SURFICIAL AQUIFER SYSTEM IN EASTERN LEE COUNTY, FLORIDA

By D. H. Boggess and F. A. Watkins, Jr.

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SURFICIAL AQUIFER SYSTEM IN EASTERN LEE COUNTY, FLORIDA

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ABSTRACT

The surficial aquifer system in eastern Lee County consists of an upper water-bearing unit, which is generally unconfined, and a lower water-bearing unit, which is confined and is the major source tapped by most wells. The top of the lower unit, which is of primary interest in this report, ranges in depth from 40 to 60 feet below land surface in the east-central part of the county to more than 120 feet in the southern part. In the extreme southern part of the county, a middle water-bearing unit also contains water under artesian pressure.

Recharge to the lower unit occurs primarily by leakage from the overlying saturated section through the confining beds. Water levels in the lower unit fluctuate similarly to those in the upper (unconfined) unit. Ground water in the lower unit moves from areas of highest water level in the south part of Lehigh Acres, northward toward the Caloosahatchee River, and toward the coast.

The lower unit contains freshwater throughout much of its extent and is the source of public water supply at Lehigh Acres and Green Meadows where an average of about 3 million gallons per day was withdrawn in 1980. In several areas, the concentrations of chlorides and dissolved solids exceed drinking water standards.

Yields of wells that tap the lower unit range from 10 to 1,100 gallons per minute. Transmissivities ranging from about 1,700 to 7,750 feet squared per day were determined for different areas of the unit. Storage coefficients range from 0.0001 to 0.0003.

INTRODUCTION

Over the past decade, rapid urbanization of Lee County has resulted in a major increase in water demands for most purposes, particularly for municipal and domestic uses. These increased demands have been met by more intensive use of existing water-supply systems and the development of new facilities and sources of supply. The most critical problems are local overdevelopment of sources, declining water levels, and saltwater intrusion. This report presents information that can help pinpoint these and other problems of developing water supplies to meet the rapid increase in urban demands.

Purpose and Scope

The purpose of this report is to present and evaluate hydrologic and selected geologic information collected in Lee County from 1966 to 1980. Most hydrologic information relates to the surficial aquifer system in the central and eastern parts of the county where the shallow water-bearing zones are thickest and are most productive. The lower unit of the surficial aquifer system is of primary importance in this group of water-bearing zones.

Acknowledgments

The assistance of local well drillers, utility managers, and State and County agencies in providing information on wells or well fields is gratefully acknowledged. The cooperation of the residents of Lee County in furnishing information on privately owned wells or permitting testing of these wells is greatly appreciated. This investigation was a result of the cooperative efforts of the County Commission of Lee County and personnel of the South Florida Water Management District.

DESCRIPTION OF AREA

Lee County, on the southwest coast of Florida, comprises a land area of 786 mi^2 (fig. 1). This investigation covers the central and eastern three-fourths of the county.

Land altitudes in the area range from a few feet above sea level along the Caloosahatchee River and the Gulf of Mexico to about 25 feet along the Lee County-Charlotte County boundary and 35 feet along State Highway 82 near the Lee County-Hendry County boundary.

The Caloosahatchee River is the principal drainage for the northern part of the study area. Small south-trending tributaries discharge into the river on the north side (fig. 2). Primary tributaries on the south are the Orange River, Hickey Creek, and Bedman Creek. The Orange River connects inland with several canals in the Lehigh Acres area that are designed to reduce flooding in that area, and joins the Caloosahatchee River 7 miles downstream from Franklin Lock. The Orange River is influenced by the tidal fluctuation in the Caloosahatchee River. Bedman Creek connects with the east termini of the Lehigh Acres Canal system by way of Dog Canal and joins the Caloosahatchee River at Alva more than 6 miles upstream of Franklin Lock where a freshwater head of 2.5 to 3.5 feet above sea level is maintained.

A prime function of the Caloosahatchee River is the regulation of the water level in Lake Okeechobee several miles upstream. Therefore, the river receives large volumes of freshwater from the lake seasonally. Another important function of the river is to supply drinking water to Fort Myers and parts of Lee County by pipelines whose intakes are upstream of Franklin Lock. The river is also being considered as a source of municipal supply for the City of La Belle in Hendry County. Large quantities of water are withdrawn from the river for irrigation of citrus and other crops (La Rose and McPherson, 1980).

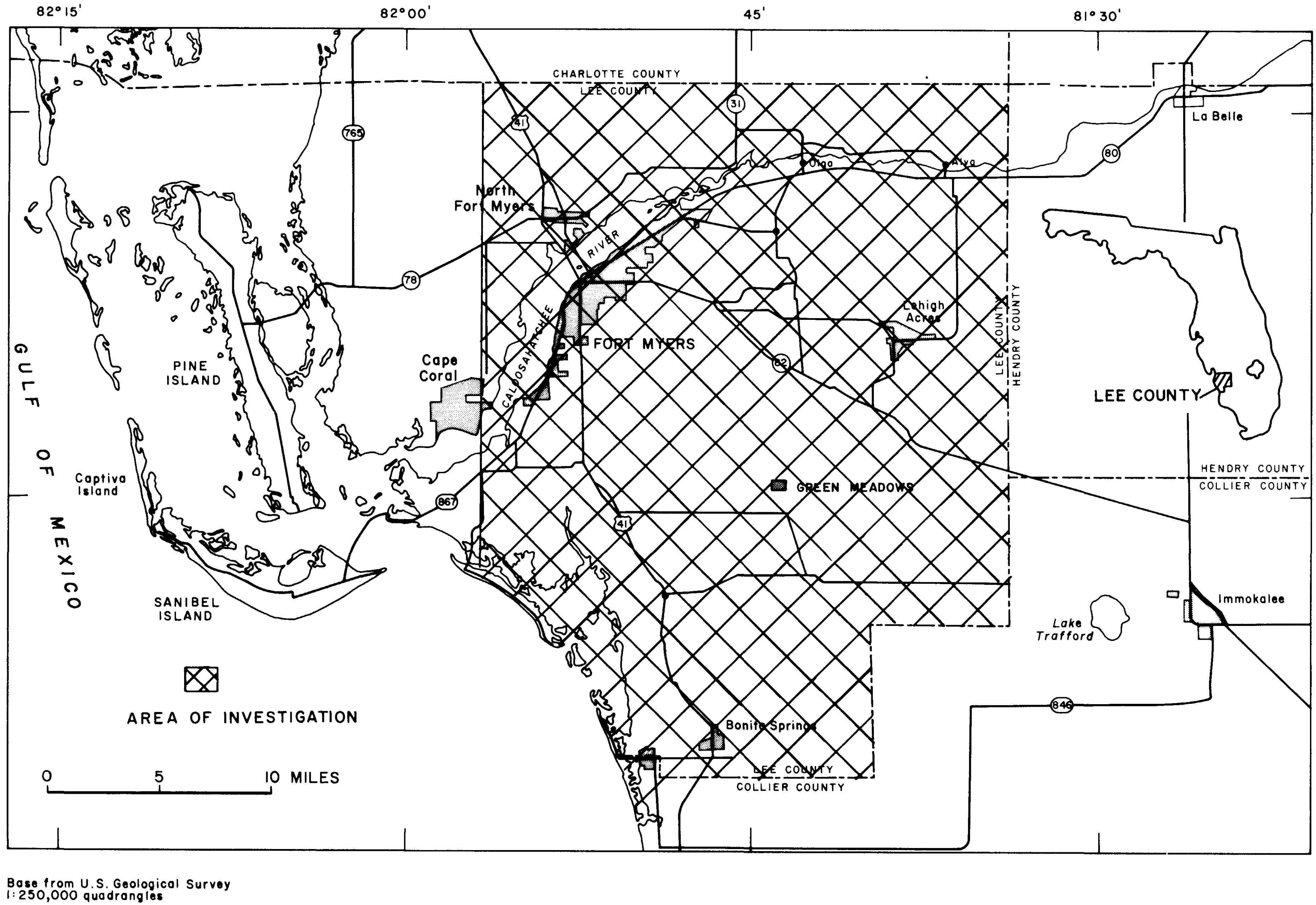
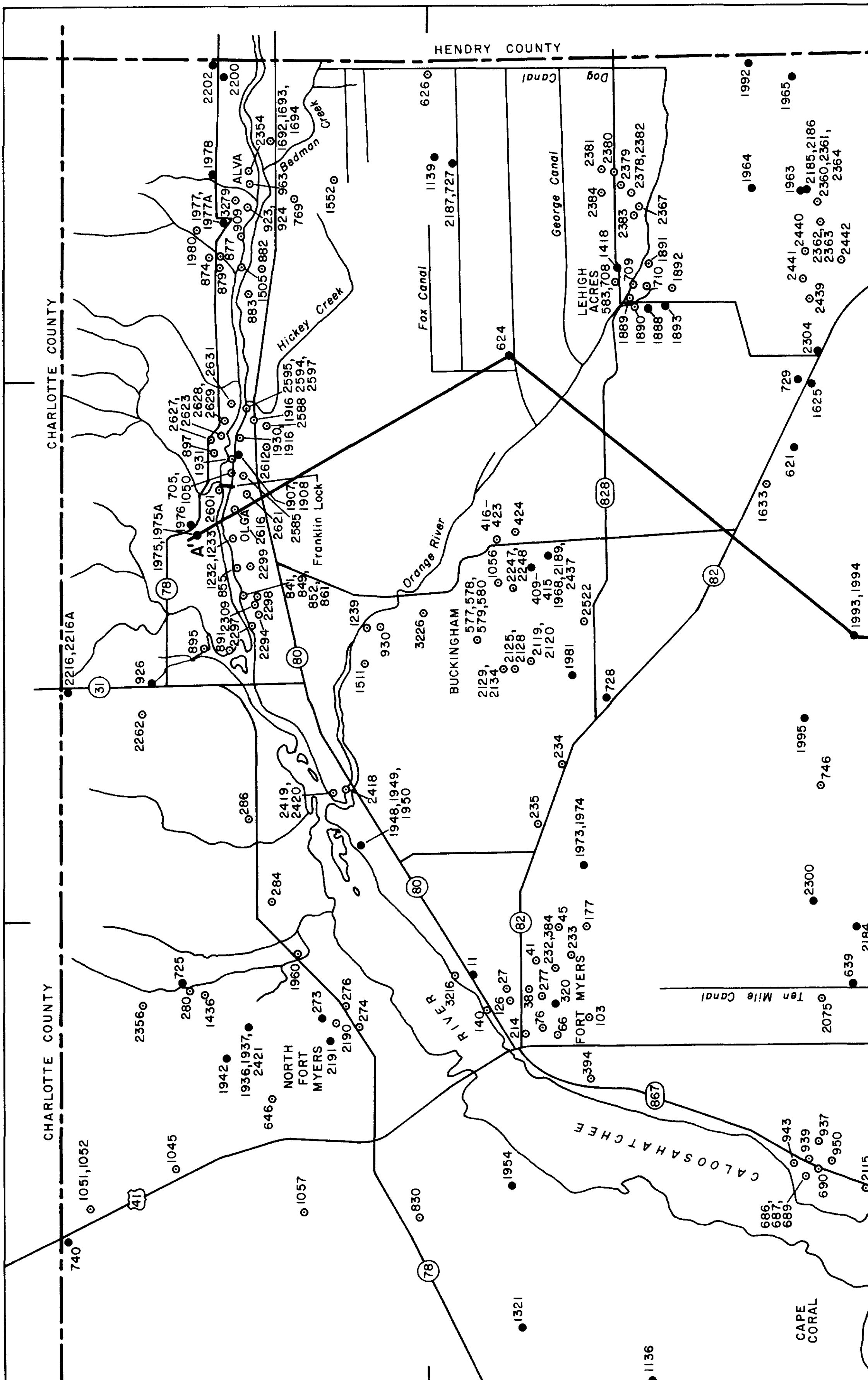


Figure 1.--Lee County showing area of investigation.


HENDRY COUNTY
CHARLOTTE COUNTY
CHARLOTTE COUNTY
81°40'
81°50'
26°40'
ALVA
OLGA
BUCKINGHAM
LEHIGH ACRES
FORT MYERS
NORTH FORT MYERS
CAPE CORAL
Bedman Creek
Hickey Creek
Orange River
Franklin Lock
Fox Canal
George Canal
Dog Canal
Ten Mile Canal
CALOOSAHATCHEE RIVER
A'

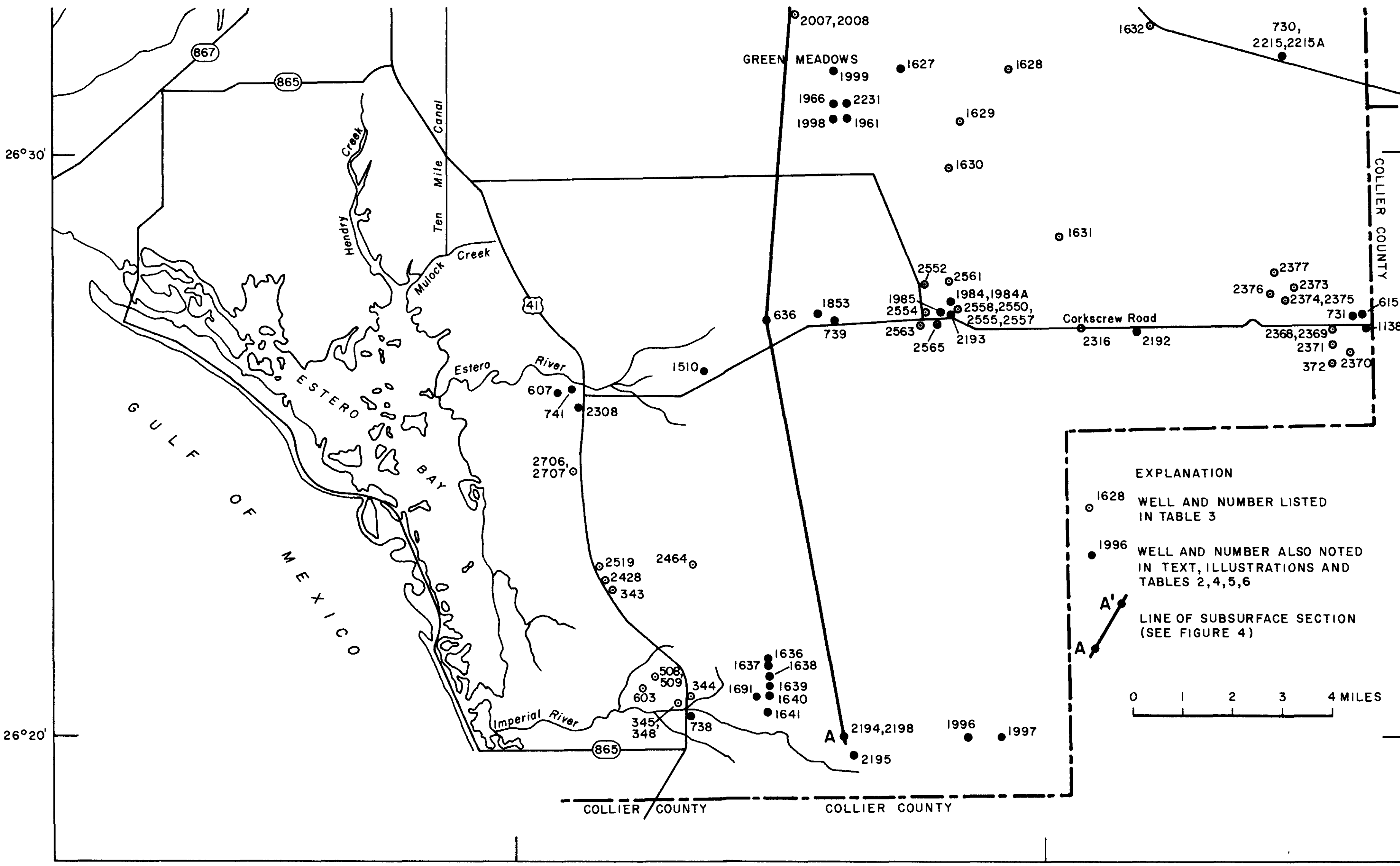


Figure 2.--Eastern part of Lee County showing the location of wells and the subsurface section.

Most of the area south of Florida Highway 82 drains sluggishly southwest toward the Gulf Coast and the Caloosahatchee River estuary. The principal drainage routes near the coast are the Tenmile Canal, the Imperial River, the Estero River, and Hendry Creek. The Tenmile Canal tends to reduce problems of high water in the urban area west of the canal.

The climate of Lee County is subtropical. Monthly average temperatures range from 18°C in January to 28°C in August with an annual average temperature of 23°C. Rainfall is unevenly distributed throughout the year as shown in figure 3 and in table 1. For the period of record 1971-80, about 75 percent of the average annual rainfall of 52 inches occurred during May through September. Thus, a well-defined wet and dry season occurs (fig. 3). This uneven distribution affects the hydrology of the area and causes problems in satisfying increasing water demands. Problems are usually during dry seasons when pumping or water-storage facilities are overtaxed, or canal-water salinity near the the water intake areas in the Caloosahatchee River exceeds State drinking water standards.

WELL INVENTORY

The investigation in general consisted of an inventory of selected privately owned wells and analysis of information on previously drilled test holes. Concurrently with the investigation, additional test holes were drilled, and geophysical logs were obtained. Data from the inventory and information and observations obtained during test drilling were used to define the overall framework of the body of sediments that potentially can yield freshwater and to delineate the principal water-yielding units within those sediments. Many test holes were converted to observation wells by the installation of casings and well screens at sites where the water-yielding zones were composed of unconsolidated materials. Therefore, the depth of the well as completed with casing and screen may not correspond with the total depth that a specific test hole was drilled. The observation wells were then pumped to determine the approximate yield of each site, and water samples were collected for chemical analysis. Wells installed during the investigation and several privately owned wells were used to obtain measurements of ground-water levels. Selected wells were equipped with water-level recording gages and others were measured with a steel tape, usually at monthly intervals.

The well numbers given in table 2 (at the end of report) are part of a countywide system. As an example of assigned numbers, well L-345 is also well 262034081464801; the L refers to Lee County. The identification number is based on the latitude and longitude grid. The first six digits are the latitude, the next seven digits are the longitude, and the last two are a sequence number for wells within the 1-second grid.

Construction data, water-level measurements, well yields, and data for water temperature and chloride concentration for selected wells tapping the surficial aquifer system are given in table 2 (see fig. 2 for well location). Most privately owned wells are 2 to 4 inches in diameter and are less than

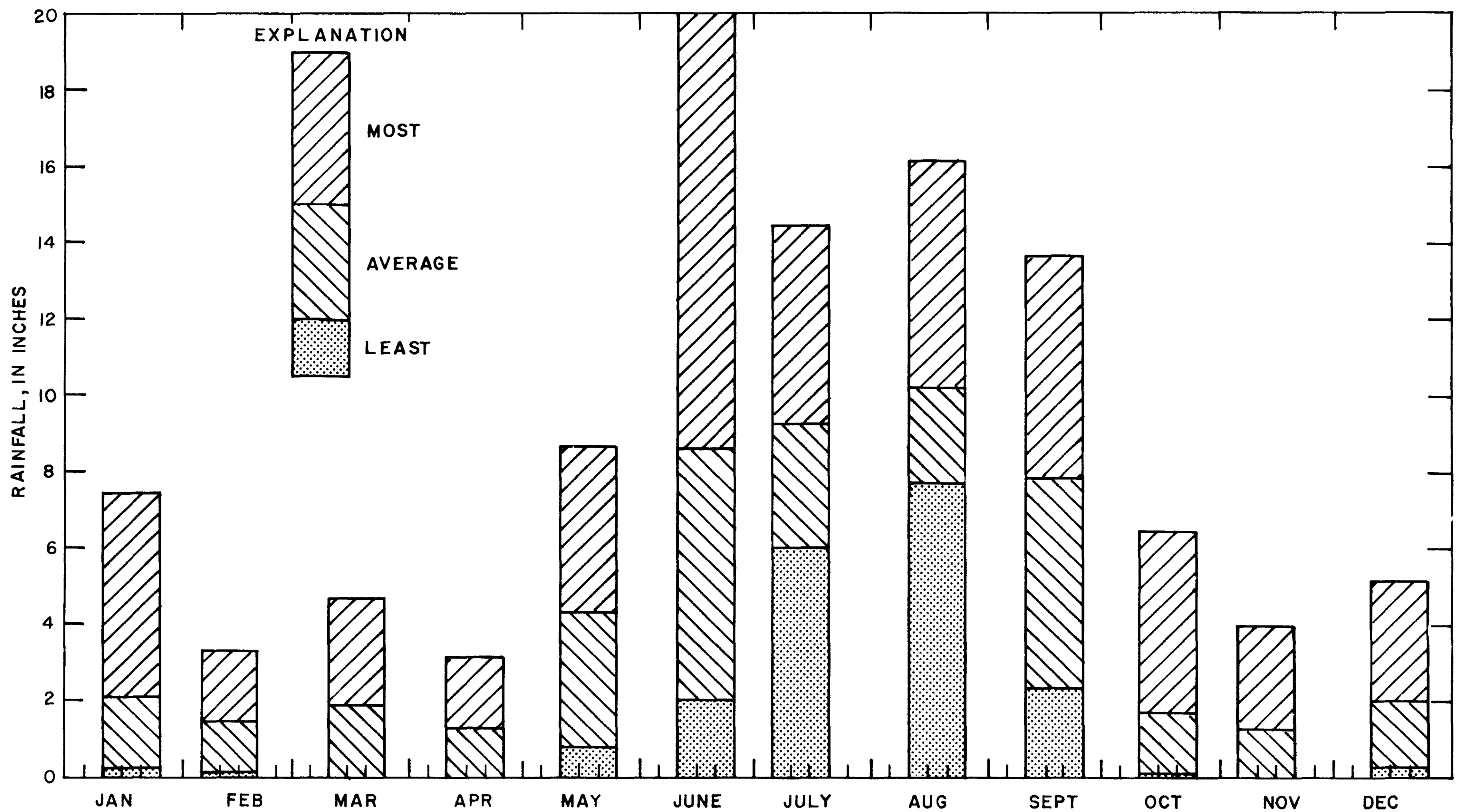


Figure 3.--Rainfall at Fort Myers, 1971-80.

Table 1.--Rainfall at Page Field near Fort Myers, 1971-80

[Rainfall in inches]

Month	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Average
January	0.85	0.77	3.14	0.36	0.26	0.21	3.53	2.48	7.45	2.44	2.15
February	1.55	2.14	2.23	.81	.27	1.20	.15	3.36	1.94	1.04	1.47
March	.55	4.72	3.89	.03	1.47	.91	.09	3.43	.43	3.59	1.91
April	.70	.27	1.71	.11	.80	.90	.76	2.35	3.12	1.52	1.22
May	3.77	5.20	.78	2.40	2.78	5.22	6.51	2.52	5.32	8.73	4.32
June	6.18	7.86	3.99	20.10	10.55	10.59	8.96	6.75	8.31	1.99	8.53
July	9.50	9.72	9.57	14.47	10.81	6.14	9.60	10.29	5.96	7.02	9.31
August	8.06	16.22	8.66	7.70	7.74	8.95	10.58	10.90	14.79	8.79	10.24
September	9.21	2.33	8.38	4.31	12.60	8.81	9.21	5.18	13.65	4.64	7.83
October	6.49	2.20	.16	.19	3.05	1.96	.43	1.45	.39	1.54	1.79
November	.16	3.85	.10	1.46	.49	2.10	1.50	.04	.46	3.15	1.33
December	.30	1.43	1.72	.89	.69	1.68	2.74	4.35	5.16	.55	1.95
Total	47.32	56.71	44.33	52.83	51.51	48.67	54.06	53.10	66.98	45.00	52.05

200 feet in depth. Few wells are screened, although the permeable sections may contain loose sand. Major concentrations of wells are along the Caloosahatchee River. Most large diameter wells (6 to 16 inches) are used for public supply or for crop and golf course irrigation. These large wells are concentrated in Lehigh Acres, at several locations along Corkscrew Road, and at the former U.S. Air Force base near Buckingham, east of Fort Myers. Large diameter wells furnish the municipal supply for Bonita Springs.

During the investigation, 38 wells were drilled to obtain further geologic and hydrologic data. Because of problems caused by caving sand in the water-bearing zones, well screens were used in the construction and completion of 21 of these wells. Most wells were completed with 4-inch diameter PVC (polyvinyl chloride) casing and PVC screens. Sizes of screen slots ranged from 0.012 to 0.030 inch. The length of each screen was 10 feet. Sections of blank casings were used between well screens in some wells to seal off borehole intervals of low or no yield.

COMPOSITION OF SHALLOW SEDIMENTS

The Hawthorn Formation of middle Miocene age consists of gray-white, sandy, phosphatic limestone in central and western Lee County and underlies the Tamiami Formation. The formation dips east and grades laterally from limestone in the west to marl in the east. In test well L-639, south of Fort Myers (location in fig. 2), the top of the Hawthorn Formation occurs at a depth of 133 feet; in well L-615, 20 miles to the southeast, the top of the Hawthorn Formation probably occurs more than 360 feet below the surface. The top of the Hawthorn Formation is even deeper in the southern part of Lee County; in well L-2194, 3 miles east of Bonita Springs, the top is 480 feet below land surface.

According to Peck (1976, p. 82), the Tamiami Formation ranges in age from middle Pliocene to late Miocene and is unconformable beneath the surficial Pliocene-Pleistocene deposits. The Tamiami Formation consists of variable lithologies, resulting from changes in depositional environments. Selected well logs are given in table 3.

In the central and northern parts of the study area, the upper part of the Tamiami Formation is predominantly gray or green clay, as shown in logs for wells L-1973, L-1975, and L-1993 (table 3). The clay is underlain by quartz sand, gray sandstone and, locally, by tan limestone. The lower part of the formation commonly consists of gray clay, containing quartz sand and phosphatic material. Large quantities of black phosphatic material usually occur in the lowermost part of the formation, apparently derived from the erosion of sediments of the older Hawthorn Formation.

In the southern part of the study area, the uppermost part of the Tamiami Formation consists predominantly of gray limestone or calcareous sandstone, as shown in the logs of wells L-615, L-636, and L-2194 (table 3; locations in fig. 2). This shallow unit is younger than and overlies most of the sediments of the Tamiami Formation, as described in wells in the central and northern parts of the county. For example, in well L-624 in Lehigh Acres (fig. 2), a

Table 3.--Lithologic logs for selected wells and test holes in Lee County

Description	Depth interval (ft)	Thickness (ft)
Well L-615, southeast corner of Lee County		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, medium, brown (iron stained).	0-15	15
Limestone, gray, sandy and sandstone.	15-30	15
Tamiami Formation		
Limestone, gray; few shells.	30-45	15
Limestone, gray; abundant shell fragments.	45-75	30
Limestone, gray, sandy; shell fragments.	75-90	15
Limestone, gray-tan.	90-135	45
Limestone, light-gray, sandy, marly.	135-175	40
Clay, green.	175-220	45
Sandstone, gray, calcareous.	220-240	20
Sandstone, gray-tan, calcareous.	240-255	15
Sandstone as above; shell fragments, sand and quartz gravel.	255-270	15
Sandstone and green clay.	270-285	15
Sand, fine, tan.	285-300	15
Clay, gray; limestone fragments.	300-350	50
Clay, gray.	350-360	10
Surficial aquifer system	0-285	
Upper and middle units (undifferentiated)	0-175	
Lower unit	220-285	
Well L-624, Lehigh Acres		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, dark-brown, clayey.	0-10	10
Limestone, creamy-tan.	10-20	10
Limestone; clay, gray.	20-30	10
Tamiami Formation		
Clay, green.	30-45	15
Clay, green, sandy.	45-60	15
Sandstone, gray, calcareous.	60-75	15
Sandstone as above; large shell fragments.	75-105	30
Limestone, tan; shell casts and molds.	105-120	15
Clay, gray.	120-180	60
Clay, green-gray, sandy.	180-195	19
Clay, dark-gray, sandy, phosphatic.	195-235	40

Table 3.--Lithologic logs for selected wells and test holes in Lee County--Continued

Description	Depth interval (ft)	Thickness (ft)
Well L-624, Lehigh Acres--Continued		
Hawthorn Formation		
Limestone, gray, phosphatic; clay, gray.	235-270	35
Limestone, gray-white, phosphatic, sandy.	270-300	30
Limestone, gray, phosphatic.	300-315	15
Limestone; clay, green.	315-330	15
Limestone, white, phosphatic, marly.	330-345	15
Limestone, gray-white.	345-360	15
Limestone as above; marl, gray-white.	360-390	30
Clay, gray, phosphatic.	390-435	45
Limestone, light-gray-tan.	435-450	15
Clay, gray.	450-480	30
Clay, gray-tan.	480-495	15
Surficial aquifer system	0-120	
Upper unit	0-30	
Middle unit	Missing	
Lower unit	60-120	
Well L-636, Corkscrew Road		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, fine, brown (iron stained).	0-10	10
Tamiami Formation		
Limestone, creamy-tan.	10-35	25
Clay, gray; shells.	35-40	15
Clay, green.	40-100	60
Sandstone, gray, calcareous.	100-140	40
Clay, gray, sandy.	140-160	20
Clay, gray-white.	160-180	20
Clay, gray, phosphatic; shells and phosphate gravel.	180-220	40
Clay, dark gray, sandy, phosphatic.	220-240	20
Hawthorn Formation		
Limestone, gray-white, phosphatic.	240-260	20
Surficial aquifer system	0-140	
Upper unit	0-35	
Middle unit	Missing	
Lower unit	100-140	

Table 3.--Lithologic logs for selected wells and test holes in Lee County--Continued

Description	Depth interval (ft)	Thickness (ft)
Well L-639, south of Fort Myers		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, fine, tan.	0-7	7
Limestone, gray.	7-15	8
Marl, creamy-tan; shell fragments and phosphate.	15-30	15
Tamiami Formation		
Clay, gray.	30-45	15
Clay, green.	45-75	30
Sandstone, gray, calcareous; shell fragments.	75-110	35
Clay, gray, sandy, phosphatic; phosphate gravel.	110-125	15
Clay, dark-gray, sandy, very phosphatic.	125-133	8
Hawthorn Formation		
Limestone, gray-white, phosphatic; shell fragments.	133-165	32
Limestone as above; marl.	165-180	15
Limestone, gray-white, phosphatic.	180-210	30
Surficial aquifer system	0-110	
Upper unit	0-15	
Middle unit	Missing	
Lower unit	75-110	
Well L-1965, southeast of Lehigh Acres, near county boundary		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, fine, brown (iron stained).	0-6	6
Limestone, creamy-tan.	6-17	11
Marl, creamy-tan, sandy.	17-33	16
Tamiami Formation		
Clay, gray, phosphatic.	33-43	10
Clay, green, phosphatic.	43-48	5
Sandstone, light-gray, calcareous.	48-63	15
Sandstone and interbedded sand, phosphatic.	63-73	10
Sand, medium, gray; gravel and shell fragments.	73-81	8
Clay, green.	81-83	2
Sand, fine to medium, gray-green, clayey.	83-103	20
Sand, fine to medium, gray-green, clayey; frosted quartz gravel and phosphate gravel.	103-123	20

Table 3.--Lithologic logs for selected wells and test holes in Lee County--Continued

Description	Depth interval (ft)	Thickness (ft)
Well L-1965, southeast of Lehigh Acres, near county boundary--Continued		
Tamiami Formation--Continued		
Clay, green.	123-125	2
Sandstone, gray, calcareous.	125-137	12
Clay, green.	137-143	6
Sand, fine, gray-green, clayey.	143-153	10
Limestone, tan; shell casts and molds.	153-183	30
Limestone, light-gray.	183-186	3
Clay, gray.	186-203	17
Surficial aquifer system	0-186	
Upper unit	0-17	
Middle unit	48-81	
Lower unit	125-186	
Well L-1973, east of Fort Myers		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, quartz, shelly.	0-12	12
Limestone, marly, phosphatic; shell fragments.	12-31	19
Tamiami Formation		
Clay, gray, sandy, shelly.	31-45	14
Clay, gray-green, sandy.	45-50	5
Clay, green, sandy.	50-82	32
Sandstone, gray, calcareous, phosphatic.	82-95	13
Sandstone, gray, clayey.	95-100	5
Sand, fine, gray, clayey.	100-113	13
Sandstone, gray; sand, fine; phosphatic.	113-125	12
Limestone, gray, marly.	125-139	14
Clay, dark-gray, very phosphatic, sandy.	139-145	6
Clay, dark-gray, very phosphatic.	145-168	23
Hawthorn Formation		
Limestone, gray-white, phosphatic.	168-175	7
Limestone, shelly, sandy, phosphatic.	175-185	10
Limestone, shelly, phosphatic; clay, yellow.	185-195	10
Marl and limestone, phosphatic, shelly.	195-205	10
Marl, shelly, phosphatic, sandy.	205-225	20
Surficial aquifer system	0-125	
Upper unit	0-31	
Middle unit	Missing	
Lower unit	82-125	

Table 3.--Lithologic logs for selected wells and test holes in Lee County--Continued

Description	Depth interval (ft)	Thickness (ft)
Well L-1975, north of Olga		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, quartz.	0-10	10
Limestone, white, shelly; limestone, tan.	10-17	7
Limestone, white, slightly clayey.	17-20	3
Tamiami Formation		
Clay, gray.	20-32	12
Clay, dark-green, highly phosphatic.	32-41	9
Clay, green, shelly.	41-57	16
Limestone, gray, phosphatic.	57-60	3
Clay, green.	60-100	40
Sandstone, gray, calcareous.	100-106	6
Sandstone, gray; sand; frosted quartz and phosphate pebbles; clayey.	106-113	7
Limestone, tan; shell casts and molds.	113-122	9
Limestone, light-tan, slightly phosphatic.	122-141	19
Clay, light-gray.	141-158	17
Limestone, light-gray, marly.	158-188	30
Clay, gray, phosphatic, sandy.	188-198	10
Clay, dark-gray, phosphatic, sandy.	198-250	52
Hawthorn Formation		
Marl, light-gray, phosphatic, sandy; shell fragments.	250-265	15
Surficial aquifer system	0-141	
Upper unit	0-20	
Middle unit	Missing	
Lower unit	100-141	
L-1993, north of Green Meadows		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, fine, light-tan.	0-13	13
Sand, fine, brown (iron stained).	13-17	4
Limestone, creamy-tan.	17-23	6
Marl, creamy-tan.	23-34	11
Tamiami Formation		
Clay, gray, shelly.	34-37	3
Clay, green.	37-43	6

Table 3.--Lithologic logs for selected wells and test holes in Lee County--Continued

Description	Depth interval (ft)	Thickness (ft)
L-1993, north of Green Meadows--Continued		
Tamiami Formation--Continued		
Clay, dark-green.	43-63	20
Clay, green.	63-71	8
Sand, fine to medium, clayey.	71-79	8
Sandstone, gray, calcareous.	79-93	14
Sand, fine to medium, gray; sandstone, gray.	93-114	21
Clay, gray, sandy.	114-130	16
Limestone, light-tan, marly.	130-134	4
Limestone, light-gray, slightly porous.	134-150	16
Clay, gray, phosphatic, sandy.	150-163	13
Clay, dark-gray, very phosphatic, sandy; shark teeth.	163-190	27
Hawthorn Formation		
Limestone, gray-white, phosphatic; shell fragments.	190-199	9
Clay, light-gray; shell fragments.	199-203	4
Limestone, light-gray, sandy, phosphatic; clay, light-gray.	203-243	40
Surficial aquifer system	0-150	
Upper unit	0-23	
Middle unit	Missing	
Lower unit	71-150	
Well L-2194, east of Bonita Springs		
Holocene, Pleistocene, Pliocene sediments, undifferentiated		
Sand, fine, light-gray.	0-3	3
Sand, fine, brown.	3-7	4
Sand, fine, light-brown.	7-9	2
Limestone, gray, sandy.	9-12	3
Limestone, gray; 1.5-foot cavity at 13 feet.	12-20	8
Limestone, gray; shell fragments.	20-32	12
Tamiami Formation		
Clay, light-green to dark-green toward base.	32-50	18
Limestone, light-gray, slightly sandy.	50-70	20
Limestone, light-gray; marly near base.	70-100	30
Limestone, light-gray and tan, phosphatic.	100-110	10

Table 3.--Lithologic logs for selected wells and test holes in Lee County--Continued

Description	Depth interval (ft)	Thickness (ft)
Well L-2194, east of Bonita Springs--Continued		
Tamiami Formation--Continued		
Sandstone, gray, calcareous.	110-130	20
Clay, olive, sandy; shell fragments.	130-145	15
Sandstone, light-gray, shelly.	145-180	35
Clay, gray, very sandy; shell fragments.	180-230	50
Limestone, tan; shell casts and molds.	230-300	70
Clay, gray, sandy.	300-305	5
Clay, gray, mixed with clay, light-green, slightly sandy.	305-355	50
Clay, light- to dark-green, phosphatic.	355-370	15
Clay, dark-gray-green, phosphatic, sandy.	370-380	10
Clay, dark-gray-green, phosphatic, sandy.	380-400	20
Clay, gray, slightly phosphatic; less sand than above.	400-450	50
Clay, dark-gray, sandy, phosphatic.	450-480	30
Hawthorn Formation		
Limestone, gray-white, phosphatic; limestone, marly at 515 to 520 feet.	480-535	55
Surficial aquifer system	0-300	
Upper unit	0-32	
Middle unit	50-130	
Lower unit	145-300	

gray sandstone in the Tamiami Formation occurs from 60 to 105 feet below land surface. About 15 miles to the southeast, in well L-615 near the Collier County boundary, this sandstone occurs 220 to 270 feet below land surface. The surficial deposits consist predominantly of fine- to medium-grained quartz sand and shell and variable quantities of clay and marl. These sandy terrace deposits--primarily Pamlico Sand of Pleistocene age--locally contain thin layers of sandstone. The underlying Fort Thompson Formation (Pleistocene) and the Caloosahatchee Marl (Pleistocene-Pliocene) contain mixed lithologies that include limestone, shell, marl, and quartz sand.

DESCRIPTION OF THE SURFICIAL AQUIFER SYSTEM[1/]

The area of investigation in Lee County and adjoining areas of Collier and Hendry Counties are underlain by a surficial aquifer system (fig. 4), which occurs within the upper 300 to 350 feet of sediments. The base of the surficial aquifer system is marked by a widespread, relatively thick, confining unit of clay, marl, and sandy clay that constitutes the upper part of the intermediate aquifer system. The surficial aquifer system extends from land surface to a depth of about 150 feet in the northern part of Lee County to as much as 350 feet in the southern part. It is thickest in the eastern and southern parts of the county and thins to the west where it contains increasing quantities of silt and fine-grained sand of low permeability.

The surficial aquifer system generally comprises two, but in places three, distinct water-yielding units which are separated by sediments of low permeability. The sediments of low permeability do not prevent, but rather they retard the circulation of ground water between the permeable units. The water producing zones within the surficial aquifer system are herein referred to as: (1) the upper unit; (2) the middle unit, which is only local in extent; and (3) the lower unit.

Below the thick confining unit, the Hawthorn Formation contains a water-yielding limestone at the top of the formation, and within the intermediate aquifer system. Little is known of the hydraulic characteristics of the limestone of the intermediate aquifer system or the water that it might yield in the area of investigation.

Upper Unit

The upper unit of the surficial aquifer system, which covers most of the study area, generally ranges in thickness from 10 to 40 feet. In the northeastern part of the county, between Alva and Lehigh Acres, the unit contains increasing quantities of clay and fine-grained sand and loses its identity. In much of the southeastern part of the county, the upper unit generally forms a continuous vertical section of permeable material to blend with the middle unit. Fine and medium-grained quartz sand is the main component, but thick discontinuous layers or lenses of hard permeable limestone occur locally. The permeable surface materials permit rapid infiltration of rainfall to the water table. The unit is tapped by a few shallow sandpoint or screened wells for small residential supplies.

[1/] Deliberations among hydrogeologists active in southwest Florida that have occurred since this report was prepared and approved by the Director of the Geological Survey have resulted in placement of the regional base of the surficial aquifer system higher in the hydrogeologic section than shown in this report. Regionally, the base of the surficial aquifer system in southwest Florida is considered to be at the first areally persistent clay layer, which is commonly green and similar in lithology to the deeper lying clays of the Hawthorn Formation. In the Lee County area, the first clay is thin and affords seeming hydrologic continuity between the water table and the "sandstone aquifer," as evidenced by the similar configuration of the potentiometric surface of the "sandstone aquifer" with that of the water table. Therefore, on the basis of local data, this report regards the "sandstone aquifer" as part of the surficial aquifer system rather than as part of the intermediate aquifer system, which is the consensus recently arrived at based on regional considerations.

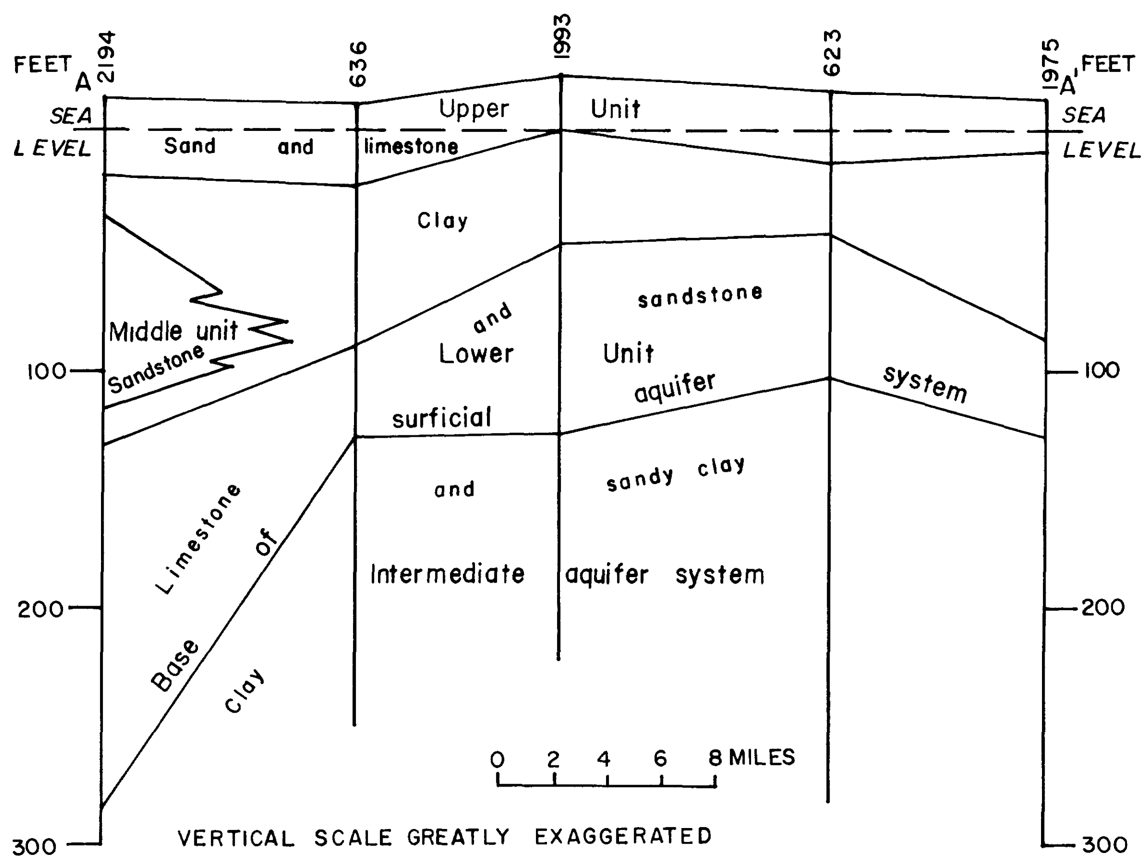


Figure 4.--Subsurface section A-A' showing the components of the surficial aquifer system.

Middle Unit

Throughout much of the southern part of the study area, a relatively widespread limestone member forms the uppermost permeable zone in the Tamiami Formation; that limestone is referred to as the middle unit of the surficial aquifer system. The unit ranges in thickness from about 10 to 100 feet and is thickest at the eastern end of Corkscrew Road (fig. 2). Farther south, in the area east of Bonita Springs, the middle unit is about 80 feet thick.

As mentioned earlier, the middle unit is hydraulically connected to the upper unit throughout much of southern Lee County, forming a virtual continuous unconfined permeable section with the upper unit. In the extreme southern part of the county, the middle unit is separated from the upper and lower units by thin beds of green clay of low permeability, as shown in the subsurface section in figure 4. The thin layers of clay cause the water in the middle unit to be under artesian pressure. However, when wells tapping the confined middle unit are pumped, water is contributed to the aquifer by leakage from above and below the unit through the thin confining clays.

Lower Unit

The lower unit of the surficial aquifer system is an areally persistent, artesian, water-bearing unit. It consists of poorly cemented sandstone in the vicinity of Lehigh Acres where it is known locally as the sandstone aquifer. The unit includes not only the sandstone but also comprises all other permeable hydraulically connected deposits. As shown in the log for well L-624 in Lehigh Acres (table 3; location shown in fig. 2), this includes the tan limestone at depths of 105 to 120 feet which directly underlies the sandstone at depths between 60 and 105 feet. In other parts of the area, the sandstone and tan limestone may be separated by thin clay layers, as indicated in the log for well L-1965 (east county boundary). The sandstone zones at depths between 48 and 81 feet and 125 and 137 feet are separated from the tan and gray limestone by clay and clayey sand at depths between 153 and 186 feet. Although separated in some places, the sandstone and limestone apparently are hydraulically connected throughout most of the area.

The lower unit is confined by laterally extensive clayey, fine-grained sand and green clay of variable thickness. The top of the unit is 40 to 60 feet below land surface in Lehigh Acres (fig. 5). From the Lehigh Acres area, the top of the lower unit slopes south to 150 feet or more where it is overlain by the middle unit. The base of the lower unit is the base of the surficial aquifer system.

The lower unit ranges in thickness from 20 feet to greater than 150 feet. The maximum thickness is in the south-central part of the area, and the minimum thickness is in the western part in the vicinity of Fort Myers; it virtually wedges out at Cape Coral near the coast. The westward thinning is accompanied by an increase in clay that reduces the permeability of the unit. The permeability of the components differs vertically and, thus, thickness alone does not necessarily imply a high potential water yield. Nevertheless, thickness of water-bearing materials can be important for water-supply development. Only small yields can be obtained from the lower unit in the western part of the study area.

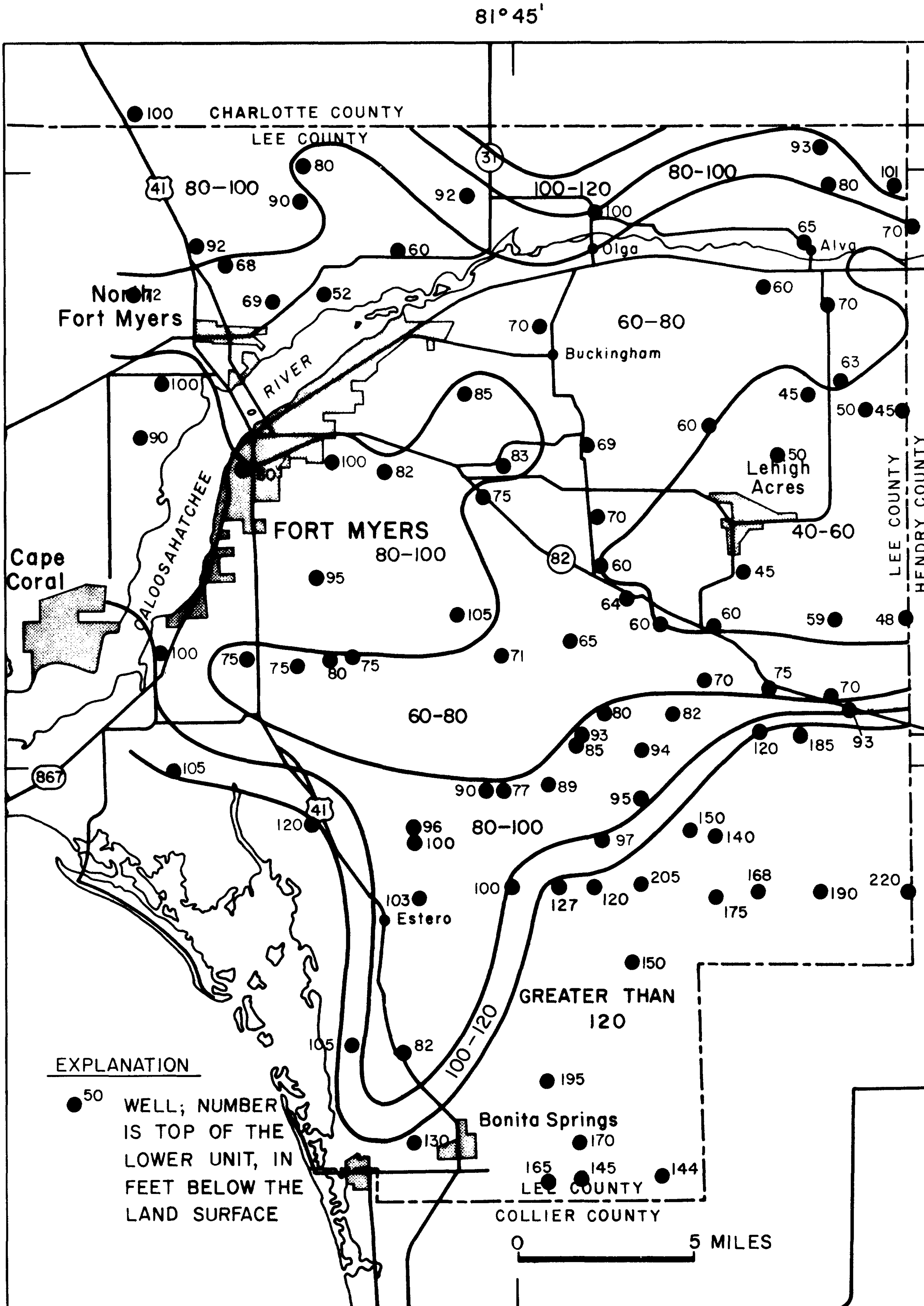


Figure 5.--eastern part of Lee County showing contours on the top of the lower unit of the surficial aquifer system.

Water-Level Fluctuations

Water levels in wells that tap the different units of the surficial aquifer system rise seasonally in response to rainfall. Levels decline as a result of pumping from wells and natural losses by evapotranspiration, vertical leakage into other units, and discharge into streams, lakes, canals, and the ocean.

The water table fluctuates within the upper unit of the surficial aquifer system. Observation wells tapping the upper unit range in depth from 8 to 33 feet. The average range of water-table fluctuations was 4.8 feet between 1976 and 1980, as determined by water-level measurements in 22 wells. This represents the average difference between the highest and lowest levels in each of these wells during that period. The average annual range in fluctuation of water levels for the same period in those wells was 3.3 feet.

Well L-1984, along Corkscrew Road, taps the lower unit at a casing depth of 206 feet, and adjacent companion well L-1984A taps the upper unit at a depth of 41 feet. The annual range of water-level fluctuations in well L-1984 is nearly twice that of the water table in the upper unit in well L-1984A (fig. 6). The water table of the upper unit in that area ranges from about 2 feet higher during the wet season to as much as 6 feet higher than the water level in the lower unit during the dry season. The upper unit receives recharge by direct infiltration of rainfall, and the resulting rise in the water table indicates a specific increase in volume of ground-water storage in that unit. The rise of the potentiometric surface in well L-1984, however, indicates an increase in artesian pressure and an equivalent increase in storage. Part of the increase in pressure is attributed to compression caused by the added weight of the water in the unconfined upper unit. Data obtained from dual companion deep and shallow observation wells provide a comparison of water levels, direction of interunit water movement, and differences in water quality.

Recharge to the lower unit occurs where the water table in the upper unit or the potentiometric surface of the middle unit is higher than the potentiometric surface of the lower unit. This relation prevails not only in the Corkscrew Road area, as shown in figure 6, but also throughout much of the study area, as shown in figures 7 and 8 and other field observations. Figure 7 shows a constant and relatively large downward gradient from the upper unit to the lower unit. During the dry season of 1976, head difference was as much as 7 feet in part of the area north of the Caloosahatchee River near the county boundary. Comparison of water levels in well L-2215 (lower unit) with those in companion well L-2215A (upper unit) shows similar head differences (fig. 8) in the area south of Lehigh Acres.

In topographically low areas, particularly adjacent to the Caloosahatchee River, the potentiometric surface of the lower unit in general is consistently higher than the water table in the upper unit. This relation is shown in the hydrographs of wells L-1975 and L-1975A on the north side of the river at Olga during 1976-80 (fig. 9). Thus, leakage was upward under head differences, ranging from 2 to 5 feet. Wells L-1975 and L-1975A at Olga are downstream of Franklin Lock

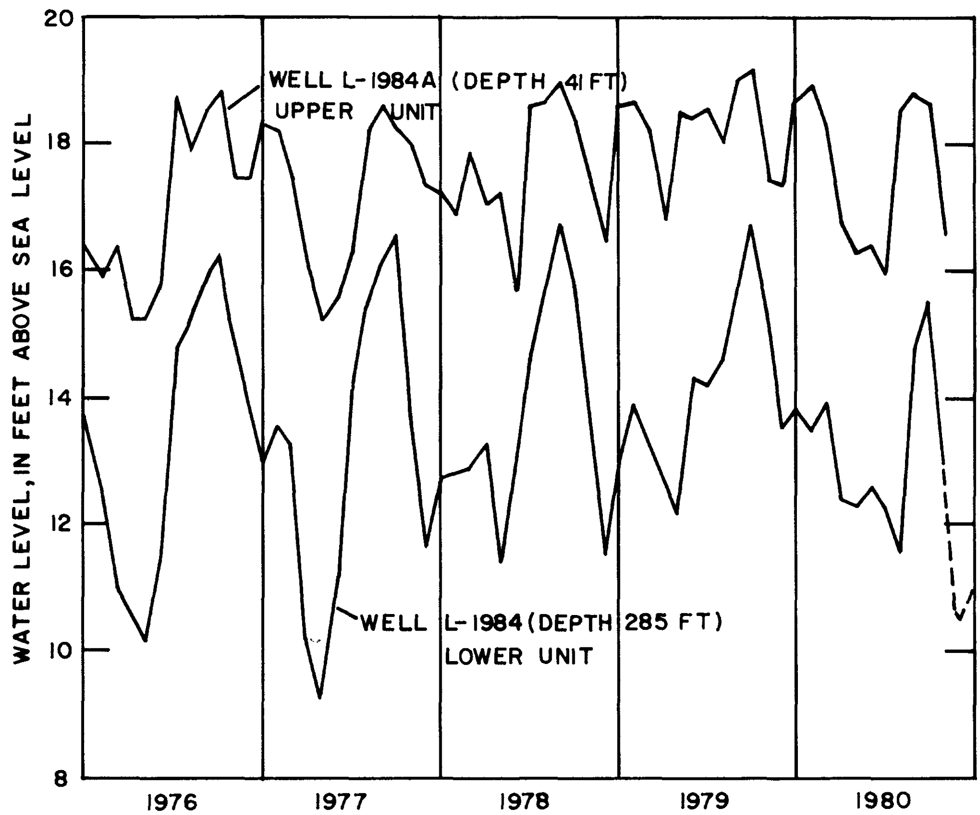


Figure 6.--Wells L-1984 and L-1984A along Corkscrew Road, for 1976-80.

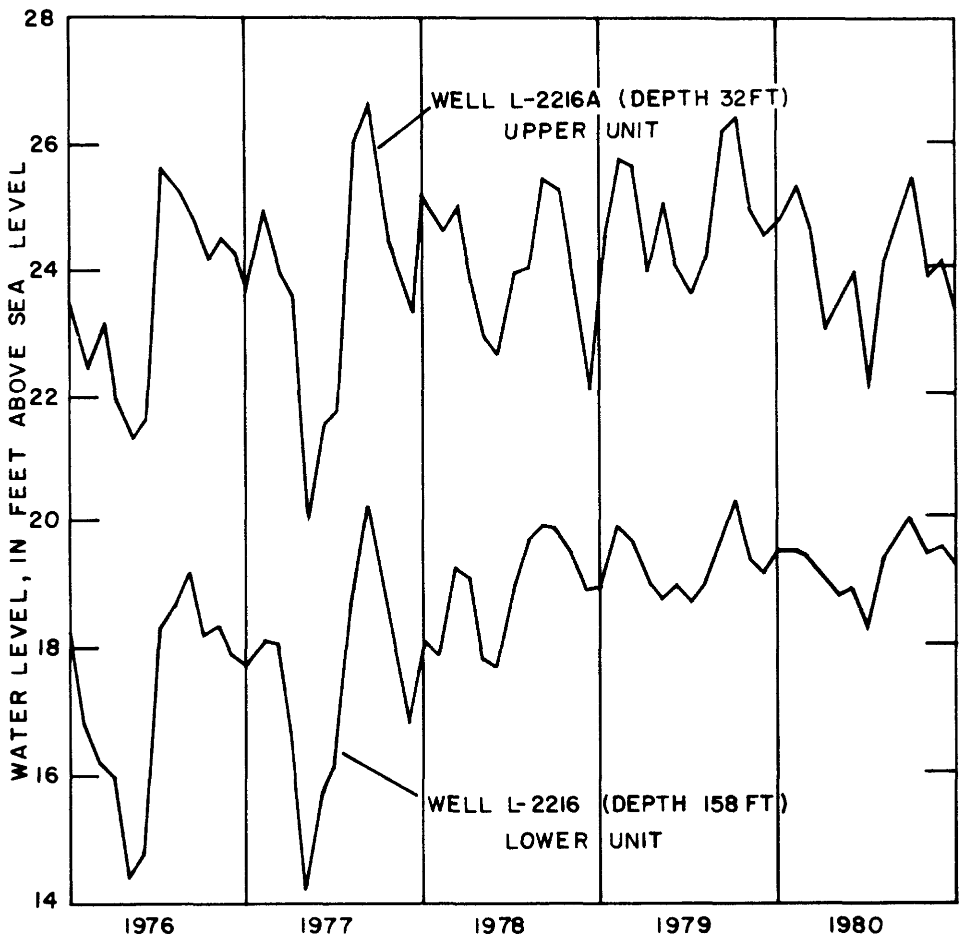


Figure 7.--Wells L-2216 and L-2216A northeast of Fort Myers along north county boundary, for 1976-80.

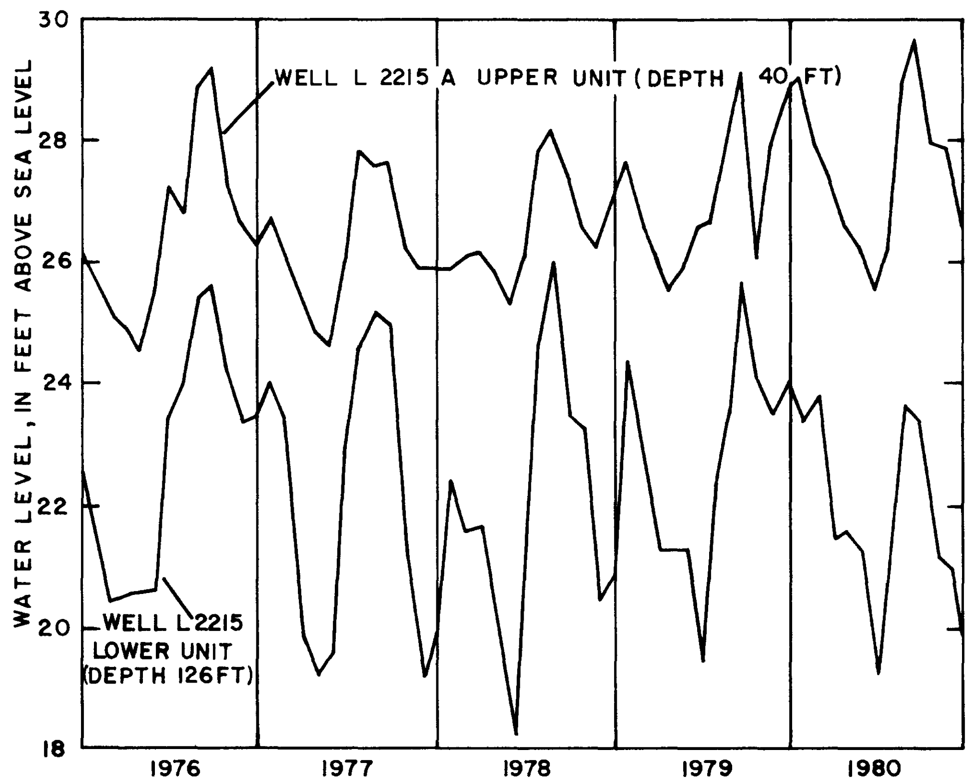


Figure 8.--Wells L-2215 and L-2215A south of Lehigh Acres, for 1976-80.

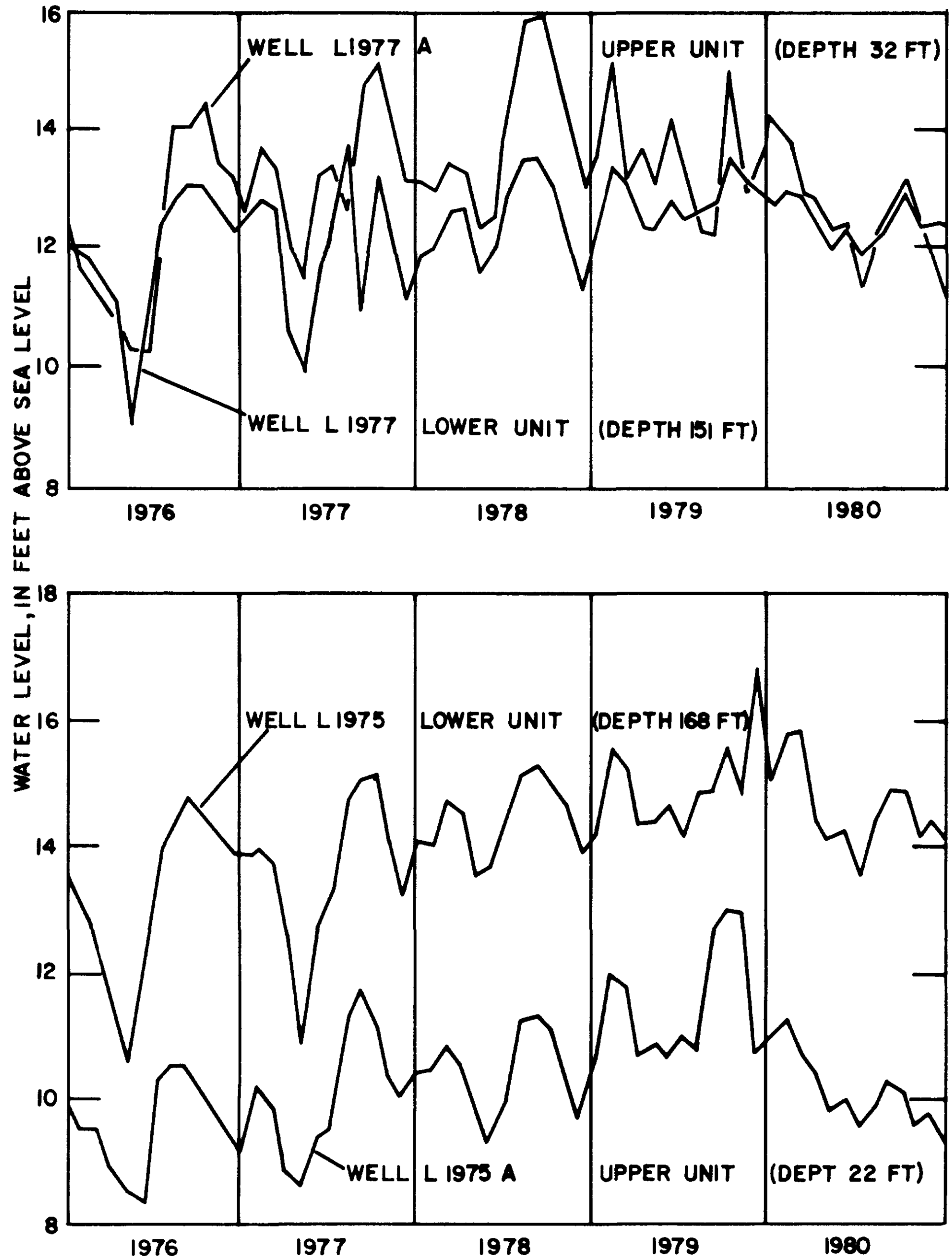


Figure 9.--Wells L-1977 and L-1977A at Alva and wells L-1975 and L-1975A at Olga, for 1976-80.

in the Caloosahatchee River and, therefore, are within the uncontrolled (tidal) reach of the basin. Ground-water levels there are affected by continuous drainage by the river. Drainage has lowered the water table in that area, but the potentiometric surface of the lower unit has not been equally affected; thus, the potentiometric surface is still consistently higher than the water table.

Farther upstream at Alva, water levels in companion wells L-1977 (tapping the lower unit) and L-1977A (tapping the upper unit) show reversals of head for relatively short intervals but, primarily, the water table is higher than the potentiometric surface of the lower unit. Wells L-1977 and L-1977A are located within the upstream controlled part of the basin where the river level is maintained at 3 feet above sea level for long periods. Drainage to the river is minimal during dry seasons and, as a result, the adjacent water table is maintained at higher altitudes than the water table in the downstream part of the basin. When the locks are open for extended periods, the water table declines to levels below the potentiometric surface, and temporary upward leakage to the upper unit occurs.

Discharge from the units within the surficial aquifer system occurs as pumping and by natural losses from evapotranspiraton, leakage to other units, and runoff to surface-water bodies. The water-level drawdown effects of pumping are superimposed on the effects of natural losses and gains. Water-level fluctuations in the lower unit (well L-1418) and pumpage at Lehigh Acres for 1971-80 are shown in figure 10. Well L-1418 and all of the municipal supply wells in the Lehigh Acres well field tap the lower unit. Although pumpage has progressively increased between 1971 and 1980 (fig. 10), water levels in the lower unit at well L-1418 have not been greatly affected because the supply wells that were added to the water system have been located at sites remote from this observation well.

Water-level fluctuations in the lower unit (well L-1998) and pumpage from the Green Meadows well field, southwest of Lehigh Acres, are shown in figure 11. Although early records of pumpage from this field are not available, water-level records indicate that sustained pumping did not occur until the end of 1975. Water levels prior to that time are indicative of the prepumping conditions. Some increase in pumpage has occurred since 1975 and is reflected by progressively lower water levels in the lower unit.

The only public supply system tapping the middle unit of the surficial aquifer system is at Bonita Springs. A comparison of fluctuations in water levels in well L-1691 with pumpage at Bonita Springs (fig. 12) indicates that water levels have not been greatly affected, although pumpage has more than doubled since 1974. A comparison of the rates of pumping at the three well fields with the differences in the magnitude of water-level fluctuations suggests that the relative permeability of the water-producing units is greatest at the Bonita Springs well field and lowest at the Green Meadows well field.

Potentiometric and Water-Table Surfaces

Maps of the potentiometric surface of the lower unit of the surficial aquifer system in April 1977 and in September 1979 represent low and high water conditions. The general direction of water movement in the lower unit

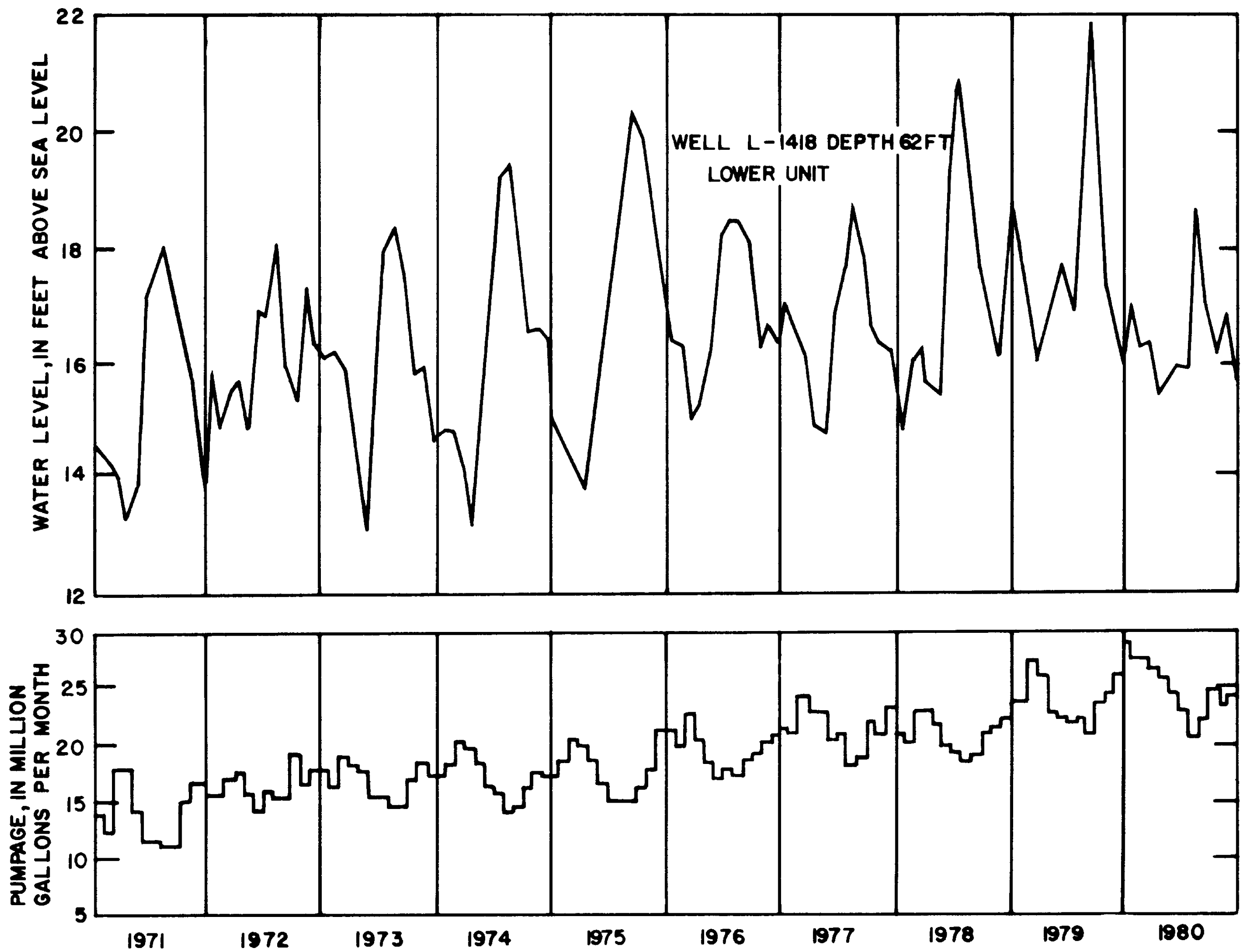


Figure 10.--Well L-1418 at Lehigh Acres and municipal pumpage at Lehigh Acres, for 1971-80.

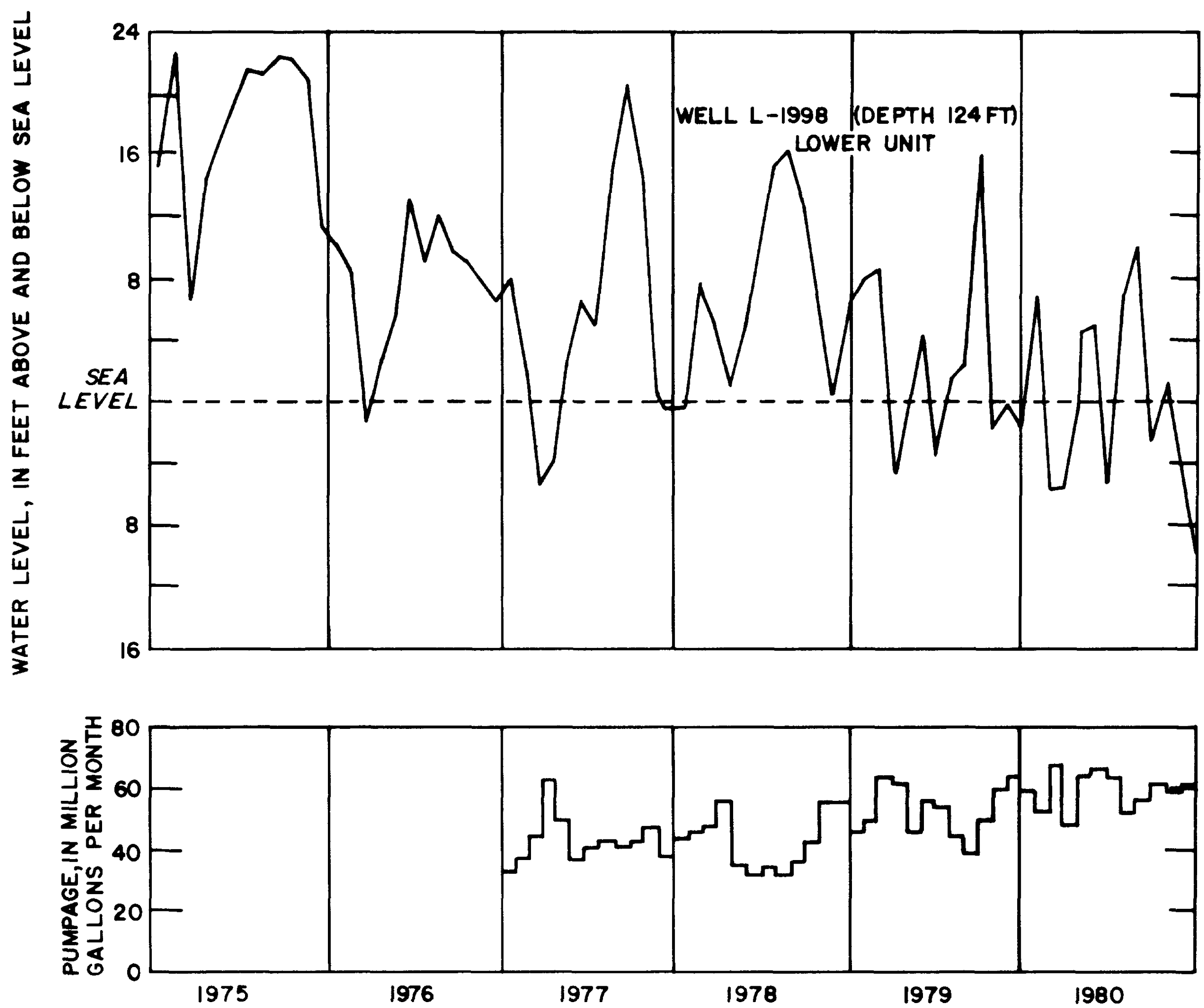


Figure 11.--Well L-1998 at Green Meadows and municipal pumpage at Green Meadows, for 1975-80.

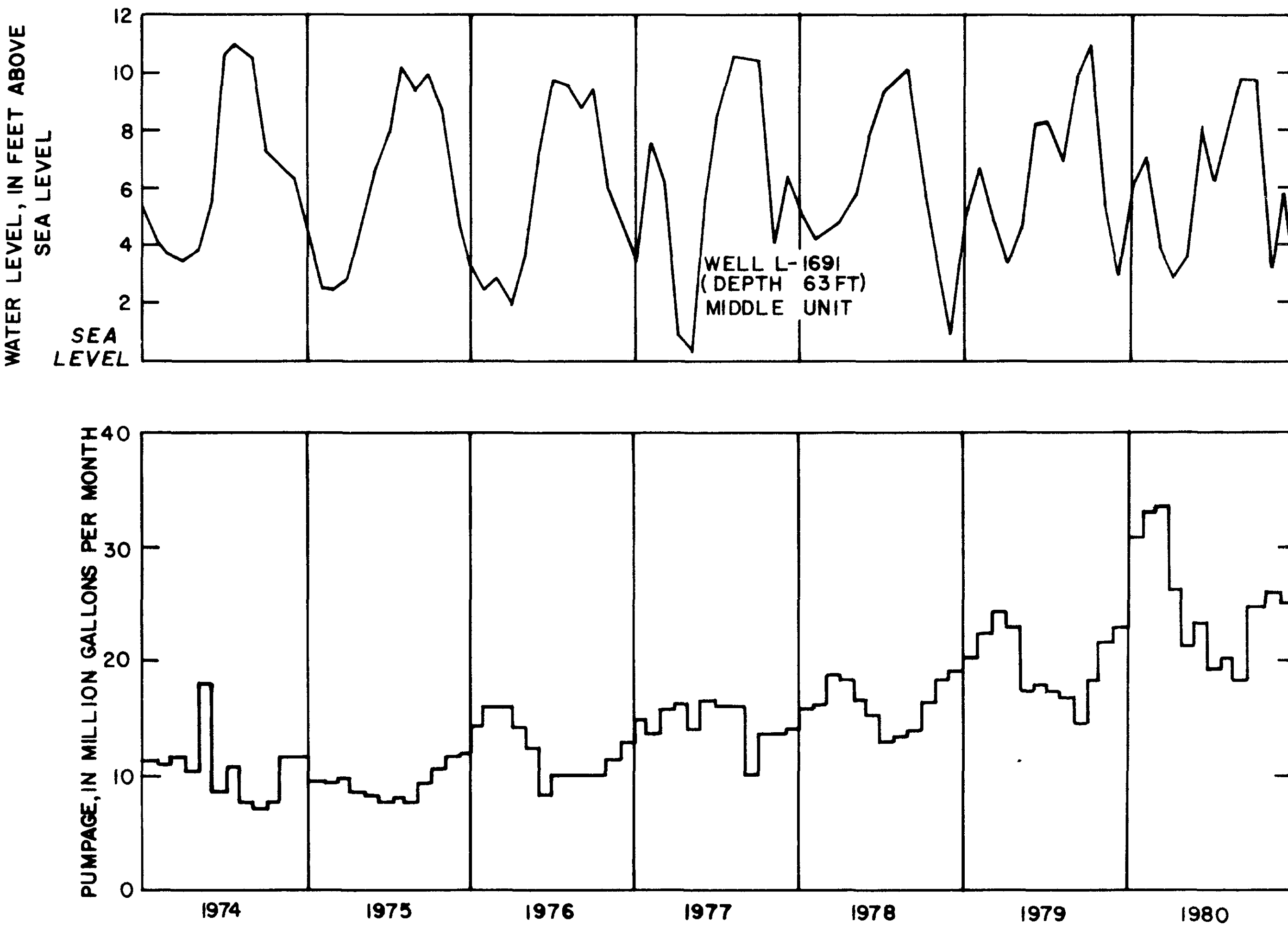


Figure 12.--Well L-1691 at Bonita Springs and municipal pumpage at Bonita Springs, for 1974-80.

is from areas of high head, along the east county boundary, toward areas of low head along the Gulf of Mexico and the Caloosahatchee River. Flow directions are perpendicular to the contours in figures 13 and 14. On the north side of the Caloosahatchee River, the contours indicate movement of ground water from Charlotte County southward toward the river. The closed contours in the south-central area show that part of the ground water that moves southwest toward the Gulf of Mexico was being diverted to the wells pumping in the Green Meadows well field and in the vicinity of Corkscrew Road. The reentrant in the contours in the northeastern area is due to withdrawals in the Lehigh Acres area. Comparison of data notes that dry-season water levels are 5 to 10 feet below wet-season levels, and that the greatest differences are in the eastern part of the county, the Green Meadows well-field area and the vicinity of Bonita Springs.

The blanketing upper unit of the surficial aquifer system is a secondary source of freshwater for shallow wells but is a primary source of recharge by downward leakage to underlying units in most of the area. Water-table contour maps for April 1977 (dry season) and September 1979 (wet season) are shown in figures 15 and 16 for comparison with the potentiometric maps of the lower unit. The contour configurations of the dry-season maps are similar, indicating comparable lateral flow direction in both units. Of importance is that the altitude of the water table was higher than that of the potentiometric surface, the largest vertical hydraulic gradients occurring in the vicinity of the Green Meadows and Bonita Springs areas. The distorted water-table contours adjacent to the Orange River confirm the effects of local drainage of the upper unit by the river. Neither water-table contour map reflects the effects of the municipal pumping in the well-field areas.

The water-table contour map in figure 15 indicates that the water table was maintained relatively high in the Fort Myers well field area, adjacent to State Road 82 and east of Fort Myers, during the dry season. Maintenance of the high ground water is the result of the diversion of water by pipeline from an intake site upstream of Franklin Lock on the Caloosahatchee River to the well-field area, where it is distributed to shallow ditches that dissect the area for artificially recharging the upper unit in that area.

The wet-season water-table map (fig. 16) is similar to the dry-season map but at a higher altitude by about 5 feet through most of the area. During the wet season, much of the area within the 25-foot contour was flooded or swampy as was the area to the south toward Bonita Springs.

Hydraulic Properties

Hydraulic properties include transmissivity (the rate of movement of water through the aquifer), storage (the volume of water stored in the aquifer), and leakance coefficient (the vertical movement of water through leaky confining beds). Although rate of leakage through confining beds is usually small, the collective effect over a large area may be important in moderating drawdown of water levels in areas of heavy withdrawals. Another characteristic related to hydraulic properties is the specific capacity of a well. Specific capacity is the rate of discharge from a well divided by the drawdown

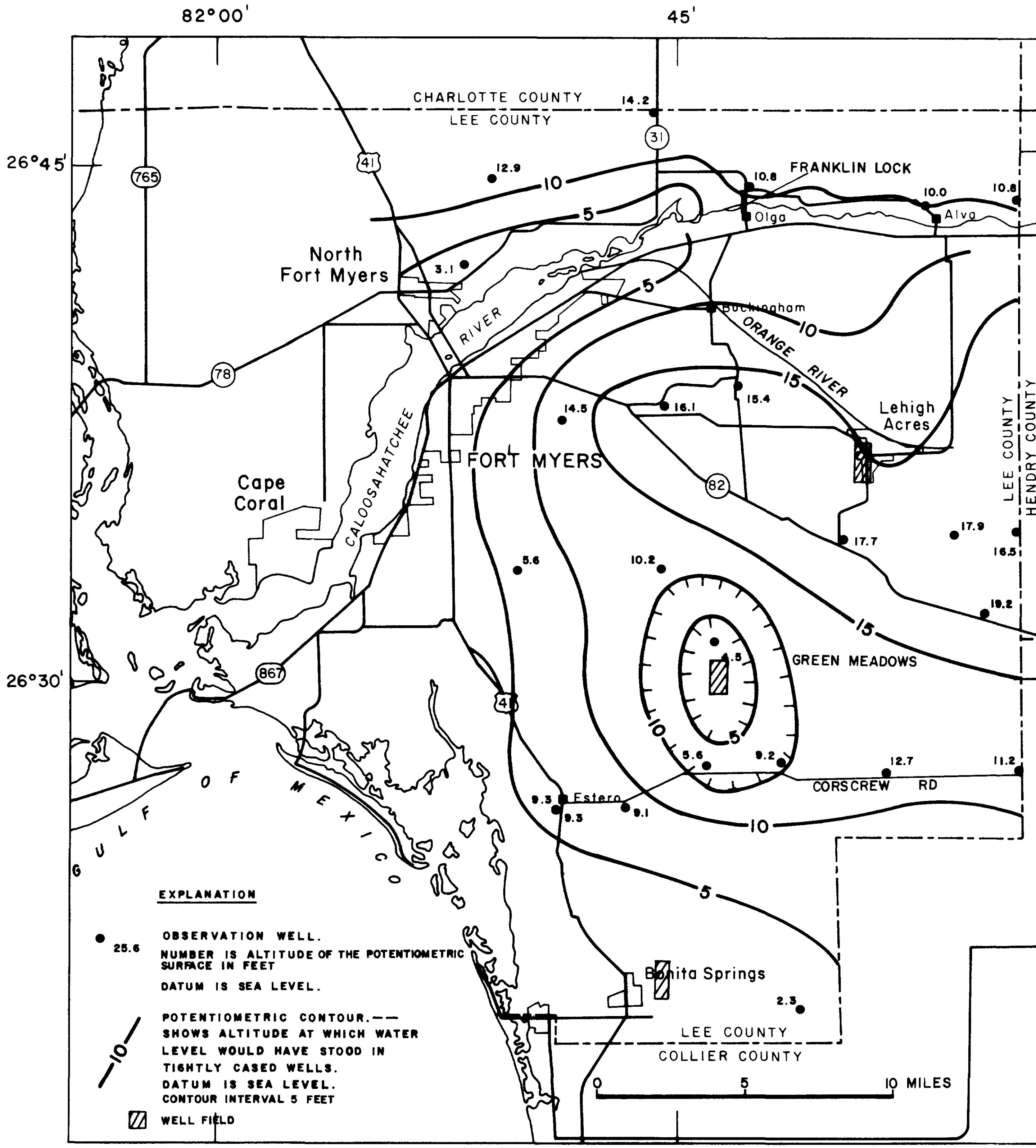


Figure 13.--Eastern part of Lee County showng contours on the potentiometric surface of the lower unit of the surficial aquifer system, April 1977.

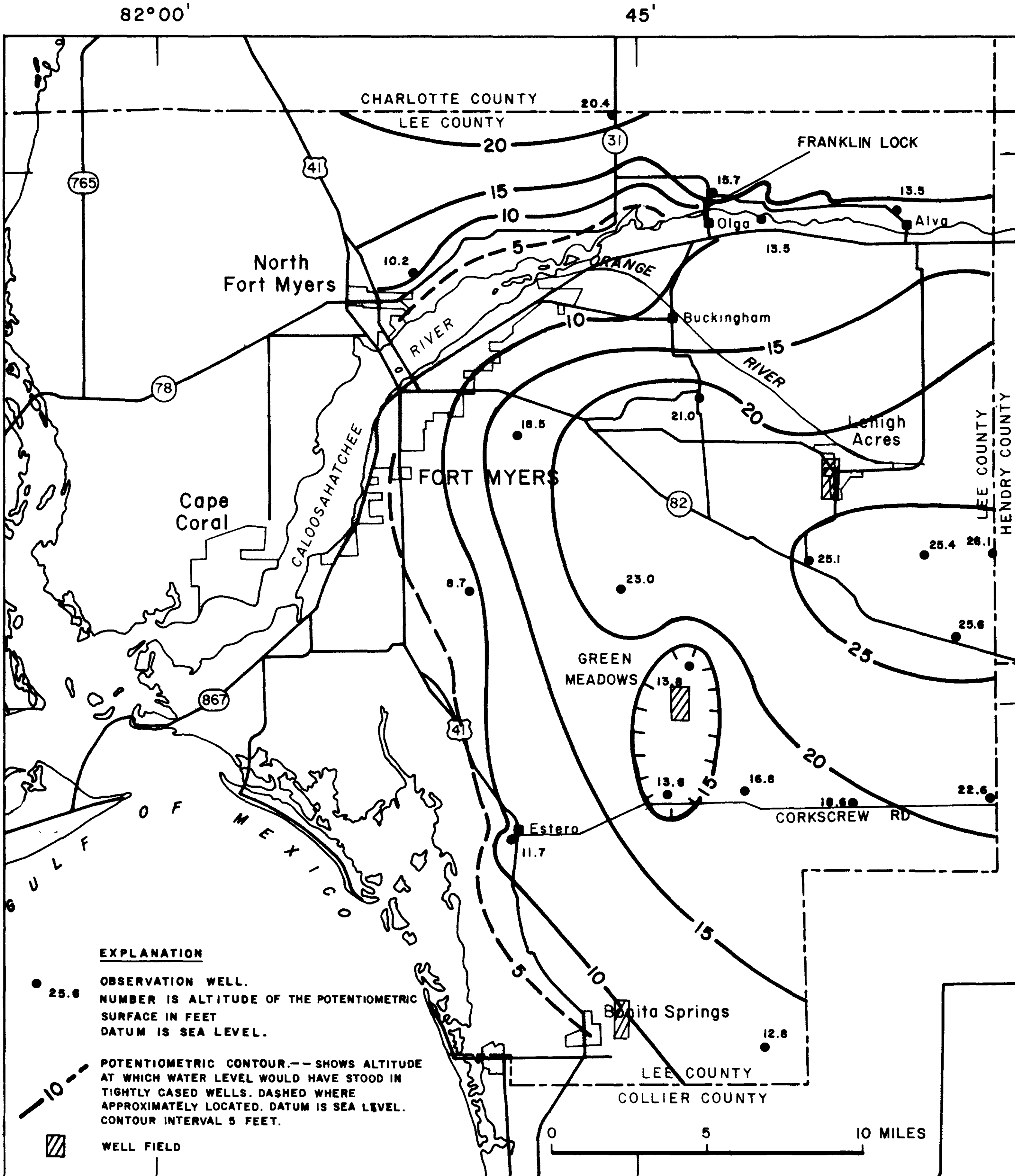


Figure 14.--Eastern part of Lee County showng contours on the potentiometric surface of the lower unit of the surficial aquifer system, September 1979.

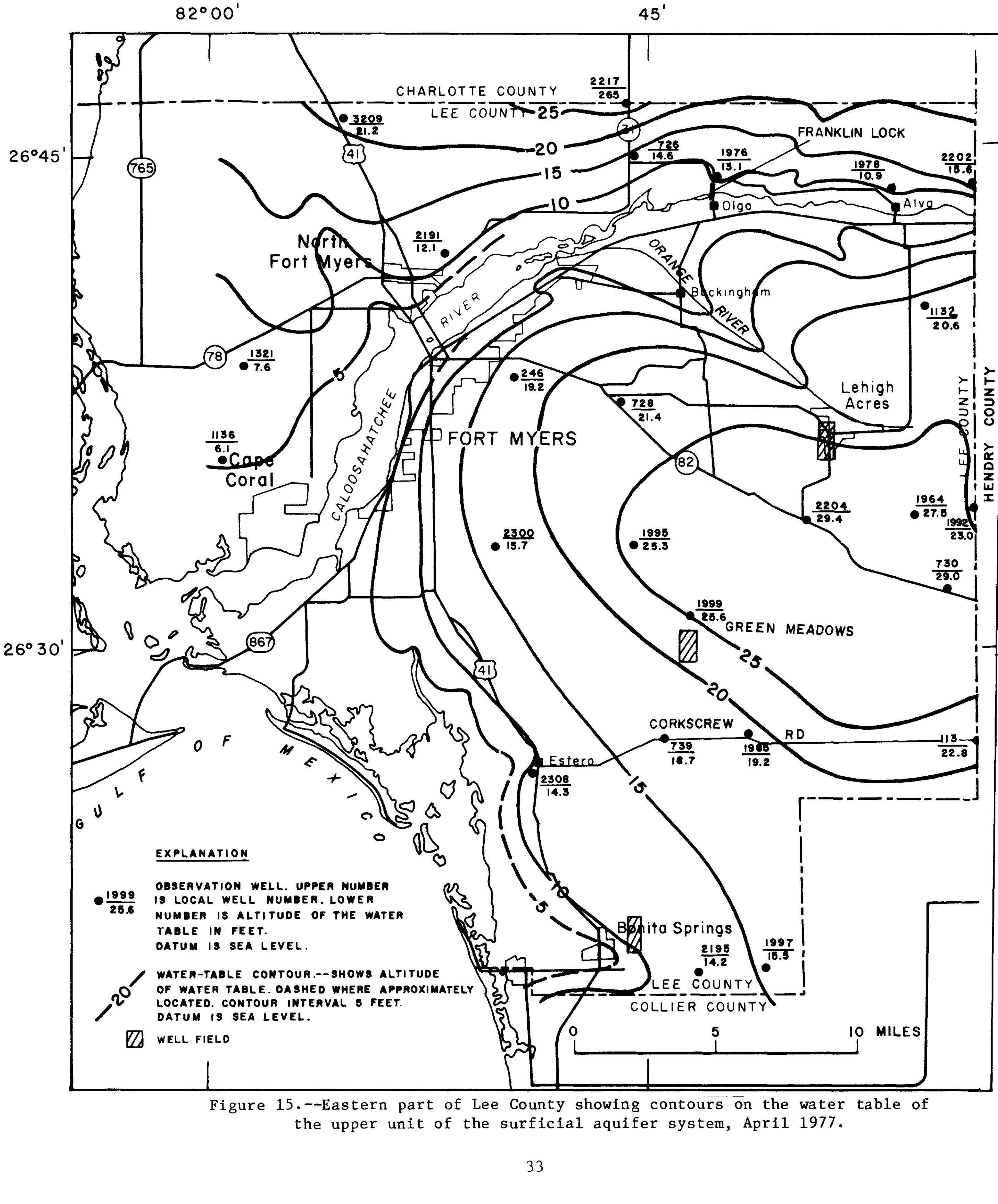


Figure 15.--Eastern part of Lee County showing contours on the water table of the upper unit of the surficial aquifer system, April 1977.

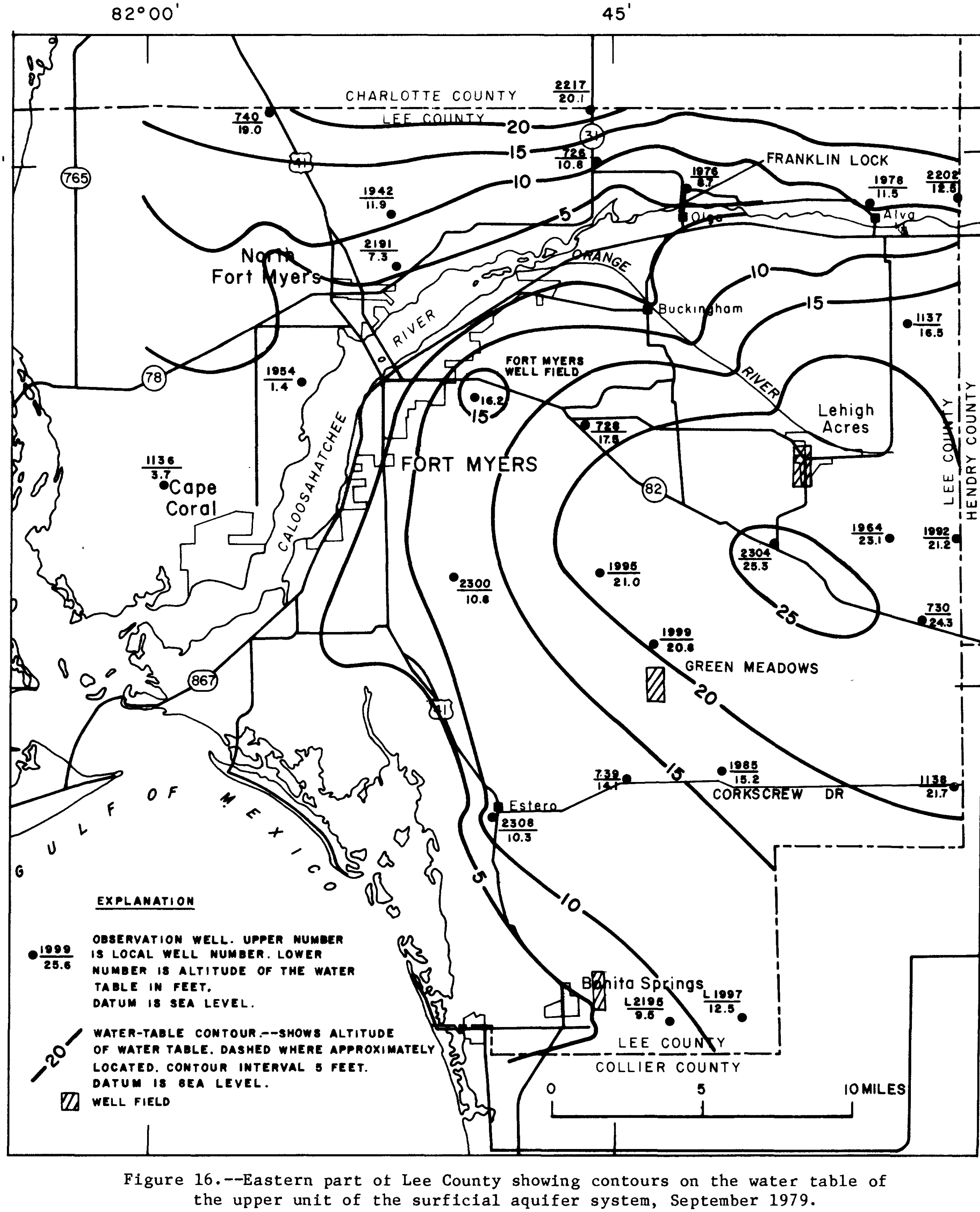


Figure 16.--Eastern part of Lee County showing contours on the water table of the upper unit of the surficial aquifer system, September 1979.

of water level in the well. The specific capacity varies with time, but it is generally proportional to the transmissivity of the aquifer (Lohman and others, 1972, p. 11), assuming drawdown from well loss factors is minimal. Extensive testing, such as that required for determining most of the properties, is not needed to obtain specific capacity; therefore, specific capacity data are usually available.

Aquifer tests on public supply wells L-1888 to L-1893 (fig. 2) in Lehigh Acres in 1970 by Gee and Jensen Consultants (Dao Duy, written commun., 1977) indicated that the transmissivity of the lower unit ranges from 1,700 to 7,750 ft^2/d, and the storage coefficient ranges from 0.0001 to 0.0003. The analyses were based upon the straight-line method developed by Cooper and Jacob (1946). A transmissivity of 4,000 ft^2/d and a storage coefficient of 0.0003 were considered representative of the lower unit in the Lehigh Acres area. Values of leakance were not estimated from these tests.

Two aquifer tests conducted at the Green Meadows well field (wells L-1961, L-1966, L-2231, fig. 2) in 1974, by the Layne-Western Company, Inc. (Nuzman, 1979, p. 9-10), indicated that the transmissivity of the lower unit ranges from 4,920 to 5,750 ft^2/d. The smaller value was selected by Nuzman as representative of the area. The Cooper and Jacob straight-line method was used to analyze these tests. In the first test, the pumping rate was 780 gal/min, and the specific capacity was 21 (gal/min)/ft of drawdown. In the second test, the pumping rate was 950 gal/min, and the specific capacity was 23.7 (gal/min)/ft of drawdown.

Missimer and Associates, Inc. (1978, p. 5-20 to 5-30), conducted tests on the lower unit at wells L-1984 and L-2193, about 4 miles southeast of Green Meadows along Corkscrew Road (fig. 2). Because the straight-line method of analysis does not account for leakage from the confining beds, a method described by Hantush and Jacob (1955) was used. The average values obtained by this method included transmissivity of 2,670 ft^2/d, storage coefficient of 0.0003, and leakance coefficient of 0.000063 (ft/d)/ft. This represents a leakage rate of about 40,000 $(gal/d)/mi^2$ for an average head difference of 3 feet across the confining bed. These values were considered representative for the lower unit and were used by Missimer and Associates, Inc., in predicting aquifer response to imposed stresses.

Specific capacity tests conducted on wells that tap the lower unit of the surficial aquifer system ranged from 0.2 to 22.1 (gal/min)/ft of drawdown. The efficiency of the wells tested is unknown inasmuch as they were constructed primarily for measurement of water levels and were not developed for maximum yield. The specific capacity values are, therefore, considered to be low.

Yields of wells that tap the the surficial aquifer system in eastern Lee County vary widely, ranging from about 10 to 1,100 gal/min. Yield primarily depends upon the permeability of the water-bearing unit penetrated by the well. Other factors that affect yield are the well diameter, length of open hole (uncased section) within the wellbore, and extent of development of the well--particularly where screens are used in completion, size of openings in well screens, and type of pumping equipment. Large diameter wells (6 to

16 inches) usually produce 150 gal/min or greater throughout the area. Wells usually are more productive in the southern part where yields range from 200 to 400 gal/min. The maximum yield of 1,100 gal/min was obtained from well L-1966 in the Green Meadows well field. Well L-1966 has a 16-inch casing and taps the lower unit.

Yields from small diameter wells (2 to 4 inches) range from 5 to 100 gal/min. Wells used for domestic and lawn-watering purposes are mostly 2 inches in diameter. Near the Caloosahatchee River, many of these wells flow naturally at rates of 5 to 20 gal/min. Many 4-inch wells listed in table 2 are observation wells finished with well screens. Yields greater than those observed could probably be obtained from these 4-inch wells after additional development.

Ground-Water Quality

The chemical characteristics of ground water in the study area are related to the proximity of the Gulf of Mexico and to the type of geologic material through which the water moves. Because saltwater occurs along the coast, in the Caloosahatchee River and other tidal creeks and canals, and in deep formations, it is a potential source of contamination to the surficial aquifer system. The geologic materials within the surficial aquifer system, predominantly limestone, dolomite, and other carbonate materials, contribute to dissolved solids in the ground water. The quality of water in the middle and lower units is indicated by chemical analyses of samples in tables 4 and 5. Trace elements in water from the middle and lower units are listed in table 6.

The State of Florida has established maximum contaminant levels for constituents in drinking water through primary and secondary drinking water regulations (Florida Department of Environmental Regulation, 1982). The following tables compare the primary and secondary drinking water regulations with constituents contained in ground water in the middle and lower units:

Florida Primary Drinking Water Regulations
[Concentrations are in milligrams per liter]

Contaminant	Range in surficial aquifer system: Middle unit	Range in surficial aquifer system: Lower unit	Maximum contaminant level1/
Arsenic (As)	0 - 0.001	0 - 0.001	0.05
Barium (Ba)			1.0
Cadmium (Cd)	0 - 0.002	0 - 0.002	0.010
Chromium (Cr)	0	0 - 0.001	0.05
Lead (Pb)	0.003 - 0.016	0 - 0.022	0.05
Mercury (Hg)	0	0 - 0.005	0.002
Nitrate (as N)			10
Selenium (Se)			0.01
Silver (Ag)			0.05
Sodium (Na)	20 - 100	26 - 520	160

1/ mg/L (milligrams per liter) is converted to ug/L (micrograms per liter) by multiplying by 1,000.

Table 4.--Analyses of water from the middle unit of the surficial aquifer system

[Constituents in milligrams per liter, except as noted]

Well No.	Depth (ft)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Bicarbonate (B)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$: Calcium/magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Specific conductance (umhos @ 25°C)	pH	Temperature (°C)	Color (Pt-Co units)
L-738	75	3/19/74	41	0.18	62	24	0.6	100	10	54	120	0.5	319	262	250	0	573	570	974	7.5	25	20
1636	75	5/9/74	50	.03	58	23	.6	80	10	50	77	.7	309	253	240	0	508	502	709	7.4	26	20
1691	63	3/19/74		.01	30		.2	20	1		26	.1	111	91	88	0	127	137	253	8.4	26	10
		6/11/76	45	.15	67	22	.6	70	8	53	76	.7	302	248	260	11	502	491	765	7.4		10
1966 1/	197	1/23/75	8	.21	126	4	.6	30	1	3	48	.2	380	315	340	28	437	414	820	7.2	27	100
		6/15/76	8		130	4	.6	29	1	12	45	.2	392	321	340	19	461	420	705	7.0	25	100
2198	137	3/25/76	40	.02	71	22	.7	75	7	71	71	.5	320	262	270	7	531	520	840	7.4	26	25

1/ Sample may contain some water from the lower unit.

Table 5.--Analyses of water from the lower unit of the surficial aquifer system

[Constituents in milligrams per liter, except as noted]

Well No.	Depth (ft)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Bicarbonate (B)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$: Calcium/magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Specific conductance (umhos @ 25°C)	pH	Temperature (°C)	Color (Pt-Co units)
L-414	94	4/11/74	30	0.74	87	21	0.4	36	2	0.5	59	0.5	359	294	300	10	428	414	712	7.6	24	30
708	58	5/9/74	18	.70	120	24	.5	110	3	68	190	.4	367	301	400	98	790	715	1,180	7.3	26	30
725	116	4/10/74	49	.33	61	44	1.2	85	8	24	190	.9	263	216	330	120	596	594	1,060	7.7	25	6
		5/8/75	45	.10	76	42	2.2	85	8	34	200	.7	292	240	370	130	736	636	1,100	7.5	25	5
		6/3/76	46	.15	75	42	1.4	89	8	35	200	.8	287	235	360	130	692	639	1,130	7.3	25	0
727	68	4/11/74		.06	22	21	.1	79	4	3	170	.3	102	85	140	56	340	347	684	8.6	25	5
		6/7/76		.25	140	37	1.2	80	3	130	200	.6	310	254	500	250	834	799	1,240	7.3	28	0
729	103	4/19/74	6	.01	59	7	.2	26	1	2	45	.2	191	157	170	18		240	425	7.6	25	80
		9/5/75	23	.10	85	13	.2	57	2	24	68	.3	330	271	270	0	466	430	760	7.5		30
		4/7/76	23	.04	88	13	.3	57	2	22	67	.4	332	272	270	0	450	440	755	7.4		30
731	234	4/19/74				13	.1	60	8		56	.5	161	132	77	0	236	228	435		24	3
		4/9/76	27	.08	52	18	.4	51	6	24	47	.5	275	226	200	0	361	360	600	7.5	27	10
		3/24/76	40	.03	69	22	.7	110	9	66	130	.5	312	256	260	4	596	600	995	7.4	26	20
1418	62	4/19/76	13	.12	130	32	.6	150	3	83	300	.2	324	266	460	190	913	870	1,510	7.2	26	20
1510	161	6/10/76	32	.05	140	36	1.5	105	6	83	370	.6	244	200	500	300	976	941	1,640	7.4	27	0
1625	218	9/5/75	27	.04	33	30	.6	99	12	23	79	.8	341	279	210	0	468	470	810	7.7		10
1853	150	3/12/75	54	.05	100	43	1.5	140	15	90	330	.6	235	193	430	240	980	890	1,440	7.8		10
		3/23/76	54	.22	130	43	1.1	130	10	85	310	.7	232	191	500	310	935	880	1,420	7.8	27	10
		6/4/76	55	.00	120	48	.6	140	11	200	310	.6	239	196	500	300	1,010	1,000	1,440	7.0	27	10
1907	57	6/14/76	38	.30	66	35	3.6	120	8	76	190	.8	264	217	310	96	718	668	1,130	7.4	26	0
1908	56	6/9/76	42	.01	68	34	3.5	110	8	57	200	1.0	253	208	310	110	696	648	1,060	7.5		0
1936	85	11/10/75	64	.20	100	40	.5	45	3	70	100	.5	366	300	410	110	646	600	1,200	7.2	26	0
1937	85	4/24/74	46	.04	79	41	1.0	47	5	73	87	.7	336	276	370	92	617	545	870	7.8	26	1
1961	157	8/9/74	25	.05	76	14	.5	48	4	43	50	.6	299		250	3	418	408	640	7.7	26	7
1963	274	8/8/74	23	.06	110	51	2.9	250	9	200	450	.7	279		490	260	1,340	1,230	2,080	7.3	26	7
	155	3/4/75	37		28	25	1.5	120	10	58	68	1.7	329	270	170	0	518	511	865	8.3	24	30
	155	4/8/76	33	.02	32	25	1.5	120	9	59	87	1.8	322	264	190	0	559	530	850	7.5	27	20
1965	218	3/4/75	23		73	50	2.1	170	12	98	320	.9	230	189	390	200	904	862	1,550	8.1	26	4

Table 5.--Analyses of water from the lower unit of the surficial aquifer system--Continued

[Constituents in milligrams per liter, except as noted]

Well No.	Depth (ft)	Date of collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Strontium (Sr)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Bicarbonate (B)	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$: Calcium/magnesium	Hardness as $CaCO_3$: Noncarbonate	Dissolved solids: Residue at 180°C	Dissolved solids: Calculated	Specific conductance (umhos @ 25°C)	pH	Temperature (°C)	Color (Pt-Co units)
L-1965	218	4/8/76	23	0.04	72	48	2.0	160	10	95	310	0.8	228	187	380	190	878	830	1,480	7.5	26	15
1968	146	11/14/74	29	.01	84	23	1.0	50	4	25	79	.5	308	253	310	53	432	448	760	7.3	25	20
		4/7/76	29	.03	86	19	.5	57	2	31	75	.5	840	279	290	11	480	470	780	7.3	26	15
1974	134	12/9/74	21	.13	45	26	.7	44	7	8	81	.9	238		220	25	350	351	625	7.4	26	3
		4/5/76	24	.04	44	28	.9	45	6	11	87	.6	228	187	230	43	360	360	630	7.7	26	5
1975	168	5/8/75	52	.01	53	27	1.8	65	6	19	120	1.0	246	202	250	44	507	466	785	7.8	26	10
		4/14/76	54	.03	48	27	1.0	63	6	18	130	1.0	202	165	230	65	470	450	730	7.6	26	10
1977	151	5/8/75	28	.01	140	91	2.0	470	19	260	1,000	.8	153	126	730	600	2,360	2,090	3,600	7.8	26	3
		4/15/76	25	.04	140	92		520	18	410	1,000	.8	145	119	750	630	2,250	2,300	3,850	7.4	26	10
1981	106	4/6/76	33	.08	100	32	1.0	100	8	82	180	.5	344	282	380	98	785	710	1,190	7.2	26	10
1984	288	3/12/75	25	.07	80	14	.5	21	3		26	.3	313	257	260	1	328	324	605	7.7	26	8
		3/22/76	47	.03	61	20	.5	46	5	35	35	.8	308	252	230	0	402	400	630	7.4	27	15
1994	155	3/25/76	25	.02	91	19	.5	46	3	43	77	.5	314	258	310	48	481	460	770	7.3	26	30
1998	124	6/10/76	25	.04	73	15	.5	52	3	39	62	.6	270	221	240	23	424	403	670	7.1	26	10
2075	82	3/16/75	39	.00	93	24	.6	37	4	30	66	.3	366	300	330	32	492	474	835	7.2	26	7
2184	110	6/7/76	55	.00	47	23	.6	140	8	68	75		346	284	210	0	648	600	840	7.1	26	10
2185	106	6/1/76	25	.01	120	32	.7	150	4	120	260	.5	304	249	430	180	924	863	1,500	7.4	26	5
2186	151	6/8/76	32	.02	40	28	1.3	130	8	62	140	1.4	311	255	220	0	558	597	950	7.5	26	0
2190	105	6/2/76	32	.00	95	32	.9	140	3	69	230	1.6	306	251	370	120	852	755	1,320	7.1	28	0
2192	184	6/15/76	64	.05	52	20	.3	180	10	82	120	1.5	387	317	210	0	771	720	1,120	7.1	28	30
2193	298	3/23/76	48	.04	54	25	.5	47	5	40	40	.9	300	246	240	0	412	410	620	7.9	28	10
2200	166	6/3/76	32	.04	130	88		470	18	250	970	2.1	173	142	700	560	2,260	2,060	3,600	6.9	26	0
2215	126	6/9/76	61	.10	97	22	.5	38	3	80	46	.5	310	254	330	79	514	501	740	7.5	26	10
2216	158	6/2/76	55	.05	60	41	2.5	110	8	31	220	1.7	257	211	320	110	682	657	1,100	7.3	27	0
2418	127	1/14/77	37	.03	52	44	1.3	38	6	38	52	.6	343	281	310	31		438		7.4	25	5
2419	115	1/13/77	37	.00	47	46	1.4	59	8	44	98	.6	319	262	310	47	497	498		7.5	26	10
2420	110	1/13/77	37	.05	47	43	1.4	52	8	43	75	.7	330	271	300	25	472	469		7.6	26	10

Table 6.--Analyses of trace elements in water from the middle and lower units of the surficial aquifer system

[Constituents in micrograms per liter]

Well No.	Depth (ft)	Date of collection	Aluminum (Al)	Arsenic (As)	Boron (B)	Cadmium (Cd)	Chromium (Cr)	Cobalt (Co)	Copper (Cu)	Lead (Pb)	Lithium (Li)	Manganese (Mn)	Mercury (Hg)	Molybdenum (Mo)	Nickel (Ni)	Vanadium (V)	Zinc (Zn)
Middle unit																	
L-1691	63	6/11/76	20	0	160	2	0	0	0	16	10	0	0.0	0	0	1.0	10
1996 1/	197	1/23/75	30	1	70	0	0	0	1	3	3	0	.0	1	0	.0	6
Lower unit																	
725	116	6/3/76	20	1	110	0	1	0	0	18	20	0	.4	0	0	2.6	10
727	68	6/7/76	0	0	110	1	0	0	0	14	10	0	.1	0	0	2.9	10
1510	161	6/10/76	0	0	90	0	0	0	0	2	10	0	.0	0	0	11	10
1907	57	6/14/76	20	0	150	1	0	4	0	0	10	10	.2	0	0	2.3	10
1908	56	6/9/76	10	0	130	0	0	0	0	0	20	0	.0	0	0	2.9	10
1961	157	8/9/74	0	0	100	1	0	2	2	7	7	0	.1	1	1	.0	0
1963	274	8/8/74	0	1	100	0	0	2	2	3	17	17	.0	5	1	3.2	0
1998	124	6/10/76	0	0	70	0	0	0	0	6	0	0	.0	0	0	.8	0
2185	106	6/1/76	0	0	100	0	1	0	0	0	8	10	.3	2	0	6.6	0
2186	151	6/8/76	0	0	190	0	0	0	0	0	20	0	.0	0	0	1.7	20
2190	105	6/2/76	0	0	90	0	1	0	0	0	10	10	.2	0	0	12	10
2200	166	6/3/76	10	0	200	0	1	0	0	14	30	10	.5	0	0	26	0
2215	126	6/9/76	0	0	100	2	0	0	0	19	10	0	.0	0	0	.6	10
2216	158	6/2/76	10	0	120	0	0	0	0	22	20	0	.3	0	0	6.3	0

1/ Sample may contain some water from the lower unit.

Florida Secondary Drinking Water Regulations
[Concentrations are in milligrams per liter, except for color and pH]

Contaminant	Range in surficial aquifer system		Maximum contaminant level[1/]
	Middle unit	Lower unit	
Chloride (Cl)	26 - 120	45 - 1,000	250
Copper (Cu)	0 - 0.001	0 - 0.002	1
Iron (Fe)	0.01 - 0.21	0.01 - 0.74	0.03
Manganese (Mn)	0	0 - 0.017	0.04
Sulfate (SO_4)	5 - 71	2.0 - 410	250
Zinc (Zn)	0.006 - 0.010	0 - 0.020	5
Color (Pt-Co units)	10 - 100	0 - 80	15
pH (units)	7.0 - 8.4	6.9 - 8.6	6.5 min
Total dissolved solids	137 - 570	328 - 2,360	500

Dissolved Solids

Dissolved solids concentrations in water from the lower unit of the surficial aquifer system (table 5) range from 236 to 2,360 mg/L (milligrams per liter) (fig. 17). Dissolved solids concentrations that exceed 800 mg/L are locally considered to be an indicator of saltwater contamination. Highest concentrations of dissolved solids exceeded 2,000 mg/L in the vicinity of Alva in wells L-1977 and L-2200 (table 5). Comparison of the chemical analyses for these wells with analyses from wells in the general area that tap artesian zones below the surficial aquifer system (Boggess, 1974; table 5) indicates that upward leakage from the deep wells may have caused the contamination of the lower unit near Alva. Other parts of the study area may be similarly affected by upward leakage of saltwater as indicated by the many deep wells in the area and the dissolved solids analyses in table 5 that exceed 500 mg/L. Well L-1963, southeast of Lehigh Acres, produced water with 1,340 mg/L of dissolved solids when the well was open to a depth of 274 feet. After the well was plugged back to 155 feet, the dissolved solids concentration decreased to about 550 mg/L.

Chloride

The middle and lower units of the surficial aquifer system contain water with chloride concentrations ranging from 26 to 1,000 mg/L as shown in tables 4 and 5. Analyses of samples from many other wells (table 2) in the study area indicate chloride concentrations ranging from 30 to 7,300 mg/L. Water from the lower unit usually contains chloride concentrations less than 250 mg/L, except in areas along the Caloosahatchee River where concentrations

1/ mg/L (milligrams per liter) is converted to ug/L (micrograms per liter) by multiplying by 1,000.

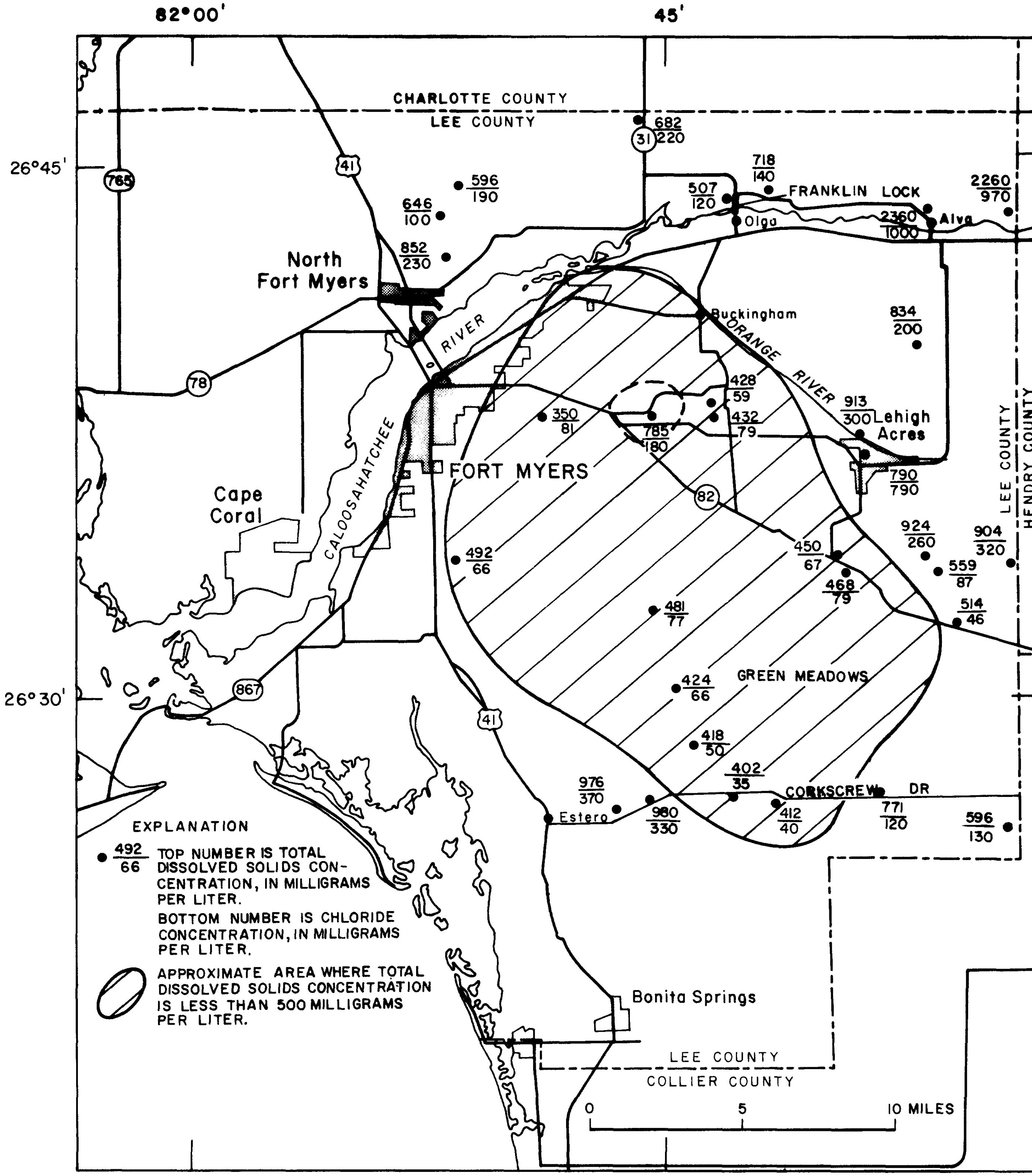


Figure 17.--Eastern part of Lee County showing distribution of dissolved solids and chlorides in the lower unit of the surficial aquifer system, 1974-77.

are higher (fig. 17). The high chloride concentrations (500 to 1,100 mg/L) in water from some wells near the river may be the result of upward leakage from deep saline-water aquifers through open well bores or wells with corroded casings (Boggess and others 1977, p. 11-13). Unflushed remnants of ancient seawater invasions may account for the high concentrations in some areas. The highest chloride concentration, 7,300 mg/L, was determined for water from well L-1948 (table 2) in east Fort Myers near the Caloosahatchee River. Most likely, saltwater from the Caloosahatchee River has leaked through corroded sections of the well casing to cause heavy contamination.

The middle unit contains water with relatively low concentrations of chloride ranging from 26 to 120 mg/L. These concentrations indicate that contamination from the deep artesian sources has not occurred.

Water Use

Water use in Lee County will probably continue to increase. In 1970, 8.3 Mgal/d were withdrawn in the county for public supply (Pride, 1973, p. 7). By 1975, public supply pumpage had doubled to 16.8 Mgal/d (Leach, 1978, p. 12). Pumpage at Lehigh Acres increased from 0.10 Mgal/d in 1961, to 0.38 Mgal/d in 1970, and to 0.84 Mgal/d in 1980. At Bonita Springs, pumpage increased from 0.31 Mgal/d in 1974 to 0.84 Mgal/d in 1980.

Pumpage from the three principal public supply systems is given in table 7. Well fields in Lehigh Acres and Green Meadows tap the lower unit, and municipal wells at Bonita Springs tap the middle unit. A series of new wells that tap both the upper and lower units has been installed to supply the Corkscrew Road area.

Leach (1978, p. 25) reported that in 1975 about 42,200 acres of cropland were irrigated in Lee County. This included 7,000 acres of citrus, 5,700 acres of truck crops, 25,000 acres of pasture, and 4,500 acres of other crops. About 65 Mgal/d were withdrawn for crop irrigation, of which 50 Mgal/d were from ground-water sources.

Ground water for irrigation is obtained from the surficial aquifer system or from deeper artesian aquifers. An estimated 15 Mgal/d are withdrawn from the middle and lower units. Irrigation of lawns and golf courses may add an additional 2 Mgal/d for an estimated total of 17 Mgal/d for irrigation use.

Most of the urbanized areas are served by public supply systems. In remote areas, individual residential wells provide the domestic supplies. In 1980, about 10,000 people were served by domestic wells tapping the surficial aquifer system. At an estimated per capita consumption of 150 gal/d, domestic use would average about 1.5 Mgal/d. Self-supplied industrial and commercial use adds about 0.25 Mgal/d. Other users are institutions such as the Sunniland Training Center, which has its own well field and treatment facility, and livestock ranches, which total an estimated 0.25 Mgal/d. Estimated total use of water from the surficial aquifer system averaged about 23 Mgal/d in 1980.

Table 7.--Pumpage of the surficial aquifer system by public supply systems, 1975-80

[Pumpage in million gallons]

Year	Yearly totals combined: Middle unit, Bonita Springs	Lower unit, Lehigh Acres	Lower unit, Green Meadows	Yearly totals	Daily average
1975	112.3	213.6	--	--	--
1976	114.2	236.7	--	--	--
1977	161.4	260.5	504.9	--	--
1978	197.0	272.7	506.3	956.0	2.6
1979	240.0	287.3	622.3	1,149.6	3.2
1980	306.2	305.0	698.2	1,309.4	3.6

SUMMARY AND CONCLUSIONS

The surficial aquifer system in central and eastern Lee County contains upper, middle, and lower water-bearing units that yield freshwater to wells. The upper unit is unconfined and occurs throughout most of the study area, ranging in thickness from about 10 to 40 feet. Separated from the upper unit by laterally extensive clay and marl is the lower unit containing water under artesian pressure. Permeable materials in the lower unit range in thickness from 20 to greater than 150 feet and consist of quartz sand, sandstone, and limestone. In the southern part of the study area, a permeable artesian middle unit consisting of limestone occurs between the upper and lower units.

Recharge to the lower unit, the main source, occurs as downward leakage from the overlying units. The potentiometric surface of the lower unit fluctuates similarly to the fluctuations of the water table in the upper unit, although at lower altitudes. In low-lying areas along the Caloosahatchee River, the potentiometric surface of the lower unit is consistently higher than the water table, indicating upward leakage from the surficial aquifer system to the river.

Water movement in the lower unit is from the high head in the southern part of Lehigh Acres, north toward the Calooshatchee River, and west and south toward the Gulf of Mexico. In north Lee County, ground water moves south from Charlotte County toward the Caloosahatchee River.

Yields of wells tapping the middle and lower units range from 10 to 1,100 gal/min. Large diameter wells generally produce 150 gal/min. Yields of 200 to 400 gal/min can be obtained from some wells in the southern part of Lee County.

Water from the surficial aquifer system is used for most purposes without extensive treatment. Dissolved solids concentrations frequently exceed 500 mg/L, and in some areas the chloride concentration exceeds 250 mg/L. Concentrations of trace elements, including arsenic, cadmium, chromium, lead, and mercury, were generally less than recommended maximum levels for drinking water in water samples tested. Estimated water use from the surficial aquifer system was about 23 Mgal/d in 1980; about 17 Mgal/d were used for irrigation and 5 Mgal/d for public supply and domestic use.

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Table 2.--Record of wells in the surficial aquifer system in eastern Lee County[1]/

[Unit: U, upper unit; M, middle unit; L, lower unit]

Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-11	263918081504701	80		2.5	6	+0.75	11/15/43					L	
27	263834081512301	72		2	16	3.05	11/20/43					L	
38	263823081512301	84		2.5	17	1.50	11/12/43					L	
41	263818081510001	95		2	17	.59	11/12/43					L	
45	263801081502801	77		2	18	.14	11/11/43					L	
66	263755081520701	92		2.5	16	+ .64	11/27/43					L	
76	263812081514801	103		2	15	2.77	12/07/43					L	
103	263706081513801	120	86	3	16			F1		160	08/29/68	L	
126	263829081513701	94		2	15	3.60	12/16/43					L	
140	263855081514301	71		2.5	5	+1.70	12/18/43					L	
177	263735081503001	87		2	18	1.48	01/22/44					L	
214	263824081515401	83		6	13	.60	04/07/44					L	
227	263815081513601	105		2	17							L	
232	263808081511201	106	104	4	17							L	
233	263757081505301	85	80	4	17	+ .39	06/30/44					L	
234	263743081470301	100	70	4	23							L	
235	263803081480201	120	99	4	22	2.22	11/16/44					L	
273	264132081515801	106		2	10	+2.10	08/09/44					L	
274	264111081515701	75		2	11	+1.80	08/09/44					L	
276	264125081513301	68		2	7	+1.40	08/10/44					L	
280	264416081511101	103		4	18	.00	08/10/44					L	
284	264240081493401	100		2	10							L	
286	264254081475101	83		2	8	1.40	08/10/44					L	

1/ Most wells are finished with open-end below casings--large diameter supply wells usually finished with screens. Wells in upper unit are screened and are used for water-table measurements.

Table 2.--Record of wells in the surficial aquifer system in eastern Lee County[1]/--Continued

[Unit: U, upper unit; M, middle unit; L, lower unit]

Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-320	263755081513701	87		2	16	1.10	09/07/44					L	
343	262231081480901	76		3	13	3.03	09/13/44					M	
344	262035081464401	70		2	8							M	
345	262034081464801	75		4	7	+2.50	09/19/44		26			M	
348	262033081464501	75		4	7							M	
384	263805081511101	75		2	17	+ .10	06/13/44					L	
394	263717081525901	94		2	12	.70	07/24/44					L	
409	263818081431601	95	90	8	23			162				L	
410	263822081432101	111	60	6	21			168				L	
411	263828081432201	90	60	8	21			168				L	
412	263825081431701	90	61	8	21			168				L	
413	263821081432001	90	60	8	21							L	
414	263824081431601	94	60	8	22				24	59	04/11/74	L	Chemical analysis
415	263818081431801	90		8	22							L	
416	263847081425201	90	63	8	21			168				L	
417	263851081425001	90	61	8	22							L	
418	263855081424701	93	60	8	22	5.68	01/23/46	168	25	46	03/21/46	L	
419	263852081424301	90	63	8	22			170				L	
420	263849081424701	90	60	8	22				25	75	01/23/46	L	
421	263849081425401	90	62	8	22							L	
422	263854081425401	90	60	8	22							L	
423	263857081425001	90	61	8	21							L	
424	263832081424501	90	61	6	23							L	

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Table 2.--Record of wells in the surficial aquifer system in eastern Lee County[1]/--Continued

[Unit: U, upper unit; M, middle unit; L, lower unit]

Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-508	262054081472601	90	34	6	8	0.66	10/13/49	375	26	176	10/13/49	M	
509	262059081472201	84	32	6	8	1.96	10/13/49	26				M	
577	263917081443301	145	95	8	17	.09	09/24/57	110				L	
578	263919081442901	155	102	8	17	1.00	03/07/58					L	
579	263920081443501	115	98	8	17							L	
580	263923081443101	115	100	8								L	
583	263623081380701	50		4	25	10.73	12/19/66					L	
603	262047081480501	345			7								Test hole
607	262551081490201	230			13								Test hole
615	262703081335801	390			27								Test hole, table 3
621	264333081410001	360			28								Test hole
624	263835081394401	495			18								Test hole, table 3
626	263906081335901	500			24								Test hole
636	262657081453201	260			19								Test hole, table 3
639	263246081511401	210			17								Test hole, table 3
646	264238081532101	210			17								Test hole
667	263719081562901	300			8								Test hole
686	263355081544101	90		2	6					260	05/13/69	L	
687	263351081543701	92		2	6					200	05/13/69	L	
689	263353081543301	93		2	6					240	05/13/69	L	
690	263338081543401	80		2	6					400	05/14/69	L	
705	264320081413401	94	80	4	10			F38	27	460	11/10/66	L	
708	263625081380801	58	50	6	24			150	26	164	02/27/69	L	Chemical analysis

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Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-709	263623081382401	66	54	6	24	19.70	12/19/66	150	25			L	
710	263609081382001	70	52	6	24	20.60	12/19/66	150	25			L	
725	264416081510501	116	81	4	20			30	25	215	07/23/68	L	Chemical analysis
726	264440081454001	32	30	4								U	
727	263950081355401	68	67	4	23	4.09	07/24/68	2	26	210	07/24/68	L	Chemical analysis
728	293708081455701	32	30	4								U	
729	263335081394301	103	81	4	29	3.85	08/09/68	100	25	75	07/31/68	L	Chemical analysis
730	263147081353001	42	40	4								U	
731	262703081340201	234	165	4	25			100	24	72	08/05/68	L	Chemical analysis
738	262022081464201	75	61	4	11	2.30	09/02/68	100	25	120	08/28/68	M	Chemical analysis
739	262730081435501	32	30	4								U	
740	264605081555001	32	30	4								U	
741	262552081485701	119	102	4	13	3.01	10/01/68			170	09/01/68	L	
746	263319081480201	87	81	2	19			83		250	11/07/68	L	
769	264212081362801	70		6	12				24	480	08/20/68	L	
830	264002081554401	92	82	3	12				25	90	11/21/68	L	
841	264309081435801	69	63	2	5				24	750	08/11/67	L	
849	264302081440801	69	63	2	5	+6.00	08/21/68		24	215	08/21/68	L	
852	264302081435501	80	63	2	5					800	08/21/68	L	
855	264309081440101	78		2	5					675	08/21/68	L	
861	264310081440401	80		2	5	+7.80	08/22/67		25	200	08/22/67	L	
874	264335081373801	68		2	12			F10	24	1,100	02/27/68	L	
877	264331081370301	100			11					1,100	02/27/68	L	

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L-879	264326081451701	84		2	7					750	02/27/68	L	
882	264243081374201	56		2	13					400	11/25/68	L	
883	264300081382201	90	86	4	5			F20	24	650	11/25/68	L	
891	264322081450301	74		2	6				24	555	12/03/68	L	
895	264338081450001	80		2	5	+9.40	12/06/68		24	255	12/06/68	L	
897	264322081410401	100		3	8	+7.50	01/21/69		24	176	01/21/69	L	
909	264307081371201	86		2	10					1,055	04/16/69	L	
923	264259081363201	65		2	16					30	04/22/69	L	
924	264253081363901	60		1.3	15					375	04/22/69	L	
930	264102081443001	78	64	2	9	+4.90	10/31/69	F6	25			L	
937	263348081541601	100		2	9					106	07/23/69	L	
939	263353081542501	94		2	9					260	07/23/69	L	
943	263403081543001	105	100	2	6					228	07/24/69	L	
950	263324081543801	95		2	7	2.28	07/28/69					L	
963	264253081361901	87		2	16					320	08/29/69	L	
1045	264407081544101	110		3	20					525	02/24/70	L	
1050	264325081413901	72		2	2	+4.45	03/16/70	F12	26	275	03/16/70	L	
1051	264536081552801	150		2	22			F10	24	110	03/23/70	L	
1052	264534081552501	90		2	22					85	03/23/70	L	
1056	263851081432901	71		6	18	2.96	02/27/70					L	
1057	264201081553701	79		3	14	+4.90	09/28/67		25	190	09/28/67	L	
1136	263620081583501	32	30	4								U	
1137	263940081355001	27	25	4								U	

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Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-1138	262705081335501	32	30	4								U	
1232	264312081425101	90		1.3	6				29	1,020	08/09/69	L	
1233	264316081424601	90		1.3	6			F5	26	680	08/09/69	L	
1239	264109081442501	86		2	6			F8	27	580	08/09/69	L	
1418	263630081375301	62	55	8	23	9.00	01/21/71		26	300	04/19/76	L	Chemical analysis
1436	264400081511401	82	60	2	18					400	05/13/71	L	
1505	264311081374301	54	42	2	7					1,025	11/17/71	L	
1510	262607081462201	161	57	2	17			75	27	370	06/10/76	L	Chemical analysis
1511	264118081452201	75	60	2	5					700	11/24/71	L	
1552	264142081360801	125	40		18					500	02/23/72	L	
1625	263329081394301	218	162	2	30	6.15	09/03/75	60		79	09/05/75	L	Chemical analysis
1627	263133081423701	230		2	26					70	03/01/72	L	
1628	263129081404001	255	130	2	28			45		80	05/05/71	L	
1629	263039081413401	246	82	2	26			60		40	09/24/71	L	
1630	262917081413501	165			25					40	03/18/72	L	
1631	262819081393701	230		2	28					60	03/18/72	L	
1632	263209081375701	239	110	2	36			60		110	02/15/71	L	
1633	263425081415001	244	89	2	29							L	
1636	262121081451801	75	64	8	13			200	26	83	11/08/71	M	Chemical analysis
1637	262109081451701	74	65	8	13					84	11/17/71	M	
1638	262058081451701	69	64	8	13					81	11/17/71	M	
1639	262049081451701	69	64	8	13					86	11/12/71	M	
1640	262037081451601	68	64	8	13							M	

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L-1641	262025081451601	70	62	8	13			200		94	12/23/71	M	
1691	262042081455001	63	58	4	12	6.31	06/21/73	36	26	80	05/31/73	M	Chemical analysis
1692	264232081354401	84	63	2	12					800	06/07/73	L	
1693	264245081352601	60	50	2	11			18		800	06/07/73	L	
1694	264233081351301	80	60	2	16					825	06/07/73	L	
1853	262706081435401	150	130	4	20			60	26	330	03/12/75	L	Chemical analysis
1888	263608081384301	68	58	8	27			200				L	
1889	263631081383101	85	50	8	24			150				L	
1890	263623081384401	62	51	8	26			100				L	
1891	263608081380301	85	57	8	27			200				L	
1892	263557081382601	80	63	8	26			250				L	
1893	263554081384401	80	63	8	27			200				L	
1907	264308081410001	57	55	2	8	+3.13	03/28/74	F1	25	220	03/28/74	L	Chemical analysis
1908	264308081405401	56		2	7				24	220	03/26/74	L	Chemical analysis
1916	264307081405001	92			6				26	220	03/28/74	L	
1930	264249081402601	94		2	6			F3				L	
1931	264313081411701	80	63	2	6				27	360	04/01/74	L	
1936	264251081520401	85	42	2	16	19.23	04/17/74	30	26	100	11/10/75	L	Chemical analysis
1937	264250081520301	85	63	2	16				26	87	04/24/74	L	Chemical analysis
1942	264330081523001	42	40	4								U	
1948	264120081483201	110	80	2	5					7,300	09/23/74	L	
1949	264119081483601	120		2	5					310	05/13/74	L	
1950	264119081483201	80		2	5					250	05/13/74	L	

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L-1954	263840081550001	32	30	4								U	
1960	264214081525401	105		2	11					110	07/15/74	L	
1961	263044081430501	157	99	16	25	3.55	08/12/74	781	26	50	08/09/74	L	Chemical analysis
1963	263344081361701	155	68	4	31	1.60	08/07/74	100	27	87	04/08/76	L	Chemical analysis
1964	263440081362501	27	25	4								U	
1965	263353081335801	218	50	4	29			100	26	310	04/08/76	L	Chemical analysis, test hole, table 3
1966	263058081432501	141	95	16	24			1,100				L	
1968	263807081430301	146	70	4	24			100	26	75	04/07/76	L	Chemical analysis
1973	263718081485001	225			21								Test hole, table 3
1974	263718081485002	134	85	4	21			40	26	87	04/05/76	L	Chemical analysis
1975	264359081424701	168	102	4	13			100	26	130	04/14/76	L	Chemical analysis, test hole, table 3
1975A	264359081424702	22	20	4								U	
1976	264400081423801	32	30	4								U	
1977	264320081365701	151	65	4	17			115	26	1,000	05/08/75	L	Chemical analysis
1977A	264320081365702	32	30	4								U	
1978	264340081361001	32	30	4								U	
1980	264350081370801	101	30	2	13					1,060	09/04/74	L	
1981	263737081453301	106	75	4	24			100	26	180	04/06/76	L	Chemical analysis
1984	262713081414601	288	206	4	21			100	27	35	03/22/76	L	Chemical analysis
1984A	262713081414602	41	20	2	21							U	Water levels
1985	262720081414501	42	40	4								U	

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L-1992	263442081340501	32	30	4								U	
1993	263251081452801	243			25								Test hole, table 3
1994	263251081452802	155	70	4	25			115	26	77	03/25/76	L	Chemical analysis
1995	263350081461501	27	25	4								U	
1996	261954081410101	197	65	4	15			50	27	48	01/23/75	M,L	Chemical analysis
1997	262000081404501	42	40	4								U	
1998	263041081433102	124	100	4	27			21	26	62	06/10/76	L	Chemical analysis
1999	263135081435501	42	40	4								U	
2007	263225081453101	66		1.5	26				25	100	11/13/74	L	
2008	263227081453101		88	1.5	26					150	11/13/74	L	
2075	263319081514601	82	63	2	19				26	66	03/16/75	L	Chemical analysis
2115	263259081551601	300			8								Test hole
2119	263808081451601	84		2	21					120	05/15/75	L	
2120	263815081451601	100	45	2	21					204	05/15/75	L	
2125	263843081453101	105	84	2	21					824	05/15/75	L	
2128	263846081452601	80		2	21					512	05/16/75	L	
2129	263850081452501	90		2	21					236	05/16/75	L	
2134	263852081451601	95		2	21					130	05/16/75	L	
2184	263247081501701	110	75	4	15	6.94	08/27/75	3	26	75	06/07/76	L	Chemical analysis
2185	263344081361501	106	69	4	31	6.98	08/28/75	40	26	260	06/01/76	L	Chemical analysis
2186	263344081361703	151	133	4	31	7.72	08/28/75	38	26	140	06/08/76	L	Chemical analysis
2187	263950081355403	145	135	4	22	5.16	08/28/75	60	27	350	01/04/77	L	
2189	263807081431101	333	71	4	24	3.34	08/28/75					L	

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L-2190	264144081520301	105	71	4	14	6.70	08/27/75	6	28	230	06/02/76	L	Chemical analysis
2191	264145081521001	32	30	4								U	
2192	262659081382501	184	155	4	27	7.96	08/27/75	10	28	120	06/15/76	L	Chemical analysis
2193	262713081414401	298	206	4	19			60	28	40	03/23/76	L	Chemical analysis
2194	261957081432201	137	81	4	15	2.96	09/02/75					M	Test hole, table 3
2195	261940081433801	32	30	4								U	
2198	261954081432201	137	80	4	15	3.35	08/02/75	115	26	71	03/25/76	M	Chemical analysis
2200	264329081340401	166	122	4	17			45	26	970	06/03/76	L	Chemical analysis
2202	264340081340501	44	42	4								U	
2215	263147081353002	126	99	4	30	4.46	10/21/75	88	26	46	06/09/76	L	Chemical analysis
2215A	263147081353003	40	38	4								U	
2216	264608081454101	158	130	4	26	8.01	10/29/75	30	27	220	06/02/76	L	Chemical analysis
2216A	264608081454101	32	30	4								U	
2217	263132081433201	185	95	16	25	4.47	11/10/75	900				L	
2262	264456081463701	96	60	2	22					680	12/24/75	L	
2294	264250081442201	90		2	5					550	04/29/76	L	
2297	264258081443701	108	91	2	5					300	04/29/76	L	
2298	264248081440701	101	91	2	5			50		250	04/29/76	L	
2299	264258081432501	100	89	2	5							L	
2300	263340081493501	27	25	4								U	
2304	263340081392501	27	25	4								U	
2308	262540081484501	32	30	4								U	
2309	264250081442301	97	87	2	5	.74	04/29/76	50				L	

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L-2316	262704081392001	210	93	8	26			60		45	08/09/76	M	
2354	264255081360601	73	68	2	12					940	10/01/76	L	
2356	264501081513301	165	105	4	22			15		300	10/14/76	L	
2360	263336081362901	80		8	30			240				L	
2361	263329081363701	81	64	8	27			240				L	
2362	263338081370101	80	60	8	31			240				L	
2363	263334081370201	80	60	8	29	5.42	07/08/77	240				L	
2364	263328081362301	82	60	8	29							L	
2367	263617081363901	60	40	6	26			150				L	
2368	262659081341501	155	84	6	27			350				M	
2369	262655081341501	139	84	8	27			400				M	
2370	262635081335801	150	75	8	23			325				M	
2371	262643081341301	180	80	10	25			200				M	
2372	262626081341201	210	85	10	24			200				M	
2373	262731081350701	210	95	10	29			300				M	
2374	262717081351201	285	120	10	29	6.40	11/24/76	375				M,L	
2375	262712081351201	480	240	8	29			250				L	
2376	262723081352701	302	120	10	29			350				M,L	
2377	262745081352601	235	100	10	29			350				M,L	
2378	263625081363601	60	40	6	26			150				L	
2379	263631081362201	62	41	6	26			150				L	
2380	263647081360001	59	43	6	25			150				L	
2381	263652081355501	62	43	6	25			150				L	

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Table 2.--Record of wells in the surficial aquifer system in eastern Lee County[1]/--Continued

[Unit: U, upper unit; M, middle unit; L, lower unit]

Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-2382	263623081363301	60	40	6	24			150				L	
2383	263621081364101	60	40	6	24			150				L	
2384	263649081361401	58	35	6	24			150				L	
2418	264120081472501	127	75	6	5	4.30	01/05/77	93	25	52	01/14/77	L	Chemical analysis
2419	264133081474301	115	73	6	5				26	98	01/13/77	L	Chemical analysis
2420	264132081473701	110	78	6	5				26	75	01/13/77	L	Chemical analysis
2421	264254081520501	84	42	2	17							L	
2428	262250081481601	127	82	4	13			20				M	
2437	263807081430501	121	68	2	24							L	
2439	263347081382601	108	88	8	27	2.17	07/08/77	280				L	
2440	263348081373201	113	79	8	30			369				L	
2441	263349081380201	95	83	8	29			224				L	
2442	263321081374401	115	84	8	29			300				L	
2447	263833081432901	95		2	22					62	05/03/77	L	
2448	263835081433001	85	84	2	22					58	05/03/77	L	
2464	262258081463901	120	63	2	14							M	
2519	262258081481801	110	85	4	13			35		150	07/08/77	M	
2522	263717081442401	110		6	24							L	
2550	262711081413701	134	67	6	20							M	
2552	262741081421501	195	155	4	21							L	
2554	262715081421101	264	200	4	20							L	
2557	262716081413401	290	225	4	19							L	
2558	262732081413201	305	30	4	20							L	

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Table 2.--Record of wells in the surficial aquifer system in eastern Lee County[1]/--Continued

[Unit: U, upper unit; M, middle unit; L, lower unit]

Well No.	Latitude-Longitude No.	Depth (ft)	Casing (ft)	Diameter (in)	Altitude of land surface (ft)	Water level above (+) or below land surface datum (ft)	Date of measurement	Yield (gal/min) flow-F	Temperature (°C)	Chloride (mg/L)	Date	Unit	Remarks
L-2561	262750081413301	284	195	4	21							L	
2563	262706081421301	285	195	4	18							L	
2565	262708081415001	284	220	4	18							L	
2585	264254081412601	76		2	9					310	01/11/78	L	
2588	264243081403601	90		2	10					330	01/12/78	L	
2594	264302081403901	60		2	7					160	01/12/78	L	
2595	264258081402001	120		2	5					200	01/12/78	L	
2597	264257081402201			4	6	+5.20	01/12/78			230	01/12/78	L	
2601	264326081414701	135		4	12					180	01/23/78	L	
2606	262441081484701	130	110	4	17	1.00	09/02/77			125	09/02/77	L	
2607	262441081484702	130	112	4	17			60		113	09/30/77	L	
2612	264235081410201	80	63	4	9	+3.00	02/07/78	F30		260	02/07/78	L	
2616	264311081421901	94		3	6	+ .02	02/08/78					L	
2621	264301081414401	80			11					420	02/08/78	L	
2623	264320081404801	87		2	6				24	200	03/13/78	L	
2627	264330081404601	90		2	11					200	03/13/78	L	
2628	264312081402101	120		2	8				24	220	03/13/78	L	
2629	264316081403201	120		2	8	+4.70	03/13/78	F20	24	210	03/13/78	L	
2631	264309081400701	94		2	7	+7.80	03/13/78	F5		220	03/13/78	L	
3216	263954081502901	90		2	8					625	11/22/78	L	
3226	264020081441301	88			11					660	06/18/79	L	
3279	264307081362901	80			16					925	11/09/79	L	

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*U. S. GOVERNMENT PRINTING OFFICE: 1986-631-135/20018 Region 4.