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A. S. FURCRON, Director

THE GEOLOGICAL SURVEY

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HYDRAULICS OF AQUIFERS AT ALAPAHA, COOLIDGE, FITZGERALD, MONTEZUMA, AND THOMASVILLE, GEORGIA

by

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1776

Prepared in cooperation with the U.S. Geological Survey, Water Resources Division

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HYDRAULICS OF AQUIFIERS AT ALAPAHA, COOLIDGE, FITZGERALD, MONTEZUMA, AND THOMASVILLE, GEORGIA

Charles W. Sever

ABSTRACT

The results of aquifer performance tests made on four well fields tapping limestones of Miocene, Oligocene, or Eocene age show that the hydraulic properties vary greatly from one limestone aquifer to another in southwestern Georgia.

Coefficients of transmissibility in the limestones ranged from 120,000 gpd per ft. (gallons per day per foot) at Fitzgerald, Ga., to perhaps as much as 20,000,000 gpd per ft. at Thomasville, Ga. The coefficient of storage ranged from 0.00002 to 0.003.

An aquifer performance test made on sand aquifers of Cretaceous age near Montezuma, Ga., shows the coefficient of transmissibility to be about 60,000 gpd per ft. and the coefficient of storage to be about 0.002.

The geophysical and lithologic logs and the drawdown versus distance graphs made for the well fields described in this report should enable prediction of the amount of interference between wells and also aid in determining the proper construction and spacing of wells.

INTRODUCTION

Purpose of the Investigations

Ground-water investigations have been made at municipal well fields in Alapaha, Coolidge, Fitzgerald, and Thomasville and at the industrial well field of Southern Frozen Foods, Inc., Montezuma, Ga. (fig. 1), for the purposes of evaluating the quantity and quality of ground water available for industrial and municipal use and providing information for the orderly development of this resource. These investigations were made by the U. S. Geological Survey, in cooperation with the Georgia Department of Mines, Mining and Geology, as part of a project to evaluate the ground-water resources of Georgia.

Well-numbering System

The field well-numbering system used in this report is based upon geographic coordinates. Each well is assigned two numbers separated by a letter. The first number and the letter refer to the coordinate system shown on figure 1 and identifies the individual 7½-minute quadrangle in which the well is located. The final number represents the well numbered serially within a quadrangle. Accordingly, well 18G18 was the 18th well to be located within the 7½-minute quadrangle represented by coordinates 18 and G.

Wells for which drill cuttings are available have been given a Georgia Geological Survey (GGS) number. These numbers are shown in table 3. Drill cuttings from these wells are on file in the sample library of the Georgia Department of Mines, Mining and Geology in Atlanta.

Previous Investigations

General information about the hydrogeology and water quality of southwestern Georgia are included in Stephenson and Veatch (1915), Cooke (1943), Wait (1960), and Callahan (1964).

Herrick (1961) has published detailed lithologic and paleontologic logs of numerous wells in the area, some of which are located within the well fields described in this report.

Results of aquifer performance tests made at other well fields in southwestern Georgia are included in reports by Wait (1963) and Sever (1963, 1965).

Acknowledgments

The author thanks the superintendents of the water departments of each city described herein for their cooperation and assistance. Thanks also are due Mr. John Flatt with Layne Atlantic Company, Mr. John Carr with John Carr Drilling Company, Mr. Dayton Everett with Everett Drilling Company, Mr. Rowe with Rowe Brothers Drilling Company, and Mr. Frank Creasy with Creasy Drilling Company for their assistance in testing the aquifers. The author acknowledges the interest and assistance of the staff of the Georgia Department of Mines, Mining and Geology, Dr. A. S. Furcron, Director.

CHEMICAL QUALITY OF GROUND WATER

The mineral content of ground water, though usually higher than that of surface water, does not vary seasonally. Surface waters may fluctuate appreciably in both mineral content and temperature over a short period of time. The chemical composition of ground water varies as a result of the type of rock and the length of time the water is in the aquifer. Water from a limestone aquifer is usually high in mineral content because of the solubility of the calcium carbonate, while water from a relatively insoluble sand and gravel aquifer may be low in dissolved minerals. Generally, the farther from the recharge area the water is withdrawn from the aquifer, the higher the mineral content.

Most drinking water standards are based on those set by the U. S. Public Health Service in 1962 for water used on common carriers engaged in interstate commerce (table 1). At the same time, the American Water Works Association endorsed these standards and recommended that they be adopted as minimum criteria for all public supplies in the United States.

Hardness classification by the U. S. Geological Survey is related to parts per million (ppm) of calcium carbonate:

0-60 ppm	soft
61-120 ppm	moderately hard
121-180 ppm	hard
more than 180 ppm	very hard

Chemical analyses of water from wells at Coolidge, Montezuma, and Thomasville are given in table 1.

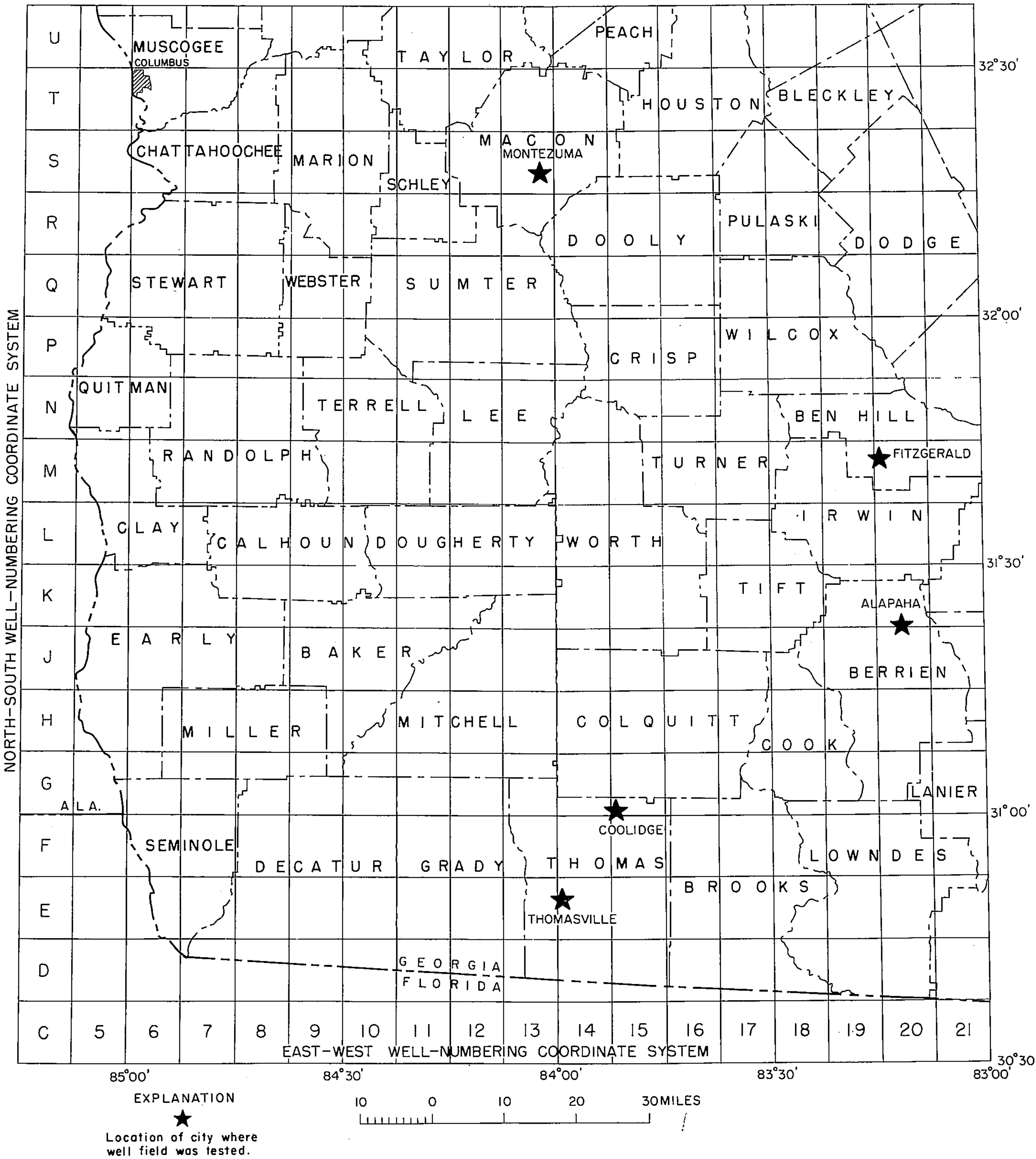

Figure 1. Location of study areas and geographic coordinates of the well-numbering system for southwestern Georgia.

Table 1. Chemical analyses of water
(Analyses by U. S. Geological Survey unless otherwise shown)

Well No.	Date of collection	Temperature (°F)	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$		Specific Conductance (micromhos at 25° C)	Laboratory pH	Color
			Parts per million												Ca Mg	Non-carbonate			
U. S. Public Health Service drinking-water standards				0.3	----	------	------	----	------	250	250	[a]1.2	45	500	------	------	------	----	----
COOLIDGE																			
15G7	10-6-64	74	25	0.09	65	31	22	3.5	148	185	15	0.7	0.1	420	288	166	615	8.0	5
SOUTHERN FROZEN FOODS, INC., MONTEZUMA																			
20M2	8-2-61	75	23	0.06	22	9.0	3.5	0.8	114	0.8	3.0	1.2	0.0	122	92	0	192	7.9	0
THOMASVILLE																			
14E10	2-5-38	71	24	0.02	45	22	7.9	1.0	153	77	7.8	0.3	0.1	265	203	------	------	------	----
14E10	12-2-51	71	25	.10	----	------	------	----	157	------	7.5	------	------	------	203	------	418	7.8	----
14E11	12-2-51	71	25	------	----	------	------	----	157	------	7.5	------	------	------	210	------	425	7.7	----
[b]14E12	1949	----	18	.1	----	31.8	------	----	------	69.6	11.6	------	------	308	187	------	------	7.9	----
14E12	3-8-58	76	22	.00	47	20	7.8	1.0	158	82	9.0	.4	.0	288	200	70	418	7.8	2
14E12	12-2-51	71	26	.07	47	22	6.9	----	157	79	7.6	.4	.1	271	208	------	416	------	1
[c]14E12	8-1-61	72	22	.04	48	21	7.8	1.0	158	78	8.0	.7	.0	298	206	77	------	7.5	25

[a] Recommended maximum concentration for area covered by this report (average maximum daily air temperature of 63.9 - 70.6°F).

[b] Law and Company, analyst.

[c] Sampled after 30 days of pumping.

AQUIFERS AND HYDRAULIC PROPERTIES

Most municipalities and industries located in the Georgia Coastal Plain obtain their water supply from wells that tap water-bearing sedimentary rocks called aquifers. Most of these aquifers are actually aquifer systems, as they are not a single water-bearing bed but generally include several interconnected or related water-bearing beds. Wells that tap limestone aquifers in southwestern Georgia obtain most of their water from a few thin, highly-permeable beds rather than from the entire thickness of the aquifers. Knowledge of the stratigraphic position, thickness, distribution, and yield of these beds, as well as the hydraulic properites of the aquifer system, aid in the proper construction and spacing of wells. In Georgia, the Suwannee Limestone, the Ocala Limestone, and the Lisbon Formation make up the principal artesian aquifer system, the most extensively used aquifer system in south Georgia.

Methods of Investigations

The geologic age of the different rock formations was determined by examining samples of the rocks penetrated by the drilling of water wells. The tops and bottoms of each formation were located and traced from well to well by comparing their electrical and gamma-radiation properties. Water-bearing zones within the aquifer system were located by means of a current meter. A caliper log was made to determine the inside diameter of the well bore. The hydraulic properties of an aquifer were determined by pumping a well at a known constant rate and measuring the water-level change in the pumped well or in nearby observation wells penetrating the aquifer. These data are used to solve equations which express the relationship between the hydraulic properties of an aquifer and the lowering of water levels near a pumped well (Theis, 1935 and Ferris and others, 1962).

Hydraulic Properties of the Aquifers

The principal hydraulic properties influencing the development of an artesian aquifer are the coefficients of transmissibility (T) and storage (S). The ability of an aquifer to transmit ground water is expressed by the coefficient of transmissibility, which is defined as the rate of flow of water in gallons per day, through a vertical strip of the aquifer 1 foot wide and extending the full saturated thickness under a hydraulic gradient of 100 percent (1 foot per foot). The storage properties of an aquifer are expressed by the coefficient of storage, which is defined as the volume of water released from storage per unit surface area of the aquifer per unit decline in head or water level. Hydraulic properties of the aquifers tested during these studies are summarized in table 2.

Table 2. Summary of hydraulic coefficients.

Well field	Aquifer	Coefficient of transmissibility (gpd/ft)	Coefficient of storage gals
Alapaha	Suwanee Limestone	240,000	Not determined
Coolidge	do.	1,300,000	0.00002
Fitzgerald	Principal artesian aquifer	120,000	.003
Montezuma (Southern Frozen Foods)	Providence Sand, Cusseta Sand and Blufftown Formation	60,000	.002
Thomasville	Ocala Limestone	20,000,000	Not determined

Effects of Pumping

When a well is pumped, water levels decline in a funnel shape, called a cone of depression, with the greatest drawdown at the pumped well. With continuous pumping, water is taken from storage at greater distances from the pumped well and the cone of depression grows in size and depth until a state of equilibrium is reached. Water-level decline is theoretically directly proportional to the pumping rate and diminishes outward from the pumped well.

In a multiple well system, a cone of depression is formed around each pumped well. When the cones overlap, the wells are said to interfere and water levels decline in a manner directly proportional to the pumping rates and inversely proportional to the logarithm of the distance between wells.

Pumping from wells in artesian aquifers has a widespread effect on water levels. Hydraulic properties detemined for the various well fields described in this report were used to evaluate the magnitude of interference between theoretical wells located within or near the well fields for different pumping rates.

In determining the theoretical drawdown near a pumping well the aquifers tapped were assumed to be insulated from other aquifers by thick impermeable aquicludes. However, water will permeate through most materials if sufficient time and pressure are involved. Most artesian aquifers receive recharge through permeable breaks in the confining aquicludes or by leakage from the aquiclude itself. Therefore, the predicted drawdowns given for well fields in this report probably are conservative.

AQUIFER PERFORMANCE TEST AT ALAPAHA, BERRIEN CO., GA.

The city of Alapaha has two municipal wells (20K2 and 20K4). Locations of the two wells are shown on figure 2 and their construction data are summarized in table 3.

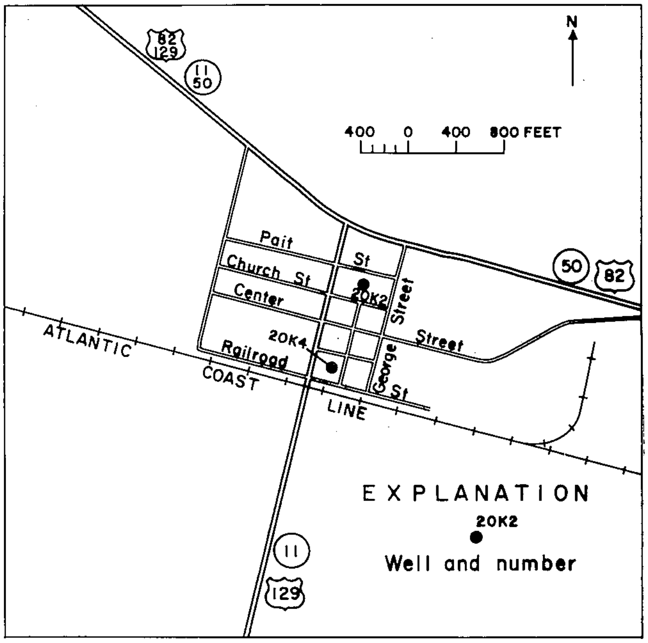

Figure 2. Alapaha well locations.

During construction of well 20K2, the driller collected samples of the rock penetrated by the well and permitted the author to make electric-resistivity and self-potential logs of the upper part of the well before the casing was installed. After completion, these two types of logs were made of the lower part of the well and a gamma-radiation log was made of the entire well. Figure 3 shows these logs and a summary description of the rock samples. The well taps the Suwannee Limestone which is the uppermost member of the principal artesian aquifer system in Berrien County.

Hydraulic Properties of the Aquifer

On August 25, 1965, a short aquifer performance test was made by measuring the recovery of the water level in well 20K2 for a half hour after it had been pumped at 41 gpm (gallons per minute) for about 24 hours. The coefficient of transmissibility of the Suwannee Limestone at Alapaha is estimated to be about 240,000 gpd per ft.

AQUIFER PERFORMANCE TEST AT COOLIDGE, THOMAS COUNTY, GA.

Prior to 1902, Coolidge obtained its municipal water supply from two large, shallow dug wells.

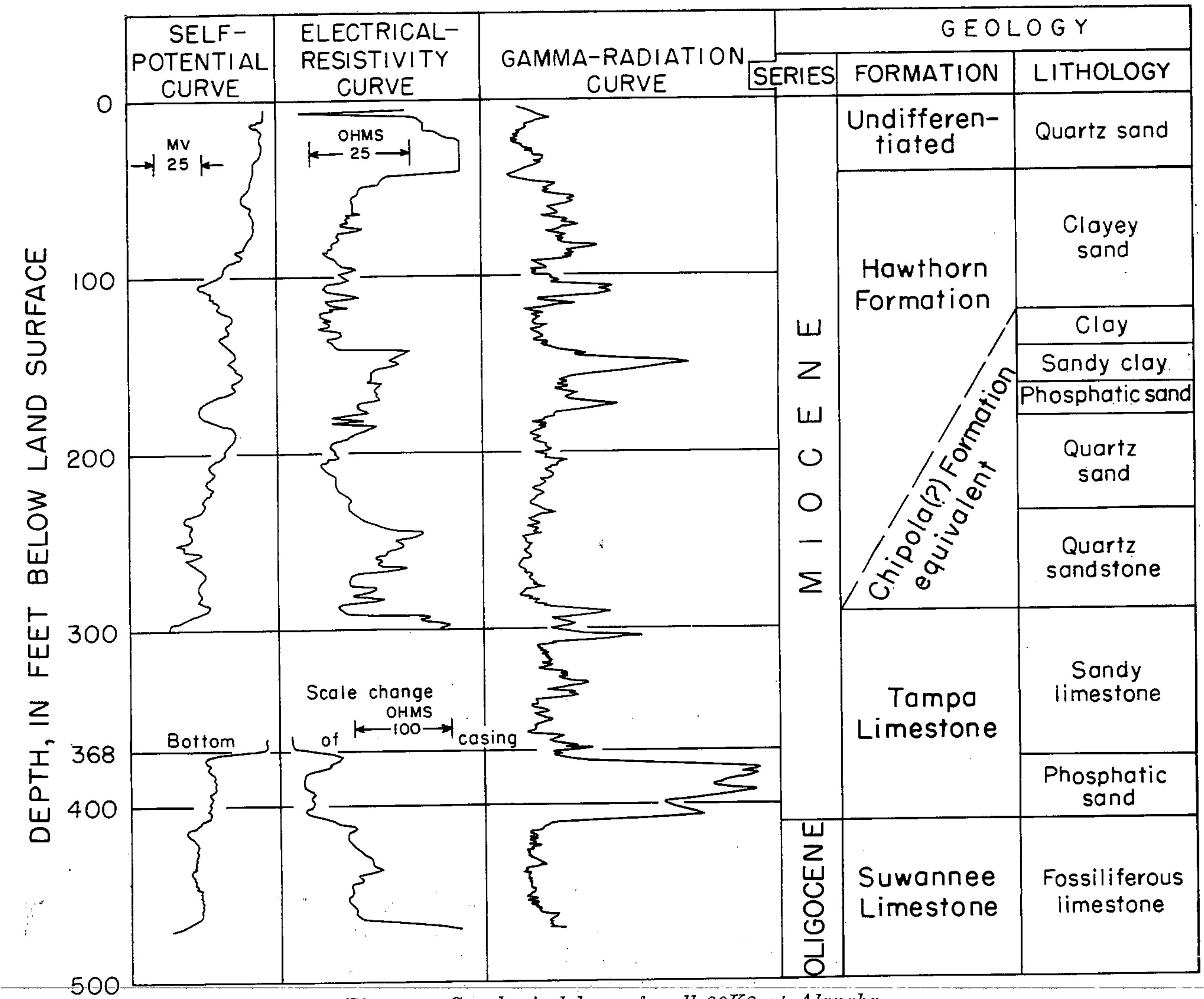

Figure 3. Geophysical logs of well 20K2 at Alapaha.

In about 1902, the city drilled a 4-inch cased well (15G15) on the northwest side of town and abandoned the two shallow wells. Water from this well began to taste bad and in 1932 the city drilled another well (15G7) and destroyed the old well. In 1962 the pump in well 15G7 broke down and for a period of about two months, the city was almost out of water. The city then decided to drill another well. In February, 1964, Rowe Brothers Drilling Co., Tallahassee, Fla., drilled a new well (15G11) about 65 feet east of well 15G7 (fig. 4). Construction data of these wells are summarized in table 3.

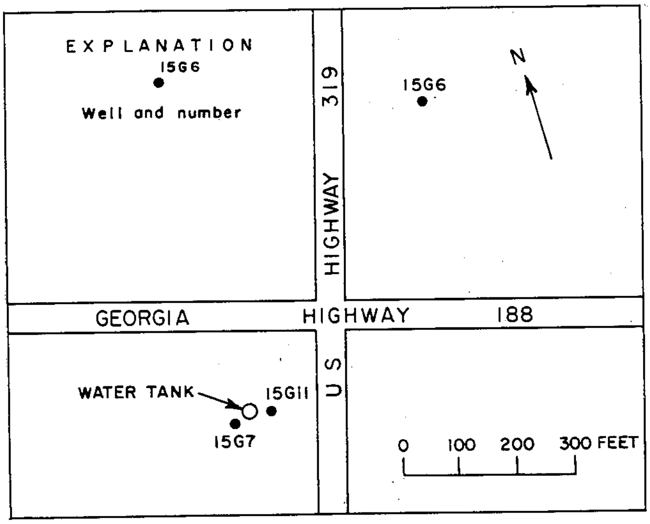

Figure 4. Coolidge well locations.

During construction of well 15G11, electric-resistivity and self-potential logs were made of the upper part of the well before installing the casing; then after completion, these two types of logs were made of the lower part of the well and a gamma-radiation log was made of the entire well. Electric-resistivity, self-potential, gamma-radiation, and caliper logs also were made of well 15G6.

Samples of the rocks penetrated by well 15G11 were collected by the driller and examined by the author. A summary description of these samples is given on figure 5 together with the logs made of wells 15G6 and 15G11.

Current-Meter Test

On February 5, 1965, water was allowed to flow into well 15G11 through a fire hose at a rate of about 400 gpm while a current meter traversed the well. All the water put into the well apparent-

Table 3. Record of wells

Use of water: ES, emergency supply; IS, industrial supply; N, none; OW, observation of water level; PS, public supply
Geophysical logs: C, caliper; CM, current meter; ER, electrical-resistivity; SP,* self-potential; GR, gamma-radiation

Well numbers								Casing			Screen Settings		
Field	City	GGS	Owner	Driller	Date drilled	Altitude of land surface (ft)	Well depth (ft)	Size (in.)	From (ft)	To (ft)	Size (in.)	From (ft)	To (ft
					ALAPAHA								
20K2	2	1368	City of Alapaha	Dayton Everetts	1965	291	550	8	0	368	none	------	----
20K4	1	-------	do.	W. R. McGrew	1948 or 49	291	545	8	0	350(?)	none	------	----
					COOLIDGE								
15G6	------	-------	J. O. Pilkinton	W. R. McGrew	1942	244.6	335	6	0	212	none	------	----
15G7	2	------	City of Coolidge	C. C. Renolds	1932	252.5	383	6	0	210	none	------	----
15G11	3	925	do.	Rowe Bros.	1963	254.5	385	6	0	234	none	------	----
15G15	1	-------	do.	Unknown	1902	245	?	4	0	?	none	------	----
					FITZGERALD								
19M1	D or 4	355	City of Fitzgerald	Layne-Atlantic	1953	?	612	12	0	283	none	------	----
20M1	B or 2	-------	do.	W. R. McGrew	1925	357.8	474	10	0	220	none	------	----
								8	198	260			
20M2	A or 1	-------	do.	Unknown	1898	354.6	727	10	0	268	none	------	----
20M3	C or 3	154	do.	Layne-Atlantic	1948	359.3	750	12	0	260	none	------	----
					MONTEZUMA								
13S1	1	-------	Southern Frozen Foods Inc.	Layne-Atlantic	-------	------	584	10	0	160	-------	------	
								8	160	190	8	190	21
								8	210	230	8	230	23
								8	235	450	8	450	46
								8	465	475	-------	------	
13S32	2	-------	do.	do.	-------	------	556	10	0	170	-------	------	
								8	170	180	8	180	19
								8	190	200	8	200	21
								8	210	226	8	226	23
								8	231	430	8	430	44
								8	440	492	8	492	49
								8	497	500	8	500	51
								8	510	520			
					THOMASVILLE								
14E10	4	56	City of Thomasville	Virginia Supply & Well	1936	262	305	16	0	112	none	------	----
14E11	3	186	do.	?	1933	257	550	16	0	100(?)	none	------	----
14E12	5	-------	do.	Layne-Atlantic	1949	259	399	16	0	95	none	------	----
14E13	6	401	do.	Merrill Gray	1950	259	400	20	0	157	none	------	----
14E14	2	-------	do.	?	1917	257	505	12	0	100	none	------	----
14E15	1	-------	do.	?	Prior to 1917	258	548	6	0	------	none	------	----
14E16	------	132	do.	Layne-Atlantic	1948	258	1,635	------	------	------	none	------	----

Depth to water (ft.)	Specific capacity of well (gpm/ft)	Use of water	Geophysical Logs	Water-bearing formations	Remarks
				ALAPAHA	
216	40	PS	ER, SP, GR	Suwannee Limestone	
-----	-----	PS	-----	do.	
				COOLIDGE	
17.9	-----	N	ER, SP, GR, C	Suwannee Limestone	Well abandoned.
180.4	-----	PS	-----	do.	
182.6	-----	PS	ER, SP, GR, CM	do.	
?	-----	N	-----	?	Well destroyed.
				FITZGERALD	
160	64	PS	-----	Suwannee and Ocala Limestone	See Herrick, 1961, p. 20; driller lost circulation at 295 ft.
150	-----	PS	-----	do.	
157	-----	PS	ER, SP, GR, C, CM	do.	See Stephenson and Veatch, 1915, p. 141.
161	43	PS	-----	Suwannee and Ocala Limestone, Lisbon Formation.	See Herrick, 1961, p. 17.
				MONTEZUMA	
-----	6.8	IS	-----	-----	
-----	-----			Providence Sand	
-----	-----			do.	
-----	-----			Blufftown Formation	
-----	-----			-----	
-----	14.5	IS	-----	-----	
-----	-----			Providence Sand	
-----	-----			do.	
-----	-----			do.	
-----	-----			Cusseta Sand	
-----	-----			Blufftown Formation	
-----	-----			do.	

				THOMASVILLE	
194	1,000	PS	-----	Suwannee Limestone	
192	1,060	PS		Suwannee and Ocala Limestone	
190	-----	PS		do.	
-----	-----	PS		do.	See Herrick, 1961, p. 400.
-----	-----	ES		do.	
195	-----	OW	CR, CM	do.	
-----	-----	N		Several	Well abandoned and cemented back to an unknown depth. See Herrick, 1961, p. 398.

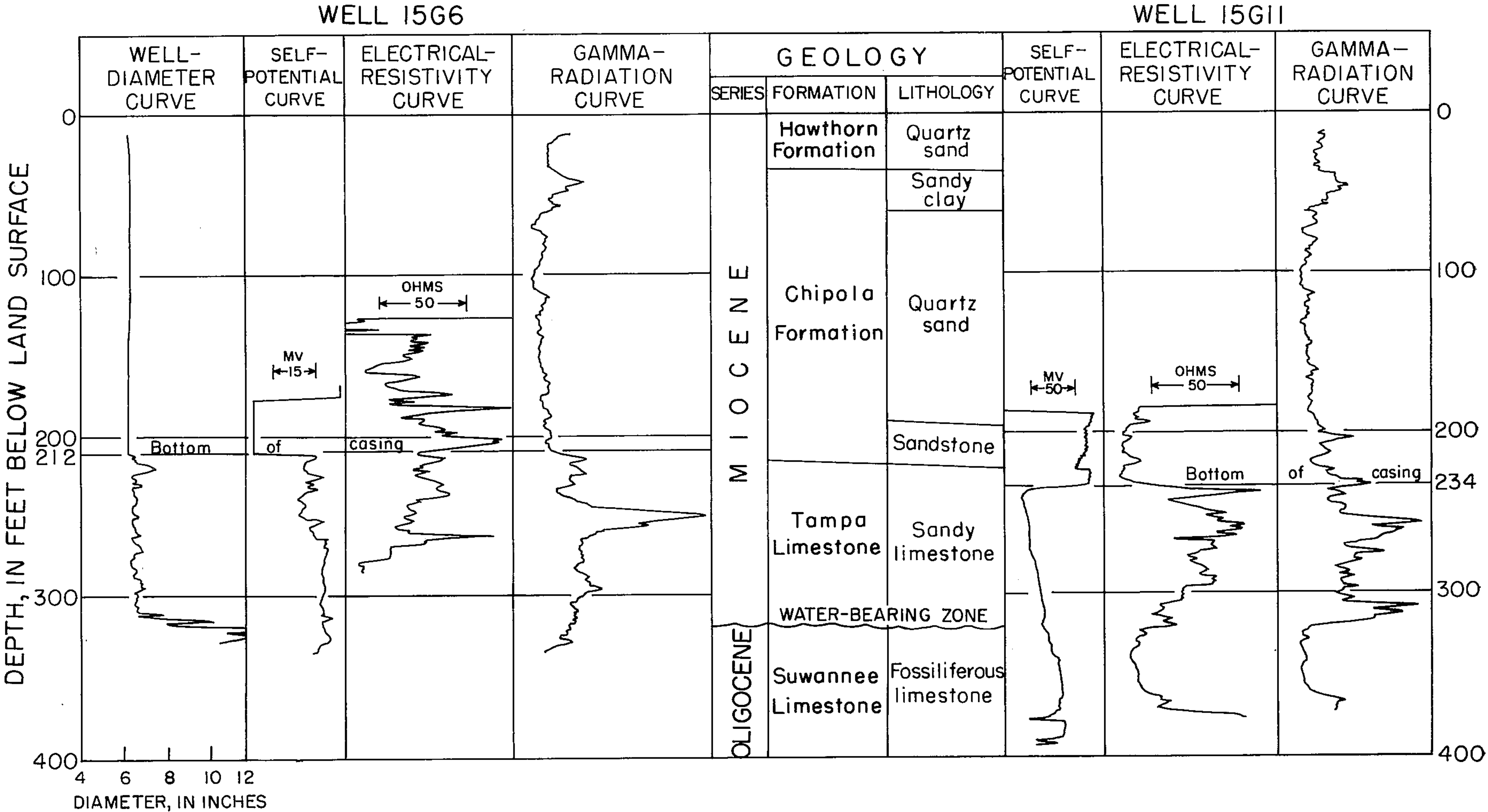

Figure 5. Geophysical logs of wells at Coolidge.

ly flowed into a thin permeable bed between 326 and 328 feet below land surface. Based upon this test, the water-bearing zone in well 15G11 is the upper few feet of the Suwannee Limestone. However, the driller reportedly lost circulation into another permeable bed at 382 feet, but the lowermost 9 feet of this well were presumably plugged with drill cuttings and the author was unable to test the well from 376 to 385 feet.

Hydraulic Properties of the Aquifer

On February 11 and 12, 1964, an aquifer performance test was made to determine the hydraulic properties of the Suwannee Limestone aquifer at Coolidge, Ga.

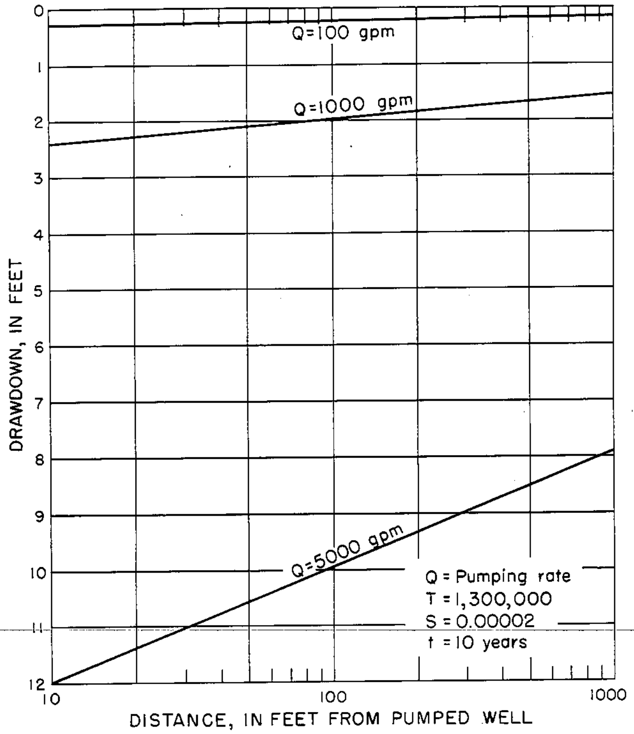

Figure 6. Theoretical water-level decline with respect to distance from a pumped well located at Coolidge, after 10 years continuous pumping at 100 gpm, 1,000 gpm, and 5,000 gpm.

During the test, well 15G7 was pumped at a rate of 165 gpm and the decline in water level was recorded in wells 15G6, 576 feet to the north, and 15G11, 65 feet to the east. (See fig. 4.) By analyzing the data obtained during this test, using the nonequilibrium formula (Ferris and others, 1962), the coefficient of transmissibility was determined to be about 1,300,000 gpd per ft. The coefficient of storage was determined to be about 0.00002.

Effects of Pumping

The amount of interference in nearby wells by a pumped well, all tapping the Suwannee Limestone at Coolidge, can be estimated using the graph in figure 6. This graph shows the decline of water levels in wells 10 feet to 1,000 feet from a well pumped continuously for 10 years at rates of 100 gpm, 1,000 gpm, or 5,000 gpm. For example, figure 6 shows that pumping a well continuously for 10 years at 5,000 gpm would cause a decline of about 10 feet in a well 100 feet away and about 8 feet in a well 1,000 feet away. With intermittent pumping, the decline should be less than that shown on figure 6.

Chemical Quality of Water

Water pumped from the municipal wells in Coolidge does not exceed the recommended maximum concentration for chemical constituents and is suitable for municipal, irrigation and many industrial uses although it is very hard (288 ppm). Much of its hardness is noncarbonate and is due to dissolved sulfate. A chemical analysis of water from well 15G7 is given in table 1.

AQUIFER PERFORMANCE TEST AT FITZGERALD, BEN HILL COUNTY, GA.

The city of Fitzgerald obtains its water supply from four deep drilled wells, three of which (20M1, 20M2, and 20M3) are located at the water works on Hooker Street (fig. 7). The fourth well (19M1) is located at the corner of Bragg and Ocmulgee Streets. Construction data for these four wells are given in table 3. Samples of the

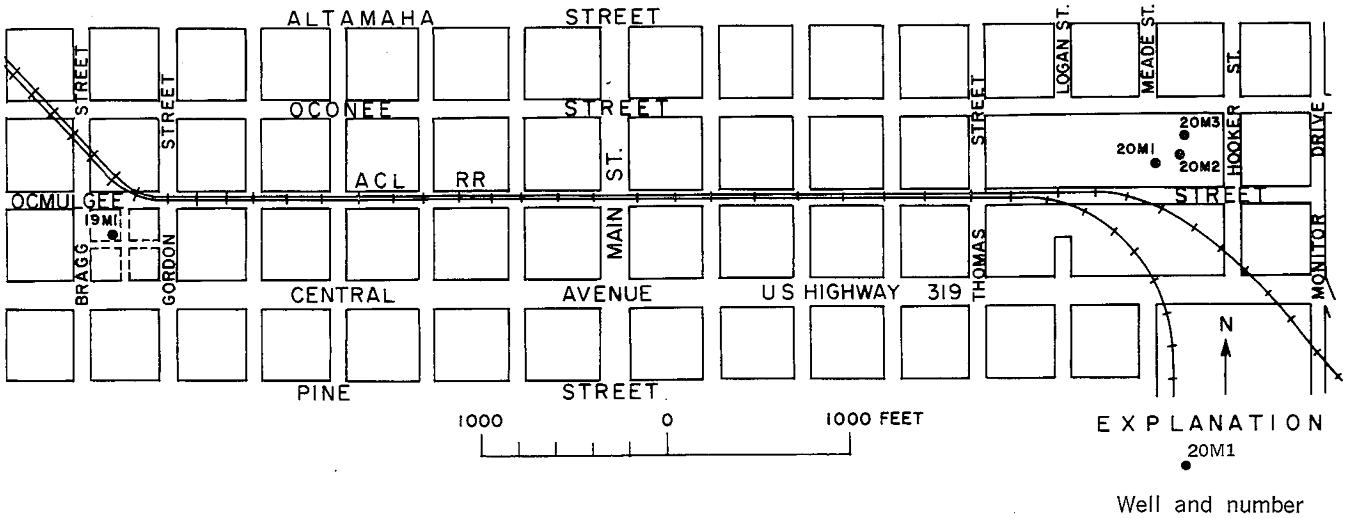

Figure 7. Fitzgerald well locations.

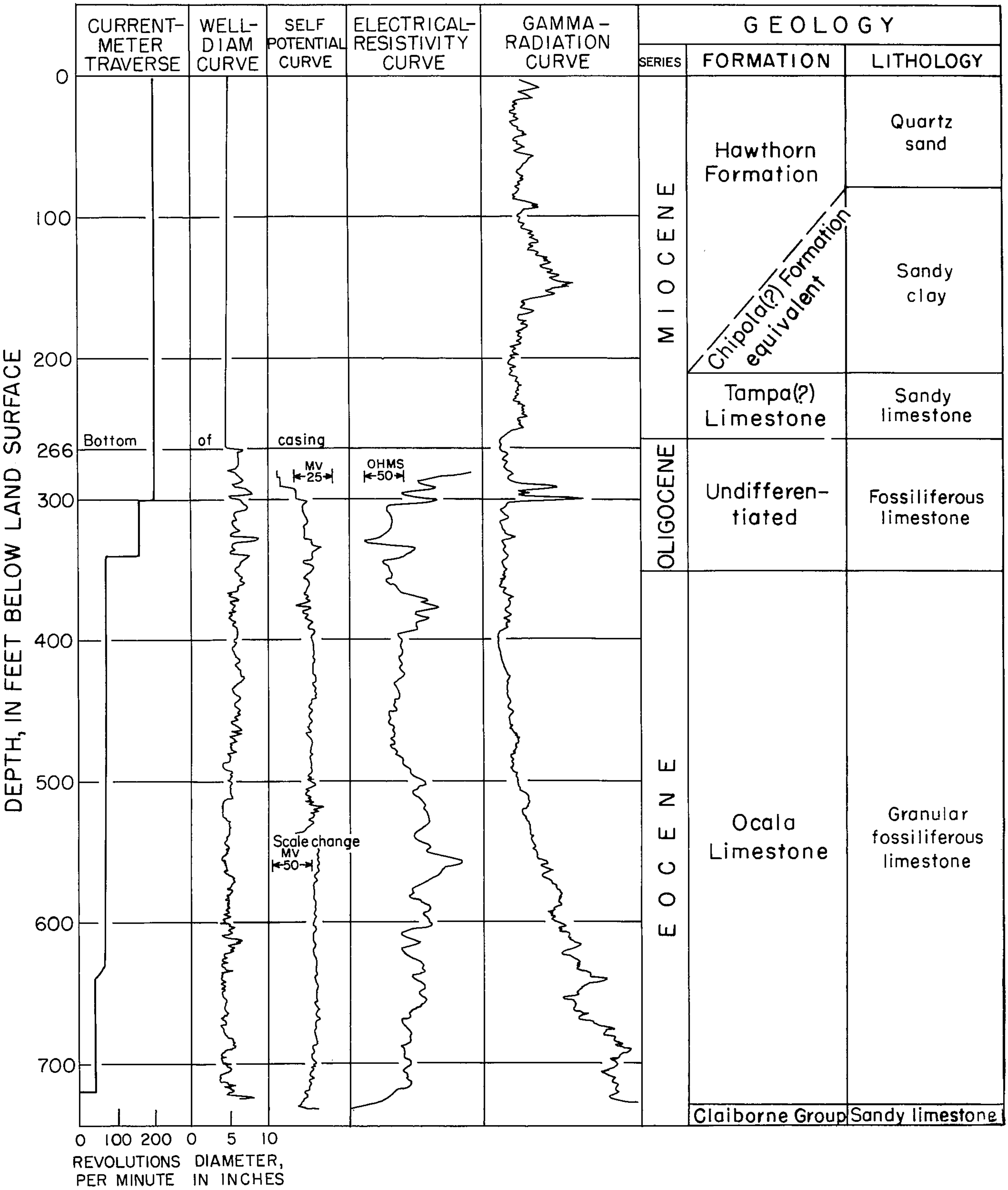

Figure 8. Geophysical logs of well 20M2 at Fitzgerald.

rocks penetrated by wells 19M1 (GGS 355) and 20M3 (GGS 154) were collected by the driller and later examined and described by S. M. Herrick (1961, p. 17-20).

During April, 1965, the pump in well 20M2 was pulled out for repairs. While the pump was out of the well, the author made electric-resistivity, self-potential, gamma-radiation, caliper, and current-meter logs of the well. These logs together with a brief summary of Herrick's descriptions of the rock samples are given on figure 8.

Current-Meter Test

On April 6, 1965, water was allowed to flow through two fire hoses at a rate of about 700 gpm into well 20M2 while a current meter traversed the well. Table 4 summarizes the data obtained by this test. Four permeable beds were located between 300 and 720 feet. The most permeable bed was at the contact between the Suwannee and Ocala Limestones at a depth of 339 to 340 feet. This bed is estimated to yield about 45 percent of the water pumped by the municipal wells at Fitzgerald and to be capable of yielding up to 3,000 gpm to a well.

Hydraulic Properties of the Aquifer

From April 1 to April 16, 1965, a water-level recorder was maintained on well 20M2 to record the drawdown and recovery of the water level in response to the intermittent pumping of wells 20M1 and 20M3 located nearby. Pumping of well 20M1 (98 feet away) at a rate of 500 gpm for 8 hours caused a decline in the water level in well 20M1 of about 5 feet. Pumping of well 20M3 (204 feet away) at a rate of 1,000 gpm for 8 hours caused a decline of about 5 feet in well 20M1.

Analysis of the data obtained on April 12, 1965, by using Theis' (1935) nonequilibrium formula shows that the coefficient of transmissibility of the aquifers tapped by these wells is about 120,000 gpd per foot and that the coefficient of storage is about 0.003.

Effects of Pumping

The amount of interference by a pumped well with nearby wells that tap the same limestones as the municipal wells at Fitzgerald can be estimated for long periods of time using the graph in figure 9. This graph shows the decline in water level at distances of 10 feet to 1,000 feet from a well pumped continuously for 10 years at 500 gpm, 1,000 gpm, or 5,000 gpm. For example, figure 9 shows that a well pumped continuously for 10 years at 1,000 gpm will cause declines about 15 feet in a well located 100 feet away and about 10 feet in a well located 1,000 feet away.

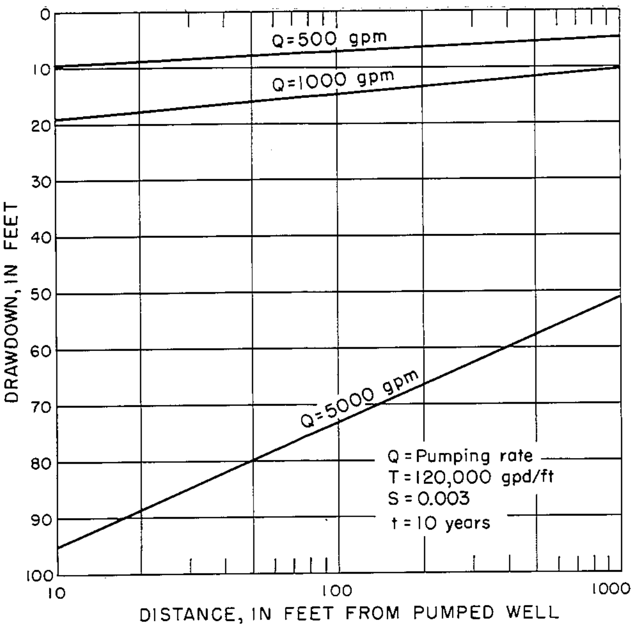

Figure 9. Theoretical water-level decline with respect to distance from a pumped well at Fitzgerald, after 10 years continuous pumping.

AQUIFER PERFORMANCE TEST AT THE WELL FIELD OF SOUTHERN FROZEN FOODS, INC., MONTEZUMA, MACON COUNTY, GA.

Southern Frozen Foods, Inc., obtains part of its water from two wells, 13S31 and 13S32, located on their property in Montezuma, Ga. and part from the city of Montezuma. The industry reportedly drilled another well during 1965.

Wells 13S31 and 13S32 were drilled by Layne-Atlantic Co. in April, 1960, and July, 1962, respectively. Construction data for these wells are summarized in table 3.

Hydraulic Properties of the Aquifers

On April 27 and 28, 1965, an aquifer performance test was made at the Southern Frozen Foods, Inc., well field to determine the hydraulic properties of the sand aquifers tapped by their wells.

During the test, well 13S31 was pumped at 525

Table 4. Location and yield of the water-bearing beds in well 20M2 at Fitzgerald.

Amount of casing (feet)	Depth to top of permeable bed (feet)	Altitude of top of bed	Thickness of bed (feet)	Estimated total well yield supplied by each bed (percent)	Estimated maximum yield of each bed[1] (gpm)
266	300	55	2	20	1,500
	339	16	1	45	3,000
	632	—277	4	15	1,000
	718	—363	2	20	1,500

[1] Maximum yield is based upon a maximum pumping level of 300 feet below land surface.

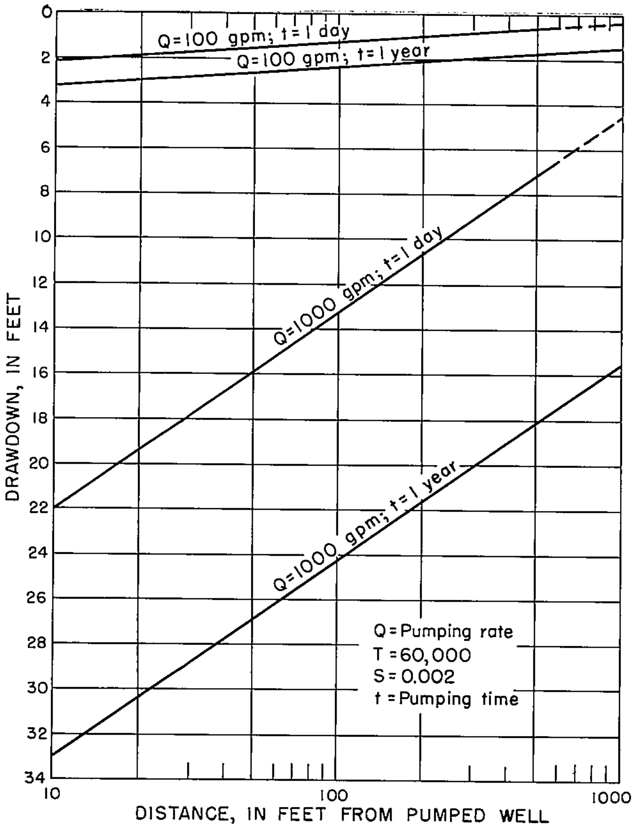

Figure 10. Theoretical water-level decline with respect to distance from a pumped well at Southern Frozen Foods, Inc., well field after one day and one year of continuous pumping at 100 gpm and 1,000 gpm.

gpm for an undetermined length of time; then the pump was stopped at 4:10 p.m. on April 27 and the water-level recovery in well 13S32, located 550 feet to the northeast, was recorded for the next 22 hours.

By analyzing the recovery curve using the modified nonequilibrium formula, the coefficient of transmissibility of the combined Providence Sand, Cusseta Sand, and Blufftown Formation aquifers was determined to be about 60,000 gpd per foot. Their coefficient of storage was determined to be about 0.002.

Effects of Pumping

The amount of interference by a pumped well with nearby wells in the Southern Frozen Foods, Inc., well field can be estimated using the graph in figure 10. This graph shows the decline in water level at distances of 10 feet to 1,000 feet from a well pumped continuously for one day and one year at pumping rates of both 100 gpm and 1,000 gpm. For example, pumping a well at 1,000 gpm for one day will cause a decline of 7 feet in the water level of a well 500 feet away. With continued pumping, the decline increases and after one year the water level in a well 500 feet away will have declined about 18 feet. With intermittent pumping, the decline should be less than that shown on figure 10.

The amount of interference by wells in the Southern Frozen Foods, Inc., well field with municipal or other wells located in the area can be

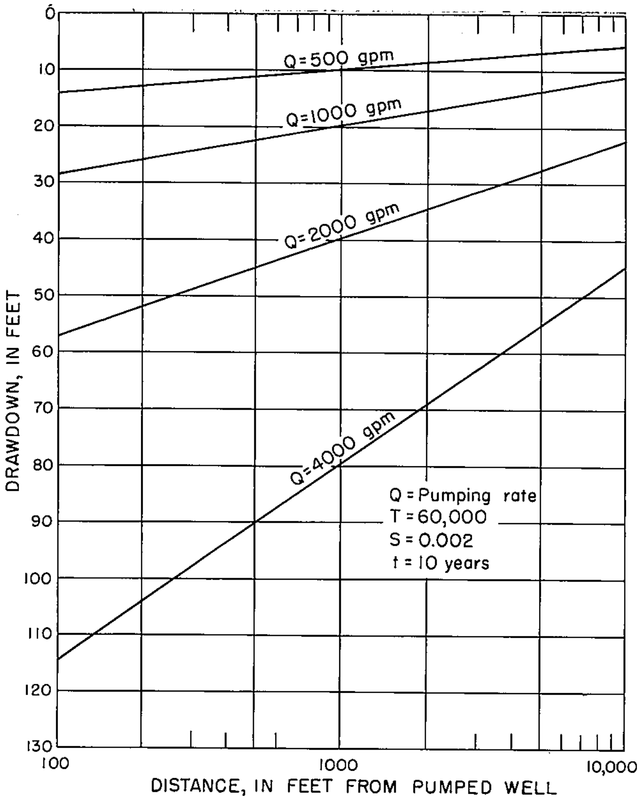

Figure 11. Graph showing theoretical water-level decline with respect to distance from a pumped well at Southern Frozen Foods, Inc., well field after 10 years continuous pumping at 500 gpm, 1,000 gpm, 2,000 gpm, and 4,000 gpm.

estimated using the graph in figure 11. This graph shows the water-level decline in wells 100 to 10,000 feet from a well continuously pumped at 500 gpm, 1,000 gpm, 2,000 gpm, and 4,000 gpm, for a period of 10 years. For example, figure 11 shows that continuous pumping for 10 years at a rate of 1,000 gpm in a well at Southern Frozen Foods, Inc., would cause a water-level decline of about 14 feet in a well 5,000 feet away. However, with intermittent or seasonal pumping the decline should be less than that shown on figure 11.

Chemical Quality of Water

Water pumped from the industrial wells at Southern Frozen Foods, Inc., is moderately hard (92 ppm) and of good chemical quality. It does not exceed the recommended maximum concentration for chemical constituents and would be suitable for municipal, irrigation, and many industrial uses. However, its fluoride (1.2 ppm) content is at the recommended maximum concentration for consumption. A chemical analysis of water from well 20M2 is given in table 1.

AQUIFER PERFORMANCE TEST AT THOMASVILLE, THOMAS COUNTY, GA.

The city of Thomasville obtains its water from 5 wells spaced 70 to 700 feet apart (fig. 12) that tap the Ocala Limestone. A continuous record of changes in water level caused by pumping of these 5 wells is being obtained from a sixth well (14E15) located within the well field. Construction data for all of the wells at the Thomasville well field are given in table 3.

Samples of the rocks penetrated by wells 14E10 (GGS 56), 14E11 (GGS 186), 14E13 (GGS 401), and 14E16 (GGS 132) were collected by the driller and later examined and described by Herrick (1961, p. 398-401) and Applin and Applin (1964, p. 212-216). A geologic summary of well 14E16 (GGS 132), a 1,635 foot deep exploratory well, follows:

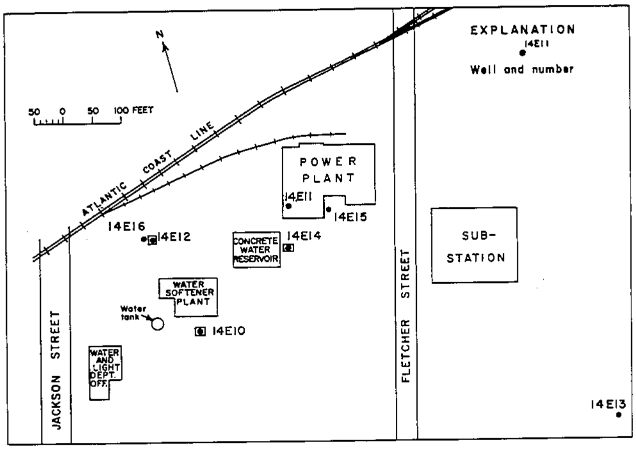

Figure 12. Thomasville well locations.

Current-Meter Test

On February 4, 1964, water was injected through two fire hoses at a rate of about 760 gpm into well 14E15 while a current meter traversed the well. All of the water appeared to flow into a 7-foot-thick permeable bed in the Ocala Limestone at a depth of 420 to 427 feet below land surface. No additional permeable beds were found in the well.

Effects of Pumping

During December, 1963, a water-level recorder was installed on well 14E15 and a record was kept of the time each pump in the municipal well field was started or stopped. Figure 13, a copy of the recorder graph of well 14E15 for December 26 to 30, 1963, shows how the water level changed in response to pumping from three of the Thomasville wells. The water level generally oscillated up and down with diminishing amplitude for about 2 minutes after a pump was started or stopped. The amount and direction of this oscillation and also the change in the watel level depended upon whether the pump was started or stopped, the pumping rate, and the distance from the observation well to the pumped well. Well 14E12 is located about 310 feet west of the observation well and was pumped at a rate of 1,170 gpm. Well 14E10 is located about 310 feet to the southwest and was pumped at a rate of 1,000 gpm. Well 14E14 is located about 95 feet to the southwest and was pumped at a rate of 500 gpm.

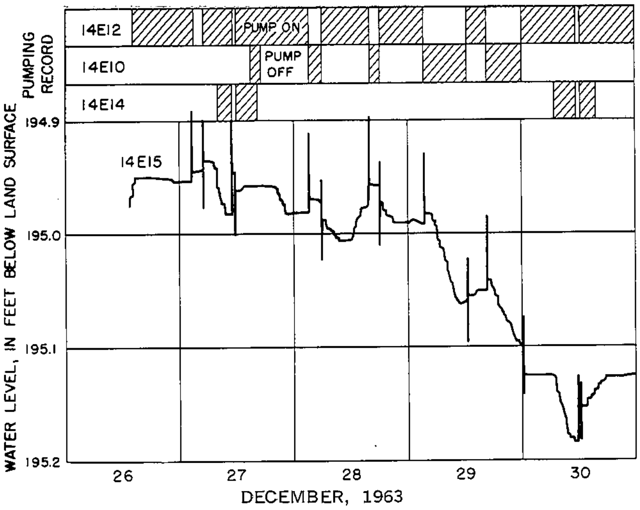

Figure 13. Response of the water level in well 14E15 to periodic pumping of wells 14E10, 14E12, and 14E14, Thomasville well field.

Hydraulic Properties of the Aquifer

The lack of development of a drawdown cone around the Thomasville well field after prolonged pumpage indicates that the aquifer tapped by the Thomasville wells is extremely permeable. This permeability probably results in part from ground-water solution of the limestone along numerous joints created during folding and faulting of the rocks in the Thomasville area (Sever, 1966).

Aquifer performance tests were made at the Thomasville well field by recording the drawdown of water levels in well 14E15 caused by pumping other municipal wells at rates of 500 gpm to 3,200

Geologic summary of well 14E16

Geologic Age	Lithology	Thickness (feet)	Depth (feet)
Pliocene to Recent (undifferentiated)	Clayey sand	35	35
Miocene (undifferentiated)	Sand and sandy limestone	135	170
Oligocene (undifferentiated)	Fossiliferous limestone	130	300
upper Eocene (Ocala Limestone)	Dolomitic limestone	725	1,025
middle Eocene (Lisbon Formation)	Glauconitic limestone	587	1,612
middle Eocene (Tallahatta Formation)	Glauconitic sand	23	1,635

gpm. Close spacing of wells, oscillation of water levels after each pump was started or stopped, intermittent pumping of nearby wells, and the short time interval between pumping cycles of municipal wells make the data obtained from the aquifer performance tests difficult to interpret. However, analyses of these data suggest that the coefficient of transmissibility of the principal artesian aquifer system at Thomasville is extremely large—possibly as large as 20 million gpd per foot. The coefficient of storage is small—probably less than 0.00001.

Chemical Quality of Water

Water from the municipal wells in Thomasville is very hard (187-210 ppm) but contains mineral concentrations that are well below the recommended limits for drinking water. The concentrations of dissolved minerals from three of the municipal wells are summarized in table 1.

Thomasville has recently built a modern water-softening plant but chemical analyses of the treated water are not presently available. However, the treated water should be much softer and lower in dissolved solids.

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