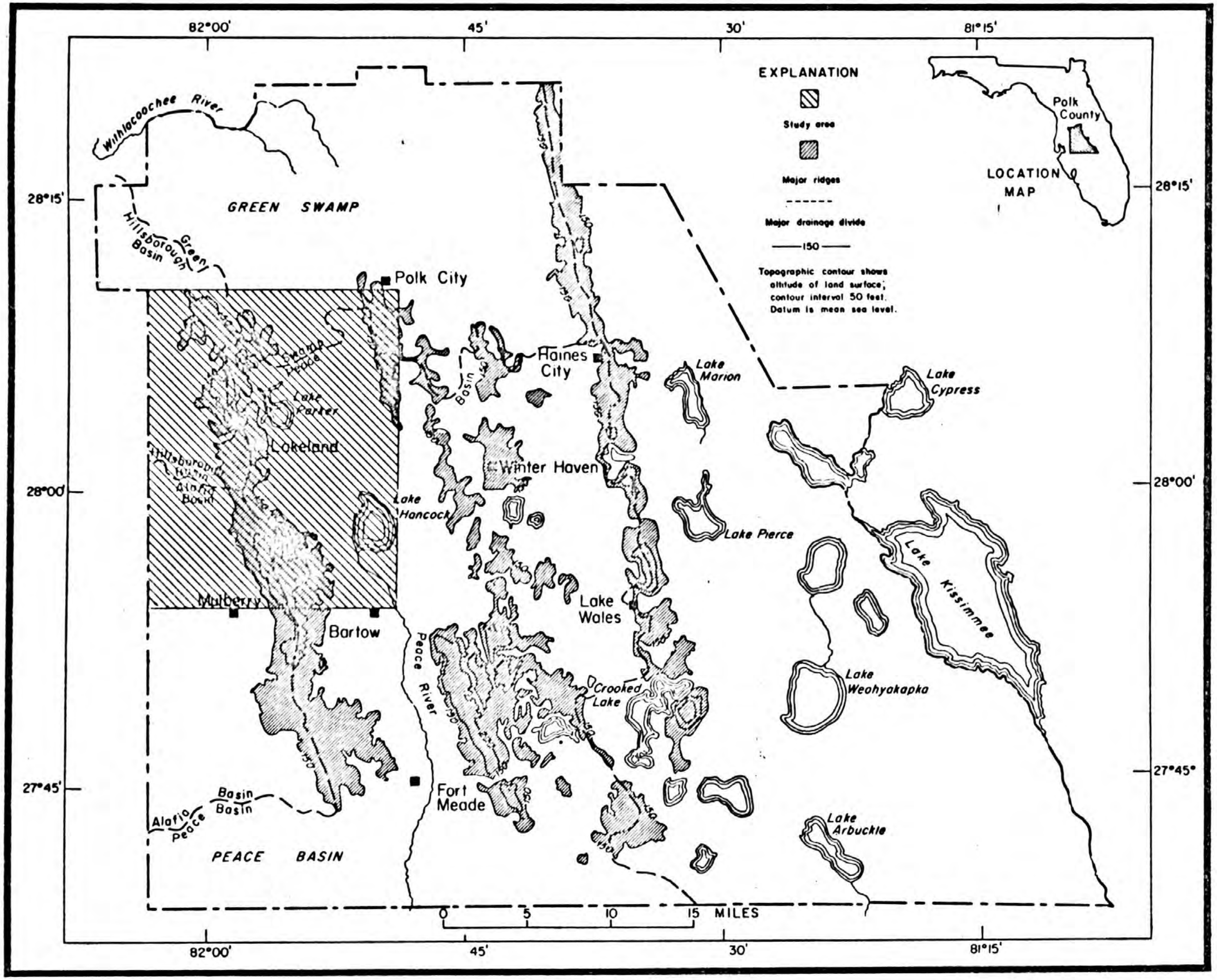


Figure 1. Map showing Polk County and the area of study

Purpose and Scope

The purposes of this preliminary report are to: (1) summarize the existing water-supply data available for the Lakeland ridge area; (2) define the problems that presently exist or may be anticipated in relation to the available water supply; and (3) specify what information is lacking but needed to manage the area's water resources effectively.

The investigation upon which this report is based was made by the U. S. Geological Survey in cooperation with the Southwest Florida Water Management District and the City of Lakeland. It was under the general supervision of C. S. Conover, District Chief for Florida, and under the immediate supervision of J. S. Rosenshein, Chief of the Tampa Subdistrict.

WATER-RESOURCES MANAGEMENT PROBLEMS

Water-level declines in the Lakeland ridge area in the past two decades have caused water managers to be concerned about the continued availability of ground water of good chemical quality. These declines create obvious problems, such as the necessity to lower pump intakes, and may have less obvious consequences, such as the increased hazard of upward movement of water of poor quality.

Additionally, these declines increase the head differential between the principal artesian aquifer, which is the Floridan aquifer, and those aquifers closer to the earth's surface, thus increasing recharge rates to the principal aquifer from the overlying aquifers. Although this increased recharge may capture water otherwise lost to evapotranspiration, the recharge may also affect the quality of water in the principal artesian aquifer.

Declines of water level in the Floridan aquifer are the result of an expanding cone of depression caused by increased withdrawals, which will continue to expand until it underlies an area sufficiently large to induce enough additional recharge to equal the withdrawals.

The data necessary to assess the problems that exist and those problems that may be foreseen can be categorized into three types: (1) characteristics of the aquifers, (2) quality of the water, and (3) water use. The data that are presently available and specific data needed in these categories are discussed further in this report.

SUMMARY OF EXISTING HYDROLOGIC INFORMATION

Surface-Water Data

The Lakeland ridge is the drainage divide between the Peace River basin on the east and the Hillsborough and Alafia River basins on the west (fig. 1). To the north, the Withlacoochee River has its headwaters in the Green Swamp area. Although the ridge area has no large streams, lakes are abundant, with more than a dozen occurring in the vicinity of Lakeland. These surface-water resources have been studied, and the reports noted below and in the list of selected references provide considerable relevant information.

Heath (1961) presented considerable data on the surface-water resources of Polk County. Hydrographs and stage-duration curves were given for 107 gaging stations throughout the county. Of these, 18 gaging stations are in the area covered by this report and are listed in table 1 of this report. Included in the table are either the maximum and minimum water levels or flow for the period of record at each gaging station. The location of each gaging station is shown in figure 2. The most recent information on these gaging stations is tabulated in "Water Resources Data for Florida," an annual publication of the U. S. Geological Survey.

Kenner (1964) provided a map showing depth contours of selected Florida lakes, one of which, Lake Parker, is in the study area. Stewart (1966) made a more comprehensive study of the hydrology of Lake Parker and Scott Lake. (See fig. 2.) His evaluation indicated that Lake Parker is underlain by sand and sandy clay and that water from the lake leaks downward through these materials to recharge the underlying aquifers.

The Withlacoochee River basin was described by Pride, Meyer, and Cherry (1966). Streamflow rates and flow-duration curves for the Withlacoochee River basin were given along with the results of chemical analyses of the water. Although highly colored, the water is low in mineral content. Some parts of the Hillsborough and Peace River basins were also discussed in that report.

Menke, Meredith, and Wetterhall (1961) discussed the Hillsborough and Alafia River basins. Streamflow in the Hillsborough and Alafia Rivers was described as well as the water quality. The streams of both basins were found to be more highly mineralized than the streams of the Withlacoochee basin.

Table 1.- Surface-Water Gaging Stations, Lakeland Ridge Area

(msl - mean sea level)

Gaging Station Number (see Fig. 2)	Station Name	Period of Record	EXTREME OF RECORD: Maximum Gage Height (feet above msl)	Date	Minimum Gage Height (feet above msl)	Date
	Lakes					
1	Lake Deeson near Lakeland	1954-60, 1965-67	135.49	9/28/54	122.52	7/31/67
2	Lake Gibson near Lakeland	1954-59	145.1	10/8/57	141.4	7/5/56
3	Lake Parker at Lakeland	1949-67	131.81	8/2/60 9/13/60	127.92	5/24/49
4	Mirror Lake at Lakeland	1954-59	178.72	5/17/57	178.28	10/28/54
5	Wire Lake at Lakeland	1954-60	198.22	7/16/59	194.00	5/1/56
6	Lake Bonny at Lakeland	1954-60	131.92	9/11/59	123.12	7/10/56
7	Lake Beulah at Lakeland	1954-59	180.47	5/15/57	178.23	7/9/56
8	Lake Morton at Lakeland	1954-59	179.54	3/23/59	176.30	3/10/55
9	Lake Hunter at Lakeland	1954-59	162.97	4/17/57	160.95	4/27/56
10	Lake Hollingsworth at Lakeland	1954-59	133.2	5/17/57	131.9	5/1/56 10/21/58
11	Crystal Lake near Lakeland	1951-52, 1954-59	137.24	11/23/59	127.04	6/10/51
12	Lake Hancock near Highland City	1950-51, 1958-67	101.88	9/16/60	95.93	6/9/65
13	Scott Lake near Lakeland	1953-67	169.19	9/13/60	163.08	7/31/67
	Streams		Maximum Flow (cubic feet per second)		Minimum Flow (cubic feet per second)	
14	Lake Parker Outlet at Lakeland	1955-59	12.2	5/2/57	0	Various occasions
15	Saddle Creek near Lakeland	1955-56	45.2	9/15/55	.38	3/8/56
16	Fox Branch near Socrum	1963-67	685	9/11/64	0	Various occasions
17	Saddle Creek at Structure P-11 near Bartow	1963-67	516	9/13/65	0	Various occasions
18	Peace River at Bartow	1939-67	4140	9/24/47	1.1	5/27/68

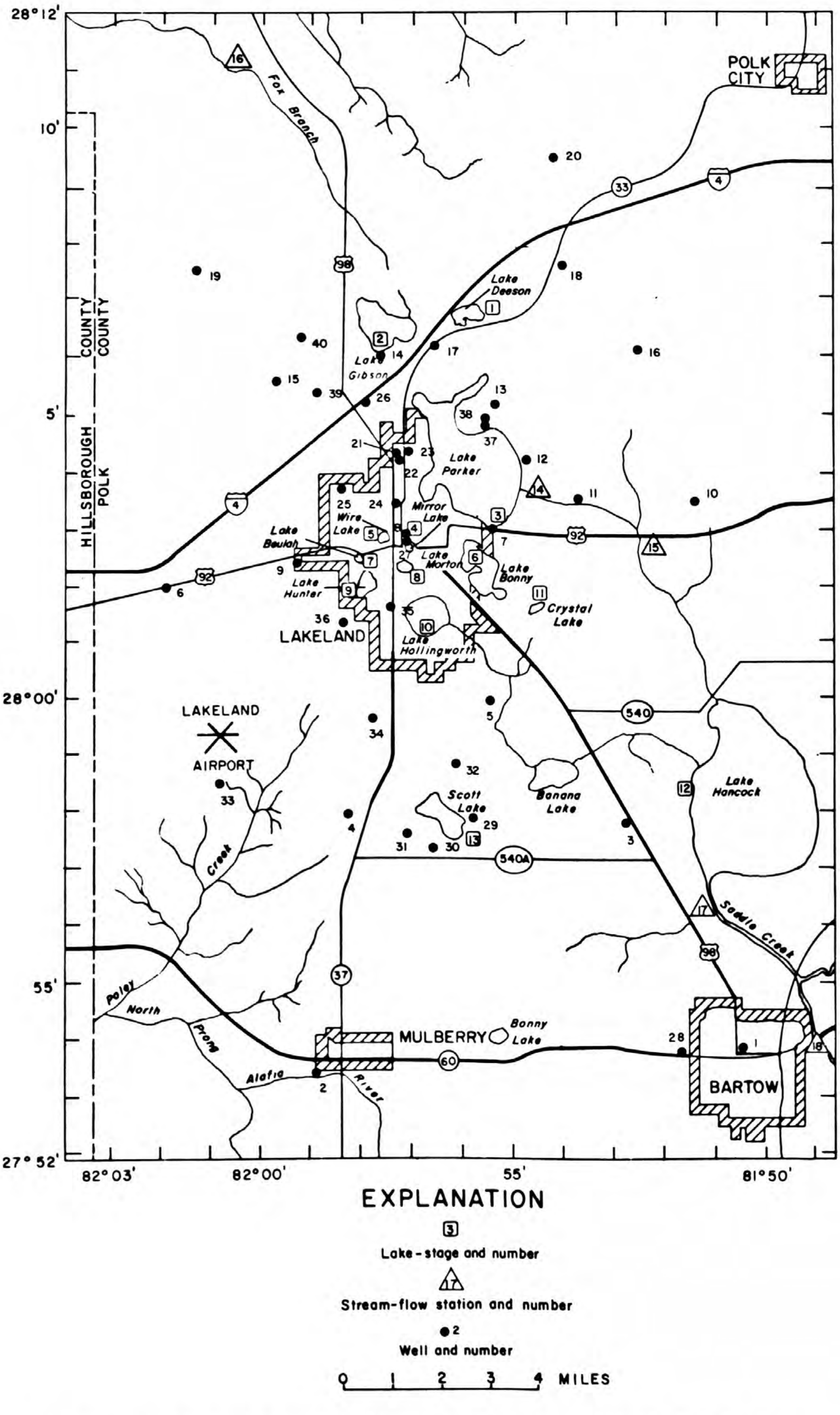


Figure 2. Map showing location of gaging stations and wells in the Lakeland ar

Toler (1967) found fluoride concentrations in the Alafia and Peace River basins to be abnormally high in the rivers. He discussed the source, amounts, and effects of fluoride in the streams in these two basins.

Ground-Water Data

Aquifers

Stewart (1966) provided the most recently published information on the aquifers of Polk County. His work drew upon many previous investigations of both the State in general and the Ridge area in particular. Some of the studies were concerned only with the phosphate-bearing deposits of economic value, whereas others described the entire geologic column. The ridge area is underlain by four aquifers, as described by Stewart (1966) and discussed briefly below. These aquifers are (1) the water-table aquifer, (2) the uppermost artesian aquifer, (3) the secondary artesian aquifer, and (4) the Floridan aquifer.

Figure 3 shows the generalized geology and relation of the aquifers in the study area. The stratigraphic nomenclature used in this report conforms to the usage of the Florida Geological Survey. It conforms also to the usage of the U. S. Geological Survey, with the exception of the Ocala Group and its subdivisions, and the Tampa Formation of Miocene age.

The sandy and clayey surficial materials contain the water-table aquifer, which is used for some small domestic supplies but is relatively unimportant as a source of water for other uses. The aquifer sand is of Miocene to Holocene age.

The uppermost artesian aquifer does not underlie all the study area. The pebble phosphate deposits underlying the surficial deposits form this aquifer, which, like the water-table aquifer, is used only for small domestic supplies.

Limestone of the Hawthorn Formation constitutes the secondary artesian aquifer, which is confined by the clay of the Hawthorn and Tampa Formations. The secondary artesian aquifer is a source of water for domestic and small irrigation supplies.

The water-bearing characteristics of these aquifers are not well known, and they are relatively unimportant as sources of supply.

The Floridan aquifer is the major source of water in the ridge area and occurs within limestones of Eocene to Miocene ages. The Suwannee Limestone, which underlies most of the Lakeland ridge area constitutes the uppermost part of the Floridan. However, locally, as indicated on figure 3, limestone of the Tampa Formation is sufficiently connected hydraulically with the underlying rocks to be included as part of the aquifer. In places where the Suwannee Limestone is not present, the limestone units of the Ocala Group contain the uppermost part of the Floridan aquifer. The base of the Avon Park Limestone is for practical purposes the base of the aquifer. Many wells in the Lakeland ridge area are terminated in cavities in the limestone of the Floridan aquifer. Such wells characteristically yield large volumes of water with small drawdown. Stewart (1966, p. 54-63) reports the location and depths at which solution cavities are known to occur in wells drilled in Polk County.

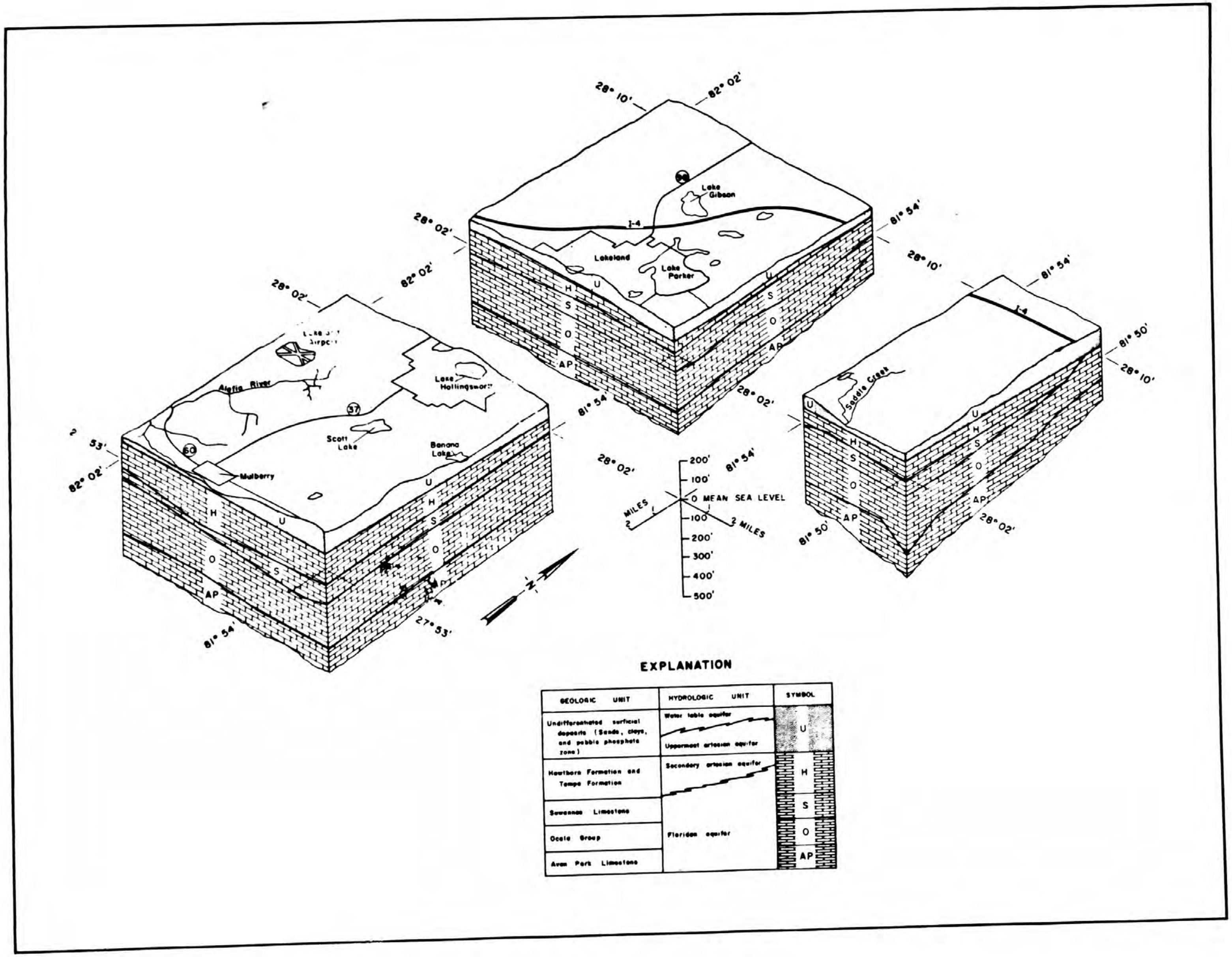


Figure 3. Block diagram showing generalized ground-water geology of the Lakeland ridge area

Hydraulic Properties of the Floridan Aquifer

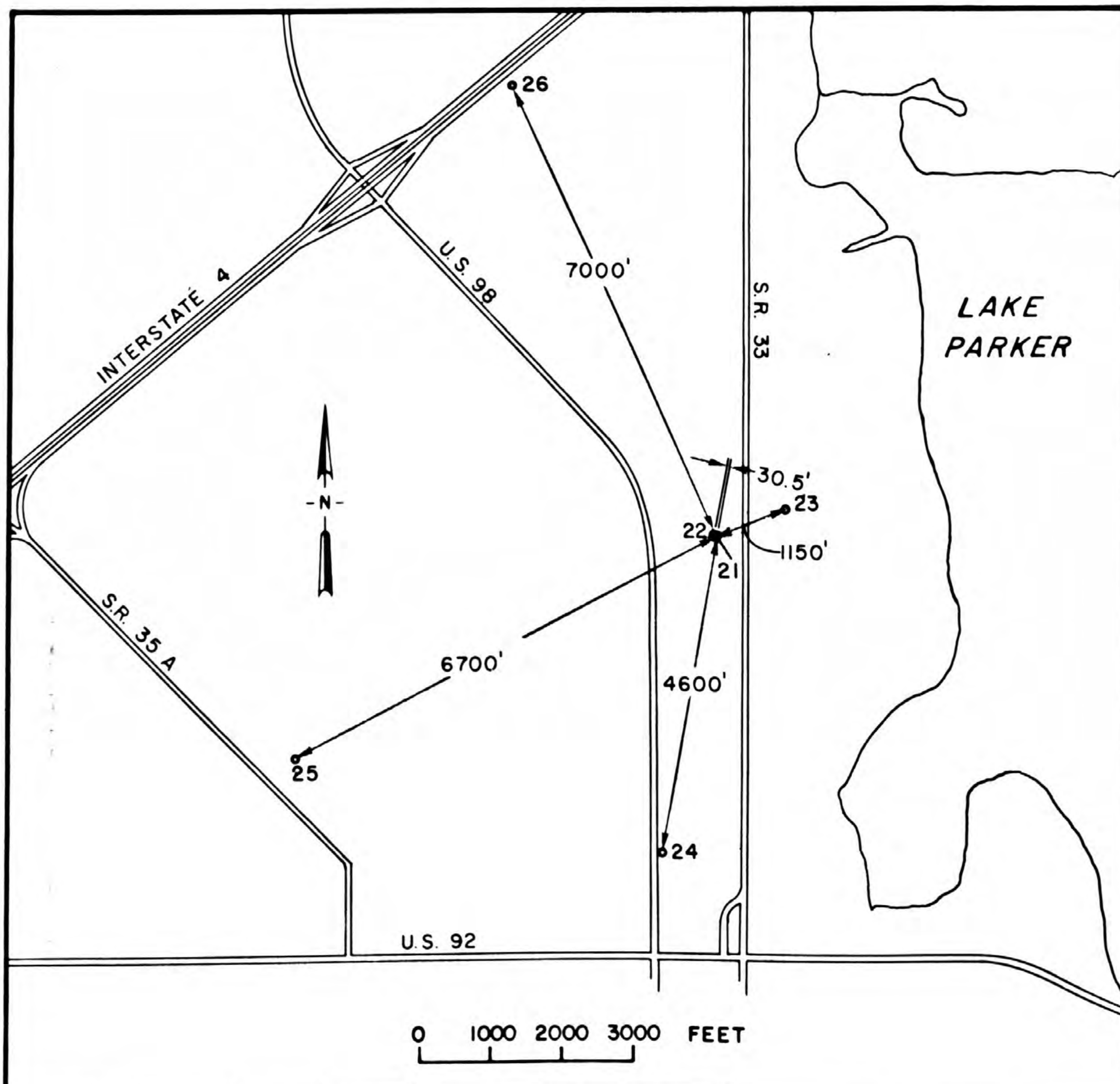
Water-level changes in an aquifer are caused by recharge to the aquifer, and discharge from the aquifer; both natural discharge and withdrawal by pumping. The magnitudes of these changes are governed by changes in the foregoing stresses and the hydraulic properties of the aquifer.

The water-conducting capacity of an aquifer is called transmissivity and is defined as the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient. The storage coefficient is the volume of water an aquifer releases from or takes into storage per unit surface area per unit change in head.

An indication of transmissivity is given by the specific capacities of wells; that is, the quantity of water the well yields for each foot of drawdown of the water level. Determination of transmissivity from specific-capacity data has the disadvantage of giving only a very localized estimate. In addition, well characteristics greatly affect specific capacity. Stewart (1966) compiled data on the specific capacities of 173 wells in Polk County. These values range from more than 2000 gpm per ft (gallons per minute per foot of drawdown) to less than 10 gpm per ft in the Lakeland ridge area. As Stewart (1966) pointed out, the specific capacities could and did vary considerably for wells a few hundred feet apart, especially where one of the wells tapped a cavity system.

Aquifer tests in which pumping rates are controlled and the resultant drawdowns are measured in observation wells provide a more reliable method for determining transmissivity and storage coefficient. Values for transmissivity have been determined for the Floridan aquifer in various parts of the state by such tests. Menke, Meredith, and Wetterhall (1961) reported a value of 220,000 gpd per ft (gallons per day per foot) determined from tests near Plant City, about 10 miles west of Lakeland. Stewart (1966) reported a value of 1 million gpd per ft determined from tests northeast of Lake Parker.

In February 1969, an aquifer test was made at the site of a well west of Lake Parker. The pumped well was 650 feet deep and cased to 200 feet below land surface. Five observation wells were used in the test. Their depths and other pertinent data are shown along with the test layout on figure 4. The data from this test were analyzed, using a composite plot of $\frac{r^2}{t}$ versus s, where r is the distance from the observation well to the pumped well, in feet; t is time, in days, from the start of pumping; and s is the observed drawdown, in feet, at the corresponding time. The values determined from this test indicate a transmissivity of 750,000 gpd per ft and a coefficient of storage of 0.9×10^{-3}. These values indicate the high water-transmitting potential of the Floridan aquifer in this immediate area.



Well No.	Altitude of Land Surface (feet)	Well Depth (feet)	Casing Depth (feet)	Drawdown at End of Test (feet)	Remarks
21	174	660	198	11.92	Pumped well (3500 gpm) Time (3 hrs. 15 min.)
22	174	647	185	5.92	Observation well
23	167	920	660	2.11	Observation well
24	213	865	203	1.57	Observation well
25	231	790	273	.46	Observation well
26	170	823	224	.20	Observation well

Figure 4. Map showing aquifer pumping test layout

Ground-water levels

The level to which water rises in wells penetrating an aquifer forms an imaginary surface referred to as the potentiometric surface. The altitude of the potentiometric surface varies locally in response to both recharge to and discharge from the aquifer.

In June 1969, the potentiometric surface was mapped in the Lakeland ridge area and is shown in figure 5. This map indicates that water levels are highest northeast of Lakeland and lowest in the southwest section of the study area. The potentiometric surface has been mapped by previous investigations including Stringfield (1936), Stewart (1966), Pride, Meyer, and Cherry (1966), and Kaufman (1967).

Kaufman's (1967) comparison of the potentiometric surfaces as measured in 1934, 1959-60, and 1965 showed as much as 50 feet of decline in the Bartow-Mulberry areas from 1934 to 1965. The June 1969 map was compared with a similar map for June 1956 by Stewart (1966, fig. 21), and the change in water levels in the Floridan aquifer for this period is summarized on figure 6. This figure shows that water levels have declined more than 20 feet in the southern part of the study area and that the decline decreases toward the north. Northeast of Lakeland water levels are nearly unchanged.

Water-level declines in the Floridan aquifer during 1950-69 reflect the effects of increasing ground-water pumpage and deficiency of rainfall. These effects are illustrated in figure 7, which shows the water level in two wells near Lakeland, the city's monthly pumpage, and monthly precipitation at Lakeland during 1950-69.

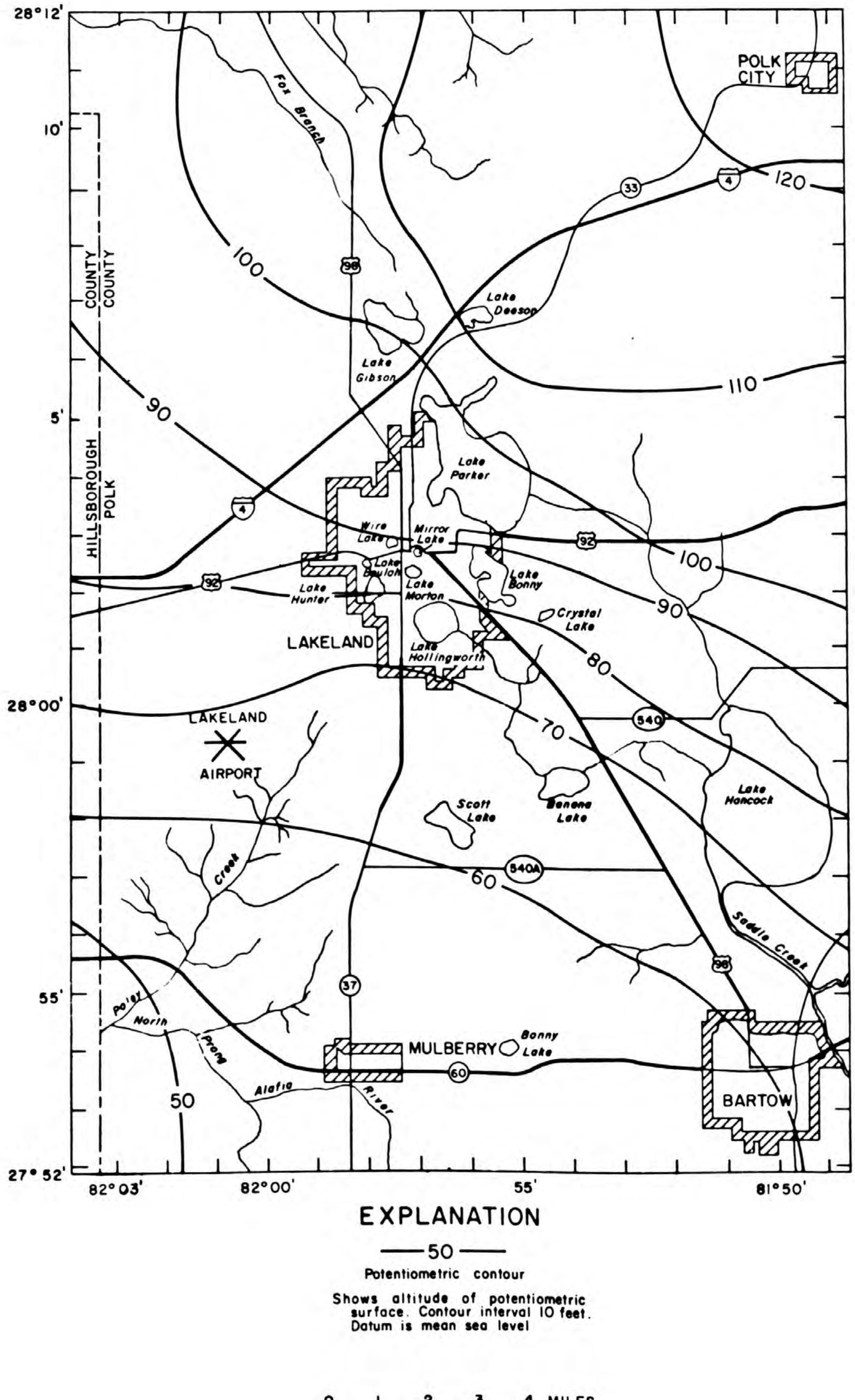


Figure 5. Contour map of the potentiometric surface of the Floridan aquifer in June 1969 in the Lakeland ridge area

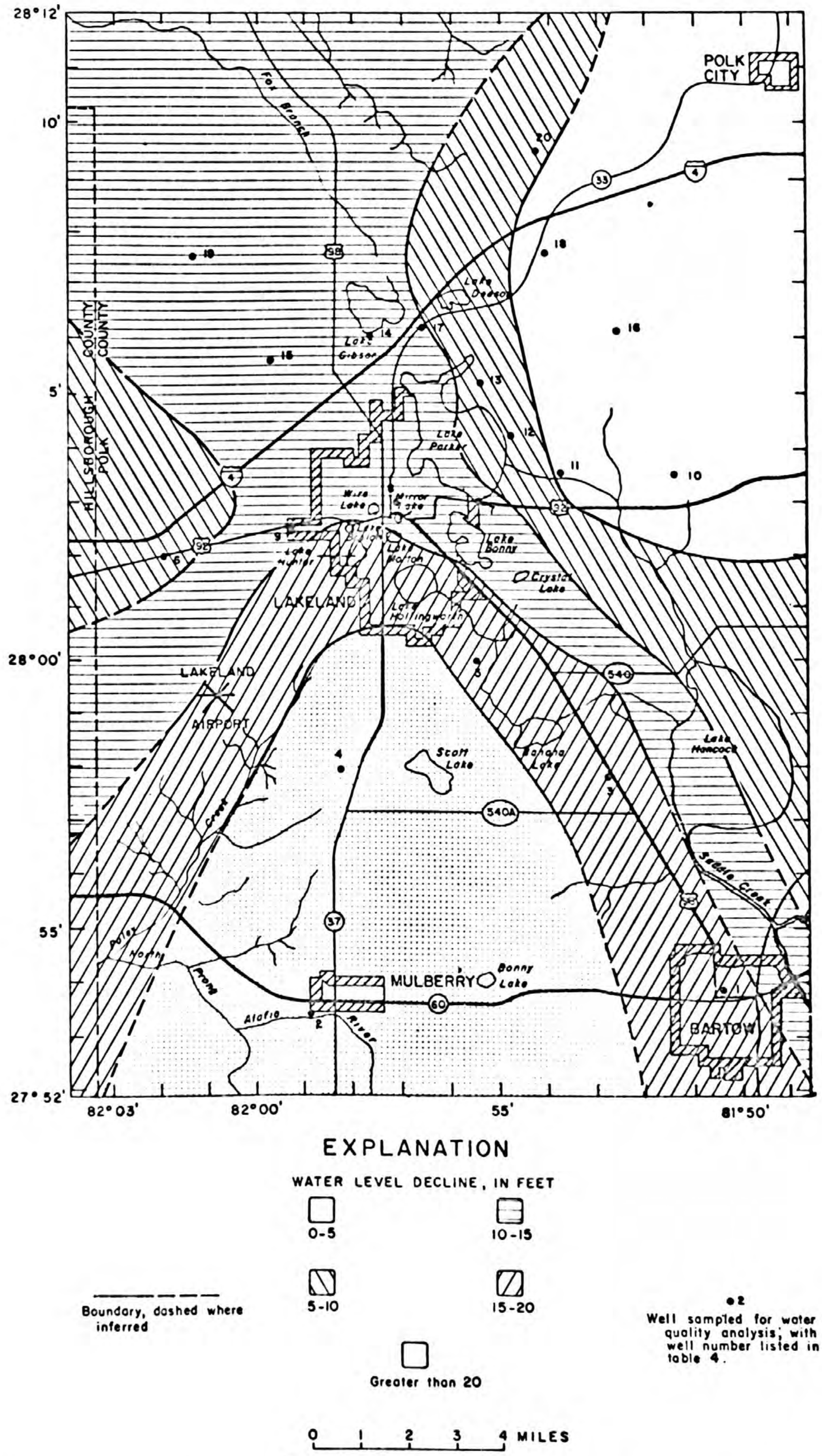


Figure 6. Map showing areas of water-level declines in the Floridan aquifer from June 1956 to June 1969 and locations of selected quality monitoring wells

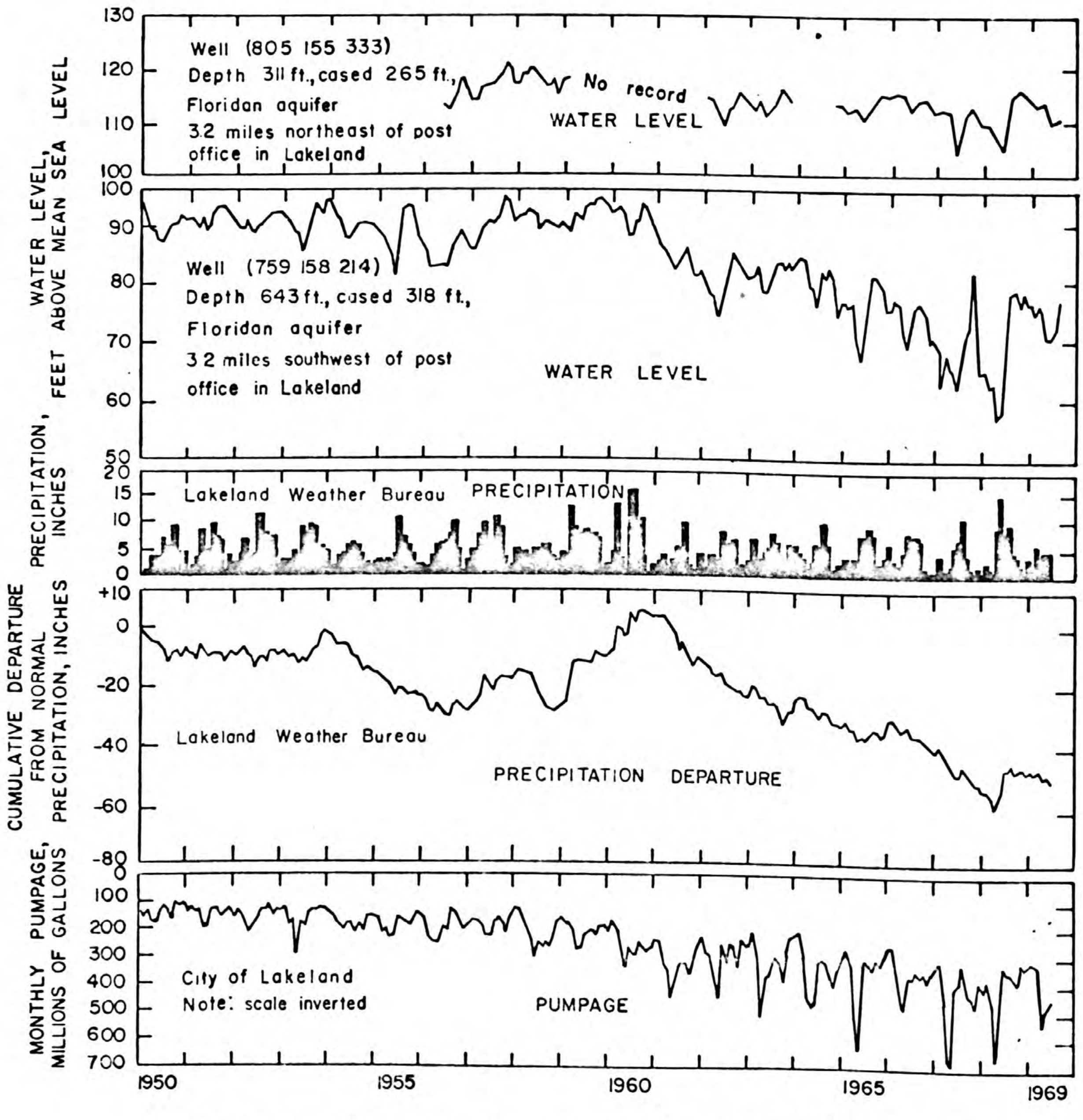


Figure 7. Graphs showing water levels in selected wells near Lakeland, municipal pumpage, and monthly precipitation at Lakeland, Florida 1950-1969

Although Lakeland's pumpage is only part of the total pumpage in the area, the trend of increasing ground-water withdrawal for municipal use is paralleled by increased industrial and agricultural withdrawals.

Water-levels can be expected to continue to decline as ground-water withdrawals increase. These declines are the result of a cone of depression, which is centered near Ft. Meade south of the study area. The cone of depression will continue to enlarge until it underlies an area sufficiently large for recharge to the aquifer to balance the increased withdrawals.

Stewart (1966) estimated that recharge to the Floridan aquifer was on the average 5 inches per year in the Peace River basin. Based upon this estimate, recharge within the study area of 300 square miles is about 72 mgd (million gallons per day), which is only slightly more than present estimates of minimum withdrawals for 1968. These withdrawals are discussed later in this report. Because only a part of the existing cone of depression is in the study area, the estimates of pumpage and recharge do not reflect total pumpage near the center of the cone nor recharge induced outside the study area.

Quality of the Ground Water

Stewart (1966) and Pride, Meyer, and Cherry (1966) discussed the chemical characteristics of ground water in Lakeland and the surrounding areas. Toler (1967) discussed the occurrence of fluoride in underground water in the ridge area and found that concentrations were not significantly high.

The Lakeland ridge is underlain by aquifers that generally supply good quality water. Cities in the area draw municipal supplies from these aquifers, and at present the only treatment facilities normally utilized are for aeration and chlorination. One of the main concerns of these municipalities is deterioration of the water quality.

Lakeland maintains 27 wells throughout the city and in nearby communities from which public water supplies are drawn. The water quality is generally good and meets water-quality standards for interstate carriers established by the U. S. Public Health Service, 1962. However, most wells yield water that is hard, and some yield water that contains objectionable quantities of hydrogen sulfide.

Hydrogen sulfide is a naturally occurring gas that imparts an unpleasant taste and odor to water and can be detected by smell in concentrations of less than 1 mg/l (milligrams per liter) (Hem 1970). Hydrogen sulfide is not generally present in water from wells less than about 450 feet deep, and its occurrence may be restricted to certain zones in the geologic section. Water samples were obtained from two wells recently drilled about one-quarter mile west of Lake Parker for city supply. One of these wells was drilled to 920 feet below land surface and cased to 660 feet (well 23, fig. 2). The concentration of hydrogen sulfide in this water was negligible. Because the altitude of land surface for both wells is nearly the same, the gas appears to be present in this immediate area somewhere in the section between 650 and 920 feet below land surface, and, therefore, between 150 and 400 feet below the top of the Avon Park Limestone.

Highly mineralized water is present at depths of about 1,500 feet below msl (mean sea level) in this area, or about 400 feet below the top of the Lake City Limestone (Pride, Meyer, and Cherry, 1966). The depth to this highly mineralized water depends upon the water level of fresh water in the aquifer and the characteristics of the aquifer. High levels of fresh water cause the interface between the fresh and highly mineralized waters to remain at relatively greater depths. Long periods of excessive withdrawals that lower water levels in the aquifer may allow upward movement of the poorer quality water.

One method of monitoring water-quality changes is to measure the change in specific conductance, which varies with the mineral content. Instruments have been installed in a well near Mirror Lake in Lakeland to measure and record hourly the specific conductance at two depths in the Floridan aquifer (well 27, fig. 2). This installation is diagrammed in figure 8. From June 1968 to November 1969 conductance at the lower probe (1,100 feet below land surface) ranged from about 2,500 to 4,000 micromhos; the temperature changes were small and averaged about 30°C. Conductance at the upper probe ranged from about 400 to 1,000 micromhos, and the temperature averaged about 27°C. The changes in conductance noted at the two depths are probably due to the movement of water within the aquifer.

From 1955 to 1962, water samples for analyses were collected from several wells in the study area. Some of these wells were sampled again in 1969, and their locations are shown on figure 6. A comparison of the earlier analyses with those of 1969 (table 2)

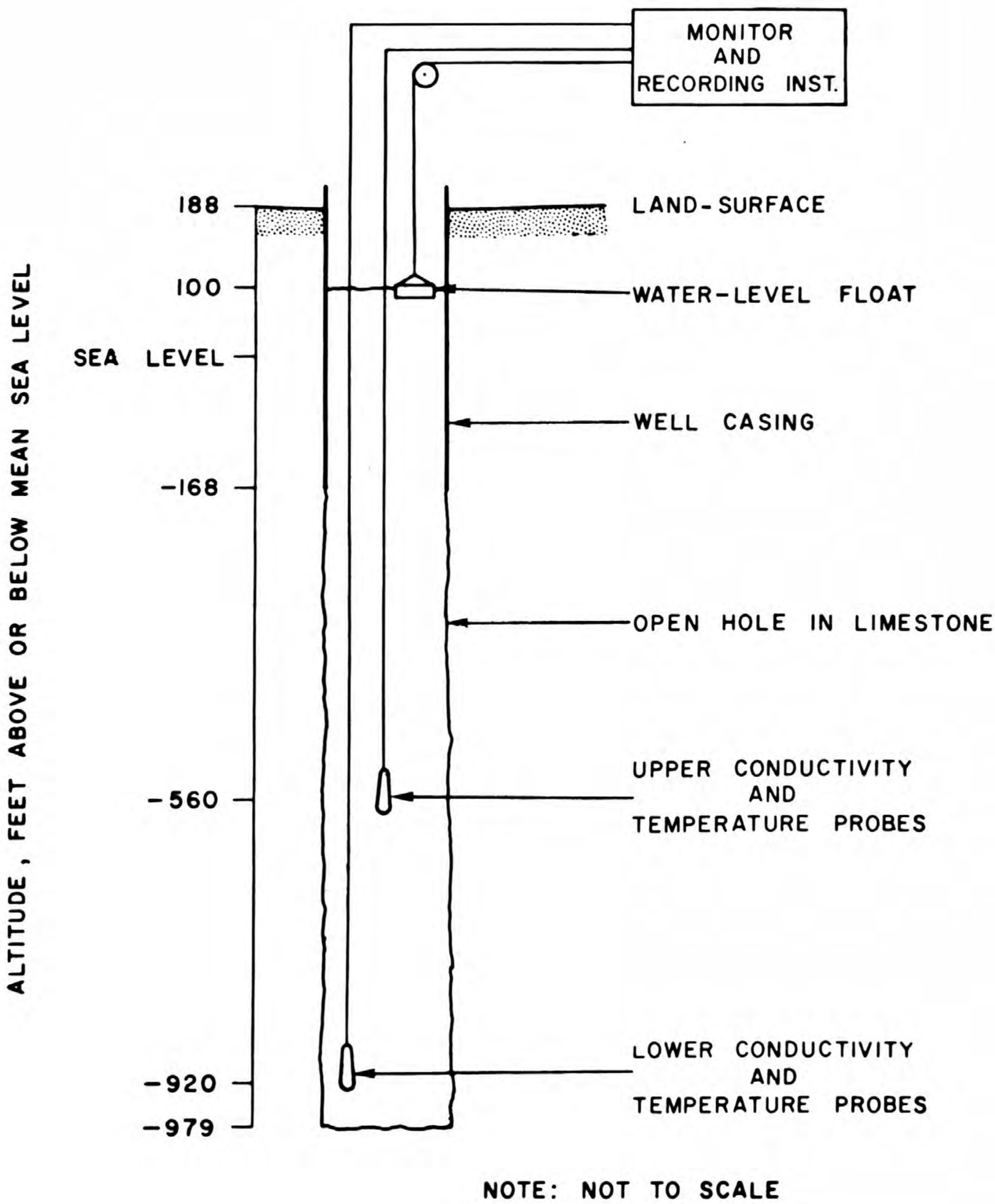


Figure 8. Schematic diagram of the quality-monitoring installation at Lakeland, Florida

Table 2. Chemical analyses for selected wells in the Lakeland Ridge Area

Chemical constituents in milligrams per liter (Analyses by U. S. Geological Survey)
(Water level: a, from recorder chart; e, estimated; m, measured.)

Well Number	Date Sampled	Water level ft belowland surface	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$		Specific Conductance (micromhos at 25°C)	pH	Temperature (°C)
																Calcium, Magnesium	Non-carbonate			
1	5-8-59	31e	3.2	0.01	20	11	8.2	0.8	48	54	12	0.2	0.0	----	157	95	56	234	7.4	----
	9-11-69	61e	18	.18	95	24	8.9	1.1	182	174	12	.6	.7	0.05	491	339	190	650	7.6	25.0
2	5-7-59	18a	17	---	46	11	6.8	.8	178	14	8.5	.4	.0	----	191	160	14	326	7.7	26.0
	11-7-69	34a	4.4	.03	20	11	8.4	1.0	112	4.0	6.0	.3	1.1	.2	117	96	4	205	7.3	25.0
3	6-11-56	37e	16	.08	54	11	13	.7	192	8.8	24	.0	1.5	----	227	180	23	396	7.4	----
	9-16-69	55e	14	.54	82	14	16	1.1	260	52	20	.2	.3	----	336	262	49	485	7.5	25.0
4	6-11-56	79m	---	---	---	---	----	---	---	---	---	---	---	.0	178	156	---	299	7.2	----
	4-15-66	101e	---	---	---	---	----	---	---	3.6	7.0	.3	---	---	---	158	---	319	---	----
	9-10-69	104e	16	---	39	12	6.0	.6	180	.0	7.0	.2	.9	.2	176	148	0	290	7.9	25.0
5	6-11-56	33m	---	---	--	---	---	---	---	---	---	---	---	.0	286	216	--	418	7.4	---
	11-7-69	31a	---	.12	23	4.8	4.1	---	96	.3	5.0	.6	---	.2	102	77	0	170	7.8	24.5
6	6-7-66	54e	---	---	--	---	---	---	---	.8	10	.4	---	---	---	150	--	325	---	----
	9-17-69	55e	---	2.4	49	6.1	---	---	---	.4	11	.5	---	---	212	148	--	310	7.6	24.5
7	6-9-56	32e	---	---	--	---	---	---	---	---	---	--	---	.3	237	188	--	383	7.2	----
	9-18-69	37e	16	.48	59	10	8.0	.9	206	.0	10	.3	10	.5	221	188	19	350	8.2	25.0

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Table 2. Chemical analyses for selected wells in the Lakeland Ridge Area. Continued

Well Number	Well Sampled	Water level ft below L.S.D.	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCo_3$		Specific Conductance (micromhos at 25°C)	pH	Temperature (°C)
																Calcium, Magnesium	Non-carbonate			
8	3-16-62	---	18	0.01	54	14	6.9	1.0	230	3.6	8.5	0.2	0.2	---	238	192	4	395	7.3	--
	3-25-63	---	---	---	59	13	6.5	1.2	232	10.0	9.0	--	--	0.01	--	202	12	400	7.6	--
	9-18-69	110e	19	0.30	59	14	7.8	0.4	238	0.0	9.0	0.2	12	--	245	205	10	389	7.6	26.0
9	6-11-56	67e	---	---	--	--	--	--	--	--	--	--	--	0.1	211	172	--	322	7.8	--
	9-17-69	73e	---	0.14	41	13	--	--	--	0.1	10	0.5	--	0.05	185	156	--	280	7.9	28.0
10	2-14-55	11e	---	0.06	38	21	--	--	216	7.0	12	--	--	--	214	182	--	366	7.9	--
	11-11-69	7m	22	0.0	40	18	15	0.8	222	4.0	12	1.0	0.6	0.1	225	174	.0	370	8.0	23.5
11	2-15-55	28e	---	0.03	46	21	--	--	237	5.0	10	--	--	--	244	202	--	380	7.8	--
	9-17-69	23e	---	0.48	43	20	--	--	---	0.1	21	0.5	--	0.04	218	190	--	320	8.1	24.0
12																				
	9-26-56	28e	---	--	4.5	28	--	--	260	--	18	--	--	--	280	228	14	435	7.2	--
	9-17-69	29e	---	1.2	33	19	--	--	---	0.1	23	--	--	0.02	214	161	--	310	7.6	23.0
13	12-5-55	27e	---	--	64	12	4.7	--	241	1.0	10	--	--	--	211	209	--	362	7.6	--
	11-9-59	15a	12	1.2	24	7.8	5.2	0.5	118	2.0	6.5	0.2	0.1	--	115	92	--	196	7.9	--
	11-10-69	20m	16	0.20	63	7.9	5.2	0.8	226	0.0	8.0	0.6	1.2	0.2	218	190	5	365	8.0	23.5
14	6-9-56	57e	---	--	--	--	--	--	---	--	--	--	--	--	168	144	--	280	7.3	--
	9-18-69	59e	---	0.48	38	12	--	--	---	0.1	14	0.8	--	0.04	171	145	--	290	7.7	24.5
15	6-11-56	100m	---	--	--	--	--	--	---	--	--	--	--	0.0	151	122	--	239	7.6	--
	9-19-69	110e	---	0.00	30	9.0	--	--	---	0.1	9.0	0.4	--	0.0	142	112	--	200	7.9	24.5

Table 2. Chemical analyses for selected wells in the Lakeland Ridge Area. Continued

Well Number	Date Sampled	Water level ft below L.S.D.	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Phosphate (PO_4)	Dissolved solids	Hardness as $CaCO_3$: Calcium, Magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific Conductance (micromhos at 25° C)	pH	Temperature (°C)
16	6-9-56	86m	--	--	--	--	--	--	--	--	--	--	--	0.1	298	260	--	526	7.6	25.5
	11-10-69	28e	--	0.0	42	15	6.0	--	196	0.0	8.0	0.4	--	--	188	167	6	315	8.2	26.0
17	1-2-56	21m	--	--	32	18	5.2	--	166	1.0	7.0	--	--	--	180	154	--	295	7.8	--
	11-11-69	22m	--	0.01	35	12	3.7	--	174	0.10	4.0	0.3	--	0.6	146	137	0	250	8.1	24.0
18	1-30-56	13m	--	--	50	22	7.9	--	252	1.0	12	--	--	--	236	215	--	412	7.6	--
	11-10-69	18e	22	0.05	60	28	12	0.6	322	0.0	17	0.3	0.1	0.05	306	265	1	566	8.0	23.0
19	6-11-56	52m	--	--	--	--	--	--	--	--	--	--	--	--	141	110	--	223	7.7	--
	9-19-69	61e	--	0.15	26	5.3	--	--	--	0.1	11	0.4	--	--	123	87	--	190	7.4	26.0
20	6-14-62	--	14	0.31	40	4.4	4.8	0.5	142	2.8	6.0	0.4	0.2	--	138	118	2	241	8.1	--
	9-19-69	30e	14	0.61	39	5.0	4.7	0.3	146	0.0	6.0	0.3	0.0	0.07	147	119	0	240	7.6	24.0

shows no extensive deterioration of water quality. Specific conductance of water from wells 1, 3, and 18 increased by more than 10 percent. Wells 1 and 3 are within the area of 15-20-foot water-level decline, and well 18 is within the area of 0-5 foot water-level decline (fig. 6). The specific conductance of water from the other wells throughout the study area has not changed or has decreased by more than 10 percent. The depths and other information about these wells are given in table 3.

Water Use

Ground-water is the principal source of water supply for municipal, industrial, and agricultural use in Polk County. Stewart (1963) recorded the location, pumpage rates, use, and other information for 1,300 wells in Polk County. Table 3 lists this information for some additional wells drilled in the Lakeland ridge area since the previous survey. The locations of these wells are shown on figure 2, where they are numbered serially. Table 4 is a list showing both the well serial numbers, as used in this report, and the U. S. Geological Survey well number based on the latitude and longitude of the well location. This table is included as a cross-reference. In addition Kaufman (1967) discussed the amount of ground-water pumpage for large users in the Peace and Alafia basins and showed graphically the increase in pumpage from 1934 to 1965.

The monthly variation in Lakeland's pumpage from 1950 to September 1969 can be seen in figure 7. This pumpage increased from 1,620 million gallons in 1950 to 4,830 million gallons in 1968, or an average

TABLE 3. Record of wells in the Lakeland Ridge Area.

Type of pump: T, turbine; C, centrifugal; S, Submersible
Type of power: E, electric
(For additional wells in Polk County, See Stewart, 1963)

Use: PS, public supply; O, observation;
I, irrigation; N, industrial;
U, unused; H, private supply

Well Number	Owner	Driller	Year Drilled	Depth of well (feet)	Casing		Measuring Point		Altitude of land surface (feet)	Water Level		Type of pump	Type of power	Reported yield in (gpm)	Use	Remarks
					Diameter (inches)	Total depth (feet)	Description	Feet above land surface		Below land surface (feet)	Date measured					
1	City of Bartow	W. F. Hamilton	1904	600	6	?	-	-	121	34	1949	T	E	400	PS	City No. 1
2	IMC Co.	unknown	?	710	10	237	Top of casing	3	100	21	2/55	-	-	-	O	
3	City of Lakeland	O. W. Rodgers	1936	252	6	90	Access hole in pump base	1.0	125	61.50	6/69	T	E	—	PS	City No. 18
4	Polk County	H. Godwin	1955	325	6	163	-	-	164	77	8/55	T	E	-	U	
5	ABC Realty	Layne Atlantic	1948	1220	24	243	Top of casing	4	122	33	5/56	-	-	-	O	
6	R. C. Taylor	unknown	1940	300	6	?	-	-	137	-	-	S	E	-	H	
7	City of Lakeland	Stevens Southern	1948	746	20	160	Access hole in pump base	1.1	135	23	6/48	T	E	1,500	PS	City No. 6
8	-do-	Layne Atlantic	1945	828	24	280	-	-	201	98	1945	T	E	4,000	PS	City No. 5
9	Publix Markets	O. W. Rodgers	1951	635	8	114	-	-	158	67	7/56	T	E	-	N	
10	W. B. Glisson	H. Godwin	1954	193	3	36	Top of casing	.3	117	10.63	10/59	-	-	-	O	
11	Polk County	P. Morrill	1953	355	6	55	Access hole in top sanitary seal	.5	123	28.35	5/55	S	E	-	PS	
12	W. W. Deeson	H. Godwin	1953	126	4	78	-	-	134	18	6/64	C	E	-	H	
13	USGS	H. Godwin	1955	311	4	265	Top of casing	3.6	135	27.0	2/56	-	-	-	O	
14	See Remarks	M. R. Vaughn	1939	550	12	67	-	-	158	-	-	T	E	-	H	United Brotherhood of Carpenters and Joiners of America
15	Polk County	Barney's Pump Co.	1954	261	6	203	Air line	1.1	207	105	6/64	T	E	125	PS	
16	Borden Chem. Co.	Layne Atlantic	1950	1285	18	375	Top of casing	0	128	87	6/56	-	-	-	U	

Table 3. Record of wells in the Lakeland Ridge Area. continued.

Well Number	Owner	Driller	Year Drilled	Depth of well in feet	Casing: Dia. (in.)	Casing: Total depth in feet	Measuring Point: Description	Measuring Point: Feet above land surface	Altitude of land surface (ft.)	Water Level: Below land surface	Water Level: Date measured	Type of pump	Type of power	Reported yield in GPM	Use	Remarks
17	USGS	H. Godwin	1956	103	3	63	Top of casing	2.9	139	21	1/56	-	-	-	O	
18	American Cyanimid	H. Godwin	1956	411	6	53	-	-	135	13	1/56	T	E	290	H	
19	Polk County	J. P. Whatley	1952	198	6	88	Air line	-	160	52	7/56	T	E	200	PS	
20	J. H. Ward	unknown	1955	140	3	135	-	-	145	-	-	C	E	-	H	
21	City of Lakeland	Paul Everhart	1969	660	20	198	Top of casing	2.0	173	74.3	2/69	T	E	-	PS	City No. 29
22	City of Lakeland	Paul Everhart	1968	647	8	185	-do-	0.5	173	70.5	12/68	-	-	-	O	Test hole for City No. 29
23	-do-	Layne Atlantic	1968	920	16	660	-do-	4.0	167	77.7	5/69	-	-	-	O	Abandoned for public supply
24	-do-	Fla. Water Well Co.	1953	865	18	203	Access hole in pump base	1.0	213	107	1/53	T	E	2000	PS	City No. 9
25	-do-	Gardenshire	1956	790	20	273	Access hole in pump base	0.1	231	13723	1/59	T	E	3000	PS	City No. 12
26	-do-	Layne Atlantic	1968	823	20	224	Top air line drop pipe	1.0	170	84.0	4/68	T	E	-	PS	City No. 31
27	City of Lakeland	R. Neikirk	1925	1167	15	356	Top of casing	3.0	188	100	3/68	-	-	-	O	City No. 4
28	Ben Hill Griffin	Frank May	1969	970	12	713	Top of casing	1.0	120	52.2	10/69	T	E	-	N	
29	City of Lakeland	-	1965	356	6	213	Access hole in top sanitary seal	1.0	210	146.4	6/69	S	E	150	PS	City No. 25
30	-do-	-	1966	790	10	-	Access hole in pump base	1.0	225	-	-	T	E	450	PS	City No. 28
31	-do-	-	1965	640	8	224	-do-	1.0	220	158.3	6/69	T	E	300	PS	City No. 24
32	-do-	-	1964	603	8	376	-do-	1.0	194	138.4	6/69	T	E	400	PS	City No. 23
33	-do-	Paul Everhart	1969	550	20	203	Top edge access pipe	1.0	130	64.4	6/69	T	E	5000	PS	City No. 32
34	-do-	-	1966	921	20	230	-	-	186	-	-	T	E	2300	PS	City No. 26

Table 3. Record of wells in the Lakeland Ridge Area. continued.

Well Number	Owner	Driller	Year Drilled	Depth of well in feet	Casing		Measuring Point		Altitude of land surface (ft.)	Water Level		Type of pump	Type of power	Reported yield in GPM	Use	Remarks
					Dia. (in.)	Total depth in feet	Description	Feet above land surface		Below land surface	Date measured					
35	City of Lakeland	-	1964	891	20	264	-	-	204	-	-	T	E	-	PS	City No. 22
36	-do-	-	1966	703	20	239	Access hole in pump base	1.0	170	94.6	6/69	T	F	3000	PS	City No. 27
37	-do-	Brandon Well Drilling	1969	555	16	200	-	-	139	-	-	T	E	-	PS	At Power Plant No. 3
38	-do-	-do-	1969	545	16	200		-	139	-	-	T	E	-	PS	-do-
39	See Remarks	-	1965	749	16	200	Access hole in pump base	1.0	240	145.0	6/69	T	E	2300	I	United Brotherhood of Carpenters and Joiners of America
40	See Remarks	Sadler-Taylor Irrigation Co.	1969	669	12	244	-do-	1.0	195	93.7	8/69	T	E	-	I	-do-

Table 4. Latitude-longtitude location numbers for wells used in this report.

Well number in this report	Latitude-longitude Number
1.	275353N-0815033.1
2.	275326N-0815858.1
3.	275751N-0815220.1
4.	275759N-0815813.1
5.	275959N-0815525.1
6.	280159N-0820156.1
7.	280254N-0815525.1
8.	280246N-0815704.1
9.	280227N-0815918.1
10.	280336N-0815128.1
11.	280325N-0815345.1
12.	280407N-0815443.1
13.	280503N-0815528.1
14.	280559N-0815748.1
15.	280529N-0815947.1
16.	280606N-0815232.1
17.	280614N-0815636.2
18.	280702N-0815422.1
19.	280727N-0820113.1
20.	280922N-0815412.1
21.	280416N-0815719.2
22.	280416N-0815719.1
23.	280420N-0815707.1
24.	280331N-0815726.1
25.	280344N-0815825.1
26.	280518N-0815758.1
27.	280244N-0815708.1
28.	275349N-0815138.1
29.	275752N-0815552.1
30.	275713N-0815646.1
31.	275731N-0815703.1
32.	275848N-0815605.1
33.	275826N-0820044.1
34.	275936N-0815741.1
35.	280151N-0815729.1
36.	280120N-0815823.1
37.	280446N-0815537.1
38.	280449N-0815537.1
39.	280520N-0815856.1
40.	280613N-0815902.1

of 13.2 mgd in 1968. Although municipal supplies account for only part of the total ground-water pumpage in the study area, the trend of increasing water use shown in figure 7 is paralleled by an increasing demand for water by industry and agricultural operations.

In 1965, the most recent year for which data are available, the estimated ground-water pumpage by phosphate mines in the combined Peace and Alafia river basins was 72,000 million gallons (Kaufman, 1967). Assuming that water use is about the same for each mine, about 25 percent of this total is pumped from the Lakeland ridge area by the phosphate industry. If pumpage for 1968 was about the same as it was in 1965, the withdrawal for phosphate mining and processing during 1968 was 18,000 million gallons, or an average of 49 mgd.

Water use for citrus irrigation varies considerably both annually and seasonally. In the study area, about 15,000 acres were used for citrus cultivation in 1968, and about 40 percent of this acreage is irrigated. Pumpage for citrus irrigation was about 1,950 million gallons in 1968, or an average of 5.3 mgd based upon the estimated application requirement of 1 foot per acre annually reported by Kaufman (1967).

In summary, about 67.5 mgd was pumped from the aquifers underlying the Lakeland ridge in 1968. However, this is a minimum, as only citrus irrigation, phosphate production, and Lakeland's municipal pumpage were considered. This pumpage is expected to increase with the continued growth of population and industry, and, although the author has made no estimates for the study area, the

Florida Board of Conservation (1966) estimates the pumpage may reach 1,200 mgd by 1980 for the combined Peace and Alafia basins.

ADDITIONAL DATA NEEDED

Although considerable hydrologic data are available for the Lakeland ridge area, this information is not of sufficient detail for use as a basis for decisions that would allow for optimum use of the water supply.

The following data are needed:

a. The hydraulic characteristics of the aquifers and confining layers and how they vary over the area.

b. The location of all wells yielding large quantities of water and accurate water-use data.

c. The quality of water at various depths in the aquifers.

d. The effects of rainfall variation on water levels in the Floridan aquifer and its significance compared to the effects of pumpage on water levels.

Summary

A considerable amount of hydrologic data are available for the Lakeland ridge area. Lake-level and stream-flow data are collected and published by the U. S. Geological Survey in cooperation with local and state agencies. Climatological data are available through the National Weather Service (U. S. Weather Bureau). The geologic setting of the Lakeland ridge area has been studied and defined in previous investigations. Information that is currently available is adequate to define, in general, the hydrologic conditions of the area. However, this information is not sufficiently detailed to allow management decisions to be made for optimum use of the available water supply or to identify possible alternatives for water-supply developments.

Additional data are needed to define the hydraulic characteristics of the aquifers and confining layers and how they vary over the area. The location of wells of large yield and accurate water-withdrawal data also need to be determined.

The levels to which the potentiometric surface will be lowered by the anticipated increase in ground-water withdrawals can be reasonably predicted with this information.

Presently the Floridan aquifer is not being dewatered. However, the observed lowering of the potentiometric surface may have other undesirable effects such as the increased hazard of upward movement of poor quality water, which is of special concern to municipal water users. Additional data are needed to define the depths at which highly mineralized water occurs.

Ground-water pumpage in the study area is estimated to have been at least 67 mgd in 1968. This pumpage is expected to increase considerably as the population of the area grows and as industrial and agricultural enterprises expand. The second phase of this investigation is directed toward gathering and evaluating these data, which are necessary to establish a sound basis for management decisions.

SELECTED REFERENCES

Altschuler, Z. S., Jaffe, E. B., and Cuttitta, Frank, 1956, The aluminum phosphate zone of the Bone Valley formation, Florida, and its uranium deposits: U. S. Geol. Survey Prof. Paper 300, p. 495-504.

Altschuler, Z. S., and Young, E. J., 1960, Residual origin of the "Pleistocene" sand mantle in central Florida uplands and its bearing of marine terraces and Conozoic uplift: U. S. Geol. Survey Prof. Paper 400-B, p. 202-207.

Applin, P. L., and Applin, E. R., 1944, Regional subsurface stratigraphy and structure of Florida and southern Georgia: Am. Assoc. Petroleum Geologists Bull., v. 28, no. 12, p. 1673-1753.

Bergendahl, M. H., 1956, Stratigraphy of parts of DeSoto and Hardee counties, Florida: U. S. Geol. Survey Bull. 1030-B, p. 65-98.

Bishop, E. W., 1956, Geology and ground-water resources of Highlands County, Florida: Florida Geol. Survey Rept. of Inv. 15.

Carr, W. J., and Alverson, D. C., 1959, Stratigraphy of middle Tertiary rocks in part of west-central Florida: U. S. Geol. Survey Bull. 1092.

Cathcart, J. B., and McGreevy, L. V., 1959, Results of geologic exploration by core drilling, 1953, land-pebble phosphate district, Florida: U. S. Geol. Survey Bull. 1046-K, p. 221-298.

Cathcart, J. B., 1963, Economic geology of the Plant City quadrangle, Florida: U. S. Geol. Survey Bull. 1142-D.

____1964, Economic geology of the Lakeland quadrangle, Florida: U. S. Geol. Survey Bull. 1162-G.

____1966, Economic geology of the Fort Meade quadrangle, Polk and Hardee counties, Florida: U. S. Geol. Survey Bull. 1207.

Cooke, C. W., 1945, Geology of Florida: Florida Geol. Survey Bull 29.

Cooper, H. H., Jr., and Stringfield, V. T., 1950, Ground water in Florida: Florida Geol. Survey Inf. Circ. 3.

Florida Board of Conservation, 1966, Florida land and water resources, Southwest Florida: Tallahassee, Florida, p. 146.

Healy, H. G., 1962, Water levels in artesian and nonartesian aquifers of Florida in 1960: Florida Geol. Survey Inf. Circ. 33.

____1968, Water levels in artesian and nonartesian aquifers of Florida, 1963-64: Florida Geol. Survey Inf. Circ. 52.

Heath, R. C., 1961, Surface-water resources of Polk County: Florida Geol. Survey Inf. Circ. 25.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U. S. Geol. Survey Water-Supply Paper 1473.

Kaufman, M. I., 1967, Hydrologic effects of ground-water pumpage in the Peace and Alafia river basins, Florida, 1934-1965: Florida Geol. Survey Rept. of Inv. 49.

Kenner, W. E., 1961, Stage characteristics of Florida lakes: Florida Geol. Survey Inf. Circ. 31.

____1964, Maps showing depths of selected lakes in Florida: Florida Geol. Survey Inf. Circ. 40.

Ketner, K. B., and McGreevy, L. J., 1959, Stratigraphy of the area between Hernando and Hardee counties, Florida: U. S. Geol. Survey Bull. 1074-C.

Kohout, F. A., 1959, Hydrologic features of the Lake Istokpoga and Lake Placid areas, Highlands County, Florida: Florida Geol. Survey Rept. of Inv. 19.

Matson, G. C., and Sanford, Samuel, 1913, Geology and ground waters of Florida: U. S. Geol. Survey Water-Supply Paper 319.

Menke, C. G., Meredith, E. W., and Wetterhall, W. S., 1961, Water resources of Hillsborough County, Florida: Florida Geol. Survey Rept. of Inv. 25.

Mohler, F. C., 1962, Summary of available water resources data for Florida: Florida Div. Water Resources and Conserv., Tallahassee, Florida.

Peek, H. M., 1951, Cessations of flow of Kissengen Spring in Polk County, Florida: Florida Geol. Survey Rept. of Inv. 7, part 3.

Pride, R. W., Meyer, F. W., and Cherry, R. N., 1961, Interim report on the hydrologic features of the Green Swamp area in central Florida: Florida Geol. Survey Inf. Circ. 26.

Pride, R. W., and Crooks, J. W., 1962, The drought of 1954-1956, its effect on Florida's surface-water resources: Florida Geol. Survey Rept. of Inv. 26.

Pride, R. W., Meyer, F. W., and Cherry, R. N., 1966, Hydrology of the Green Swamp area in central Florida: Florida Geol. Survey Rept. of Inv. 42.

Sellards, E. H., 1908, A preliminary report on the underground water supply of central Florida: Florida Geol. Survey Bull. 1.

Stewart, H. G., Jr., 1959, Interim report on the geology and ground-water resources of northwestern Polk County, Florida: Florida Geol. Survey Inf. Circ. 23.

____1963, Records of wells and other water-resources data in Polk County, Florida: Florida Geol. Survey Inf. Circ. 38.

____1966, Ground-water resources of Polk County, Florida: Florida Geol. Survey Rept. of Inv. 44.

Stringfield, V. T., 1936, Artesian water in the Florida peninsula: U. S. Geol. Survey Water-Supply Paper 773-C.

Toler, L. G., 1967, Fluoride in water in the Alafia and Peace River basins, Florida: Florida Geol. Survey Rept. of Inv. 46.

University of Florida, 1969, Florida statistical abstracts: Bur. of Econ. and Business Research, College of Business Adm.

Unklebay, A. G., Heath, R. C., and Peek, H. M., 1959, Bibliography and index of articles relating to the ground-water resources of Florida, 1861-1955: Florida Geol. Survey Special Publ. 4.

U. S. Bureau of Mines, 1966, Minerals Yearbook, Vol. I-II: Washington, D. C., p. 527.

U. S. Public Health Service, 1962, p. 29.

U. S. Geological Survey, 1967, Water resources data for Florida, Part 1, Surface water: Tallahassee, Water Resources Division.

Vernon, R. O., 1957, Ground water as a resource in Florida's agriculture: Soil and Crop Sci. Fla. Proc. 1956, v. 16, p. 55-62.

Wakefield, J. W., 1960, Water resources and conservation in Florida: Am. Water Works Assoc. Jour., v. 52, no. 8, p. 970-978.

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